THE EIGHT NATIONAL COMMUNICATION OF THE SLOVAK REPUBLIC ON CLIMATE CHANGE

Under the United Nations
Framework Convention
on Climate Change
and the Kyoto Protocol

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LIST OF ABBREVIATIONS

8NC SR	The Eight National Communication of the Slovak Republic on Climate Change
APVV	Slovak Research and Development Agency
BR SR	The Biennial Report of the Slovak Republic
CER	Certified emission reduction
CGCM3.1	Type of Global Circulation Model
CNG	Compressed natural gas
COST	Cooperation in Science and Technology
CRF	Common reporting format
CSEUR	Consolidated System of EU registries
CTF	Common tabular format
EBRD	European Bank for Reconstruction and Development
EF	Emission Factor
ECHAM5	Type of Global Circulation Model
ERU	Emission reduction units
EU ETS	European Union Emission Trading Scheme
GCM	Global Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIC	Gross inland energy consumption
GWP	Global warming potential
CHP	Combined heat and power
IPCC	Intergovernmental Panel on Climate Change
ITL	Independent Transaction Log
KNMI	Koninklijk Nederlands Meteorologisch Instituut – author of the Regional Circulation model RACMO
LPG	Liquid petroleum gas
LULUCF	Land use, land-use change and forestry
MŠVVaŠ SR	Ministry of Education, Science, Research and Sport of the Slovak Republic
MŽP SR	Ministry of Environment of the Slovak Republic
MPI	Max Planck Institute – author of the Regional Circulation model REMO
MS	Member state
NA	Not applicable
NACE	The waste generation by classification of economic activities
NGO	Nongovernmental non-profit organization
ODA	Official Development Assistance
OMK FMFI UK	Division of Meteorology and Climatology, Faculty of Mathematics, Physics and Informatics, Comenius University
PaMs	Policies and measures
PV	Photovoltaic
QA	Quality Assurance
QC	Quality Control
RCM	Regional Circulation Models
RISO	Regional Waste Information System
SAŽP	Slovak Environmental Agency
SHMÚ	Slovak Hydrometeorological Institute
SRES	Special Report on Emissions Scenarios (IPCC)
UNFCCC	United Nations Framework Convention on Climate
WAM	With additional measures
WEM	With existing measures
WOM	Without measures

CHAPTER 1 INTRODUCTION

Climate change has become one of the biggest environmental policy challenge of the 21st century. The World Economic Forum's 2022 Global Risks Report[1], which regularly ranks the top 50 global risks according to their impacts, potential and linkages to other issues, lists extreme weather events, failure of climate change mitigation and adaptation, biodiversity loss as well as drought and water crisis among the top 5 risks the world faces in 2021-2022. The report calls for a deepening of our efforts to protect the environment and calls for new approaches that apply a broader "systemic view" to interconnected challenges and that involve a larger and more diverse set of actors.

Although the impact of climate change varies in different parts of the world, its socio-economic and environmental impact always requires proactive solutions. The necessary policy measures shall be based on a detailed analysis of current greenhouse gas (GHG) emissions in each sector, emission projections and an assessment of the impact of the policies and measures adopted or planned. Such a detailed analysis and a good starting point for any policy formulation is also a country's National Report prepared under the rules of the United Nations Framework Convention on Climate Change (UNFCCC).

To fulfil this commitment, the Slovak Republic submits its Eighth National Climate Change Report of the Slovak Republic, which includes the Fifth Biennial Report of the Slovak Republic and tables in a common tabular format (CTF).

The Eighth National Climate Change Report of the Slovak Republic, the Fifth Biennial Report of the Slovak Republic and the CTF tables contain the necessary information on all aspects of the implementation of the UNFCCC and the Kyoto Protocol at the national level, provide detailed analyses of how our commitments are being met, and provide information on important changes in climate change policy since the submission of our last national report in 2017.

The most important achievements in the context of meeting the UNFCCC and Kyoto Protocol targets since 2017:

- Mitigation targets are being successfully met while sustaining economic growth and reducing carbon intensity;
- Improving collaboration between ministries and other government agencies to deliver our climate change commitment more effectively;
- Continuation of research programmes and projects related to climate change in various fields such as forestry, hydrology, water management, agriculture and renewable energy sources;
- Improving education programmes and awareness of climate change among the public, including the organisation of several international environmental events.

To summarise our mitigation commitments, under the second commitment period of the Kyoto Protocol, the Slovak Republic agreed to reduce its total greenhouse gas emissions by 20% compared to 1990.

In 2020, total emissions in the Slovak Republic excluding land use, land-use change and forestry (LULUCF) were by 49.57% lower than in 1990.

In accordance with Decision 2/CP.17, the Slovak Republic also submits in Annex 1 to this National Report the Fifth Biennial Report of the Slovak Republic, which includes:

[1] https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf

- Information on greenhouse gas emissions and trends, including information on the national inventory system;
- Quantified economy-wide emission reduction target;
- Policies and measures;
- GHG emissions projections by sector and gas.

This National Report also includes the Provision of Financial, Technological and Capacity-Building Support to Developing Countries, including CTF tables.

Tabular information as defined by the CTF UNFCCC biennial reporting guidelines for developed country Parties[2] is attached as Annex 2 to this National Report.

[2] Decision 19/CP.18

CHAPTER 2 EXECUTIVE SUMMARY

Ad CHAPTER 3: NATIONAL CONDITIONS

As of 31 December 2021, the population of the Slovak Republic totalled 5 434 712. The average population density is 110.8 inhabitants per km². In the context of demographic development, the reduction of emissions per capita is a very positive trend - in 2020 it was 6.78 tonnes of CO_2 eq. compared to 13.85 tonnes of CO_2 eq. in 1990.

According to global climatological classifications, the Slovak Republic is located in a temperate climate zone with average monthly precipitation totals evenly distributed throughout the year. Over the period 1881-2021, the Slovak Republic has seen a significant increase in annual mean air temperature of 0.15°C over 10 years and a non-significant trend in annual precipitation of about 1%. However, there has been a change in the temporal distribution of atmospheric precipitation during the year, with an increase in the number of droughts, which are more intense and longer lasting, and an increase in the number of floods and flash floods.

Based on the Annual Reports of the National Bank of Slovakia (NBS) for the relevant years, the gross domestic product (GDP) accelerated its annual growth rate to 3.4% in 2017 (from 3.3% in 2016). Economic growth accelerated as a result of growth in domestic demand, with household consumption growth being a crucial component. However, the development of net exports also contributed positively. Nominal GDP created reached EUR 85 billion. Gross domestic product accelerated to an annual growth rate of 4.1% in 2018 (from 3.2% in 2017), driven by domestic demand, as both investment and household consumption increased. Nominal GDP generated amounted to EUR 90 201.8 million, which was by 6.3% more than in 2017. The Slovak economy slowed its growth rate in 2019 to 2.3% year-on-year (from 4.0% in 2018).

In terms of the structure of primary energy sources used, the SR has a balanced share of individual energy sources in gross inland consumption, which in 2020 was as follows: gaseous fuels (natural gas) 24.9%, oil and petroleum products 22.7%, nuclear fuel (heat) 24.0%, solid fuels 13.7% and renewable energy sources (RES, waste and electricity generated in hydroelectric power plants) 14.7%.

Gross inland energy consumption (GIC) in the Slovak Republic has a long-term downward trend. The overall decline in GIC of the Slovak Republic between 2001 and 2020 is 11.1%. GIC reached a peak in 2005 with a consumption of more than 18 699 thous. tonnes of oil equivalent. However, from 2005 to 2020, GIC was on a downward trend, with an overall decline of 12%.

Energy intensity as a ratio of gross inland consumption to gross domestic product for a given calendar year is an important economic indicator of a national economy. It measures the energy consumption of an economy and its overall energy efficiency. Energy intensity in the Slovak Republic has been on a downward trend over the last 20 years. Between 2001 and 2020, the Slovak Republic reduced its energy intensity by 53%.

Ad CHAPTER 4: INFORMATION ON GREENHOUSE GAS INVENTORY

Total greenhouse gas emissions in the Slovak Republic (excluding LULUCF) decreased by 49.6% from 1990 to 2020. The largest relative change was in the agricultural and energy sectors, where GHG emissions decreased substantially by 57% and 56%, respectively, compared to 1990. The reduction was due to fundamental changes in agricultural management practices and increases in energy efficiency and fuel consumption. The gradual introduction of stringent policies and measures in the past has resulted in total GHG emissions (excluding LULUCF) declining compared to 1990, already by more than 40% in 2012.

Between 2019 and 2020, total GHG emissions decreased by 7%, the decrease was mainly due to a decrease in emissions in the energy and industry sectors, mainly due to a reduction in industrial production in the steel and iron sector, as well as a year-on-year reduction in LULUCF production. Since the last, Seventh National Communication of the Slovak Republic published in 2017, emissions have fallen by 9%, with the lowest level in 2020 for the reasons mentioned above. In the meantime, there have been a number of updates and revisions to methodologies, emission factors, and submitted materials in the emissions inventory that have impacted the emissions time series.

Ad CHAPTER 5: POLICIES AND MEASURES

The overall policy framework for addressing climate change in the Slovak Republic consists of European climate-related strategies and policies, complemented by specific national policies and measures targeting the most critical areas.

All relevant policies and measures at EU level are strengthened to meet the 2030 targets of at least a 55% reduction in net greenhouse gas emissions by 2030 compared to 1990 levels. Achieving these emission reductions over the next decade is key to making Europe the world’s first climate-neutral continent by 2050 and to making the European Green Deal a reality. With the proposals, the Commission is presenting the legislative tools to achieve the targets agreed in the European climate legislation and the fundamental transformation of our economy and society for a fair, green and prosperous future. As can be seen from recent greenhouse gas emissions, the Slovak Republic is on track to meet its commitments.

Legally binding target trajectories for the period 2013-2020 are set out in the EU-ETS Directive (Directive 2003/87/EC and related amendments) and the Effort Sharing Decision (Decision 406/2009/EC).

Ad CHAPTER 6: PROJECTIONS AND OVERALL IMPACT OF POLICIES AND MEASURES

The Eighth National Climate Change Report presents the results of GHG emission projections up to 2040 (in some sectors up to 2050) for three scenarios: the reference scenario “with existing measures (WEM)”, “with additional measures (WAM)” and “without measures (WOM)”, disaggregated by sectors, by gases and in an overall aggregated form.

The years 2019 and 2020 have been identified as the base years for GHG emissions projections. The reductive impacts of the assessed policies and measures are quantified for the years 2020 to 2040.

Despite the existing limitations resulting from dynamic changes in critical parameters, the feasibility of achieving the reduction targets as well as the potential for further emission reductions beyond 2020 can be obtained from the modelling results.

Projections of cumulative GHG emissions under the WEM scenario gradually increase until 2025, then start to decline slightly. A similar trend can be observed in the WAM scenario.

Ad CHAPTER 7: VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

Scientific evidence from recent years (including IPCC reports and data from the SHMÚ) shows that increasing greenhouse gas concentrations due to human activities are having a major impact on the Earth's climate system. The latter responds to changes in greenhouse gas concentrations through global warming and rapid, complex changes to the whole system. The manifestations and impacts of climate change and global warming are also significantly manifested in Slovakia. The observed upward trend in the Earth's surface temperature is the most noticeable manifestation of ongoing climate change, especially since the second half of the 1980s, and in Slovakia especially since the early 1990s.

Slovakia has seen a significant increase in above-normal temperature years since 1991, with 2018 and 2019 being extremely warm. In the period 2001-2022, dry, rainfall-free periods have been shown to occur more frequently, which, combined with warmer average climatic conditions, leads to more frequent and more widespread soil drought. A major problem in Central Europe and Slovakia is the significant change in the temporal and spatial distribution of precipitation and snow cover. Precipitation in the warm part of the year occurs more often in the form of intense torrential downpours and in the cold part of the year more often in liquid form. The climate change scenarios described in this report assume comparable increases in monthly and annual temperatures of 1.5 to 4.7 °C in Slovakia. While the temperature scenarios are very similar in all Slovak locations, the precipitation scenarios show some regional differences. Higher increases in annual precipitation totals are expected in the north of the country, with summer decreases in precipitation more significant in the southern lowlands. A comparable increase (decrease) is also projected for daily maximum precipitation totals.

The solution, which should finally prevent or at least minimise the risks and negative consequences of climate change, represents a combination of measures focused on reducing the greenhouse gas emissions (mitigation) with the measures decreasing vulnerability and allowing human and ecosystem adaptation at lower economic, environmental and social costs. Adaptation aims to mitigate the adverse impacts of climate change, reduce vulnerability and increase adaptive capacity of natural and man-made systems to actual or expected negative impacts of climate change, and strengthen the resilience of society as a whole by raising public awareness of climate change and building the knowledge base for more effective adaptation. This chapter focuses on projected climate change impacts, vulnerability and adaptation measures in the sectors of the Slovak economy, agriculture, forestry, biodiversity, public health, water management, tourism, transport and energy.

Ad CHAPTER 8: PROVIDING FINANCIAL, TECHNOLOGICAL AND CAPACITY-BUILDING SUPPORT TO DEVELOPING COUNTRIES

The related activities were from projects implemented in the period 2019-2020 on the basis of financial assistance provided by the Slovak Republic to developing countries. The following activities were selected from the overall portfolio: climate change adaptation activities, mitigation projects, support and capacity building projects for water management, organic farming, food security, and renewable energy development.

All Slovak bilateral and multilateral climate finance support provided to developing country Parties in 2019-2020 was channelled through Official Development Assistance (ODA) according to the OECD DAC methodology.

Ad CHAPTER 9: RESEARCH AND SYSTEMATIC OBSERVATION

The Ministry of Education, Science, Research and Sport of the Slovak Republic is a body with full competences and administrative skills for the management of research and development in the Slovak Republic according to Act No. 172/2005 Coll. on the organisation of state support for research and development. Similarly, ministries, central government bodies and the Slovak Academy of Sciences have developed their own sectoral concepts to support research and development. Institutions involved in climate change research include the SHMÚ, universities and other research institutions.

National projects in this field are as important as international ones, and their scope and results are mostly comparable to European standards. This includes a large number of projects that do not deal directly with climate change issues, but with physical, chemical and biological processes associated with comparable impacts such as climate change. The list of projects includes projects in the climatology, forestry, hydrology, water management and agriculture sectors.

The Slovak Republic has a long tradition of hydrological, meteorological and climatic observations. Hydrological and meteorological observations and measurements in the Slovak Republic are guaranteed by Act No. 201/2009 Coll. on the state hydrological service and the state meteorological service. These measurements and observations are carried out by the SHMÚ in Bratislava.

Ad CHAPTER 10: EDUCATION, TRAINING AND AWARENESS RAISING OF THE POPULATION

The Ministry of Education, Science, Research and Sport of the Slovak Republic is generally responsible for education in this area, but the Ministry of Environment of the Slovak Republic also makes a significant contribution to training and raising public awareness, either directly or through its branches, such as the Slovak Environment Agency and the Slovak Hydrometeorological Institute. Education and information on this subject is also provided by selected university and scientific institutions, interest groups, as well as professional and non-governmental organisations.

Climate change is a technically challenging and cross-cutting topic that goes beyond the content of primary and secondary school curricula. The issue of climate change and its adverse effects is a component of a wide range of topics in environmental education in primary and secondary schools. These activities include global education, training programmes, national competitions as well as international activities. Its importance at college and university level has increased in recent years.

Other climate-related activities include conferences, workshops, festivals, exhibitions, training, information centres and involvement in international activities.

CHAPTER 3 NATIONAL CONDITIONS FOR GREENHOUSE GAS EMISSIONS AND REMOVALS

This chapter provides a brief overview of the natural conditions relevant to climate change policy, including the legal and institutional framework for its implementation in practice. The chapter also includes a description of the geographical, economic and climatic profiles of the Slovak Republic (SR), including current population trends, with an emphasis on the most significant changes since 2017, when the Seventh National Climate Change Report of the Slovak Republic was submitted. In addition, this chapter presents the main characteristics of those economic sectors that contribute significantly to greenhouse gas emissions and removals; it also provides an overview of trends in key indicators relevant to greenhouse gas emissions.

3.1 INSTITUTIONAL AND LEGISLATIVE ARRANGEMENTS

Since the establishment of the Slovak Republic in 1993, the arrangement of state bodies has not changed. The president - the head of state - is directly elected for a five-year term, the highest legislative body is the National Council of the Slovak Republic with 150 members elected for a four-year term, and the Government of the Slovak Republic is headed by the prime minister. The Government of the Slovak Republic consists of 4 deputy prime ministers and 11 ministers. The arrangement and responsibilities of central government bodies are governed by Act No. 134/2020 Coll. on the organisation of government activities and the organisation of central government.

The Ministry of Environment of the Slovak Republic (MŽP SR) is responsible for the development of national environmental policy and measures related to climate change and adaptation. The international legal context for climate change policy is set by the United Nations Framework Convention on Climate Change (UNFCCC) adopted in New York on 9 May 1992. On behalf of the Slovak Republic, the UNFCCC was signed on 19 May 1993[3]. The Slovak Republic expressed its consent to the UNFCCC by Resolution of the National Council of the SR No. 555 of 18 August 1994[4]. The Kyoto Protocol was signed on behalf of the SR in New York on 26. February 1999. The National Council expressed its consent to the Kyoto Protocol by Resolution No. 1966 of 20 March 2002[5]. On 8 December 2012, an amendment to the Kyoto Protocol was adopted in Doha, Qatar,[6] setting the second commitment period of the Kyoto Protocol (2013-2020) with legally binding emission reduction targets. The National Council of the Slovak Republic expressed its consent to the Doha Amendment by Resolution No. 1571 of February 2015. The national ratification process is complete. The European Union and its Member States deposited their instruments of ratification of the Doha Amendment in October 2020, which thus entered into force on 31 December 2020.

The Paris Climate Conference (COP21) in December 2015 adopted the first ever legally binding global climate agreement - the Paris Agreement. On 5 October 2016, a double quorum was reached for the entry into force of the Paris Agreement. The Paris Agreement entered into force on 4 November 2016. The National Council of the Slovak Republic approved the Paris Agreement by Resolution No. 215 of September 2016. The Slovak Republic deposited its instrument of ratification jointly with the EU on 5 October 2016.

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[3] Communication of the Ministry of Foreign Affairs of the Slovak Republic No. 548/2006 Coll.

[4] The instrument of ratification was deposited with the depositary of the United Nations on 25 August 1994

[5] The instrument of ratification was deposited with the depositary of the United Nations on 30 May 2002

[6] http://unfccc.int/kyoto_protocol/doha_amendment/items/7362.php

The Slovak Republic joined the European Union (EU) on 1 May 2004, and a number of environmental legislative requirements were adopted, including climate change and air protection regulations. The EU considers climate change to be one of its four priorities. On 28 November 2018, the European Commission presented its long-term Clean Planet for All strategy to achieve a prosperous, modern, competitive and climate-neutral economy by 2050. This strategy encompasses almost all EU policies and is in line with the Paris Agreement targets to keep global temperature rise below 2°C.

On 11 December 2018, the European Parliament and the Council adopted Regulation (EU) No. 2018/1999 on the Governance of the Energy Union and Climate Action (Governance Regulation), which established a governance mechanism for the implementation of strategies and measures designed to meet the objectives and targets of the Energy Union and the EU's long-term greenhouse gas emission commitments under the Paris Agreement, in particular the EU's ambition to achieve climate neutrality by 2030.

The European Green Deal was unveiled on 11 December 2019. This is a new growth strategy that aims to transform the EU into a fair and prosperous society with a modern and competitive economy that uses resources efficiently and will keep greenhouse gas emissions at zero by 2050.

The European Climate Law legally defines the commitment in the European Green Deal for Europe's economy and society to be climate neutral by 2050. The law also sets an interim target to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Climate neutrality means achieving net zero greenhouse gas emissions for EU countries as a whole, mainly by reducing emissions, investing in green technologies and protecting the natural environment. The Law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part. The Climate Law includes measures to monitor progress and adapt our actions according to existing systems, such as the process for managing Member States' national energy and climate plans, regular reports from the European Environment Agency, and the latest scientific evidence on climate change and its impacts. Slovakia is part of these actions and was among the first countries in the EU (end of 2019) to agree to climate neutrality by 2050.

In 2020, many countries were experiencing the worst economic downturn since the 1930s as a result of the COVID-19 pandemic. Some economists believe it will be essentially V-shaped: first a sharp fall, then a steep return to normal. In May 2020, the European Commission proposed stimulus packages called "sustainable recovery", mostly focusing on investments in buildings, transport, energy and industry. The plan aims not only to reduce emissions, but also to create new jobs, innovate and build a circular economy.

The Climate Change Policy Department of the MŽP SR serves as the National Focal Point for the UNFCCC. Together with the Greenhouse Gas Emissions Reduction Policy Department, this department plays a key coordinating role to ensure that we meet our international commitments under the UNFCCC and the Kyoto Protocol.

Based on the scope and cross-cutting nature of climate change and adaptation, the Joint Commission for the Climate and Energy Package was established by Government Resolution No. 416/2008 of 18 June 2008 at the level of Secretaries of State, comprising Secretaries of State from selected ministries.

In 2011, the Commission for the Climate and Energy Package at the level of Secretaries of State was replaced by the Commission for the Coordination of Climate Change Policy at the level of Secretaries of State (the Commission) based on Government Resolution of the Slovak Republic No. 821/2011.

The Commission was chaired by the State Secretary of the MŽP SR. The other members were the State Secretaries of the Ministry of Economy, the Ministry of Agriculture and Rural Development, the Ministry of Transport and Construction, the Ministry of Education, Science, Research and Sport, the Ministry of Health, the Ministry of Interior, the Ministry of Finance, the Ministry of Foreign and European Affairs and the Chairman of the Regulatory Office for Network Industries.

The Commission's main objective was effective coordination in the development and implementation of mitigation and adaptation policies and the selection of appropriate measures to meet international commitments.

An important output of these activities is also a report entitled "Report on the interim status of implementation of the international commitments undertaken by the Slovak Republic in the field of climate change policy", submitted annually to the Government in order to inform it based on a detailed analysis of the current progress in this area. So far, 5 reports have been submitted - the latest in April 2019.[7] Reports will be submitted irregularly after 2019.

The Commission was replaced in 2021 by the Council of the Government of the SR for the European Green Deal (CG EGD), which met for the first time on 20 April 2021. The CG EGD serves as an expert, advisory, coordinating and initiating body of the Government of the Slovak Republic on matters related to the European Green Deal as a vision for achieving the Sustainable Development Goals (i.e. national priorities for the implementation of the 2030 Agenda for Sustainable Development) and the transition to a carbon-neutral economy by 2050 and the related implementation of key policies and measures towards achieving the climate and environmental goals and the continued transformation of the economic, environmental, energy and social system of the Slovak Republic, including the transformation of industry, agriculture, transport, tourism, manufacturing, non-manufacturing, consumer and social sectors.

The CG EGD is chaired by the Minister of MŽP SR; other members are relevant ministers and representatives of state authorities and the National Council of the Slovak Republic, local government authorities, local governments and representatives of the Academy.

Within the Coordination Committee, a Working Group for the preparation of an adaptation strategy to the adverse impacts of climate change and an Ad Hoc Working Group for the preparation of a low-carbon strategy for the Slovak Republic were established in 2012. These working groups include experts from other relevant ministries, academic and university positions, and other professional institutions.

Government Resolution of the SR No. 148/2014 of 26 March 2014 approved the National Adaptation Strategy of the Slovak Republic, the update of which was approved on 17 October 2018 by Government Resolution of the SR No. 478/2018. The Adaptation Plan for the implementation of the Slovak Climate Change Adaptation Strategy was adopted on 31 August 2021 by Government Resolution No. 476/2021. Based on qualitative and quantitative analyses, adaptation measures were prioritised in the Action Plan. The Action Plan identified short-term targets for the period 2021-2023 and medium-term targets for the period 2024-2027. The Action Plan should contribute to a better translation of adaptation measures into the sectoral policies of the ministries concerned. It also includes a proposal for a vulnerability monitoring system, a proposal for a system of mid-term evaluation of the adaptation process in the conditions of Slovakia, including tracking the links between costs and benefits, and a proposal for a platform for the publication and sharing of positive experience.

[7] https://rokovania.gov.sk/RVL/Material/23680/1

The Environmental Policy Strategy of the Slovak Republic until 2030 - Greener Slovakia (or Envirostrategy 2030) was adopted in February 2019 and defines the vision until 2030, taking into account possible, probable and desired future developments, identifies basic systemic problems, sets targets for 2030, proposes framework measures to improve the current situation, and includes basic outcome indicators that will enable verification of the achieved results. As part of climate change mitigation, Slovakia will reduce greenhouse gas emissions in emissions trading sectors by 43% and outside these sectors by at least 20% compared to 2005. An effective emissions trading scheme will continue. Adaptation measures in the regions will reflect their specificities and be sufficiently responsive to climate change.

In 2019, the Integrated National Energy and Climate Plan of the Slovak Republic (NECP) for 2021-2030 was adopted[8], processed according to Regulation (EU) of the European Parliament and of the Council No.2018/1999 on the Governance of the Energy Union and Climate Action. The main quantified energy and climate targets for 2030 are a Union-wide reduction of greenhouse gas emissions of at least 40% compared to 1990 (with individual Member States setting shares according to local conditions), a binding Union-wide target of at least 32% for the share of renewable energy sources (RES) in gross final energy consumption, with a share of RES in transport of at least 14% in each Member State, a national energy efficiency contribution of at least 32.5%, and an interconnectedness of electricity grids of at least 15%. The main quantified targets of the NECP in the framework of the Slovak Republic by 2030 are the reduction of greenhouse gas emissions for non-ETS sectors by 20% (the share has been increased from the originally declared level of 12%). The share of RES is set at 19.2% for 2030 and alternatively at 20% (increased from the initially declared 18%), in both cases meeting the required target of 14% RES in transport. The elaborated measures for achieving the national energy efficiency contribution of the Slovak Republic show values slightly lower (30.3%) than the European target of 32.5%. The industry and buildings sectors will be key to achieving the targets. Electricity grid interconnection is already above 50% and will remain so in 2030, so the target of at least 15% will be met.

The Low-Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050[9] (NUS SR) was approved by the Government of the Slovak Republic on 5 March 2020. The LCS represents the Slovak Republic's response to the commitments in the fight against climate change resulting from its membership in the European Union and the United Nations and the related obligation to develop a long-term strategy with a scope of at least 30 years. The aim of the strategy is to identify existing and propose new additional measures within the Slovak Republic to achieve climate neutrality by 2050. The primary objective of the NUS SR is to identify all measures, including additional ones that will lead to achieving climate neutrality in the Slovak Republic by 2050. The strategy also includes national reduction targets for 2030 based on the European targets (***Table 3.1***). The above objectives are specified in detail in the Integrated National Energy Plan of Slovakia by 2030. National targets were set in the 2030 Envirostrategy adopted in February 2019.

[8] https://energy.ec.europa.eu/system/files/2020-03/sk_final_necp_main_en_0.pdf (https://www.economy.gov.sk/energetika/navrh-integrovaneho-narodneho-energetickeho-a-klimatickeho-planu)

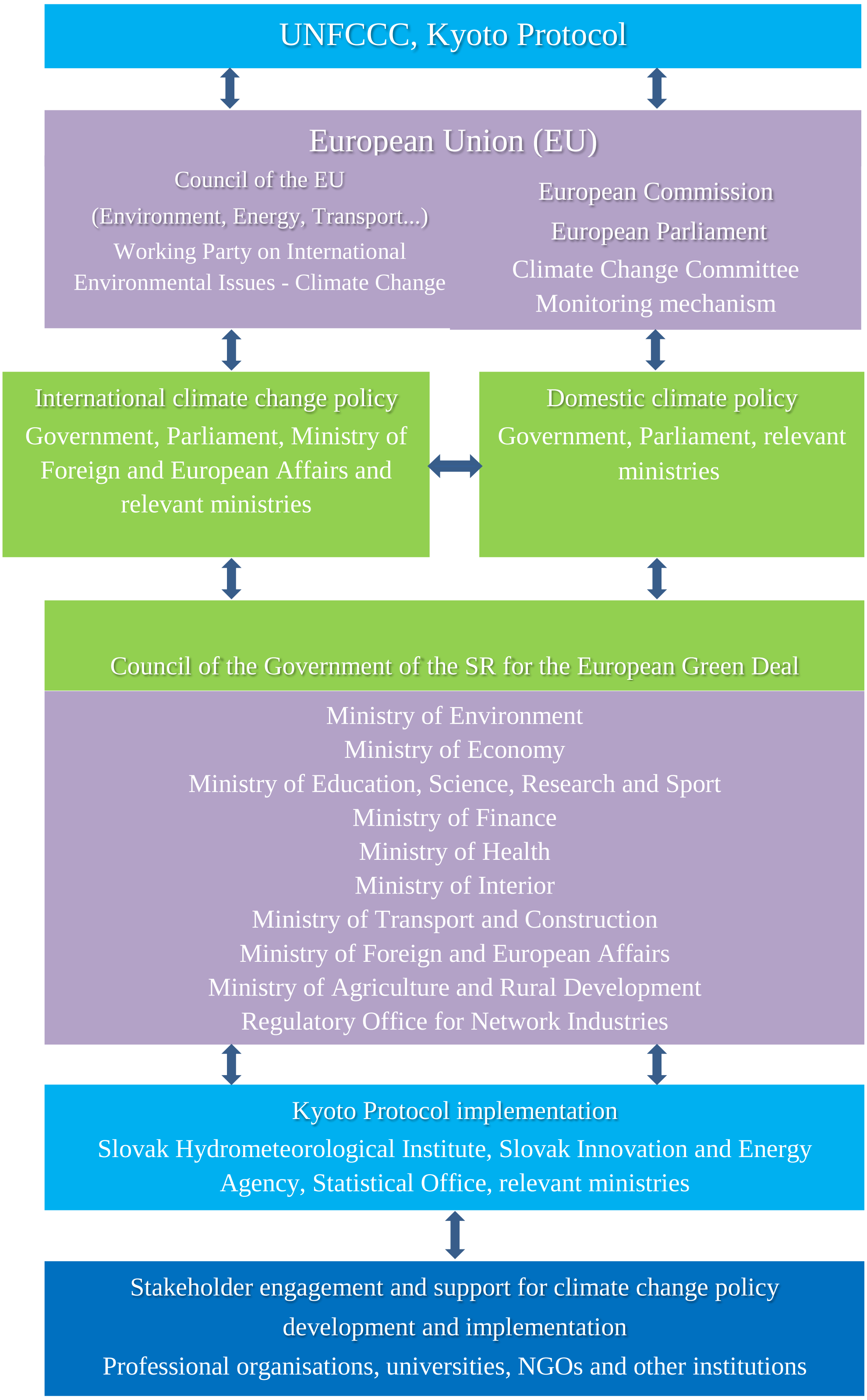
[9] https://ec.europa.eu/clima/sites/lts/lts_sk_sk.pdf

Table 3.1: *Reduction targets by 2030*

COMMITMENT	EU targets	National targets of the SR	Targets used in the WEM reference scenario and GHG reductions achieved	Targets used in the WAM scenario and GHG reductions achieved
Greenhouse gas emissions (as of 1990)	Minimum - 40%		-41% (resulting reductions according to the model)	-47% (resulting reductions according to the model)
Emissions in the ETS sector (as of 2005)	-43%	-43%[1]	-38.4% (only reductions achieved for CO_2)	-53.5% (only reductions achieved for CO_2)
Non-ETS greenhouse gas emissions (as of 2005)	-30%	-12% (-20%[2])	-10% (resulting reductions according to the model)	-19.42% (resulting reductions according to the model)
Share of renewable energy sources (RES)	32%	19.2%	14.3%	18.9%
Energy efficiency	32.5%	30.3%	25%	28.36%

Source: NUS SR

Figure 3.1: *Institutional arrangement for climate change policy and its implementation*



3.2 DEMOGRAPHIC PROFILE

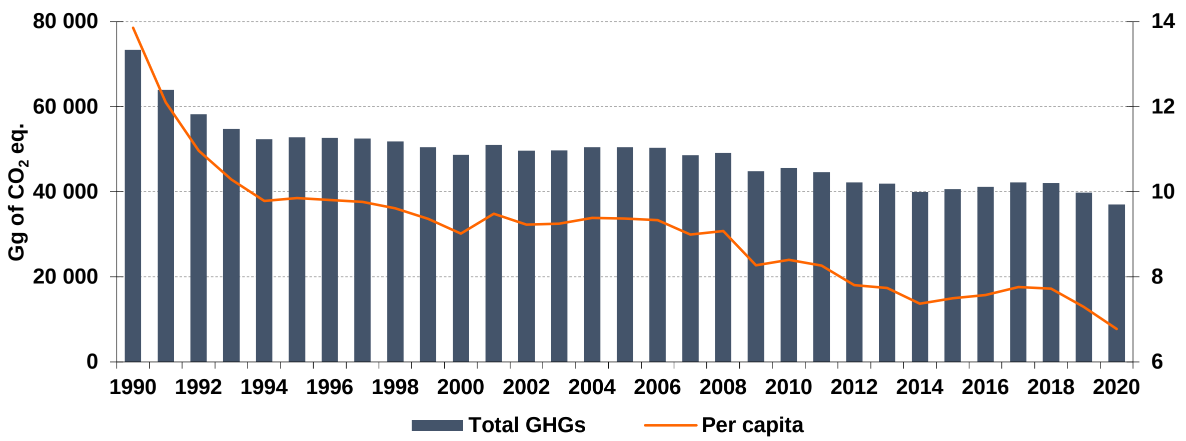
As of 31 December 2021, the population of the Slovak Republic totalled 5 434 712. The average population density is 110.8 inhabitants per km². Apart from the cities, the population is concentrated in the lowlands, basins, while the hills and mountains are sparsely populated. Extensive settlement and land use have profoundly affected the original landscape structure and ecosystems. The capital Bratislava is the largest city in the Slovak Republic with the number of inhabitants 475 503.

In 2021, there were 56 565 live births and 73 461 deaths. The natural population decline thus reached 16 896 persons. Thus, these numbers show a slight downward trend in population despite recent years when this trend has been halted.

The average age of the Slovak population is 39.7 years for men and 42.8 years for women. However, the main demographic trend is an increase in the proportion of the group aged 65 and over. The main reason for this is the change in reproductive behaviour, which has caused the Slovak Republic to fall below the fertility rate needed to rebuild its population.

In the context of demographic development, the decline in emissions per capita is a very positive trend - in 2020 it was 6.78 t CO_2 eq. compared to the 1990 value of 13.85 t CO_2 eq. per capita. This level of emissions per capita in the Slovak Republic was below the EU average, which at the time was 7.37 t CO_2 eq. per capita[10].

Figure 3.2: *Total per capita greenhouse gas emissions in the Slovak Republic from 1990 to 2020* [11]



3.3 GEOGRAPHIC PROFILE

Information on the geographical profile of the Slovak Republic is provided in the Fifth National Communication of the Slovak Republic on Climate Change, Chapter 2.3.11.

3.4 CLIMATIC PROFILE

In terms of the global climatic classification, the territory of Slovakia belongs to the temperate climate zone with regular alternation of four seasons and variable weather with relatively even distribution of precipitation during the year. The climate of Slovakia is influenced by the prevailing westerly air flow in temperate latitudes between permanent pressure formations, the Azores pressure high and the Icelandic pressure low. The westerly flow from the Atlantic Ocean brings humid oceanic air of temperate

[10] http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

[11] National Inventory Report of the Slovak Republic 2022 (https://unfccc.int/documents/461882)

latitudes, which moderates temperature amplitudes during the day and year and brings atmospheric precipitation to the territory of Slovakia. The influence of the Atlantic Ocean on the climatic conditions of Slovakia is gradually decreasing from west to east. Microclimatic factors, in particular the shape and orientation of the relief in relation to the cardinal directions, also influence the climate in different areas.

Between 1881 and 2021, Slovakia experienced a significant increase in annual mean air temperature of 0.15°C over 10 years. For annual atmospheric precipitation, we observed only a slight change of up to about 1%. However, there has been a change in the temporal distribution of atmospheric precipitation during the year, with an increase in the number of droughts, which are more intense and longer lasting, and an increase in the number of floods and flash floods.

Up to an altitude of 800 m a.s.l. a decrease in snow cover was recorded, a slight increase is observed only in the top positions of mountains with an altitude above 1 000 m a.s.l.

In the south-west of Slovakia, the relative humidity drops to about 6%.

These conditions indicate a gradual desertification of the landscape, especially in the south of the country (increase in potential evapotranspiration and decrease in soil moisture).

The characteristics of solar radiation have changed only insignificantly except for a transient decrease between 1965 and 1985.

Figure 3.3: *Deviation of average air temperature for the cold (October-March) and warm (April-September) half-years from the 1961-1990 normal in Slovakia in the period 1881-2021/2022*

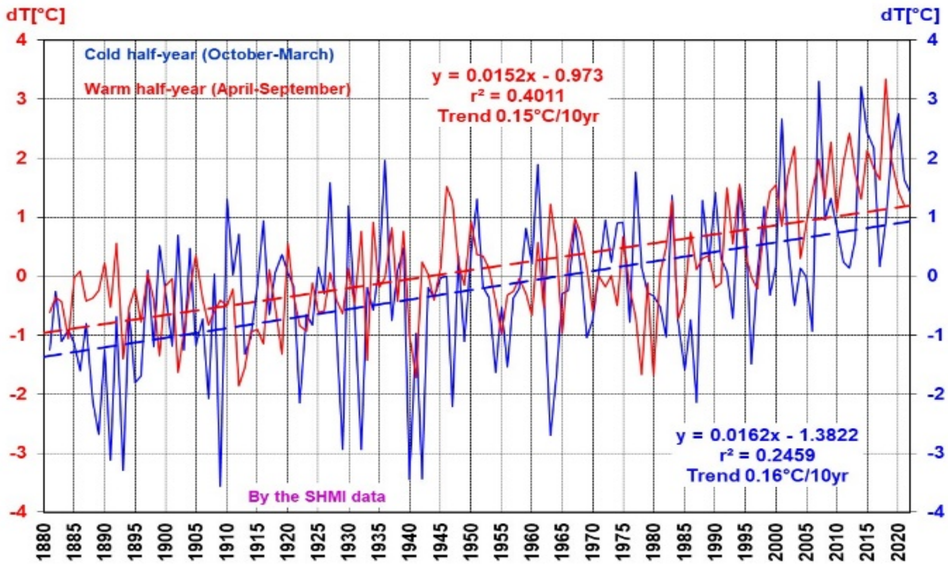


Figure 3.3 and ***3.4*** show the deviations of mean seasonal temperatures from normal in Slovakia for the period 1980-2021 and mean surface precipitation in Slovakia for the period 1881-2021. The temperature increase (approximated by a linear trend) over the last 43 years is even more significant than over the entire period 1881-2021.

Figure 3.4: *Deviation of average air temperature for the cold (October-March) and warm (April-September) half-years from the 1961-1990 normal in Slovakia in the period 1881-2021/22*

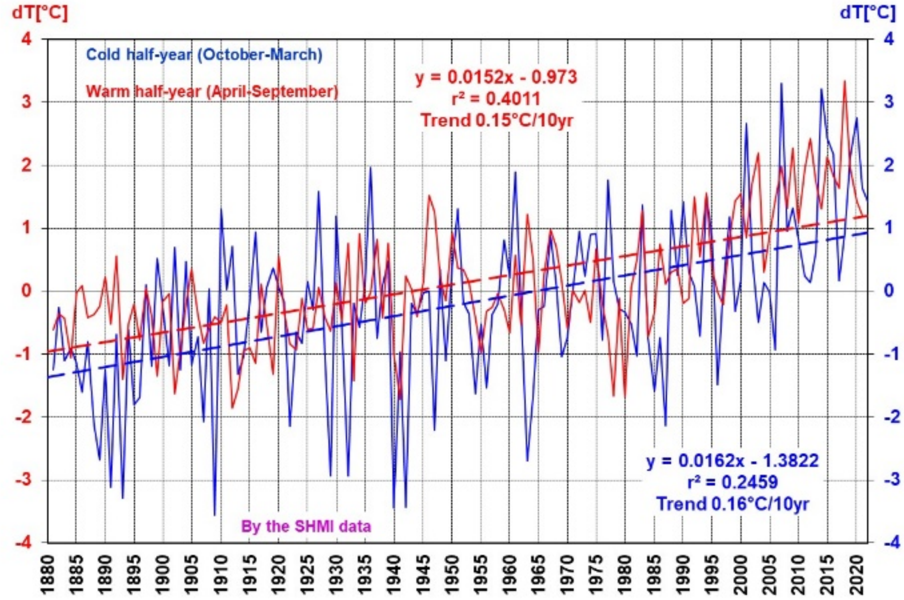
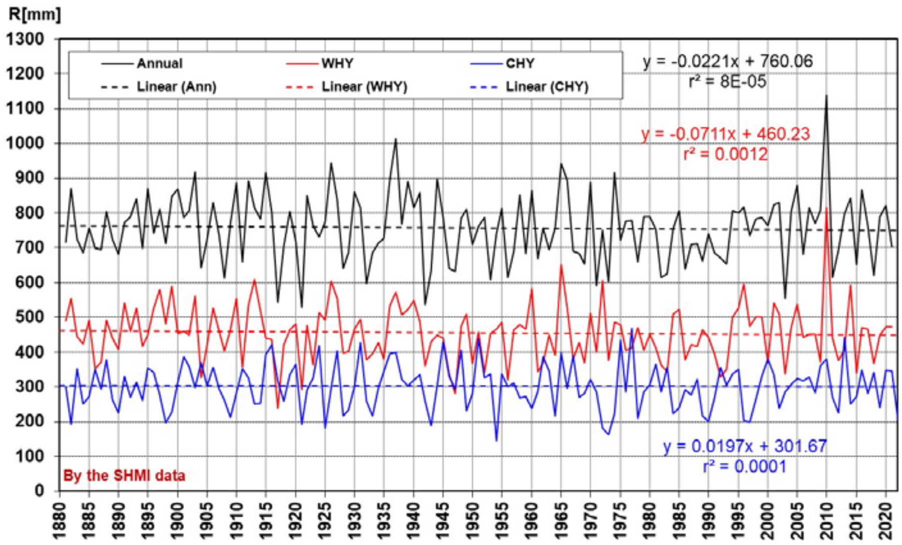
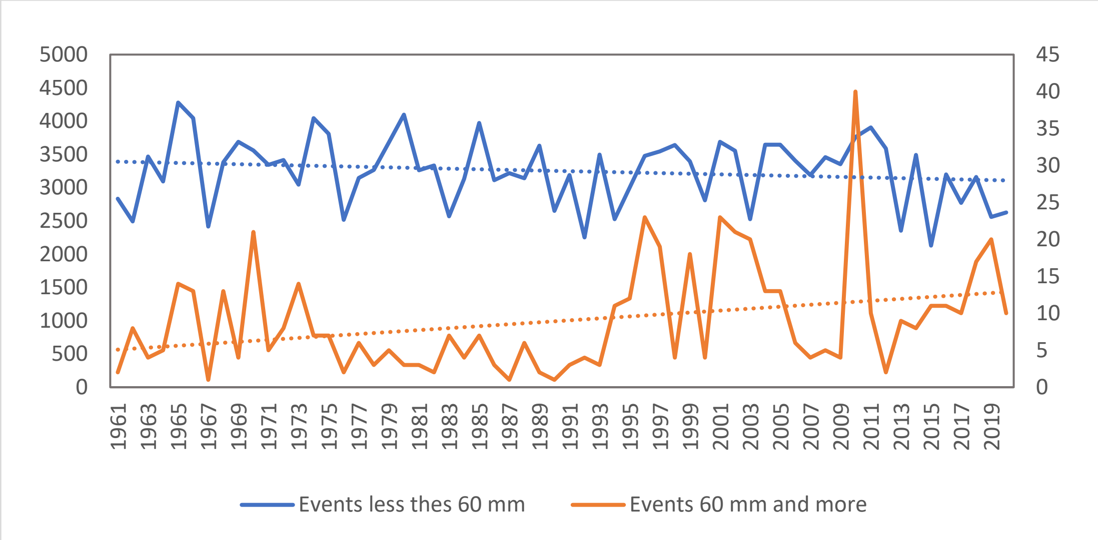


Figure 3.5: *Spatial atmospheric precipitation in Slovakia for the period 1881-2021/22: annual mean, mean for the cold (October-March) and warm (April-September) half-years*



Particular attention needs to be paid to climate change and variability, especially precipitation totals and the hydrological cycle (***Figure 3.5***). In the period 1991-2020, compared to the period 1961-1990, there have been relatively significant changes in the number of days with atmospheric precipitation up to 60 mm (***Figure 3.6***), especially in the distribution during the year. In spring and summer, the number of days with precipitation up to 60 mm decreases. Significantly, different changes compared to spring and summer were demonstrated in autumn and winter, where we registered a clear increase in these days, almost in our entire territory, with the exception of the northernmost regions. In winter, however, this increase is not as pronounced as in autumn. At the same time, the number of days with precipitation above 60 mm increases during the summer period. This trend results in a higher risk of localised flooding. On the other hand, local to regional moderate to extreme drought has occurred annually since 2017, caused by long periods of relatively warm weather and low rainfall. Based on indicators of air temperature, precipitation totals, evapotranspiration, snow cover and some other elements, the last two decades (2001-2010, but especially 2011-2020) are close to the conditions expected, given climate change scenarios, in 2030/2040.

Figure 3.6: *Number of days with precipitation totals up to 60 mm and 60 mm or more (secondary axis) - number of events at 117 stations in Slovakia in summer 1961-2020*



3.4.1 Assessment of Extreme Weather Events by 2022

Extremes of air temperature, atmospheric precipitation, humidity, sunshine duration, evaporation, and snow cover were evaluated as part of the extreme weather events assessment. For air temperature, the number of days with average daily air temperature equal to or above 24°C and 27°C and the number of days with air temperature below 0°C and -5°C, the number of summer ($T_{max} \geq 25$ °C) and tropical days ($T_{max} \geq 30$°C), the number of frost days (day with minimum temperature T_{min} below 0°C), the number of days with severe frost ($T_{min} < -10$°C), and others were analysed.

For the assessment of extreme rainfall episodes, daily precipitation totals above 100 mm, which usually cause localised flash flooding, were used.

The number of days with sultry weather (water vapour pressure above 18.7 hPa) and the number of days with snow cover of 1 cm, 10 cm, 50 cm or 100 cm were also evaluated. These results show different patterns of climate change in lowland and mountainous areas. More detail in the decades from 1951-1960 to 2011-2020 can be seen in ***Tables 3.2*** and ***3.3*** and ***Figure 3.7***.

Table 3.2: *Climatic characteristics of average and extreme weather elements in Hurbanovo (south-western part of Slovakia) 115 m above sea level by decade in the period 1951-2020*

CHARACTERISTICS	1901-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Annual average temperature (T), °C	9.7	9.9	9.9	10.0	10.1	10.7	11.1	11.8
Means of maximum aver. daily T in Summer, °C	26.3	26.7	27.0	26.3	27.3	27.8	28.9	29.2
Number of daily aver. T 24°C and more, Days	8	9.2	12.2	8.4	11.4	17.6	23.0	28.1
Number of daily aver. T 27°C and more, Days	1	1.2	1.0	0.2	1.0	3.6	4.5	7.6
Number of daily aver. T below 0°C, Days	50.7	46.8	56.6	40.0	48.0	44.3	45.7	35.0
Number of daily aver. T below -5°C, Days	16.9	12.6	17.0	7.8	13.5	9.6	9.5	5.7
Mean daily max. temperature in Summer, °C	26.1	25.5	26.1	25.6	26.0	27.2	27.5	28.6
Number of daily max. T 25°C and more, Days	67.8	77.5	76.5	71.6	75.7	86.0	89.9	101.7

CHARACTERISTICS	1901-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Number of daily max. T 30°C and more, Days	14.8	17.3	22.9	14.5	21.2	27.8	33.9	40.7
Mean daily minimum temperature in Winter, °C	-3.7	-3.0	-4.7	-2.1	-3.1	-2.6	-2.7	-1.5
Number of daily min. T below 0°C, Days	96.8	95.9	103.5	88.5	90.5	90.0	85.6	76.8
Number of daily min. T below -10°C, Days	14.2	10.7	15.1	6.4	10.4	7.5	8.0	4.6
Number of daily min. T 20°C and more, Days	1.0	1.1	0.6	1.2	1.9	3.2	3.9	6.7
Annual mean relative humidity (RH), %	75.6	76.1	74.4	74.2	72.4	73.1	72.7	71.9
Number of days with aver. RH below 50%	6.3	5.2	8.8	11.2	15.5	16.2	18.3	20.1
Summer mean water vapour pressure (WVP), hPa	15.4	16.2	15.4	15.1	14.8	15.8	16.3	16.8
Number of days with aver. WVP above 18.7 hPa	13.4	18	14.1	11.9	9.7	16.8	22.0	29.5
Summer mean saturation deficit (SD), hPa	6.6	6.9	7.6	7.4	8.1	8.8	9.1	10.3
Number of days with aver. SD 10 hPa and more	22.9	23.1	30.5	24.6	34.4	42.8	46.0	44.8
Annual mean sum of sunshine duration (SSD), hours	1 987	1 850	1 774	1 831	1 951	1 979	2 082	2 146
Number of days with 10 hr SSD and more	66.3	79.5	55.5	62.8	66.2	71.4	86.0	89.4
Annual mean precipitation totals (PPT), mm	581	567	556	518	497	555	589	567
Number of days with 10 mm PPT and more	16.3	15.7	15.8	15.1	12.8	15.0	17.8	16.2
Number of days with snow cover 1 cm and more	37.7	34.1	50.4	27.2	32.9	34.0	34.8	18.8
Number of days with snow cover 10 cm and more	13.5	12.4	22.2	6.1	12.8	14.3	5.5	1.6
Average annual potential evapotranspiration sum, mm	N	692	730	742	773	782	792	820
Average annual actual evapotranspiration sum, mm	N	445	432	417	417	442	464	452

Tables 3.2 and ***3.3*** show that for some climate characteristics and extremes there have been significant changes, especially in the 2001-2010 and 2011-2021 periods compared to the 1901-1990 or 1951-1990 periods: the number of days with an average temperature of 27°C or more and tropical nights with a minimum temperature of 20°C or more increased more than 5 times, the number of tropical days increased about 2 times, the number of days with an average relative humidity below 50% increased about 3 times, and the number of sultry days (average water vapour pressure above 18.7 hPa) increased about 2 times, the average summer saturation supplement increased by 30%, the number of days with saturation supplement of 10 hPa or more increased by 80%, the number of days with daily atmospheric precipitation above 10 mm increased by about 15% across Slovakia, but the number of all days with precipitation decreased slightly. In the south of Slovakia precipitation totals decreased, but in the north they increased (near Oravská Lesná by approx. 10% compared to the period 1951-1990).

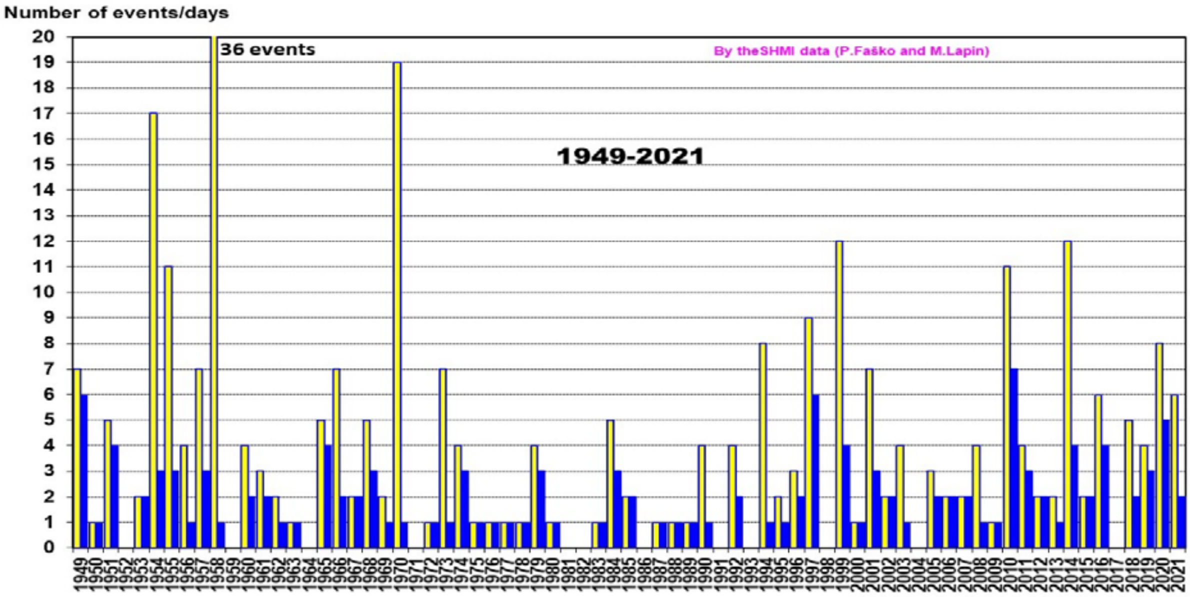
Potential evapotranspiration has increased across Slovakia, more so in the south (near Hurbanovo by about 100 mm since 1951). The number of days with snow cover decreased slightly across Slovakia, while the number of days with a total snow cover of 10 cm or more decreased significantly in the lowlands.

Table 3.3: *Some climatic characteristics of average and extreme weather elements in Oravská Lesná (northern part of Slovakia), 780 m above sea level by decade in the period 1951-2020*

CHARACTERISTICS	1901-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Annual mean precipitation totals (PPT), mm	1 109	1 045	1 155	1 059	1 071	1 170	1 241	1 140
Average annual potential evapotranspiration sum, mm	N	448	452	437	461	467	492	528
Average annual actual evapotranspiration sum, mm	N	421	434	416	440	434	459	483
Number of days with snow cover 1 cm and more	N	126.9	139.3	126.5	120.6	132.6	124.6	100.2
Number of days with snow cover 10 cm and more	N	107.7	114.5	104.1	95.6	106.7	113.6	78.6
Number of days with snow cover 50 cm and more	N	30.4	51.7	30.6	42.5	29.1	40.3	21.4
Number of days with snow cover 100 cm and more	N	4.2	3.1	4.1	6.0	3.4	10.1	3.6

Heavy and intense atmospheric precipitation plays a very important role in flash floods, as evidenced by measurements at about 700 rain gauge stations since 1949. ***Figure 3.7*** shows some increase in such events since 1994, but even in 1949-1970 there were as many or more heavy rainfall events than in the last 27 years (36 events/stations on 29 June 1958).

Figure 3.7: *Number of events (yellow column) and number of days (blue column) with daily atmospheric precipitation of 100 mm or more in Slovakia in the period 1949-2021/22 (measurements from about 700 rain gauge stations)*



3.5 ECONOMIC PROFILE

Based on the Annual Reports of the National Bank of Slovakia (NBS) for the relevant years, the gross domestic product accelerated its annual growth rate to 3.4% in 2017 (from 3.3% in 2016). Economic growth accelerated as a result of growth in domestic demand, with household consumption growth being a crucial component. However, the development of net exports also contributed positively. Nominal GDP created reached EUR 85 billion. Gross domestic product accelerated to an annual growth rate of 4.1% in 2018 (from 3.2% in 2017), driven by domestic demand, as both investment and household consumption increased. Nominal GDP generated amounted to EUR 90 201.8 million, which was by

6.3% more than in 2017. The Slovak economy slowed its growth rate in 2019 to 2.3% year-on-year (from 4.0% in 2018). The reason for the slowdown was a gradual easing of foreign demand with a negative impact on Slovak export performance. The main source of growth was the domestic part of the economy. Household consumption grew by 2.2%, supported by a still favourable labour market situation. Wages and salaries continued to grow relatively strongly in 2019 and represented the main source of income for the population. Consumption growth was driven by services, especially spending on restaurants and hotels. This was partly related to the substantial use of holiday vouchers and also to the preference of households to consume more luxurious goods. Conversely, growth in spending on everyday goods, such as food, has slowed. Although households had sufficient income, they spent relatively less on consumption than in the past and saved more. This resulted in an increase in the savings rate above 10%, where it last was in 2000. The Slovak economy, like other countries, was unexpectedly hit by the COVID-19 pandemic in early 2020. Subsequently, the anti-pandemic measures taken resulted in a 5.2% decline in economic activity. The domestic part of the economy was particularly affected. While households reduced their consumption only slightly, firms largely curtailed investment activity. Despite a full-year decline in exports, net exports contributed positively to economic growth. This was due to a reduction in imports in the context of lower domestic demand and, at the same time, a more pronounced use of stocks. Under the measures in place, consumers were not able to spend their money as they could and wanted to. This was mainly reflected in the low sales of services, which were most affected by the pandemic. Conversely, spending on food and housing rose as a result of the increased use of teleworking. Caution about future developments also played a part in the lower household consumption.

In terms of the structure of primary energy sources used, the SR has a balanced share of individual energy sources in gross inland consumption, which in 2020 was as follows: gaseous fuels (natural gas) 24.9%, oil and petroleum products 22.7%, nuclear fuel (heat) 24.0%, solid fuels 13.7% and renewable energy sources (RES, waste and electricity generated in hydroelectric power plants) 14.7%.

Gross inland energy consumption (GIC) recorded a decline of 12% between 2005 and 2020, with slight fluctuations. The energy efficiency target expressed in absolute value of primary energy consumption for 2020 was met (686 PJ).

In terms of natural conditions and the country's current technological capabilities, the Slovak Republic is poor in primary energy resources. Almost 90% of primary energy sources (including nuclear fuel) are imported. For this reason, the Slovak Republic's dependence on imports is high, but in view of the current situation in Ukraine, it is also taking steps to reduce this dependence or to seek other ways of obtaining resources. In 2019, dependency reached 69.8%, the highest level for the entire reporting period. This was driven by a significant year-on-year increase in dependency of 9.6% points. In the long term, the level of import dependency ranged from 60.1% (2015) to 69.8% (2020).

Slovakia, along with the whole of Europe, is facing a socio-economic crisis linked to the coronavirus pandemic, which has significantly affected the state of the economy. Economic growth in the euro area slowed to 1.2% in 2019, down from 1.9% in the previous year. The slowdown in economic growth was mainly influenced by the weakening of the global economy and international trade. In 2020, the coronary crisis persisted and continued to adversely affect the state of the world's economies. The anti-pandemic measures translated into a significant closure of the economies, especially at the turn of the first two quarters. In the first half of the year, the economy declined by around 15%. As the number of infected declined, the economy subsequently recovered rapidly. At the end of the year, however, anti-pandemic measures had to be tightened again and the economy again declined slightly.

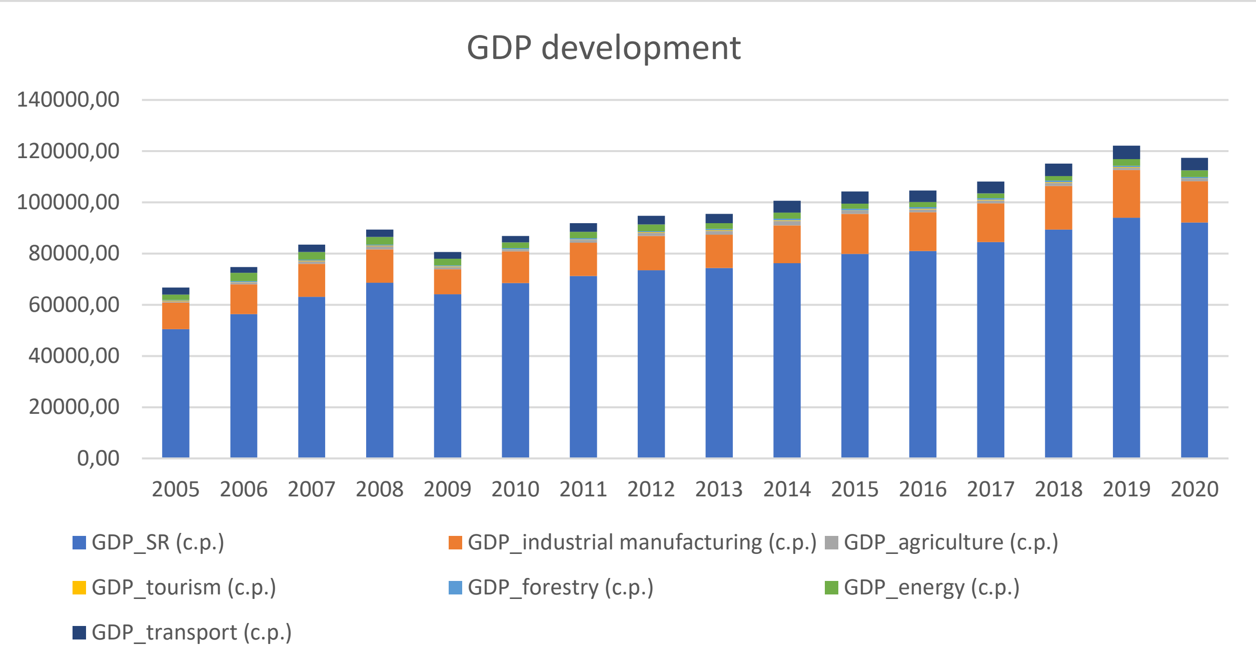
Slovak economic growth slowed to 2.3% year-on-year in 2019 compared to 4.0% in 2018. . The reason for the slowdown was a gradual easing of foreign demand with a negative impact on Slovak export performance. Under the impact of the pandemic and strict quarantine measures, the Slovak economy shrank by 5.2% in 2020. All components except net exports contributed to the decline. The domestic part of the economy was particularly affected. While households have reduced their consumption only slightly, firms have largely curtailed investment activity. Despite a full-year decline in exports, net exports contributed positively to economic growth. This was due to a reduction in imports in the context of lower domestic demand and, at the same time, a more pronounced use of stocks.

Table 3.4: *GDP development (EUR milion GDP SR + selected sectors (current prices, c.p.)*

Category	GDP_SR (c.p.)	GDP_industrial manufacturing (c.p.)	GDP_agriculture (c.p.)	GDP_tourism (c.p.)	GDP_forestry (c.p.)	GDP_energy (c.p.)	GDP_transport (c.p.)
2005	50 485.66	10 403.84	527.53	135.14	288.46	2 132.69	2 730.72
2006	56 361.42	11 641.50	694.75	139.01	344.65	3 265.66	2 325.34
2007	63 163.35	12 847.11	1 025.79	167.39	420.31	3 053.80	2 831.45
2008	68 590.53	13 033.16	1 263.09	174.91	469.70	2 975.29	2 889.66
2009	64 095.52	9 727.48	936.15	192.92	398.92	2 650.26	2 669.12
2010	68 492.15	12 358.84	621.46	186.06	452.15	2 266.16	2 535.35
2011	71 214.39	12 995.79	1 128.33	219.54	410.77	2 555.66	3 288.04
2012	73 483.82	13 403.99	1 227.49	201.23	440.76	2 593.13	3 457.56
2013	74 354.85	13 007.84	1 498.56	223.89	521.45	2 219.22	3 708.70
2014	76 255.86	14 687.38	1 851.68	233.74	571.98	2 367.18	4 633.76
2015	79 888.15	15 663.61	1 139.47	171.89	579.25	2 087.67	4 723.38
2016	81 014.25	15 085.70	1 211.89	171.35	582.82	2 102.44	4 412.26
2017	84 442.87	15 166.60	1 157.67	218.19	593.45	1 911.42	4 697.15
2018	89 430.02	16 930.54	1 307.08	203.67	611.25	1 753.08	4 871.09
2019	94 048.03	18 555.59	956.65	140.86	606.32	2 606.30	5 180.64
2020	92 079.25	16 149.64	1 015.49	87.24	596.94	2 613.19	4 839.51

Source: EnviDat

Figure 3.8: *GDP development (EUR million)*



Source: EnviDat

Figure 3.9: *Population unemployment in Slovakia*

Source: DATAcube

Table 3.5: *Environmental expenditure (EUR million)*

INDICATOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Investments to protect the environment	260.0	269.47	252.11	201.79	246.67	581.74	287.70	273.35	304.07	327.71	221.63
Investments financed from state resources	23.3	37.62	46.35	27.01	37.10	73.90	41.02	40.08	52.93	40.37	39.98
Investments financed from foreign resources	56.2	73.73	63.84	46.75	39.22	155.88	55.20	6.95	57.69	64.28	11.66
Total current costs for environmental protection	474.0	515.83	550.65	554.10	547.54	599.44	616.10	639.29	835.80	883.50	864.60
Total revenue from environmental protection	449.02	528.17	596.99	579.54	644.69	716.19	736.99	808.88	1063.09	1068.68	1036.20
Revenue from the sale of products, instruments and components	5.78	16.03	17.43	10.70	13.02	21.11	26.60	32.00	41.85	38.94	37.78
Revenue from the sale of technology	1.63	-	-	-	-	-	-	-	-	-	-
Revenue from services provided	326.4	329.37	381.60	407.05	465.10	525.39	523.44	553.92	632.84	651.61	637.68

Source: DATAcube

Table 3.6: *Gross domestic expenditure on research and development (EUR million)*

INDICATOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gross domestic expenditure on research and development	416.37	468.44	585.23	610.88	669.63	927.27	640.84	748.96	750.95	776.59	838.93

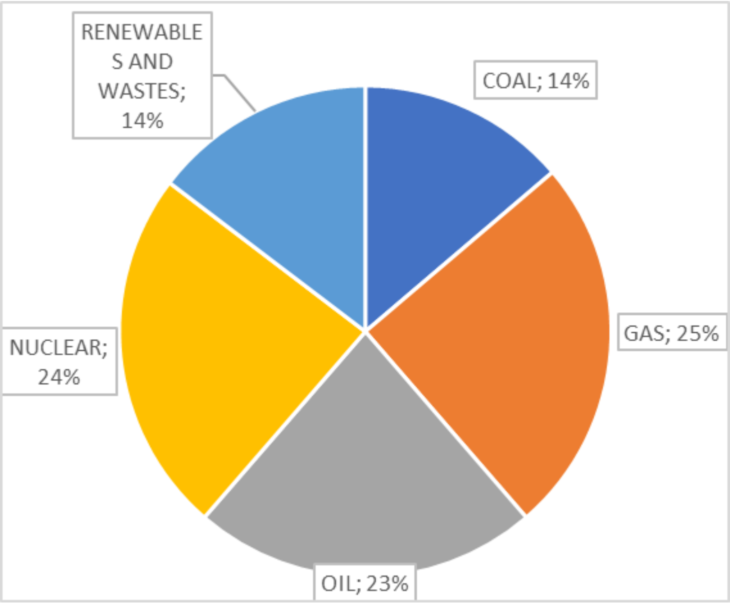
Source: DATAcube

As ***Table 3.6*** shows, total research and development expenditure, excluding inflation, has grown continuously since our accession to the EU and doubled over the period under review.

3.6 ENERGY SECTOR

The Slovak Republic has a balanced energy mix with gross inland energy consumption composed of nuclear fuels, fossil fuels and renewable sources. The shares of energy sources in gross inland consumption in 2020 were as follows: natural gas 24.9%, nuclear 24.0%, oil 22.7%, coal 13.7% and renewable sources including hydropower 14.7%. The Energy Policy of the Slovak Republic approved by the Government of the Slovak Republic in 2014 was updated in December 2019 by approving the Integrated National Energy and Climate Plan for 2021-2030.

Figure 3.10: *Energy mix in the Slovak Republic in 2020*



Source: Statistical Office of the Slovak Republic

The long-term priority of the Slovak Republic’s energy policy is to build a competitive low-carbon economy, moving towards carbon neutrality. The transition to a low-carbon economy comes with additional costs that will need to be covered. The situation is complicated by the impact of the long-lasting COVID-19 pandemic and the consequences of Russia’s invasion of Ukraine, which began in February 2022. It will therefore be necessary to adopt measures that respect the principle of security of supply and the primacy of energy efficiency, while RES should not be the main objective, but one of the instruments of such a transformation. It will also be essential to maximise the use of the new financial support mechanisms in 2021-2030 (Recovery Plan, Modernisation Fund, Innovation Fund), which can make a significant contribution to the transition to a low-carbon economy if the priority projects at the domestic level are properly adjusted.

Measures to ensure environmental sustainability:

- Ensure financial mechanisms as well as use the proceeds from the auctioning of allowances under the Emissions Trading Scheme to support the energy and industrial sectors, focusing on priority areas in line with the principles of sustainable development as outlined above;
- Step up action to reduce CO_2 emissions, especially in the transport sector;
- Rigorously assess the construction of new energy conversion sources in the light of possible negative impacts on environmental sustainability and on reduced efficiency;
- Optimising the share of RES, especially in heat and cold production;

- The use of natural gas and, in the longer term, decarbonised gases and hydrogen;
- Develop measures to achieve economic growth based on a low-carbon, circular, less energy- and material-intensive economy;
- Ensure timely implementation of the integrated National Energy and Climate Plan (NECP);
- Contribute to the achievement of the environmental sustainability of the objectives set through appropriate and targeted regulatory measures;
- Energy recovery of waste.

Due to the high share of nuclear sources in electricity generation and the high share of natural gas in heating, the Slovak Republic has one of the lowest-emission energy mixes in the EU. There is some room for decarbonisation of the energy sector only in the replacement of coal by low-emission or alternative fuel sources, in energy efficiency measures and in the decarbonisation of transport. After the replacement of solid fossil fuels by renewable energy sources (planned for 2023), we will have one of the least emission-intensive energy sectors in the whole EU (namely the seventh least emission-intensive energy sector in the whole EU in terms of CO_2 intensity of electricity and heat production) and thus the potential for a more significant implementation of RES should be sought in countries where solid fossil fuels are used to a greater extent - there the implementation of RES and decarbonisation will be much more cost-effective.

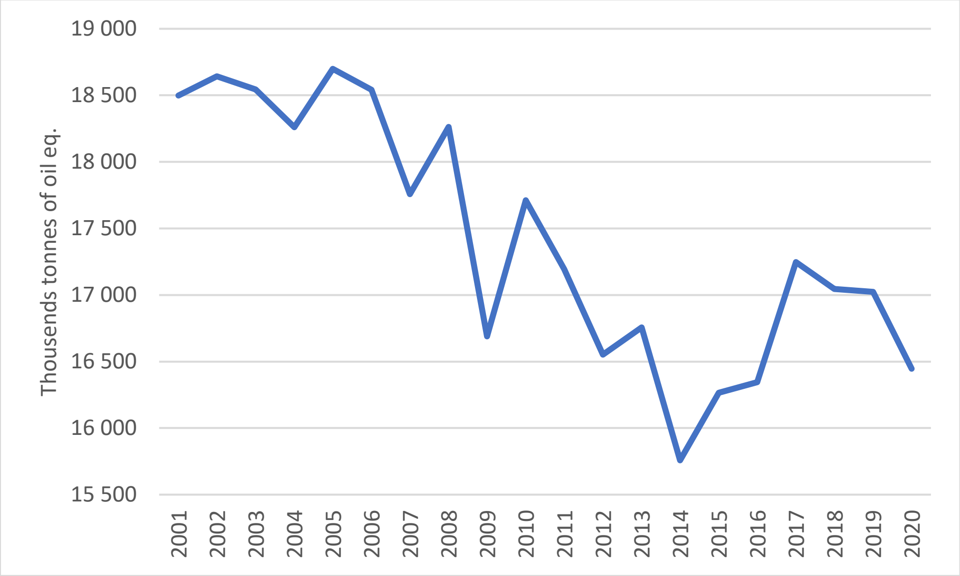
The projection of RES use takes into account the principle of cost minimisation in an integrated approach to RES use and greenhouse gas emission reduction. This means that an appropriate combination of RES and low-carbon technologies will reduce fossil fuel consumption and therefore greenhouse gas emissions. The use of RES will be a priority in the coming period, especially in transport and for heat and cold production, while support for electricity generation will be limited.

The heating sector, and within it in particular district heating, is important for the energy transformation in the coming years. Reducing the share of coal in heating in favour of renewable energy sources will improve the sustainability and security of heat supply. The high degree of centralisation of heat supply creates good technical preconditions for the use of biomass, bio-methane and geothermal energy. Given the low-carbon electricity generation mix, the challenge is the gradual electrification of public passenger transport in particular.

Gross inland consumption (GIC) in the Slovak Republic has a long-term downward trend. The decline in GIC was mainly due to industrial restructuring in the 1990s, the arrival of investors in higher value-added sectors and the wider application of energy efficiency principles through the introduction of modern production technologies with lower energy consumption, building insulation, consumer switching to low-energy appliances and saving as a result of price deregulation.

The overall decline in GIC of the Slovak Republic between 2001 and 2020 is 11.1%. GIC reached a peak in 2005 with a consumption of more than 18,699 thous. tonnes of oil equivalent. However, from 2005 to 2020, GIC was on a downward trend, with an overall decline of 12% (***Figure 3.11***).

Figure 3.11: *Gross inland consumption of the Slovak Republic in the period 2001-2020 GIC*



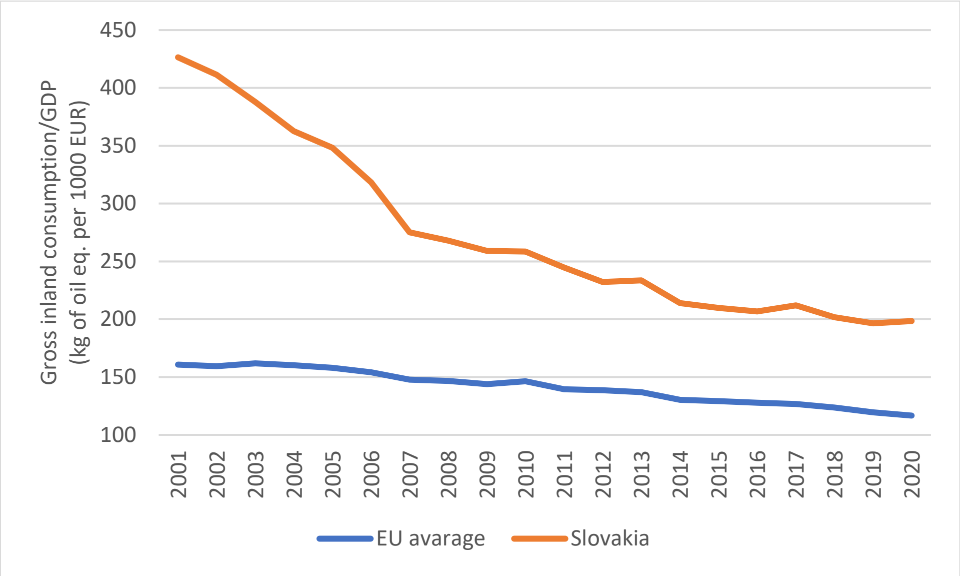
Source: Eurostat

3.6.1 Development of the Energy Intensity of the Slovak Republic

Energy intensity as a ratio of gross inland consumption to gross domestic product for a given calendar year is an important economic indicator of a national economy. It measures the energy consumption of an economy and its overall energy efficiency. Energy intensity in the Slovak Republic has been on a downward trend over the last 20 years. Between 2001 and 2020, the Slovak Republic reduced its energy intensity by 53% (***Figure 3.12***). This is the fourth highest reduction in percentage terms among all EU Member States. Between 2001 and 2015, Slovakia achieved the most significant decrease in energy intensity among all EU Member States.

This positive development is the result of the successful restructuring of industry, the introduction of energy efficient production processes in industry and effective energy saving measures in the household sector by replacing domestic appliances by options that are more efficient.

Figure 3.12: *Energy intensity of the Slovak Republic in the period 2001-2020*



Source: Eurostat

The Slovak Republic has also improved its relative energy intensity compared to other EU Member States, as in 2001 it was the fourth most energy intensive economy among the 27 EU Member States, while in 2020 cumulative improvements in energy intensity in the Slovak Republic resulted in an improvement to the eighth most energy intensive economy in the EU. Despite the progress achieved, the Slovak Republic remains an energy-intensive economy with an energy intensity about 1.7 times higher than the average of the 27 EU Member States.

3.6.2 Nuclear Energy in the Slovak Republic

Nuclear power is a major driver of low-carbon growth. In terms of efficiency towards meeting EU targets, the diversified power supply and carbon capture and storage scenarios with a substantial share of nuclear power are among the least costly development scenarios.

Besides the safety of operation, the second most important factor in the use of nuclear power is how to deal with the back-end of nuclear power.

Government of the Slovak Republic pursuant to Act No. 238/2006 Coll. on the National Nuclear Fund (Resolution No. 328/2008 of 21 May 2008) approved the “Strategy for the Back-End of Nuclear Energy”[13] by the Board of Trustees of the National Nuclear Fund and ordered the Chairperson of the Nuclear Regulatory Authority of the Slovak Republic and other relevant ministers to implement it by 31 December 2013.

The draft “Strategy for the Back-End of Peaceful Use of Nuclear Energy in the Slovak Republic” was approved under the guidance of the Ministry of Economy of the Slovak Republic in October 2012. It was submitted to the Government in September 2013 following the completion of the Environmental Impact Assessment (EIA) process.

The main objective of the Strategy is to protect the environment from the long-term consequences of nuclear power used for electricity generation and other consequences of peaceful use of nuclear energy. The strategy assesses the financial security of the back-end of the nuclear power sector, including impacts on the competitiveness of electricity generators and the reliability of the power transmission system. The strategy is guided by the “polluter pays” principle. It also reflects recent developments that are part of the EU Radioactive Waste Management Directive.

The National Programme for the Management of Spent Nuclear Fuel and Radioactive Waste was approved by the Government of the Slovak Republic by Resolution No. 387 of 8 July 2015, was sent to the European Commission in August 2015 in accordance with Directive 2011/70/EURATOM and became a strategic document for the back-end of peaceful use of nuclear energy in the Slovak Republic as well as an update of the strategic document Strategy for the Back-End of Peaceful Use of Nuclear Energy in the Slovak Republic.

3.7 TRANSPORT

The number of cars in the Slovak Republic is continuously increasing. In 2020, the total number of passenger cars was 2 415 203. An increase of 15.6% was recorded compared to 2015. The same upward trend was observed for CO_2 emissions in road transport, which increased from 7 012.99 Gg CO_2 in 2015 to 7 636.69 Gg CO_2 in 2019, with emissions falling to 6 813.31 Gg CO_2 in the pandemic year 2020. The observed upward trend was probably only temporarily interrupted by the pandemic year 2020, which saw a slight decrease of 3% compared to 2015. Measures such as new vehicle technologies, advanced fuels, biofuels, etc. did not prevent emissions from rising.

Table 3.7: *Number of motor vehicles*

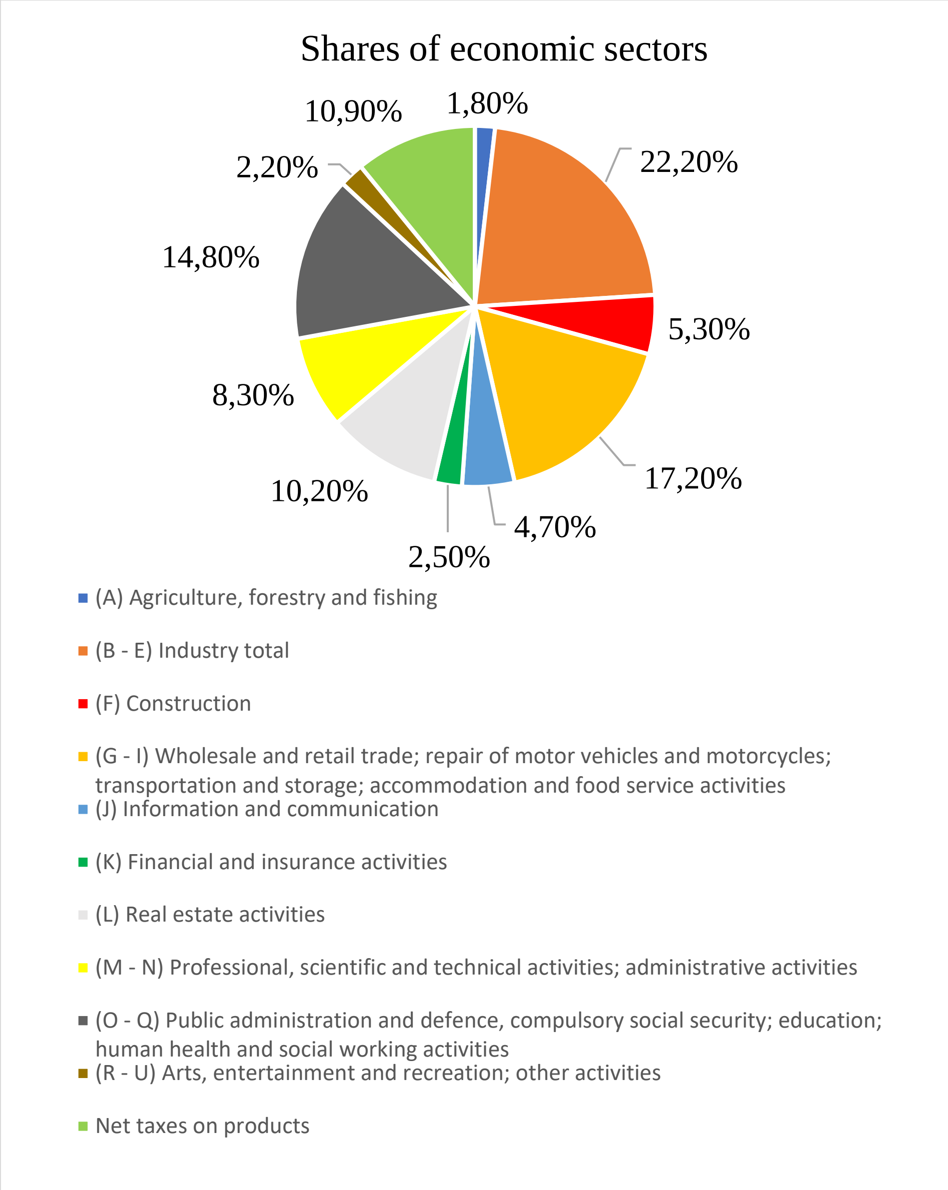
Parameter	2016	2017	2018	2019	2020
Passenger cars	2 089 316	2 191 538	2 292 006	2 365 022	2 415 206
Low power vehicles	244 578	250 683	258 917	261 964	265 225
High power vehicles	74 528	77 076	77 799	77 714	75 793
Buses	8 486	8 649	8 773	8 758	7 652
Motorcycles and mopeds	122 150	129 047	136 785	144 272	151 340

Source: Presidium of the Police Force of the Slovak Republic, SHMÚ

3.8 INDUSTRIAL SECTOR

Industry is the main component of the Slovak national economy. This is confirmed by ***Figure 3.13***, which shows the percentage share of economic sectors in GDP in 2021. In European comparison, Slovakia is one of the most industrialised countries in the European Union.

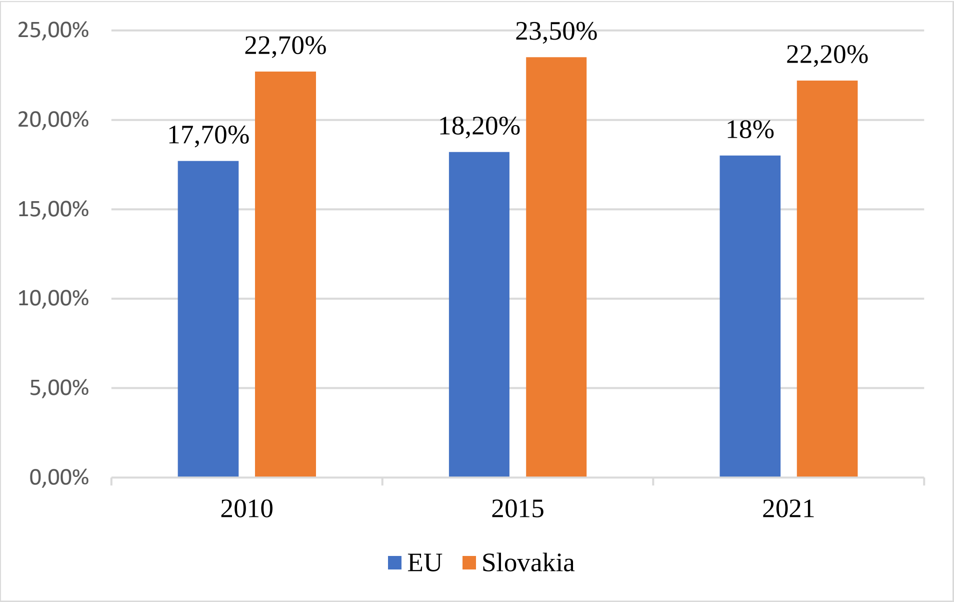
Figure 3.13: *Shares of economic sectors in GDP of the Slovak Republic (%) in 2021*



Source: Statistical Office of the SR – STATdat.

In contrast to the EU average, where industry contributed 17.7% to total GDP in 2010, in the Slovak Republic industry accounted for 22.7% of GDP in that period, of which industrial production accounted for 18%. In 2015, industry accounted for 18.2% of GDP in the EU, compared to 23.5% in the Slovak Republic.

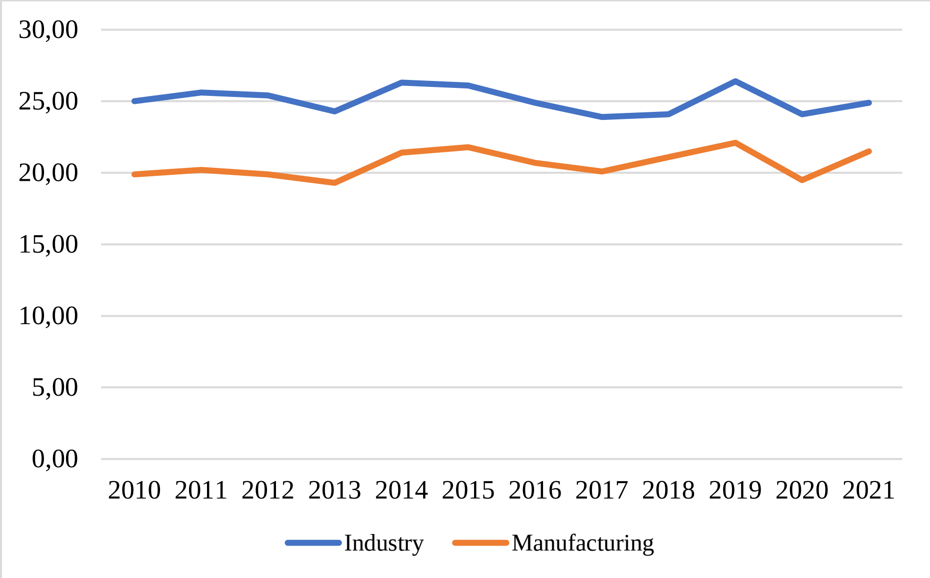
Figure 3.14: *Industry's share of GDP in the EU and SR (%) in 2010, 2015 and 2021*



Source: Eurostat

In 2021, industry's share of EU GDP fell to 18% compared to 2015, and its share of Slovakia's GDP also fell to 22.2%. Manufacturing accounted for 18% of GDP in 2010 and 19.2% in 2021. A more pronounced decline in industry's share of GDP occurred in 2020, when this indicator dropped from 23.6% to 21.5% compared to the previous year. Manufacturing also recorded a year-on-year decline, namely from 19.7% in 2019 to 17.5% in 2020. The reason for the sharp decline in the performance of the industry and the overall economy in 2020 was the outbreak of the COVID-19 pandemic. Slovak industry experienced a historic decline in activity during the first wave of the corona crisis. The main cause was the industry's dependence on car production, but strict quarantine measures, which negatively affected all sectors of the Slovak economy, also contributed to the decline. The curve of the development of the share of industry and manufacturing in GDP of the Slovak Republic for the period 2010-2021 is plotted in ***Figure 3.15***.

Figure 3.15: *Industry's share of GDP in the SR (%) in 2010 to 2021*



Source: Eurostat

As the downturn in activity during the corona crisis was relatively short-lived, most industries suffered less than during the crisis in 2008 and 2009. It also resulted in a more buoyant recovery in manufacturing than during the global financial crisis.

Industry accounted for 23.6% of employment in 2010, of which 21.3% was in manufacturing. In 2021, the industry accounted for 23.3% of total employment and 21.3% of this was accounted for by manufacturing. The number of employees in the industry in 2021 increased by 8.4% compared to 2010.

In terms of revenue generation of industrial sectors, the first position is occupied by the production of means of transport, which in 2021 contributed to the generation of total revenues from industrial production by 34.7%. Compared to 2010, this share grew to 25.4%. During the period under review, revenue generation from the production of transport equipment increased by 122.5%.

In second place is the manufacture of metals and fabricated metal products except machinery and equipment. In 2010, its share of manufacturing revenues was 15.4%, rising to 17.9% in 2021. Revenue generation from the manufacture of metals and fabricated metal products except machinery and equipment increased by 89.6% in 2021 compared to 2010.

Manufacture of rubber and plastics products and other non-metallic mineral products ranks third in terms of revenue generation. In 2010, its share of manufacturing revenues was 8.1%, rising to 8.5% in 2021. Revenue generation in 2021 increased by 70.6% compared to 2010.

Table 3.8 shows a comparison of revenue generation of individual industries (according to NACE Rev.2) of the Slovak Republic for the years 2010 and 2021.

Table 3.8: *Revenues from own production and goods in industry by NACE Rev. 2 in 2010, 2020 and 2021 (thousands EUR current prices)*

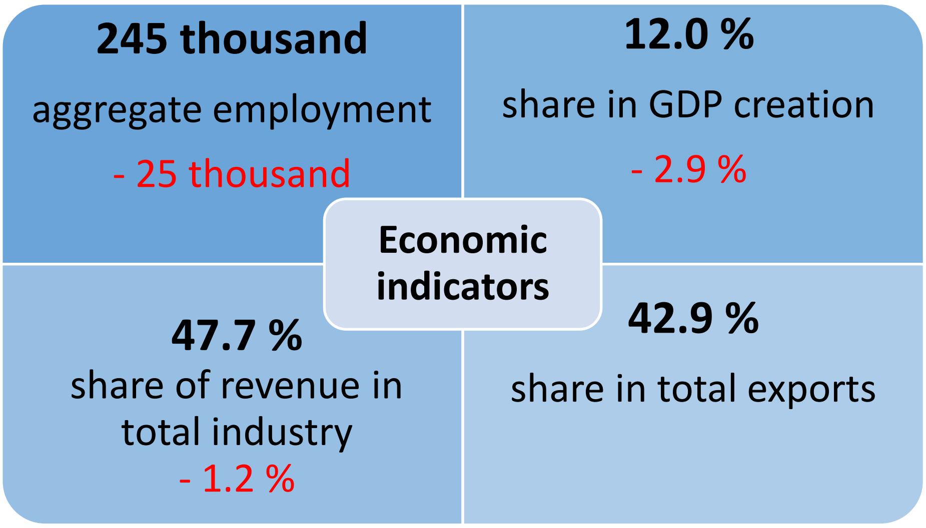
Industrial sectors	**2010**	**2020**	**2021**
B,C,D,E Industry total	67 484 077	91 977 447	105 654 824
B Mining and quarrying	507 084	569 557	576 025
C Manufacturing	54 716 393	77 691 805	89 178 366
CA Manufacture of food products, beverages and tobacco	3 757 703	4 796 905	5 035 111

Industrial sectors	2010	2020	2021
CB Manufacture of textiles, wearing apparel, leather and related products	1 303 950	1 660 579	1 734 747
CC Manufacture of wood and paper products, printing	3 099 110	3 813 550	4 653 641
CD Manufacture of coke and refined petroleum products	3 194 026	2 003 567	2 971 390
CE Manufacture of chemicals and chemical products	2 026 110	1 571 120	2 145 114
CF Manufacture of basic pharmaceutical products and pharmaceutical preparations	320 003	184 860	179 365
CG Manufacture of rubber and plastics products and other non-metallic mineral products	4 443 038	6 764 706	7 580 908
CH Manufacture of metals and fabricated metal products, except machinery and equipment	8 409 197	11 915 599	15 947 145
CI Manufacture of computer, electronic and optical products	6 816 063	3 751 332	4 387 263
CJ Manufacture of electrical equipment	2 363 998	3 678 842	4 252 920
CK Manufacture of machinery and equipment n.e.c.	2 630 632	5 062 220	5 850 001
CL Manufacture of transport equipment	13 902 893	29 320 509	30 932 557
CM Other manufacturing, repair and installation of machinery and equipment	2 449 670	3 168 016	3 508 205
D Electricity, gas, steam and air conditioning supply	11 264 333	12 385 550	14 365 729
E Water supply; sewerage, waste management and remediation activities	996 267	1 542 034	1 534 704

Source: DATAcube

Based on the above, we can confirm the key importance of the automotive sector in the industrial structure of Slovakia. In 2020, it accounted for 12% of GDP, by 2.9% less compared to 2019. In total, it employed approximately 245 thousand workers in 2020. It accounted for 47.7% of total industry revenues and contributed 42.9% of total exports in 2020.

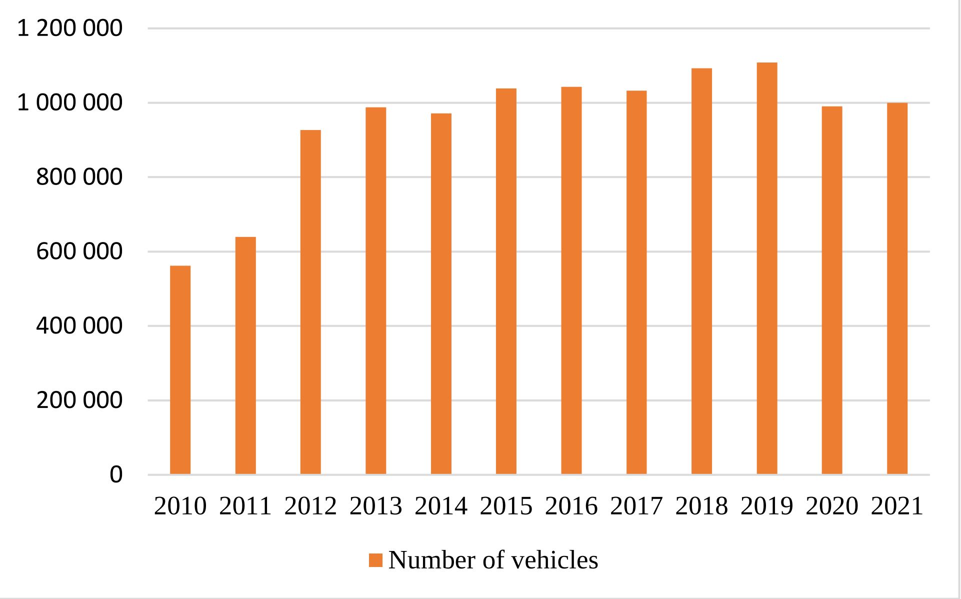
Figure 3.16: *Economic indicators of the automotive industry in the Slovak Republic in 2020*



Source: Automotive Industry Association of the SR, Statistical Office of the SR

Thanks to four established car manufacturers (Volkswagen, Stellantis, Kia, Jaguar Land Rover) and more than 350 local suppliers, Slovakia is the world leader in car production per capita (184 passenger cars produced per 1 000 inhabitants in 2021). In January 2022, the 15 000 000th Slovak vehicle was produced. The largest number of vehicles produced, namely 1 107 902, is recorded in 2019. Compared to 2010, this number has increased by 97.2%. Subsequently, in 2020, due to the aforementioned corona crisis outbreak, it fell by 11.8% compared to 2019.

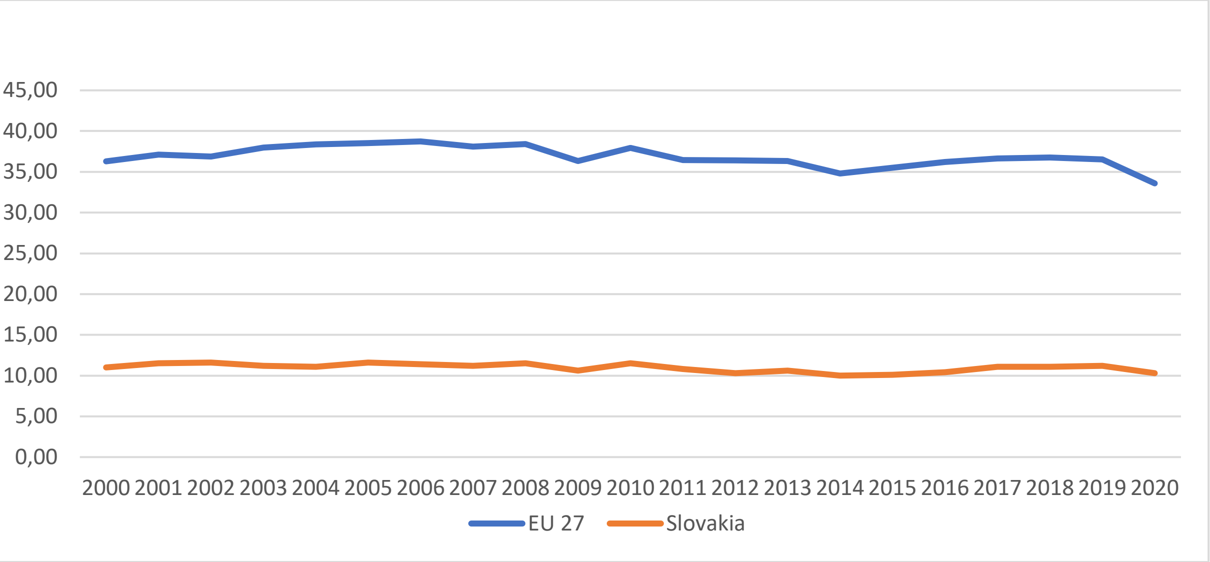
Figure 3.17: *Number of vehicles produced in SR (pcs) between 2010 and 2021*



Source: Automotive Industry Association of the SR, Statistical Office of the SR

In terms of energy consumption, the Slovak Republic is significantly below the EU average, while the development of final energy consumption is constant. The peak in energy consumption was in 2010, at 11.50 Mtoe, but this was also due to the recovery from the 2008-2009 crisis period. The COVID-19 pandemic and the prolonged halt in economic activity contributed to historically low consumption both at EU level and in the energy consumption of the Slovak Republic. The final energy consumption was 10.30 Mtoe.

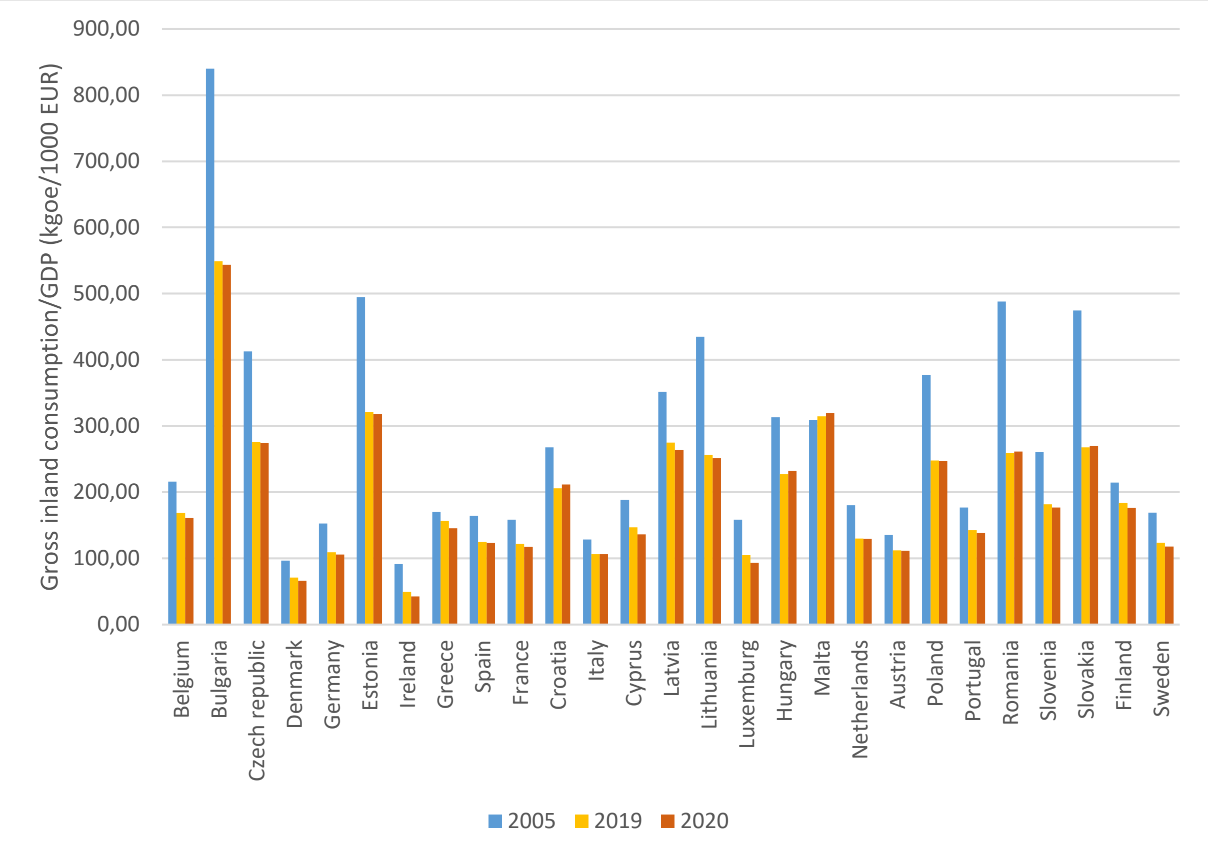
Figure 3.18: *Final energy consumption of the EU and the SR (Mtoe) 2000-2020*



Source: Eurostat

Energy intensity as a ratio of gross inland consumption to gross domestic product for a given calendar year is an important economic indicator of a national economy. It measures the energy consumption of an economy and its overall energy efficiency.

Figure 3.19: *Energy intensity of EU-27 countries in 2005, 2019, 2020*



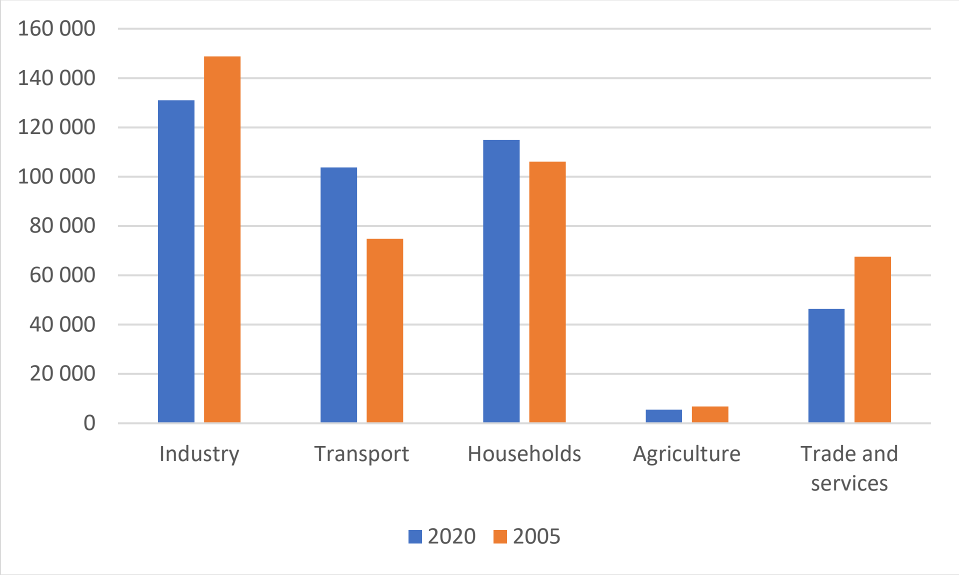
Source: Eurostat

In terms of development of energy intensity of the Slovak Republic, a decreasing trend is visible, while this positive development is largely influenced by, for example, the restructuring of industry and the introduction of low-energy production processes in industry.

Between 2005 and 2020, the Slovak Republic reduced its energy intensity by 43%, ranking third in reducing energy intensity.

Despite the positive trend, the SR is one of the most energy-intensive countries, which is due to the structure of our industry. When the final energy consumption is analysed in more depth, it is clear that the industrial sector, on which the economy of our country depends, is the main consumer of energy.

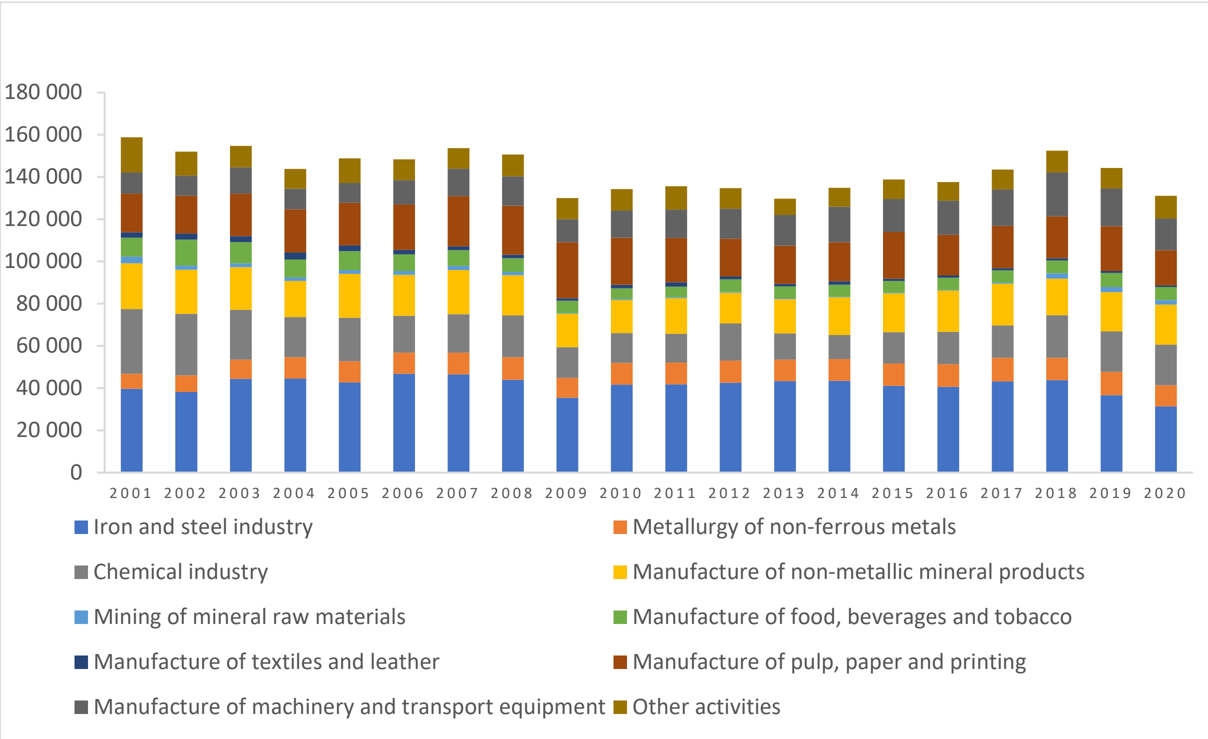
Figure 3.20: *Final energy consumption in the Slovak Republic by sector in 2005 and 2020 (TJ)*



Source: DATAcube

The industrial sectors that contributed the most to fuel and energy consumption were: metallurgy 23.89%; chemical industry and the manufacturing of non-metallic mineral products, both around 15%, followed by pulp, paper and printing 12.65% and machinery manufacturing 11.46%. Compared to 2015, there has been a change in the structure of the distribution of consumption and a reduction in the differences between industries, with the highest reduction in the final energy consumption occurring in the metallurgical sector, which accounted for up to 30% of the final energy consumption in the industry in 2015.

Figure 3.21: *Final energy consumption of the Slovak Republic by sector in industry (TJ) 2001-2020*



Source: DATAcube

3.9 WASTE MANAGEMENT SECTOR

In the period 2016-2020, the waste management in the Slovak Republic has undergone a dynamic process, which started with the adoption of the new Waste Act in 2016. The backbone of the new legislation is the new rules on extended producer responsibility, which has been introduced for 6 commodities - packaging, non-packaging products, batteries and accumulators, electrical equipment, vehicles and tyres. The biggest change in the legislation concerned packaging and non-packaging products, where more targeted responsibility was introduced, financial flows were made more transparent, the volume of funds invested in the separate collection of municipal waste was substantially increased, and the overall efficiency of separate collection was improved with an increase in collection capacity.

Significant legislation was also introduced in the area of separate collection of biodegradable municipal waste, both for “green” biodegradable waste from gardens and parks and for household kitchen waste. However, in the area of kitchen waste, the unsatisfactory state of collection and recovery remains and further legislative changes were prepared to remove exemptions from the obligation to collect kitchen waste and to further disadvantage the landfilling of mixed municipal waste.

3.9.1 Waste Generation and Management

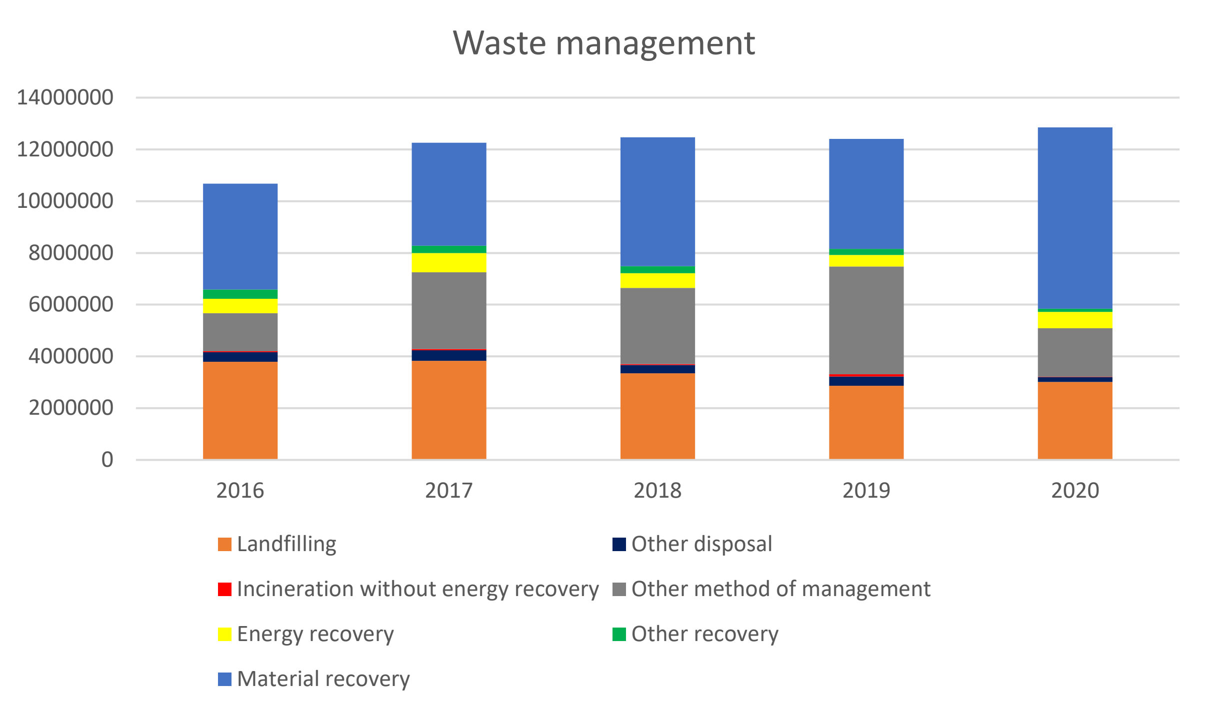
On average, about 12 million tonnes of waste are generated annually in the Slovak Republic. All spheres of waste generation are included, i.e. industrial and public spheres (including municipal waste).

Table 3.9: *Waste generation by statistical classification of economic activities (EN NACE Rev.2) (t)*

SK NACE	Activity	2016	2017	2018	2019	2020
A	Agriculture, forestry and fishing	788 571	678 152	529 812	427 185	562,363
B	Mining and quarrying	316 627	336 157	274 660	273 699	205,866
C	Manufacturing	3 445 859	3 908 117	3 414 089	2 918 417	3,067,597
D	Electricity, gas, steam and air conditioning supply	957 778	896 497	975 473	898 773	696,660
E	Water supply; sewerage, waste management and remediation activities	957 950	1 082 492	1 522 812	1 429 004	1,139,218
F	Construction	967 276	534 375	541 878	1 547 359	1,150,030
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	381 623	563 277	606 323	463 428	596,459
H	Transportation and storage	210 842	1 141 828	1 692 244	1 446 075	2,126,265
I	Accommodation and food service activities	5 148	4 871	8 914	12 719	12,725
J	Information and communication	23 380	3 689	5 065	11 215	5,739
K	Financial and insurance activities	462	342	1 388	455	4,172
L	Real estate activities	103 822	228 667	191 061	252 871	138,743
M	Professional, scientific and technical activities	369 026	112 506	73 571	65 007	167,789
N	Administrative and support service activities	29 941	178 385	71 088	96 754	176,857
O	Public administration and defence; compulsory social security	1 981 562	2 406 654	2 451 235	2 440 530	2,653,734
P	Education	1 582	2 462	2 479	3 253	4,471
Q	Human health and social work activities	91 073	137 496	101 538	110 967	44,610
R	Arts, entertainment and recreation	1 926	977	1 576	1 761	33,394
S	Other service activities	36 805	35 236	2 434	8 197	59,172
TOTAL		**10 671 254**	**12 252 182**	**12 467 639**	**12 407 669**	**12 845 864**

Industrial production has long been the largest contributor to waste generation, generating more than 3 million tonnes of waste annually. The second largest generator of waste is general government, which also includes municipal waste from municipalities. The transport and storage sector, the construction sector and the water supply; sewerage, waste management and remediation activities sector contribute significantly to the generation of waste. Decreases in waste generation can be observed in the agriculture, forestry and fisheries sectors, as well as in the electricity, gas, steam and cold air supply sectors.

Figure 3.22: *Total waste management (t)*



Source: MŽP SR

In the overall waste management, a gradual decrease in landfilling can be observed for the period 2016-2020. There was a negative trend in 2016-2019 due to the change in national reporting, with an increase in other waste management methods as a result of an outdated waste information system and insufficient statistics on the material flow of waste. In 2020, there was a partial improvement in the quality of data on the material flow of waste, which was reflected in an increase in the amount of waste recovered.

Energy recovery of waste averages 600 000 tonnes of recovered waste per year, with energy recovery of municipal waste being the main contributor. Co-incineration of waste in cement kilns contributes significantly to the energy recovery of waste.

Incineration without energy recovery saw a significant decline in 2020, but contributes little to waste management overall, as hazardous waste is predominantly disposed of in this way.

3.9.2 Municipal Waste

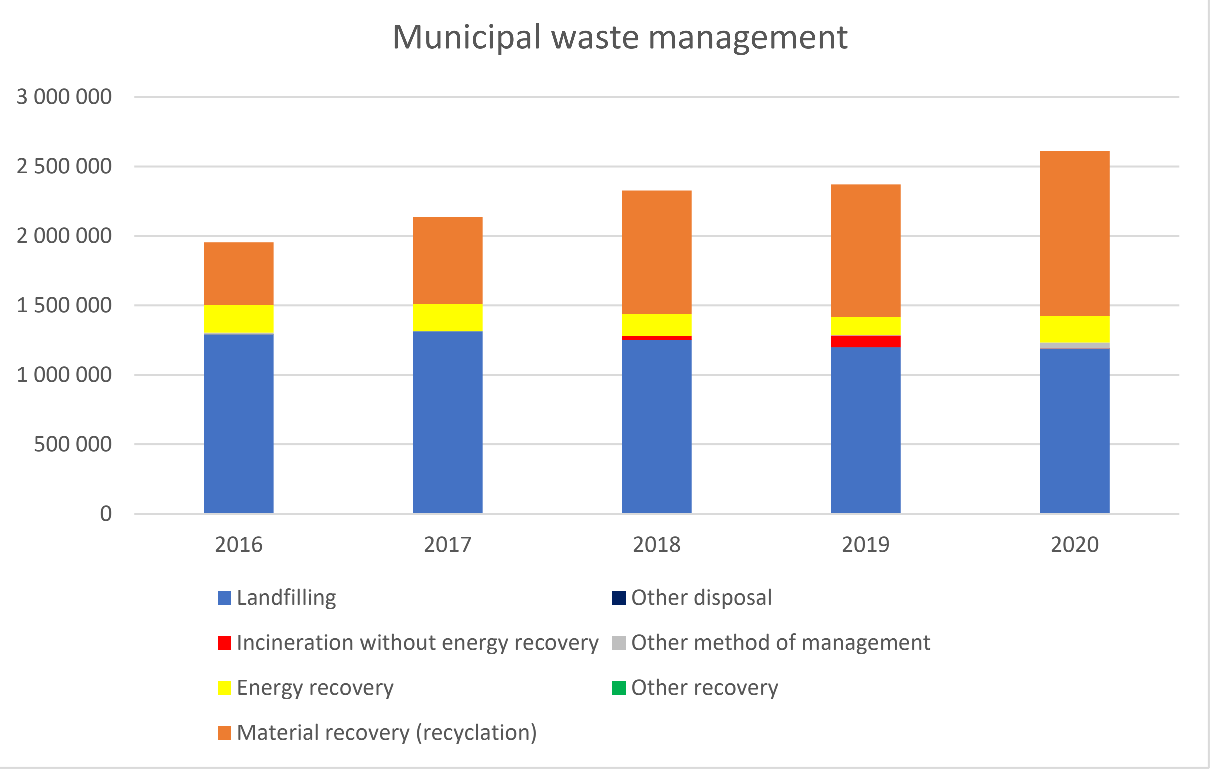
Municipal waste generation has been on the rise since 2016, due to several legislative changes and changes in national and international reporting, in addition to the natural increase in waste due to rising living standards and the population’s purchasing power. The main reason for the change in the statistical indicators for municipal waste is the new definition of municipal waste, which, after its implementation in practice for the first time, is already reflected in the 2020 data. The main change to the definition of municipal waste is that, in addition to household waste, municipal waste also includes a proportion of similar waste from other sources, i.e. from trade, services, etc.

In 2020, municipal waste production reached 2.6 million tonnes, or 480 kg per capita. This brings the Slovak Republic significantly closer to the average municipal waste production in the EU27, which reached 505 kg/capita in 2020.

One of the reasons for the increase in municipal waste is a change in the statistical counting of ferrous and non-ferrous metals from scrap yards and waste buyers, which have largely been counted as municipal waste since 2016.

The level of municipal mixed waste generated has a gradually decreasing trend, which can be expected to continue in the period 2020-2025, if the landfilling of municipal mixed waste is further discouraged through economic instruments and after the introduction of compulsory treatment before landfilling.

Figure 3.23: *Municipal waste management (t)*



Source: MŽP SR

On the positive side, municipal waste recycling rates are increasing, reaching 45% in 2020, up from only 23% in 2016. The rate of landfilling, which is expected to fall to 10% of total municipal waste generated by 2035, fell to 46% in 2020.

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3.10 HOUSING, HOUSEHOLDS AND PUBLIC BUILDINGS SECTOR

According to the data provided by cities and municipalities to the Statistical Office of the Slovak Republic, as construction authorities supervising housing construction, in 2021 the construction of 24 497 dwellings started[12], 20 649 dwellings were completed[13] and at the end of the reporting period there were 79 947 dwellings under construction. Of the total number of completed dwellings, 13 945 were in single-family houses, a share of 67.5%. The existing housing stock in 2021 was reduced by 1 422 dwellings, of which 1 365 were due to demolition.

Another indicator is the average living floor space, which was 71.54 m^2 in 2021. On average, there is a gradual upward trend in the living floor space of dwellings, e.g. the value of this indicator has increased by 2.14 m^2 compared to the value in 2020 (69.4 m^2).

Table 3.10: *Indicators of housing construction in the Slovak Republic during the period 2013-2021*

Indicator	2013	2014	2015	2016	2017	2018	2019	2020	2021
Number of dwellings/flats	15 100	14 985	15 471	15 672	16 946	19 071	20 171	21 490	20 649
of which									
Number of houses	10 208	10 041	9 860	11 195	11 547	12 687	13 338	13 421	13 945
Average useful floor space of dwelling m^2	119.5	118.8	113.7	116.81	112.84	112.26	109.69	109.81	114.69
Average living floor space of dwelling m^2	73.7	72.6	71.4	73.83	66.8	70.9	69.75	69.4	71.54

Source: Information on housing construction in the Slovak Republic in 2021[14]

The most common type of heating in dwellings in the Slovak Republic is local central heating (970 715, i.e. 43.42% of the total number of inhabited dwellings in the Slovak Republic) and district central heating (772 829, i.e. 34.57% of the total number of inhabited dwellings in the Slovak Republic), according to the results of the 2021 Census of Population (Population, Houses and Dwellings Census).

3.11 AGRICULTURAL SECTOR

The agricultural sector accounts for approximately 7% of the total volume of greenhouse gas emissions produced in the Slovak Republic. In 2020, according to the SHMÚ, the volume of greenhouse gases produced from agriculture decreased by 56,91% compared to 1990 and increased by 2% compared to 2015 to 2 579.71 Gg CO_2 eq. The agricultural sector is the sector with the most significant decline compared to the 1990 base year due to the downward trend in livestock numbers and the use of synthetic fertilizers. Greenhouse gas emissions from agriculture have been on a declining trend since 1990 and have changed little since 2005.

Approximately 50.6% of the produced volume of emissions consists of nitrous oxide, emitted into the air mainly from cultivated agricultural land and to a lesser extent (5.8%) as a consequence of livestock farming (degradation of animal excrements) in the Slovak Republic.

Of the emissions produced, 37.5% are methane (CH_4) emitted into the air, mainly as a direct product of metabolism in herbivores (enteric fermentation) and as a product of digestion of animal excrements (3.4%). Ammonia emitted from agricultural land accounted for 69.7% of total ammonia emissions from agriculture. The share of ammonia produced from livestock production was 24.7%. Broilers (23%), pigs

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[12] building permits issued

[13] certificates of occupancy issued

[14] https://www.mindop.sk/ministerstvo-1/vystavba-5/bytova-politika/dokumenty/informacie/informacia-o-bytovej-vystavbe-v-slovenskej-republike

(19.1%), other cattle (19.6%), dairy cows (17.6%) and laying hens (10.6%) produced the highest proportion of ammonia from livestock production.

Table 3.11: *Development of gross agricultural production (GAP), in the SR[15]in mil. €*

Indicator	Average 2016-2020	2020	2021*
GAP (in current prices)	2095.8	2086.1	2279.7
of which			
Gross crop production	1301.3	1319.1	1481.2
Gross livestock production	794.5	767	798.4

*Estimate of the Research Institute of Agriculture and Food Economics (2022), *Estimate based on provisional data for 2020*

3.11.1 Livestock Production

Livestock production in value terms increased by 0.6% year-on-year, due to a total 2.8% decline in the natural production of slaughter animals, while prices of livestock commodities increased by 0.7%. Slaughter animal production increased for poultry (1.3%) and cattle (0.1%); sheep (2.8%) and cow's milk (1.3%) production also increased.

Year-on-year (2020-2021), the number of cattle decreased to 416.8 thousand (0.8%), of which the number of dairy cows decreased to 120.1 thousand heads (1.6%). The number of pigs reached 512.4 thousand heads, which was by 2.3% less compared to 2020. The number of sheep decreased by 0.8% to 346.3 thousand heads. The number of goats increased by 0.3% to 37.3 thousand heads. The quantity of poultry totalled 12,074 thousand heads, which was by 0.3% less than in 2020.

Table 3.12: *Overview of livestock numbers in the Slovak Republic[16]*

Number in thousands	2017	2018	2019	2020	2021	2022*
Cattle	441.4	438.8	424.5	420.2	416.8	414.2
of which dairy cows**	129.9	127.9	125.9	122.1	120.1	-
Sheep	365.3	351.2	353.5	349.2	346.3	344.5
Goats	37.1	36.9	37.1	37.2	37.3	37.4
Pigs	614.3	627.1	537.5	524.4	512.4	501.7
Poultry	13 353.8	14 056.9	12 151.3	12 112.5	12 074	12 035.6

**Estimate of the Research Institute of Agriculture and Food Economics (2022), ** Source: Situation and outlook report for the first half of 2022 - Cattle*

3.11.2 Crop Production

Crop production increased by 6.1% in value terms. In 2020, field crops were sown on an area of 1 346.0 thousand hectares, which represented a decrease of 0.2% (2.9 thousand hectares) compared to the previous year. The share of sown area in utilised agricultural land in the Slovak Republic increased by 0.1 p.p. to 70.5%. The area under grain cultivation decreased by 1.3% year-on-year to 773.2 thousand hectares. Of this, cereals were sown on an area of 761.3 thousand hectares, which meant a year-on-year decrease by 1.6% (11.5 thousand hectares). Wheat area decreased by 4.2% year-on-year (17.3 thousand hectares) to 390.9 thousand hectares, on the contrary, the area under barley increased by 4.7% (6.0 thousand hectares) to 132.9 thousand hectares. The area under oilseeds increased by 3.7% (9.7 hectares) to 269.5 thousand hectares. Total potato area fell by 9.6% to 7.4 thousand hectares (by 0.8 thousand

[15] Ministry of Agriculture and Rural Development, Green Report, 2021 (https://www.mpsr.sk/en/index.php?navID=16)

[16] Ministry of Agriculture and Rural Development of the SR, Report on Agriculture and Food Sector in the Slovak Republic (Green Report), 2017-2021

hectares). Of these, the area of other ware potatoes fell by 12.9% year-on-year to 6.0 thousand hectares. The area of productive orchards increased by 4.2% to 5.0 thousand hectares.

3.12 FORESTRY SECTOR

According to the Green report[17] (Report on the forest sector of the Slovak republic 2020), the area of forest land in the Slovak Republic in 2020 amounted to 2.025 mil. hectares. The area of forest stands reached 1.951 mil. hectares, while the long-term trend of its increase persists. Since 1990, the area of forest stands has increased by 29.8 thousand hectares, or 1.55%. The increase, approximately 975 ha per year over the period, is mainly due to a change in the type of land use. The forest cover, calculated from the area of forest land, was 41.3%.

Deciduous tree species predominate in the forest stands with a 63.9% share. Beech (34.6%), spruce (22.1%), oaks (10.4%), and pine (6.6%) have the highest representation. The representation of conifers has decreased by 6.4% since 1980 (from 42.5% to the current 36.1%). Over this period, spruce representation decreased mainly due to the action of harmful agents in the forests. In contrast, the representation of beech increased by 5.1% and that of rare deciduous trees (maple, ash) by 2.4%. In addition to the overall representation of individual tree species, the mixing of tree species in forest stands is also an important indicator of species diversity and forest stability. In this respect, more stable deciduous and mixed forests prevail in the Slovak Republic, with a cumulative representation of 74.2%, of which deciduous (45.3%), predominantly deciduous (8.5%) and mixed forests (20.4%). Their representation is increasing annually.

The age structure of forests in the Slovak Republic is unbalanced, with a higher proportion of older (mostly mature for felling) forest stands over 70 years of age and young forest stands up to 20 years of age. The increase in the proportion of young forest stands is related to the high extent of forest regeneration due to the current increased harvesting possibilities as well as the impact of harmful factors (regeneration of damaged stands).

In the Slovak Republic, the trend of increasing growing stocks has persisted so far. According to SISL, in 2020, the total volume of growing stock reached 484.5 million m^3 under-bark standing. Compared to 2019, it increased by 1.5 million m^3. The growing stock in coniferous forests was 194.8 million m^3 (40.2% of the total stock). Stock in these forests has been in decline since 2010 due to the detrimental impact of harmful agents (particularly noticeable in spruce forests). Increase of the stock of hardwood has continued, reaching 289.7 m^3 (59.8% of the total growing stock) in 2020.

It can be stated that currently the forests of the Slovak Republic contain the historically highest growing stocks for at least the last century. This situation results from the current age structure of forests, which is characterised by a higher representation of older forest stands in the 8 - 15+ age stages, in which high growing stocks are accumulated. Growing stocks are projected to decline in the coming years and decades due to a gradual change in the age structure. This trend is also confirmed by the observed decrease in the average annual increase in the growing stock in Slovak forests, which was as follows during the previous five-year periods: 1991-1995: 5.9 mil. m^3, 1995-2000: 6.4 mil. m^3, 2000-2005: 5.8 mil. m^3, 2005-2010: 4.6 mil. m^3, 2010-2015: 3.2 mil. m^3; after 2015, the average annual increase in growing stocks was only 1.2 mil. m^3. A similar trend to the annual change in the total growing stock can be observed in the annual change in the average growing stock per hectare. The average growing stock per hectare was 249 m^3 in 2020.

[17] Green Report Brochure 2020 (https://www.mpsr.sk/en/index.php?navID=17&id=77)

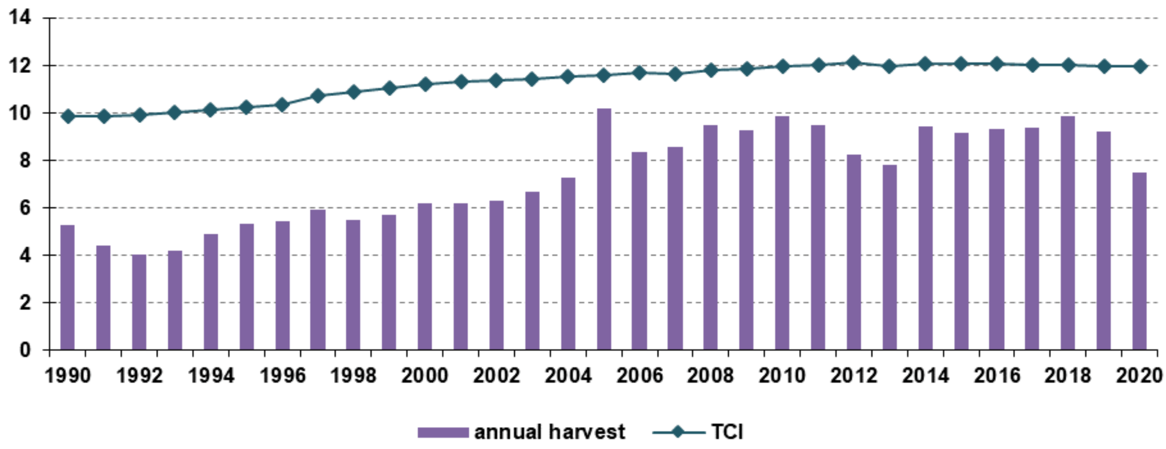
Total current increment (TCI) represents the volume of timber that actually grows in the forest in one year. In 2020, this increment amounted to 11.97 million m^3 or 6.22 m^3 per ha in Slovak forests. In recent decades, CAI has gradually increased to 12.126 million m^3 (6.25 m^3 per ha) in 2012. Since 2015, a slight annual decline in CAI has been observed.

Healthy and stable forests are also an important component of the landscape in terms of their significant contribution to carbon sequestration. This contributes to reducing overall greenhouse gas emissions, especially carbon dioxide into the atmosphere, as carbon, is stored in forest biomass, soils and wood products over the long term period. In parallel with the increase in the growing stock in forests and the area of forest land, there is also an increase in the carbon stocks in the individual balance categories. According to the Green Report 2020, the forest carbon stock in living biomass, dead organic matters and forest soils in 2020 reached a mass of 507.79 million tonnes, with the largest amount sequestered in soil (270.5 million tonnes) and aboveground tree biomass (164.74 million tonnes). Total forest carbon stocks increased by 3.2% compared to 2010, 9.3% compared to 2000 and 17.1% compared to 1990.[17]

A total of 7.5 million m^3 of timber volume was harvested in Slovakia in 2020. Actual timber harvesting was by 2.3 mil. m^3 lower than the planned harvesting, determined on the basis of current harvesting possibilities and the urgency of reforestation. 53.5% of coniferous and 46.5% of deciduous timber was harvested. Of this volume of timber harvesting, 3.5 million m^3 (47.1%) was harvested in the course of removing the effects of harmful agents in forests. The timber harvested is consistently lower than the TCI (11.97 million m^3), i.e. than the volume of timber that is added to the forests each year (***Figure 3.24***). Both planned and actual timber harvesting in the Slovak Republic are on a long-term upward trend, despite the fact that in 2020 the volume of harvesting was the lowest in the last years. The current age structure of forests with a normal to above-normal areal representation of 71-year-old and older forest stands is the main factor of increased harvesting possibilities and, consequently, timber harvesting. Most of the forests in these age stages have reached an age at which it is appropriate to start restoring them. As a consequence of these facts, the volume of planned timber harvesting is increasing, reaching 9.85 million m^3 in 2020.[17]

The conversion of even-aged stands (often monocultures) to more resilient, close-to-nature forests requires active interventions that, once implemented, will temporarily reduce the amount of carbon in the biomass of these stands. However, these measures are necessary to ensure the continuity and long-term stability of carbon stocks in these ecosystems.

Figure 3.24: *Total current increment (TCI) and total annual timber harvest (million m^3) 1990-2020*



CHAPTER 4 INFORMATION ON GREENHOUSE GAS INVENTORY

Total greenhouse gas emissions in the Slovak Republic (excluding LULUCF) decreased by 49.6% from 1990 to 2020. The largest relative change was in the agricultural and energy sectors, where GHG emissions decreased substantially by 57% and 56%, respectively, compared to 1990. The reduction was due to fundamental changes in agricultural management practices and increase in energy efficiency and fuel consumption reduction.

The gradual introduction of targeted policies and measures in the past, has resulted in decrease of total GHG emissions (excluding LULUCF) compared to 1990, already by more than 40% in 2012. More information on policies and measures is provided in Chapter 5 and Chapter 6 of this report.

4.1 SUMMARY INFORMATION

The gradual introduction of stringent policies and measures in the past, has resulted in decrease of total GHG emissions (excluding LULUCF) compared to 1990, in 2012, for the first time, it was more than by 40%. Total GHG emissions in the Slovak Republic (excluding LULUCF) decreased by 49.6% from 1990 to 2020. The largest relative change was in the agricultural and energy sectors, where GHG emissions decreased substantially by 57% and 56%, respectively, compared to 1990. The reduction was due to fundamental changes in agricultural management practices and increase in energy efficiency and fuel consumption reduction.

Between 2019 and 2020, total GHG emissions decreased by 7%, the decrease was mainly due to a decrease in emissions in the energy and industry sectors, mainly due to a reduction in industrial production in the iron and steel, as well as a year-on-year reduction of sinks in LULUCF sector. Since the last, Seventh National Communication of the Slovak Republic, published in 2017, emissions have fallen by 9%, with the lowest level in 2020, for the reasons mentioned above. In the meantime, there have been a number of updates and revisions to methodologies, emission factors, and submitted parameters in the emissions inventory, that have impacted the emissions levels in time series.

GHG emissions inventory is prepared annually under the Kyoto Protocol and the United Nations Framework Convention on Climate Change (UNFCCC). This chapter provides emission trends for the period 1990-2020, a description of the GHG inventory process, a description of the methodology and data availability. The GHG data presented in this chapter are identical to the 2020 data submitted by the Slovak Republic to the UNFCCC.[18] Summary tables of GHG emissions in tabular format are provided in CTF Tables 1(a) and 1(b) in the CTF Annex. This data and the Slovak Republic's full submission under the UNFCCC and the Kyoto Protocol are available on a website.[19]

A description of the Slovak National Inventory System and the preparation of emissions inventories under paragraph 5.1 of the Kyoto Protocol are presented in the National Inventory Report of the Slovak Republic 2022 (SVK NIR 2022, Chapter 1).

[18] Annual Greenhouse Gas Emissions Inventory of the Slovak Republic 1990-2020 and National Inventory Report of the Slovak Republic 2022 submitted on 13 April 2022.

[19] https://oeab.shmu.sk/o-nas/dokumenty.html

4.2 DESCRIPTIVE SUMMARY OF GHG EMISSION TRENDS

4.2.1 Overall GHG Emission Trends

Under the Kyoto Protocol, the Slovak Republic (like most EU Member States) has agreed to reduce its GHG emissions individually by 8% over the period 2008-2012 compared to the base year of 1990. This commitment was achieved through a combination of strong national environmental policies and measures implemented in the early 1990s and a radical change in the structure of the industry. In 2010, the EU submitted a commitment to reduce its GHG emissions by 20% below 1990 levels by 2020 (UNFCCC, 2014a). As this Convention-based target has only been put forward by the EU-28 and not by each of the Member States (MS), there are no set targets for each MS under the Convention. For this reason, the Slovak Republic, as part of the EU-28, adopts a quantified economy-wide emission reduction target together with all Member States.

In 2020, total GHG emissions in the Slovak Republic without LULUCF were lower by 49.6% compared to the base year 1990, at 37,002.7 Gg CO_2 eq. Compared to 2019, total emissions decreased by 7% (***Figure 4.1***). The decrease in emissions is also accompanied by a year-on-year decrease in wood harvest and hence an increase in LULUCF removals. Total GHG emissions excluding the LULUCF sector have continued to decline at a moderate rate in recent years compared to the base year. Significant changes in methodologies and emission factors have been introduced to ensure consistency with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, representing a significant advance in the quality of estimates through refined methodologies, completeness and accuracy. In addition, the comparison with verified emissions aloowances for all installations covered by the EU ETS has improved the energy and industry inventory.

Tables 4.1 and ***4.2*** show the cumulative GHG emissions in CO_2 eq. by gas and sector. In the period 1990-2020, total GHG emissions in the Slovak Republic did not exceed the 1990 base year level. ***Figure 4.1*** shows emissions trends without LULUCF comparable to the Kyoto and Doha targets. Due to their increased use in industry, F-gases are the only emissions with an increasing trend since 1990.

Table 4.1: *Total anthropogenic greenhouse gas emissions by gas from 1990 to 2020*

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	CO_2 eq. (Gg)							
CO_2 emissions without net CO_2 from LULUCF	61 470.19	53 283.80	48 884.20	46 348.52	43 754.33	44 142.33	44 023.48	44 095.51
CO_2 emissions with net CO_2 from LULUCF	52 006.68	43 001.49	37 964.38	35 621.24	33 619.29	34 565.09	34 532.20	34 823.35
CH_4 emissions without CH_4 from LULUCF	7 300.92	6 950.26	6 270.25	5 971.15	5 654.95	5 644.75	5 507.53	5 278.25
CH_4 emissions with CH_4 from LULUCF	7 312.03	6 959.45	6 283.03	5 995.08	5 661.41	5 652.47	5 518.28	5 286.60
N_2O emissions without N_2O from LULUCF	4 288.77	3 374.70	2 767.99	2 300.69	2 750.68	2 897.16	3 075.54	3 070.60
N_2O emissions with N_2O from LULUCF	4 421.75	3 492.80	2 885.70	2 422.66	2 856.22	2 988.96	3 163.33	3 148.96
HFC	NO	NO	NO	NO	0.20	13.32	28.39	41.21
PFC	314.86	309.73	288.24	180.32	153.23	132.65	40.72	40.16
SF_6	0.06	0.04	0.04	0.09	17.62	10.15	11.16	11.47
Total (without LULUCF)	**73 374.79**	**63 918.51**	**58 210.71**	**54 800.77**	**52 331.01**	**52 840.35**	**52 686.83**	**52 537.20**
Total (including LULUCF)	**64 055.38**	**53 763.50**	**47 421.39**	**44 219.39**	**42 307.96**	**43 362.64**	**43 294.09**	**43 351.75**
Total (without LULUCF, including indirect emissions)	**73 462.56**	**64 005.04**	**58 296.14**	**54 885.02**	**52 414.18**	**52 922.44**	**52 767.80**	**52 617.03**
Total (including LULUCF and indirect emissions)	**64 143.15**	**53 850.03**	**47 506.81**	**44 303.64**	**42 391.13**	**43 444.73**	**43 375.06**	**43 431.58**

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 eq. (Gg)							
CO_2 emissions without net CO_2 from LULUCF	43 824.66	43 035.49	41 135.93	43 220.93	41 960.93	42 293.77	42 780.24	42 788.86
CO_2 emissions with net CO_2 from LULUCF	33 488.29	33 464.06	31 648.05	34 445.37	32 695.92	33 568.03	34 082.02	37 963.68
CH_4 emissions without CH_4 from LULUCF	5 139.78	5 047.36	4 834.14	4 695.02	4 588.10	4 386.27	4 367.43	4 342.42
CH_4 emissions with CH_4 from LULUCF	5 147.98	5 101.24	4 861.24	4 707.60	4 609.14	4 427.29	4 381.65	4 368.72
N_2O emissions without N_2O from LULUCF	2 758.15	2 327.99	2 601.09	2 949.10	2 878.62	2 835.45	3 064.39	3 030.29
N_2O emissions with N_2O from LULUCF	2 830.22	2 426.60	2 671.01	3 003.96	2 934.29	2 900.33	3 111.32	3 081.68
HFC	54.61	77.29	105.04	138.78	178.46	213.52	254.39	292.99
PFC	29.10	16.27	14.91	16.02	17.18	26.45	23.63	24.16

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	CO₂ eq. (Gg)							
SF_6	12.65	12.64	13.04	13.33	14.78	15.06	15.43	16.38
Total (without LULUCF)	**51 818.95**	**50 517.05**	**48 704.17**	**51 033.18**	**49 638.08**	**49 770.51**	**50 505.50**	**50 495.10**
Total (including LULUCF)	**41 562.85**	**41 098.10**	**39 313.30**	**42 325.05**	**40 449.77**	**41 150.66**	**41 868.43**	**45 747.62**
Total (without LULUCF, including indirect emissions)	**51 897.65**	**50 593.85**	**48 769.61**	**51 098.70**	**49 709.84**	**49 838.50**	**50 581.18**	**50 562.03**
Total (including LULUCF and indirect emissions)	**41 641.56**	**41 174.90**	**39 378.74**	**42 390.57**	**40 521.53**	**41 218.65**	**41 944.11**	**45 814.55**

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013
	CO_2 eq. (Gg)							
CO_2 emissions without net CO_2 from LULUCF	42 552.11	40 968.27	41 359.05	37 622.06	38 403.93	37 984.84	35 910.38	35 565.55
CO_2 emissions with net CO_2 from LULUCF	34 634.02	33 500.71	35 007.17	31 483.54	33 136.06	32 359.24	29 149.03	28 086.25
CH_4 emissions without CH_4 from LULUCF	4 194.41	4 085.75	4 074.64	3 921.23	3 907.62	3 866.58	3 740.46	3 718.54
CH_4 emissions with CH_4 from LULUCF	4 211.02	4 113.10	4 091.79	3 946.55	3 927.65	3 890.63	3 786.49	3 733.79
N_2O emissions without N_2O from LULUCF	3 157.56	3 085.21	3 151.26	2 713.21	2 670.59	2 145.29	1 911.73	1 952.17
N_2O emissions with N_2O from LULUCF	3 199.86	3 132.36	3 188.77	2 754.96	2 707.35	2 184.66	1 966.33	1 987.20
HFC	341.49	388.26	454.47	516.93	597.24	605.03	628.20	646.88
PFC	42.47	29.42	42.76	21.00	25.01	20.11	25.66	9.81
SF_6	16.71	17.39	18.85	19.51	19.62	20.80	21.24	22.30
Total (without LULUCF)	**50 304.74**	**48 574.31**	**49 101.03**	**44 813.94**	**45 624.02**	**44 642.64**	**42 237.67**	**41 915.25**
Total (including LULUCF)	**42 445.58**	**41 181.26**	**42 803.80**	**38 742.48**	**40 412.94**	**39 080.46**	**35 576.95**	**34 486.23**
Total (without LULUCF, including indirect emissions)	**50 376.31**	**48 631.27**	**49 163.72**	**44 872.78**	**45 673.22**	**44 700.25**	**42 284.16**	**41 961.66**
Total (including LULUCF and indirect emissions)	**42 517.15**	**41 238.22**	**42 866.50**	**38 801.32**	**40 462.14**	**39 138.08**	**35 623.43**	**34 532.64**

GREENHOUSE GAS EMISSIONS	2014	2015	2016	2017	2018	2019	2020	% compared to 1990
	CO_2 eq. (Gg)							
CO_2 emissions without net CO_2 from LULUCF	33 656.20	34 468.23	34 912.88	36 112.65	36 102.97	33 776.19	31 094.73	-49.41
CO_2 emissions with net CO_2 from LULUCF	28 362.10	28 643.75	29 022.54	30 322.94	31 287.26	28 190.89	23 435.02	-54.94

GREENHOUSE GAS EMISSIONS	2014	2015	2016	2017	2018	2019	2020	% compared to 1990
	CO_2 eq. (Gg)							
CH_4 emissions without CH_4 from LULUCF	3 521.03	3 518.56	3 470.82	3 442.93	3 340.12	3 318.38	3 261.56	-55.33
CH_4 emissions with CH_4 from LULUCF	3 543.65	3 543.97	3 491.82	3 466.26	3 363.14	3 345.36	3 285.96	-55.06
N_2O emissions without N_2O from LULUCF	2 103.42	1 913.49	2 057.47	1 904.94	1 918.74	1 946.98	1 944.73	-54.66
N_2O emissions with N_2O from LULUCF	2 144.27	1 958.68	2 099.92	1 948.68	1 962.02	1 992.28	1 986.87	-55.07
HFC	653.84	734.88	673.37	739.06	702.77	720.74	678.88	100.00
PFC	11.15	8.50	6.49	8.62	7.78	5.19	5.61	-98.22
SF_6	14.17	14.31	5.82	7.08	9.39	8.86	17.20	29 370.00
Total (without LULUCF)	**39 959.81**	**40 657.98**	**41 126.85**	**42 215.29**	**42 081.77**	**39 776.35**	**37 002.71**	**-49.57**
Total (including LULUCF)	**34 729.17**	**34 904.10**	**35 299.96**	**36 492.64**	**37 332.37**	**34 263.33**	**29 409.53**	**-54.09**
Total (without LULUCF, including indirect emissions)	**40 009.35**	**40 714.32**	**41 179.37**	**42 262.77**	**42 134.89**	**39 821.65**	**37 048.58**	**-49.57**
Total (including LULUCF and indirect emissions)	**34 778.71**	**34 960.45**	**35 352.48**	**36 540.12**	**37 385.48**	**34 308.63**	**29 455.41**	**-54.08**

Table 4.2: *Total anthropogenic greenhouse gas emissions by sector from 1990 to 2020*

CATEGORIES OF SOURCES AND REMOVALS OF GREENHOUSE GASES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	CO_2 eq. (Gg)							
1, Energy	56 279.49	49 847.40	45 611.66	41 642.02	39 181.66	38 723.51	38 353.40	38 183.69
2, Industrial processes	9 701.66	7 509.96	7 147.33	8 171.74	8 386.20	9 307.81	9 627.11	9 674.96
4, Agriculture	5 987.29	5 148.28	4 049.95	3 586.17	3 458.56	3 504.26	3 401.06	3 355.57
5, Land use, land-use change and forestry	-10 155.01	-10 789.32	-10 581.38	-10 023.05	-9 477.71	-9 392.74	-9 185.45	-10 155.01
6, Waste	1 406.35	1 412.88	1 401.77	1 400.84	1 304.59	1 304.78	1 305.26	1 322.97

CATEGORIES OF SOURCES AND REMOVALS OF GREENHOUSE GASES	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 eq. (Gg)							
1, Energy	37 634.91	36 890.74	35 982.78	37 939.61	35 484.42	36 271.90	35 723.70	36 222.32
2, Industrial processes	9 815.02	9 434.79	8 529.84	8 703.28	9 740.42	9 345.51	10 623.90	10 089.27
4, Agriculture	3 024.87	2 835.08	2 817.09	2 999.84	3 008.11	2 728.74	2 717.18	2 725.96

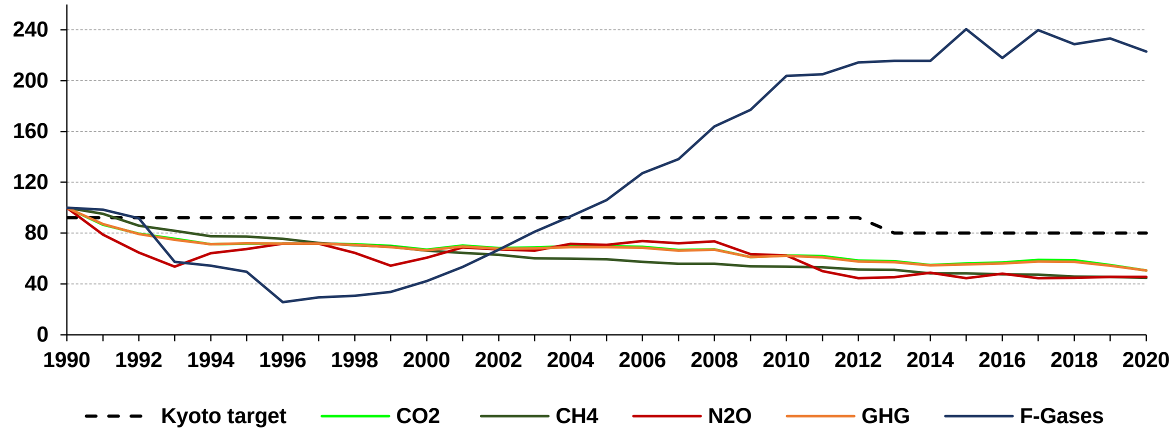
CATEGORIES OF SOURCES AND REMOVALS OF GREENHOUSE GASES	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 eq. (Gg)							
5, Land use, land-use change and forestry	-10 256.10	-9 418.95	-9 390.87	-8 708.12	-9 188.31	-8 619.85	-8 637.07	-4 747.48
6, Waste	1 344.15	1 356.43	1 374.46	1 390.44	1 405.13	1 424.35	1 440.72	1 457.54

CATEGORIES OF SOURCES AND REMOVALS OF GREENHOUSE GASES	2006	2007	2008	2009	2010	2011	2012	2013
	CO_2 eq. (Gg)							
1, Energy	35 331.43	33 683.04	34 171.36	31 675.45	32 020.50	31 466.97	29 208.81	29 026.03
2, Industrial processes	10 941.23	10 800.48	10 678.67	9 115.13	9 423.49	9 024.28	8 954.82	8 667.76
4, Agriculture	2 520.27	2 604.87	2 747.98	2 478.74	2 607.63	2 534.11	2 427.73	2 585.58
5, Land use, land-use change and forestry	-7 859.16	-7 393.05	-6 297.22	-6 071.46	-5 211.08	-5 562.18	-6 660.74	-7 429.03
6, Waste	1 511.81	1 485.91	1 503.01	1 544.62	1 572.40	1 617.27	1 646.31	1 635.89

CATEGORIES OF SOURCES AND REMOVALS OF GREENHOUSE GASES	2014	2015	2016	2017	2018	2019	2020	% compared to 1990
	CO_2 eq. (Gg)							
1, Energy	26 696.56	27 346.69	27 508.71	28 445.74	28 295.65	26 848.46	24 608.52	-56.27
2, Industrial processes	8 882.80	9 083.21	9 291.36	9 573.54	9 553.52	8 688.33	8 129.84	-16.20
4, Agriculture	2 744.44	2 537.98	2 682.97	2 521.07	2 543.37	2 572.24	2 579.71	-56.91
5, Land use, land-use change and forestry	-5 230 65	-5 753 87	-5 826 89	-5 722 64	-4 749 40	-5 513 02	-7 593 17	-18 52
6, Waste	1 636.01	1 690.10	1 643.80	1 674.94	1 689.23	1 667.33	1 684.65	19.79

Total cumulative GHG emissions, emissions determined as of 20 October 2022

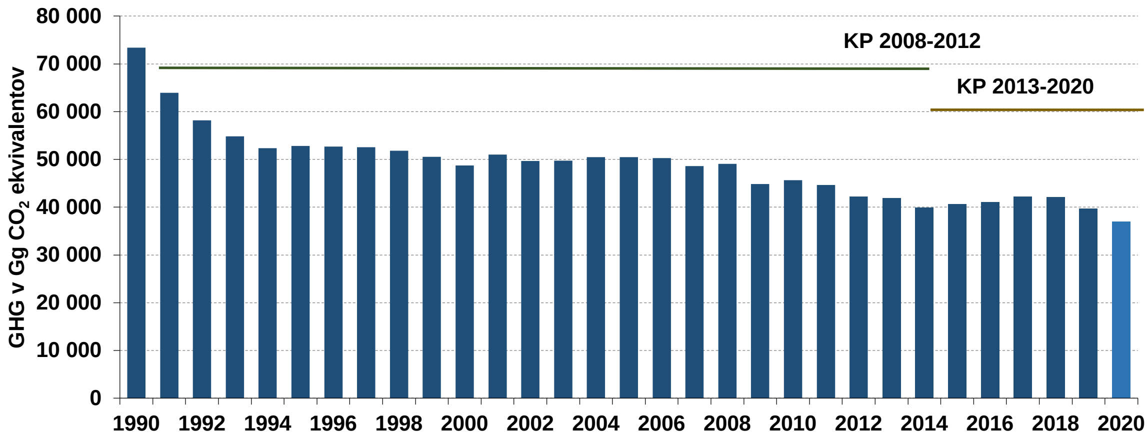
Figure 4.1: *Trends in GHG emissions (1990-2020) compared to the Kyoto target (8% and 20%) in the Slovak Republic*



GHG emissions excluding LULUCF; emissions are determined as of 10 October 2022

Total GHG emissions, including removals from the LULUCF sector, amounted to 29 409.53 Gg CO_2 eq. in 2020 and decreased by more than 54% compared to the base year 1990 (64 055.38 Gg CO_2 eq.). Total carbon removals in forest ecosystems in the Slovak Republic shows high fluctuations due to the sensitivity of the LULUCF sector to meteorological conditions and weather extremes.

Figure 4.2: *Trends in total GHG emissions (1990-2020) compared to the Kyoto target (8 % and 20 %) in the Slovak Republic*



4.2.2 Emissions Trends by Gas

Total anthropogenic carbon dioxide emissions without LULUCF in 2020 decreased by 49.4% compared to the base year (1990). In 2020, total CO_2 emissions are 31 094.73 Gg. CO_2 emissions have fallen by 10% compared to 2015 as reported in the previous – Seventh National Communication. CO_2 emissions were at historic minimum in 2020, declining mainly in the energy and industrial sectors, the decline was driven mainly by reductions in energy intensity and heavy industrial production. CO_2 emissions together with removals from the LULUCF sector have decreased significantly compared to 2019 (by 17%) and have decreased by up to 56.5% compared to 1990.

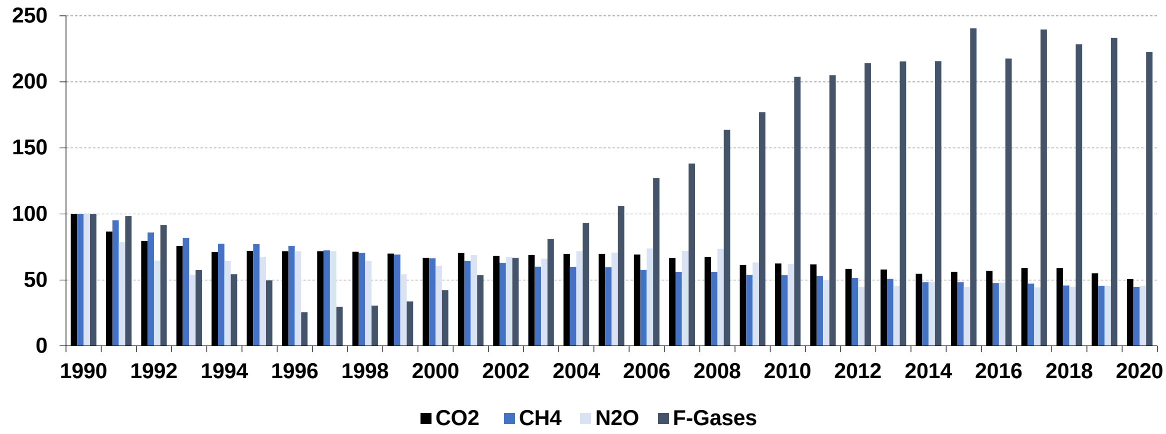
Total anthropogenic methane emissions without LULUCF have decreased by 55.3% compared to the base year (1990) and are currently at 3 261.6 Gg CO_2 eq. In absolute value, CH_4 emissions were

130.5 Gg without LULUCF. Methane emissions from the LULUCF sector were 0.89 Gg of CH_4, mainly caused by forest fires. The trend in methane emissions is influenced by the implementation of new waste legislation and fugitive emissions abatements technologies and measurements; the year-on-year decrease (2019 and 2020) was due to reductions in agricultural emissions.

Total anthropogenic N_2O emissions excluding LULUCF have decreased by 54.7% compared to the base year (1990) and currently stand at 1 944.7 Gg CO_2 eq. N_2O emissions in absolute value amounted to 6.5 Gg of N_2O without LULUCF. N_2O emissions from the LULUCF sector are 0.14 Gg. N_2O emissions are declining mainly due to declining animal numbers and fertiliser use.

Total anthropogenic emissions of F-gases were as follows: 678.9 Gg of HFC, 5.6 Gg of PFC and 17.1 Gg of SF_6 expressed in CO_2 eq. HFC emissions have increased since 1995 due to an increase in the consumption and substitution of PFCs. The trend of PFC emissions is decreasing and SF_6 emissions are slightly increasing due to their increasing consumption in the industry (***Figure 4.3***).

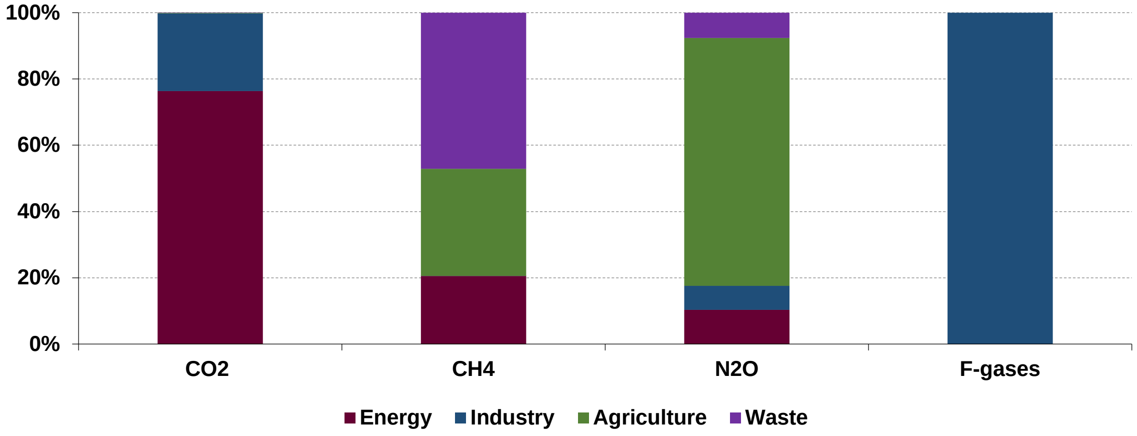
Figure 4.3: *Trends in GHG emissions by gas from 1990 to 2020 relative to 1990 levels (%)*



4.2.3 Emission Trends by Main Source Category

The main share of CO_2 emissions comes from the energy sector (fuel combustion and transport) with 76% of the total carbon dioxide emissions in the 2020 inventory, 23% of CO_2 is produced by industrial processes and product use, and negligible amounts are produced by waste (0.01%) and agriculture (0.2%). Energy-related CO_2 emissions from waste incineration are included in the energy sector. 47% of CH_4 emissions come from the waste sector, 21% from the energy sector and 32% from agriculture. More than 75% of N_2O emissions come from agriculture (nitrogen from the soil), 7% from the industrial process sector (nitric acid production), 8% from waste and 10% from the energy sector. F-gases are produced in large quantities in the industrial process sector (***Figure 4.4***).

Figure 4.4: *Emissions trends by sector by gas in 2020*



Total GHG emissions from the energy sector, estimated using the sectoral approach, were 24 183.4 Gg CO_2 eq. in 2020, including emissions from transport (7 069.2 Gg CO_2 eq.), which represents a decrease of 55% compared to the base year and a decrease of 10% compared to 2015. The transport sector declined by 3% compared to 2015 and increased by 3.5% compared to the base year.

Total emissions from the industrial process sector were 8 129.8 Gg CO_2 eq. in 2020, which represented a 16% reduction from the base year and a 10% reduction from 2015. This sector also includes emissions from the use of solvents and other products and indirect CO_2 emissions.

Emissions from the agricultural sector were estimated at 2 579.7 Gg CO_2 eq. This is a 57% decrease compared to the base year and a 2% increase compared to 2015. The agricultural sector is the sector with the most significant decline compared to the 1990 base year due to the downward trend in livestock numbers and the use of synthetic fertilizers.

Emissions from the waste sector were estimated at 1 684.7 Gg CO_2 eq. Emissions are at the same level as in 2015, up more than 20% from the base year due to an increase in methane emissions from landfills. Emissions from waste incineration with energy use are included in the energy sector.

Structural changes in the energy sector and the implementation of economic instruments have played an important role in achieving the current situation where the trend in GHG emissions does not follow the GDP growth. In this context, the most important measure seems to be the adoption of the national legislation on air quality, which was approved in 1991 and started a positive trend in the reduction of emissions of basic air pollutants and, indirectly, of GHG emissions. At the same time, the consumption of primary energy sources as well as total energy production has fallen.

Total anthropogenic GHG emissions by sector from 1990 to 2020 are shown in ***Tables 4.1*** and ***4.2*** in this **Chapter**.

Transport is a significant source of GHG emissions in the energy sector, accounting for 19% of total GHG emissions in the Slovak Republic. The share of transport is increasing year by year and the policies and measures adopted until now, have not had a visible positive impact on the trend of transport emissions in recent years. Road transport emissions are modelled by COPERT model 5.[20] GHG

[20] https://www.emisia.com/utilities/copert/

emissions from non-road transport are balanced using the EMEP/EEA 2019 methodology[21] by transport mode (air, water and rail).

Fugitive methane emissions from extraction (only 0.3% of total GDP) and distribution of fossil fuels are important as the Slovak Republic is an important transit country for the transport of oil and natural gas from the countries of the former Soviet Union to Europe. Raw materials are transported through high-pressure pipelines and the distribution network and pumped by pipeline compressors.

The industrial process sector includes all GHG emissions from technological processes producing raw materials and products with a 36% share on the total GDP in the Slovak Republic. Within the development of the GHG emissions balance in the Slovak Republic, a permanent effort is placed on the analysis of individual technological processes and the difference between emissions from fuel combustion in the production of heat and energy and emissions from technological processes and production. The most important emission sources are balanced separately, the emission and oxidation factors as well as other parameters entering the balancing equations are evaluated repeatedly and the results are compared with verified emissions in the European Emissions Trading Scheme. The baseline inventory of solvent emissions is based on the balance of non-methane volatile organic compounds (NMVOCs) according to the revised methodology of the 2019 EMEP/EEA Guidebook. Emissions are converted according to stoichiometric coefficients to CO_2 emissions. Indirect CO_2 emissions were recalculated for the whole time series based on the IPCC 2006 methodology.

Agriculture with more than 2% of the total GDP of the Slovak Republic is the largest source of methane and N_2O emissions in the emissions inventory of Slovakia. The emissions inventory is compiled annually on the basis of sectoral statistics and, in recent years, on the basis of the new regionalisation of the agricultural area of the Slovak Republic. The Ministry of Agriculture and Rural Development of the Slovak Republic publishes the annual statistics “Green Report”, a part of the agriculture and food industry.[22]

The area of forest land in the Slovak Republic covers 41% of the territory and logging has historically been an important economic activity. Since 1990, removals from the LULUCF sector have been at the level of 8-10% of total GHG emissions; in recent years, removals have increased to around 15% of total GHG emissions. The historically stable trend was disrupted in 2004 by a wind calamity in the High Tatras, which resulted in increased harvesting of timber damaged by the calamity and pests, and consequently a drop in total removals to half of the previous volumes.

The forestry and land use sector cover a wide range of biological and technical processes within the landscape, which are reflected in the GHG emissions inventory. This sector includes all GHGs (CO_2, CH_4 and N_2O) and the air pollutants from forest fires (NOx and CO). The individual inventory categories are linked to the relevant processes associated with all five carbon pools (living biomass, above and below ground, dead biomass, soil carbon) as defined in the conclusions of the Marrakech Conference of the Parties (Marrakech Accords).[23] In addition, wood products are reported as another LULUCF pool, such as harvested wood products (HWP) (CRF sector 4.G).

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[21] European Environmental Agency, “EMEP/EEA air pollutant emission inventory guidebook 2019–Update Oct. 2021 on road transport,” 2021. [Online]: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view. [Quotation 2022].

[22] https://www.mpsr.sk/zelena-sprava/121

[23] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-kyoto-protocol/overview/background-and-resources/the-guidelines-to-implement-the-kyoto-protocol-the-marrakesh-accords-and-the-578-implications

The inventory of the LULUCF sector is based on the definition of representative land use types: forest land, grassland, cropland, wetlands, settlements and other land and their changes over time. The first three types of land use are the most important, as they cover more than 90% of the territory of the Slovak Republic. In terms of balancing greenhouse gas emissions, these processes only relate to carbon dioxide (CO_2) balance.

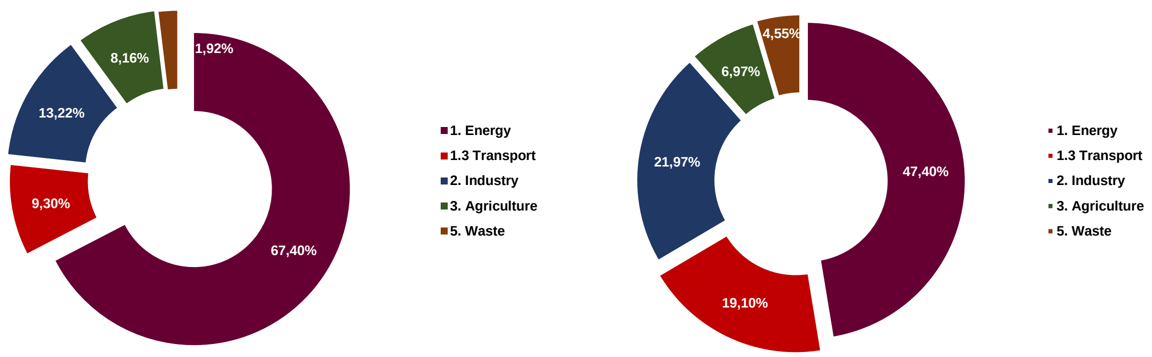
Several significant changes in methodology and estimation have been made in the waste sector. Methane emissions from solid waste disposal account for the largest share of total emissions from the sector. The GHG emissions methodology is based on tier 2 approach - biodegradable waste decay approach and has been used in the recalculation of the entire time series up to 1950. The trend in methane emissions is stable and dependent on agreed legislation and lower waste generation, landfilling and recycling. A more detailed description of the Monte Carlo method for uncertainty analysis is given in the references.[24]

Emissions from waste incineration with energy use are reported under the energy sector, in category 1.A.1.a (other fuels). Emissions from waste incineration without energy use are reported in the waste sector.

Table CTF 1(b) in the Annex provides an overview of GHG emissions in the main source categories for the years 1990-2020. By far, the most important sector is energy (i.e. combustion and fugitive emissions from fuels), accounting for 66% of total GHG emissions in 2020. The second largest sector is industrial processes (22%), followed by agriculture (7%) and waste (5%). A comparison of the share of each sector in 2020 with the base year is shown in ***Figure 4.5***. Significant declines are visible in the energy sector (excluding transport) and increases in the waste and transport sectors.

Emissions from international aviation and shipping are excluded from the national totals and are therefore not shown in ***Figure 4.5***. Emissions from international transport are the sum of international aviation and shipping. These emissions are reported as information items, they are excluded from the national totals. Greenhouse gas emissions from international aviation grew continuously between 1992 and 2008. They declined between 2009 and 2015, partly due to the economic recession, and then rose again, except in 2020, when the impact of the COVID-19 pandemic became apparent. Total GHG emissions from international transport reached 70.12 Gg CO_2 eq. in 2020. Emissions from international aviation account for more than 95%, as the Slovak Republic is a landlocked country and does not have a significant share of maritime transport.

Figure 4.5: *Sectoral share of total GHG emissions in 1990 (left) and 2020 (right)*



[24] Szemesová J., M. Gera Odhad emisií zo skládok pevných odpadov podľa metodiky analýzy neistoty, Bioklimatológia a živelné riziká [Estimation of emissions from solid waste landfills by uncertainty analysis methodology, Bioclimatology and natural hazards], ISBN 978-80-228-17-60

Detailed information on GHG emissions, trends and reductions are published in the Slovak Republic's National Inventory Report 2022.[25]

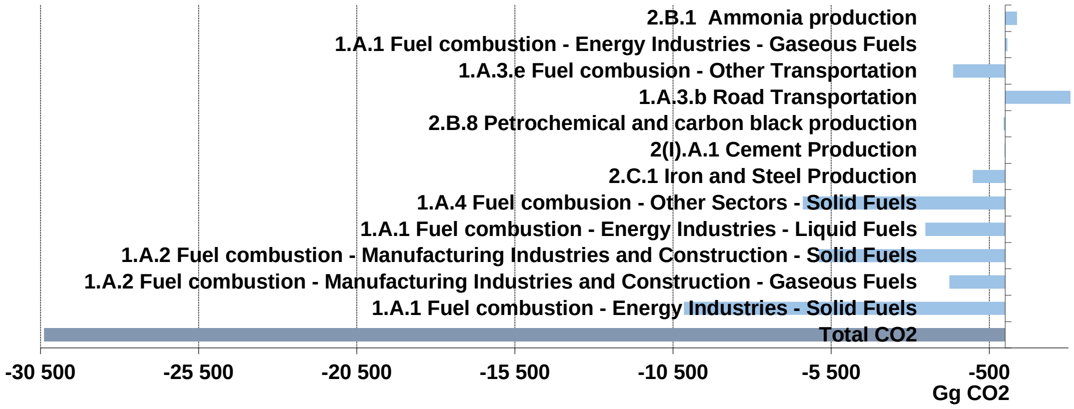
4.2.4 Change in Emissions from Key Categories

Key categories are defined as sources or removals of emissions that have a significant impact on the inventory as a whole, in terms of absolute emission levels, trends or both. The Slovak Republic has developed an analysis of key source categories for 2020 and 1990 emissions in accordance with the 2006 IPCC Guidelines using Approach 1. Quantitative analyses include combined uncertainty (for emission factors and activity data) and recognised key tier categories with and without the LULUCF sector (see SVK NIR 2022, Chapter 1.2.12 and Annex 1 for more information).[8]

CO_2 emissions from category 1.A.3.b - Road Transportation - diesel oil are the largest key category, accounting for 22% of total CO_2 emissions without LULUCF in 2020. Between 1990 and 2020, road transportation emissions increased by 2.2 Mt CO_2, which is a 50% increase due to an increase in fossil fuels consumption in this key category (***Figure 4.6***). Since 1990, the largest increase in CO_2 emissions related to road transportation has been found. ***Figure 4.6*** below shows that solid fuels from category 1.A.1 - Fuel Combustion - Energy Industries is the second largest key category without LULUCF (8.7%) and there has been a 79% decrease in this category between 1990 and 2020. Improvements in energy efficiency and the switch from coal to natural gas are the main factors explaining the decline in emissions.

CO_2 emissions from fuels in category 2.C.1 - Iron and Steel Production are the largest key category without LULUCF in the industrial process and product use (IPPU) sector and account for 10% of total CO_2 emissions in 2020. CO_2 emissions from category 1.A.2 - Energy Industry and production are the third largest key source in the Slovak Republic, accounting for 10% of total GHG emissions in 2020. Between 1990 and 2015, emissions from this category fell by 65%.

Figure 4.6: *Absolute change in CO_2 emissions by major key categories between 1990 and 2020*

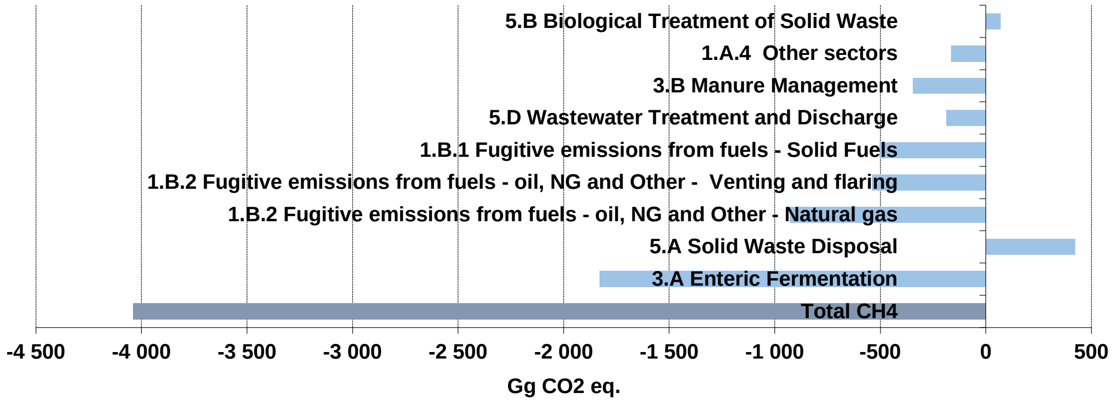


Methane emissions account for 8.8% of total emissions in 2020 and have fallen by 55% since 1990 to 130.46 Gg of CH_4 in 2020. The three largest key sources are 5.A - Solid Waste Disposal with 35%, 3.A - Enteric Fermentation with 30% and 5.D - Wastewater Treatment with 8.5% shares of the total CH_4 emissions in 2020 and together account for 72% of the CH_4 emissions in 2020. ***Figure 4.7*** shows that the main reasons for the decrease in CH_4 emissions were a reduction in enteric fermentation, mainly due to declining animal numbers, and reductions in fugitive emissions and coal mining. ***Figure 4.7***

[25] https://oeab.shmu.sk/o-nas/dokumenty.html

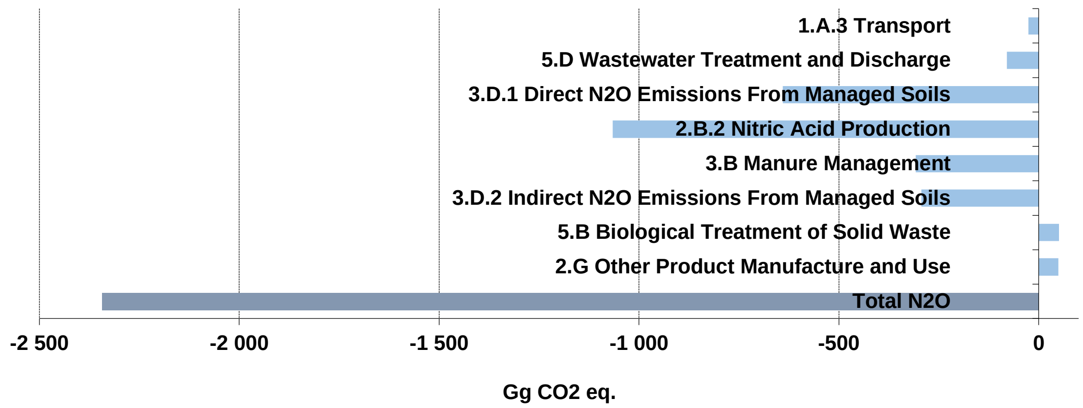
shows a significant decrease in categories 3.A and 3.B and an increase in category 5.A, due to a change in the IPCC methodology used for landfills considering a time layer from 1960 onwards. A minor increase in emissions is visible in category 5.B - Biological Treatment of Solid Waste, which is related to the change in waste management in Slovakia.

Figure 4.7: *Absolute change in CH_4 emissions by major key categories between 1990 and 2020*



N_2O emissions are responsible for 5.3% of total GHG emissions and in 2020, they decreased by 55% to 6.53 Gg of N_2O without LULUCF (***Figure 4.8***). This trend has been driven by three major key sources: 3.D.1 - Direct N_2O Emissions from Managed Soils (57 %), 3.D.2 - Indirect N_2O Emissions from Managed Soils (10 %) and 3.B - Manure Management with a 7.7% share of total N_2O emissions in 2020. The main reasons for the reduction in N_2O emissions were reduction measures in nitric acid production (category 2.B.2) and a reduction in agricultural activities (***Figure 4.8***). N_2O emissions increased in category 5.B -Biological Treatment of waste and 2.G - Other Product Manufacture and Use. This increase was caused by an increase in operations and production.

Figure 4.8: *Absolute change in N_2O emissions by major key categories between 1990 and 2020*



Emissions of fluorinated gases account for 1.9% of total GHG emissions. In 2020, emissions were 701.69 Gg CO_2 eq., which was 2.2 times higher than the 1990 level. The largest key source is category 2.F.1 - Refrigeration and Air Conditioning, which accounts for 95% of fluorinated gas emissions in 2020. HFC emissions from the consumption of halogenated hydrocarbons have reached a large increase between 1990 and 2020. The main cause has been the phase-out of ozone-depleting substances such as chlorofluorocarbons under the Montreal Protocol and their replacement by HFCs (mainly in refrigeration, air-conditioning and the production of foam and aerosols). On the other hand, PFC emissions have fallen substantially. The decline began in 1996 and was strongest between 1999 and 2000.

4.2.5 Key Drivers Influencing Emission Trends

The main drivers of change over the 1990-2020 period are described in more detail in **Chapter 2** (National Conditions) of this Report.

Since the last Seventh National Communication of the Slovak Republic on Climate Change published in 2017, GHG emissions have fallen by 9%, reaching their lowest level in 2020, partly due to a decline in fuel consumption due to the COVID-19 pandemic, but mainly due to reduced production in the energy and industrial sectors.

4.2.6 Main Causes of Emission Changes in 2018-2020

Total GHG emissions in the Slovak Republic decreased significantly in 2020, by 7% compared to the previous year, due to emission reductions in the energy and industry sectors associated with the economic impact of the COVID-19 pandemic. Total GHG emissions without the LULUCF sector have been declining continuously since the base year, with an almost stable trend in recent years and a more pronounced decline in the most recent inventory years. In an effort to maintain consistency with EU ETS data and the new IPCC 2006 and IPCC 2019 Guidelines, significant changes in methodologies and emission factors have been introduced. The analysis of changes in GHG emissions trends between 2018 and 2020 was:

- Decrease in CO_2 emissions in the energy sector - category 1.A.1 - Energy Industries (0.6 Tg CO_2) due to a decrease in electricity and heat production.
- Decrease in CO_2 emissions in the energy sector - category 1.A.2 - Manufacturing Industries (0.4 Tg CO_2) due to a decrease in the production of heavy metals and chemicals.
- Decrease in CO_2 emissions in the energy sector - category 1.A.3 - Transport (1 Tg CO_2) due to a decrease in road transportation performance.
- Decrease in CO_2 emissions in the industrial processes and product use sector - category 2.C - Metal Production (450 Gg CO_2) caused by the phased out of one of the three furnaces in the largest company producing steel and iron in Slovakia.
- Increase in CO_2 removals in the LULUCF sector (2 000 Gg CO_2) - category 4.A – Forest Land caused mainly due to reduced harvesting.
- Decrease in CH_4 emissions in the energy sector - categories 1.B.1 and 1.B.2 - Fugitive Emissions mainly due to improvements in infrastructure and equipment and methodologies for measuring these emissions.
- Decrease in category 2.B - Nitric Acid production by 5 Gg of N_2O emissions compared to the previous year due to a decrease in production.
- Significant decrease in F-gases (40 Gg CO_2 eq.) due to reduced servicing activities at facilities in 2020.

4.2.7 Key Drivers Influencing Emission and Removal Trends in LULUCF

Since 1970, an increasing trend in the category of forest land has been evident in the Slovak Republic. At the same time, the opposite downward trend in the cropland use category was observed. Grassland declined from 1980 to the early 1990s, and there was an increasing trend from that year to 2005. Since 2005, it has been a slight downward trend. The land use category for the settlements has been on a continuous upward trend throughout the period. This situation is mostly due to the construction of transport infrastructure, industrial premises, municipal development and the raising of standards and infrastructure in the country, and is often associated with the reduction of cropland and other categories of land. Wetlands represent 1.9% (94 kha) of the Slovak territory and are considered to be constant, with no changes in land use.

The LULUCF sector with net removals of -7 659.71 Gg CO_2 eq. in 2020 is a very important sector and consists of several main categories: 4.A - Forest Land with net removals of -6 499.74 Gg CO_2, 4.B - Cropland with net removals of -1 094. Gg CO_2, 4.C - Grassland with net removals of -92.8 Gg CO_2, 4.E - Settlements with emissions of 79.3 Gg CO_2 and 4.F - Other Land with emissions of 94.8 Gg CO_2. In 2020, the LULUCF sector had total methane emissions of 24.4 Gg CO_2 eq. and total N_2O emissions of 42.1 Gg CO_2 eq. This report also includes N_2O emissions from land use conversion to cropland, grassland, built-up area and other land and removals in 4.G - Harvested Wood Products (HWP). Emissions of other pollutants are from forest fires and controlled forest burning. In 2020, the estimated NOx emissions were 0.62 Gg and the estimated CO emissions were 22.22 Gg (***Table 4.3***).

Table 4.3: *Summary of total emissions and removals by category in 2020*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO
	EMISSIONS/REMOVALS (Gg)		EMISSIONS (Gg)			
4. LULUCF	**NO**	**-7,659.71**	**0.98**	**0.14**	**0.62**	**22.22**
A. Forest land	NO	-6,499.74	0.98	0.05	0.62	22.22
B. Cropland	NO	-1,094.39	NO	0.04	NO	NO
C. Grassland	NO	-92.82	NO	0.00	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	79.30	NO	NO	0.02	NO	NO
F. Other land	94.80	NO	NO	0.02	NO	NO
G. Harvested wood products	NO	-146.86	NO	NO	NO	NO
H. Other	NO	NO	NO	NO	NO	NO

4.2.8 Information on Indirect Greenhouse Gas Emissions

The Slovak Republic provides an estimate of indirect GHG emissions such as CO, NOx, SO_2 and NMVOC for the years 1990-2020, which was originally submitted under the NEC Directive and the CLRTAP Convention as of 15th March 2022.

Several changes and recalculations have been made in the NECD 2022 report, such as:

- Emissions from the metal processing industrial category 2.C.4 have been moved to category 2.C.7.c.
- A new methodology has been implemented for non-road transportation categories throughout the time series.
- Road transportation emissions were re-distributed using a new version of the COPERT 5 model.[26]

[26] https://www.emisia.com/utilities/copert/

- In the agricultural sector, emissions in category 3.B have been recalculated due to the implementation of mitigation measures and the new methodology provided and recommended by the TFEIP.[27]
- A recalculation of emissions from the application of inorganic fertilisers due to new fertiliser consumption in the soil for the years 2000-2011 has been carried out. The revision was carried out in cooperation with the Central Control and Testing Institute in Agriculture. The Statistical Office of the Slovak Republic took over the adjusted data.
- A recalculation of emissions from the application of sludge from wastewater treatment plants has been carried out due to the implementation of a new database of industrial sludge consumption for agricultural purposes. The source of the data is the Statistical Office of the Slovak Republic. At the same time, the dataset used in the estimation of emissions was consistent with the data used and presented in the waste sector.
- In addition, the pollutant data (indirect greenhouse gas emissions) reported in categories 5.C - Waste Incineration without energy use have been recalculated. Emissions from industrial sludge were calculated for the first time in category 5.C.b.i as well as the incineration of wastewater sludge in category 5.C.b.iv.

According to the analyses, no major discrepancies (+/-5%) in the reporting of indirect GHG emissions under the NECD (or CLRTAP) (submitted on 15th March 2022) and GHG inventories (submitted on 15th April 2022) occur. Due to differences in methodology, there were small discrepancies in aviation and shipping (international aviation and shipping are included in the NECD totals), emissions from forest fires are not included in the inventory under NECD, and NOx emissions from manure management are not included directly in the GHG inventory (indirect N_2O emissions are calculated based on NOx emissions in category 3.B.2 - Manure Management).

***Table 4.4:** Anthropogenic emissions of NOx, CO, NMVOC and SO_2 by gas and sector in 2020*

EMISSIONS	TOTAL	ENERGY	INDUSTRY	AGRICULTURE	LULUCF	WASTE
	Gg					
NOx	**54.85**	41.94	5.75	7.12	0.56	0.04
CO	**278.59**	208.03	70.50	NO	20.14	0.05
NMVOC	**97.27**	59.89	26.77	6.74	0.24	3.87
SO_2	**13.35**	6.65	6.65	NO	0.02	0.05

These emissions can be found in:

- SO SR in the STATdat database.
- SHMÚ website – AEA data is available for 2008-2019 in aggregated form in PDF files for the specified years.

4.2.9 Accuracy/Uncertainty of Data

The assessment of uncertainty by Approach 1 can be found in the SVK NIR 2022, in Annex 3.[8] The quantification of GHG emission uncertainties by level and the assessment of trends were calculated using the Approach 1 method published in the 2006 IPCC Guidelines. In 2020, Approach 1 for determining emission inventory uncertainties calculated including LULUCF a level of annual (2020)

[27] TFEIP = Task Force on Emissions Inventories and Projection

emissions uncertainty of -11.61% and trend (1990-2020) uncertainty of -6.62% Without LULUCF, the estimated uncertainty was lower at 3.64% at the year level and 1.14% at the trend level.

Slovakia uses a hybrid combination of Approaches 1 and 2 to calculate the overall inventory accuracy (Annex 3 in the SVK NIR 2020). Uncertainty analyses conducted by Approach 1 in transport were performed using Table 3.2 (IPCC 2006), and country-specific uncertainties on activity data and emission factors were entered into the calculation table.

The Slovak Republic has also prepared an uncertainty analysis following the methodology given in Approach 2 (Chapter 3 IPCC 2006 GL) for the complete Energy, IPPU and Waste sectors for 2015 (latest results). The methodology and results have been published and described in previous SVK NIR reports. Based on the Improvement Plan (Chapter 1.2 of the SVK NIR 2022[8]), the calculation of uncertainties of the GHG emission inventories by the Approach 2 - Monte Carlo method in the Energy and IPPU sectors is updated every 5 years due to other urgent tasks in this area (Approach 2 in the LULUCF uncertainty analyses). The results of the Monte Carlo simulations have been almost identical since 2011. Uncertainty analyses by Approach 2 for fuel combustion in the energy sector (including transport) by fuel classification were estimated within the confidence interval (-2.38%; +3.12%). Uncertainty analyses by Approach 2 for the IPPU sector, including the solvent and other product use sector by technological emissions, were estimated within the confidence interval (-3.66%; +3.63%). The results of the Monte Carlo method for estimating uncertainties have been published in the following documents[28,29], and a detailed description is provided in Chapters 3 and 4 of the SVK NIR 2018.[30]

4.2.10 Changes since the Seventh National Communication of the Slovak Republic on Climate Change

Since the publication of the Seventh National Communication of the Slovak Republic on Climate Change, a number of updates and revisions of methodologies, emission factors, source and gas coverage, and the structure of submissions have been introduced in the GHG inventory and the National Inventory System of the Slovak Republic, which has had an impact on the time series. The most significant change relates to the implementation of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and selected parts of the methodologies and updates reflecting the IPCC 2019 Refinements. These changes were fully in line with international requirements and were reviewed and accepted.

The main changes and recalculations associated with the implementation of the 2006 IPCC Guidelines and 2019 IPCC Refinements and recalculations based on the recommendations of previous peer reviews are highlighted in ***Table 4.5***.

[28] J. Szemesová, M. Gera: Príspevky ku geofyzike a geodézii [Contributions to geophysics and geodesy], 37/3, 2007

[29] Szemesová J., Gera M. Analýza neistoty pre odhad emisií zo skládok a citlivosť údajov pre vstupnú odchýlku, Zmena klímy [Uncertainty analysis for estimation of landfill emissions and data sensitivity for the input variation, Climatic Change] DOI 10.1007/s10584-010-9919-1, 2010

[30] https://unfccc.int/ghg-inventories-annex-i-parties/2022

Table 4.5: *Main GHG inventory revisions since the publication of the Seventh National Communication of the Slovak Republic on Climate Change*

SECTOR	CHANGE
General part of the National Inventory System	• Harmonisation of data and inputs for GHG emission inventories and pollutant emission inventories continued. Harmonisation is a multi-year project aimed at streamlining the preparation of emission inventories. • Key source analysis and uncertainty determination were improved by implementing quantitative and qualitative uncertainty improvements on emission factors and activity data. • Quality control was improved and new tools were introduced to analyse errors and automatic corrections in the preparation of the emissions inventory and the national communication.
Energy sector	• Recalculations associated with the correction in household electricity consumption that led to the correction in biomass consumption in 2014-2020. • Peat production was harmonised at the national level according to the FAO STAT database. • The GHG emission inventory for the combustion of other fuels - municipal waste for electricity and heat generation was modified. Improvements concerned the identification of the composition and carbon and biomass content of wastes and calorific values. • The improvements that took place in the inventory of fugitive emissions in categories 1.B had the character of moving up to a higher tier approach, in some cases up to tier 3, which is directly linked to the company level. The changes and improvements are related to the introduction of methodological procedures for improving the quality of pipeline infrastructure management in Slovakia in the area of oil and natural gas transit, as well as in distribution and storage infrastructure. • The recalculated emissions concerned mainly emissions from small sources and households in category 1.A.4.b for the whole time series. Refinements in the consumption of solid fuels and biomass were incorporated based on a number of projects carried out in previous years aimed at improving the input data. • The recalculations in the road transportation category were associated with the transition to higher versions of the COPERT model and the refinement of the vehicle split structure. The improvements concerned the time series 2000-2020. New vehicle mileages by category obtained in the framework of a project aimed at analysing data from the database of vehicle inspection stations (STK) were implemented.
Industrial Processes and Product Use sector	• The recalculations were aimed at adjusting the solvent use category 2.D and the overall harmonisation of the non-methane volatile organic compound and carbon dioxide emission inventories in this category and adjusting the time series 1990-2020. • Indirect CO_2 emissions from category 2.D for the entire time series 1990-2020 were implemented in the emission inventory.
Agricultural sector	• Recalculations in this sector led to improvements and harmonisation in the methodology for accounting for animal waste and crop residues in the soil and the total nitrogen cycle. These improvements were implemented retroactively back to the year 2000. • There were improvements in the inventory of sludge applied to agricultural soils, with improved allocations of sludge in the waste and agriculture sectors. • A revision of the input data for inorganic fertilizers and for dolomite and limestone consumption on agricultural soils was applied. • As part of the continuous improvement and refinement of the emissions inventory, emissions from pig farming were recalculated according to the tier 2 approach, where country-specific emission factors and other parameters were introduced. Subsequently, the time series were recalculated. • As part of a multi-year project, emission factors and parameters were determined with regional precision to determine nitrogen loss impacts from soil leaching. Precise climatic data was also taken into account in this project.
LULUCF sector	• CSC values in dead biomass were recalculated for both broadleaves and coniferous forests in categories 4.A.1 and 4.A.2. • The emission inventory was improved with respect to the composition of forests in category 4.A.

SECTOR	CHANGE
	• The improvements concerning category 4.B - Cropland, where carbon stocks in permanent crops (orchards, vineyards, etc.) were adjusted.
Waste sector	• The main changes in the waste sector focused on the correct accounting and allocation of emissions from sludge treatment in wastewater treatment plants between 1990 and 2020. • Major improvements and methodological adjustments concern the recalculation of emissions from municipal and industrial landfills, where new country-specific parameters and new compositions of municipal and industrial wastes were implemented.

4.3 NATIONAL INVENTORY SYSTEM

4.3.1 Institutional Arrangement

The MŽP SR is responsible for the development and implementation of national environmental policy, including climate change and air protection objectives. It is responsible for the development of strategies and other implementation tools, such as laws, regulatory measures, economic and market instruments, to cost-effectively meet the adopted objectives. Concept papers as well as legislative proposals are always commented on by all ministries and other relevant bodies. After the commenting process, the proposed acts are discussed in the Legislative Council of the Government, approved by the Government and finally by the National Council of the Slovak Republic.

The MŽP SR is the main body for ensuring the conditions and monitoring the progress of the Slovak Republic in fulfilling all commitments and obligations related to climate change and adaptation policy.

The establishment of the National Inventory System (NIS) of emissions in accordance with the requirements of the Kyoto Protocol was linked to the functions that it should fulfil according to Decision 19/CMP.1 The basic characteristics of the NIS are:

- Ensure interlinkages and cooperation among the institutions, bodies and individuals involved to carry out all activities to monitor and estimate GHG emissions from all sectors/categories according to the UNFCCC Guidelines and relevant decisions according to IPCC-approved methodologies. Enable the use of all relevant data from national and international databases for the preparation and validation of GHG emission inventories.
- Define the role and competencies of all stakeholders involved, including the role of the National Focal Point to the UNFCCC.
- Define and regularly implement a quality assurance and quality control (QA/QC) process along two lines; internally and externally by a competent authority.
- Ensure a continuous process of capacity development; financial, technical and professional resources concerning QA/QC, but also in relation to new tasks arising from the international process.

The National Inventory System of the Slovak Republic was established and officially announced by the Decision of the MŽP SR on 1 January 2007 in the Official Journal: Journal, Ministry of Environment, XV., 3, 2007.[31] In accordance with paragraph 30(f) of the Annex to Decision 19/CMP.1, which provides definitions of all qualitative parameters for national inventory systems, a description of the quality assurance and quality control plan pursuant to Article 5, paragraph 1, is also required. The revised report

[31] Journal of the Ministry of Environment of the Slovak Republic, XV., 3, 2007, page 19: National Inventory System of the Slovak Republic for GHG emissions and removals under Article 5 of the Kyoto Protocol

of the National Inventory System of November 2008, was focused on the changes in the institutional arrangement, quality assurance/quality control plan and planned improvements. A regular update of the National Inventory System with all qualitative and quantitative indicators is provided in the National Inventory Reports and was also provided in the Seventh National Communication of the SR on Climate Change, published in 2020.

The Slovak Hydrometeorological Institute (SHMÚ) www.shmu.sk is authorised by the MŽP SR to provide environmental services, including annual GHG inventories according to the approved statute (http://www.shmu.sk/File/statut.pdf). The scope of services, competencies, timetable and financial budget is updated and agreed upon on an annual basis. Full details of the activities of the SHMÚ are described in the Plan of Main Tasks. The Plan, commented on by all stakeholders, is published on the SHMÚ website.[32] The deadline for approval of this Plan by the Ministry is 31 December each year. In 2021, a new structure of the SHMÚ was created.[33] The changes presented have no impact on the National Inventory System. The Department of Emissions and Biofuels (OEaB) was established in January 2017. The OEaB has two main tasks: emission inventories (GHG, NEC Directive and CRLTAP) and the National System for Biofuels and Bioliquids (suistanability certification). OEaB is also responsible for the development and maintenance of the National Emission Information System (NEIS) - a database of stationary sources for monitoring the emissions of SO_2, NO_x, CO at the regional level and for fulfilling reporting obligations under national regulations and EU directives. The NEIS software product is designed as a multi-module system, fully compliant with the requirements of the current legislation. The NEIS database also contains some technical information on resources such as fuel consumption and usage for the purposes of estimating and validating of the sectoral approach.

The OEaB includes a Single National Entity (SNE) with a defined structure and overall responsibility for compiling and finalising inventory reports and submitting them to the UNFCCC Secretariat and the European Commission as communicated in the official document. The SNE was officially appointed by the Decision of the Director General of the SHMÚ No. 16/2011 in August 2011 and amended by the Decision of the Director General of the SHMÚ No. 8/2012 in September 2012. The SNE coordinates the National Inventory System of the Slovak Republic (NIS SR). It currently has 9 full-time experts working on inventory tasks. The composition of the SNE is: a NIS coordinator, a deputy NIS coordinator and data manager, a transport expert, an agriculture expert, a waste expert, two NEIS experts and two emission projections experts. The permanent staff of the SNE is complemented in the NIS SR by some institutions and external experts from relevant sectors working on contracts updated as needed, and partly by additional experts from the OEaB (***Figure 4.9***). This figure shows the new structure of the NIS, in which the Climate Change Policy Committee is the intergovernmental body responsible for the implementation of climate change policy at the inter-ministerial level. Table 1.3 in the SVK NIR 2022[8] contains an updated list of internal experts within the SHMÚ and a list of external experts and institutions within the NIS SR.

4.3.2 Quality Assurance/Quality Control (QA/QC) Procedures

This section outlines the quality management and inventory process. QA/QC details for each category with improvements and recommendations are discussed in the relevant section of the SVK NIR2022.[8]

[32] https://www.shmu.sk/File/Kontrakt_SHMU/PHU_OVZDUSIE_2021.pdf

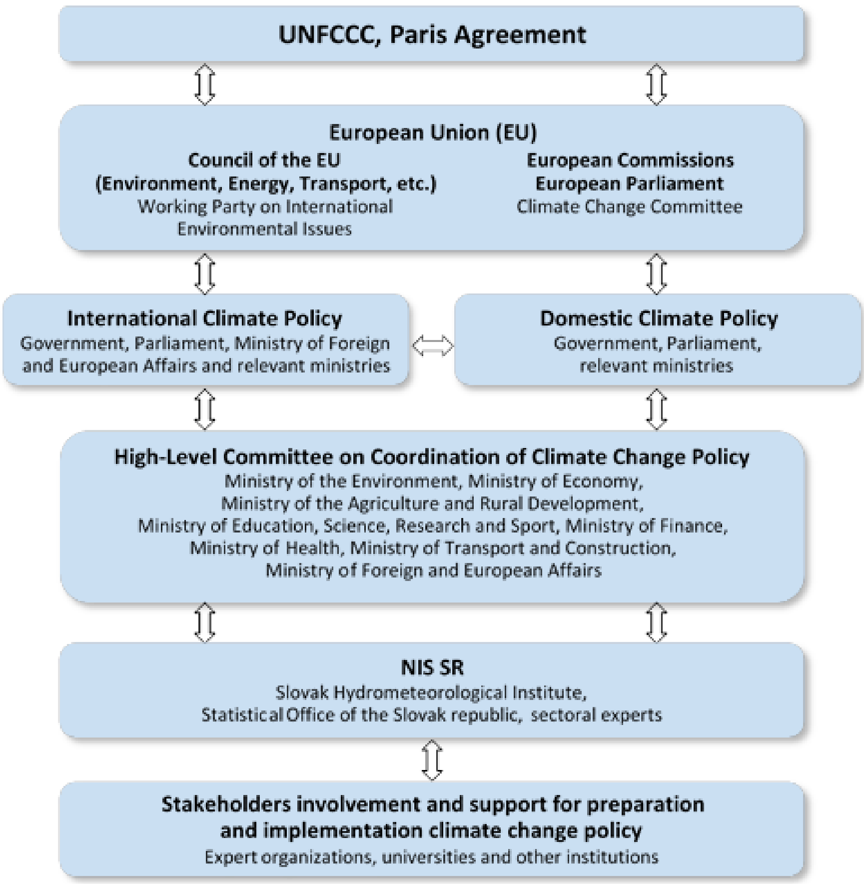
[33] http://www.shmu.sk//File/Org_Struktura_SHMU/Org_strukt_1_1_2021.pdf

4.3.3 Quality Management

The Slovak Hydrometeorological Institute has developed and implemented a quality management system (QMS) according to the requirements of EN ISO 9001:2008. As part of the introduction of the QMS for the SHMÚ as a global standard, the certification itself is carried out according to sub-processes within the structure of the SHMÚ. The emissions inventory process was subject to internal and external audits during March 2010 by the certification body ACERT, which is accredited by the Slovak National Accreditation Service. The quality manager has attended several QMS training courses. The recertification process takes place every two years.

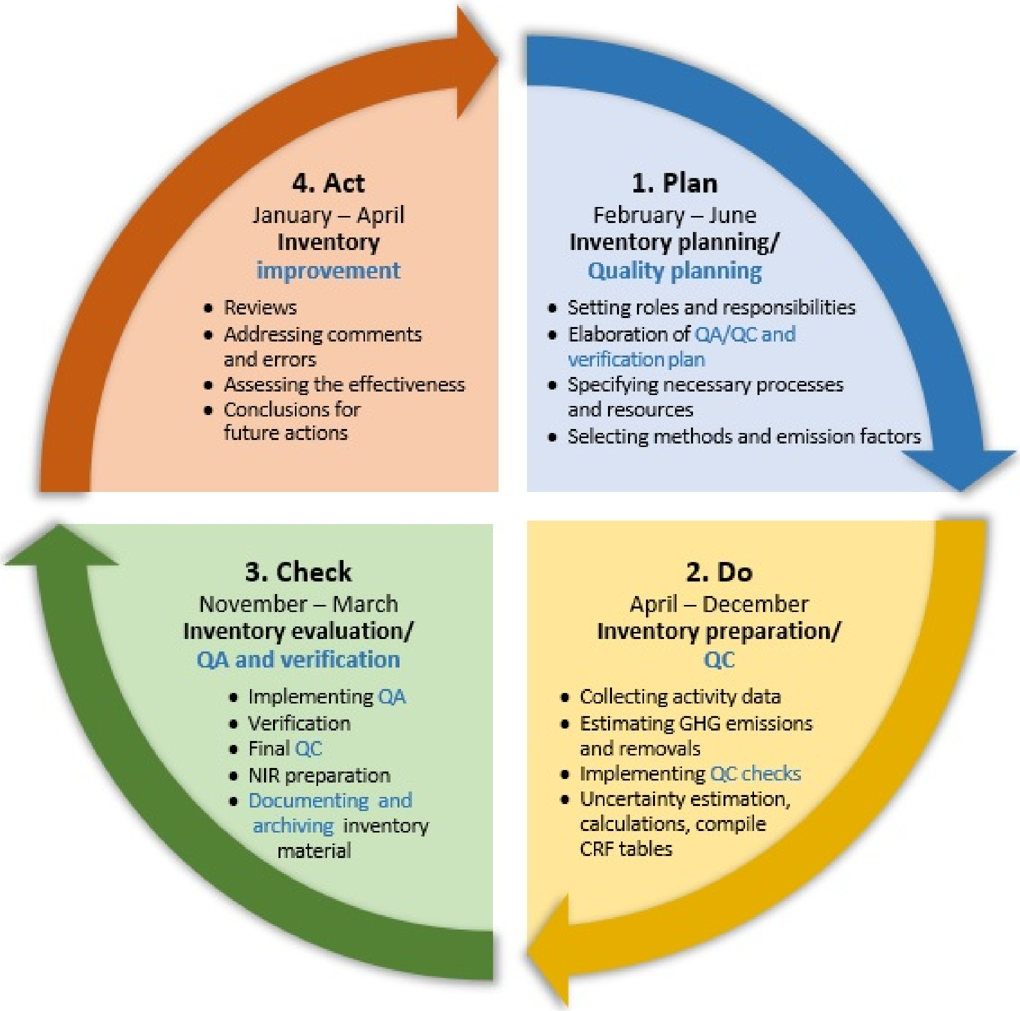
The aim of the National Inventory System (NIS) is to establish a high-quality inventory of GHG emissions. In the context of GHG emissions inventories, high quality will ensure that both the national system structures (i.e. all institutional, legal and procedural arrangements) for estimating GHG emissions and removals and the inventory submissions (i.e. outputs, products) are consistent with the requirements, principles and elements arising from the UNFCCC and the MRV Principles. The 2006 IPCC Guidelines are fully implemented and the 2019 IPCC Refinements is currently being assessed for best use, especially in categories that are missing in the 2006 IPCC Guidelines and partially incorporated into the emissions inventory.

Figure 4.9: *Institutional arrangement of the National Inventory System of the Slovak Republic*



The starting point for achieving a quality of the GHG inventory is to consider the expectations and requirements towards the inventory. The quality requirements set for the annual inventory - transparency, consistency, comparability, completeness, accuracy, timeliness and continuous improvements - are met through the rigorous implementation of the QA/QC process. ***Figure 4.10*** shows a model for the early steps provided in the inventory process, QA/QC activities, and verification procedures.

Figure 4.10: *PDCA Cycle (Plan, Do, Check, Act)*



The SHMÚ has established a policy of continuous training processes for internal and external experts. Experts are trained during the SVK NIS seminars, which are held twice a year. The minutes of the meetings and all relevant documents are sent to the SVK NIS sector experts. Communication with the SVK NIS is through emails, phone calls, visits, information systems, website (private zone) and meetings. Although the efficiency of communication in information system is high, an internet forum has been created to improve it.

Sector experts apply the QA/QC methodology according to the quality manual, collect data from providers and process the emission inventory for a given sector – they provide partial reports with information on the quality and reliability of data on activities and emissions. The quality manual including e.g. guidelines, QA/QC plans, templates and checklists is available to all experts of the national inventory system via the Internet. The set of templates and checklists consists of the following documents:

- QA/QC plan (external, internal)
- Matrix of responsibility
- General QC
- QC of sources by category

- Quality assurance
- Archive document
- Improvement plan
- List of recommendations

All documents are approved after being filled in by experts by a responsible inventory system person and then archived. The quality manager has the overall responsibility for documentation, formal contact with sector experts and approval activities, taking over the sectoral reports and archiving them.

4.3.4 Inventory Planning (PLAN)

The inventory planning stage involves setting quality objectives and developing QA/QC plans to prepare for incoming inventory, compilation, and reporting work. The setting of quality objectives is based on inventory principles.

The quality objectives for all sectors are:

- Timeliness
- Completeness
- Consistency
- Comparability
- Accuracy
- Transparency
- Improvement

Quality objectives and planned QC and QA activities related to all sectors are set out in all QA/QC plans (internal and external). These documents describe deadlines and responsibilities and are updated on an annual basis. They are evaluated by the NIS quality manager and approved by the MŽP SR.

4.3.5 Quality Control Procedures (DO)

General and category-specific QC procedures are performed by experts during calculations and inventory compilation.

General quality control includes routine checks, accuracy, completeness of data, identification of errors, deficiencies, and documentation and archiving of inventory materials. Adequate procedures must be adopted by sector experts for the development and modification of tables to minimise calculation errors. Checks will ensure compliance with established procedures and also allow for the detection of remaining errors. The parameters, emission units and emission factors used in the calculations must be clearly highlighted and specified.

Category-specific QC includes a review of source categories, activity data and emission factors, focusing on key categories and on categories where significant methodological changes or data revisions have been made.

QC forms are completed by experts during the inventory compilation, and results from QC activities are documented and archived.

4.3.6 Quality Assurance (CHECK)

Quality assurance is carried out after QC checking is applied to the completed inventory. QA check is done by experts in the sector who are not involved in the preparation of the inventory. QA procedures include reviews and audits to assess the quality of the inventory, its development and reporting process, determine the conformance of the procedures performed, and identify areas where improvements could be made. These procedures are at different levels and include basic reviews of the draft report, general public review, external review, internal audit, the EU and UNFCCC reviews.

Once the inventory is completed, it will be posted to the OEaB website for public comment.

A wider range of researchers and stakeholders in NGOs, industry and academia, trade associations as well as the general public have the opportunity to contribute to the final document. Comments received during these processes are reviewed and incorporated into the NIR or reflected in inventory estimates as appropriate.

In checking the quality of the data for each sector, the NIS coordinator, the NIS quality manager, and other stakeholders must carry out the following general activities:

Checking: Check that the data in the reports (calculations and documents) for each sector meet both general and specific procedures.

Documentation: Record all verification results by completing the checklist, including conclusions and discrepancies to be corrected. Such documentation helps to identify potential ways to improve the inventory as well as to store evidence of the material that was checked and the time at which the check was carried out.

Follow-up of corrective actions: All corrective actions necessary for documenting the activities carried out and the results achieved must be taken. If such a check does not provide a clear clue concerning the steps to be taken, the quality control, a bilateral discussion between the expert and NIS coordinator will take place.

Data transfer: All checked documents (including the final questionnaire and all annexes) will be inserted in the project file and copies will be sent to all NIS experts. As data quality control procedures must always be followed, it is not compulsory to carry out all checks annually during the preparation of the inventories. Certain activities, such as verification of the electronic data quality or project documentation for checking whether all documents have been provided, must be carried out every year or at least at set intervals. Some checks may be conducted only once (however, comprehensively) and then only from time to time.

Part of the QA procedures is bilateral cooperation with the Czech Republic. The first meeting took place in July 2013 and since then has been repeated every year, later, experts from other countries - Hungary, Poland and Austria - joined in.

4.3.7 Verification Activities

An independent verification procedure was introduced after the inter-ministerial High-Level Committee on Coordination of Climate Change Policy was established. The members of the Committee nominated experts involved in the verification and approval process for the selected parts of the emission inventory. The stakeholders (experts) are responsible for the official and legislative agreement of the presented results and ensure harmonisation among the international reporting.

Verification refers to the collection of activities and procedures that can be followed during the planning and development, or after the completion of an inventory, that can help to establish its reliability. The parameters and factors used and the consistency of data are checked regularly. Completeness checks are undertaken, new and previous estimates are compared every time. Data entry into the database is checked repeatedly by the sector expert for uncertainty. If possible, data from different data sources are compared and thus verified. Comprehensive consistency checks between national energy statistics and IEA time series, checks of the results of the EU internal review for the EU28 (from 1 February 2020 EU-27) and analyses of its relevance for the Slovak Republic take place.

Confidential information is provided to the SVK NIS experts based on bilateral agreements but cannot be reported separately (only on aggregated level or as a national total).

4.3.8 Inventory Improvement (ACT)

The main objective of the QA/QC process is to continuously improve the quality of the inventory. The recommendation and improvement plans are updated once a year after periodic reviews by the UNFCCC and the EU. The prioritisation process is based on the issues and recommendations raised during the reviews, on consultations with experts and an assessment of the level of uncertainty - the higher the uncertainty, the higher the priority. The results of the prioritisation are included in the improvement plans. The manager quality develop a detailed list of recommendations and improvement plans, these are delivered to the sector experts for consideration and prioritisation of planned actions for the next inventory cycle.

Recent examples can be found in the categories of pigs in agriculture or in fugitive methane emissions. The underlying assumptions used to estimate the uncertainties applied to EF and AD are mostly based on the default values given in the IPCC 2006 GL and/or expert judgement. Prioritisation is also carried out on an annual basis by quantitatively assessing the uncertainty assessment (UA) for the base year and the last inventory year. This approach is part of the annual QA/QC cycle.

The comparisons identified several key categories, which are handled by approach 1. These categories are prioritised when moving to a higher level of calculation.

In recent years, the prioritisation of the improvement plan has focused on the energy sector and the harmonisation of the different data sources for the energy balance. The calculation levels for key categories based on the results of the uncertainty assessment are continuously improving, for example in the agricultural sector (change of methodology from tier 1 to tier 2 for enteric fermentation and fertilisation of pigs and direct emissions to land). A high priority in the waste sector has been assigned to sludge distribution. The improvement of uncertainties in the LULUCF sector started in 2017 and the process is ongoing and fully implemented (Chapter 6 of the SVK NIR 2022)[8].

4.3.9 Inventory Methodology and Data Used

The compilation of emission inventories starts with the collection of activity data. A comprehensive description of the inventory preparation for GHG emissions is described in methodologies for individual sectors. The methodologies are updated on an annual basis within the improvement plan and recommendation list and they are archived after formal approval at the webpage of the National Inventory System https://oeab.shmu.sk/, by sectoral experts and the NIS coordinator. The most important source of activity data is the Statistical Office of the Slovak Republic and the sectoral statistics of the ministries. The National Emissions Information System (the NEIS database) is also an important reference source of emission data on fuels and other characteristics of stationary air pollution sources. NEIS is operated within the SHMÚ-OEaB. Other important sources are listed in ***Table 4.6***.

Table 4.6: *List of important information sources for inventory preparation*

SECTOR	SOURCE OF INPUT DATA
Energy	Energy Statistics of the SR, www.statistics.sk, NEIS - www.air.sk, www.spp.sk, www.transpetrol.sk, EU ETS Reports, Reports of EU ETS verifiers
Industrial processes and product use	Association of Cement and Lime Producers, Sovak Association Cooling, Air Conditioning and Heat Pumps, Pulp and Paper Industry Federation of Slovak Republic, EU ETS Reports, Reports of EU ETS Verifiers Association For Coating And Adhesives, Solvent Distributors, The Research Institute of Petroleum and Petroleum Gas
Agriculture	Green Report of the Ministry of Agriculture of the SR - Agriculture, Institute for Fertilisers Research, http://www.mpsr.sk/sk/index.php?navID=122
LULUCF	Green Report of the Ministry of Agriculture of the SR - Forest, Land Register Office, http://www.mpsr.sk/sk/index.php?navID=123
Waste	Statistical Office of the SR, RISO database, IS Waste, Water Research Institute (VÚVH), SHMÚ, NEIS, Slovak Environmental Inspection

Collected input data are compared and checked with international statistics (Eurostat, IAE, FAO and others). In some cases, the collected input data are compared with the results from models (e.g. in road transportation it is the COPERT model, the model for the waste sector, etc.).

The archiving of documents and the database is the responsibility of the data and quality managers of the NIS SR. The archiving of the database is the responsibility of the NIS coordinator. Documents and emission inventories are archived at three levels. Official documents, methodologies and reports are archived and stored on the National Inventory System website. Access to sensitive documents is based on username and password. Statistics and calculations are archived at the level of external institutions and managed by sector experts. All other relevant documents, materials and reports are stored electronically and in hard copy at the OEaB.

Archiving is governed by the rules for archiving systems in organisations at SHMÚ level. Documents are archived in electronic and printed form. Electronic archiving of sector reports, inventory submissions and other specific documents (ERT reports, ARRs, National Communications, etc.) are on the website https://oeab.shmu.sk/o-nas/dokumenty.html, with password (full details for experts) and without password (less detailed information for the public). Documents necessary for quality management systems are archived in electronic form on the SHMÚ website (Intranet). Printed documents are archived in the central archive of the SHMÚ and at the OEaB.

The archiving system allows for easy reproduction of information, protection against loss of data and information, and allows for reproducibility of estimates. The archiving system includes relevant data sources and spreadsheets, reproduces inventories, and reviews all decisions on assumptions and methodologies. The archiving system checklist includes the following archiving activities: methods used, including those used to estimate uncertainty and data sources for each category; comments from experts; revisions, changes in data inputs or methods and calculations, also the reason and source of the changes; description of the software used to calculate emissions. Each new inventory cycle takes advantage of the efficient management of data and documents during the development of the previous inventory.

All information used to create the inventory is archived in one place in electronic and/or hard copy (paper) form so that future managers can use all relevant files to respond to feedback, including questions about methodologies. Archived information includes all emission factors and activity data at the most detailed level and documentation of how these factors and data were developed and summarised to prepare the inventories. This information also includes internal documentation of QA/QC procedures, external and internal revisions, documentation of key categories, and identification of key categories and planned improvements and recommendations. All archiving information is recorded in the archiving system form.

4.4 NATIONAL REGISTRY

The Slovak Republic operates its National Registry in a consolidated manner with the EU Member States who are also Parties to the Kyoto Protocol plus Iceland, Liechtenstein and Norway. The platform, which implements the national registries in a consolidated manner (including the National Registry of the Slovak Republic), is called the Consolidated System of EU Registries (CSEUR). The Slovak National Registry was successfully connected to the ITL with other EU countries in October 2008 and it has been fully functional since.

Table 4.7: *Organisation designated as Registry System Administrator of the Slovak Republic*

NAME OF THE INSTITUTION:	ICZ SLOVAK REPUBLIC, a.s.
Postal address:	Soblahovská 2050, 911 01 Trenčín, Slovak Republic
Telephone and fax number:	Tel.: +421 32 6563 730, Fax: +421 32 6563 754
E-mail:	emisie@icz.sk
Website:	emisie.icz.sk
Contact person:	Dr. Eva Vicenová
Position:	Unit Manager (Emission Registry)
E-mail:	miroslav.hrobak@icz.sk

4.4.1 Changes in the National Registry Software

The EU Member States who are also Parties to the Kyoto Protocol plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Parties' registries - in particular Decision 13/CMP.1 and Decision 24/CP.8. The platform, which implements the national registries in a consolidated manner (including the registries of the Slovak Republic and the EU), is called the Consolidated System of EU Registries (CSEUR).

The following changes were made to the National Registry of the Slovak Republic during the reporting period:

REPORTED ITEM	DESCRIPTION
15/CMP.1 annex II.E paragraph 32(a) Change of name or contact	There were no name or contact changes during the reporting period.
15/CMP.1 annex II.E paragraph 32(b) Change regarding cooperation arrangement	During the reporting period, there was a change in the cooperation agreement as the United Kingdom of Great Britain and Northern Ireland no longer operates its registry in a consolidated manner under the Consolidated System of EU Registries.
15/CMP.1 annex II.E paragraph 32(c) Change to database structure or the capacity of the national registry	After version 11.5 (the production version at the time of the last submission of Chapter 14), 6 new EUCR releases (versions 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2) have been issued. No changes were applied to the database, the model of which is shown in Annex A. No change to the application backup plan or disaster recovery plan was required. There was no change in the capacity of the National Registry during the reporting period.

REPORTED ITEM	DESCRIPTION
15/CMP.1 annex II.E paragraph 32(d) Change concerning compliance with technical standards	The changes introduced with versions 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2 compared to version 11.5 of the National Registry are listed in Annex B. It should be noted that each release of the registry is subject to regression testing and tests related to new features. These tests include thorough testing against DES and are performed prior to the corresponding major release to production (see Annex B). There was no other change in the compliance of the registry with the technical standards during the reporting period.
15/CMP.1 annex II.E paragraph 32(e) Change in procedures for discrepancies	There were no changes to the procedures for discrepancies during the reporting period.
15/CMP.1 annex II.E paragraph 32(f) Change regarding security	No security-related changes were introduced.
15/CMP.1 annex II.E paragraph 32(g) Change to the list of publicly available information	There were no changes to the list of publicly available information during the reporting period.
15/CMP.1 annex II.E paragraph 32(h) Change of internet address	There were no changes to the internet address of the registry during the reporting period.
15/CMP.1 annex II.E paragraph 32(i) Change regarding data integrity measures	There were no changes to the data integrity measures during the reporting period.
15/CMP.1 annex II.E paragraph 32(j) Change regarding test results	There were no changes regarding test results during the reporting period.

CHAPTER 5 POLICIES AND MEASURES

Policy development process, supplementary information required under Article 7(2) of the Kyoto Protocol and cross-cutting policies and measures

The activities of the Slovak Republic (SR) on the development of policies and measures to mitigate GHG emissions have intensified since the publication of the Seventh National Climate Change Report of the Slovak Republic. Ministry of the Environment of the Slovak Republic and the Slovak Hydrometeorological Institute (SHMÚ) have taken all necessary steps to improve mechanisms for monitoring, evaluating and improving tools and measures to meet national reduction commitments under the UNFCCC. All relevant policies and measures at EU level shall be strengthened to meet the 2030 objectives of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Achieving these emissions reduction over the next decade is key to making Europe the world's first climate-neutral continent by 2050 and to making the European Green Deal a reality. With the proposals, the Commission is presenting the legislative tools to achieve the objectives agreed in the European climate legislation and the fundamental transformation of Slovak economy and society for a fair, green and prosperous future. As can be seen from recent GHG inventories, the Slovak Republic is on track to meet its commitments.

Contents of the chapter:

- *Description of the policy-making process in the Slovak Republic (Section 5.1).*
- *Monitoring and evaluation (Section 5.1.1).*
- *Supplementary information required under the Kyoto Protocol (Section 5.2.).*
- *Descriptions of cross-cutting and sectoral policies and measures for the energy, transport, industry, agriculture, forestry and waste sectors (Sections 5.4 to 5.9).*
- *Description of interactions between policies and measures (Section 5.11).*

5.1 POLICY-MAKING PROCESS

The MŽP SR is responsible for the development and implementation of the national environmental policy, including measures to combat climate change, both in terms of climate change mitigation and adaptation to the adverse effects of climate change. The preparation and coordination of the development of all strategic documents and legal instruments in specific sectoral policies of other ministries is also within the competence of the MŽP SR.

The main bodies within the MŽP SR dealing with climate change tasks are the Climate Change Policy Department and the Emissions Trading Department, which operate under the Climate Change and Air Protection Section.

Pursuant to Government Resolution No. 821/2011, the Commission for the Climate and Energy Package has been replaced by the Commission for Climate Change Policy Coordination (the Commission). The Commission was established on 15 January 2012 at the level of Secretaries of State.

In 2021, this Commission was replaced by the Council of the Government of the Slovak Republic for the European Green Deal. Council of the Government of the Slovak Republic for the European Green Deal serves as an expert, advisory, coordinating and initiating body of the Government of the SR for matters related to the European Green Deal as well as the vision for achieving the Sustainable

Development Goals (i.e. national priorities for the implementation of the 2030 Agenda for Sustainable Development) and the transition to a carbon-neutral economy by 2050 and the related implementation of key policies and measures towards achieving the climate and environmental goals and the continued transformation of the economic, environmental, energy and social system of the Slovak Republic, including the transformation of industry, agriculture, transport, tourism, manufacturing, non-manufacturing, consumer and social sectors.

Council of the Government of the Slovak Republic for the European Green Deal is chaired by the MŽP SR; other members are the relevant ministers and representatives of the state authorities and the National Council of the Slovak Republic, local government authorities, municipalities and representatives of the Academy. The competence, tasks, composition and principles of organisation and operation of this Council are regulated by the Council of the Government of the Slovak Republic for the European Green Deal[34]. Within the Council of the Government of the Slovak Republic for the European Green Deal, six working groups have been created (Energy, Industry, Transport, Agriculture and LULUCF, Waste and Circular Economy) - the members of these working groups are, in addition to representatives of individual ministries, representatives of the private sector, the third sector, including representatives of local government.

5.1.1 Monitoring and Assessment

Council of the Government of the Slovak Republic for the European Green Deal, in combination with the above working groups, provides an institutional framework not only for the policy-making process, but also for the process of monitoring and evaluation of the policies already adopted in relation to the implementation of our international commitments in the field of mitigation and adaptation).

The first level of the monitoring and evaluation process is the preliminary review of the inventory reports and the independent review of the Annual Report of the Slovak Republic submitted annually on 15 January based on Article 26 of Regulation (EU) No. 2018/1999, Regulation (EU) No. 2018/841 and Implemented Regulation (EU) No. 2020/1208.[35,36,37] This review is carried out annually by independent experts from the European Commission.

As part of the "internal" review of current climate change policies, the MŽP SR regularly submits to the Government for approval a Report on the interim status of implementation of the international commitments made by the Slovak Republic in the field of climate change policy. The most recently published report on the interim status of implementation of Slovakia's international climate change policy commitments for 2017-2019 is in fact the seventh report.[38] The published report adopted by

[34] https://www.minzp.sk/ezd/rada/

[35] Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council

[36] Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

[37] Commission Implementing Regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014

[38] Report on the interim status of implementation of Slovakia's international commitments in the field of climate change policy.

Government Resolution No. 145 of 3 April 2020[39] also includes a separate chapter on the fulfilment of Slovakia's international commitments under the UN Framework Convention on Climate Change and the Kyoto Protocol[40], which informs the Government in detail on the status of the fulfilment of our reduction commitments on the basis of information from the latest available inventories of greenhouse gas emissions. The content of the report provides an overview of current developments in climate change policy in the broader international, European and national context, with an emphasis on the key roles that the Slovak Republic has played in this agenda in 2017 and 2018. In addition, it provides information on the main challenges and tasks that lie ahead on this agenda. Through this report, the government is informed at regular intervals on the status of our reduction commitments based on information from the latest available GHG inventories.

If necessary, and based on the report, governmental or ministerial resolutions may be adopted to implement specific tasks to further regulate or improve the implementation of our climate change commitments.

5.1.2 Overall Policy Context

The overall policy framework in the SR consists of national conceptual and strategic sectoral documents as well as European climate policy strategies. A detailed description of policies and measures at EU level is presented in the EU's Seventh National Climate Change Report and the EU's Third Biennial Report.

5.1.3 Political Context at EU Level

a) EUROPE 2020 Strategy

Europe 2020 is a ten-year growth strategy and builds on the lessons of the Lisbon Strategy. The headline objective of Europe 2020 is to deliver "smart, sustainable and inclusive growth" as a result of greater coordination of national and European policies. The three priorities of the Europe 2020 strategy are outlined in the Europe 2020 Communication.[41] The strategy for smart, sustainable and inclusive growth includes:

- Smart growth - developing an economy based on knowledge and innovation.
- Sustainable growth - promoting a more resource-efficient, greener and more competitive economy.
- Inclusive growth - promoting a high-employment economy ensuring social and territorial cohesion.

b) Climate and Energy Package

In December 2008, the European Parliament and the Council agreed on the EU Climate and Energy Package, which for the first time provided an integrated and ambitious package of policies and measures to combat climate change, together with renewable energy and energy efficiency elements. The climate and energy package was formally adopted in 2009. It includes the above 20-20-20 objectives:

[39] https://rokovania.gov.sk/RVL/Material/23680/1

[40] Meeting Slovakia's international commitments under the UN Framework Convention on Climate Change and the Kyoto Protocol

[41] COM (2010) 2020 Final

- Reduce greenhouse gas emissions by at least 20% below 1990 levels by 2020, with a firm commitment to increase this objective to 30% in the event of a satisfactory international agreement;
- Achieve 20% renewable energy (as a share of total EU gross final energy consumption) by 2020, complemented by a target of at least 10% renewables in transport;
- Save 20% of total primary energy consumption by 2020 compared to the unchanged reference scenario.

In order to meet the headline objectives, the Climate and Energy Package contains four pieces of complementary legislation:[42]

- Directive revising the European Emissions Trading Scheme (EU ETS), which covers around 40% of the EU's greenhouse gas emissions;
- Effort sharing decision setting binding national objectives for emissions from sectors not covered by the EU ETS;
- Directive setting binding national objectives for increasing the share of renewable energy sources in the energy mix;
- Directive establishing a legal framework for the safe and environmentally sound use of carbon capture and storage technologies - the Carbon Capture and Storage Directive.

c) 2030 Climate and Energy Framework

In June 2021, the European Commission adopted a package of proposals to adapt EU policies on climate, energy, land use, transport and taxation to reduce net greenhouse gas emissions by at least 55% below 1990 levels by 2030. Achieving these emission reductions over the next decade is key to making Europe the world's first climate-neutral continent by 2050 and to making the European Green Deal a reality. With the proposals, the Commission is presenting the legislative tools to achieve the objectives agreed in the European climate legislation and the fundamental transformation of our economy and society for a fair, green and prosperous future. The EU ETS sectors are expected to reduce emissions by 61% (compared to 2005 levels), the ETS will be strengthened and reformed for this purpose. Sectors not covered by the ETS are expected to reduce emissions by 40% (compared to 2005 levels), in the case of the Slovak Republic the national objective is increased from 12% to 22.7%. At least 27% of the EU's energy consumption from renewable energy sources. At least 27% improvement in energy efficiency. Legislative proposals are discussed in the European Parliament and the Council, with a period of 18 months for implementation in national legislation.

d) Roadmap 2050

In 2011, the European Commission launched three roadmaps to support the debate on a long-term framework for climate and energy policies in Europe:

- Roadmap to a competitive low-carbon economy in 2050[43]

[42] http://europa.eu/rapid/press-release_IP-09-628_en.htm

[43] COM (2011) 112 final

- Roadmap to a Single European Transport Area - Creating a competitive and resource-efficient repair system[44]
- Energy Roadmap 2050[45]

In February 2021, the European Council reaffirmed that the EU aims to reduce EU greenhouse gas emissions by 80-95% below 1990 levels by 2050, as part of efforts by developed countries as a group to reduce their emissions by a similar magnitude. While the EU has already committed to reducing greenhouse gas emissions by at least 20% below 1990 levels by 2020 as part of the Climate and Energy Package, longer-term policies are now needed to ensure that the ambitious 2050 reduction objective is achieved. That is why the European Commission has published a Communication: a Roadmap for moving to a competitive low-carbon economy in 2050, providing guidance on how the EU can decarbonise its economy.

e) 7th Environmental Action Programme

Since the 1970s, the Environmental Action Programmes have provided the basis for the development of EU environmental policy. The 6th Environmental Action Programme expired in July 2012. Political agreement on a new general Union Environment Action Programme for 2020 (entitled "Living well with the limits of our planet") was reached between the European Commission, the European Parliament and the Council in June 2013. The Seventh EAP,[46] as proposed by the European Commission in 2012, provides an overarching framework for environmental policy (without any specific objectives included for climate policy, as this is currently a separate policy area) for the next decade, setting nine priority objectives for the EU and its Member States:

- Protect, preserve and enhance the Union's natural capital.
- Making the Union a low-carbon, resource-efficient and competitive green economy.
- Protect Union citizens from environmental impacts and risks to their health and well-being.
- Maximise the benefits of Union environmental legislation by improving its implementation.
- Improve the knowledge and evidence base for Union environmental policy.
- Ensure investment in environment and climate policy and address environmental externalities.
- Improve environmental mainstreaming and policy coherence.
- Strengthening the sustainability of the Union's cities.
- Increase the Union's effectiveness in tackling international environmental and climate challenges.

5.1.4 Policy Context at National Level

National Reform Programme – is a national and regularly updated programme with the main objective of meeting the structural policy objectives of the EU 2020 Strategy. It also contains an Action Plan with target policies for specific sectors, including identified financial allocations.

[44] COM (2011) 144 final

[45] COM(2011) 885/2

[46] Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on the Union's general environmental action programme for 2020 “Living well with the limits of our planet“

National Reform Programme 2022[47] – is a national and regularly updated programme with the main objective of meeting the goals of the 2030 Agenda for Sustainable Development (Agenda 2030) and the European Pillar of Social Rights (EPSP), thus replacing the Europe 2020 strategy that has been the backbone for the past decade. It also contains an Action Plan with target policies for specific sectors, including identified financial allocations.

Slovakia's Vision and Development Strategy 2030 (Slovakia 2030)[48] **–** this long-term sustainable development strategy, approved by Government Resolution No. 41 of 20 January 2021, also fulfils the role of the National Strategy for Regional Development of the Slovak Republic. It thus integrates sectoral priorities and regional and territorial development priorities, thus linking the public administration (the Central Government Authorities) and the local government authorities (cities, municipalities, higher level territorial units). It is based on four principles: the principle of sustainability, i.e. the balance between available resources and their use, the priority of quality of life over economic growth, efficiency based on synergies and the integration of policies and their instruments.

Its objectives in the field of air include:

- Reduce air emissions by 82%, NO_X by 50%, NMVOC by 32%, NH_3 by 30% and $PM_{2.5}$ by 49% by 2030 compared to 2005 by implementing adequate environmental measures across all sources of pollution (industry, energy, transport, agriculture, domestic heating) and ensuring adequate monitoring of air pollutants, supported by the establishment of new air quality monitoring stations.
- Reduce air pollution, especially from industry, energy, local heating and transport, and encourage the establishment of new air quality monitoring stations as part of the development and information of the population In terms of environmental objectives, Slovakia 2030 is to ensure the protection, restoration and enhancement of natural resources, including ensuring the stability and health of ecosystems and their services, and the reflection of adaptation and mitigation measures to the adverse effects of climate change in all departmental strategic documents and municipal and regional development documents as an overriding public interest (e.g. in transport planning, energy, spatial planning, spatial planning, water management, land management, forestry, sustainable tourism, overall care of the countryside, etc.).

Environmental Policy Strategy of the Slovak Republic until 2030 - Greener Slovakia (or Envirostrategy 2030) – was adopted in February 2019, defines a vision for 2030, taking into account possible, probable and desired future developments, identifies key systemic issues, sets targets for 2030, proposes framework measures to improve the current situation, and includes key outcome indicators to verify the results achieved. As part of climate change mitigation, Slovakia will reduce greenhouse gas emissions in emissions trading sectors by 43% and outside these sectors by at least 20% compared to 2005. An effective emissions trading system will continue. Adaptation measures in the regions will reflect their specificities and be sufficiently responsive to climate change.

Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050 (NUS SR)[49] – was approved by the Government of the Slovak Republic on 5 March 2020. The NUS SR responses to the commitments in the fight against climate change resulting from its membership in the European Union and the United Nations and the associated obligation to develop a long-term strategy

[47] https://rokovania.gov.sk/RVL/Material/27183/1

[48] https://rokovania.gov.sk/RVL/Material/25655/1

[49] https://www.minzp.sk/files/oblasti/politika-zmeny-klimy/nus-sr-do-roku-2030-finalna-verzia.pdf

with a scope of at least 30 years. The objective of the strategy is to identify existing and propose new additional measures within the SR to achieve climate neutrality by 2050. The primary objective of the NUS SR is to identify all measures, including additional ones that will lead to achieving climate neutrality in the Slovak Republic by 2050.

5.2 ADDITIONAL INFORMATION REQUIRED UNDER ARTICLE 7(2) OF THE KYOTO PROTOCOL AND CROSS-CUTTING POLICIES AND MEASURES

The following section contains information pursuant to UNFCCC Decision 15/CMP.1, and includes supplementary information required under Article 7(2) of the Kyoto Protocol concerning the following:

- Use of flexible mechanisms under the Kyoto Protocol (Section 5.2.1).
- Complementarity related to the mechanisms under Articles 6, 12 and 17 (Section 5.2.2).
- Policies and measures under Article 2 of the Kyoto Protocol (Section 5.2.3).
- Policies and measures promoting sustainable development within the meaning of Article 2(1) of the Kyoto Protocol (Section 5.2.3.1).
- Minimisation of adverse impacts within the meaning of Article 2(3) of the Kyoto Protocol (Section 5.2.3.2).

5.2.1 Use of Flexible Mechanisms under the Kyoto Protocol by the Slovak Republic

According to current GHG emission trends, the Slovak Republic does not intend to use the units generated by the Joint Implementation (JI) and Clean Development Mechanism (CDM) mechanisms to meet its reduction commitments. In 2013, the Slovak Republic sold some of its unused AAUs under Article 17 of the Kyoto Protocol. Revenues from AAU trading are revenues for the Environmental Fund (pursuant to Act No. 414/2012 Coll. on Emission Allowance Trading). In accordance with Act No. 414/2012 Coll. and taking advantage of the existing surplus of AAUs and the current trend in emissions, the Slovak Republic sold 7 million AAUs in 2013. The Green Investment Scheme was formally approved in December 2009 as a tool to support projects and programmes to further reduce greenhouse gas emissions financed through proceeds from the sale of surplus AAUs. Proceeds from the sale were used for industrial energy efficiency projects, projects aimed at promoting renewable sources in the production of electricity and heat as a substitute for fossil fuels, and residential energy efficiency projects under the SlovSEFF Greening Programme. The SlovSEFF programme was terminated in 2022. The Slovak Republic can make use of the flexible mechanisms under the Kyoto Protocol, but apart from the sale of AAUs mentioned above, no transfers have been made to date.

5.2.2 Complementarity Related to Mechanisms under the Articles 6, 12, 17

This chapter provides information on institutional and financial arrangements and decision-making rules to coordinate and support activities related to the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol, including the participation of legal entities.

The Slovak Republic has published on the UNFCCC website the National Guidelines and Procedures of the Slovak Republic for the Approval of Projects under Article 6.[50]

[50] http://ji.unfccc.int/UserManagement/FileStorage/6IWYQACEFTXPLGBKU0SZHN849DJVM7

During the first commitment period of the Kyoto Protocol, the Slovak Republic, as host country for joint implementation projects under Article 6, applied the JI Guidelines procedure for Track 2. Pursuant to Section 11 of Act No. 414/2012 Coll. 11 of Act No. 414/2012 Coll. on Emissions Trading, all establishments in the EU ETS could also use CERs and ERUs during the third trading period up to the level set out in Commission Regulation 1123/2013/EU of 8 November 2013 on the determination of rights to use international credits pursuant to Directive 2003/87/EC of the European Parliament and of the Council, the use of CERs and ERUs is to be in accordance with Section 11 of Act No. 414/2012 Coll. on emissions trading. With effect from 1 January 2021, Section 11 has been removed from Act No. 414/2012 Coll. on emissions trading and CERs and ERUs can no longer be used in the EU ETS to meet their obligations under the 4th trading period.

According to Article 5 of the ECJ, MS can use CERs and ERUs to meet their obligations in the period 2013-2020, but the Slovak Republic did not use this option even for one year because it used AEAs, of which it always had a surplus, to comply with the ECJ.

No budget specification for flexible mechanisms under the Kyoto Protocol has been approved in the Slovak Republic. The Slovak Republic has signed a Memorandum of Understanding on JI and emissions trading mechanisms with the Netherlands, Austria, and Denmark.

5.2.3 Policies and Measures under Article 2 of the Kyoto Protocol

a) Policies and measures promoting sustainable development within the meaning of Article 2(1) of the Kyoto Protocol

Sustainable development is an overarching objective of the European Union, defined in its founding Treaty, and therefore has implications for all the policies and activities of the EU and its Member States. In future, priority actions should be more clearly specified. Governance mechanisms, including implementation, monitoring and follow-up, should be strengthened, for example through clearer links to the EU 2020 Strategy and other cross-cutting strategies.

b) Policies and measures related to aviation and maritime fuels under Article 2(2) of the Kyoto Protocol

Major policies in civil aviation include the EU ETS and the Carbon Offsetting and Reduction Scheme for International Aviation - CORSIA. CORSIA offers a harmonised way to reduce emissions from international aviation, minimising market distortions while respecting the specific circumstances and respective capabilities of ICAO Member States. The inclusion of maritime transport in the EU ETS is the subject of the current revision of Directive 2003/87/EC as part of the Fit for 55 legislative package.

c) Minimisation of adverse impacts within the meaning of Article 2(3) of the Kyoto Protocol

Legislative background:

- Kyoto Protocol - Article 3.14 requires Annex 1 countries to strive to meet greenhouse gas emission reduction commitments in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, in particular those listed in Articles 4.8 and 4.9 of the Convention.

- Decision 15/CMP.1 – paragraphs 23-26 in Article 3.14 and Article 7.1 provide further guidance and focus on reporting obligations on the following points:

  a) Progressively reducing or phasing out market imperfections, financial incentives, tax and levy exemptions and subsidies in all GHG-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities in pursuit of the Convention's objective.

b) Elimination of subsidies linked to the use of environmentally inappropriate and unsafe technologies.

c) Cooperation in the technological development of non-energy uses of fossil fuels and, in this respect, support for developing country parties.

d) Cooperating in the development, dissemination and transfer of advanced fossil fuel technologies with lower greenhouse gas emissions, and/or fossil fuel-related technologies that capture and store greenhouse gases and promoting their wider deployment; and facilitating the participation of less developed countries and other non-Annex I Parties to the UNFCCC in these efforts.

e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9 of the Convention to improve the efficiency of both upstream and downstream fossil fuel activities, taking into account the need to improve the environmental effectiveness of these activities.

f) Assisting developing countries that are heavily dependent on the export and consumption of fossil fuels to diversify their economies.

- Decision 22/CMP.1 - paragraphs 121-126 provide guidelines for review under Article 8 of the Kyoto Protocol, some of which are relevant to Article 3.14.
- Decision 31/CMP.1 - mandates the implementation of Article 3.14 commitments.

Introduction and methodological guidelines

The implementation of increasingly stringent environmental regulations and economic policies that penalise the continued use of substances, technologies that are harmful to the environment, can be associated with a range of side effects. It is not excluded that some of the possible adverse economic effects will affect some developing and less developed countries that have fewer resources for adequate corrective retaliatory measures. The magnitude of these potential impacts is typically determined by the stringency of the measures adopted, the choice of the particular policy instrument, the size and strength of the implementing economy relative to world markets, and also the current macroeconomic settings of the developing countries concerned.

This chapter identifies potential channels through which nationally implemented policies in the Slovak Republic could have had an impact on third countries. In addition, any existing evidence of the potential magnitude of impacts is highlighted. Similarly, this chapter mainly describes the activities related to the development assistance of the Slovak Republic implemented to minimize the negative impacts caused by these policies. The objective is to meet our obligations under the Kyoto Protocol in relation to transparent reporting on potential adverse social, environmental and economic impacts, particularly in developing countries.

Legislative measures adopted:

Fiscal policy instruments: fiscal policy instruments are increasingly identified as effective tools for correcting existing environment-related price distortions. The Slovak Republic has excise duties on fossil fuels, electricity and mineral oils. However, the current drivers of fiscal policy still remain much more tied to the government's current budget situation than to the provision of fiscal incentives for green behaviour. Since 2009, there have been only minor changes, such as a reduction in the excise duty on diesel, the removal of existing exemptions for coal taxpayers and an increase in the excise duty on LPG, CNG and electricity. No impact on any third countries is foreseen from the fiscal policies already in place and therefore no specific policies have been considered to offset any negative effects.

Biofuels policy: biofuels are used to meet targets required by EU legislation. Increased demand and consequently production of biofuels may be reflected in increased commodity prices or cause changes in land use resulting from reduced supply of commodities in direct competition with commodities used worldwide for biofuels. Therefore, international trade represents a major channel through which potentially negative economic, social and environmental impacts[51] could be transmitted towards developing countries. However, considering the relatively low quantities of biofuels used in the Slovak Republic and the domestic production of raw materials for their production, we do not foresee any negative effects either on the destruction of forests or on the contribution to the rising world prices of agricultural commodities.[52] Despite its low contribution to this development, the Slovak Republic is actively contributing to the shaping of international sustainability standards in its own legislative process (and internally in the EU), or within international institutions such as the WTO, FAO, etc. In addition, the Slovak Republic is also actively involved in strengthening know-how on improving food security and agriculture, land and water management in Kenya. In addition, scholarships were offered to students from developing countries, with preference given to students in environmental sciences.

Policies to reduce greenhouse gases: the main policy choice was emissions trading with a resulting price per tonne of emissions. Complementary policies adopted objectives to reduce greenhouse gas emissions in non-trading sectors, increase the share of renewable energy, increase energy efficiency as well as new legislation setting stricter quality standards for fuels and cars. The policies adopted may have had some implications for third countries, either through basic carbon market pricing mechanisms or requirements to comply with new and more stringent environmental regulations. CO_2 emissions trading (either EU ETS or Kyoto emissions trading) and increasingly stringent fuel quality standards may have had some impact. The main example of indirect impact on third countries is the integration of the aviation sector into the trading system. Among indirect effects, the main example is the concern about possible carbon leakage. Most of the impacts of carbon leakage (shifts of industrial activity to countries without any GHG reduction commitments, potential downward pressure on oil prices, etc.) on third countries could be rather positive for them.[53] Measures in place to minimise potential carbon leakage include ensuring that economic sectors facing an imminent threat of carbon leakage continue to receive free CO_2 allowances under the circumstances. Furthermore, increasingly stringent fuel quality standards in Europe could actually prove to be a positive influence, as they could trigger an increase in investment in the fuel processing industry in third countries. Rising fuel prices in Europe as a result of the carbon price (or tax) and quality improvements could play against rising oil prices, particularly as a result of the growing scarcity of this commodity. Such effects could on the one hand negatively affect the returns of oil exporting countries, which on the other hand may still be offset by rising demand from the rest of the world. The ultimate net impact will depend on the benefits derived from the expansion of industrial production and the costs required to clean up higher levels of pollution, including dealing with the consequences. Apart from emissions trading, the Slovak Republic has not used any other flexible

[51] Implied excessive land-use change, food shortages or deterioration of food security.

[52] We stress that a different conclusion can be reached if the implications of overall EU biofuels policies are taken into account. Similarly, this could also be true when considering existing agricultural policies under the EU Common Agricultural Policy.

[53] In some specific cases where a polluter seeks a site in a developing country, thereby causing an increase in local pollution, the increased environmental harm may outweigh the economic benefit.

instrument under the Kyoto Protocol to meet its GHG reduction targets, therefore no impact on third countries is reported in this sense. The actions considered in the development of the Climate Change Adaptation Strategy are local in nature with no implications for third countries.

5.3 CROSS-SECTORAL POLICIES AND MEASURES

5.3.1 European Emissions Trading Scheme (EU ETS)

The EU ETS was established by Directive 2003/87/EC and has undergone several revisions to strengthen its implementation over its three trading periods (2005-2007, 2008-2012, and the current 2013-2020 period).

The first phase (2005-2007) was a three-year pilot period of learning-by-doing in preparation for the second phase, when the EU ETS should operate efficiently to help ensure that the EU and Member States meet their emission targets under the Kyoto Protocol. Before the start of the first phase, the Slovak Republic had to decide how many allowances to allocate to each EU ETS plant on its territory. This was done through the first National Allocation Plan. The Slovak Republic prepared and published the National Allocation Plan on 1 May 2004. The decision of the European Commission on Phase I of the National Allocation Plan of the Slovak Republic was approved on 20 October 2004. Statistics from the first phase:

- 175 establishments;
- 38 establishments have cancelled their accounts;
- permit refused for 1 establishment.

Table 5.1: *Statistics from Phase I of the National Allocation Plan*

Year	2005	2006	2007
Allocation (tons)	30 299 021	30 357 450	30 357 404
Verified emissions (tons)	24 892 813	25 200 029	24 153 151

Source: MŽP SR

The second phase of the EU ETS was the five-year period 2008-2012, corresponding to the first commitment period of the Kyoto Protocol. The EC decision on Phase II of the National Allocation Plan of the Slovak Republic was approved on 29 November 2006 and modified by the decision of 7 December 2007. Statistics from the second phase:

- 193 establishments;
- 30 establishments have cancelled their accounts;
- permit refused for 1 establishment.

Table 5.2: *Statistics from Phase II of the National Allocation Plan*

Year	2008	2009	2010	2011	2012
Allocation (tons)	32 166 094	32 140 581	32 356 123	32 617 164	33 432 258
Verified emissions (tons)	25 336 706	21 595 209	21 698 625	22 222 534	20 932 903

Source: MŽP SR

The third phase of the EU ETS started on 1 January 2013 and introduced several changes to the EU ETS. It brought harmonised rules for the allocation of free allowances, introduced auctions as the main instrument for meeting the reduction objective, added additional sectors to the scope (i.e. civil aviation, aluminium) and set an annual reduction target of 1.74%. The Slovak Republic notified the Commission of the list of establishments covered by the Directive on its territory on 17 August 2012.

Table 5.3: *Statistics from Phase III of the National Allocation Plan*

Year	2013	2014	2015	2016	2017
Allocation (tons)	16 466 336	15 821 315	15 029 434	14 526 743	13 849 714
Verified emissions (tons)	21 829 374	20 918 069	21 181 280	21 264 045	22 063 225
Year	**2018**	**2019**	**2020**	**2021**	
Allocation (tons)	13 746 320	13 414 163	13 048 220	11 597 175	
Verified emissions (tons)	22 1930396	19 903 840	18 169 997	20 898 870	

Source: MŽP SR

From January 2021, the Emissions Trading Scheme entered its 4th phase, which will last until 31 December 2030. The emission cap is reduced by a linear factor of 2.2% from 2021 onwards. A completely new element of the trading system is the Modernisation Fund.

Auction: Auctioning is a way of distributing emission allowances. Preliminary auctioning started in 2012 with an auction of 120 million EUAs, of which the Slovak Republic's share was 1.8 million EUAs. The auctions are held on a single auction platform, the European Energy Exchange (EEX), every Monday, Tuesday and Thursday (separately for Poland on Wednesdays and for Germany on Fridays). All proceeds from the auction have been income of the Environmental Fund of the Slovak Republic since 2015.

Table 5.4: *Revenues of the Slovak Republic from auctions during the period 2012 – 2021*

Period	2016	2015	2014	2013	2012
	EUR				
Revenues of the Slovak Republic (EUA)	64 991 430	84 312 060	57 590 625	61 702 620	12 193 290
Revenues of the Slovak Republic (EUAA)	55 815	197 300	44 590	-	-
Total revenue SVK	65 047 245	84 509 360	57 635 215	61 702 620	12 193 290
Period	**2017**	**2018**	**2019**	**2020**	**2021**
	EUR				
Revenues of the Slovak Republic (EUA)	275 832 390	241 854 770	244 474 150	229 635 710	87 007 265
Revenues of the Slovak Republic (EUAA)	332 330	213 555	239 360	178 950	57 205
Total revenue SVK	276 164 720	242 068 325	244 713 510	229 814 660	87 064 470

Source: MŽP SR

MSR: The Market Stability Reserve (MSR) was introduced as a long-term solution to tackle the existing surplus of allowances in the EU ETS. It is an automated mechanism that will automatically reduce the volume of allowances in the auction if there is a significant surplus of allowances on the market. If the need for additional allowances arises, the MSR shall be used to increase the volume of allowances in the auction. The MSR has been in place since 2019 and all temporarily withdrawn allowances will become part of this reserve. This will result in a continuous increase of the carbon price in the EU ETS and a stable environment for investors for the next decade.

Affected greenhouse gases: CO_2, CH_4, N_2O, HFC, PFC and SF_6

Type of measure: regulatory

5.3.2 Joint Effort Legislation

The legislative framework for Member States' collective efforts to reduce greenhouse gas emissions is divided into the period 2013 to 2020 and the period 2021 to 2030. The legislative basis for the first period is Decision No. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 (Effort Sharing Decision - ESD). The basis for the second period is Regulation No. 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 to contribute to climate action to meet their commitments under the Paris Agreement and amending Regulation (EU) No. 525/2013 (Effort Sharing Regulation - ESR).

The Effort Sharing Decision sets annual emission limits for Member States' greenhouse gas emissions for the period 2013-2020, which are legally binding and apply only to greenhouse gas emissions that are not part of the scope of the EU ETS, i.e. small energy and industry outside the scope of the EU ETS, transport (excluding aviation), buildings, agriculture and waste. Each Member State must define and implement national policies and measures to reduce emissions in these sectors, such as the promotion of public transport, energy performance standards for buildings, and biogas, waste management and agriculture measures.

The annual emission allowance allocations (AEAs) in tonnes of carbon dioxide equivalent for the period 2013 to 2020 are the maximum annual allowable emissions that have been determined on the basis of reviewed and verified data, the AEAs are held in accounts in the national allowance registry. The transparency of the transfer of the abovementioned quotas between Member States is ensured by notification to the Commission and registration of each transfer in the registers of the two Member States concerned. The emission reduction objective for the Slovak Republic is a positive emission limit of +13% by 2020 compared to 2005 levels. The Slovak Republic, through its policies and measures, has achieved the national objective set by the ECJ for 2020.

Table 5.5: *Compliance under the ECJ*

Year	2013	2014	2015	2016	2017
AEA Units (tons)	24 023 495	24 383 530	24 743 565	25 103 599	25 041 595
Verified emissions (tons)	21 080 248	19 782 144	20 084 623	19 758 694	22 063 225
Year	**2018**	**2019**	**2020**		
AEA Units (tons)	25 344 020	25 646 446	25 948 871		
Verified emissions (tons)	21 065 066	20 087 964	18 877 704		

Table 5.6: *Progress made in meeting the Effort Sharing Decision (ESD) JI targets*

2020 Objective according to the ECJ (% vs. 2005)	+13.0%
2015 ESD emissions (% vs 2005)	-13.2%
2020 ESD emissions (% vs 2005)	-18.4%

Source: MŽP SR, year 2005 = 23 137.11 Gg CO_2 eq.

Road transport and residential heating are among the largest contributors of GHG emissions within the ESD sectors. Transport currently contributes 19.1% of total greenhouse gas emissions (in CO_2 eq.) and its share of total emissions has been on an increasing trend since 1990. Therefore, it is necessary to continuously pay attention to and implement effective policies and measures to reduce emissions from road transport in the Slovak Republic.

Table 5.7: *Assessment of greenhouse gas emissions under the ETS and ESD in 2020*

Category	Unit	Total GHG emissions	ETS Emissions	ESD Emissions	ETS/ESD ratio in %
GHG Emissions	Gg of CO_2 eq.	37 002.71	18 170.00	18 887.70	49/51

Source: SHMÚ

Affected greenhouse gases: CO_2, CH_4, N_2O and perfluorocarbons (PFC)

Type of measure: regulatory

5.3.3 Integrated National Energy and Climate Plan 2021-2023 (NECP) adopted by Government Resolution No. 606/2019

The Integrated National Energy and Climate Plan is a broad conceptual material, which is based on existing or upcoming strategic materials of several ministries, sets the framework for the implementation of legislative and non-legislative measures aimed at climate protection and long-term sustainable energy. The main quantified targets of the NECP in the framework of the Slovak Republic by 2030 are the reduction of GHG emissions for non-ETS sectors by 20% (the share has been increased from the originally declared level of 12%). Taking into account the EC's recommendation to increase the ambition in renewable energy sources (RES), the current draft of the NECP foresees an objective of 19.2% RES in 2030. Ministry of Economy SR will take all available steps to accelerate the development of RES especially in heat production during 2021-2030 and to bring Slovakia closer to a higher share of RES in 2030. The elaborated measures for achieving the national energy efficiency contribution of the Slovak Republic show values slightly lower (30.3%) than the European target of 32.5%. The industrial and buildings sectors will be key to achieving the objectives. Electricity interconnection is already above 50% and will remain so until 2030, so the objective of at least 15% interconnection will be met

Affected greenhouse gases: CO_2, CH_4 and N_2O

Type of measure: regulatory

5.3.4 Biofuels Policy

Directive No. 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives No. 2001/77/EC and 2003/30/EC was adopted on 23 April 2009. Directive (EU) 2015/1513 of the European Parliament and of the Council amending Directive 98/70/EC on the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources was adopted on 9 September 2015. The authority responsible for the implementation of both directives is the Ministry of Economy of the Slovak Republic. The MŽP SR is responsible for the implementation of the sustainability criteria for biofuels and bioliquids, for calculations to determine the impact of biofuels and bioliquids on greenhouse gas emissions and for the calculation of greenhouse gas emissions released during the life cycle of fossil fuels pursuant to Article 7a of Directive 2009/30/EC and Council Directive (EU) 2015/652 of 20 April 2015 laying down calculation methodologies and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels.

In relation to the sustainability criteria, the Slovak Republic has implemented Articles 17, 18 and 19 of Directive 2009/28/EC and essentially identical Articles 7b, 7c and 7d of Directive 2009/30/EC, Article 7a of Directive 2009/30/EC, Directive 2015/652 and the relevant articles of Directive 2015/1513 through Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High Efficiency Combined

Generation, as amended, and Decree No. 271/2011 Coll. of the MŽP SR, establishing sustainability criteria and objectives for the reduction of greenhouse gas emissions from fuels, as amended.

This Act addresses, among other things, the basic roles and responsibilities of competent authorities and economic operators in a context that demonstrates the fulfilment of sustainability criteria for biofuels and bioliquids, which are prerequisites for meeting the national greenhouse gas emission reduction target as well as the objectives for renewable energy sources.

Decree of the MŽP SR No. 271/2011 Coll., as amended, has been in force since September 2011. This Decree contains the details of demonstrating compliance with the sustainability criteria for biofuels and bioliquids.

For assessing compliance with sustainability criteria along the biofuel production chain and bioliquids, voluntary schemes have been established. These schemes are subject to the approval of the European Commission and are therefore not subject to national approval and national control, and each Member State must accept the results of these schemes unconditionally.

Decree of the Ministry of Agriculture and Rural Development No. 295/2011 Coll., which lays down a detailed declaration of the producer and supplier of biomass for the production of biofuels or bioliquids, has been in force since October 2011. The Slovak Republic has had a national system for demonstrating compliance with the sustainability criteria for biofuels and bioliquids in operation since 2011. This system is based on independent verifiers whose training is organised and who are subject to mandatory examination and registration by the MŽP SR.

Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) replaced Directive 2009/28/EC, and its implementation is the responsibility of the Ministry of Economy of the Slovak Republic, and the MŽP SR is the co-observer in the field of sustainability criteria for biofuels, bioliquids and biomass fuels. It is currently being implemented into Slovak law.

Affected greenhouse gases: CO_2, CH_4 and N_2O

Type of measure: regulatory

5.3.5 Taxation of Energy Products and Electricity

The most significant in terms of tax revenue generation is the mineral oil tax. Revenues from electricity, coal and natural gas are relatively low. The Slovak Republic generates relatively little revenue from environmental taxes (***Figure 5.1***, ***Figure 5.2*** and ***Figure 5.3***) and the implicit tax rate (***Figure 4.4***) on energy is low. There is considerable scope for environmental tax reforms. The largest share of total energy use and CO_2 emissions in the Slovak Republic is accounted for by heating and energy use in industrial processes.

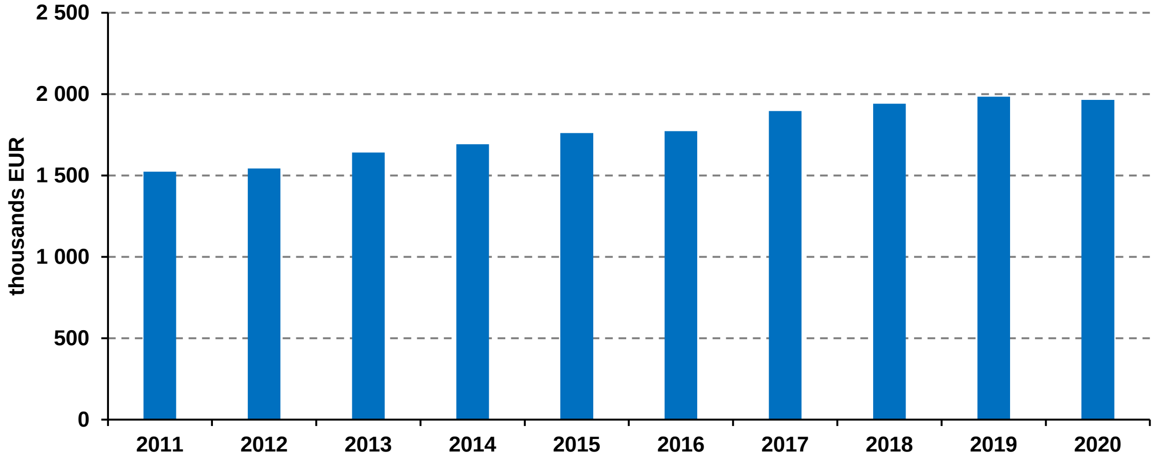
As part of the Fit for 55 package, a draft directive on energy taxation has been published. Energy taxation can help realise the ambition of a net reduction in greenhouse gas emissions of at least 55% by 2030 compared to 1990, as well as the goal of zero pollution through the application of the 'polluter pays' principle, by ensuring that the taxation of motor fuels, heating fuels and electricity better reflects their environmental and health impacts. Such a taxation approach has a direct role to play in supporting the green transformation by sending the right price signals and providing the right incentives for sustainable consumption and production.

The Energy Taxation Directive can contribute to the more ambitious objective of reducing greenhouse gas emissions by at least 55% by 2030 by ensuring that the taxation of motor and heating fuels better reflects their environmental and health impacts. This can be achieved by removing disadvantages for clean technologies and introducing higher levels of taxation for inefficient and polluting fuels, together with carbon pricing through emissions trading.

Affected greenhouse gases: CO_2, CH_4 and N_2O

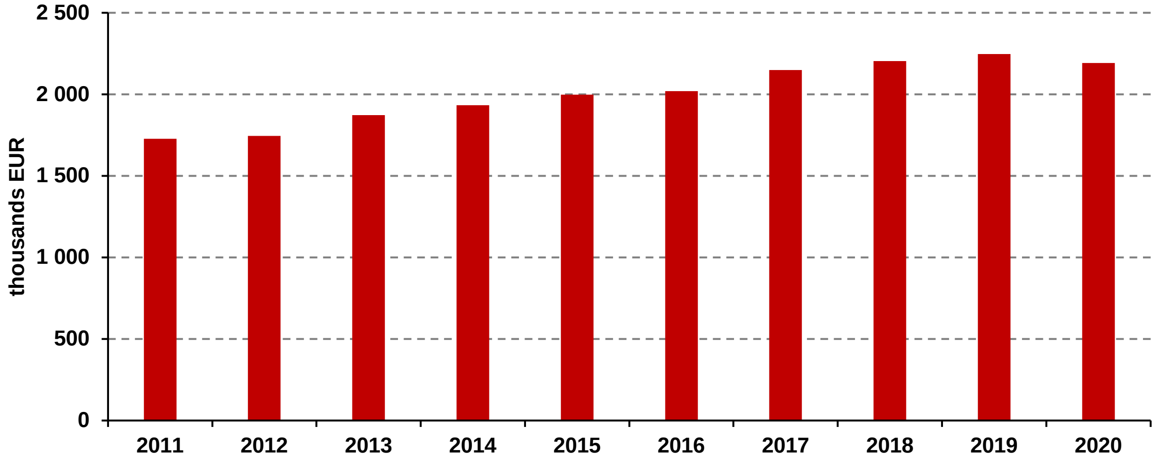
Type of measure: regulatory

Figure 5.1: *Tax revenue from taxation of energy products in the Slovak Republic* [54]



Source: Eurostat

Figure 5.2: *Total environmental taxes in the Slovak Republic* [55]

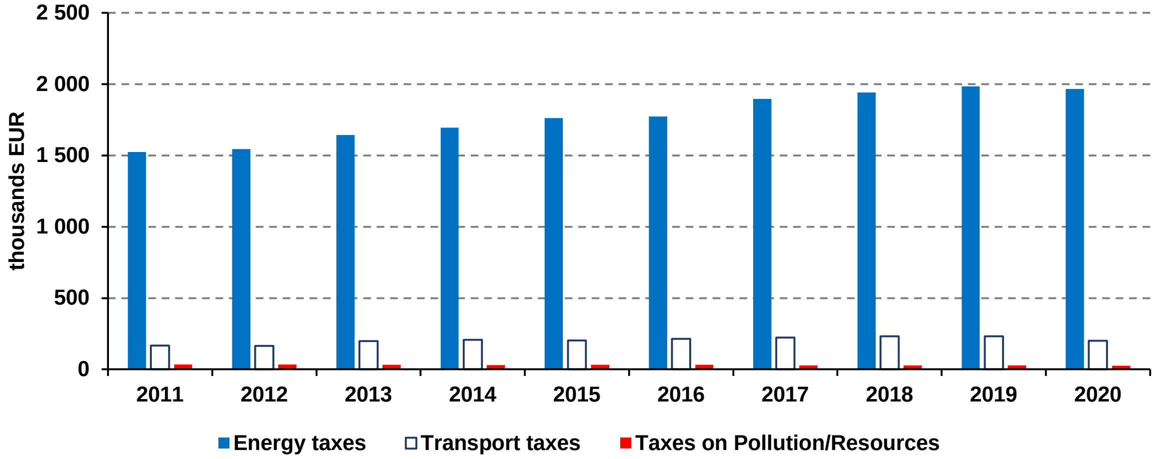


Source: Eurostat

[54] https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/line?lang=en

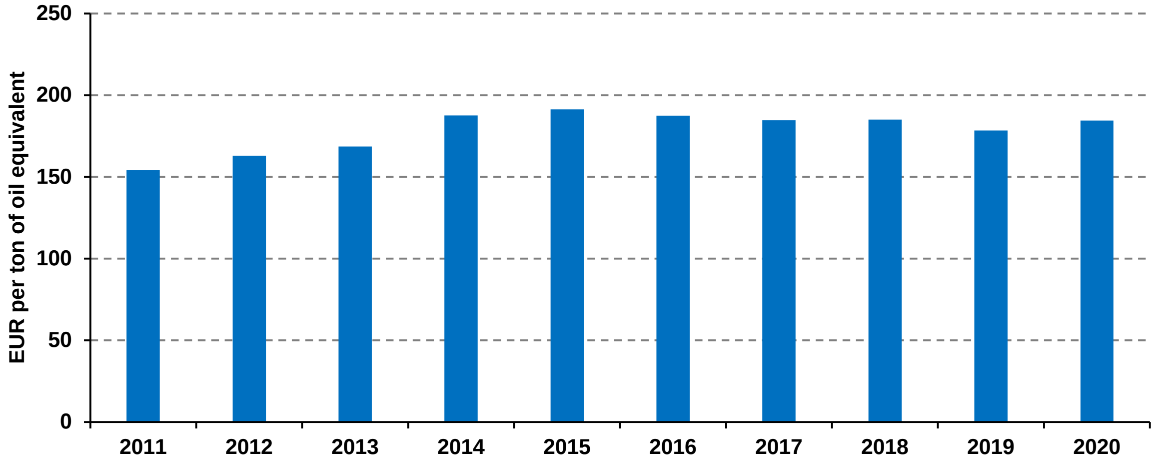
[55] https://ec.europa.eu/eurostat/databrowser/view/env_ac_tax/default/table?lang=en

***Figure 5.3:** Environmental taxes in the Slovak Republic by category*



Source: Eurostat

***Figure 5.4:** Development of the implicit tax rate on energy products in the Slovak Republic*



Source: Eurostat

5.3.6 Carbon Capture and Storage

Directive 2009/31/EC on the geological storage of carbon dioxide has been transposed into national legislation by Act No. 258/2011 Coll. on the permanent storage of carbon dioxide in the geological environment and on the amendment and supplementation of certain acts. Suitable geological sites have been identified in the Slovak Republic.

Affected greenhouse gases: CO_2

Type of measure: regulatory

5.3.7 National Emission Caps

The current Directive 2001/81/EC on national emission caps will be replaced from 1 July 2018 by the revised NEC Directive 2016/2284. Its main objective is to reduce the adverse health impacts of air pollution, including more than halving the number of premature deaths caused by air pollution each year. This revised Directive contains national emission reduction commitments for each Member State for the period up to 2030 (with interim objectives set for the period up to 2025) for six specific pollutants:

NO_x, SO_2, NMVOC, NH_3, $PM_{2,5}$ and CH_4. The NES Directive is transposed into national legislation by Act No. 137/2010 Coll. on Air and supplemented by Act No. 401/1998 Coll. on Air Pollution Charges.

Affected greenhouse gases: air pollutants: NO_X, SO_2, NMVOC, NH_3, $PM_{2,5}$and CH_4

Type of measure: regulatory

5.3.8 National Emissions Reduction Programme

Directive (EU) 2016/2284 on the reduction of national emissions of certain air pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC sets emission reduction targets for sulphur oxides, nitrogen oxides, non-methane volatile organic compounds, ammonia and $PM_{2.5}$ by 2030. Government Resolution No. 103/2020 of 5 March 2020 approved the National Emission Reduction Programme, which proposes policies and measures to achieve the above-mentioned national commitments in two phases, for the period from 2020 to 2029 and for the period after 2030. The National Emission Reduction Programme contributes to achieving the air quality objectives under Directive 2008/50/EC, as well as ensuring consistency with plans and programmes set out in other relevant policy areas, including climate, energy, agriculture, industry and transport. At the same time, it will encourage a shift of investment towards clean and efficient technologies.

Affected greenhouse gases: air pollutants: NO_X, SO_2, NMVOC, NH_3, $PM_{2,5}$

Type of measure: regulatory

5.4 SECTORAL POLICIES AND MEASURES: ENERGY

Since the publication of 7th National Climate Change Report of the Slovak Republic, some of the measures mentioned in this report have been implemented to varying degrees and have affected the level of GHG emissions in the projected base year 2019. The basic development of the activities determining the level of projected emissions resulted from the assumptions of macroeconomic development and the concepts of the relevant sectors of the national economy. Dynamic changes in global politics as well as economic developments in recent months have also significantly complicated the preparation of GHG emission projections, especially in view of the constant changes in the estimated development of macroeconomic indicators for the near future. The long-term development of greenhouse gas emissions also depends on other parameters, such as energy market developments, technological developments and the trading of CO_2 emission allowances. The ETS is one of the measures that was implemented before the projected base year, but the new trading period will continue to have an impact in the future. Nevertheless, the additional impact of this measure is limited due to the technical and economic potential. Despite the existing constraints resulting from dynamic changes in critical parameters, it is possible to reach a state of actual compliance with emission reduction objectives, as well as to create the conditions for further emission reductions after 2022.

The policies and measures used in the energy sector were taken from the Low Carbon Strategy of the Slovak Republic (LCDS)[56], the National Programme for the Reduction of Pollutant Emissions[57] and the Recovery Plan of the Slovak Republic.[58]

[56] https://www.minzp.sk/klima/nizkouhlikova-strategia

[57]https://www.minzp.sk/ovzdusie/ochrana-ovzdusia/narodne-zavazky-znizovania-emisii/narodny-program-znizovania-emisii/

[58] https://www.planobnovy.sk/kompletny-plan-obnovy/zelena-ekonomika

5.4.1 Impact of European legislation - Ecodesign Framework Directive

It sets out the ecodesign requirements for energy-using products governed by Framework Directive 2009/125/EC, which recasts Directive 2005/32/EC, as amended by Directive 2008/28/EC. The implementing regulations cover a wide range of products, including heaters, vacuum cleaners, computers, air conditioners, dishwashers, light fittings, fridges and freezers, televisions and electric motors.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2005

Implemented in the scenario: WEM

5.4.2 Impact of European legislation - Energy Labelling Directive (Directive 2010/30/EU)

The Labelling Directive establishes a framework for the harmonisation of national measures concerning information for the end-user, in particular through labelling and through standard information on the product, on the consumption of energy and, where appropriate, other essential resources during their use, as well as supplementary information concerning energy-intensive products, thereby enabling end-users to choose more efficient products. The Directive applies to energy-related products that have a "significant direct or indirect impact on energy consumption“. It shall also be applied to other essential resources as appropriate during use. The transposition of the Directive was ensured by Act No. 182/2011 Coll. on the labelling of energy-related products and on amending and supplementing certain acts.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2011

Implemented in the scenario: WEM

5.4.3 Impact of European legislation - Energy Performance of Buildings Directive (2010/31/EU)

This Directive promotes the improvement of the energy performance of buildings, taking into account external climatic and local conditions as well as indoor environmental requirements and cost-effectiveness. The transposition of the Directive was ensured by Act No. 300/2012 Coll. amending Act No. 555/2005 Coll. on the Energy Performance of Buildings and on Amendments and Additions to Certain Acts, as amended, and amending Act No. 50/1976 Coll. on Spatial Planning and Building Code.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: in force since 2012

Implemented in the scenario: WEM

5.4.4 Impact of European legislation - Energy Efficiency Directive (Directive 2012/27/EU)

Energy efficiency is a key area of action without which the full decarbonisation of the Union's economy cannot be achieved. On the basis of the Energy Efficiency Directive, the Union has been able to exploit cost-effective energy saving opportunities under the current energy efficiency policy. In December 2018, the Energy Efficiency Directive was amended as part of the Clean Energy for All Europeans package, notably to include a new headline Union energy efficiency target for 2030 of at least 32.5% (compared to projected energy use in 2030) and to extend and strengthen the energy savings obligation beyond 2020.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: in force since 2012

Implemented in the scenario: WEM

5.4.5 Impact of European legislation - Directive 2009/73/EC, Directive 2009/72/EC, Regulation (EC) 715/2009, Regulation (EC) 714/2009

European legislation relates in particular to the establishment of the internal energy market, including the provisions of the EU's 3rd Internal Market Package, which consists of Directive 2009/72/EC (Article 4) and Directive 2005/89/EC (Article 7). In the gas sector, a number of measures are expected to be implemented in the context of the strengthening of the internal gas market, e.g. to: enable and facilitate a liquid and competitive environment for the internal gas market; to enable and strengthen the diversification of routes and sources and thus increase the security of gas supply through increased flexibility of the gas network; to contribute to improving sustainable development in Europe, as natural gas plays a key role in the energy mix of the European Union, in particular with regard to economic development and environmental protection.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: in force since 2009

Implemented in the scenario: WEM

5.4.6 Impact of European legislation - Directive on the Promotion of the Use of Energy from Renewable Sources - Renewable Energy Directive - including the amendment on ILUC (Directive 2009/28 EC as amended by Directive (EU) 2015/1513)

The basic frameworks for the use of biofuels are Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, as well as Directive (EU) 2015/1513 of the European Parliament and of the Council amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources. With regard to the sustainability criteria, the Slovak Republic has implemented Articles 17, 18 and 19 of Directive 2009/28/EC and essentially identical Articles 7b, 7c and 7d of Directive 2009/30/EC, Article 7a of Directive 2009/30/EC, Directive 2015/652 and the relevant articles of Directive 2015/1513, through Act No. 309/2009 Coll. on the Promotion of Renewable Energy

Sources and High Efficiency Combined Generation, as amended, and Decree of the MŽP SR No. 271/2011 Coll., establishing sustainability criteria and targets for the reduction of greenhouse gas emissions from fuels, as amended. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) replaced Directive 2009/28/EC.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: in force since 2009

Implemented in the scenario: WEM

5.4.7 Impact of European legislation - "Clean Energy for All Europeans"

Implementation of the Commission's proposed EU target for a 27% share of renewable energy sources (RES) in total consumption by 2030, which was based on the draft "Clean Energy for All Europeans" package presented by the European Commission in November 2016. The modelling did not take into account the fact that a considerably more ambitious EU target (32%) was eventually adopted in December 2018.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2016

Implemented in the scenario: WEM

5.4.8 National Renewable Energy Action Plan, Government Resolution No. 677/2010

The impact of renewable energy sources in heat and power generation. Increase the share of electricity generation from renewable energy sources in the energy system. Increase biomass consumption for electricity and heat production.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2011

Implemented in the scenario: WEM

5.4.9 Impact of European legislation - EU ETS Directive 2003/87/EC as last amended in 2018 (Directive (EU) 2018/410)

The EU ETS is an economic and regulatory measure with a high positive impact on reducing greenhouse gas emissions, stimulating the use of biomass in the fuel mix and forcing technological innovation.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2013

Implemented in the scenario: WEM

5.4.10 Act No. 137/2010 Coll. on Air Protection as amended

This Act is supplemented by Act No. 401/1998 Coll. on air pollution charges, which serves to control and regulate emission limits for basic air pollutants.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2010

Implemented in the scenario: WEM

5.4.11 Increasing Energy Efficiency with a number of measures in force since 2014 on the energy consumption side, according to which energy savings show up as a reduction in final energy consumption

These measures are broken down by sector (buildings, industry, public sector, transport and appliances). In the buildings sector, it is mainly about improving the thermal-technical performance of buildings by carrying out cost-effective deep renovation. Legislation and changes to national technical standards since 2012 have introduced conditions for progressively stricter energy performance requirements for new and substantially renovated buildings, which are regularly reviewed. Measures in the buildings sector represent the most important source of potential energy savings by 2030.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2014

Implemented in the scenario: WEM

5.4.12 Optimisation of district heating systems

Switching from fossil fuels to biomass and natural gas and installing combined heat and power (CHP) units in district heating systems. Industrial cogeneration plants produce industrial steam, which can also be used for district heating or is a secondary use of industrial steam. Other measures are also taken into account (e.g. improving the efficiency of central heat supply (CHP) systems, installing innovative district heating technologies, improving heat supply from combined heat and power plants).

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2015

Implemented in the scenario: WEM

5.4.13 Closure of solid fuel heating plants

Phasing out of solid fuel heating plants from 2025

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2015

Implemented in the scenario: WEM

The specification of the **WAM** scenario according to the Low Carbon Development Strategy of the Slovak Republic depends on the logic of the draft EU scenarios and in particular on the EUCO3030 scenario[59], which sets the EU target for energy efficiency for 2030 at 30%.

The **WAM** scenario includes all measures from the **WEM** scenario named in the Low Carbon Development Strategy of the Slovak Republic, and additionally includes measures and more ambitious targets for RSE and EE, ambitious plans of the new EC under the Green Deal.[60]

5.4.14 Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050 (NUS SR)

The Low Carbon Development Strategy of the Slovak Republic through modelling sets the national target for RES at -18.91%, the national target for ESR is -20% and the national target for primary energy efficiency savings has been set in the model at -28.36%.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: in force since 2020

Implemented in the scenario: WAM

5.4.15 Increasing carbon prices under the EU ETS after 2020

The EU ETS carbon price affects the energy sector as well as energy-intensive industries and is a major driver of emissions reductions. Electricity generators will need to respond to the pressure of rising allowance prices to facilitate their own transition from coal to other low- to zero-emission sources.

Affected greenhouse gases: CO_2

Type of measure: economic

State: in force since 2020

Implemented in the scenario: WAM

5.4.16 Early decommissioning of solid fuel power plants

The decommissioning of the Vojany and Nováky power plants is foreseen in 2025 and 2023, in that order.

Affected greenhouse gases: CO_2

Type of measure: economic

State: estimated after 2023

Implemented in the scenario: WAM

[59] http://www.e3mlab.eu/e3mlab/index.php?option=com_content&view=article&id=532%3Aeuco-scenarios&catid=1%3Alatest-news&Itemid=82&lang=en

[60] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal#documents

5.4.17 Decarbonising electricity generation after 2020 through RES and nuclear development

Decarbonisation of electricity generation is achieved through renewables. Eligible renewable energy technologies include photovoltaic, solar, wind turbine and biomass.

Affected greenhouse gases: CO_2

Type of measure: economic

State: estimated after 2022

Implemented in the scenario: WAM

5.4.18 Renewable energy support scheme

They present RES support schemes in electricity generation with envisaged RES technologies such as solar photovoltaics, onshore wind turbines, biogas/biomethane and biomass. The scenarios assume support of 50 MW in the period 2021-2025, followed by support of a further 500 MW on the basis of auctions.

Affected greenhouse gases: CO_2

Type of measure: economic

State: estimated after 2022

Implemented in the scenario: WAM

5.4.19 Increasing the share of nuclear energy in the energy mix of the Slovak Republic

This increase in the medium term (2020-2025) will be mainly due to the commissioning of two new nuclear reactors at the Mochovce Nuclear Power Plant. The output of one new Mochovce unit will be 471 MWe (up to 535 MW in the future) and one reactor will thus cover 13% of Slovakia's electricity consumption. The new units will replace the capacity shortfall of the Novak lignite power plant, which will be in operation only until the end of 2023, as well as Slovakia's negative electricity import/export balance. Slovakia will thus once again become self-sufficient in the country's electricity supply and will be prepared for higher electricity consumption in the future, which will come with the development of electromobility.

Affected greenhouse gases: CO_2

Type of measure: regulatory, economic

State: estimated after 2023-2035

Implemented in the scenario: WAM

5.4.20 Continued reduction of final energy consumption in all sectors after 2020

The measure puts emphasis on policies supporting the acceleration of the renewal of the building stock (residential and non-residential, public and private), with a focus on carrying out cost-effective in-depth renovations and applying minimum energy performance requirements for near-zero energy buildings after 2020 for new buildings.

Most of the above measures were applied at the level of the Compact Primes for Slovakia[61] (CPS), model, and from which trends in energy consumption or other parameters were taken for emissions modelling in the TIMES model.[62]

Affected greenhouse gases: CO_2

Type of measure: regulatory, economic

State: estimated after 2022

Implemented in the scenario: WAM

5.4.21 Assessment of the future structure of appliances used for domestic heating based on survey data

The SHMÚ in cooperation with the Statistical Office of the Slovak Republic carries out a statistical survey, which aims to provide quantitative data on the sources, use of thermal energy in households (family houses) with individual heating, as well as on the equipment used for heating and heating such as boilers, fireplaces, stoves, cookers and also information on the consumption of mainly solid fuels. 494 municipalities will participate in this survey, with a total of 6,650 households. In the framework of the statistical survey in question, the characteristics (manufacturer, type/series, maximum output, age, fuel consumption) of heaters, as well as solar heating equipment, photovoltaic panels or heat pumps are collected. Households' use behaviour is also monitored - how much fuel residents procure, for how long, how firewood is stored before burning, or from what sources they procure coal and firewood. The results of the survey will be used, for example, to monitor the fulfilment of renewable energy targets and to compile emission balances of the Slovak Republic from individual household heating.

Affected greenhouse gases: CO_2

Type of measure: regulatory, economic

State: estimated after 2022

Implemented in the scenario: WAM

5.4.22 Green Households II

National Green Households projects are prepared under the Operational Programme Environmental Quality, which is managed by the MŽP SR. This is the second stage of a second phase of support aimed at the use of so-called small-scale renewable energy sources in family and apartment buildings with a budget of EUR 48 million. The objective of the project is to increase the share of RES use in households and the related reduction of greenhouse gas emissions. The project supports the Replacement of old solid fuel heating equipment (boilers) in households with low-emission systems.

The project should help to revitalise the market environment for household renewable energy equipment. At the same time, it should contribute to improving the awareness and practice of installers of RES equipment and to increasing interest in studies in related fields.

Affected greenhouse gases: CO_2

[61] https://www.minzp.sk/klima/nizkouhlikova-strategia; Integrated National Energy and Climate plan for 2021 to 2030 for Slovakia,“ 2019 [Online]: https://ec.europa.eu/energy/sites/ener/files/sk_final_necp_main_en.pdf

[62] https://iea-etsap.org/index.php/etsap-tools/model-generators/times

Type of measure: regulatory, economic

State: in force since 2015

Implemented in the scenario: WAM

5.4.23 Recovery and Resilience Plan - Restore Home Project

It represents a long-term programme of renovation of family houses funded through the Recovery Plan. This long-term programme of renovation of family houses will contribute to the renewal of the Slovak countryside, to protection against the adverse effects of climate change. The objective of this programme is to rehabilitate at least 30,000 houses by June 2026. The support through this project is aimed at already implemented renovations of family houses built before 2013. The investment is aimed at owners of older family houses, it allows to finance traditional energy saving measures (e.g. thermal insulation, replacement of windows, replacement of inefficient heat sources or installation of new RES equipment) and measures to support adaptation to climate change (e.g. vegetated roofs). The applicant must provide evidence of energy savings of at least 30%. In order to mobilise comprehensive and green regeneration, the scheme includes a combination of mandatory and optional parts. The achieved energy savings of the house renovation will be verified mainly through energy certificates.

Affected greenhouse gases: CO_2, CO, NO, NO_2, PM_{10}, $PM_{2,5}$, CO, NMVOC

Type of measure: regulatory, economic

State: in force since 2022

Implemented in the scenario: WAM

5.4.24 Awareness campaign and education on good coal and biomass burning practices - LIFE IP - Improving Air Quality (Populair)

The objective of this activity is to develop and implement educational programmes and information activities that will, on the one hand, raise the awareness of local officials and the public on the issue of air pollution, its causes and impacts; on the other hand, support air quality initiatives, involve the public and provide information on the support tools on offer. Information activities will reach a wide audience through communication campaigns and project web platforms. The training programmes will be primarily aimed at local government representatives, teachers, students and pupils.

Affected greenhouse gases: CO_2, CO, NO, NO_2, PM_{10}, $PM_{2,5}$, CO, NMVOC

Type of measure: regulatory, economic

State: in force since 2020

Implemented in the scenario: WAM

5.5 SECTORAL POLICIES AND MEASURES: ROAD TRANSPORT

5.5.1 Act No. 277/2020 on the Promotion of the Use of Energy from RES[63]

The latest amendment of Act No. 309/2009 on the promotion of renewable energy sources and high-efficiency cogeneration transposes Directive (EU) 2018/2001 of the European Parliament and of the

[63] https://www.slov-lex.sk/static/pdf/2009/309/ZZ_2009_309_20220901.pdf

Council on the promotion of the use of energy from renewable sources and sets targets for minimum RES shares.

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

State: in force since 2007

Implemented in the scenario: WEM

5.5.2 Impact of European legislation - Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO_2 Emission Performance Standards for New Passenger Cars and Light Commercial Vehicles[64]

The regulation includes a CO_2 reduction objective for passenger cars and light commercial vehicles. The reduction limit is 15% by 2025 and 55% for passenger cars and 50% for light commercial vehicles by 2030.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory

State: in force since 2019

Implemented in the scenario: WEM

5.5.3 Impact of European legislation - Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 Setting CO_2 Emission Performance Standards for New Heavy Duty Vehicles[65]

The regulation includes a target for reducing CO_2 emissions for trucks by 15% by 2025 and by 31% by 2030 compared to the reference period /July 2019-June 2020).

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory

State: in force since 2019

Implemented in the scenario: WEM

5.5.4 Energy efficiency in road transport[66]

Increasing the energy efficiency of internal combustion engines and other types of propulsion is expected in the context of European Parliament Regulations 2019/631 and 2019/1242.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory

State: in force since 2019

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[64] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0631

[65] https://eur-lex.europa.eu/eli/reg/2019/1242/oj

[66] https://www.minzp.sk/klima/nizkouhlikova-strategia; https://ec.europa.eu/energy/sites/ener/files/sk_final_necp_main_en.pdf

Implemented in the scenario: WEM

5.5.5 Promoting the sale of low- and zero-emission vehicles[67]

Significant support is foreseen for the sale of electric vehicles. Support will be introduced on the basis of the Action Plan for the Development of Electric Vehicles in the Slovak Republic.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.5.6 Long-term financial mechanism to support the development of charging infrastructure for electromobility[68]

Based on the Action Plan for the Development of Electric Vehicles in the Slovak Republic and the EU proposal revision to AFIR under Fit for 55, charging points are to be built along the main thoroughfares approximately every 60 km.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.5.7 Setting stricter requirements for periodic technical inspections of vehicles[69]

Stricter technical and emission controls should result in the capture and removal of the oldest and non-compliant vehicles from transport. Strict rules are now in place for technical and emission control stations, but despite these measures, the rules are still being circumvented. The effect of this measure is projected to gradually diminish by 2050 as a result of changes in vehicle owner behaviour and good maintenance and disposal of older vehicles.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory

State: planned for 2023

Implemented in the scenario: WAM

5.5.8 Vehicle registration fee based on grams of CO_2/km emissions

The introduction of a new registration fee, or "environmental tax", considers the CO_2 emissions produced by passenger cars.

Affected greenhouse gases: CO_2, CH_4, N_2O

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[67] https://www.mhsr.sk/uploads/files/5wuw3LIe.pdf

[68] https://www.minzp.sk/klima/nizkouhlikova-strategia

[69] https://environment.ec.europa.eu/topics/air_en

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.5.9 Modal shift to public transport - Strategic Transport Development Plan 2030[70]

The measure is intended to make public passenger transport (PPT) in and between cities more attractive. Inter-city rail transport is to be favoured, with the possibility of using a Park and Ride system.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.5.10 Modal shift in the transport of goods[72]

The railway transport of goods over longer distances should be preferred through the construction of the railway terminal Žilina.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: planned for 2025

Implemented in the scenario: WAM

5.5.11 Introduction and promotion of hydrogen powered vehicles (FCEV)[71]

Launching support for the purchase of hydrogen powered vehicles across all categories, but especially in freight and buses. The measure is built on the EU Hydrogen Strategy.

Affected greenhouse gases: CO_2, CH_4, N_2O

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.5.12 Blending biomethane into CNG and LNG[65]

In Slovakia, this obligation will be introduced by an amendment to Act No. 309/2009 on the promotion of renewable energy sources and high-efficiency cogeneration. Under the amendment, the share of biomethane will grow from 2% to 14% in 2030

Affected greenhouse gases: CO_2

Type of measure: regulatory and economic

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[70] https://www.minzp.sk/klima/nizkouhlikova-strategia, https://www.mindop.sk/index/open_file.php?file=doprava/dopinfra/program/Dokumenty/fondyeu20142020/StrategickyPlan2030/Strategicky_plan_2030.pdf

[71] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301

State: planned for 2023

Implemented in the scenario: WAM

5.6 SECTORAL POLICIES AND MEASURES: INDUSTRY

Although the EU ETS Directive[72] has been in force since 2005 and is now in its fourth phase (2021-2030), the ESR[73] has been in force since 2013-2020, with a base year of 2005 (the year from which emission reductions under the ESR are calculated). Another difference between the two systems is the application of their obligations. While the EU ETS does not contain country-specific commitments, but annual trajectories of emission cap reductions, for the ESR the commitment is valid at the country level. Emissions under both systems undergo annual international inspections.

Two scenarios, **WEM** and **WAM**, have been prepared for the purpose of determining the objective for 2030 and subsequently for 2050 in the different categories of industrial activities not included in the EU ETS. Separately for all three groups of IPPU categories, namely CO_2, CH_4 and N_2O emissions in categories 2.A – 2.D, HFCs emissions in category 2.F and N_2O and SF_6 emissions in category 2.G.

The policies and measures taken into account in each scenario are based on a number of national documents:

- Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050[74]
- National Emissions Reduction Programme (NAPCP)[75]
- Integrated National Energy and Climate Plan of Slovakia (NECP)[76]

In addition to these documents, separate laws and European legislation also intervene in the preparation of individual scenarios. Act No. 277/2020 amending Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High Efficiency Combined Generation significantly interferes with the preparation of laws.[77] Within the framework of common European legislation, these are in particular directives setting emission limits and the European Parliament's Energy Union Governance Regulation 2018/1999, complemented by Regulation 2021/1119[78], which establishes a framework for achieving climate neutrality.[79]

The policies and measures used were taken from the Low Carbon Strategy of the Slovak Republic from the National Programme for the Reduction of Pollutant Emissions and from the Recovery Plan of the Slovak Republic.[80]

The presented reduction potential is based on the **WEM** and **WAM** scenarios reported for emission projections in 2021 under Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action.

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[72] https://eur-lex.europa.eu/legal-content/SK/TXT/HTML/?uri=CELEX:02003L0087-20180408&from=EN

[73] https://eur-lex.europa.eu/legal-content/SK/TXT/HTML/?uri=CELEX:32018R0842&from=EN

[74] https://www.minzp.sk/klima/nizkouhlikova-strategia

[75]https://www.minzp.sk/ovzdusie/ochrana-ovzdusia/narodne-zavazky-znizovania-emisii/narodny-program-znizovania-emisii

[76]https://www.minzp.sk/ovzdusie/ochrana-ovzdusia/narodne-zavazky-znizovania-emisii/narodny-program-znizovania-emisii

[77] Act No. 309/2009 on the Promotion of Renewable Energy Sources and High Efficiency Combined Production and on Amendments and Additions to Certain Acts

[78] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG

[79] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal#documents

[80] https://www.planobnovy.sk/kompletny-plan-obnovy/zelena-ekonomika/

The specification of the **WAM** scenario according to the Low Carbon Development Strategy of the Slovak Republic depends on the logic of the draft EU scenarios and in particular on the EUCO3030 scenario, which sets the EU target for energy efficiency for 2030 at 30%.

Most of the above measures were applied at the level of the Compact Primes for Slovakia (CPS[81]), model, and from which trends in energy consumption or other parameters were taken for emissions modelling in the TIMES model[82] (**WEM** = **WAM** scenario).

5.6.1 Best Available Techniques (BAT) for servicing electrical equipment

Stable SF_6 emission factors from electrical equipment due to the use of BAT in servicing electrical equipment.

Affected greenhouse gases: SF_6

Type of measure: regulatory and economic

State: in force since 2015

Implemented in the scenario: WEM, WAM

5.6.2 New mandatory parameters for fluorinated gases

In addition to the parameters described in the **WEM** scenario for fluorinated gases, foams containing HFCs will be banned, high GWP refrigerants will also be restricted. Increased use of fluorinated gases not covered by the IPCC (such as heavy fuel oils (HFOs)) will start to increase significantly after 2025. The use of lower GWP fluorinated gases in aerosols and fire extinguishers will be mandatory. Obligation to include zero GWP gases (as supplementary gases) in new installations to replace gases used in refrigeration after 2033.

Affected greenhouse gases: HFC

Type of measure: regulatory and economic

State: planned for 2025

Implemented in the scenario: WEM, WAM

5.6.3 Impact of European legislation - Regulation (EU) No. 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated GHG

The implementation of Regulation 517/2014 of the European Parliament and of the Council will result in a reduction of F-gas emissions, due to the ban on the placing on the market of certain F-gases under this Regulation.

Affected greenhouse gases: HFC, PFC, SF_6

Type of measure: regulatory

State: in force since 2015

Implemented in the scenario: WEM, WAM

[81] . https://www.minzp.sk/files/iep/2019_01_low-carbon-study.pdf

[82] https://iea-etsap.org/index.php/etsap-tools/model-generators/times

5.6.4 Implementation of the EU ETS in the industrial sector processes

The implementation of the EU ETS stimulates the use of biomass in the fuel mix of energy producers and encourages technological innovation. This policy is an economic and regulatory measure with a high positive impact on reducing greenhouse gas emissions. The EU ETS policy is expected to force emitters to install new boilers to replace some less efficient or obsolete equipment and also to allow a switch to alternative fuels (biomass, natural gas or biogas).

Affected greenhouse gases: HFC, PFC, SF_6

Type of measure: regulatory

State: in force since 2013

Implemented in the scenario: WEM, WAM

5.6.5 Further reduction of N_2O content in aerosol cans

Further reduction of N_2O in aerosol cans after 2025. The more significant, i.e. marked, decrease in emissions after 2025 will be due to the replacement of anaesthesia.

Affected greenhouse gases: N_2O

Type of measure: regulatory and economic

State: in force since 2017

Implemented in the scenario: WAM, WEM

5.6.6 Impact of EU legislation - Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on Binding Annual GHG Emission Reductions by Member States from 2021 to 2030 to Contribute to Climate Action to Meet their Commitments under the Paris Agreement and amending Regulation (EU) No. 525/2013

This Regulation shall apply to greenhouse gas emissions from the IPCC categories relating to energy, industrial processes and product use, agriculture and waste established pursuant to Regulation (EU) No. 525/2013, with the exception of greenhouse gas emissions from activities listed in Annex I to Directive 2003/87/EC.

While EU ETS emissions have their reduction mechanisms set by allocated allowances at the operator level, ESR emissions are not sectoral regulated and the ESR reduction target is set only at the level of the country as a whole (for Slovakia according to Annex I: -12%).

Affected greenhouse gases: CO_2, CH_4, NO_2, HFC; PFC; SF_6

Type of measure: regulatory

State: in force since 2015

Implemented in the scenario: WEM, WAM

5.7 SECTORAL POLICIES AND MEASURES: AGRICULTURE

5.7.1 Common Agricultural Policy Strategic Plan 2023-2027[83]

The Strategic Plan sets out the rules for the use of agri-subsidies between 2023 and 2027. Strategy measures are implemented in the form of an on-farm investment strategy to reduce GHG and ammonia emissions.

Affected greenhouse gases: N_2O, CH_4

Type of measure: regulatory and economic

State: planned for 2023

Implemented in the scenario: WAM

5.7.2 Decree of the MŽP SR No. 410/2012 Coll.[84]

Obligation to comply with measures to reduce ammonia emissions at major sources of air pollution. The measure is primarily designed to reduce ammonia, but also has an impact on reducing emissions of N_2O. The projections assume compliance with slurry and manure containment at farms (sources of air pollution).

Affected greenhouse gases: $NH_{3,}$ N_2O

Type of measure: regulatory and economic

State: in force since 2012

Implemented in the scenario: WEM

5.7.3 National Emissions Reduction Programme[85]

Obligation to comply with measures to reduce ammonia emissions also at medium sources of air pollution. The measure is primarily designed to reduce ammonia, but also has an impact on reducing N_2O emissions. The measure will also be implemented in the amendment to the Air Act No. 137/2020 Coll. and the Decree of the MŽP SR 410/2012 Coll. The projections assume compliance with isolation of slurry and manure from the surroundings on medium and large farms (sources of air pollution).

Affected greenhouse gases: $CH_{4,}$ N_2O

Type of measure: regulatory and economic

State: New sources of pollution since 2021, existing sources since 2030

Implemented in the scenario: WAM

5.7.4 Impact of European legislation - Methane Strategy[86]

This strategy sets out measures to reduce methane emissions in Europe and internationally. It introduces legislative and non-legislative measures in the energy, agriculture (monitoring methane emissions at

[83] https://www.mpsr.sk/spolocna-polnohospodarska-politika-2023-2027/462

[84] https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2012/410/

[85] https://www.minzp.sk/files/oblasti/ovzdusie/ochrana-ovzdusia/dokumenty/strategia-ochrany-ovzdusia/vlastny-material-narodny-program-znizovania-emisii-sr_final.pdf

[86] https://ec.europa.eu/energy/sites/ener/files/eu_methane_strategy.pdf

farm level, recovering waste and residue streams from agriculture through anaerobic digestion, improving the quality of animal feed (innovating compound feed), feed additives and feeding techniques) and waste management sectors, which account for around 95% of methane emissions associated with human activities worldwide.

Affected greenhouse gases: CH_4, N_2O

Type of measure: regulatory and economic

State: in force since 2021

Implemented in the scenario: WAM

5.7.5 Impact of European legislation - Farm to Fork Strategy[87]

The strategy aims to reduce the use of pesticides, fertilisers and antibiotics in agriculture. This strategy has been developed in synergy with the European Green Deal, which aims to mitigate the environmental and climate footprint of the European food system. European target for a 20% reduction in inorganic nitrogen fertilisers compared to 2030.

Affected greenhouse gases: N_2O

Type of measure: regulatory and economic

State: planned for 2025

Implemented in the scenario: WAM

5.7.6 Impact of European legislation - Code of Good Agricultural Practice[88]

The current Framework Code was issued under the Gothenburg Protocol Amendment to provide recommendations on good agricultural practice in livestock farming and manure application to achieve reductions in ammonia emissions. This is an update of the 2001 document, reflecting new opportunities and knowledge. This document is intended to serve as a starting point for the development of national codes. Opportunities to reduce ammonia emissions from agricultural activities are not only a challenge in relation to improving the environment, but also an opportunity for farmers to take advantage of the benefits that nitrogen savings bring. Agriculture as the dominant source of ammonia emissions, mainly from livestock excreta in stables, manure storage, processing, manure treatment and land application, and from animal excreta during grazing.

Affected greenhouse gases: N_2O, CH_4

Type of measure: regulatory and economic

State: in force since 2020

Implemented in the scenario: WAM, WEM

[87] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381

[88] https://www.minzp.sk/files/oblasti/ovzdusie/ochrana-ovzdusia/metodicke-postupy-prirucky/kodex_spravnej_polnohosp_praxe_final.pdf

5.7.7 Low Carbon Strategy of the Slovak Republic[89]

Efficient storage of animal waste, specifically storage of liquids in tanks isolated from the surroundings or in tanks with access to oxygen and storage of manure in plastic sheeting with no or minimal addition of water. Interventions in animal feeding to reduce emissions. Efficient treatment of animal waste and use of biogas, especially as a local energy source. Increase the use of nitrogen fertilisers with stabilised nitrogen at the expense of urea.

Affected greenhouse gases: N_2O, CH_4

Type of measure: regulatory and economic

State: planned for 2025

Implemented in the scenario: WAM

5.7.8 Impact of European legislation - Fit for 55[90]

Greenhouse gas reductions under the Green Deal, the package also implies a Farm to fork strategy. Regulating and setting ambitious targets for reducing emissions from agriculture and related land use, which should include strict criteria for biomass-based renewable energy production, reducing the use of inorganic fertilisers, reducing the use of chemical pesticides, increasing the area under organic farming, and meeting the EU's 2030 climate targets

Affected greenhouse gases: N_2O, CH_4

Type of measure: regulatory and economic

State: planned for 2025

Implemented in the scenario: WAM

5.8 SECTORAL POLICIES AND MEASURES: WASTE

In general, the more waste we produce, the more we have to get rid of. Some waste disposal methods release both pollutants and greenhouse gases into the air. Recycling is one method of reducing the impact of waste disposal on the air and climate. However, there are also ways of dealing with waste that are more environmentally friendly. The waste management sector consists of the following categories:

- 5.A Landfilling of solid waste
- 5.B Biological treatment of solid waste
- 5.C Incineration and uncontrolled burning of waste
- 5.D Wastewater treatment

The most common disposal methods are landfill and, to a lesser extent, incineration. As waste from landfills decomposes, non-methane volatile organic compounds (NMVOCs) and methane are released into the air, and particulate matter (PM) emissions are released when the waste is handled.

Incineration is the second most common method of waste disposal in the Slovak Republic. In the past, this energy was not often used and waste was only disposed of. Modern plants now use waste as a fuel in the production of energy or heat, and waste is recovered in this way. In this case, the emissions from

[89] https://www.minzp.sk/klima/nizkouhlikova-strategia

[90] https://www.minzp.sk/files/oblasti/politika-zmeny-klimy/oznamenie_celex-52021dc0550-sk-txt.pdf, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

combustion are classified in the energy sector. In our country, waste incineration contributes significantly to the amount of dioxins and furans (PCDDs/PCDFs) that are emitted into the air. Since dioxins are virtually undegradable in nature and can persist for hundreds of years, they are deposited in animal tissues and thus enter the human food chain. Dietary intake, especially of meat, fish, eggs, milk and fats, is the most important route of entry of dioxins into the human body. Incineration of waste also releases high levels of heavy metal emissions into the air. Modern waste incinerators capture these substances efficiently, but this was not common practice in the past. Heavy metals are deposited in the soil and subsequently in organisms, from which they are difficult to break down. Thanks to the food chain, the contamination of organisms is gradually increasing. Animals at the end of the food chain, and therefore humans, are particularly at risk from heavy metals. The risk is particularly higher in coastal areas where seafood consumption is generally higher.

Recycling is not the only sustainable way to recover waste. Composting any organic waste, such as food and garden waste, is one of them. The organic waste decomposes into mulch within a few weeks, which can be used as a fertiliser for the soil. Many households practise small-scale composting and large-scale composting systems are being developed with the collection of organic waste from parks and urban amenities. Similar types of organic waste can also be treated in biogas plants. Unlike composting, here the waste is decomposed anaerobically (without access to air) and biogas is produced, which can be further burned to generate energy that can be used for heating.

Also included in this sector are cremations of human and animal remains, which are also a source of air pollution through emissions of heavy metals and POPs.

Wastewater treatment also releases pollutants and greenhouse gases (both CH_4 and N_2O). In general, emissions of POPs as well as NMVOCs, CO and NH_3 occur in wastewater treatment plants, but in most cases these are negligible.

5.8.1 Act No. 79/2015 Coll. on Waste and on amendments and additions to certain acts, as amended[91]

This Act emphasises the sorting of packaging and recyclable materials. It also changes the funding scheme for separate collection from the State Recycling Fund to the Producer Responsibility Organisation. Disposal of waste is only allowed at permitted controlled landfills). This Act prohibits the disposal of garden waste, biodegradable waste by landfill and incineration, and requires the separate collection of kitchen waste. In particular, the Act aims to reduce the amount of waste that is disposed of by landfilling, to adjust and focus on waste prevention, to minimize the negative impacts of waste generation and management on the environment and human health, to introduce and apply extended producer and importer responsibility in a standard way common in other EU Member States and to translate it to the municipal level.

Affected greenhouse gases: CO_2, CH_4, and N_2O

Type of measure: regulatory and economic

State: in force since 2015

Implemented in the scenario: WEM, WAM

[91] https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2015/79/20220630

5.8.2 Waste Management Programme of the Slovak Republic for 2021-2025[92]

The main objective of the waste management of the Slovak Republic for the period 2021-2025 is the diversion of waste from landfill disposal, especially for municipal waste, increasing recycling together with improving sorted collection and introducing and increasing reuse. It includes a number of key climate change mitigation objectives: Increase the rate of separate collection of municipal waste to 60% by 2025 and the rate of preparation for re-use and recycling of municipal waste to 55%; reduce the share of biodegradable municipal waste in mixed municipal waste to 25% by 2025, divert municipal waste from landfill to 10% by 2035. In the area of textile collection, the main objective is to create a functional system for textiles in the Waste Act with effect from 1 January 2025.

Affected greenhouse gases: CO_2, CH_4, and N_2O

Type of measure: regulatory and economic

State: in force since 2021

Implemented in the scenario: WEM, WAM

5.8.3 Concept of Water Policy of the Slovak Republic until 2030 with a view to 2050

The main objective of the concept is to ensure the gradual restoration of damaged water bodies, to halt water pollution and the decline in groundwater quantity, as well as to ensure the availability of drinking water in the regions. It defines ten priorities, interlinked areas, one of the main objectives being to increase the proportion of the population connected to sewerage systems, with the aim of achieving 85% coverage by 2050.

Affected greenhouse gases: CH_4 and N_2O

Type of measure: regulatory

State: in force since 2022

Implemented in the scenario: WEM, WAM

5.8.4 Act No. 302/2019 on the Back-up of Disposable Beverage Packaging and on amending and supplementing certain acts

This law triggered the operation of the back-up of disposable beverage containers. This Act applies to disposable beverage packaging placed on the market in the Slovak Republic and to waste from such packaging. The Act regulates, among other things, the competence of state administration bodies in the field of backup of disposable beverage packaging and waste from such packaging, state supervision and the procedure of state supervision bodies in its performance, administrative offences and the procedure for the imposition of fines.

Affected greenhouse gases: CH_4,

Type of measure: regulatory and economic

State: in force since 2019

Implemented in the scenario: WEM, WAM

[92]https://www.minzp.sk/files/sekcia-enviromentalneho-hodnotenia-riadenia/odpady-a-obaly/registre-a-zoznamy/poh_sr_2021_2025_vestnik.pdf

5.9 SECTORAL POLICIES AND MEASURES: LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR (LULUCF)

In 2021, there have been quite a number of changes in sectoral policies and measures relating to the LULUCF sector itself, or policies and measures that have a more significant impact on its operation. At EU level, this mainly involved the publication of the EU Forest Strategy, as well as a proposal to revise Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land-use change and forestry in the 2030 framework for climate and energy policies. At the national level, progress has been made in the preparation of the National Forestry Programme of the Slovak Republic 2022-2030; the preparation of the Strategic Plan of the Common Agricultural Policy for the period 2023-2027 or the adoption of the amendment to the Law on Nature and Landscape Protection.

5.9.1 Impact of European legislation - EU Forest Strategy 2030[93]

The EU Forest Strategy 2030 sets out a policy framework for forests at EU level up to 2030, aiming to ensure healthy and resilient forests and their multifunctional role for the benefit of European society. The strategy, which is part of the European Green Deal, proposes options for the introduction of various regulatory, financial and voluntary instruments to enable the forestry and downstream sectors to contribute to a successful transition towards a climate-neutral economy. While primarily focused on the EU's forests, the Strategy recognises that forest-related challenges are inherently global and therefore also aims to strengthen the EU's contribution to global efforts to protect and restore the world's forests.

Affected greenhouse gases: CO_2

Type of measure: strategic (note: this is an EU-level strategic document setting out priorities for Europe's forests and their sustainable management up to 2030)

State: in force since 2021 up to 2030

Implemented in the scenario: BAU without direct mitigation potential

5.9.2 Impact of European legislation - Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the Integration of GHG Emissions and Removals from LULUCF into the 2030 Climate and Energy Policy Framework[94]

The Regulation sets EU targets for greenhouse gas emissions and removals in the LULUCF sector, as well as rules on the accounting of emissions and removals for the purpose of this target and the conditions and monitoring of compliance with these objectives. This Regulation is part of the implementation of the Union's commitments under the Paris Agreement on climate change. The Regulation is currently under revision with the aim of increasing the contribution of the LULUCF sector at EU and Member State level to the Union's target of reducing greenhouse gas emissions by 55% by 2030 compared to 1990.

Affected greenhouse gases: CO_2

Type of measure: regulatory

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[93] https://data.consilium.europa.eu/doc/document/ST-13537-2021-INIT/sk/pdf

[94] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0001.01.ENG

State: in force since 2020, in the process of revision

Implemented in the scenario: BAU (the objectives are not based on any projection scenarios and the regulation does not define any measures to be incorporated into the projection scenarios).

5.9.3 Rural Development Programme 2014-2020 extended until 2022[95]

Measures of the Slovak Republic Rural Development Plan for the period 2014-2020 provide financial support for measures included in the **WEM** scenario such as:

- afforestation of land not used for agriculture,
- establishment of stands of fast-growing trees on agricultural land,
- grassing of agricultural land,
- fire reduction measures,
- sustainable forest management, including restoration of forest ecosystems after natural disturbances.

The duration of the programme has been extended to 2022, with projects to be implemented by 2025. Some of these measures are also included in the National Forestry Programme and the Low Carbon Strategy of Slovakia.

Affected greenhouse gases: CO_2

Type of measure: economic

State: in force since 2022

Implemented in the scenario: WEM

5.9.4 Slovak Rural Development Programme for the period 2023-2027[96]

A substantial part of the support of the Slovak Republic Rural Development Plan for the period 2023-2027 is focused on adaptation to climate change. The planned measures are intended to contribute to the specific objective of CAP S04: SO4 "Contribute to climate change mitigation and adaptation, including the reduction of greenhouse gas emissions and improved carbon storage as well as the promotion of sustainable energies". In particular, these are the following measures:

- protection and maintenance within the established agroforestry system,
- setting up an agroforestry system,
- afforestation of agricultural land,
- investment in increasing the water retention function of forests,
- integrated projects for good management practice in forests (part - non-productive investments),
- integrated projects for good management practice in forests (part - productive investments),
- forest restoration projects.

Affected greenhouse gases: CO_2

Type of measures: economic

State: in preparation (2023)

Implemented in the scenario: WAM

[95] https://agriculture.ec.europa.eu/common-agricultural-policy/rural-development_sk

[96] https://agriculture.ec.europa.eu/common-agricultural-policy/rural-development_sk

5.9.5 National Forestry Programme of the Slovak Republic 2022-2030[97]

The National Forestry Programme of the Slovak Republic is the basic document of the state forestry policy and a strategic and political instrument of the state for the direction of sustainable forest management at the national level, including prevention of deforestation (as an integrated part of sustainable forest management). Its preparation represents efforts to streamline inter-ministerial cooperation and the implementation of international commitments related to forests and forestry.

Affected greenhouse gases: CO_2

Type of measures: economic

State: in preparation (2023)

Implemented in the scenario: WAM

5.9.6 Motivating forest managers to implement forest protection measures in the most threatened stands within the National Forestry Programme

One of the strategic objectives of the National Forestry Programme is to implement adaptation measures in forests threatened by climate change. It is followed by a specific objective and measures aimed at improving the effectiveness of the implementation of forest protection measures against biotic and abiotic harmful agents (mainly bark beetles and wind) in the most threatened stands. The measures are aimed at slowing down the decay of the currently most threatened forests in Slovakia (spruce and pine forests, unstable forest stands). The expected outcome of the measures is a steady-state annual volume of calamitous forest harvesting lower by 30% compared to the projection for 2030 for the zero option (without measures), or a reduction from a steady-state peak of 5.5 million m^3 in 2020 to a value of 4.4 million m^3 in 2030. However, the expected reduction in the volume of calamitous logging is dependent on future support and timely implementation of the above measures. In case of insufficient support or other obstacles to the timely implementation of the measures, there is a high probability that these results will not be achieved.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2023

Implemented in the scenario: WAM

5.9.7 Motivating forest managers to introduce future climate target tree species into stands where natural regeneration cannot be expected (within the National Forestry Programme)

The measure is part of an objective aimed at modifying tree species composition in order to increase the resilience of stands to drought and reduce vulnerability to biotic and abiotic factors. It should be targeted to promote 1) the introduction of beech and fir into threatened and declining spruce forests, 2) the introduction of summer oak and winter oak into stands of pine, hornbeam, acacia, cedar and other lowland and foothill trees, and 3) the introduction of an appropriate mix of habitat-appropriate valuable broadleaved trees. The introduction should be carried out in the form of bio groups (clumps) of the introduced tree species on about 10% of the area of the affected stand. The objective also includes the

[97] https://www.mpsr.sk/aktualne/sme-o-krok-blizsie-k-finalnej-verzii-narodneho-lesnickeho-programu-na-roky-2022-2030/16990/

creation of conditions for the conservation of the gene pool of forest tree species and its use in assisted migration, the incorporation of Models of Adaptation of Slovak Forests to Climate Change (NLC, 2019), Alternative Models of Forest Management - outputs of the ALTERFOR project (TUZVO), and other available knowledge on the role and usefulness of preparatory tree species (birch, aspen, aspen, rowan, rowan) in calamitous groves.

Maintaining vital forests by limiting the negative impacts of climate change on forests through measures aimed at forest adaptation (support for the use of alternative management models to adjust tree species composition, use of suitable provenances) is also included in the National Forestry Programme and the Low Carbon Strategy of Slovakia.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2023

Implemented in the scenario: WAM

5.9.8 Motivating forest managers to start the process of conversion to nature-friendly forms of forest management within the National Forestry Programme

The measures stem from another strategic objective of the National Forestry Programme, such as the introduction of nature-friendly forms of forest management (Strategic Objective II), which can also be expected to result in a higher stock of biomass, and hence carbon sequestered in forests. The measure is intended to motivate forest managers to start a relatively complex and long-term process of transition of forests to nature-friendly forests, at least on ¼ of the area of forests in Slovakia, where especially at the beginning, temporarily increased operational and overhead costs are expected.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2023

Implemented in the scenario: WAM

5.9.9 Expansion of areas under strict protection

This is a measure resulting from the adopted amendment to Act No. 356/2019 Coll. of 11 September 2019 amending Act No. 543/2002 Coll. on the Protection of Nature and Landscape, as amended, and amending and supplementing certain acts.[98] Extension of the no-intervention regime to 75% of the area of national parks by 2030, i.e. an increase of approximately 130 thousand ha compared to the current situation. A temporary increase in interceptions in these forests is expected. However, the effect of this measure will diminish over time. At the same time, the modelled quantification does not include the effects of natural disturbances in these forests, which will not be actively managed to protect them against biotic and abiotic damaging agents, which may significantly affect the stability of the carbon sinks thus achieved both before and after 2030 in these forests.

Affected greenhouse gases: CO_2

Type of measure: regulatory

[98] https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2019/356/vyhlasene_znenie.html

State: in force since 2019

Implemented in the scenario: WAM

5.9.10 Transfers of unused agricultural land to forest land

Increase of the forest area by settlement and inclusion of the so-called white areas in the forest land in the range of 100 thousands ha by 2030. It results from several strategic documents - the National Forestry Programme and the Environmental Policy Strategy of the Slovak Republic until 2030.[99]

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2024

Implemented in the scenario: WAM

5.9.11 Increasing the share of long-life wood products (HWP), including for construction purposes

The measure results from the Low Carbon Development Strategy of the Slovak Republic.[100] More efficient use of products based on the principles of circular bioeconomy is also part of the upcoming National Forestry Programme of the Slovak Republic 2022.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2024

Implemented in the scenario: WAM

5.9.12 Implementation of measures to increase carbon sequestration in agricultural soils and maintain high levels of organic carbon in carbon-rich soils

Farm soils rich in carbon is key to soil productivity. Carbon-rich soils contribute to yield and long-term sustainability which can have good impacts on profit. The measure results from the Low Carbon Development Strategy of the Slovak Republic.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2023

Implemented in the scenario: WAM

5.9.13 Grassland maintenance and restoration

Grasslands in Slovakia are currently facing new challenges. The role of grasslands in providing ecosystem services is widely recognized, but the decline in the area being used for livestock production requires alternative land uses to be developed in order to stabilize the grassland area and maintain it in

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[99] https://www.minzp.sk/files/iep/03_vlastny_material_envirostrategia2030_def.pdf

[100] https://www.minzp.sk/klima/nizkouhlikova-strategia/

agricultural condition. The measure results from the Low Carbon Development Strategy of the Slovak Republic.

Affected greenhouse gases: CO_2

Type of measure: regulatory

State: planned for 2024

Implemented in the scenario: WAM

5.10 POLICIES AND MEASURES THAT ARE NO LONGER IN FORCE

No policies and measures with a significant impact on reducing GHG emissions have been repealed without replacement. Act No. 572/2004 Coll. on Emission Allowance Trading and on Amendments and Additions to Certain Acts has been fully replaced by Act No. 414/2012 Coll. on Emission Allowance Trading and on Amendments and Additions to Certain Acts.

Slovak Government Regulation No. 488/2010 Coll. has been fully replaced by Slovak Government Regulation No. 342/2014 Coll. laying down the rules for granting support in agriculture in connection with decoupled direct payment schemes.

CHAPTER 6 PROJECTIONS AND OVERALL IMPACTS OF POLICIES AND MEASURES

6.1 ENERGY SECTOR

Since the publication of 7th National Climate Change Report of the Slovak Republic, some of the measures mentioned in this report have been implemented to varying degrees and have affected the level of GHG emissions in the projected base year 2019. The basic development of the activities determining the level of projected emissions resulted from the assumptions of macroeconomic development and the concepts of the relevant sectors of the national economy. Dynamic changes in global politics as well as economic developments in recent months have also significantly complicated the preparation of GHG emission projections, especially in view of the constant changes in the estimated development of macroeconomic indicators for the near future. The long-term development of greenhouse gas emissions also depends on other parameters, such as energy market developments, technological developments and the trading of CO_2 *emission allowances. The ETS is one of the measures that was implemented before the projected base year, but the new trading period will continue to have an impact in the future. Nevertheless, the additional impact of this measure is limited due to the technical and economic potential. Despite the existing constraints resulting from dynamic changes in critical parameters, it is possible to reach a state of actual compliance with the emission reduction targets, as well as to create the conditions for further emission reductions after 2022.*

6.1.1 Parameters and PAMs Used in the Energy Sector

The policies and measures used were taken from the Low Carbon Strategy of the Slovak Republic[101], the National Programme for the Reduction of Pollutant Emissions[102] and the Recovery Plan of the Slovak Republic.[103]

WEM scenario includes the following policies and measures at EU level and related national measures.

- Ecodesign Framework Directive (Directive 2005/32/EC)
- Energy Labelling Directive (Directive 2010/30/EÚ)
- Energy Performance of Buildings Directive (2010/31/EU), Energy Efficiency Directive (Directive 2012/27/EU)
- Completion of the internal energy market, including the provisions of the 3rd package (Directive 2009/73/EC, Directive 2009/72/EC), Regulation (EC) 715/2009, Regulation (EC) 714/2009
- Directive on the Promotion of the Use of Energy from Renewable Sources - Renewable Energy Directive - including the amendment on ILUC (Directive 2009/28 EC as amended by Directive (EU) 2015/1513)
- Implementation of the Commission's proposed EU objective for a 27% share of renewable energy sources (RES) in total consumption by 2030, which was based on the proposal for a

[101] Ministry of Environment of the Slovak Republic, "Low Carbon Strategy of the Slovak Republic," Ministry of Environment, 2020. [Online]: https://www.minzp.sk/klima/nizkouhlikova-strategia/

[102] Ministry of the Environment of the Slovak Republic, "National Emission Reduction Programme" Ministry of the Environment, 2020. [Online]: https://www.minzp.sk/ovzdusie/ochrana-ovzdusia/narodne-zavazky-znizovania-emisii/narodny-program-znizovania-emisii/

[103] European Commission, "Recovery Plan", Office of the Government of the Slovak Republic, 2021. [Online]: https://www.planobnovy.sk/kompletny-plan-obnovy/zelena-ekonomika/

"Clean Energy for All Europeans" package presented by the European Commission in November 2016. The modelling did not take into account the fact that a considerably more ambitious EU objective (32%) was eventually adopted in December 2018

- National Renewable Energy Action Plan, in force since 2011
- EU ETS Directive 2003/87/EC with the latest amendment in 2015 (Decision (EU) 2015/1814 - Market Stabilisation Reserve). The EU ETS is an economic and regulatory measure with a high positive impact on the reduction of greenhouse gas emissions and stimulates the use of biomass in the fuel mix and forces technological innovation
- EP and Council Regulation on emission performance standards for cars, Regulation (EC) 443/2009, as amended by EU Regulation 333/2014, EURO 5 and 6 Regulation
- EP and Council Regulation 715/2007 on type-approval of motor vehicles
- Regulation 510/2011 setting emission performance standards for new light-commercial vehicles, as amended by Regulation 253/2014
- Act No. 137/2010 Coll. on Air Protection as amended. This Act is supplemented by Act No. 401/1998 Coll. on air pollution charges, which serves to control and regulate emission limits for basic air pollutants
- Increasing energy efficiency with a number of measures in force since 2014 on the energy consumption side, according to which energy savings are reflected as a reduction in final energy consumption. These measures are broken down by sector (buildings, industry, public sector, transport and appliances). In the buildings sector, it is mainly about improving the thermal-technical performance of buildings by carrying out cost-effective deep renovation. Legislation and changes to national technical standards since 2012 have introduced conditions for progressively stricter energy performance requirements for new and substantially renovated buildings, which are regularly reviewed. Measures in the buildings sector represent the most important source of potential energy savings by 2030.
- Optimisation of district heating systems - switching from fossil fuels to biomass and natural gas and installation of combined heat and power (CHP) units in district heating systems. Industrial cogeneration plants produce industrial steam, which can also be used for district heating or is a secondary use of industrial steam. Other measures are also taken into account (e.g. improving the efficiency of central heat supply (CHS) systems, installing innovative district heating technologies, improving the supply of heat from combined heat and power plants).
- Phasing out of solid fuel heating plants from 2025.

The specification of the **WAM** scenario according to the Low Carbon Development Strategy of the Slovak Republic depends on the logic of the draft EU scenarios and in particular on the EUCO3030 scenario[104], which sets the EU target for energy efficiency for 2030 at 30%.

[104] European Commission, „EUCO scenarios," 2016. [Online]: http://www.e3mlab.eu/e3mlab/index.php?option=com_content&view=article&id=532%3Aeuco-scenarios&catid=1%3Alatest-news&Itemid=82&lang=en

The **WAM** scenario includes all measures from the **WEM** scenario named in the Low Carbon Development Strategy of the Slovak Republic, while additionally includes measures and more ambitious targets for RES and EE, ambitious plans of the new EC under the Green Deal.[105]

- The national RES target was set at 18.91% in the model
- The national target for the ESR is -20%
- The national target for primary EE savings was set at -28.36% in the model
- Increasing the EU ETS carbon price after 2020 - The EU ETS carbon price affects the energy sector as well as energy-intensive industries and is a major driver of emissions reductions. Electricity generators will need to respond to the pressure of rising allowance prices to facilitate their own transition from coal to other low- to zero-emission sources.
- Earlier decommissioning of solid fuel power plants. The decommissioning of the Vojany and Nováky plants is foreseen in 2025 and 2023, in that order.
- Decarbonising electricity generation after 2020 through RES and nuclear development.
- RES support scheme in electricity generation with envisaged RES technologies such as solar PV, onshore wind turbines, biogas/biomethane and biomass. The scenarios assume support of 50 MW in the period 2021-2025, followed by support of a further 500 MW on the basis of auctions.
- Increasing the share of nuclear energy in the energy mix of the Slovak Republic. This increase in the medium term (2020-2025) will be mainly due to the commissioning of two new nuclear reactors at the Mochovce Nuclear Power Plant.
- Continuing to reduce final energy consumption in all sectors after 2020. The measure puts emphasis on policies supporting the acceleration of the renewal of the building stock (residential and non-residential, public and private), with a focus on carrying out cost-effective in-depth renovations and applying minimum energy performance requirements for near-zero energy buildings after 2020 for new buildings.

Most of the above measures were applied at the level of the Compact Primes for Slovakia (CPS-PRIMES[1])[106] model, from which trends in energy consumption or other parameters were taken for modelling emissions in the TIMES model.[107]

In addition to the measures mentioned above, the **WAM** scenario also took into account:

- Assessment of the future structure of appliances used for domestic heating based on survey data.
- Support for the replacement of old solid fuel boilers in households with low-emission systems.
- Support for insulation of family houses - Programme Slovakia, Green renovation.
- Awareness campaign and education on good coal and biomass combustion practices.

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[105] European Commission, „EU Green Deal," 2019. [Online]: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal#documents

[106] European Commission, „Integrated National Energy and Climate plan for 2021 to 2030 for Slovakia," 2019. [Online]: https://ec.europa.eu/energy/sites/ener/files/sk_final_necp_main_en.pdf

[107] ETSAP, „The TIMES model," The Energy Technology Systems Analysis Program, 2005. [Online]: https://iea-etsap.org/index.php/etsap-tools/model-generators/times

6.1.2 Parameters and PAMs Used in the Energy Sector - Fugitive Emissions

Fugitive CH_4 emissions from transport and distribution of natural gas and oil in the Slovak Republic were calculated from the following data:

Data on natural gas and oil were obtained from sources:

- Statistical Office of the Slovak Republic
- Eustream, a.s.
- SPP Distribúcia, a.s.
- Nafta, a.s.

Data for the calculation of fugitive emissions for 2021-2050 were obtained from sources:

- EU Reference Scenario for Slovakia for 2020-2050 (EU REF 2020)
- Integrated National Energy and Climate Plan 2021-2050 (NECP[6])
- Data provided by eustream, a. s. on the projected outlook for fugitive methane emissions from natural gas transit pipelines (Long-distance transport of natural gas; 20°C, 101 325 kPa)

For the calculation of fugitive methane emissions, emission factors from the following sources were used:

- 2006 IPCC Guidelines for National GHG Inventories - Chapter 4: Fugitive emissions;
- IPCC Guidelines on best practices and management of unpredictability in national GHG inventories - Fugitive emissions from oil and gas operations.

Table 6.1: *Projected production, transmission and distribution of oil and gas in the Slovak Republic in 2021-2050*

Activity	*Units*	2019	2020	2025	2030	2035	2040	2050
Oil production	*t*	6 328	4 431	0	0	0	0	0
Oil processing	*t*	5 109 011	6 437 931	5 558 395	5 562 870	5 453 262	5 171 211	4 484 380
Natural gas production	*million m^3*	124	70	74	77	99	89	0
Long-distance transmission of natural gas	*million m^3*	69 060	56 980	67 882	67 036	66 102	68 623	63 966
Natural gas distribution	*million m^3*	4 841	5 004	5 115	4 637	4 988	4 632	3 927

Fugitive methane emissions from underground coal mining and subsequent post-mining activities in the Slovak Republic were calculated from the following data:

Data on coal production in 2019 and 2020 from individual underground mines were obtained from official sources - from HBP, a. s. and the Statistical Office of the Slovak Republic.

Data on projected coal production in 2021-2050 were obtained from sources:

EU reference scenario for Slovakia for 2020-2050 (EU REF 2020).

Government Resolution No. 580/2018, point B.3 - timeframe for the gradual closure of the Handlová and Nováky mining fields belonging to HBP, a. s.

Emission factors from the 2006 IPCC Guidelines for National GHG Inventories - Chapter 4: Fugitive emissions. For the period from 2023 onwards, all mines are categorised as "closed mines" (**WAM** scenario), for the period from 2023 onwards, all mines are categorised as "closed mines", except for the Čáry mine (**WEM** scenario). The emission factor for fugitive methane emissions from abandoned mines was estimated by exponential regression to 2050.

Table 6.2: *Coal production and projected mining activity to 2050*

Mine	***Units***	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Cigeľ	*kt*	0	0	0	0	0	0	0
Handlová	*kt*	236	174	0	0	0	0	0
Nováky	*kt*	925	595	0	0	0	0	0
HBP, a. s. total	*kt*	1 161	769	0	0	0	0	0
BD, a. s.	*kt*	0	0	0	0	0	0	0
BČ, a. s.	*kt*	270	212	483	31	21	17	10
Slovak Republic total	***kt***	**1 431**	**981**	**483**	**31**	**21**	**17**	**10**

6.1.3 Parameters and PAMs Used in the Energy Sector – Transport

For the **WEM** and **WAM** scenarios, existing measures in the transport sector and other sectoral information from the Ministry of Economy and the Ministry of Transport and Construction of the Slovak Republic have been taken into account. The transport projections were prepared according to the COPERT model, which is based on data from the SYBIL database. Data for the projected transport parameters were obtained from the CPS-PRIMES model and the Low Carbon Strategy of the Slovak Republic. Transport emissions projections have been prepared with the following assumptions:

- Act No. 277/2020, which is a partial national transposition of Directive (EU) 2018/2001 of the European Parliament and of the Council (RED II) on the promotion of the use of energy from renewable sources.
- Impact of EU legislation - Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO_2 emission performance standards for new passenger cars and light-commercial vehicles.
- Impact of EU legislation - Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO_2 emission performance standards for new heavy duty vehicles.
- Impact of EU legislation - Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and climate action.
- Continuation of direct support for the use of low-emission vehicles on the basis of the Action Plan for the Development of Electric Vehicles in Slovakia.
- Long-term financial mechanism to support the development of charging infrastructure based on the Action Plan for the Development of Electric Vehicles in the Slovak Republic.
- Setting stricter requirements for periodic technical inspections of vehicles.
- Vehicle registration fee based on g CO_2/km emissions.
- Modal shift in passenger transport.
- Modal shift in the transport of goods.
- Introduction and promotion of hydrogen powered vehicles (FCEV).
- Mixing biomethane into CNG and LNG.

6.1.4 Energy Sector, Including Transport - Projections

The energy sector produces GHG emissions from the combustion and conversion of fossil fuels. Fugitive methane emissions arise from the extraction, transport and processing of fuels.

Table 6.3: *Parameters used to project energy consumption in the relevant sectors of the economy in years 2020-2050*

Item	*Units*	2019	2020	2025	2030	2035	2040	2050
Final energy demand: total	*TJ*	420 711	399 519	470 059	473 620	460 376	444 069	394 161
Final energy demand: industry	*TJ*	199 109	193 612	220 015	218 243	215 853	215 785	210 426
Final energy demand: transport	*TJ*	117 596	102 507	146 322	157 264	150 216	139 437	103 751
Final energy demand: residential sector	*TJ*	72 822	74 667	69 679	64 906	60 967	56 123	48 033
Final energy demand: agriculture/forestry	*TJ*	5 604	6 370	6 417	6 634	6 651	6 589	6 284
Final energy demand: services	*TJ*	25 580	22 363	27 626	26 573	26 689	26 135	25 667
Number of passenger kilometres	*million pkm*	30 580	33 729	38 527	43 337	46 905	49 026	51 485
Tonne-kilometres of freight transport	*million tkm*	5 483	13 992	15 200	16 456	17 468	18 111	18 723
Final energy demand for road transport	*TJ*	108 915	98 092	139 611	150 557	143 536	132 528	97 040

In the **WOM** scenario, all implemented measures are included in the 2020 base year scenario emission levels. Emission levels in the coming years are determined only by the final energy growth rate. The **WOM** scenario is identical to the **WEM** scenario.

The base (reference) year for modelling the GHG emissions projection was the latest revised inventory year 2020 in all scenarios. Projections of greenhouse gas emissions were made for the years 2020-2050 under the following scenarios:

Existing Measures Scenario (**WEM**) **-** includes policies and measures adopted and implemented at EU and national level by the end of 2021. Despite the lack of knowledge about new policies and measures after 2021, the **WEM** scenario is not a scenario in which energy efficiency improvements do not develop. Energy efficiency improvements in all sectors will continue in the future. Market mechanisms are the driving force behind efficiency improvements. In industrial processes, improving energy efficiency is essential for productivity growth, which is part of sustainable growth in added value. In the buildings and transport sectors, energy efficiency is improving thanks to an increasing share of more efficient equipment and vehicles. On the other hand, the industry sees reducing operating costs as a marketing factor that can attract revenue growth. The decoupling of energy consumption from economic growth will therefore continue in the future due to technological advances.

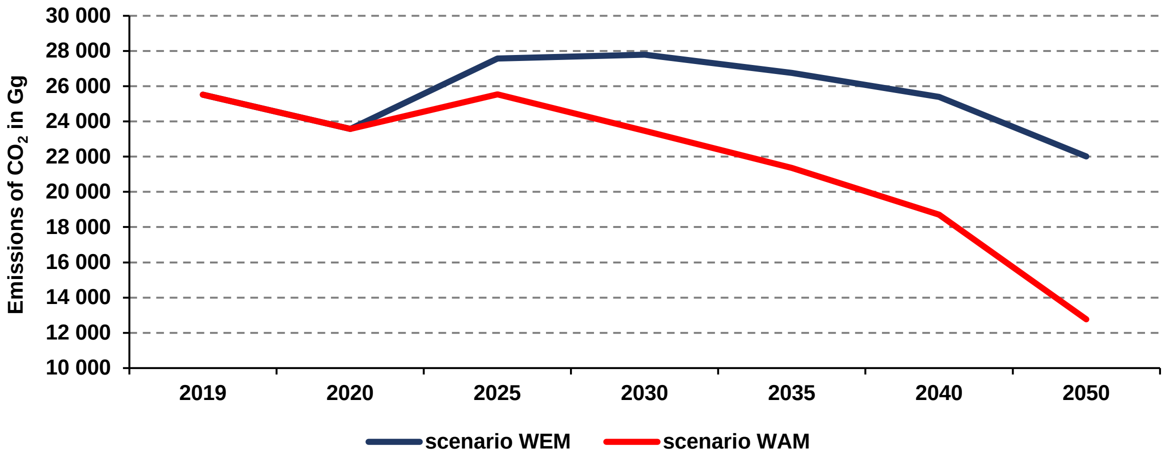
The scenario with additional measures (**WAM**) - is equivalent to the Dcarb2 scenario of the CPS-PRIMES model, in the energy and industry and partly also in the transport categories. The "Clean Energy for All Europeans" policy package launched by the European Commission (EC) in November 2016 was considered when designing the **WAM** scenario. In addition, the EUCO scenario of the CPS-PRIMES model for 2030 and 2050 supported the impact assessment of the measures and targets proposed by the EC in the policy package.

CO_2 Emissions projections - *Figure 6.1* shows the results of modelling projections of CO_2 emissions under the relevant scenarios. The projected economic growth dynamics will lead to an increase in CO_2 emissions. The impact of the included measures resulted in emission reductions in the **WOM**, **WEM** and **WAM** scenarios.

Table 6.4: *Projections of CO_2 emissions in the Energy sector (Gg)*

WOM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**25 912.20**	**23 737.03**	**27 853**	**28 063**	**27 028**	**25 686**	**22 279**
1.A Fuel combustion activities	25 893.12	23 723.86	27 836.40	28 052.38	27 017.11	25 675.41	22 272.65
1.A.1 Energy sectors	7 020.39	6 404.07	5 239.10	5 095.69	4 976.26	4 894.01	4 738.19
1.A.2 Manufacturing and construction industries	6 278.55	5 882.12	7 493.14	7 373.37	7 244.05	7 093.62	6 869.17
1.A.3 Transport	8 035.30	6 990.37	10 643.48	11 388.51	10 782.76	9 914.94	7 196.32
1.A.4 Other sectors	4 476.21	4 379.13	4 372.42	4 104.65	3 923.54	3 683.33	3 383.07
1.A.5 Others	82.67	68.17	88.26	90.17	90.49	89.52	85.89
1.B Fugitive emissions from fuels	19.08	13.17	16.45	10.67	11.19	10.53	6.54
WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**25 912.20**	**23 737.03**	**27 853**	**28 063**	**27 028**	**25 686**	**22 279**
1.A Fuel combustion activities	25 893.12	23 723.86	27 836.40	28 052.38	27 017.11	25 675.41	22 272.65
1.A.1 Energy sectors	7 020.39	6 404.07	5 239.10	5 095.69	4 976.26	4 894.01	4 738.19
1.A.2 Manufacturing and construction industries	6 278.55	5 882.12	7 493.14	7 373.37	7 244.05	7 093.62	6 869.17
1.A.3 Transport	8 035.30	6 990.37	10 643.48	11 388.51	10 782.76	9 914.94	7 196.32
1.A.4 Other sectors	4 476.21	4 379.13	4 372.42	4 104.65	3 923.54	3 683.33	3 383.07
1.A.5 Others	82.67	68.17	88.26	90.17	90.49	89.52	85.89
1.B Fugitive emissions from fuels	19.09	13.17	16.45	10.67	11.19	10.53	6.54
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**25 912.20**	**23 737.03**	**25 814**	**23 744**	**21 641**	**18 987**	**13 048**
1.A Fuel combustion activities	25 893.12	23 723.86	25 810.40	23 740.93	21 637.87	18 983.59	13 045.42
1.A.1 Energy sectors	7 020.39	6 404.07	5 255.31	4 486.39	4 403.15	4 277.32	3 447.03
1.A.2 Manufacturing and construction industries	6 278.55	5 882.12	7 185.86	6 869.28	6 813.27	6 546.98	4 653.97
1.A.3 Transport	8 035.30	6 990.37	9 037.02	8 372.73	6 683.00	4 723.58	1 936.52
1.A.4 Other sectors	4 476.21	4 379.13	4 243.95	3 922.36	3 647.96	3 346.19	2 922.00
1.A.5 Others	82.67	68.17	88.26	90.17	90.49	89.52	85.89
1.B Fugitive emissions from fuels	19.09	13.17	3.81	3.41	3.22	2.94	2.26

Figure 6.1: *Projections of CO_2 emissions in the Energy sector in* ***WEM*** *and* ***WAM*** *scenarios*



CH_4 Emissions projections – energy related CH_4 emissions arise from the combustion and conversion of fossil fuels. Fugitive methane emissions arise from the extraction, transport and processing of fuels. Projections of CH_4 emissions from the combustion and conversion of fossil fuels were modelled using the fuel consumption in each scenario according to the IPCC method and the IPCC recommended aggregated emission factors. For transport CH_4 emissions, the COPERT model emission factors were used for each vehicle type. The modelling used the same scenarios as for CO_2 emissions from combustion and fuel switching. This approach makes it possible to determine the impact of CO_2 reduction measures on the level of CH_4 emissions. Annual fugitive CH_4 emissions were calculated for the following activities (***Table 6.5***):

Underground mining and post-mining activities.

Transport and processing of crude oil and petroleum products.

Extraction and transport of natural gas.

Incineration and degasification.

Table 6.5: *Projections of CH_4 emissions in the Energy sector (Gg)*

WOM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**28.70**	**26.84**	**24.40**	**19.02**	**18.55**	**17.42**	**15.07**
1.A Fuel combustion activities	10.26	10.36	10.01	9.48	8.89	8.44	7.61
1.B Fugitive emissions from fuels	18.44	16.48	14.39	9.54	9.66	8.98	7.46
1.B.1 Solid fuels	9.82	7.14	5.67	1.56	1.34	1.20	0.98
1.B.2 Oil and gas	8.61	9.33	8.72	7.99	8.33	7.78	6.48
WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**28.70**	**26.84**	**24.40**	**19.02**	**18.55**	**17.42**	**15.07**
1.A Fuel combustion activities	10.26	10.36	10.01	9.48	8.89	8.44	7.61
1.B Fugitive emissions from fuels	18.44	16.48	14.39	9.54	9.66	8.98	7.46
1.B.1 Solid fuels	9.82	7.14	5.67	1.56	1.34	1.20	0.98
1.B.2 Oil and gas	8.61	9.33	8.72	7.99	8.33	7.78	6.48
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**28.70**	**26.84**	**20.14**	**18.57**	**18.08**	**16.68**	**14.05**
1.A Fuel combustion activities	10.26	10.36	10.42	10.03	9.59	9.12	8.27
1.B Fugitive emissions from fuels	18.44	16.48	9.72	8.54	8.49	7.56	5.78
1.B.1 Solid fuels	9.82	7.14	1.47	1.29	1.15	1.05	0.89
1.B.2 Oil and gas	8.61	9.33	8.26	7.25	7.34	6.51	4.89

N_2O Emissions projections - energy-related N_2O emissions arise from the combustion and conversion of fossil fuels. N_2O emissions from transport have been calculated within this sector. Projections of N_2O emissions were similarly calculated using the IPCC method, which uses recommended emission factors. In the transport sector, the emission factors for each vehicle type are taken from the COPERT model. The scenarios for calculating emissions from combustion and fuel conversion are the same as those for CO_2 and CH_4 emissions, making it possible to analyse the impact of measures to reduce CO_2 emissions and N_2O production.

Table 6.6: *Projections of N_2O emissions in the Energy sector (Gg)*

WOM	2019	2020	2025	2030	2035	2040	2050
1. Energy sector	**0.734**	**0.673**	**0.799**	**0.821**	**0.800**	**0.781**	**0.698**
1.A Fuel combustion activities	0.734	0.673	0.779	0.821	0.800	0.781	0.698
1.A.1 Energy sectors	0.110	0.098	0.086	0.100	0.082	0.083	0.076
1.A.2 Manufacturing and construction industries	0.113	0.113	0.118	0.118	0.116	0.115	0.071
1.A.3 Transport	0.308	0.250	0.355	0.396	0.399	0.388	0.366
1.A.4 Other sectors	0.202	0.211	0.219	0.206	0.202	0.194	0.184
1.A.5 Others	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**0.734**	**0.673**	**0.779**	**0.821**	**0.800**	**0.781**	**0.698**
1.A Fuel combustion activities	0.734	0.673	0.779	0.821	0.800	0.781	0.698
1.A.1 Energy sectors	0.110	0.098	0.086	0.100	0.082	0.083	0.076
1.A.2 Manufacturing and construction industries	0.113	0.113	0.118	0.118	0.116	0.115	0.071
1.A.3 Transport	0.308	0.250	0.355	0.396	0.399	0.388	0.366
1.A.4 Other sectors	0.202	0.211	0.219	0.206	0.202	0.194	0.184
1.A.5 Others	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**0.734**	**0.673**	**0.692**	**0.678**	**0.618**	**0.569**	**0.459**
1.A Fuel combustion activities	0.734	0.673	0.692	0.678	0.618	0.569	0.459
1.A.1 Energy sectors	0.110	0.098	0.085	0.089	0.072	0.073	0.066
1.A.2 Manufacturing and construction industries	0.113	0.113	0.112	0.111	0.109	0.108	0.060
1.A.3 Transport	0.308	0.250	0.271	0.258	0.222	0.176	0.131
1.A.4 Other sectors	0.202	0.211	0.223	0.219	0.214	0.211	0.201
1.A.5 Others	0.001	0.001	0.001	0.001	0.001	0.001	0.001

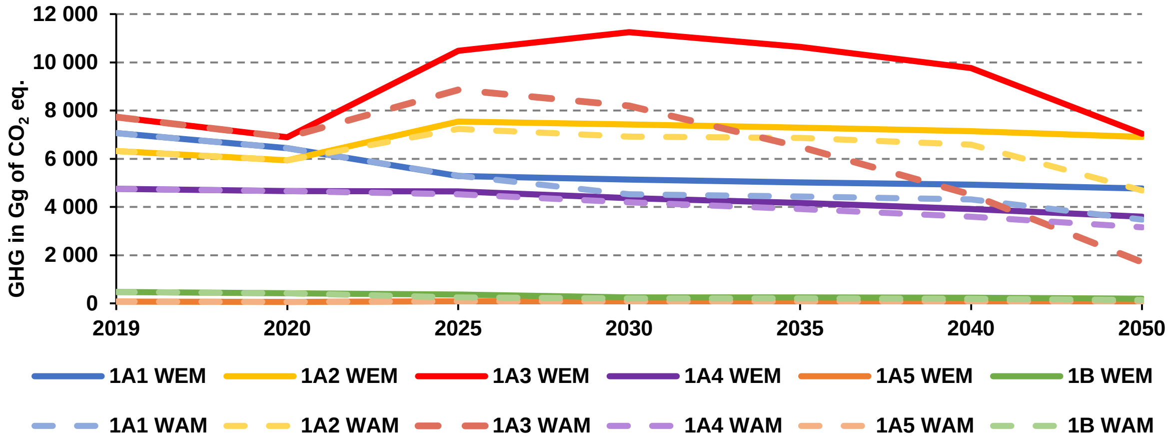
Projections of aggregate GHG emissions - ***Table 6.7*** shows the aggregated projections of GHG emissions in the energy sector. ***Figure 6.2*** shows a comparison of projected emissions in the energy sector in eq. CO_2 by 2050 for all scenarios, as well as their emission level index against the UNFCCC base year (1990).

Table 6.7: *Aggregate projections of GHG emissions in the Energy sector (Gg CO_2 eq.)*

WOM	2019	2020	2025	2030	2035	2040	2050
1. Energy sector	**26 848.46**	**24 608.52**	**28 703.65**	**28 802.26**	**27 739.10**	**26 362.63**	**22 869.68**
1.A Fuel combustion activities	26 368.47	24 183.42	28 327.45	28 553.09	27 486.41	26 127.60	22 676.64
1.A.1 Energy sectors	7 067.37	6 446.81	5 281.64	5 149.42	5 017.46	4 935.32	4 776.01
1.A.2 Manufacturing and construction industries	6 329.17	5 932.71	7 546.40	7 430.98	7 296.35	7 145.62	6 907.70
1.A.3 Transport	8 132.58	7 069.21	10 757.82	11 515.00	10 910.21	10 039.00	7 311.00
1.A.4 Other sectors	4 755.71	4 665.61	4 652.77	4 366.89	4 171.32	3 917.56	3 595.46
1.A.5 Others	83.65	69.09	88.83	90.80	91.06	90.09	86.46
1.B Fugitive emissions from fuels	479.99	425.09	376.20	249.17	252.69	235.03	193.04

WEM	2019	2020	2025	2030	2035	2040	2050
1. Energy sector	**26 848.46**	**24 608.52**	**28 703.65**	**28 802.26**	**27 739.10**	**26 362.63**	**22 869.68**
1.A Fuel combustion activities	26 368.47	24 183.42	28 327.45	28 553.09	27 486.41	26 127.60	22 676.64
1.A.1 Energy sectors	7 067.37	6 446.81	5 281.64	5 149.42	5 017.46	4 935.32	4 776.01
1.A.2 Manufacturing and construction industries	6 329.17	5 932.71	7 546.40	7 430.98	7 296.35	7 145.62	6 907.70
1.A.3 Transport	8 132.58	7 069.21	10 757.82	11 515.00	10 910.21	10 039.00	7 311.00
1.A.4 Other sectors	4 755.71	4 665.61	4 652.77	4 366.89	4 171.32	3 917.56	3 595.46
1.A.5 Others	83.65	69.09	88.83	90.80	91.06	90.09	86.46
1.B Fugitive emissions from fuels	479.99	425.09	376.20	249.17	252.69	235.03	193.04
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy sector	**26 848.46**	**24 608.52**	**26 531.94**	**24 429.45**	**22 283.45**	**19 577.50**	**13 537.94**
1.A Fuel combustion activities	26 368.47	24 183.42	26 285.36	24 213.54	22 068.17	19 386.76	13 391.09
1.A.1 Energy sectors	7 067.37	6 446.81	5 297.69	4 537.30	4 441.74	4 316.10	3 482.09
1.A.2 Manufacturing and construction industries	6 329.17	5 932.71	7 236.20	6 924.18	6 862.55	6 595.57	4 686.80
1.A.3 Transport	8 132.58	7 069.21	9 125.87	8 456.84	6 755.18	4 780.68	1 977.87
1.A.4 Other sectors	4 755.71	4 665.61	4 536.53	4 203.42	3 917.44	3 603.12	3 157.95
1.A.5 Others	83.65	69.09	88.83	91.07	91.07	90.09	86.46
1.B Fugitive emissions from fuels	479.99	425.09	246.81	216.91	215.47	191.94	146.76

Figure 6.2: *Projections of aggregate GHG emissions in the Energy sector up to 2050*



In order to increase comprehensiveness, comparability and transparency, great efforts are being made to improve methodological procedures in several technical directions related to the implementation of the country-specific CPS-PRIMES model for projections of GHG emissions in the energy and IPPU sectors (CPS-PRIMES), which is based on the Low Carbon Development Strategy of the Slovak Republic, prepared by the Ministry of Environment of the Slovak Republic in cooperation with the World Bank and experts from the National Technical University of Athens (E3MLab). At the same time, work is underway on the wider implementation of the new TIMES energy and industry model. A description of this model can be found in the "Report on Emissions Projections" as of 30 April 2021 under Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action.[108]

[108] European Commission, „Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action," 2018. [Online]: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG

The modelling of emissions projections in the energy sector is based on sectoral trends and developments taken from the CPS-PRIMES model, which are updated taking into account the results of the TIMES model in the public electricity and heat generation category and in EU ETS sources.

The TIMES model[7] receives data on energy consumption and production trends from the energy model. Important changes resulting from updated policies and measures or new information from affected parties have also been taken into account. The structure of the TIMES model includes individual technologies, commodities and commodity flows to facilitate the application of existing and future measures. The primary data were extraction of fuels and materials, imports, exports and production of commodities and their demand. One of the outputs is the energy supply represented by the producers (individual technologies). Consumers divided into different sectors of use are on the other side of the demand side. Once the reference energy system is built in the TIMES model, the produced energy commodities (electricity and heat) are consumed in different consumption facilities such as household, utilities, transport, industry and others. The main objective of the model is to satisfy different types of requirements over the whole time period at the lowest cost. The CPS-PRIMES model is not fully calibrated for the CRF categorization for GHG emissions reporting, so it was necessary to adjust the results from the model according to the GHG emissions inventories, which was one of the reasons for using and creating a new energy model to meet our requirements.

Emissions from households outside the CHP system (1.A.4.b) were calculated with an "excel sheet" model, which is also used to calculate fuel consumption and emissions for GHG and pollutant inventories. Important parameters such as data on the expected development of the housing stock, population or climatic parameters enter into this calculation.

6.1.5 Projections of Greenhouse Gas Emissions from International Transport (1.D)

GHG emissions from international transport are not included in the national balance sheet. However, projections of GHG emissions from international aviation and international maritime transport were developed for the scenario with measures. The data in ***Table 6.8*** shows that the projected GHG emissions from these categories are negligible compared to other sources.

Table 6.8: *Aggregated data on projections of GHG emissions from international transport in **WEM** scenario (Gg of CO_2 eq.)*

Item	2019	2020	2025	2030	2035	2040	2050
International air transport	187.16	55.13	165.02	165.02	165.02	165.02	165.02
International maritime transport	15.96	14.99	18.47	18.47	18.47	18.47	18.47
International transport	203.11	70.12	183.49	183.49	183.49	183.49	183.49

6.2 TRANSPORT SECTOR

The transport sector consists of five subcategories:

- *1.A.3.a Air transport (0.01%)*
- *1.A.3.b Road transport (96.38%)*
- *1.A.3.c Rail transport (1.15%)*
- *1.A.3.d Water transport (0.08%)*
- *1.A.3.e Other mode of transport (e.g. pipeline transport) (2.38%)*

The largest contributor to transport emissions is road transport, in particular the use of diesel trucks, but also passenger cars. The transport sector includes emissions from road transport (passenger cars, light-commercial vehicles, heavy-duty vehicles and buses, mopeds and motorcycles) as well as emissions from petrol evaporation, tyre and brake wear abrasion and road abrasion. In addition to road transport, this includes air, rail, maritime and pipeline transport (e.g. of natural gas). However, almost 97% of all emissions came from road transport in 2020, including pipeline transport. If pipeline transport, which is included in the EU ETS emissions trading system, were not counted, this would account for almost 99% of all transport emissions. For this reason, Slovakia focuses on and analyses in detail only the potential reduction of emissions from road transport.

The starting point for gaining control over emissions is a thorough understanding of the current situation and an understanding of how emissions trends have changed both quantitatively and compositionally. Based on official sources, a detailed, complete and consistent set of data on vehicles and their activity can be prepared. This set is the basis for calculating the most accurate emissions at the national level using highly advanced emissions modelling tools.

Both the **WEM** and **WAM** scenarios for transport show an increase in emissions (***Figure 6.3, Table 6.9***), with the **WAM** scenario peaking as early as 2023, followed by a slow and gradual decline in GHG emissions, which are only 10% higher in 2030 compared to 2005 and 74% lower in 2050 compared to 2005. In the **WEM** scenario, emissions will continue to rise until 2030 before declining thereafter and are still expected to be 7% above 1990 levels in 2050. The high emissions from road transport are mainly due to the fact that the development of transport as a carrier system only took place at the beginning of the 21st century, in particular with the development of the light-duty vehicle segment, which will continue to play an important role in the future. In terms of climate change, road transport will be a key sector for reducing GHG emissions.

Figure 6.3: *Trend of GHG emission projections in Gg CO_2 eq. in **WEM** and **WAM** scenarios up to 2050*

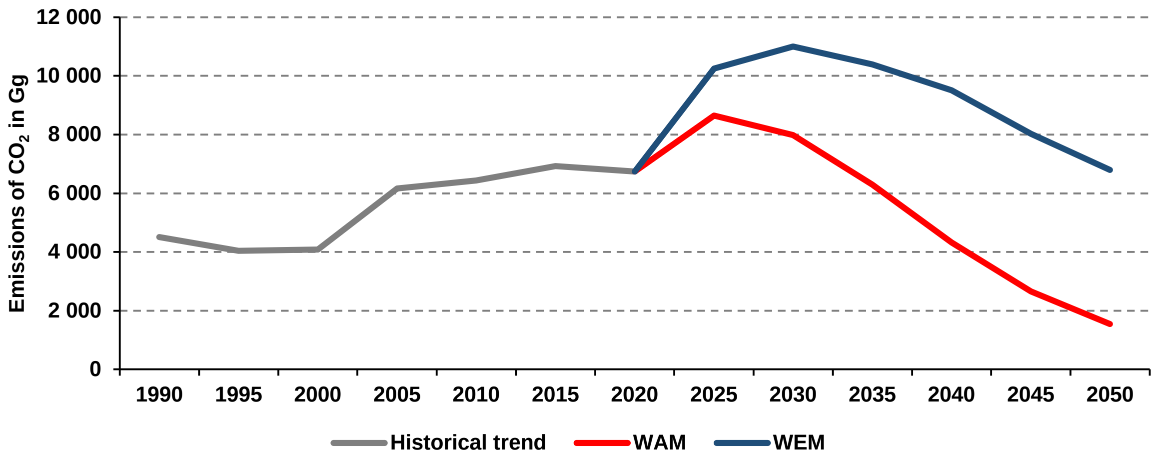


Table 6.9: *Overall trend of GHG emission projections in the Transport sector in **WEM** and **WAM** scenarios*

Year	**WEM**	**WAM**
	Gg CO_2 equivalents	
1990	6 823.77	6 823.77
1995	5 495.29	5 495.29
2000	5 725.61	5 725.61
2005	7 697.61	7 697.61
2010	7 425.74	7 425.74
2015	7 301.70	7 301.70
2020	7 069.21	7 069.21
2025	10 757.82	9 125.87
2030	11 515.00	8 456.84
Comparison with 1990	**69.75%**	**23.93%**
Comparison with 2005	**49.59%**	**9.86%**
2035	10 910.21	6 755.18
2040	10 039.00	4 780.68
2045	8 547.43	3 096.46
2050	7 311.00	1 977.87
Comparison with 1990	**7.14%**	**-71.02%**
Comparison with 2005	**-5.20%**	**-74.31%**

6.2.1 Input Parameters for Road Transport

Input (historical) data for the calculation of GHG emission projections from road transport are the IS EVO (Vehicle Registration Information System) database of the Traffic Inspectorate of the Presidium of the Police Force of the Slovak Republic (DI PPZ), the database of the Slovak Technical Inspection (STK) of the Ministry of Transport and Construction of the Slovak Republic (MDV SR) and the transport indicators from the CPS-PRIMES of the model provided by the Institute of Environmental Policy (IEP - MŽP SR). The Sybil database is an important input source of information in the preparation of emission projections and input parameters.

This database is being prepared by EMISIA[109] on the basis of:

- EUROSTAT statistical data (national statistics)
- Project outputs (FLEETS[110], TRAACS[111], NMP project[112]) for all EU countries
- EC Statistical Pocketbooks[113]
- ACEA (The European Automobile Manufacturers' Association)
- ACEM (The Motorcycle Industry in Europe)
- CO_2 monitoring database (operated by the EEA)
- EAFO
- NGVA EUROPE/NGV GLOBAL
- UNFCCC reports
- Proprietary algorithms for preparing the age structure to 2050

The data in this database is based on the same input parameters as the EU Reference Scenario[6] for Slovakia, which was discussed and presented in 2018-2019. The EU Reference Scenario for Slovakia was modelled using the PRIMES model and its transport module TREMOVE. The fleet development trends are therefore based on the same parameters and complex calculations, taking into account changes in the market as well as dynamic developments in the sector. This model is not directly applicable to Slovak conditions, as it requires a lot of detailed data, which Slovakia does not have.

Using trends from the Sybil database, an estimate of fleet development was prepared based on real data for the years 2013-2020. The data for this time period were obtained from IS EVO. Data and emissions prior to 2013, i.e. the period 1990-2012, were compiled according to official DI PPZ statistics and historical emission inventories.

Another important factor for calculating emissions and energy demand is the average value of annual mileage in each vehicle category and the average value of total vehicle kilometres travelled in each category. These data for the historical years 1990-2012 were taken from emission inventories. Subsequently, for the years 2013-2020, these figures were calculated using the information contained in the Service Technical Inspection. Specifically, it is information from the odometer about the kilometres travelled. Using the VIN number or EVN number, the data is matched with the data from IS EVO.

A detailed description of the methodology was published in the first phase of the project "Improving the allocation of road transport emissions in the AEA module”.[114]

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[109] Spin-off of the Applied Thermodynamics Laboratory of the Aristotle University of Thessaloniki: https://www.emisia.com/

[110] Aristotle University of Thessaloniki (LAT/AUTh), „Project FLEETS,“ 2005. [Online]. Available: http://www.e3mlab.eu/e3mlab/index.php?option=com_content&view=article&id=75:fleets&catid=38:energy-policy-projects&Itemid=59&lang=en

[111] EMISIA, „Project TRACCS,“ 2010. [Online]. Available: https://traccs.emisia.com

[112] EMISIA, „Project NMP: New Mobility Patterns in European Cities,“ 2022. [Online]. Available: https://www.emisia.com/news/new-project-for-ec-dg-move

[113] European Commission, „EU transport figures: Statistical pocketbook 2021,“ Publications Office, 2021. [Online]. Available: https://data.europa.eu/doi/10.2832/27610

[114] J. Horváth, J. Labovský, Z. Jonáček a L. Zetochová, „Improving the allocation of road transport emissions in AEA module and coherence between AEA and PEFA modules,“ 2022. [Online]. Available: https://oeab.shmu.sk/app/cmsSiteBoxAttachment.php?ID=85&cmsDataID=0

The COPERT model itself operates with 5 vehicle categories:

- Passenger cars (M1)
- Light-commercial vehicles (N1)
- Heavy-duty vehicles- trucks (N2 and N3)
- Buses (M2 and M3)
- L-category (L1 to L7)

6.2.2 Projections of Input Data and Parameters

Estimates for the period 2021-2050 were taken directly from the Sybil database and then broken down into individual fuel bases, segments (by engine capacity or vehicle weight) and emission standards. The model works with up to 620 separate data streams in total. The numbers of vehicles in each data stream each year are determined by an age composition matrix and a "survival rate" calculated from the data of the above-mentioned projects and the Weibull distribution and EUROSTAT data.

Vehicle propulsion is subdivided and described in detail in the model, but for the purposes of this report, the different types of propulsion are divided into three groups: conventional, alternative, and emission-free. Conventional propulsion is diesel and gasoline with their bio-component. CNG, LPG, LNG, hybrid (both diesel and petrol) and plug-in hybrid (both diesel and petrol) are being considered as alternative powertrains. Emission-free propulsion (BEV) is currently represented by electric and hydrogen propulsion.

The overall trend of the fleet can be seen in ***Figure 6.4*** (**WEM** scenario) and ***Figure 6.5*** for (**WAM** scenario).

Figure 6.4: *Fleet development and projections by drive mode in **WEM** scenario up to 2050*

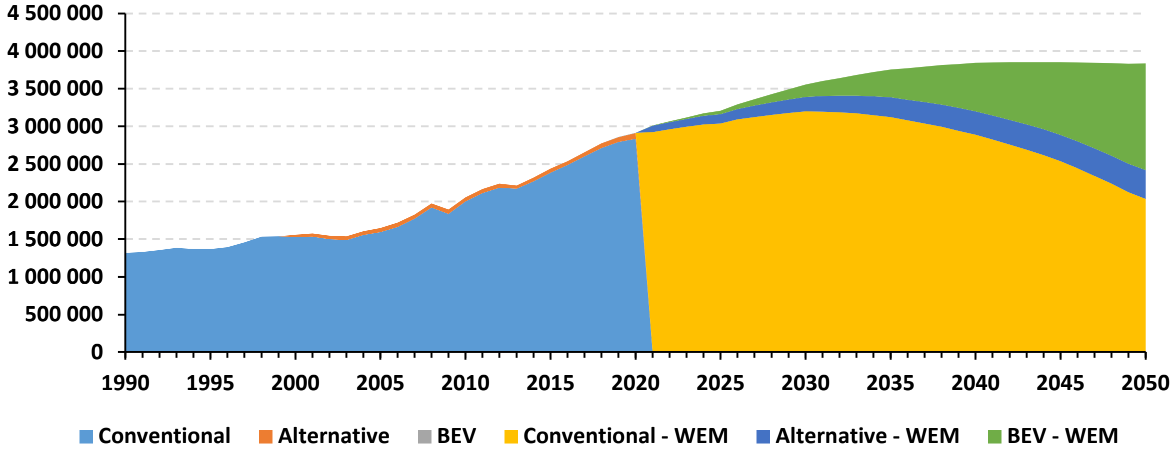
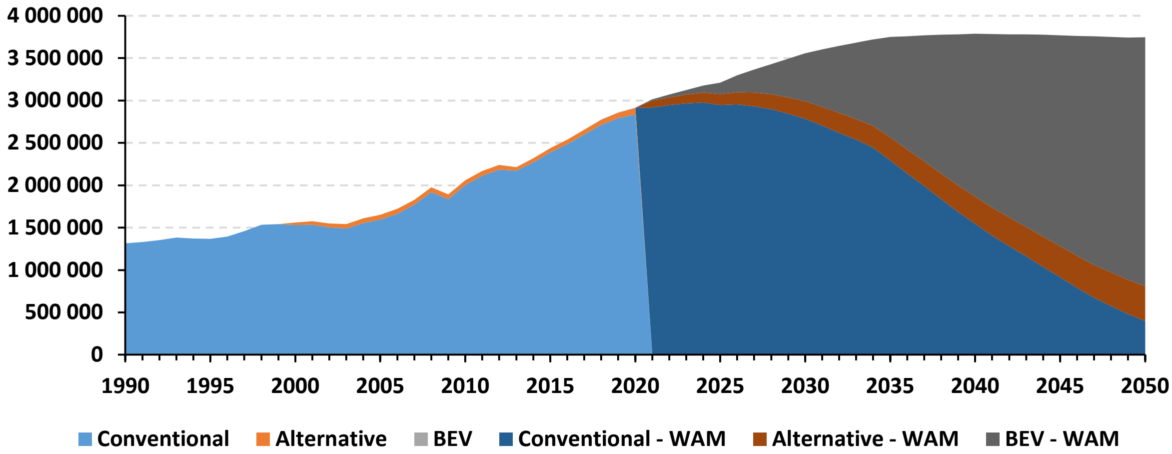


Figure 6.5: *Fleet development and projections by drive mode in **WAM** scenario up to 2050*



Passenger cars (M1) - passenger cars account for the largest share of the fleet. In recent years, there has been a significant increase in their number. It is a big assumption that we are still not at the peak of the number of passenger cars. This trend is expected to peak around 2040, followed by a gradual and slow decline in the number of passenger cars, also driven by a declining demographic curve.

WEM scenario expects conventional passenger car sales to break even in 2030 (***Figure 6.6***). In the case of the **WAM** scenario, this breakthrough could happen earlier, sometime around 2024. For alternative propulsion, there is a slightly lower increase in the **WAM** (***Figure 6.7***) and this is due to the greater weight given to zero-emission vehicles in the fleet development for this scenario (***Figure 6.8***), which in turn highlighted the exponential growth of these vehicles up to 2050.

Figure 6.6: *Trend and projections of conventionally fuelled passenger cars in **WEM** and **WAM** scenarios up to 2050*

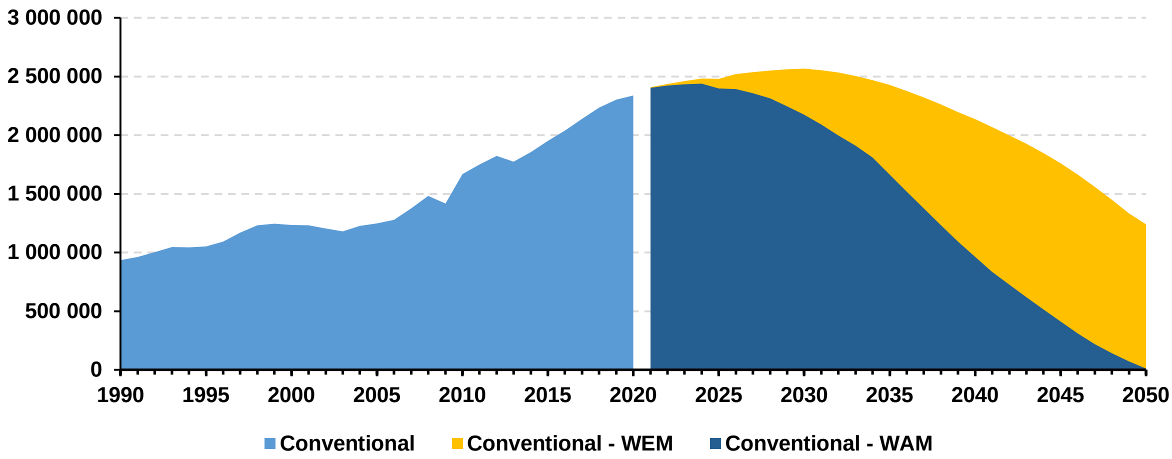


***Figure 6.7:** Trend and projections of alternative fuel passenger cars (CNG, LPG, LNG and hybrid) in **WEM** and **WAM** scenarios up to 2050*

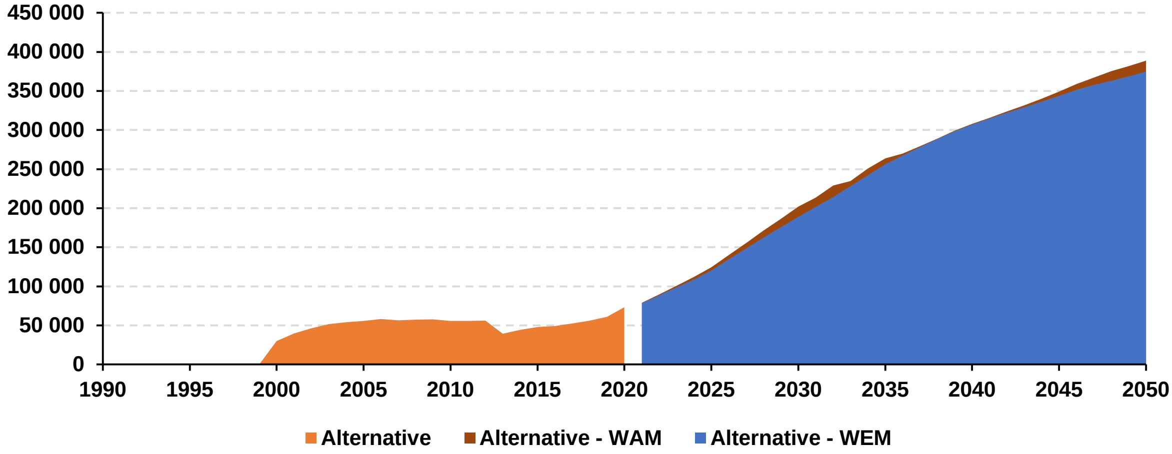
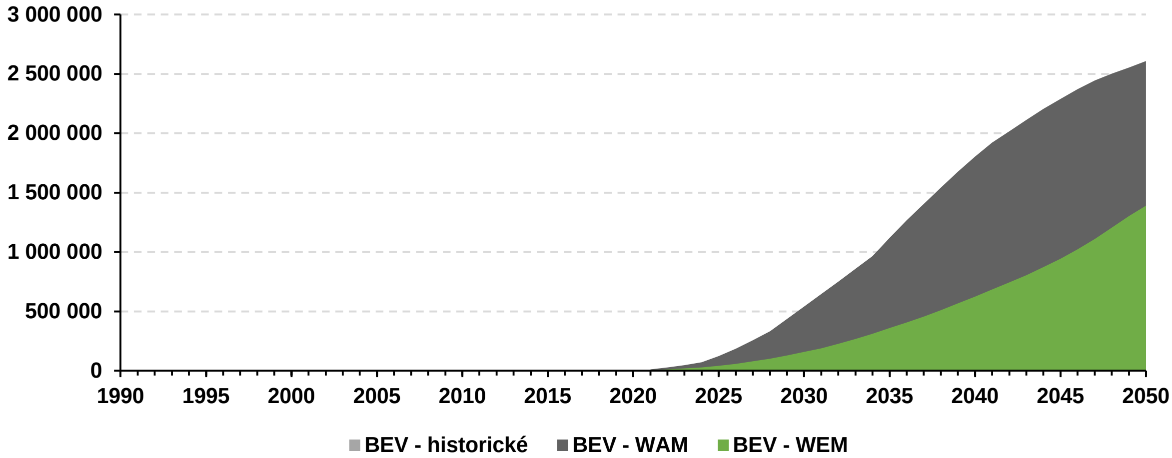


***Figure 6.8:** Trend and projections of electric and hydrogen powered passenger cars in **WEM** and **WAM** scenarios up to 2050*



Light-commercial vehicles (LCV or N1) - category N1 - up to 7.5 tonnes has undergone a significant change, moving from a category of no major importance in the 1990s to one of the key categories for future decarbonisation. The reason for its significant growth and the assumption of further growth is mainly due to the development of courier services and transport in this way in the "last mile" section. If the Slovak Republic does not try to decarbonise this part of road transport, the number of these conventionally fuelled vehicles (petrol and diesel) could reach up to 450 000 in 2050 (***Figure 6.9***). For light-commercial vehicles, there is little expectation of switching to alternative propulsion as there would be a reduction in transport space (***Figure 6.10***) and hence the **WAM** scenario will not affect this category. For the overall decarbonisation of road transport, it will be necessary to decarbonise in particular the 'last mile' in the form of zero-emission vehicles (***Figure 6.11***).

Figure 6.9: *Trend and projections of light-commercial vehicles with conventional propulsion in **WEM** and **WAM** scenarios up to 2050*

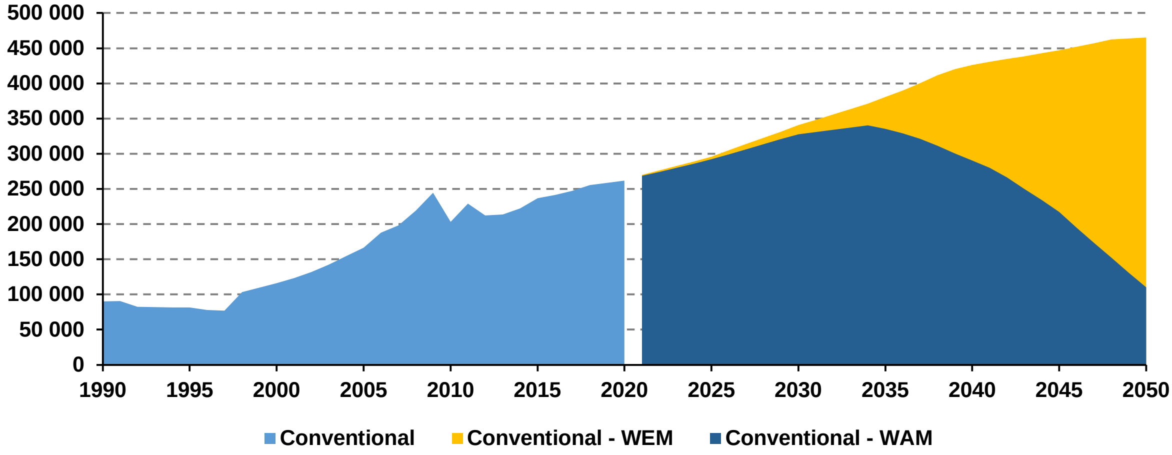


Figure 6.10: *Trend and projections of light-commercial vehicles with alternative propulsion in **WEM** and **WAM** scenarios up to 2050*

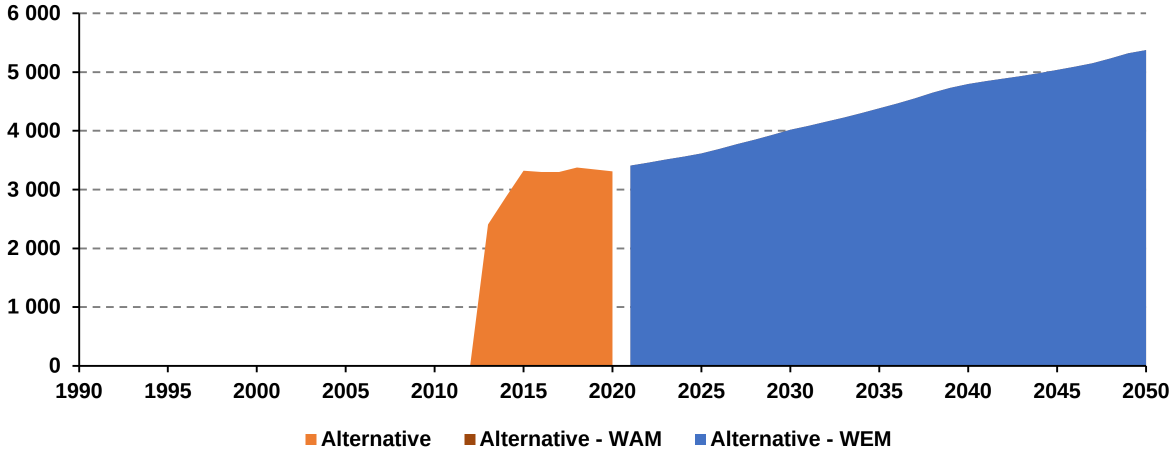
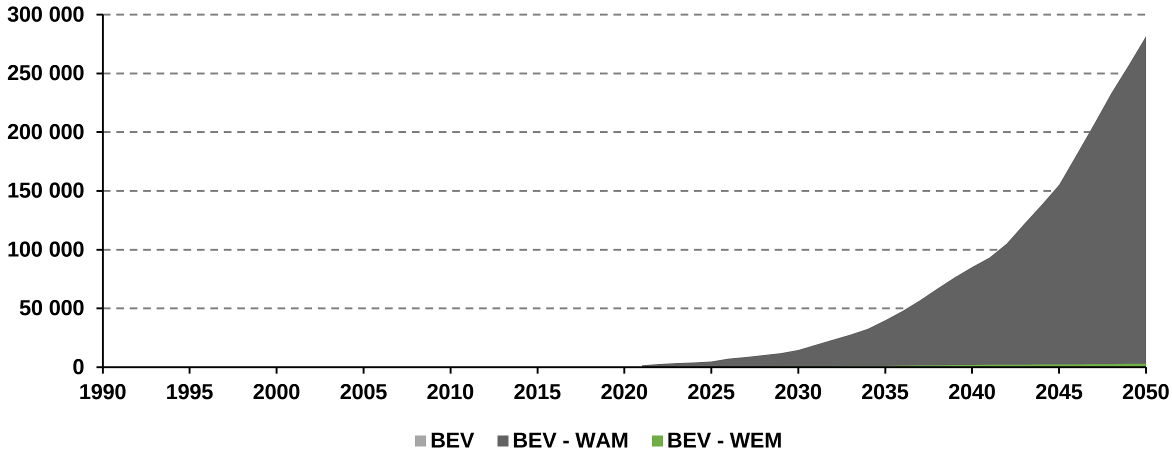


Figure 6.11: *Trend and projections of electric and hydrogen light-commercial vehicles in **WEM** and **WAM** scenarios up to 2050*



Heavy-duty vehicles – trucks (HDV or N2 and N3) - traditional freight transport - is also extremely specific within road transport, mainly because of the possibilities of replacing conventional fuels with alternative fuels. This often leads to greenwashing campaigns about emission-free transport in the form of LNG/CNG. Decarbonisation is challenging due to the need for extremely high range and engine power. At the same time, these projections do not yet reflect the EC's latest proposal to end the sale of GHG-emitting trucks around 2040.

In the **WEM** scenario, there is a steady increase in the number of HDVs (***Figure 6.12***) as the production of products that will need to be transported over medium and long distances is projected to increase. Alternative fuels (***Figure 6.13***) can contribute to reducing GHG emissions but cannot be the ultimate solution in this category. The **WAM** scenario assumes a significant change and an exponentially increasing shift away from conventional fuels towards zero-emission fuels (***Figure 6.14***). This variation is limited, as for the other categories, only by the production capacities of the car manufacturers.

Figure 6.12: *Trend and projections of heavy-duty vehicles with conventional propulsion in **WEM** and **WAM** scenarios up to 2050*

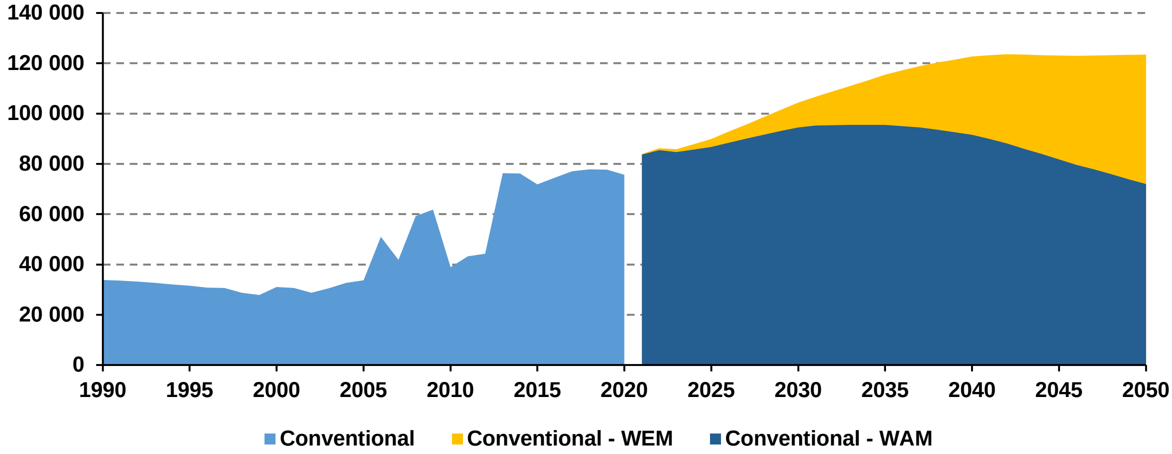


Figure 6.13: *Trend and projections of alternative-fuel heavy-duty vehicles in **WEM** and **WAM** scenarios up to 2050*

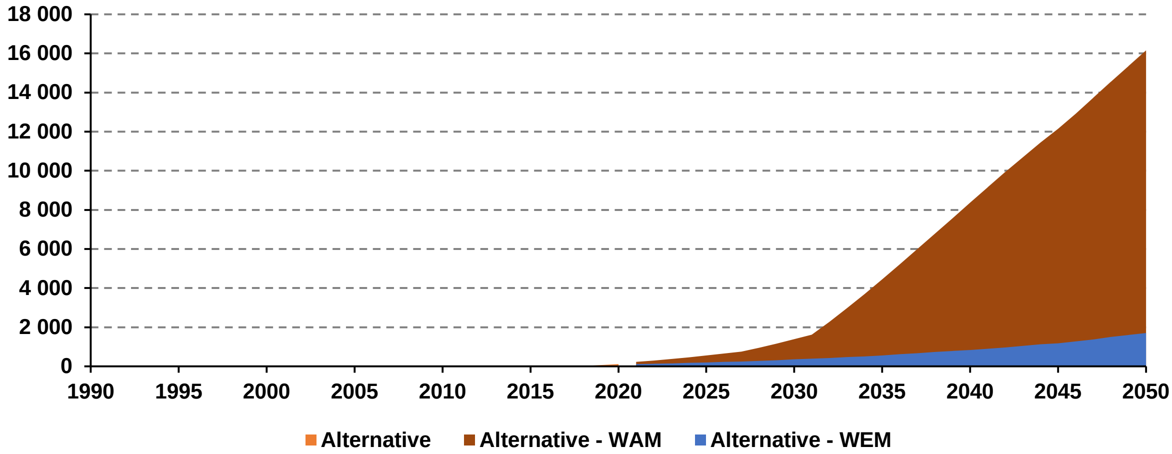
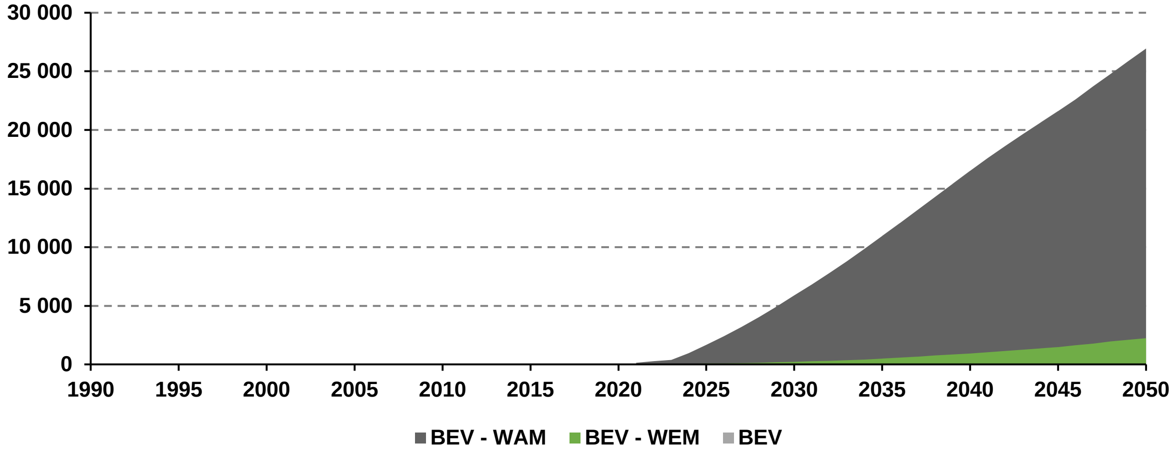


Figure 6.14: *Trend and projections of electric and hydrogen heavy-duty vehicle in **WEM** and **WAM** scenarios up to 2050*



Buses (M2 and M3) - in the case of public passenger transport (PPT), there is no assumption for changes between the trend of the fleet in the **WEM** and **WAM** scenarios. The **WAM** scenario assumes a shift of ridership to rail and a densification of PPT intervals, which is reflected in higher annual bus ridership. This assumption was subsequently reflected in the model. In the **WEM** scenario, emissions from PPT account for about 3.1% of total emissions, and in the **WAM** scenario, they are projected to account for about 3.7% in 2030 after annual ramps. Given the small share of road transport currently involved, no major interventions in the form of measures to change the bus fleet have been necessary.

The decline in alternative fuel buses between 2015 and 2020 is mainly due to the phasing out of CNG buses. This trend is changing with the gradual introduction of hybrid buses and their gradual growth, replacing not only conventional buses but also older CNG-powered buses.

Figure 6.15: *Trend and projections of conventionally powered buses in **WEM** and **WAM** scenarios up to 2050*

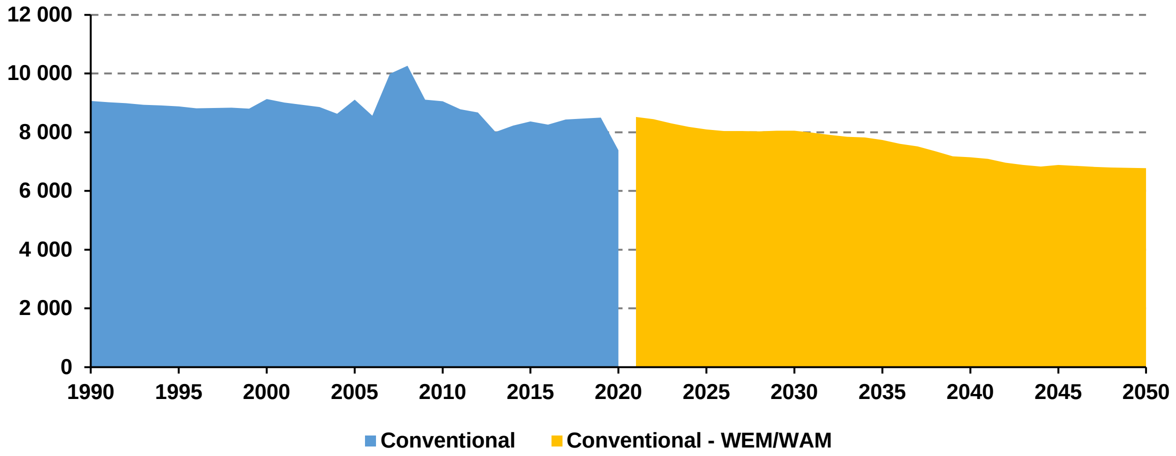


Figure 6.16: *Trend and projections of alternative fuel buses in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*

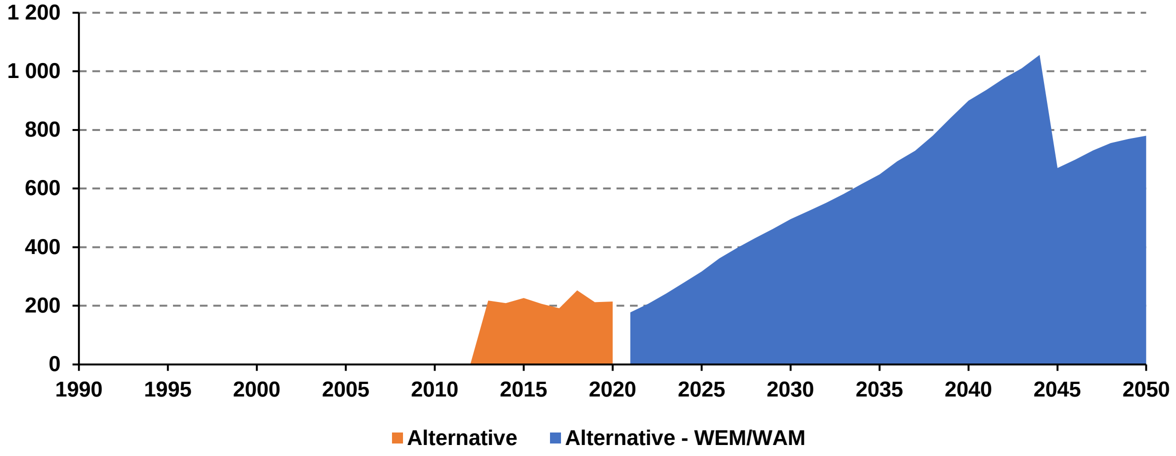
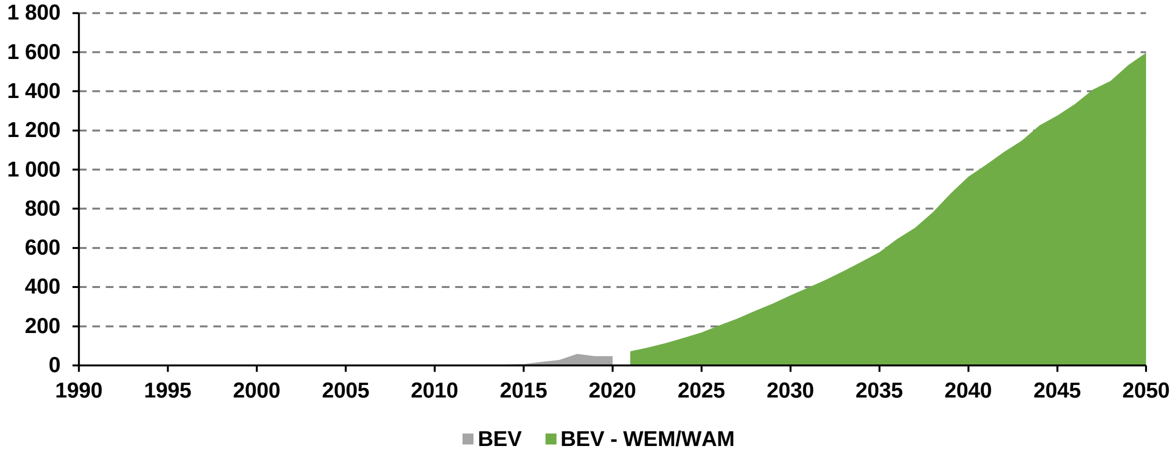


Figure 6.17: *Trend and projections of electric and hydrogen buses in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*



L-category (L1 toL7) - this category includes all two- and three-wheel vehicles. In addition to these, quadricycles (ATVs) and micro-cars are included. The term micro-car is used in the model to unite all vehicles of category L (1-7) that use diesel as a source of energy.

Overall, this category consists of:

- Mopeds
- Motorbikes
- ATVs
- Buggies
- Micro-cars

This is the smallest and least important vehicle category in terms of emissions. These vehicles account for around 0.3% of greenhouse gas emissions and projections show that this trend should not change, with the massive decarbonisation of the passenger car category seeing the share rise to around 1% only in 2050.

Figure 6.18: *Trend and projections of L-category conventionally powered vehicles in **WEM=WAM** scenario up to 2050*

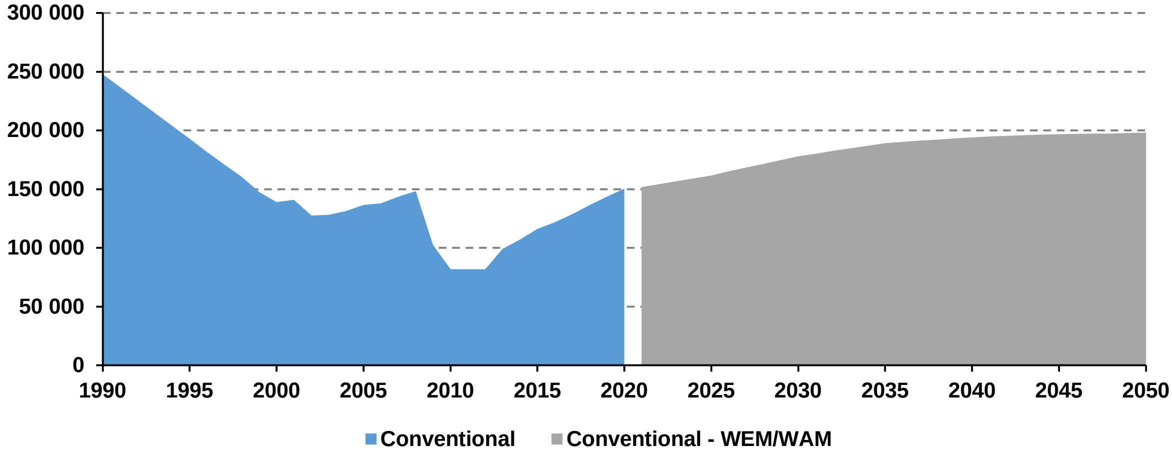
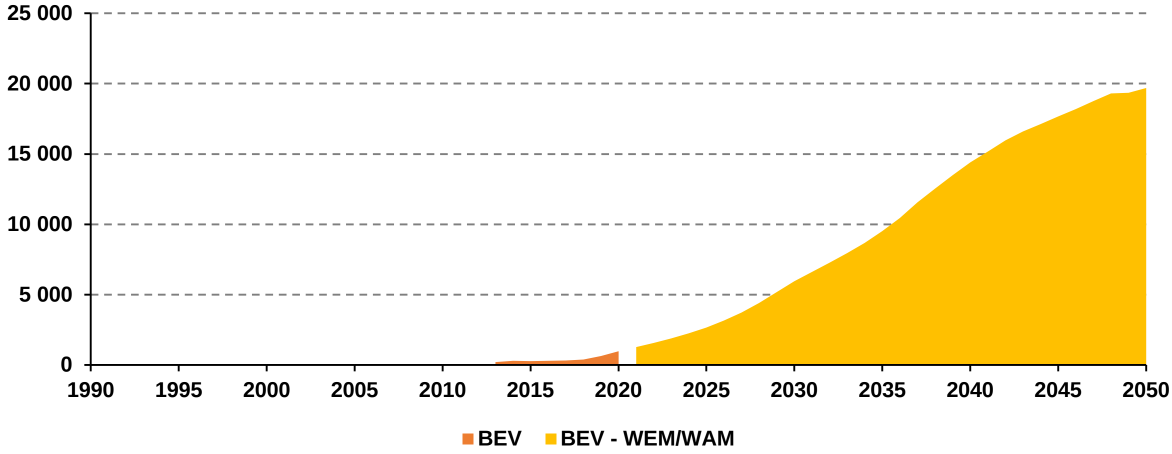


Figure 6.19: *Trend and projections of electric and hydrogen L-category vehicles in **WEM=WAM** scenario up to 2050*



6.2.3 Policies, Measures and Scenarios

For the purpose of setting the 2030 target, two road transport scenarios have been prepared. The **WEM** scenario describes the likely trend of the vehicle fleet and its emissions without further external interventions in the form of additional measures and the introduction of new policies by government and public institutions.

In contrast, the **WAM** scenario foresees a number of additional measures and policies that will need to be put in place both nationally and locally. The policies and measures used are based directly on legislation or on national and EU strategies and action plans. The reference year was 2005. The reason for choosing this year as a reference year for comparison is that in 1990 road transport in Slovakia was not yet developed in all areas and did not reflect the current situation. In 1990, the light-commercial vehicle segment, which plays an important role alongside other segments today and especially in the future, was almost non-existent. At the same time, the last validated year with real values was determined to be 2020.

Road transport is mainly affected by policies and measures in three areas: energy, transport and environment. Energy policies and measures focus mainly on energy efficiency and renewable in transport. Conversely, transport policies and measures focus on transport infrastructure and environmental policies and measures focus directly on reducing emissions of greenhouse gases and pollutants.

The policies and measures taken into account in each scenario are based on a number of national documents:

- Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050 (NUS SR[1])
- Action plan for the development of electromobility in Slovakia[115]
- National Emissions Reduction Programme (NAPCP)[2]
- Strategic plan for the development of transport in Slovakia up to 2030[116]
- Integrated National Energy and Climate Plan of Slovakia (NECP[6])
- Review and update of the National Policy Framework for the Development of the Alternative Fuels Market[117]
- EU hydrogen strategy[118]

In addition to these documents, separate laws and European legislation also intervene in the preparation of individual scenarios. Act No. 277/2020 amending Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High Efficiency Combined Heat and Power Generation and amending Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High Efficiency Combined Heat and Power Generation.[119] Within the framework of common European legislation, these are in particular directives setting emission limits and the European Parliament's Energy Union Governance Regulation 2018/1999, complemented by Regulation 2021/1119[8], which establishes a framework for achieving climate neutrality.[5]

WEM scenario **-** the baseline scenario, which includes only policies and measures in place by the end of 2020. All measures are contained directly in the Low Carbon Strategy of the Slovak Republic (NUS SR) and subsequently in the National Energy and Climate Plan (NECP) or the NECP directly refers to other strategies where these measures are found. The **WEM** scenario contains only five known measures that affect the energy mix and the vehicle fleet.

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[115] Ministry of Economy of the Slovak Republic, "Action Plan for the Development of Electromobility in the Slovak Republic," 2019. [Online]. Available: https://www.mhsr.sk/uploads/files/5wuw3LIe.pdf

[116] Ministry of Transport and Construction of the Slovak Republic, "Strategic Plan for the Development of Transport in the Slovak Republic until 2030," 2016. [Online]. Available: file:///C:/Users/p5977/Documents/DP/lit/Strategicky_plan_2030.pdf

[117] Ministry of Economy of the Slovak Republic, "National policy framework for the development of the alternative fuels sector," 2019. [Online]. Available: https://www.economy.gov.sk/uploads/files/crnljLKj.pdf

[118] European Commission, „A hydrogen strategy for a climate-neutral Europe," 2020. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301

[119] Act No. 309/2009 on the Promotion of Renewable Energy Sources and High Efficiency Combined Production and on Amendments and Additions to Certain Acts

They are:

- Act No. 277/2020[19], which is a partial national transposition of Directive (EU) 2018/2001 of the European Parliament and of the Council (RED II)[120] on the promotion of the use of energy from renewable sources
- Sale of low-emission vehicles (electric hybrids or plug-in hybrids) or directly zero-emission vehicles (electric cars)[15]
- Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO_2 emission performance standards for new passenger cars and light-commercial vehicles[121]
- Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO_2 emission performance standards for new heavy-duty vehicles[122]

The RED II Directive - on the promotion and use of energy from renewable sources is currently still not fully transposed into national legislation (to be done in the course of 2022). Its validity and inclusion in the **WEM** scenario was necessary and mandatory based on the scenario preparation framework. The revised RED II Directive sets new targets for the blending of renewable fuels (biofuels) into fossil fuels.

The new increased targets are:

2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
7.6%	8.0%	8.2%	8.6%	8.8%	9.2%	9.5%	10.0%	10.4%	10.8%	11.4%

At the same time as this increased target, the possibility of double counting the energy share of advanced biofuels has also been introduced. However, the double counting of advanced biofuels has no impact on the production of greenhouse gas emissions. There are missing shares of biofuels in the outputs, which, for the purposes of achieving RED II targets, should just be the second (double) counting of advanced biofuels.

In the case of possible RED III targets, these are not directly linked to transport emissions projections. The 13% greenhouse gas savings target does not apply to the combustion of biofuels, but to their production phase (well to tank). Thus, savings in these emissions must be reflected in the energy or industrial sector. At the same time, as it is not an approved measure before 2020, it cannot be implemented in the **WEM** scenario.

The promotion of electromobility to date and its results can be seen in ***Figures 6.8*** and ***6.11***. The projected share of low- and zero-emission vehicles (BEVs) in the SR fleet can be seen in ***Figure 6.20***. Passenger cars account for the largest share of electro-mobility, accounting for 89% in 2020, 98% in 2025 and up to 99% of all electric vehicles on the road in 2030.

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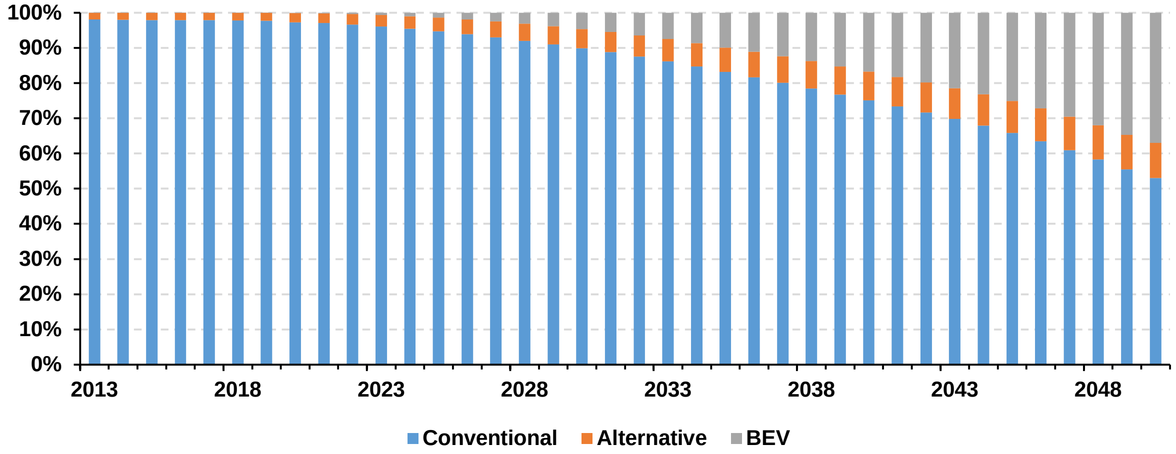
[120] European Commission, „Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources,“ 2018. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

[121] European Commission, „Regulation (EU) 2019/631 of the European Parliament and of the Council setting CO_2 emission performance standards for new passenger cars and for new Light-duty vehicles,“ 2019. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0631

[122] European Commission, „Regulation (EU) 2019/1242 of the European Parliament and of the Council setting CO_2 emission performance standards for new heavy-duty vehicles,“ 2019. [Online]. Available: https://eur-lex.europa.eu/eli/reg/2019/1242/oj

Figure 6.20: *Share of low- and zero-emissions vehicles on total vehicle fleet in the Slovak Republic - historical development and projections up to 2050*



The estimated percentage of EVs in the passenger car category is shown in ***Table 6.10***. This is a more conservative estimate of the number of EVs in 2030 than in the EU Reference Scenario. According to the EU Reference Scenario, the share of EVs in the EU as a whole is expected to reach 25% in 2030.

Table 6.10: *Share of electric vehicles in the passenger car fleet according to historical data and projected development*

Years	2015	2020	2025	2030	2035	2040	2045	2050
Bev share on passenger cars	0.01%	0.08%	1.58%	5.40%	11.74%	20.18%	30.53%	45.47%
Number of electric vehicles (pcs)	194	2 644	41 844	157 304	357 644	619 698	930 934	1 366 982

Energy efficiency manifests itself in the model identically to the real options. The potential for improving combustion quality and engine efficiency to the level of "ultra-efficiency" was estimated at 15% in the ERTRAC report[123] for passenger cars with spark-ignition engines. For diesel engines for passenger cars, this estimate was a 12% improvement by 2050, but for light and heavy duty vehicles there is only a 10% chance of making the engine more efficient. This coefficient directly reduces the outputs of energy demand and CO_2 emissions. Both EU regulations (2019/631 and 2019/1242) are also incorporated into the model in this way. ***Table 6.11*** shows the coefficient used for selected vehicle groups in the model for new vehicles.

Table 6.11: *Energy efficiency coefficients for selected groups of new vehicles*

Years/Category	2020	2025	2030	2035	2040	2045	2050
Passenger cars	0.6%	1.9%	3.4%	4.5%	5.2%	5.7%	6.1%
Light-commercial vehicles	0.9%	2.8%	4.6%	6.1%	7.2%	8.2%	9.2%
Heavy-duty vehicles	0.7%	3.0%	5.2%	6.7%	7.8%	8.6%	9.3%
Buses	0.6%	2.9%	5.1%	6.6%	7.6%	8.4%	9.1%
L-category	0.7%	2.8%	4.7%	5.9%	6.4%	6.8%	7.3%

WAM scenario is built on policies and measures, strategies and action plans that have not been put into practice before 2020. The list of policies and measures used is summarised in ***Table 6.12***.

[123] Ministry of Transport and Construction of the Slovak Republic, "Transport Service Plan of Slovakia for Railway Passenger Transport," 2022. [Online]. Available: https://www.mindop.sk/ministerstvo-1/doprava-3/strategia/verejna-osobna-doprava/plan-dopravnej-obsluznosti-slovenska-pre-zeleznicnu-osobnu-dopravu

Table 6.12: *List of policies and measures used in* ***WAM*** *scenario for Transport sector*

PAMs	Source (strategy, action plan, etc.)	Quantifiable (yes/no)
Continued direct support for the use of low-emission vehicles	Action plan for the development of electric vehicles in the Slovak Republic	Yes
Long-term financial mechanism to support the development of charging infrastructure	Action plan for the development of electric vehicles in the Slovak Republic	No, supporting
Setting stricter requirements for periodic technical inspections of vehicles	National Emissions Reduction Programme	Yes
Vehicle registration fee based on g CO_2/km emissions	Act in preparation at the Ministry of Finance of the Slovak Republic	Yes
Information campaign	Action plan for the development of electric vehicles in the Slovak Republic	No, supporting
Education in schools; awareness of new skills and knowledge in education	Review and update of the National Policy Framework for the Development of the Alternative Fuels Market	No, supporting
Modal shift in passenger transport	Strategic Transport Development Plan 2030	yes
Modal shift in the transport of goods	Strategic Transport Development Plan 2030	Yes
Introduction and promotion of hydrogen powered vehicles (FEEV)	European Hydrogen Strategy	Yes
Addition of biomethane to CNG and LNG	RED II, Act No 309/2009 Coll. (still in the legislative process)	yes

The **WAM** scenario has the working title "100in50" as a reference to the drive to achieve carbon-free road transport in 2050. The measure to support the continuation of direct support for the use of low-emission vehicles is mentioned in the Action Plan for the Development of Electromobility in the Slovak Republic[15] and is also referred to in the National Emission Reduction Programme.[2] In this measure, the penetration of electric vehicles in the passenger car segment is assumed to be more efficient, up to twice as strong, than in the **WEM** scenario. It is expected that further significant subsidy schemes will be introduced and that the share of electric vehicles will increase to 65% between 2025 and 2050. ***Table 6.13*** shows how the more significant increase is reflected in the number of EVs in the fleet.

Table 6.13: *Share of electric vehicles in the passenger car fleet after the introduction of the measure "Continued direct support for the use of low-emission vehicles"*

Years	2020	2025	2030	2035	2040	2045	2050
Share of electric vehicles in the passenger car fleet	0.19%	3.80%	13.88%	26.78%	39.67%	52.57%	65.47%
Number of electric vehicles (pcs)	4 544	100 427	404 332	815 529	1 218 148	1 603 241	1 968 268

An indicator of the implementation of this measure and also an indicator for the trajectory of the reduction of CO_2 emissions from new passenger cars is the share of new BEVs in the total sales of new passenger cars. The share that would need to be met each year to meet the 55% reduction target in g CO_2/km for newly registered vehicles by 2030 and was agreed as part of the Fit for 55 package.[124] This share can be seen in ***Table 6.14***. Legislation limiting emissions from new vehicles to 100% comes into force in 2035.

[124] European Commission, „Fit for 55," 2021. [Online]. Available: https://www.minzp.sk/files/oblasti/politika-zmeny-klimy/oznamenie_celex-52021dc0550-sk-txt.pdf

Table 6.14: *Indicator of progress towards the Fit for 55 target*

Year	Share of new BEV	Share of subsidised BEV of new BEVs
2021	8.38%	27.8%
2022	11.69%	100.0%
2023	19.46%	14.1%
2024	23.57%	26.7%
2025	37.05%	71.3%
2026	43.89%	67.2%
2027	47.96%	66.4%
2028	49.64%	74.4%
2029	65.01%	55.5%
2030	62.69%	64.0%
2031	65.15%	57.7%
2032	64.66%	60.1%
2033	69.10%	51.3%
2034	67.23%	56.1%
2035	64.22%	63.8%

Stricter technical and emission inspections should result in the capture and removal of the oldest and non-compliant vehicles from transport. Strict rules are now in place for technical and emission inspection stations, but despite these measures, there is still circumvention of the rules. According to expert estimates, the introduction of additional inspection mechanisms could help to phase out between 0.01% and 0.05% of vehicles older than 15 years per year. This measure is expected to have a gradually diminishing effect under the influence of positive changes in the behaviour of vehicle owners. In the model, this measure manifests itself as a change in the age structure of the passenger car fleet.

The introduction of a new registration fee or "environmental tax", takes into account the production of CO_2 emissions by passenger cars and is expertly estimated at between 0.1% and 0.3% of the end-of-life passenger cars with the highest emissions. These are mostly older vehicles, as are the technical and emissions inspections. The effect of this measure is reflected in the model in the change in the age structure of passenger cars. A gradual fading will also be observed for this measure.

Modal shift in passenger transport implies a shift of passengers from passenger transport to public passenger transport (PPT). As a result, the occupancy rate of passenger cars is expected to increase by 50% compared to 2020, reducing in particular the amount of kilometres travelled by passenger cars by up to 33% by 2050. The transfer of passengers to the PPT will go in two directions at the same time: road PPT and rail PPT. In the case of the rail PPT, it is expected that there will be an improvement in the quality of transport as well as the restoration of a number of connections. The prerequisite for this is the approved new Transport Service Plan for rail passenger transport.[125] In the case of bus services, it is expected that there will be a slight increase in kilometres travelled. This effect on public bus services was reflected in a 10% increase in average annual boarding.

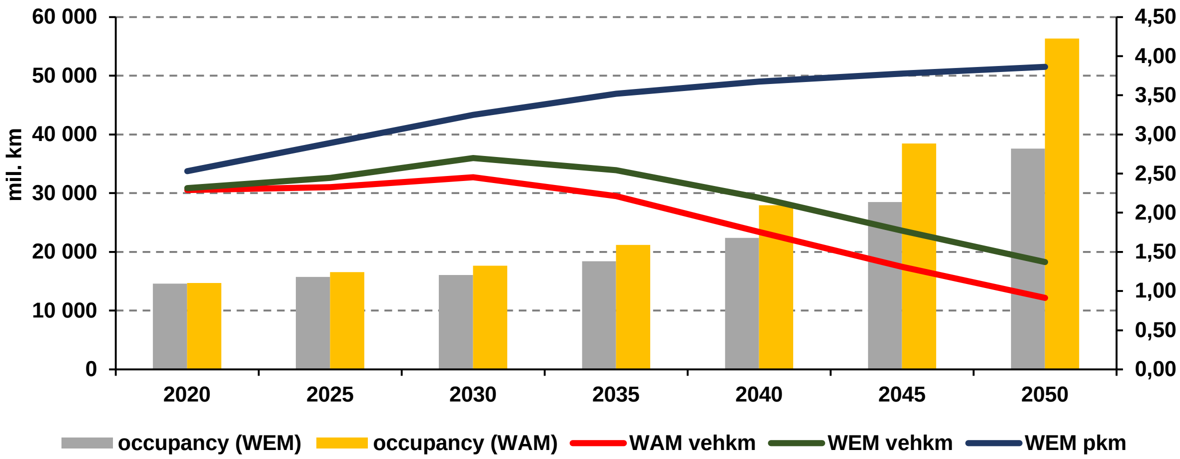
For shorter distances and in the city, it is also possible to use bicycle transport in addition to PPT. This possibility should also result from the National Strategy for the Development of Cycling Transport and

[125] Ministry of Transport and Construction of the Slovak Republic, "Transport Service Plan of Slovakia for Railway Passenger Transport," 2022. [Online]. Available: https://www.mindop.sk/ministerstvo-1/doprava-3/strategia/verejna-osobna-doprava/plan-dopravnej-obsluznosti-slovenska-pre-zeleznicnu-osobnu-dopravu

Cycling Tourism in the Slovak Republic.[126] It is estimated that it could reduce the share of road passenger transport in cities by up to 10% by 2030. For the purposes of the projections, more conservative estimates of 3% have been used.

The input data are pkm (person-km), which are the output macroeconomic indicators from the CPS-PRIMES model for the Low Carbon Development Strategy of the Slovak Republic.[1] From these, the vehicle occupancy was then calculated, to which the streamlining and increase in occupancy was applied. It was then possible to calculate the new mileage with increased vehicle occupancy while maintaining passenger kilometres (***Figure 6.21***).

Figure 6.21: *Changes in passenger car occupancy, annual passenger vehicle miles travelled, and passenger car miles travelled by CPS-PRIMES model*

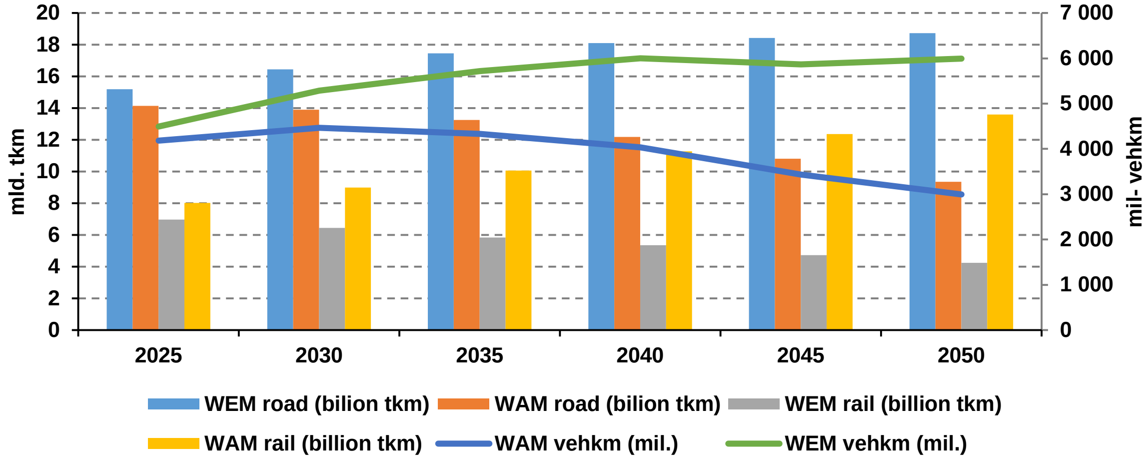


Modal shift in freight transport - the movement of goods in Slovakia is currently mainly carried out by freight transport. From this point of view, modal shift in freight transport is more than necessary. According to the freight modal shift policy, the volume of goods transported by freight is expected to decrease by 50% by 2050. This goal is foreseen in the Low Carbon Development Strategy of the Slovak Republic.[1] As a consequence of shifting some of the goods to the railways, the annual vehicle mileage will be reduced and ultimately the number of lorries will also be reduced. A possible reduction in the number of lorries has not been estimated, as the **WAM** scenario currently only assumes a reduction in annual mileage.

The calculation procedure is analogous to the modal shift in passenger transport. In this case, tonne-kilometres (tkm) play a role, which were also obtained from the CPS-PRIMES model for the Low Carbon Development Strategy of the Slovak Republic[1] as a macroeconomic indicator (***Figure 6.22***).

[126] Ministry of Transport and Construction of the Slovak Republic, "Cycle transport and cycling tourism," 2015. [Online]. Available: https://www.mindop.sk/ministerstvo-1/doprava-3/strategia/cyklisticka-doprava-a-cykloturistika

Figure 6.22: *Changes in freight transport, annual boarding and goods transported by road and rail (billion tkm)*

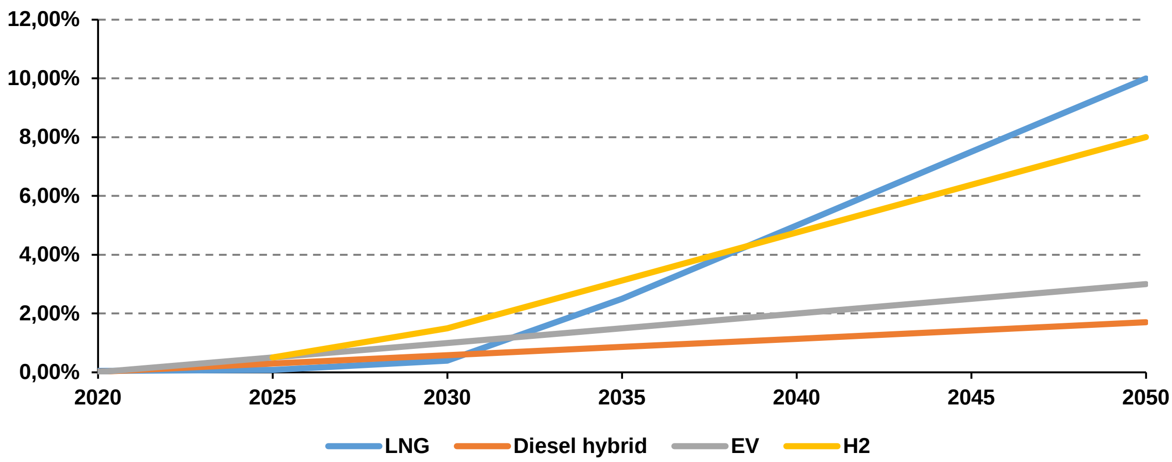


The most influential measure in this scenario appears to be the phasing out of fossil fuel-powered cars and light duty vehicles and their replacement by electric and hydrogen vehicles, especially for last mile goods movements. A complete ban on the sale of these pure fossil fuel vehicles (diesel and petrol) is due to take place in 2035.

This measure will result in an exponential growth of BEVs in the light-commercial vehicle category. This measure could also facilitate the introduction of low emission zones in cities. The deployment measure is not part of the package of measures for the **WAM** scenario as the quantification of such a measure would be difficult and burdened with high error.

Similarly, traditional fossil fuel trucks are expected to be phased out and replaced by hybrid, electric, hydrogen or LNG vehicles. To support this measure, the same subsidy mechanism will need to be put in place as for passenger cars. The uptake of these motorisations is generally slow and only becomes apparent after 2030. In the case of hydrogen propulsion, the European Hydrogen Strategy[18] speaks of a maximum hydrogen deployment rate of 16% by 2050. In Slovakia, this level is set at 8% in the **WAM** scenario, based on a consensus of experts in the field. Hybrid and electric motorisation is at 4.7% by 2050. The uptake of LNG vehicles is projected at 10% by 2050 (***Figure 6.23***). This growth is assumed to be in addition to the natural growth of alternative and zero-emission trucks.

Figure 6.23: *Percentage growth of additional trucks using alternative and BEV fuels*



The introduction of hydrogen passenger cars, similar to trucks, was estimated in the European Hydrogen Strategy report[18] to reach a maximum possible implementation rate of 20% of the vehicle fleet by 2050. In Slovakia, this level is reduced to 10% in the **WAM** scenario following a consensus of experts in the field.

The addition of bio-based methane (biomethane) to vehicle fuels is now common practice in other EU countries. In Slovakia, this obligation will be introduced by the amendment of Act No. 309/2009 on the Promotion of Renewable Energy Sources and High Efficiency Combined Production as the amendment was not adopted before 31 December 2020,[20] it could not be implemented as a **WEM** scenario measure. This amendment introduces an obligation to add a bio-component to compressed natural gas (CNG) and liquefied natural gas (LNG) from 2023.

The minimum energy content of this bio-ingredient is determined as follows:

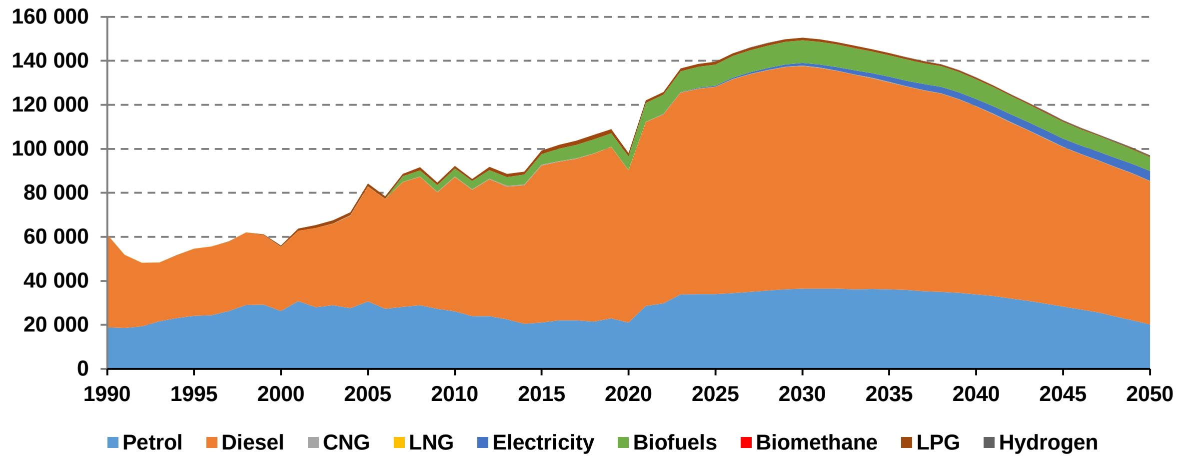
2023	2024	2025	2026	2027	2028	2029	2030
2.0%	3.0%	4.0%	6.0%	8.0%	10.0%	12.0%	14.0%

Even at the highest achievable share in 2030 (14% of the bio-based component), this does not have a significant reduction impact on emissions and traffic intensity in the scenario.

6.2.4 Projections of Greenhouse Gas Emissions from Road Transport

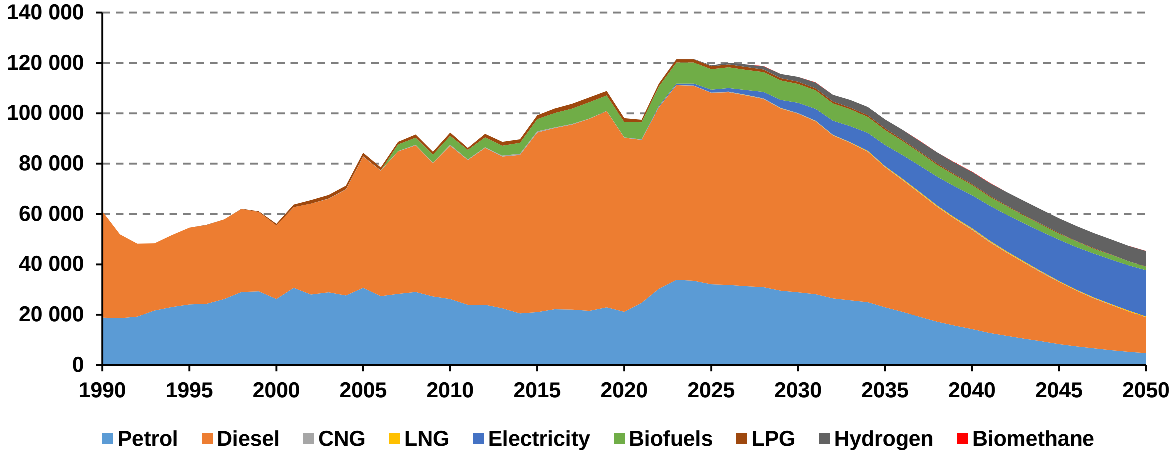
In terms of energy, according to the **WEM** scenario, Slovakia will be dominated by diesel until 2050. Its consumption will slowly decrease in this scenario but will still account for up to 67% of the total energy consumption of road transport in 2050. Of the other alternative fuels, electricity consumption will be the most dominant, rising gradually from a share of 1% (1 200 TJ or 330 GWh) in 2030 to around 5% (4 450 TJ or 1 230 GWh) in 2050 (***Figure 6.24***).

Figure 6.24: *Historical trend and projections of the energy demand for road transport in **WEM** scenario up to 2050*



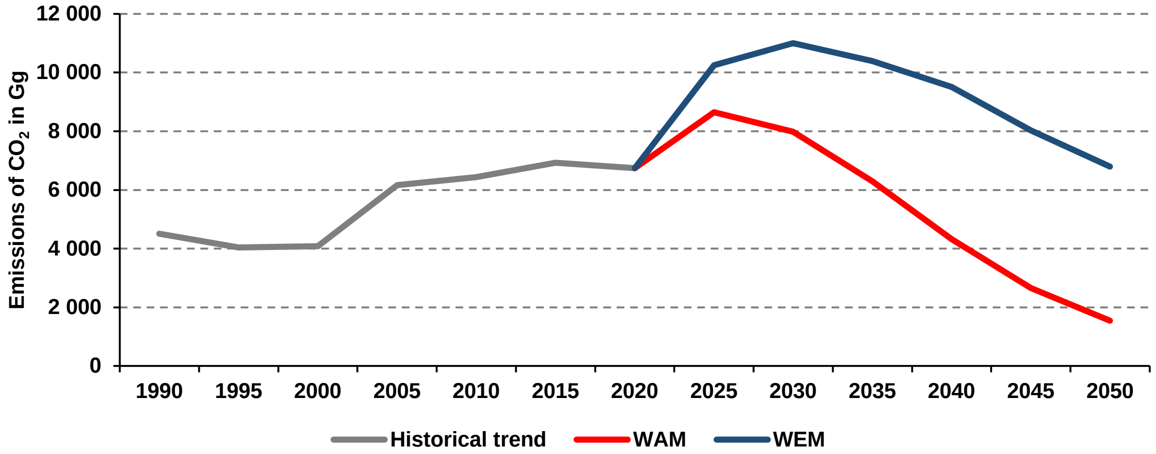
In the **WAM** scenario, significant diversification and an overall decline in fuel and energy consumption is expected in 2050. In this case, electricity will be the most used resource, accounting for 3% (4 000 TJ or 1 100 GWh) in 2030 and up to 40% (18 300 TJ or 5 000 GWh) of the total energy demand in 2050 (***Figure 6.25***). Diesel will still have a similarly significant but significantly smaller share, with a share of 62% in 2030, falling to half (31%) in 2050. This significant share, despite strong decarbonisation, is mainly due to the truck category, which is extremely difficult to decarbonise while maintaining the parameters required of them.

Figure 6.25: *Historical trend and projections of the energy demand for road transport in **WAM** scenario up to 2050*



CO_2 emissions are the most significant GHG for road transport. All measures are primarily aimed directly at reducing these emissions. Therefore, the CO_2 emission scenarios (***Figure 6.26***) also follow the trend of GHG emissions expressed in CO_2 equivalents.

Figure 6.26: *Historical trend and projections of CO_2 emissions from road in **WEM** and **WAM** scenarios up to 2050*



CH_4 and N_2O emissions (***Figure 6.27*** and ***6.28***) are insignificant in terms of the amount produced by road transport and the impact on total GHG emissions in Slovakia, as they already account for only 1% of total GHG emissions from road transport. Methane emissions decline in the **WAM** scenario, but at a significantly slower rate than the other two GHGs. This is mainly due to the introduction of compressed or liquefied natural gas vehicles as an alternative to petrol and diesel vehicles. On the one hand, these fuels reduce overall CO_2 emissions, but on the other hand they reduce the effect of other measures that also reduce methane emissions.

Figure 6.27: *Historical trend and projections of CH_4 emissions in road transport in **WEM** and **WAM** scenarios up to 2050*

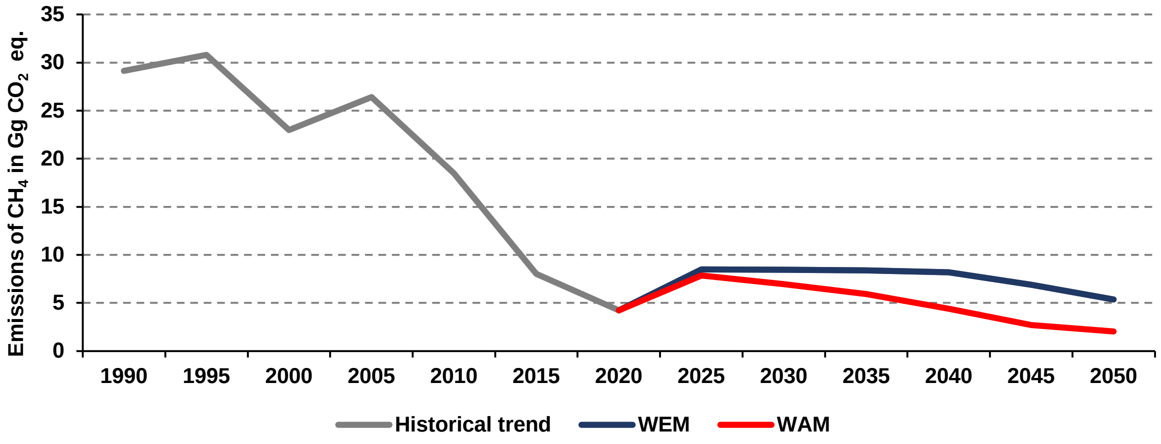
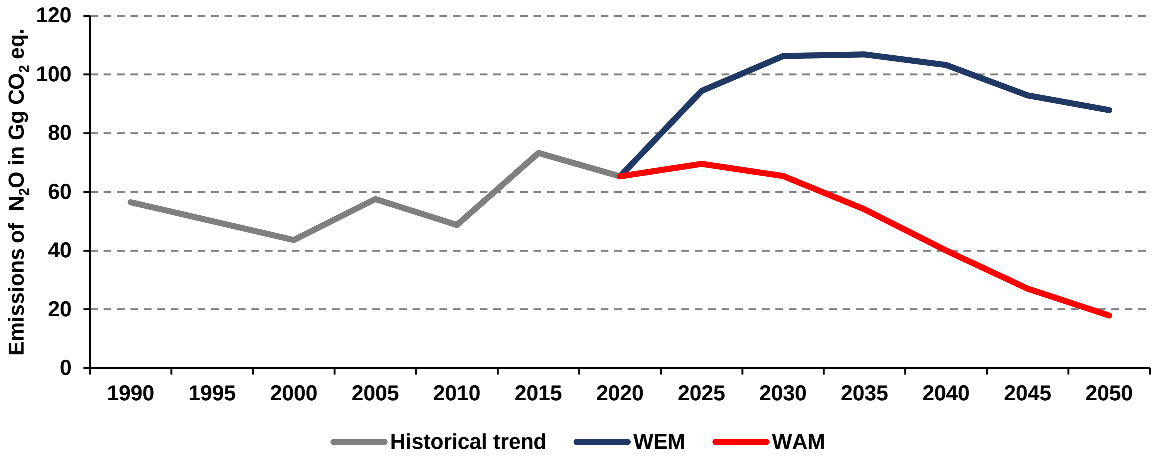


Figure 6.28: *Historical trend and projections of N_2O emissions in road transport in **WEM** and **WAM** scenarios up to 2050*



Total emissions in CO_2 equivalents - the **WEM** scenario (***Table 6.15***) results in a 78% increase in GHG emissions, in CO_2 equivalents, in 2030 compared to 2005. The passenger car and light duty-vehicle segments account for the largest share of this increase. In contrast, heavy-duty vehicles (trucks over 7.5 tonnes) will only contribute around 5% of this increase.

Table 6.15: *Comparison of greenhouse gas levels with reference years in **WEM** scenario*

WEM							
Gas	**Emission category**	**2030**		**2035**		**2050**	
		Comparison with 1990	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**
CO_2 eq.	Road transport	142.1%	78.0%	129.0%	68.3%	50.2%	10.4%
CH_4	Road transport	-71.0%	-68.0%	-71.2%	-68.3%	-81.6%	-79.8%
N_2O	Road transport	88.1%	84.6%	89.2%	85.6%	55.6%	52.7%
CO_2	Road transport	144.2%	78.5%	130.8%	68.7%	51.0%	10.4%

WEM							
Gas	**Emission category**	**2030**		**2035**		**2050**	
		Comparison with 1990	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**
CO_2	Passenger transport	350.5%	145.2%	292.4%	113.6%	47.4%	-19.8%
CH_4	Passenger transport	-61.0%	-56.9%	-60.8%	-56.7%	-78.1%	-75.8%
N_2O	Passenger transport	210.6%	22.8%	158.6%	2.3%	-14.5%	-66.2%
CO_2	Light duty	424.4%	57.1%	484.9%	75.2%	538.1%	91.1%
CH_4	Light duty	-79.2%	-81.6%	-76.5%	-79.2%	-59.9%	-64.4%
N_2O	Light duty	1,706.0%	153.9%	1 925.9%	184.8%	2,267.8%	232.9%
CO_2	Heavy duty vehicles and buses	6.6%	17.8%	7.6%	18.9%	-2.6%	7.6%
CH_4	Heavy duty vehicles and buses	-87.3%	-88.3%	-89.6%	-90.4%	-92.2%	-92.8%
N_2O	Heavy duty vehicles and buses	19.5%	197.1%	34.8%	235.4%	42.3%	254.0%
CO_2	L-categories	-32.0%	5.4%	-21.3%	21.8%	-22.2%	20.5%
CH_4	L-categories	-86.0%	-52.4%	-83.9%	-45.5%	-83.2%	-43.1%
N_2O	L-categories	-13.7%	7.3%	3.4%	28.5%	8.4%	34.7%

The output of the **WAM** scenario (***Table 6.16***), which is already extremely ambitious at this point in time, shows some muting of the increase in GHG emissions. The increase in 2030 will be 29% compared to 2005, and in 2050 the measures introduced in this scenario will make it possible to achieve emission reductions of around 75% compared to 2005 levels. In this case, it should be noted that the strongest measure will be the obligation for manufacturers to reduce CO_2 emissions from new vehicles by 100% after 2035. If this deadline is postponed, it will have a significant impact on future emissions by 2050 and it is very likely that Slovakia will not be able to meet its carbon neutrality commitment because of road transport.

Table 6.16: *Comparison of greenhouse gas levels with reference years in **WAM** scenario*

WAM							
Gas	**Emission category**	**2030**		**2035**		**2050**	
		Comparison with 1990	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**	**Comparison with 1990**	**Comparison with 2005**
CO_2 eq.	Road transport	75.6%	29.0%	38.5%	1.8%	-66.0%	-80.6%
CH_4	Road transport	-76.1%	-73.7%	-79.7%	-77.6%	-93.0%	-92.3%
N_2O	Road transport	15.8%	13.6%	-4.3%	-6.1%	-68.4%	-68.9%
CO_2	Road transport	77.3%	29.6%	39.8%	2.2%	-65.8%	-75.0%
CO_2	Passenger transport	245.7%	88.1%	136.8%	28.9%	-79.0%	-88.6%
CH_4	Passenger transport	-67.6%	-64.2%	-74.3%	-71.6%	-94.2%	-93.6%
N_2O	Passenger transport	121.1%	-12.6%	45.4%	-42.5%	-90.8%	-96.3%
CO_2	Light duty	414.2%	54.0%	418.3%	55.2%	58.6%	-52.5%
CH_4	Light duty	-79.0%	-81.3%	-78.3%	-80.8%	-8.6%	-89.0%

WAM							
Gas	Emission category	2030		2035		2050	
		Comparison with 1990	Comparison with 2005	Comparison with 1990	Comparison with 2005	Comparison with 1990	Comparison with 2005
N_2O	Light duty	1 634.7%	143.9%	1 661.3%	147.6%	455.5%	-21.9%
CO_2	Heavy duty vehicles and buses	-48.1%	-42.7%	-54.0%	-49.2%	-74.1%	-71.4%
CH_4	Heavy duty vehicles and buses	-91.6%	-92.3%	-90.7%	-91.4%	-94.5%	-95.0%
N_2O	Heavy duty vehicles and buses	-47.4%	30.8%	-49.4%	25.8%	-70.0%	-25.3%
CO_2	L-categories	-32.0%	5.4%	-21.3%	21.8%	-22.2%	20.5%
CH_4	L-categories	-86.0%	-52.4%	-83.9%	-45.5%	-83.2%	-43.1%
N_2O	L-categories	-13.7%	7.3%	3.4%	28.5%	8.4%	34.7%

Total GHG emissions from road transport in Slovakia in the **WAM** scenario increase by +29% in 2030 compared to 2005 but decrease by -81% in 2050 compared to 2005 (***Table 6.16***).

6.2.5 Projections of Greenhouse Gas Emissions from Non-Road Transport

In addition, projections of GHG emissions from non-road transport in the Slovak Republic have been prepared, but their relevance to the overall GHG emissions projections is negligible, so only the **WEM** scenario has been prepared. Projections of non-road emissions were calculated using ARIMA (AutoRegressive Integrated Moving Average) modelling. Emission from pipeline transport have been prepared based on information about projections of long distance transmission of natural gas through the pipelines system (***Table 6.17***).

Table 6.17: *Projections of GHG emissions in non-road transport in* ***WEM*** *scenario*

Gases	Transport Sector	*Unit*	2019	2020	2025	2030	2035	2040	2045	2050
CO_2	Air transport	*kt*	1.83	0.88	1.25	1.34	1.34	1.34	1.34	1.38
	Rail transport		81.02	72.53	97.85	100.97	104.41	108.06	115.21	120.50
	Navigation transport		4.17	5.35	2.64	2.25	2.06	1.87	1.02	0.52
	Pipeline transport		398.28	167.83	290.91	287.28	283.28	294.08	280.53	274.13
CH_4	Air transport	*ton*	0.04	0.02	0.031	0.031	0.031	0.031	0.031	0.032
	Rail transport		4.87	4.36	5.50	5.70	5.90	6.10	6.34	6.57
	Navigation transport		0.40	0,51	0.30	0.30	0.30	0.30	0.25	0.23
	Pipeline transport		7.14	3.03	0.01	0.01	0.01	0.01	0.01	0.005
N_2O	Air transport		0.05	0.02	0.019	0.019	0.019	0.019	0.019	0.020
	Rail transport		33.58	30.10	37.80	39.00	40.40	41.80	61.61	71.38
	Navigation transport		0.11	0.14	0.06	0.06	0.06	0.06	0.04	0.03
	Pipeline transport		7.14	0.30ň	0.001	0.001	0.001	0.001	0.001	0.0005

6.2.6 Methodology, Model Used and Sensitivity Analysis

Emission Inventory	SVK_CRF_13-04-2022 (1990-2020)
Baseline year for projections	2020
Baseline year for policies and actions	2020
Emissions projections for the period	2021-2050
Reduction targets	2030 a 2050
Expression of the reduction compared to the years	1990 (base year for greenhouse gas emissions)
	2005 (base year for emissions in the Regulation ESR[127])

Input data for the calculation of GHG projections from road transport are databases provided by the Traffic Inspectorate of the Presidium of the Police Force of the Slovak Republic (IS EVO - Information System of Vehicle Registration) and the Ministry of Transport and Construction of the Slovak Republic (STK - Slovak Technical Inspection), transport indicators from the CPS-PRIMES model (MŽP SR - IEP), which was developed for the needs of the Low Carbon Strategy[1].

An important aspect in the preparation is the Sybil database. This database is being prepared by EMISIA on the basis of:

- EUROSTAT statistics (national statistics),
- Project outputs (FLEETS, TRAACS, NMP project) for all EU countries,
- EC Statistical Pocketbooks
- ACEA (The European Automobile Manufacturers' Association)
- ACEM (The Motorcycle Industry in Europe)
- CO2 monitoring database (operated by the EEA)
- EAFO (European Alternative Fuels Observatory)
- NGVA EUROPE/NGV GLOBAL (The Natural & bio Gas Vehicle Association)
- UNFCCC reports
- Proprietary algorithms for the preparation of the age structure up to 2050

The data in this database are based on the same input parameters as the EU reference scenario for Slovakia. The EU reference scenario for Slovakia was modelled using PRIMES and its transport module TREMOVE. However, for the conditions of Slovakia, as a small country, this model is directly inapplicable, as it requires a lot of detailed data, which Slovakia does not have.

Using trends from the Sybil database, an estimate of fleet development was prepared based on real data for the years 2013-2020. The data for this time period were obtained from IS EVO. Data and emissions prior to 2013, i.e. the period 1990-2012, were compiled from official Traffic Inspectorate of Police statistics and historical emission inventories.

Another important factor for calculating emissions and energy demand is the average value of annual mileage in each vehicle category and the average value of total vehicle kilometres travelled in each

[127] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 that contribute to climate action to meet their commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

category. These data for the historical years 1990-2012 were taken from emission inventories. Subsequently, for the years 2013-2020, these data were calculated using the information contained in the Vehicle Technical Inspection (VTI) database.

The model itself operates with 5 vehicle categories:

- Passenger cars (M1)
- Light-commercial vehicles (N1)
- Heavy-duty vehicles - trucks (N2 and N3)
- Buses (M2 and M3)
- L-category (L1 to L7)

Estimates for the period 2021-2050 were taken directly from the Sybil database. These estimates are based on European statistics and qualified estimates by transport experts. Subsequently divided into individual fuel bases, segments (by engine capacity or vehicle weight) and emission standards, the model works with up to 620 separate data streams in total. The numbers of vehicles in each data stream each year are determined by an age composition matrix and a "survival rate" calculated on the basis of data from the above-mentioned projects and EUROSTAT data.

The COPERT model is used for the actual calculation using the CLI module, which allows new technologies that are not directly defined by the model to be brought into the model. This includes emissions-intensive technologies such as LNG, flexi-fuel, e-fuel or hydrogen engines.

The COPERT model always reflects and incorporates the latest developments and scientific knowledge into emissions calculations. The emission calculation methodology is described in the EMEP/CORINAIR Atmospheric Emissions Inventory Guidebook (EMEP GB) on tailpipe emissions from road transport. The model has roughly 50 predefined (and modifiable) parameters, ranging from environmental conditions (air temperature and humidity) to parameters detailing the generation of emissions in individual vehicle types. When using the CLI module, many of these parameters are unavailable and set to the default value.

Basic emission factors are integrated in the model, which are adjusted based on user-supplied input parameters. Emission factors are defined for each greenhouse gas separately. Carbon dioxide emissions are specific as they are calculated based on the ratio of hydrogen to carbon in fuels and thus the amount of CO_2 depends on the total amount of fuel burned. Actual values for 2020 were used for the model, except for new technologies where it was necessary to supply emission factors directly.

In terms of technology and the use of different technologies within a single vehicle (plug-in hybrids, CNG, LPG), basic settings were used. In the case of CNG and LPG, it is assumed that 100% of these fuels are used at the expense of petrol, and in the case of plug-in hybrids, the split is 75% in favour of petrol and diesel and 25% in favour of electricity (electric motor). The low share of electric motor use is based on several studies summarised by the ICCT (International council on clean transportation).

Minimum and maximum temperatures have also been introduced into the model, which affect emissions to some extent. The regional climate model KNMI-RACMO22E and its optimistic scenario RCP2.6 were used.

Other transport modes were modelled using the ARIMA (arithmetic moving average) model, as their contribution to total transport emissions does not exceed 2%.

6.3 INDUSTRY SECTOR (IPPU)

Although the EU ETS Directive[128] has been in force since 2005 and is now in its fourth phase (2021-2030), the ESR Regulation[27] has been in force since 2013-2020, with a base year of 2005 (the year from which emission reductions under the ESR are calculated). Another difference between the two systems is the application of their obligations. While the EU ETS does not contain country-specific commitments, but annual trajectories of emission cap reductions, under the ESR[27] the commitment is valid at the country level. Emissions under both schemes are subject to annual international verifications.

Two scenarios, **WEM** and **WAM**, have been prepared for the purpose of determining the target for 2030 and subsequently for 2050 in the different categories of industrial activities not included in the EU ETS. Separately for all three groups of IPPU categories, namely CO_2, CH_4 and N_2O emissions in categories 2.A - 2.D, HFCs emissions in category 2.F and N_2O and SF_6 emissions in category 2.G.

The policies and measures taken into account in each scenario are based on a number of national documents:

- Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050 (NUS SR)[1]
- National Emissions Reduction Programme (NAPCP)[2]
- Integrated National Energy and Climate Plan of Slovakia (NECP)[6]

In addition to these documents, separate laws and European legislation also intervene in the preparation of individual scenarios. Act No. 277/2020, which amends Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and High Efficiency Combined Production,[19] significantly interferes with the preparation of laws. Within the framework of common European legislation, these are mainly directives setting emission limits and the European Parliament's Energy Union Governance Regulation 2018/1999, complemented by Regulation 2021/1119,[8] which establishes a framework for achieving climate neutrality.

The policies and measures used were taken from the Low Carbon Strategy of the Slovak Republic (LCDS)[1] from the National Programme for the Reduction of Pollutant Emissions[2] and from the Slovak Recovery Plan.[3]

The reduction potential presented is based on the **WEM** and **WAM** scenarios reported for emission projections in 2021 under Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action.[8]

The specification of the **WAM** scenario according to the Low Carbon Development Strategy of the Slovak Republic depends on the logic of the draft EU scenarios and in particular on the EUCO3030 scenario,[4] which sets the EU target for energy efficiency for 2030 at 30%.

Most of the above measures were applied at the level of the CPS-PRIMES[129] model, from which trends in energy consumption or other parameters were taken for modelling emissions in the TIMES model.[7]

The IPPU sector allocates greenhouse gas emissions regulated by Directive 2003/87/EC of the European Parliament and of the Council of 13. October 2003 establishing a scheme for greenhouse gas emission

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[128] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the EU and amending Council Directive 96/61/EC

[129] The World Bank, macroeconomics, trade and investment global practice. A low-carbon growth study for Slovakia: implementing the EU 2030 climate and energy policy framework, 2019. https://www.minzp.sk/files/iep/2019_01_low-carbon-study.pdf

allowance trading within the EU and amending Council Directive 96/61/EC[28] (hereinafter referred to as EU ETS emissions) and non-EU ETS emissions allocated by Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States of greenhouse gas emissions for the period 2021 to 2030 to contribute to climate action to meet their commitments under the Paris Agreement and amending Regulation (EU) No. 525/2013[27] (hereinafter referred to as the ESR emissions).

While EU ETS emissions have their reduction mechanisms set by the allocation of allowances at the operator level, ESR emissions are not sectoral regulated and the ESR reduction target is set only at the level of the country as a whole. It is therefore very important to identify potential areas for reduction, regulation or promotion. The report looks at projections of ESR emissions from the IPPU sector. This sector accounts for process (technological) emissions, i.e. not emissions from fossil fuel combustion (which are accounted for in the Energy or Buildings sectors). More on the methodology for allocating greenhouse gas emissions to the EU ETS and the ESR can be found in the report.[130]

The projections of ESR emissions in categories 2.A-2.G were mainly prepared by forecasting the development of value added for the identified industrial category under one scenario **WEM** = **WAM**. In the absence of relevant direct policies and measures in these sectors, it is very difficult to predict developments up to 2050. It is likely to be influenced only by the availability of raw materials, energy and material prices, and supply and demand. We foresee regulation mainly at EU level. The nature of process (technological) emissions does not allow much room for manoeuvre for their regulation (they are dependent on chemical reactions and processes).

The base (reference) year for modelling the GHG emissions projection was the latest revised inventory year 2019 in all scenarios.

Projections of greenhouse gas emissions for the EU ETS emissions component have been developed for the years 2020-2050 under the following scenarios:

Existing Measures Scenario (**WEM**) - includes policies and measures adopted and implemented at EU and national level by the end of 2021. In industrial processes, improving energy efficiency is essential for productivity growth, which is part of sustainable growth in added value.

The scenario with additional measures (**WAM**) - is equivalent to the Dcarb2 scenario of the CPS-PRIMES model, in the IPPU sector the outputs from CPS-PRIMES were used to obtain trends in the different industry types.

The trend of emission projections below the ESR in categories 2.A to 2.D is very complicated to express due to the lack of legislative and market mechanisms, which are mainly driven by energy policy. The trend of emission projections depends on the technologies used, which are mainly influenced by the EU ETS Directive, therefore emission reductions cannot be expected as production grows. Changes in the trend of emissions projections in the **WEM** scenario is due to changes in production, also the **WAM** scenario. In this case, **WEM=WAM**. The **WAM** scenario could not be prepared due to missing measures. The impact of electromobility on the reduction of CO_2 emissions from urea used as a reagent in nitrogen oxide abatement technologies cannot yet be estimated.

Projections of emissions of F-gases (HFCs) in category 2.F were prepared under two scenarios, **WEM** and **WAM**. The emission projections under the WEM scenario replicate Regulation (EU) No. 517/2014

[130] Report on EU ETS and EU ETS emissions for 2022, [Online] https://oeab.shmu.sk/app/cmsSiteBoxAttachment.php?ID=70&cmsDataID=0

of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No. 842/2006. According to Annex III of this Regulation, the gas designated R404A (GWP 3922) shall be replaced by R448A (GWP 1387), R449A (GWP 1397) and R452A (2410). R410A gas shall be replaced by R452B gas (GWP 698) and R134a gas shall be replaced by R513A gas (GWP 631). In addition, R134a will be replaced by R1234YF gas in the MAC. Newer gases with a GWP higher than 750 shall be replaced with gases with a maximum GWP of 150.

The emissions projections under the **WAM** scenario took into account Regulation No. 517/2014 together with the assumption of an obligation to include zero GWP gases (as supplementary gases) in new installations to replace gases used in refrigeration after 2033.

The projections of SF_6 and N_2O emissions in category 2.G were prepared under two scenarios, **WEM** and **WAM**. The projections of SF_6 emissions in the **WEM** scenario were prepared by extrapolating the base year taking into account the time series since 1990. The mitigation measure in the scenario was the assumption of decommissioning of obsolete facilities.

The emissions projections in the **WAM** scenario took into account restrictions on the use of SF_6 gas in new installations after 2025. The projections of N_2O emissions in category 2.G.3 were prepared by extrapolating the time series over the last 10 years (**WEM** scenario). Under the **WAM** scenario, there is a gradual substitution of the driving gas N_2O in anaesthesia.

Projections of CO_2 emissions - emissions from industrial processes come from processes other than fuel combustion. CO_2 emissions account for the largest share of total greenhouse gas emissions in this sector. A general assumption for the IPPU sector is the assumption of durability of equipment and availability of input materials. The main driving force is the GDP trend. For industrial processes, the largest decline can usually only be expected as a result of a reduction in the production of a particular product. However, such a decline is not expected, but we can reduce or capture a significant amount of emissions through various modernisation processes. In Slovakia, iron and steel production accounts for the largest share of IPPU emissions.

Metal production has a long history in Slovakia and a decline in production is not expected. However, iron and steel production reflects the economic situation. After the COVID-19 crisis in 2020, there is a clear decline in production (-40%) and thus in emissions produced. However, the amount of iron and steel produced has increased after 2020 and the intention is to maintain it in the future.

Issues in the IPPU generally reflect any economic crisis. This can also be seen in steel production in 2020, when iron and steel production declined due to the COVID-19 pandemic. However, no major changes in production are expected in the coming years.

In the iron and steel sector, it is possible to reduce CO_2 emissions by reducing the consumption of coke as a fuel for energy processes and as a reducing agent in blast furnaces. However, this would result in a reduction in steel production and hence economic problems for the region. One of the most recent measures in the iron and steel sector is electric arc furnaces. The current set of measures foresees investments in technology, which should lead to significant emission savings in the sector.

The share of enterprises in the non-metallic and chemical industries is also significant.

One of the most effective measures in reducing emissions in the non-metallic industry is waste recovery. Specific waste mineral wastes can, by their chemical composition, replace natural raw materials such as limestone or clay that have to be extracted from nature. Many of them also contribute to reducing CO_2 emissions.

The trend in the chemical industry is influenced by various segments. Slovakia has a strong tradition in all major segments of the chemical industry including oil refining, fertilizer production, rubber and plastics. The product portfolio is also influenced by the strong automotive and electronics sectors in Slovakia, which serve as regular high-capacity clients for various companies in the chemicals and plastics industries.

No closure of existing chemical facilities is currently anticipated or planned. As regards the trend in emissions from the chemical industry, it is expected to be fairly constant and no significant decrease is foreseen. However, the largest reductions in this sector could be due to reductions in the production or consumption of fuels by cars and trucks, or reductions in the consumption of artificial fertilisers in agriculture. By transforming the production of petroleum-based fuels to the production of green hydrogen as a fuel using RES, or by producing more advanced biofuels and bioplastics.

Figure 6.29: *Projections of CO_2 emissions (Gg) in the IPPU sector in **WEM** and **WAM** scenarios up to 2050*

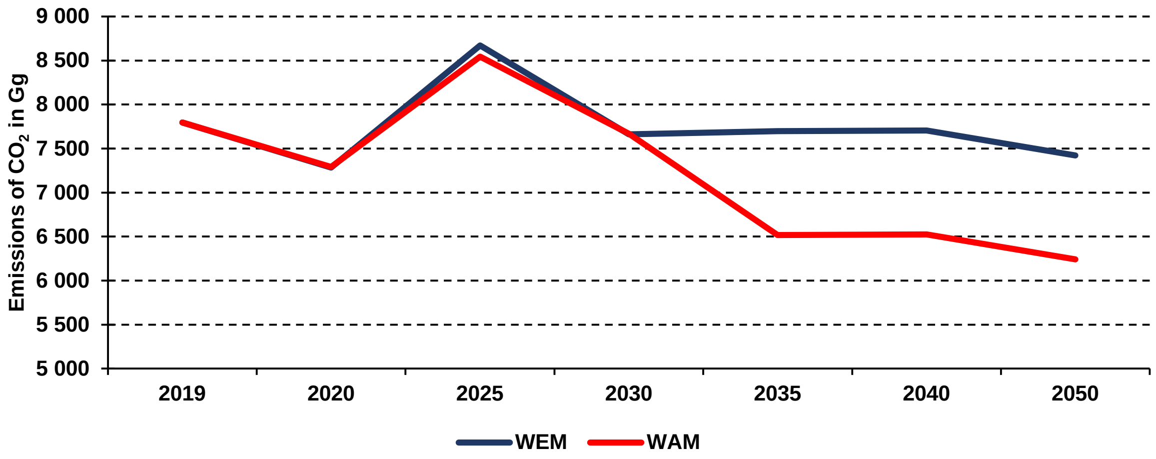

Table 6.18: *Projections of CO_2 emissions in the IPPU sector (Gg)*

WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**7 795**	**7 285**	**8 673**	**7 660**	**7 698**	**7 705**	**7 423**
A. Mineral processing	2 284.96	2 218.73	2 165.64	2 149.51	2 182.64	2 285.93	2 287.68
B. Chemical industry	1 407.03	1 437.13	1 712.29	1 772.19	1 788.65	1 766.93	1 689.99
C. Metal industry	4 068.11	3 599.08	4 765.35	3 708.75	3 700.09	3 629.23	3 422.08
D. Non-energy use of products	34.96	29.85	29.38	30.05	26.57	23.06	23.24
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**7 795**	**7 285**	**8 545**	**7 669**	**6 517**	**6 524**	**6 241**
A. Mineral processing	2 284.96	2 218.73	2 068.24	2 149.51	2 085.24	2 188.53	2 190.28
B. Chemical industry	1 407.03	1 437.13	1 681.68	1 780.87	1 758.42	1 736.59	1 659.27
C. Metal industry	4 068.11	3 599.08	4 765.35	3 708.75	2 646.35	2 575.48	2 368.34
D. Non-energy use of products	34.96	29.85	29.38	30.05	26.57	23.06	23.24

CH_4 Emissions projections - CH_4 emissions in the IPPU sector arise mainly from the production of ammonia and from the production of metal compounds, making up only a small proportion of total emissions

Table 6.19: *Projections of CH_4 emissions in the IPPU sector (Gg CO_2 eq.)*

WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**1.43**	**1.46**	**1.44**	**1.45**	**1.32**	**1.25**	**1.24**
B. Chemical industry	0.51	0.53	0.52	0.52	0.48	0.45	0.45
C. Metal industry	0.92	0.93	0.92	0.93	0.85	0.80	0.79
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**1.43**	**1.46**	**1.44**	**1.45**	**1.32**	**1.25**	**1.24**
B. Chemical industry	0.51	0.53	0.52	0.52	0.48	0.45	0.45
C. Metal industry	0.92	0.93	0.92	0.93	0.85	0.80	0.79

N_2O Emissions projections - N_2O emissions in the IPPU sector arise mainly from the production of nitric acid but also do not form a significant part of total emissions

Figure 6.30: *Projections of N_2O emissions in the IPPU sector in **WEM** and **WAM** scenarios up to 2050*

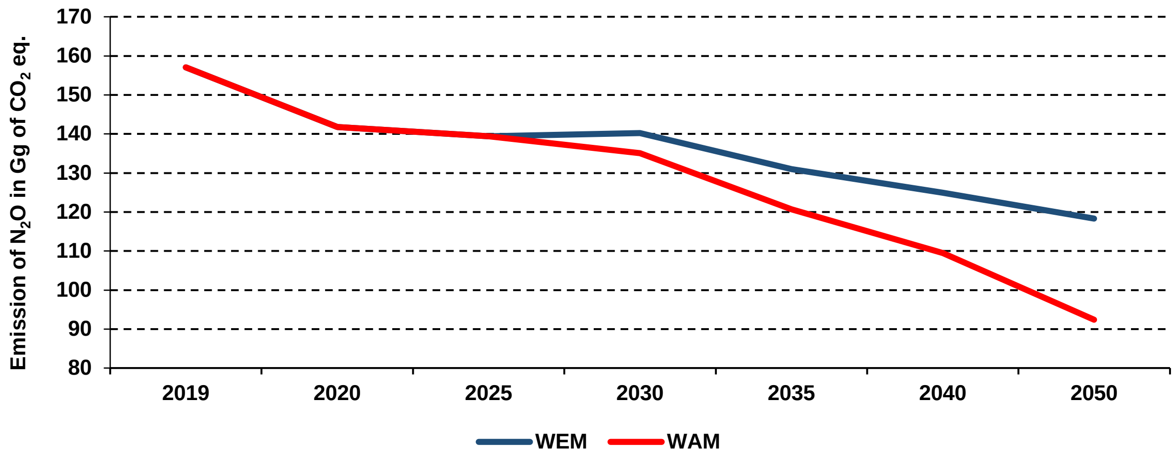

Table 6.20: *Projections of N_2O emissions in the IPPU sector (Gg CO_2 eq.)*

WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**157.05**	**141.81**	**139.41**	**140.22**	**131.02**	**124.96**	**118.31**
B. Chemical industry	91.22	76.58	75.60	79.04	72.48	69.09	67.86
G. Other processing and uses	65.83	65.23	63.81	61.19	58.54	55.87	50.45
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**157.05**	**141.81**	**139.41**	**135.09**	**120.72**	**109.47**	**92.38**
B. Chemical industry	91.22	76.58	75.60	79.04	72.48	69.09	67.86
G. Other processing and uses	65.83	65.23	63.81	56.05	48.24	40.38	24.52

Projections of F - gas emissions - F-gas projections include emissions of PFCs (aluminium production), HFCs (use of refrigerators and air conditioners) and SF_6 (electronics production). They currently account for a relatively significant share but are projected to decrease significantly.

Figure 6.31: *Projections of F-gas emissions in the IPPU sector in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*

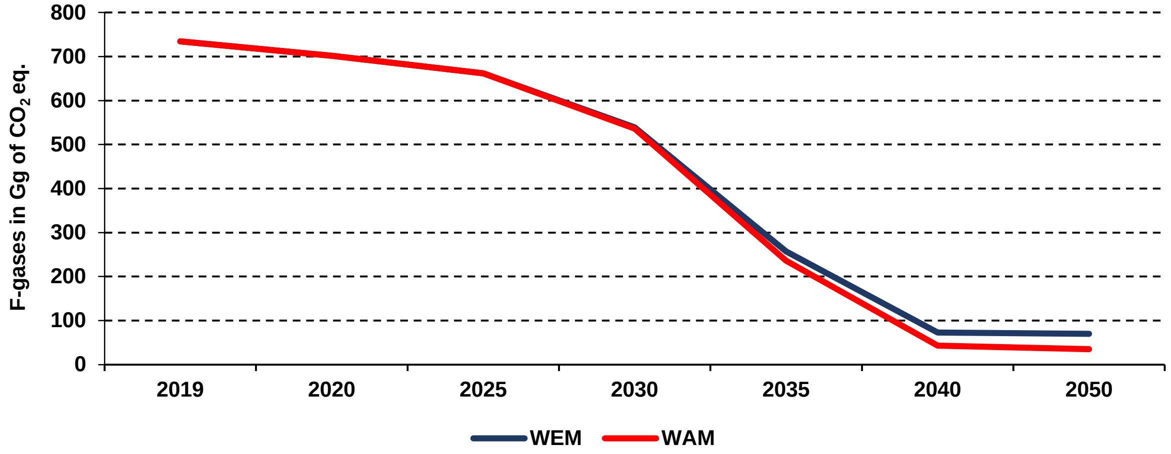

Table 6.21: *Projections of F-gas emissions in the IPPU sector (Gg CO_2 eq.)*

WEM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**734.79**	**701.69**	**662.24**	**539.01**	**257.12**	**72.70**	**69.73**
C. Metal industry - PFC	5.19	5.61	5.66	5.80	5.38	5.17	5.15
F. Use of products to ODS replacements-HFC	720.74	678.88	644.84	522.21	242.00	58.08	55.14
G. Other processing and uses - SF_6	8.86	17.20	11.74	11.00	9.73	9.45	9.45
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**734.79**	**701.69**	**661.81**	**536.13**	**236.10**	**42.80**	**34.76**
C. Metal industry - PFC	5.19	5.61	5.66	5.80	5.38	5.17	5.15
F. Use of products to ODS replacements-HFC	720.74	678.88	644.60	519.74	221.63	29.04	21.11
G. Other processing and uses - SF_6	8.86	17.20	11.55	10.58	9.09	8.59	8.49

Projections of aggregate GHG emissions - ***Table 6.22*** shows the aggregate projections of GHG emissions in the IPPU sector. The overall trend most closely reflects the impact of steel production.

Figure 6.32: *Projections of GHG emissions in the IPPU sector in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*

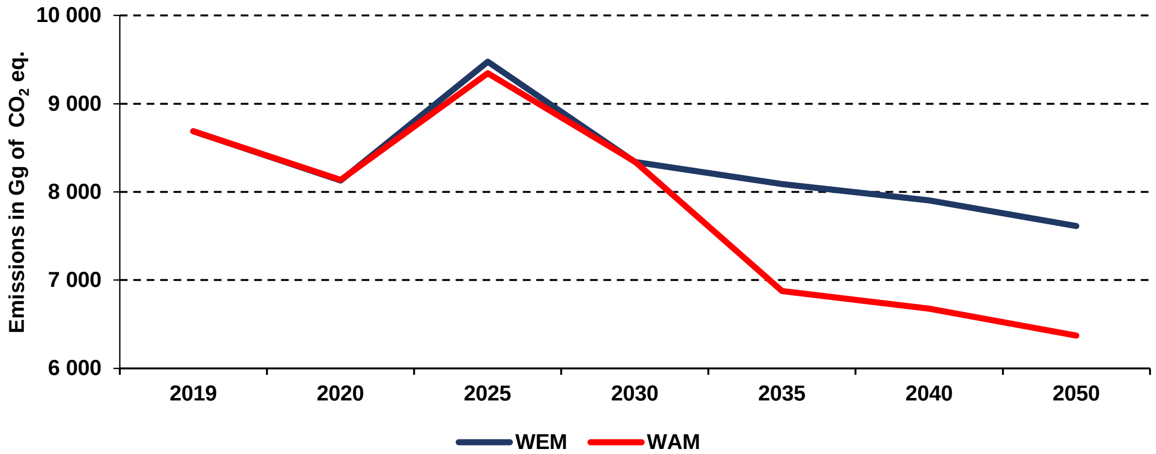

Table 6.22: *Projections of GHG emissions in the IPPU sector in **WEM** and **WAM** scenarios in Gg CO_2 eq.*

WEM	2019	2020	2025	2030	2035	2040	2050
2. Industrial processes	**8 688.33**	**8 129.84**	**9 475.76**	**8 341.18**	**8 087.41**	**7 904.06**	**7 612.27**
A. Mineral processing	2 284.96	2 218.73	2 165.64	2 149.51	2 182.64	2 285.93	2 287.68
B. Chemical industry	1 498.76	1 514.34	1 713.48	1 773.38	1 789.75	1 767.98	1 691.04
C. Metal industry	4 074.22	3 605.61	4 846.87	3 793.85	3 778.17	3 703.69	3 495.28
D. Non-energy use of products	34.96	29.85	29.38	30.05	26.57	23.06	23.24
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Use of products to ODS replacements-HFC	720.74	678.88	644.84	522.21	242.00	58.08	55.14
G. Other processing and uses – SF_6	74.69	82.43	75.54	72.18	68.27	65.31	59.90
H. Others	NO	NO	NO	NO	NO	NO	NO
WAM	**2019**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
2. Industrial processes	**8 688.33**	**8 129.84**	**9 347.31**	**8 341.84**	**6 874.72**	**6 677.20**	**6 369.50**
A. Mineral processing	2 284.96	2 218.73	2 068.24	2 149.51	2 085.24	2 188.53	2 190.28
B. Chemical industry	1 498.76	1 514.34	1 682.86	1 782.06	1 759.52	1 737.64	1 660.32
C. Metal industry	4 074.22	3 605.61	4 846.87	3 793.85	2 724.43	2 649.95	2 441.54
D. Non-energy use of products	34.96	29.85	29.38	30.05	26.57	23.06	23.24
E. Electronic industry	NO	NO	NO	NO	NO	NO	NO
F. Use of products to ODS replacements-HFC	720.74	678.88	644.60	519.74	221.63	29.04	21.11
G. Other processing and uses – SF_6	74.69	82.43	75.36	66.63	57.34	48.98	33.01
H. Others	NO	NO	NO	NO	NO	NO	NO

6.4 AGRICULTURE SECTOR

In preparing the projections, selected measures that have a detectable impact on the estimated emissions were analysed and quantification of their impact on the GHG inventory and pollutant inventory was possible. All other measures that were proposed in the strategies and not implemented in the projections do not have a measurable effect on the inventory but have an impact on agriculture as a whole in relation to the environment.

Based on the qualification of the likely impact of mitigation measures on emission inventories, we distinguish:

- Measures that have a detectable impact on emissions. This impact can be specifically attributed to the implementation of the mitigation measure. These measures are measurable and effective; this type of measure has been used in the preparation of emission projections.
- Measures that have an impact on emissions reported in inventories, but this impact cannot be specifically attributed to a particular mitigation measure. These include measures that are difficult to measure and have different, often synergistic or antagonistic effects.
- Measures whose impact on emissions reported in inventories is possible because there is a visible reduction in emissions. The effect of these measures depends on other factors.
- Measures that do not have a direct impact on emissions but may have a positive impact on farmers' actions or the environment in the sector.

The list of policies and measures implemented in the agricultural projections was taken from the National Programme for the Reduction of Pollutant Emissions,[2] the Low Carbon Strategy of the Slovak Republic[1] and the strategic document " Farm to Fork".[131] The forthcoming EU food strategy aims to reduce the use of pesticides, fertilisers and antibiotics in agriculture. By 2030, the consumption of hazardous pesticides should be reduced by 50% and the consumption of inorganic fertilisers should fall by 20%. The targets are set for the whole European Union, the Slovak Republic does not have a binding reduction resulting from the Farm to Fork Strategy, the European targets have been implemented in the projections.

The Low Carbon Strategy[1] aims to identify measures, including additional ones, to achieve climate neutrality in the Slovak Republic in 2050 and a 55% reduction in emissions in 2030 compared to 1990. This ambitious target was only formally defined at the last stage of the Low Carbon Strategy preparation, and therefore other, less ambitious emission reduction scenarios are analysed in detail.

The Common Agricultural Policy (EU CAP) will support the fight against climate change through the Whole Farm Eco-Scheme intervention (31.1), which will ensure the improvement of the structure of arable land, expand unproductive areas in the grassland and grassy inter-rows in orchards and vineyards. The intervention Investments on farms to reduce greenhouse gas and ammonia emissions will support investments in reducing greenhouse gas and ammonia emissions on farms in the form of the intervention Animal welfare - Pastoral farming (31.2). Non-productive investments necessary for the introduction of measures in agricultural production will also be supported.

The need to increase the share of the use of renewable energy sources in the total volume of energy in agriculture will be addressed by the intervention Productive investments in agricultural holdings by investing in technologies and related construction investments aimed at energy transformation, in particular of agricultural by-products and biodegradable waste. Investments in equipment for the production of energy from other renewable sources in order to use all the energy produced on the farm or holding will also contribute to increasing the share of the use of renewable energy sources.

6.4.1 Parameters and other Key Information for Developing Trends in the Agriculture Sector

- The WOM (BAU) scenario is identical to the scenario with existing WEM measures.
- The WEM scenario is a scenario with measures that includes projections of anthropogenic emissions from agricultural sources, after taking into account the effects of policies and measures adopted by the end of 2020.

The **WEM** scenario took into account policies and measures from national strategies published in the past. The list of policies and measures used was taken from the National Programme for Pollutant Emission Reduction[2] and the Low Carbon Strategy of the Slovak Republic.[1] The increase in emission projections for the **WEM** scenarios after 2005 is due to the projected increase in hectare yields in the crop production part, which puts pressure on higher consumption of applied nitrogen fertilisers; the offsetting of organic matter and nutrients to the soil in the form of applied plant matter will also increase. Emissions will also rise in the livestock sector, particularly in beef cattle, sheep and goat farming. Other livestock species are projected to stagnate or decline.

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[131] A Farm to Fork Strategy for a fair, healthy and environmentally friendly food system EK, "A Farm to Fork strategy for an equitable, healthy and environmentally friendly food system," European Commission, Brussels, 2020. [Online]. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381

More efficient storage of manure and slurry in the form of isolation of excreta from the surrounding environment by preventing soil contamination and nitrogen leaching from the stored waste, while contributing to the avoidance of NH_3 and N_2O emissions. This measure is reflected in both the **WEM** scenario and the **WAM** scenario. The **WEM** takes into account the current occurrence of the measure on farms that have been reported in the National Emissions Information System. This measure can be found in several strategic documents and legislation, in particular in the Decree of the Ministry of the Environment of the Slovak Republic No. 410/2012 Coll., which implements certain provisions of the Air Act.[132] The implementation of this measure has an impact on ammonia nitrous oxide and methane emissions from category 3.B Manure and slurry management.

- The **WAM** scenario is a scenario with measures that includes projections of anthropogenic emissions from agricultural sources, after taking into account the effects of policies and measures adopted after 2020.

The **WAM** scenario is a scenario with additional measures, it contains projections of emissions from agricultural sources that include the effects of policies and measures that will be adopted and implemented after 2020. The **WAM** scenario was modelled on the basis of strategic documents developed by the MŽP SR in cooperation with the Ministry of Agriculture and Rural Development of the Slovak Republic and strategic documents developed by the Ministry of Agriculture and Rural Development.

Methane emissions from enteric fermentation in the **WAM** scenario were modelled by taking into account the measure proposed in the Low Carbon Strategy. One of the measures in the Low Carbon Strategy is the use of additives to reduce methane and nitrogen emissions. This measure impacts on category 3.A Enteric Fermentation, 3.B Nitrous Oxide from manure and slurry management and has a partial impact on nitrous oxide emissions from category 3.D Agricultural soils. Methane from agriculture, waste and energy should also be reduced under the so-called Methane Strategy.[133] The strategy will help the European Union on its path to more ambitious emissions targets by 2030 and ultimately to carbon neutrality by 2050. The Strategy also proposes measures to improve data collection and monitoring of emissions. It also promises to invest in research and to put in place a mechanism for sharing useful practices between Member States. Measurable measures to reduce methane emissions include changing the way animals are fattened.

Nitrous oxide and ammonia emissions from manure and slurry management (more efficient manure and slurry storage) in the **WAM** scenario have been modelled by taking into account the measure of introducing requirements to reduce emissions from livestock farms classified as a medium source of air emissions. This measure was proposed in the National Emission Reduction Program and implemented in the calculation of NH_3 and N_2O emissions by implementing low-emission manure and slurry storage systems. This measure has an impact on category 3.B Manure and slurry management.

Another implemented measure that has an impact on N_2O and CH_4 emissions in category 3.B Manure and slurry management was the use of slurry and manure as feedstock in biogas plants. This measure impacts emissions reductions through two main pathways - reducing fossil fuel carbon emissions through the production of energy sources and reducing direct nitrous oxide emissions from manure and

[132] Decree of the Ministry of the Environment of the Slovak Republic implementing certain provisions of the Air Act, https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2012/410/

[133] Methane strategy. Communication from the Commission to the EP, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU strategy to reduce methane emissions. [Online]. https://ec.europa.eu/energy/sites/ener/files/eu_methane_strategy.pdf

slurry storage. Although anaerobic digestion does produce methane, it is captured and used in energy production, which has a positive impact on increasing the share of energy from renewable sources.

Nitrous oxide and carbon dioxide emissions from the application of inorganic nitrogen fertilisers (category 3.D Agricultural Soils) were modelled in the **WAM** scenario based on a measure that was implemented from the Low Carbon Strategy of the Slovak Republic. This measure recommends a switch to, or legislative restriction on, the application of urea-based nitrogen fertilisers. The implementation of this measure has an impact on the reduction of ammonia emissions, mainly due to the high volatility of ammonia from urea fertilisers. At the same time, by limiting urea consumption, carbon dioxide emissions are avoided. Nitrous oxide emissions are limited on the basis of a reduction in the total consumption of inorganic fertilisers in the resulting consumption totals.

The last measure implemented was taken from the European Green Deal, as set out in the Farm to Fork Strategy.[32] This measure provides for a 20% reduction in the consumption of inorganic fertilisers by 2030. This measure impacts emission category 3.D.1 and 3.D.2 direct and indirect N_2O emissions from agricultural soils and ammonia emissions. A list of the policies and measures that have been taken into account in the emission projections under each scenario and their effect is presented in ***Table 6.23***.

Table 6.23: *List of policies and measures implemented in the projections by scenario*

Strategy Document Legislation	Scenario	Gas/Category	Measure	Effect of the Measure
Code of Good Agricultural Practice National Emission Reduction Programme Low Carbon Strategy Decree No. 410/2012 Coll. of the MŽP SR CAP Strategic Plan 2023-2027	WEM, WAM	N_2O, NH_3 - storage of manure and slurry	Efficient storage of animal waste, specifically storage of liquids in tanks isolated from the surroundings or in tanks with access to oxygen and storage of manure in plastic sheeting with no or minimal addition of water.	Synergistic
Low Carbon Strategy	WAM	CH_4 - enteric fermentation N_2O, NH_3 - storage of manure and slurry	Animal feeding interventions to reduce emissions, such as intensive feeding of actives, impact on methane emissions	Synergistic
National Emissions Reduction Programme	WAM	N_2O, NH_3 - cropland	Obligation to comply with measures to reduce ammonia emissions also at medium pollution sources	Synergistic
Low Carbon Strategy	WAM	N_2O - storage of manure and slurry	Process animal waste efficiently and use biogas, especially as a local energy source	Synergistic
Low Carbon Strategy	WAM	CH_4 - storage of manure and slurry	Process animal waste efficiently and use biogas, especially as a local energy source	antagonistic
Low Carbon Strategy	WAM	N_2O, NH_3, CO_2 - cropland	Increasing the use of nitrogen fertilisers with stabilised nitrogen at the expense of the use of urea	Synergistic
Farm To Fork Strategy	WAM	N_2O, NH_3 - cropland	Reduction of inorganic nitrogen fertilisers by 20% compared to 2030	Synergistic
Methane Strategy[34]	WAM	CH_4 - enteric fermentation	Improving the quality of animal feed (innovating compound feed), feed additives and feeding techniques	Synergistic
Methane Strategy[34]	WAM	N_2O, NH_3 - cropland	Recover waste and residue streams from agriculture through anaerobic digestion	Synergistic
Methane Strategy[34]	WAM	CH_4	Monitoring methane emissions at farm level	informative
Strategic Plan Cap 2023-2027	WAM	CH_4, N_2O	Pastoral rearing of cattle, sheep and goats	antagonistic

Most of the implemented measures have a measurable effect on the emission inventory. A limiting factor during the preparation of the projections was the lack of detail on the measures and their implementation plans within the agriculture sector. The lack of information makes it difficult to implement them and assess their impact. For this reason, expert estimation of selected parameters was used during the preparation of the projections or European targets were used.

It is therefore necessary to add further specification of the measures in the future in order to set up the models more correctly:

- Mechanism of implementation
- Support for resource requirements
- Monitoring of implemented measures at farm or business entity level

6.4.2 Projections of Methane Emissions from Enteric Fermentation and Manure and Slurry Management (3.A and 3.B)

One effective way to reduce methane emissions from livestock is to optimize animal diets and change animal feeding schedules to reduce methane and nitrous oxide emissions. After 1990, there has been a clear decline in livestock numbers and an increase in animal performance, such as milk yield. The trend of increasing performance and decreasing numbers of animals will continue after 2020. There is currently no official national strategy to guide the future development of animal numbers and performance management. In modelling the data for the future, historical trends were assessed and corrected in the form of expert estimates with collaborating institutions, in particular the National Agricultural and Food Centre.

Methane is balanced based on the 2006 IPCC methodology. The calculation methodology is based on a common model for calculating methane from enteric fermentation and methane from manure and slurry management. In particular, the trend of cattle numbers is key, with cattle accounting for approximately 80% of total methane emissions in categories 3.A and 3.B.1. The second significant source of methane emissions is the management of manure and slurry from pig farming. The calculation model for these categories was at tier 2 level, which means the use of emission factors and parameters specific to the Slovak Republic in accordance with the 2006 IPCC methodology.

Projections of methane emissions from categories 3.A and 3.B.1 were prepared in the **WEM** and **WAM** scenarios. The **WEM** scenario takes into account the current state of utility. It is assumed that the trend of increasing productivity and decreasing animal numbers (pigs, poultry) since 1990 will continue after 2020. This scenario is sensitive to the change in livestock numbers, which is one of the most important parameters for the preparation of emission projections. The trend of increasing livestock performance will influence the increase in methane emissions. The above is likely to continue in the case of dairy cattle, especially in dairy cow herds. However, in the case of beef cattle, the tendency is for their numbers to increase. There are plenty of permanent grassland in the country that is not grazed and is suitable for cattle grazing. Meat cattle are easy to care for compared to dairy cattle. There is no need for special stables or milking parlours, but shelters are sufficient as these cattle are often grazed all year round.

The **WAM** scenario takes into account feeding measures, in particular easily digestible compound feeds, amino acids and other supplements that reduce methane emissions, and a measure from the Strategic Plan for the Common Agricultural Policy 2023-2027, which also includes a switch to pastoral livestock farming, in particular for beef cattle and sheep. At the same time, the increase in numbers of beef cattle, goats and sheep was taken into account. In this measure, the grazing of meadow and grassland is included in the feed ration, as well as the use of rotational grazing of animals due to the nature of the permanent grassland (different stages of maturity of the different grasses). In this scenario, the upper limit of digestibility of the ration is a maximum of 70%. It would also be possible to increase the digestibility of the ration during the winter period when the animals are housed by adding kernels and silage and other additives. In the case of dairy cattle, it is possible to increase the digestibility of the ration by increasing the proportion of cereals (up to a maximum of 50% of the dry matter of the feed) or by adding additives such as amino acids to reduce nitrogen excretion or to inhibit methanogenic bacteria in the compound stomach of ruminants. At the same time, it was confirmed from modelling that lower digestibility of feed ration is consequently reflected in increased methane production, i.e. the emission factor for methane EF (the amount of methane emission produced by 1 animal over a period of 1 year) was higher in all categories of beef cattle (lower digestibility of feed ration) than in dairy cattle, except for the category of dairy cows and dairy heifer calves.

It is also possible to reduce methane emissions from enteric fermentation by adding additives to the ration (3-hydroxypropionic acid, rapeseed oil, algae, etc.). The use of the additive 3-nitrooxypropanol (3-NOP) was included in the measures included in the modelling of emissions in the **WAM** scenario. Its use was implemented in the scenario on the recommendation of the National Agricultural and Food Centre - Research Institute of Animal Production. The maximum recommended level is an admixture into the ration at 100 mg^3-NOP/kg DM. Methane is produced by the microbiota naturally present in the compound stomach. 3-NOP acts as an inhibitor of methane production by interfering with the ability of this microbiota to produce methane. Based on this property, a reduction factor was introduced into the emission factor. The mitigating effect of this substance was taken from an EFSA publication of 2021 at 20% compared to a feed ration that did not contain the additive. The implementation of such a measure is limited due to the high acquisition cost of the additive and the possible shortage on the market.[134] In the projections it was included only in economically strong regions such as Bratislava, Trnava, Trenčín, Nitra, which is an expert estimate of the measure. The introduction of this measure in the projections is gradual and will require support at departmental level. The timetable for the introduction of the measures applied in the **WAM** scenario is presented in ***Table 6.24***.

Table 6.24: *Timetable for the introduction of 3-NOP - expert estimate*

Type of farm animal	The effectiveness of the measure
Dairy cow	Since 2023
Dairy cattle species	Since 2030
Beef cattle species	Since 2030
Sheep	Since 2030

The **WAM** scenario also takes into account the processing of manure and slurry as feedstock for the biogas production process, which can be used as a local energy source. This measure is relevant for cattle and pigs mainly because of the high emission production. The recovery of manure and slurry from cattle has caused a slight increase in methane emissions, particularly during storage prior to recovery. Methane emissions during manure storage are lower (MCF[135] 2%) than for slurry (10-15% on average in temperate climates). In other types of livestock the production of solid waste - manure is predominant, in pig farms the production of liquid waste - slurry is predominant.

[134] EEDAP, „Safety and efficacy of a feed additive consisting of 3-nitrooxypropanol (Bovaer®10) for ruminants for milk production and reproduction (DSM Nutritional Products Ltd),“ 2021

[135] Methane conversion factor

Under planned measures in the Common Agricultural Policy (CAP) after 2023, subsidies will be provided to farmers in the form of direct payments to improve animal welfare and to increase the proportion of grazing in selected animal species.[136]

Subsidies can be obtained per animal under the CAP if the following criteria are met:

- During the grazing season, at least from 1 May to 31 October (excluding days with adverse weather conditions), ensure grazing for a minimum of 120 days for sheep from 12 months of age (all animals per selected species per holding - farm, except for permitted exceptions, e.g. animals shortly before and after birth, sick animals, etc.). A value of 180 days was used in the calculation of the projections.
- During the grazing season, at least from 1 May to 31 October (except for days with adverse weather conditions), provide grazing for a minimum of 120 days for dairy cows (all animals per holding - farm, except for permitted exceptions, e.g. animals shortly before and after birth, sick animals, etc.). A value of 200 days was used in the calculation of the projections.
- During the grazing season, at least from 1 May to 31 October (except for days with adverse weather conditions), ensure grazing for a minimum of 150 days for heifers from 12 months of age (all animals per selected species and category per breeding-farm). The value of 150 days was used in the calculation of the projections.

This measure will cause an increase in emissions from enteric fermentation, mainly due to the predominance of roughage in the ration, which has a negative effect on the mitigation of GHG emissions due to lower digestibility. Based on the 2006 IPCC Methodological Manual, when cattle are predominantly grazing, the digestibility of the feed ration is at 55-75% (page 10.14 Table 10.2), but when it comes to emissions from manure management, the situation is reversed. Emissions from cattle grazing have a lower potential for methane formation (MCF 1%) than, for example, slurry storage (on average10-15% in temperate climates) or manure storage (MCF 2%). Final feed rations need to be adjusted so that we can effectively reduce emissions from both categories.

6.4.3 Projections of Nitrous Oxide Emissions from Manure and Slurry Management

The potential for reducing nitrous oxide emissions in agriculture is mainly related to the efficiency of manure management, in particular the handling and storage of manure and slurry and their application to the soil in a low-emission manner. Some measures are included in Decree No. 410/2012 Coll. of the Ministry of the Environment of the Slovak Republic and are also valid for farms classified under Act No. 39/2013 Coll. on Integrated Pollution Prevention and Control. Mitigation measures included in the current legislation have been included in the **WEM** scenario. Currently, a revision of the Decree of the MŽP SR No. 410/2012 Coll. is underway, as well as an amendment to the Air Act No. 137/2010 Coll., in order to introduce the obligation to comply with the principles of Good Agricultural Practice also in medium-sized agricultural units. ***Table 6.25*** shows the percentage distribution of farms that have been reported in the National Emissions Information System.

[136] Ministry of Agriculture and Rural Development, "Strategic Plan of the Common Agricultural Policy for 2023-2027," Bratislava, Ministry of Agriculture and Rural Development, 2022. [Online]. https://www.mpsr.sk/spolocna-polnohospodarska-politika-2023-2027/462

Table 6.25: *Percentage distribution of medium, large and small farms in the Slovak Republic in 2020*

Animal kind	Pigs	Poultry	Cattle	Sheep	Horses	Goats
Share of large farms	2%	30%	3%	0%	0%	0%
Share of medium-sized farms	2%	20%	5%	10%	1%	0%
Share of small farms	96%	50%	92%	90%	99%	100%

Source: National Emissions Information System

The **WEM** scenario includes mitigation measures resulting from the Decree of the MŽP SR No. 410/2012 Coll., namely the storage of manure and slurry in tanks and manure pits isolated from the surroundings. Information on existing measures and their percentage share in the reduction of nitrogen emissions was taken from the National Emission Information System.[137]

The **WAM** scenario contains measures that are synergistic and can be implemented in a computational model. This is the use of amino acids in the ration reducing the nitrogen excretion of the animals, in the model it has been implemented through a more precise optimization of the nitrogen in the ration**.** The measure was used in the estimation of nitrogen excretion per animal per year in cattle. Based on a meta-analysis, the estimate of mitigation potential compared to the reference value ranged from 17±6% Nex.

In the **WAM** scenario, the processing of animal waste in biogas plants to produce biogas that can be used as a local energy source has also been implemented. This measure was included in the Low Carbon Strategy of the Slovak Republic and the Methane Strategy[34] does not include details such as animal species, percentages of waste recovered and others that would provide measurable indicators potentially usable in the calculation of emission projections. In the preparation of the emission projections, this information was additionally expertly estimated. For the purposes of this analysis, it was assumed that 10% of organic waste - manure from cattle and pigs - would be recovered in biogas plants. Cattle and pigs are the key animal categories with the greatest potential to generate emissions from waste. Biogas from biogas plants is a promising source of renewable electricity and heat that can be used locally. Emission mitigation achieved through the inclusion and increased potential for animal waste treatment in biogas plants will be accounted for in the Energy sector. The nitrogen input data for biogas plants is balanced based on a percentage estimate from the pool. In the future it will be necessary to collect these data on an annual basis, mainly due to the lack of detailed statistics. Inaccurate data overestimates GHG and pollutant emissions.

Another measure from the National Emission Reduction Plan, which was included in the **WAM** scenario, is the obligation to comply with measures to reduce ammonia emissions also at medium sources of air pollution. The measure is primarily designed to reduce ammonia, but also has an impact on reducing N_2O emissions. The measure will also be implemented in the amendment of the Air Act No. 137/2020 Coll. and Decree No. 410/2012 Coll. of the MŽP SR. The projections assume compliance with the isolation of slurry and manure from the surroundings on medium and large farms (sources of air pollution). These data were also compared with the database of the Central Livestock Register. As can be seen in the table, the majority of farms are included in the category of small farms. As exact figures on the percentage of farms that will be affected by this change in legislation were not available, it was assumed in the preparation of the emission projections that all medium and large farms would benefit from emission reduction measures from manure and slurry management. This measure has a minimal impact on the reduction of nitrous oxide emissions. In the **WAM** scenario, the measures are assumed to be implemented immediately after 2021.

[137] National Emissions Information System: http://www.air.sk/neis.php

6.4.4 Projections of Nitrous Oxide Emissions from Cropland (3.D)

Between 2016 and 2020, we have seen a recovery in crop production, which has put pressure on the consumption of mineral nitrogen fertilizers, the application of compost, digestate, and other organic nitrogen fertilizers. The recovery may have been stimulated by direct payments for selected crops used for human and animal nutrition and biofuel production.

The **WEM** scenario assumes an estimated trend in the consumption of organic and inorganic nitrogen fertilisers based on exponential smoothing by analysing past emission trends. The **WEM** scenario has an increasing trend in the projections of nitrous oxide emissions, mainly due to the assumed continued recovery of crop production in Slovakia. After 2020, inorganic fertiliser consumption is expected to increase by 79% compared to 2005. We project an increase in the consumption of inorganic fertilizers, which will be needed to compensate for the shortage of organic nitrogen due to declining livestock numbers by 2050. N_2O emissions from livestock grazing are projected to follow an increasing trend until 2030, with a gradual stabilization of grazing emissions projections after 2050. The increase will be mainly due to an increase in the number of grazing animals (beef cattle, sheep and goats). The increase in emission projections in the **WEM** scenario is also visible in the category of applied other organic wastes, namely compost and digestate. The amount of applied matter from cultivated plants to soil will also increase.

The **WAM** scenario includes two mitigation measures that have a synergistic effect. A measure taken from the Low Carbon Strategy recommends a legislative restriction on the application of urea-based nitrogen fertilisers. The implementation of this measure has an impact on the reduction of ammonia emissions, mainly due to the high volatility of ammonia from urea fertilisers. Limiting urea consumption will also avoid nitrous oxide emissions by reducing the total consumption of inorganic fertilisers in the resulting consumption totals. Detailed information on when the legislative framework would apply was not available, so an expert estimate was used. The urea reduction had a gradual path, which is shown in ***Table 6.26***. Limiting urea also has an effect on CO_2 emissions from agriculture and in particular on NH_3 emissions.

Table 6.26: *Limiting urea consumption from 2025-2050 under the **WAM** scenario*

Year of implementation	Percentage reduction in urea consumption
2020 – 2025	Transition period, time to implement legislation
2026 – 2030	10%
2031 – 2035	20%
2036 – 2040	30%
2041 – 2045	50%
2046 – 2050	70%

The second measure, taken from the Farm to Fork strategy, is to reduce the use of pesticides, fertilisers and antibiotics in agriculture. This strategy was developed in synergy with the European Green Deal, which aims to reduce the environmental and climate footprint of the European food system. Under the **WAM** scenario, the target of reducing nitrogen fertiliser consumption by 20% by 2030 has been implemented. A transition period has been implemented in the emission projections, which is in line with the transition period for urea limitation (2020-2025). It is likely that the Slovak Republic will negotiate its own percentage reduction in fertiliser consumption and claim a transitional period, which will be legislatively enshrined at national level. After the legislative process, emission projections will need to be adjusted in line with the future national strategy in force. Even though the planned mitigation measures have been implemented, emission projections are increasing by 2030 and 2050, creating pressure to adopt much more ambitious measures.

6.4.5 Projections of Carbon Dioxide Emissions from Soil Liming and Urea Use (3.H, 3.G)

Carbon dioxide emissions from the application of urea and limestone or dolomite to agricultural soils were estimated based on the IPCC methodology. The only way in which emissions from these sources can be eliminated is by limiting inputs to the soil. Liming is an activity that has a positive effect on the soil (changing the pH on acid soils to neutral), so limiting this activity would not have a positive effect on soil quality and crop yields. Projections of carbon dioxide emissions from soil liming and urea use were prepared in the **WEM** and **WAM** scenarios. The impact of implemented policies and measures had the effect of reducing or increasing emissions. The **WEM** scenario was prepared on the basis of modelling future consumption of dolomite, limestone and urea, which takes into account the previous upward trend in consumption.

The **WAM** scenario contains one planned measure that could have been implemented in the preparation of the carbon dioxide emission projections. This is to limit the use of urea at the expense of other nitrogen fertilisers. This measure also has a synergistic effect on ammonia and nitrous oxide emissions, as urea has the highest ammonia emission potential of all nitrogen fertilisers. This measure is the same as that used for the projections of N_2O emissions from agricultural soils. Legislatively restricting this activity would have a significant impact on reducing emissions from agriculture.

6.4.6 Projections of Aggregate Emissions

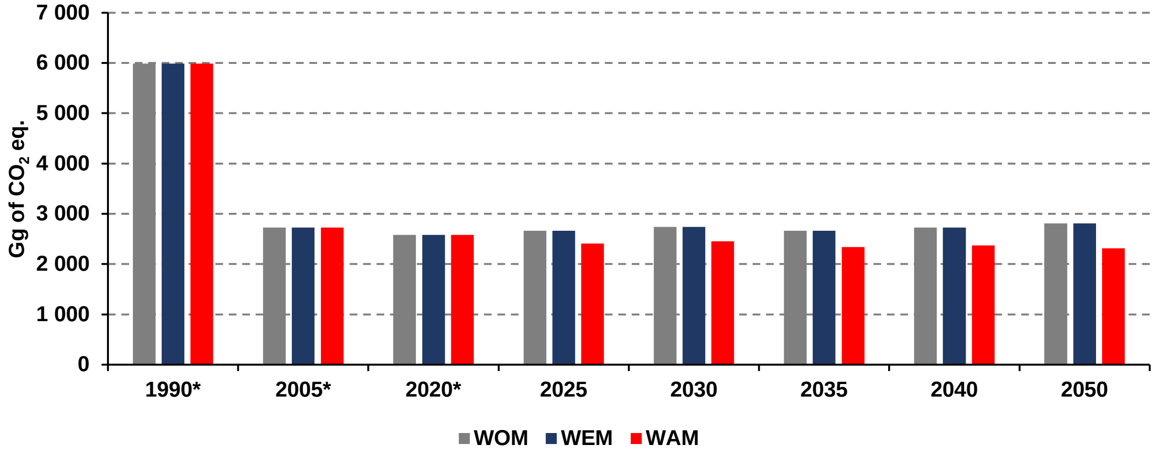
Table 6.27 and ***Figure 6.33*** show aggregated data on GHG emission projections in the agriculture sector.

Table 6.27: *Projections of aggregate emissions in Agriculture (eq. CO_2 Gg)*

WOM	**1990***	**2005***	**2020***	**2025**	**2030**	**2035**	**2040**	**2050**
3. Agriculture	**5 987.29**	**2 725.96**	**2 579.71**	**2 665.10**	**2 741.19**	**2 660.73**	**2 727.23**	**2 810.43**
3.A Enteric fermentation	2 796.69	1 156.72	966.34	939.70	955.93	897.01	922.53	956.02
3.B.1 Manure management	433.31	150.44	86.88	92.54	91.52	84.98	85.80	84.76
3.B.2 Manure management	457.54	216.10	149.90	151.93	150.03	145.15	147.34	148.42
3.D Agricultural soils	2 238.73	1 173.11	1 304.47	1 399.12	1 456.16	1 443.67	1 477.01	1 525.32
3.G Limestone and dolomite	45.73	9.28	8.45	8.08	8.20	8.32	8.44	8.69
3.H Use of urea	15.29	20.31	63.67	73.73	79.36	81.61	86.11	87.23
WEM	**1990***	**2005***	**2020***	**2025**	**2030**	**2035**	**2040**	**2050**
3. Agriculture	**5 987.29**	**2 725.96**	**2 579.71**	**2 665.10**	**2 741.19**	**2 660.73**	**2 727.23**	**2 810.43**
3.A Enteric fermentation	2 796.69	1 156.72	966.34	939.70	955.93	897.01	922.53	956.02
3.B.1 Manure management	433.31	150.44	86.88	92.54	91.52	84.98	85.80	84.76
3.B.2 Manure management	457.54	216.10	149.90	151.93	150.03	145.15	147.34	148.42
3.D Agricultural soils	2 238.73	1 173.11	1 304.47	1 399.12	1 456.16	1 443.67	1 477.01	1 525.32
3.G Limestone and dolomite	45.73	9.28	8.45	8.08	8.20	8.32	8.44	8.69
3.H Use of urea	15.29	20.31	63.67	73.73	79.36	81.61	86.11	87.23
WAM	**1990***	**2005***	**2020***	**2025**	**2030**	**2035**	**2040**	**2050**
3. Agriculture	**5 987.29**	**2 725.96**	**2 579.71**	**2 407.35**	**2 453.95**	**2 335.86**	**2 368.52**	**2 310.11**
3.A Enteric fermentation	2 796.69	1 156.72	966.34	895.38	903.40	834.50	857.39	864.92
3.B.1 Manure management	433.31	150.44	86.88	92.00	90.90	83.51	84.60	83.30
3.B.2 Manure management	457.54	216.10	149.90	115.00	115.86	109.72	111.90	112.32
3.D Agricultural soils	2 238.73	1 173.11	1 304.47	1 223.16	1 264.18	1 234.54	1 245.91	1 214.71
3.G Limestone and dolomite	45.73	9.28	8.45	8.08	8.20	8.32	8.44	8.69
3.H Use of urea	15.29	20.31	63.67	73.73	71.42	65.29	60.28	26.17

*Historical emission inventory data as of 10 October 2022

Figure 6.33: *Projections of aggregate GHG emissions in the Agriculture sector in **WEM** and **WAM** scenarios up to 2050*



Agriculture - professional software tool - Emissions projections were prepared in accordance with the 2006 Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines, Chapter IV. The calculation analysis tool is based on the MS Excel platform and the calculation includes various policies and measures (in numerical formulation) defined according to the **WEM** and **WAM** scenarios. For the projections of emissions and removals in the Agriculture category, the model developed in the context of the implementation of Regulation (EU) 2018/841 of the European Parliament and of the Council was used.

The computational analytical tool used is based on the MS Excel platform and the calculation includes various policies and measures (in numerical formulation) defined according to the **WEM** and **WAM** scenarios. There are a number of specifically developed mathematical models for the preparation of emissions projections in the agricultural sector (such as the CAPRI model, the FAPRI-UK model, the GLOBIOM model and others), but due to the need for complex input data including economic and energy indicators, their use for the purpose of reporting national projections is currently not possible. The small Slovak economy would need its own model developed exactly for our conditions. Further improvements in the preparation of projections of emissions from the agricultural sector should allow the whole calculation process to be automated, which should reduce the computation time and create room for the creation of more scenarios and the processing of sensitivity analysis. One possibility is to implement a model that is used to estimate projections from the agricultural sector.

6.5 LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR (LULUCF)

This chapter discusses the effect of adopted, implemented and planned measures and policies and analyses their impact on projections of emissions/removals (CO_2, CH_4 and N_2O) of greenhouse gases (GHGs) in each land use category 4.A Forest Land, 4. B Cropland, 4.C Grassland, 4.D Wetlands, 4.E Settlements, 4.F Other Land and 4.G Harvested Wood Products (HWP), but also across the LULUCF sector.

The National Forestry Centre (NLC) - Forestry Research Institute (FRI) in cooperation with the National Agricultural and Food Centre, the Research Institute of Soil Science and Soil Protection (NPPC-SRI) and the Research Institute of Grasslands and Mountain Agriculture (NPPC-SRI) have developed three scenarios for the development of emissions from 2020 to 2050 on the basis of available information, the scenario with existing measures (**WEM**) and the scenario with additional measures (**WAM**). The result of the modelling of the GHG emission/capture projections is presented in ***Figure 6.34*** and ***Table 6.28***. In the **WEM** scenario, the measures adopted and implemented up to 2020 have been implemented, these measures have not prevented a decrease in GHG removals of -78% compared to 1990. The **WEM** scenario took into account policies and measures from official national strategic documents and programmes valid in Slovakia until 2020, mainly from the National Forestry Programme of the Slovak Republic 2014-2020[138], Rural Development Programmes 2007-2013, 2014-2020[139] and from the Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050.[1] The **WAM** scenario incorporates measures from available official national strategic documents and programmes valid in Slovakia after 2020[1] and the Environmental Policy Strategy of the Slovak Republic 2030. When additional measures were implemented in the WAM scenario, removals decreased by -47% compared to 1990.

Historically, the lowest CO_2 removals in the LULUCF sector were recorded in 2005, with the Forests category contributing significantly due to a major wind calamity in the High Tatras. Both the **WEM** and **WAM** scenarios show decreasing removals compared to 2005 (63% for the **WEM** scenario and 10% for the **WAM** scenario). The more pronounced decrease in projected removals after 2020 in the **WEM** scenario, compared to the **WAM** scenario, is due to a higher decrease in removals in the Forest, Cropland and Permanent Grassland categories and an increase in emissions from the Residential and Other Land categories.

The LULUCF sector is unique in terms of climate change, as it can primarily capture GHG emissions, and is only a small producer of GHG emissions. The latest published results of the GHG inventory in Slovakia for the year 2020 indicate that 37 002.71 Gg CO_2 eq. The LULUCF sector captured 7 593.17 Gg CO_2 eq., representing 23.6% of all emissions produced. Forests are the most important category within LULUCF in Slovakia, accounting for more than 2/3 of the CO_2 sequestered in this sector. In addition to this category, the categories of cropland and permanent grassland, as well as harvested wood products, also show CO_2 sinks, but are much less significant from a balance sheet perspective. In contrast, CO_2, CH_4 and N_2O emissions are produced in the categories settlements and other land, also from biomass burning after forest harvesting, from forest fires, as well as from land mineralisation due to land use changes.

[138] Ministry of Agriculture and Rural Development. "Forest Strategy 2030." [Online]. https://data.consilium.europa.eu/doc/document/ST-13537-2021-INIT/sk/pdf

[139] Ministry of Agriculture and Rural Development. "Rural development programme 2014-2020 extended until 2023". [Online]. https://agriculture.ec.europa.eu/common-agricultural-policy/rural-development_sk; Ministry of Agriculture and Rural Development. "Rural Development Programme 2023-2027. [Online]. https://agriculture.ec.europa.eu/common-agricultural-policy/rural-development_sk

Figure 6.34: *Trend and projections of GHG emissions/removals in the LULUCF sector in **WEM** and **WAM** scenarios up to 2050*

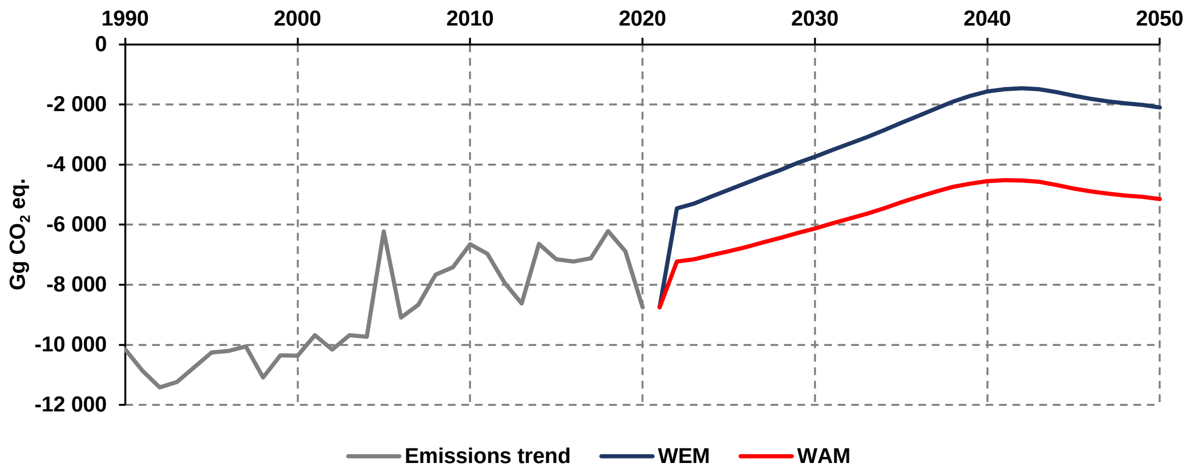


Table 6.28: *Overall trend of GHG emissions/removals projections in the LULUCF sector in **WEM** and **WAM** scenarios up to 2050*

Year	**WEM**	**WAM**
	Gg CO_2 equivalents	
1990	-9 319.41.	-9 319.41.
1995	-9 477.71.	-9 477.71.
2000	-9 390.87.	-9 390.87.
2005	-4 747.48.	-4 747.48.
2010	-5 211.08.	-5 211.08.
2015	-5 753.87.	-5 753.87.
2020	-7 593.17.	-7 593.17.
2025	-4 553.82	-6 684.23
2030	-3 456.96	-5 905.54
Comparison with 1990	**-6 291.92%**	**-36.63%**
Comparison with 2005	**-27.20%**	**24.39%**
2035	-2 310.83	-5 021.40
2040	-1 422.98	-4 466.45
2045	-1 741.17	-4 836.06
2050	-2 117.46	-5 169.57
Comparison with 1990	**-77.28%**	**-44.53%**
Comparison with 2005	**-55.40%**	**8.89%**

The modelling results above show that both scenarios show a reduction in removals from 1990 levels in 2030 and, conversely, the scenarios show a reduction in removals by 2050.

6.5.1 Historical Data of Input Parameters

Projections of emissions/removals of GHGs in the LULUCF sector were modelled for the 6 main balance land use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land) and the Harvested Wood Products category, as well as for the different GHG emission gases (CO_2, CH_4, N_2O). The available time series of input data for the period 1990-2020 were used, which were obtained from various sources (Office of Geodesy Cartography and Cadastre, NLC, Statistical Office of the Slovak Republic, National Agriculture and Food Centre-Soil Science and Conservation Research

Institute, National Agriculture and Food Centre-Grassland and Mountain Agriculture Research Institute, Fire Technical and Expert Institute of the Ministry of the Interior of the Slovak Republic, FAO database). All input data entering the accounting of GHGs emissions/removals in the LULUCF sector were used as input data for the projections.

Input data needed in the preparation of projections:

- acreages of individual land use categories - forests, cropland, permanent grasslands, wetlands, settlements, other land, (data for the period 1970-2020, source Statistical Yearbook of the Land Fund of the Slovak Republic, Office of Geodesy Cartography and Cadastre[140]), data available by regions, districts and cadastral territories,
- changes in acreage into and out of each land use category - forests, cropland, permanent grassland, wetlands, settlements, other land (data for the period 1970-2020), data available by county, district and cadastral area,
- annual tree growth in m^3/ha (1990-2020, source Summary Information on the State of Forests (SISL), as part of the Forestry Information System [141](FIS), data available by county,
- annual timber harvest in m^3 (1990-2020, source FIS), data available for Slovakia by tree species,
- area of individual trees in ha (1990-2020, source FIS), data available by county,
- representation of individual tree species in ha (1990-2020, source SFIS), data available by county,
- age structure of forests in ha (2014-2020, source FIS),
- area of forest fires in ha (1990-2020, source NLC in cooperation with the Fire Technical and Expertise Institute of the Ministry of the Interior of the Slovak Republic),
- Inputs for harvested wood products (1990-2020, source FAO database).

6.5.2 Projections of Input Data and Parameters

Projections of the main input parameters - acreage and changes in acreage in each land use category in the LULUCF sector for the period 2021-2050 were determined either through the exponential smoothing function of MS Excel, in the Forecast tool (dynamic projections), or as average values from historical data (static projections). In particular for the **WEM** scenario, a stable development of the areas (or areas of transfers between categories) based on average values over the period 1990-2020 was considered. If there is a significant break in development or intensity during this period and the current value of transfers (e.g. in the last decade) is significantly different than the average over the whole period, the calculation of the average was based only on the last decade or period with the current, new level of values.

In addition, outputs from the FCarbon model, which was developed in the context of the implementation of Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the integration of greenhouse gas emissions and removals from land use, land-use change and forestry into

[140] Statistical Yearbook on the Land Fund of the Slovak Republic, Office of Geodesy Cartography and Cadastre. https://www.skgeodesy.sk/sk/ugkk/kataster-nehnutelnosti/sumarne-udaje-katastra-podnom-fonde/

[141] https://gis.nlcsk.org/islhp/

the 2030[142] Framework for Climate and Energy Policies , amending Regulation (EU) No. 525/2013 and Decision No. 529/2013/EU, were used for the projection of input parameters in the Forests category. The main reasons for the development of the FCarbon[143] model were the requirements for consistency with GHG emissions/removals reporting and the inclusion of age-related forest dynamic characteristics.

This model simulating the future development of forests in Slovakia was developed at NLC according to the methodology proposed.[144] The model is able to simulate in each simulation step, which is 1 year, the development of the age structure of forests, stock changes through normal annual increments and harvesting rates (harvesting percentages). It is possible to model bare-root and understorey management. The simulation of forest growth in the FCarbon model is based on growth tables[145], which determine the increments of wood volume in m^3 for the main tree species in Slovakia (spruce, fir, pine, beech, oak and selected poplars). The volumes of clearance and recovery are calculated on the basis of the specified percentages of extraction from the stock. The model is optionally able to simulate changes in the area of trees and thus changes in the total forest area. The model requires the following input data (broken down by species and age class): stock (m^3), area (ha), suitability and harvesting percentage for thinning and regeneration (mean and standard deviation).

As input data for the simulation of the future development of Slovak forests were used summaries from central forestry databases, prepared for one calendar year (capturing the state at the end of the year), stratified by tree species and 10-year age stages. These summaries contained information on the area of each tree species and age class, stock (in m^3 of rough), stunting, stock rating, total normal increment and planned harvesting volume (educational and regeneration). The information from the Forest Economic Record (FER) on actual timber harvesting was broken down according to the Decree of the Ministry of Agriculture and Rural Development of the Slovak Republic No. 297/2011 Coll. on Forest Economic Record (FER) into deliberate (educational and restoration), extraordinary and accidental (executed, with timber left in the forest stand and not executed).

Area of the category Forest Land remaining Forest Land (4.A.1) - forest area and its trend are among the basic indicators of sustainable forest management. Society's demands on forests, which play an important role in mitigating climate change, conserving biodiversity, protecting water resources, preventing floods, providing timber and non-timber forest products as well as other ecosystem services, are constantly increasing. Maintaining and increasing forest cover is therefore highly desirable. According to data from the Summary Information on the State of Forests (FIS source), there is a long-term trend of its increase. Since 1990, the area of forest cover has increased by 28.3 thousand ha, or 1.47%. The increase of approximately 975 ha per year over the period is mainly due to the change in land type. The total area of forest land in 2020 was 2 027 852 ha and has increased by 46.6 thousand ha since 1990 (i.e. by 2.36%). On average, it increased by 1 607 ha per year over the period. Forest cover, calculated as a percentage of the area of forest land in the total area of the Slovak Republic (4.903 million ha, including water areas), reached 41.3% in 2020. It has increased by 1.0% since 1990. There are 0.36 ha of forest per inhabitant of the Slovak Republic.

[142] https://eur-lex.europa.eu/legal-content/SK/ALL/?uri=CELEX%3A32018R0841

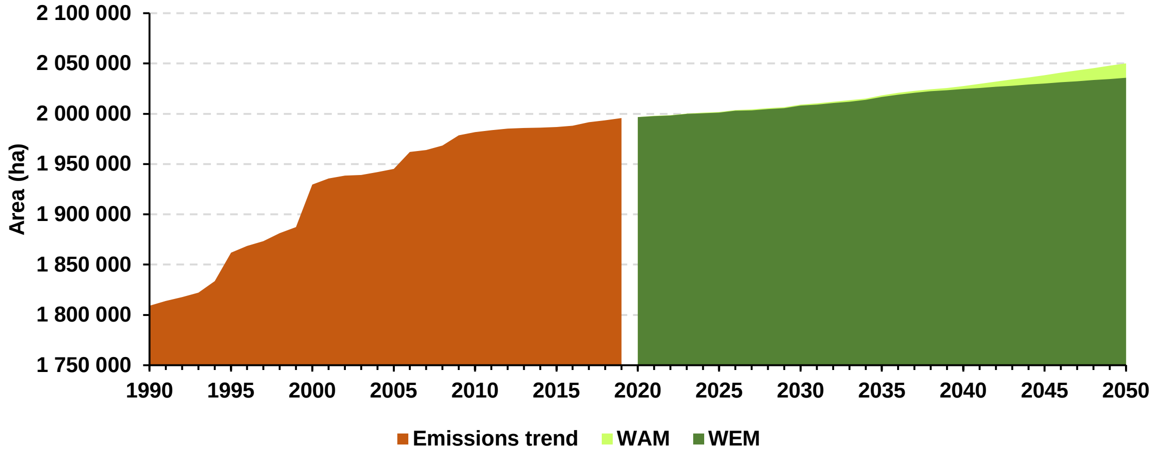
[143] https://web.nlcsk.org/cafmocc-fcarbon/

[144] Grassi, G.; Pilli, R. 2017. Projecting forest GHG emissions and removals based on the “continuation of current forest management”: the JRC method. EUR 28623 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2017. doi:10.2760/844243. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106814/jrc_report_frl.pdf; Forsell, N.; Korosuo, A.; Federici, S.; Gusti, M.; Rincón-Cristóbal, J.J.; Rüter, S.; Sánchez-Jiménez, B.; Dore, C.; Brajterman, O.; Gardiner, J. 2018. Guidance on developing and reporting Forest Reference Levels in accordance with Regulation (EU) 2018/841

[145] Halaj, J.; Petráš, R. 1998: Rastové tabuľky hlavných drevín/Yield tables of main tree species. Bratislava, Slovak Academic Press, 325 p.

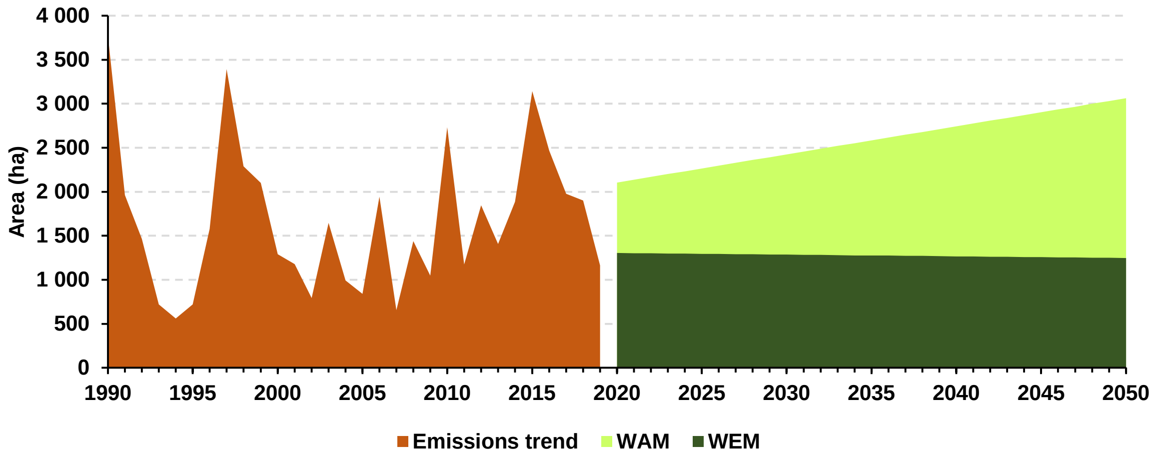
The development of acreage in the category Forest Land remaining Forest Land follows the above mentioned trend of increasing acreage of forests in the Slovak Republic. For this reason, the projection assumes an increase in forest area after 2020, both in the **WEM** and **WAM** scenarios (***Figure 6.35***).

Figure 6.35: *Trend and projections of area in category 4.A.1 - Forest Land remaining Forests Land in **WEM** and **WAM** scenarios up to 2050*



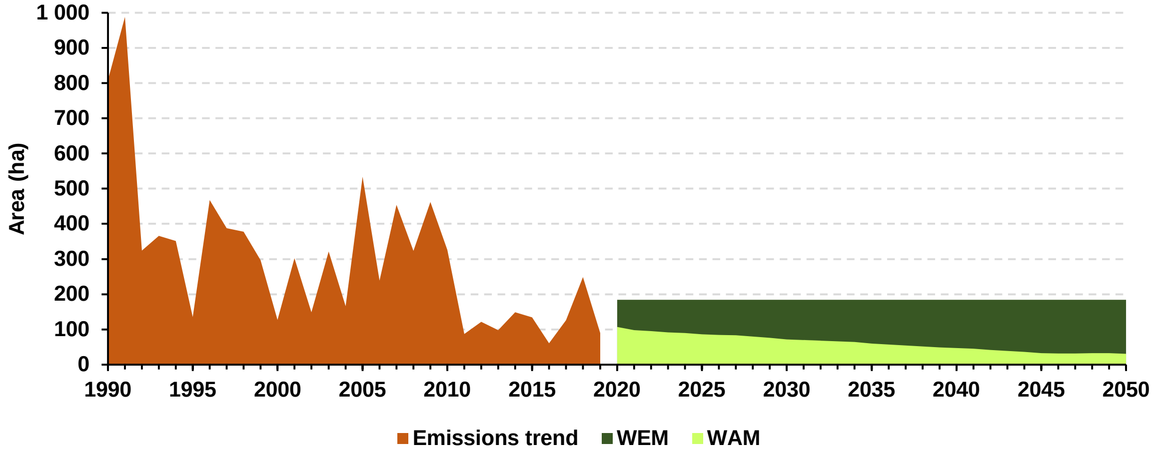
Area of the category Land converted to Forest Land (afforestation) (4.A.2) - historical acreage in this category shows a divergent pattern throughout the 1990-2020 period. The highest acreage value was recorded in 1990 at 3 770 ha and the lowest at 559 ha in 1994. The average value was 1 670 ha. The future trend shows a slightly decreasing trend (**WEM**) and an increasing trend (**WAM**) (***Figure 6.36***).

Figure 6.36: *Trend and projections of area in category 4.A.2 Land converted to Forest Land (afforestation) in **WEM** and **WAM** scenarios up to 2050*



Area of the category Forests converted to Land (deforestation) (4.A.2) - historical acreage in this category shows a divergent pattern throughout the 1990-2020 period. The highest acreage value was recorded in 1991 at 988 ha and the lowest at 61 ha in 2016. The average value was 301 ha. The future development shows a balanced trend (**WEM**) and a slightly decreasing trend (**WAM**) (***Figure 6.37***).

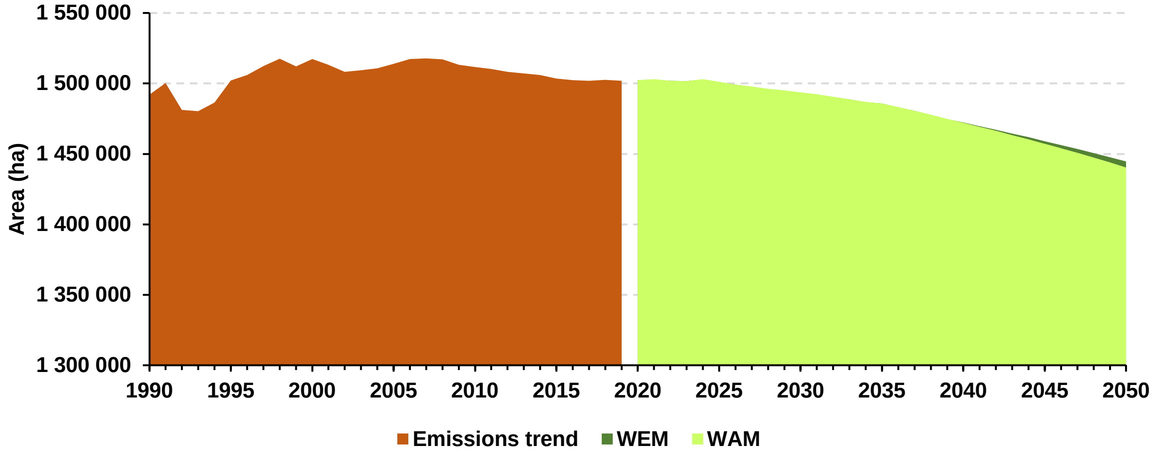
Figure 6.37: *Trend and projections of area in category 4.A.2 Forest Land converted to Land (deforestation) in **WEM** and **WAM** scenarios up to 2050*



Area of the category Cropland (4.B) - historical acreage in this category shows a slightly fluctuating pattern throughout the 1990-2020 period and a steadily declining trend since 1998. The projected future development of the cropland category includes the fact that there will be conflicting factors influencing the development of areas in the coming years, which are likely to intensify over time. On the one hand, there will be pressure for the encroachment and development of cropland for residential areas, industrial, commercial and logistics centres, as well as roads. On the other hand, there will be increasing pressure to preserve cropland, to strengthen its productive functions, especially in relation to at least partially increased food self-sufficiency, and in particular to strengthen the non-productive functions of land, such as water storage in the land, erosion protection, biodiversity, land formation, and also mitigation of the negative impacts of change and adaptation to climate change. Significant positive impacts of this category are also envisaged in relation to emissions capture and carbon sequestration. Not only the EU's Common Agricultural Policy, but also other, particularly environmentally oriented EU policies such as the European Green Deal, are working towards this.

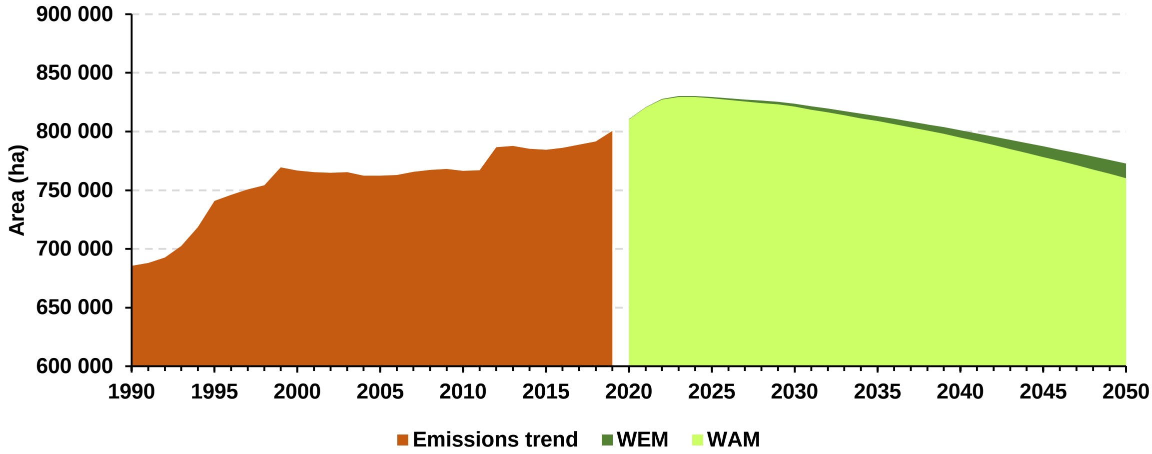
On the basis of the above, it is possible to assume a stabilisation of the acreage in this category, or a very slight decrease. As regards the internal structure, an increase in the area of individual permanent crops is expected, particularly orchards, vineyards and, it would be appropriate, hop-growing, since the products of all these crops make up a negative balance in the economic balance, and, in addition, in terms of GHG emissions, these crops show relatively high CO_2 removals. Alongside this, it is expected that within the arable sub-category there will be an increase in the proportion of land features and non-forest woody vegetation in the form of tree lines, borders, solitudes and trees in groups, which will enhance the fulfilment of the non-productive functions of the cropland and land. Future trends in cropland area show a declining trend (**WEM**) and a slightly declining trend (**WAM**) (***Figure 6.38***).

Figure 6.38: *Trend and projections of area in category 4.B – Cropland in **WEM** and **WAM** scenarios up to 2050*



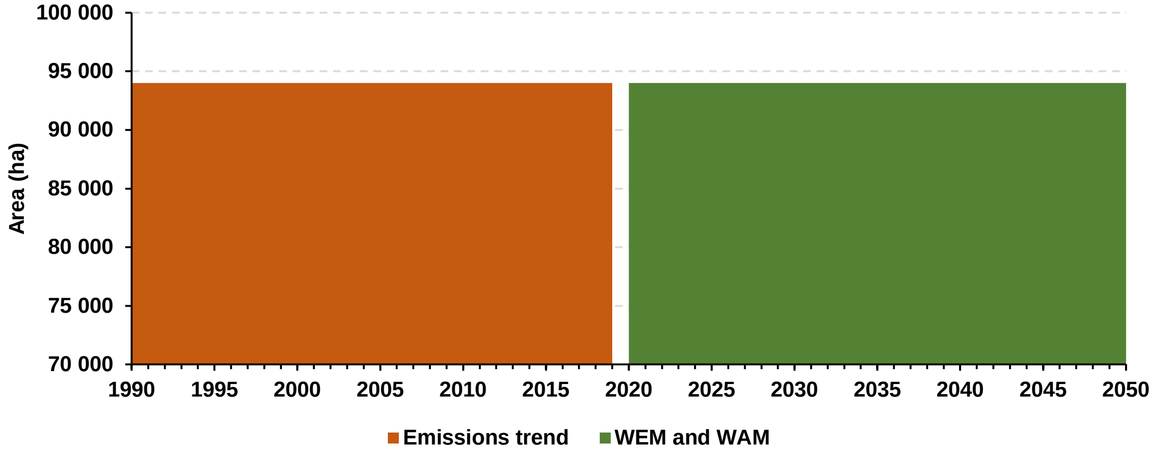
Area of the category Grassland (4.C) - the set trend gives an outlook that most probably the gradual reduction of the area of permanent grasslands will continue, mainly due to the transfer of unused and abandoned grasslands to the forest fund, ecological and water protection restrictions, the introduction of forest-pastoral systems, the transfer of land under the administration of national parks. If appropriate socio-economic and ecosystem measures or payments are introduced and applied in the land, the area in this category could be stabilised and its use improved. The trend of permanent grassland area in the future shows a decreasing trend for all scenarios (**WEM** and **WAM**) (***Figure 6.39***).

Figure 6.39: *Trend and projections of area in category 4.C – Grassland in **WEM** and **WAM** scenarios up to 2050*



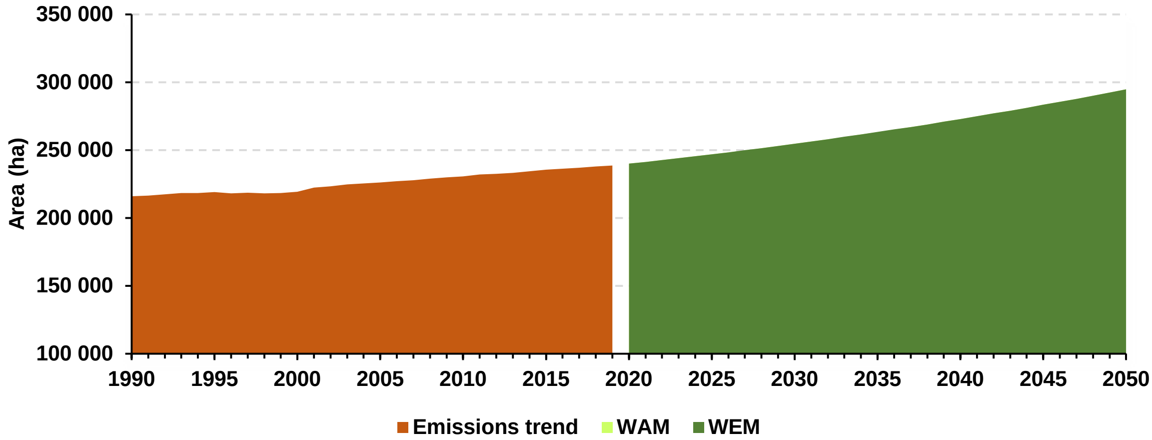
Area of the category Wetlands (4.D) - Slovakia shows no change in this category in the long term. It is realistic to assume that this will remain the case in the future, which is why the acreages for the **WEM** and **WAM** scenarios are identical (***Figure 6.40***).

Figure 6.40: *Trend and projections of area in category 4.D – Wetlands in **WEM** and **WAM** scenarios up to 2050*



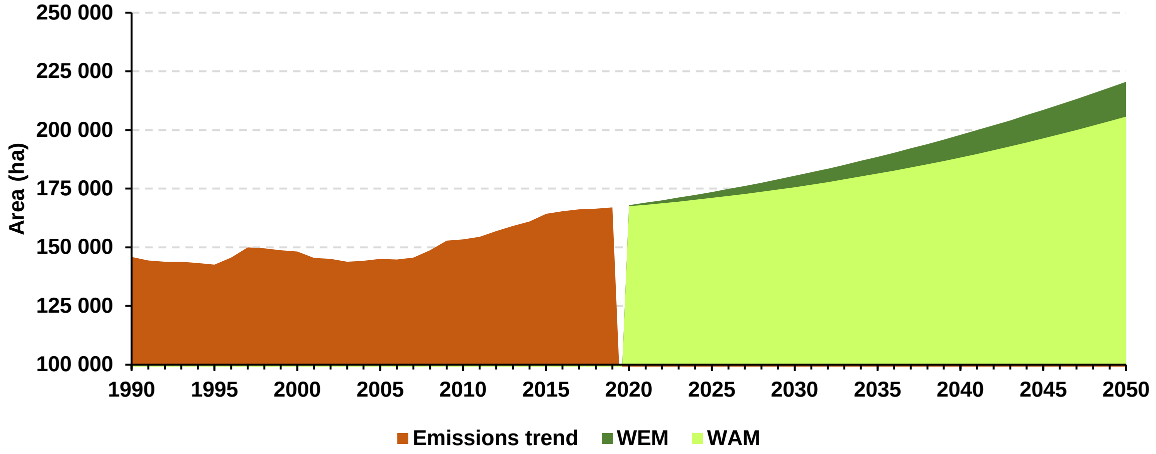
Area of the category Settlements (4.E) - the acreage of this land use category has shown a steadily increasing trend throughout the period. This situation is mostly due to the development of transport infrastructure, industrial areas, the development of towns and villages, the increase in the area of various infrastructure in the countryside. In Slovakia, it is very often associated with a decrease in the area of the category of cropland, as it is related to the occupation of good quality arable land. Future developments show an increasing trend for all scenarios (***Figure 6.41***).

Figure 6.41: *Trend and projections of area in category 4.E – Settlements in **WEM** and **WAM** scenarios up to 2050*



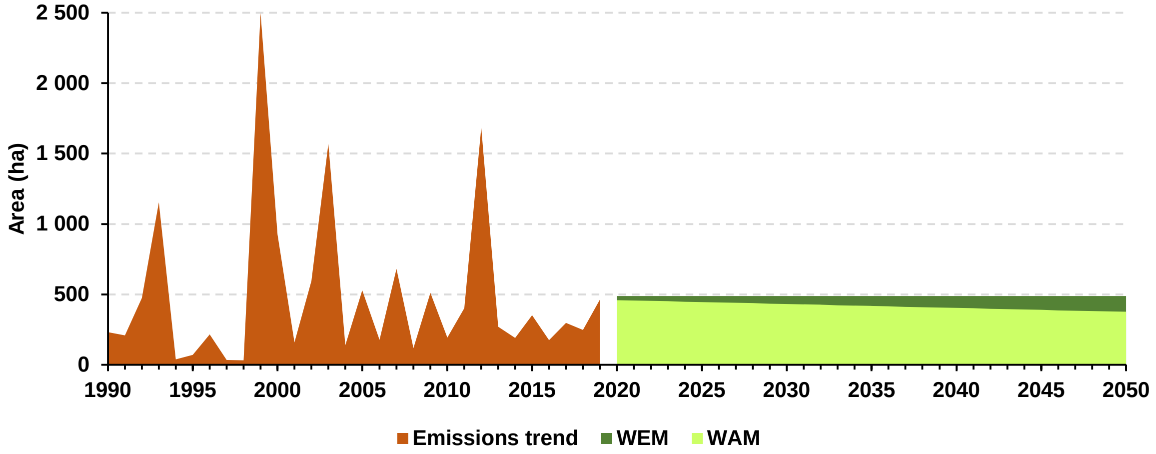
Area of the category Other Land (4.F) - the acreage of this land use category has shown a steadily increasing trend throughout the period. This situation is mostly due to the degradation of cropland, but also due to leaving the territory of Slovakia without active management. Future developments show an increasing trend for all scenarios are identical (***Figure 6.42***).

Figure 6.42: *Trend and projections of area in category 4.F – Other Land in **WEM** and **WAM** scenarios up to 2050*



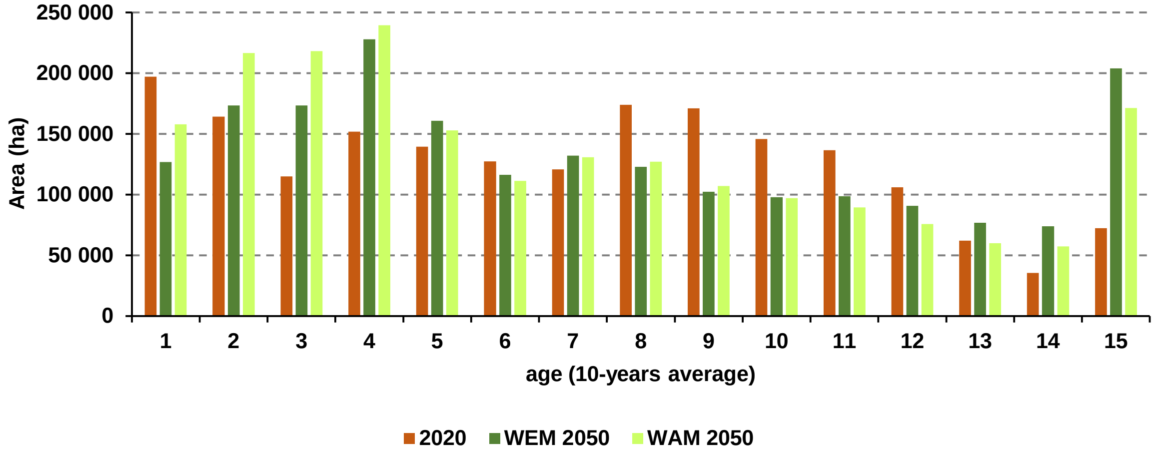
Area of the category Forest Fires - historical forest fire acreage shows a discontinuous pattern throughout the period. The highest acreage value was recorded in 1999 at 2 496 ha and the lowest at 32 ha in 1998. The average value was 488 ha. The future development shows a steady trend (**WEM**) and a slightly decreasing trend in the **WAM** scenario (***Figure 6.43***).

Figure 6.43: *Trend and projections of area in category Forest Fires in **WEM** and **WAM** scenarios up to 2050*



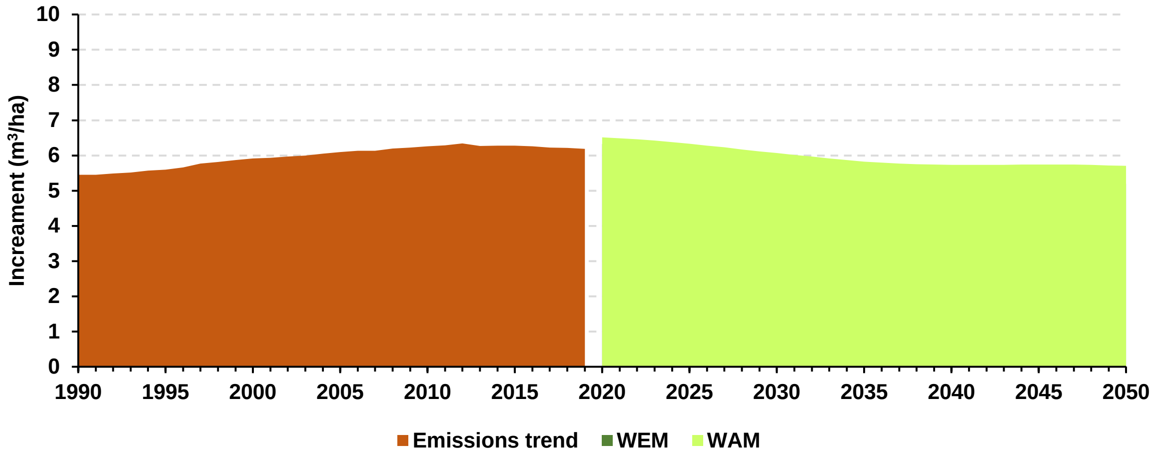
Trend of age structure, increments and timber harvests - future forest development was simulated using the FCarbon model for the period 2020-2050. Input data on forest condition were based on the summarised stand characteristics of individual tree species (age structure, stock (m^3), area (ha) and suitability) for the year 2019. Harvesting percentages (percentage of annual coarse harvest of total stock) were derived from data for the period 2013-2018, which capture the current level of stand regeneration. They were determined separately for planned and actual harvests (***Figure 6.44***).

Figure 6.44: *Change in age structure (area of forest stands at different age stages) in **WEM** and **WAM** scenarios from 2018 up to 2050*



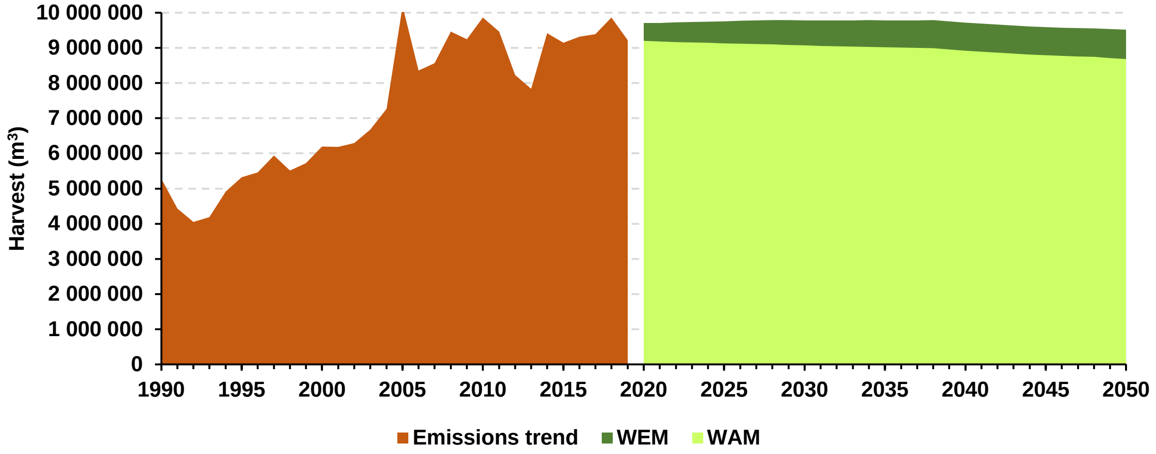
Based on these inputs, the FCarbon model calculated, at each time step (1 year) during the simulation, the trend of the age structure of the forest (by increasing the age, by transferring harvested areas to the youngest categories; (***Figure 6.44***), stock changes using current annual increments (***Figure 6.45***), and timber harvesting (via harvesting percentages; (***Figure 6.46***).

Figure 6.45: *Trend and projections of wood increments (in m³ of coarse wood per hectare) in **WEM** and **WAM** scenarios up to 2050*



Depending on the species of tree species, the management method was also simulated, namely: holm oak (mainly pine and spruce in case of calamities), but mainly understorey method (the ratio of both methods determined on the basis of the proportion of natural regeneration from the Forest Management Plans). The FCarbon model also accounted for changes in tree cover (and also in tree composition) and thus changes in total forest area under the **WAM** and **WEM** scenarios. The calculated wood mass gains and losses served as input for the calculations of carbon stock changes (***Figure 6.46***).

Figure 6.46: *Trend and projections of timber harvesting (in* m^3*) in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*



6.5.3 Policies and Measures, Scenarios

In its conclusions of 23 and 24 October 2014, the European Council endorsed a binding target to reduce domestic greenhouse gas emissions across the economy by at least 40% by 2030 compared to 1990 levels, as part of its 2030 climate and energy policies. However, the current target is -55%, which has been increased through the European Green Deal. The implementation of Regulation (EU) 2018/841 by individual Member States should also contribute to achieving this objective. This Regulation is part of the implementation of the Union's commitments under the Paris Agreement adopted under the United Nations Framework Convention on Climate Change (UNFCCC). The Union should continue to reduce its greenhouse gas emissions and increase removals in line with the Paris Agreement to the UNFCCC. Therefore, the condition of Regulation (EU) 2018/841 of the EP and Council of the EU that each Member State shall ensure that emissions do not exceed removals (zero emissions) in the period 2021 to 2025 and 2026 to 2030, taking into account the flexibility instruments provided for in Articles 12 and 13, has also been incorporated in the development of GHG emission/removal projections for the LULUCF sector.

Projections of emissions and removals were prepared for the two required scenarios of **WEM** and **WAM** development. The measures listed in ***Table 6.29*** were taken into account in the preparation of the LULUCF sector projections.

The scenario with existing measures (**WEM**) includes policies and measures adopted by the end of 2020 and their effect on LULUCF emissions/removals from 2020 onwards. As afforestation of cropland has a high carbon sequestration potential, this measure has been implemented under the individual RDP. In the first RDP 2004-2006, afforestation of unused cropland was supported by 15 projects with a total result of 100 ha of afforestation. In the following years, afforestation continued under the RDP 2007-2013 (28 projects with a total area of 133.35 ha) and the annual report on the RDP 2014-2020 for 2019 states that during the last two previous programming periods, planting of forest trees on cropland with a total area of 332 ha was carried out in Slovakia. In addition, a project was implemented for the establishment of fast-growing tree plantations on 35 ha of cropland. According to the Annual Report 2008 of the RDP 2004-2006, 29 320 ha of arable land had been grassed in Slovakia by the end of 2008.

Scenario with additional measures (**WAM**) represents scenarios of LULUCF development with applied measures expected after 2020. For forestry, no new specific measures (quantification) are currently known. In 2019, the Ministry of Forests of the Slovak Republic started the preparation of a new strategic document - the National Forestry Programme of the Slovak Republic for the period 2022-2030 (measure 5.30.3), which will follow the evaluation of the implementation of the National Forestry Programme of the Slovak Republic and the government-approved document. On this basis, the new National Forestry Programme of the Slovak Republic will also focus on the key societal themes of increasing the role of forests and the Slovak Forestry in the fight against climate change, the green economy, and the development of employment in rural areas. The new National Forestry Programme of the Slovak Republic for the period 2022-2030 will include monitoring indicators (qualitative and quantitative), which will then enable their incorporation into future projections. The Low carbon strategy states that support for increasing sinks in the LULUCF sector in the short term will be mainly implemented through the Common Agricultural Policy and through adaptation measures under the 2nd programming priority in Slovakia funded from the EU budget.

As regards the other categories (cropland and permanent grassland), it was not until November 2020 that the trilogies with the European Parliament and the EU Commission on the preparation of the Common Agricultural Policy (CAP) Strategic Plan were launched. The legislative process continues in 2021 and 2022. A two-year transition period (2021 and 2022) has been agreed. The Slovak agri-ministry is working intensively on the CAP for the next programming period, which will last until 2027.

A list of the policies and measures that have been taken into account in the projections of GHG emissions/removals in the LULUCF sector under each scenario and their effect is presented in ***Table 6.29***.

Table 6.29: *List of policies and measures implemented in the projections of GHG emissions/removals in LULUCF sector*

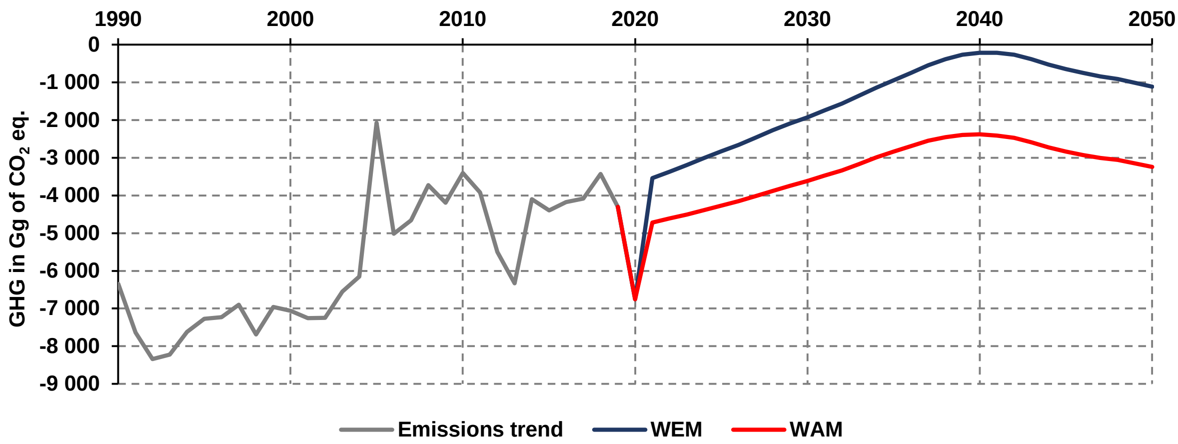
PAM	Scenario	Gas/Category	Measure	Effect of Measure
National Forestry Programme RDP Low carbon strategy	WEM	CO_2 / forest land, cropland, permanent grassland	Afforestation of unused cropland, establishment of stands of fast-growing trees on cropland, afforestation of cropland, measures to reduce fires	synergic
National Forestry Programme	WEM	CO_2 / forest land	Prevention of deforestation (as an integrated part of sustainable forest management)	Synergic
National Forestry Programme RDP	WEM	CO_2 / forest land	Protection of existing forests against natural disturbances (as an integrated part of sustainable forest management)	Synergic
National Forestry Programme Adaptation strategy[146]	WAM	CO_2 / forest land	Promote measures to increase carbon sinks as part of sustainable forest management. Adjust tree species composition to increase the resilience of stands to drought and reduce vulnerability to biotic and abiotic agents.	Synergic
Low carbon strategy Envirostrategy	WAM	CO_2 / forest land	Increasing forest cover through afforestation of agriculturally unused land while maintaining the diversity of non-forest habitats Create conditions for the settlement of the status of the so-called white areas	synergic
Low carbon strategy	WAM	CO_2 / forest land	Maintaining vital forests by limiting the negative impacts of climate change on forests through measures aimed at forest adaptation (support for the use of alternative management models to adjust tree species composition, use of suitable provenances).	synergic

[146] Ministry of the Environment of the Slovak Republic, 2018: "Climate Change Adaptation Strategy - Update", Bratislava: s.n 2018. [Online]. http://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf

PAM	Scenario	Gas/Category	Measure	Effect of Measure
Low carbon strategy	WAM	CO_2 / Products of harvested wood	Increasing the share of long-life wood products (HWP), including for construction purposes.	synergic
Low carbon strategy	WAM	CO_2 / cropland	Implementation of measures to increase carbon sequestration in agricultural soils and maintain high levels of organic carbon in carbon-rich soils.	synergic
Low carbon strategy	WAM	CO_2 / permanent grassland	Maintenance and restoration of grasslands.	synergic

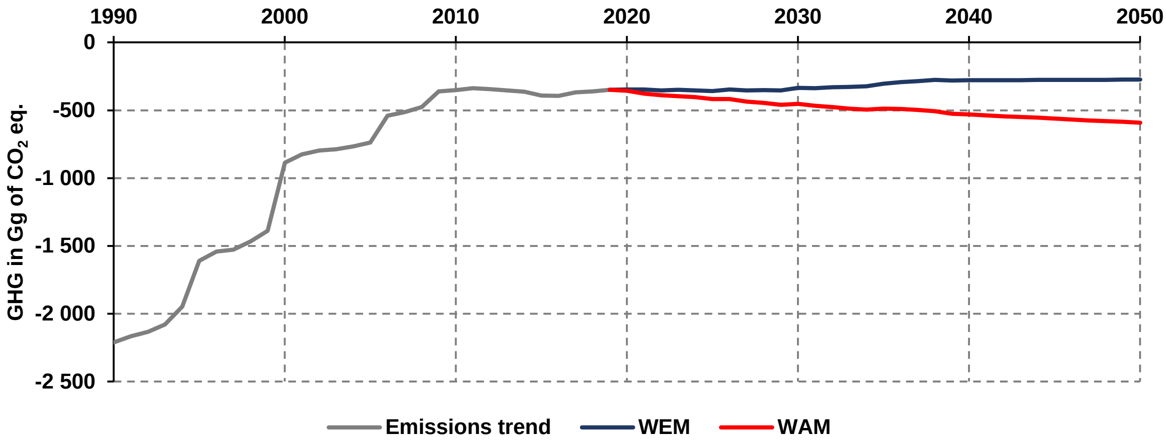
Projections of emissions and removals in Forest Land Remaining Forest Land - in this category, projections of emissions and removals of CO_2, CH_4, N_2O (Gg CO_2 eq.) were calculated for the **WEM** and **WAM** scenarios (***Figure 6.47***). CO_2 sinks are mainly from forest management, CH_4, N_2O emissions from forest fires. Assuming that forests are managed as they have been for the last 6 years (**WEM**), we can expect a significant decrease in CO_2 sinks between now and 2050. The cause is the current age structure of forest stands. Older stands are beginning to predominate in the forests, with lower annual wood mass growth compared to younger, fast-growing stands. The results of the **WAM** scenario based on harvesting of stands so far would lead to a higher level of CO_2 storage by living biomass in Slovak forests over the whole simulated period, despite an expected decrease in sinks from the current level of ~ -4 000 Gg CO_2 to ~ -2 000 by 2040 and a subsequent slight increase to ~ -2 800 Gg CO_2 in 2050. The **WEM** scenario is based on the implementation of planned extraction and may result in a larger decrease in CO_2 sinks, peaking in 2040 at ~ -200 Gg CO_2, followed by a slight increase to ~ -1 000 Gg CO_2 in 2050. Changes in the tree species composition of forests have a more pronounced effect on CO_2 sinks, compared to increasing forest area. In the WEM scenario, lower sinks occur due to lower forest area, unchanged tree species composition and also higher CH_4 and N_2O emissions from forest fires. The **WAM** scenario shows higher CO_2 removals due to higher forest area, more favourable tree species composition and lower CH_4 and N_2O emissions from forest fires.

Figure 6.47: *Trend and projections of CO_2, CH_4, N_2O emissions and removals in category 4.A.1 - Forest Land remaining Forest Land in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in Land Converted to Forest Land - in this category, projections of emissions and removals of CO_2, CH_4, N_2O (Gg CO_2 eq.) were calculated for the **WEM** and **WAM** scenarios (***Figure 6.48***). When land is converted to forest (afforestation), significant carbon sequestration or CO_2 sinks occur, mainly through new forest biomass. In the **WEM** scenario, there are lower sinks due to decreasing area under afforestation, unchanged tree species composition and also higher emissions from forest fires. The **WAM** scenario shows higher removals mainly due to higher forest cover, more favourable tree species composition and assumed lower emissions from forest fires.

Figure 6.48: *Trend and projections of CO_2, CH_4, N_2O emissions and removals in category 4.A.2 - Land converted to Forest Land in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in the Cropland - this category shows net GHG sinks (Gg) for all scenarios (***Figure 6.49*** and ***Figure 6.50***). The CO_2 sinks occur mainly in the permanent crops category and are due to additions of woody biomass in orchards, vineyards and gardens. Also, mineral soil represents a CO_2 sink in this category. CO_2 emissions in this category occur when forests are converted to cropland (deforestation) and N_2O emissions occur when soils are mineralised as a result of land-use change. Deforestation removes tree biomass and also releases carbon sequestered in fallout and forest soil. The **WEM** scenario shows lower removals, due to lower areas of permanent crops, higher CO_2 emissions from deforestation and N_2O emissions from soil mineralisation, compared to the **WAM** scenario.

Figure 6.49: *Trend and projections of CO_2 and N_2O emissions and removals in category 4.B.1 - Cropland remaining Cropland in **WEM** and **WAM** scenarios up to 2050*

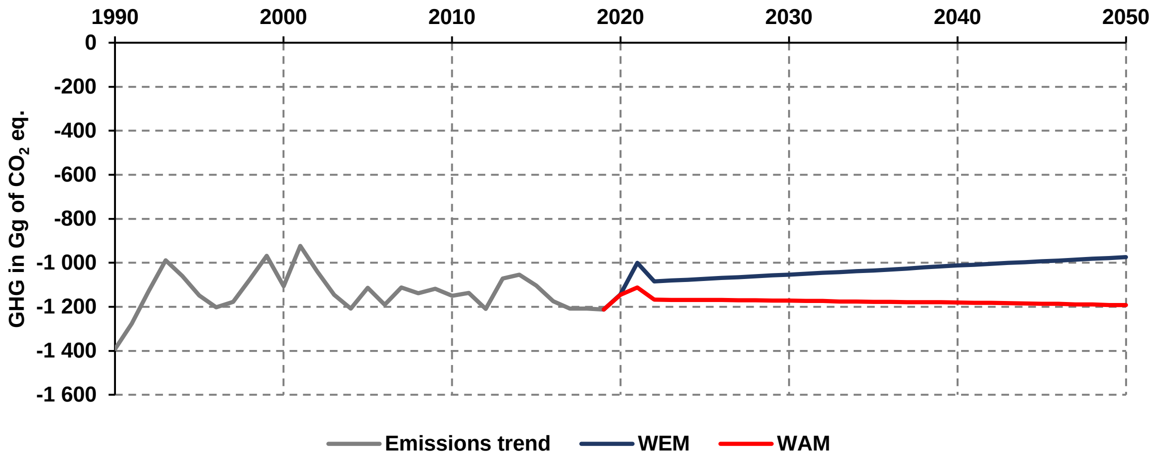
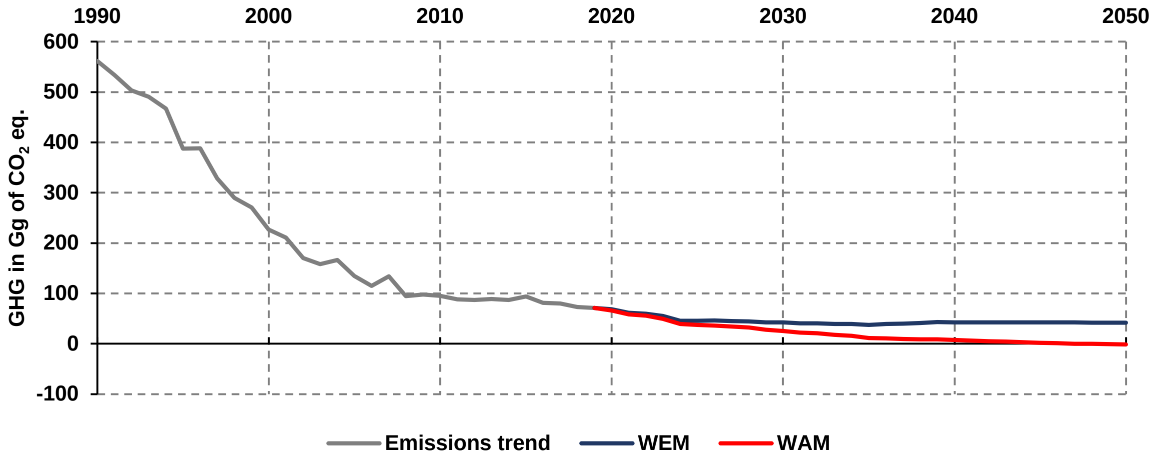
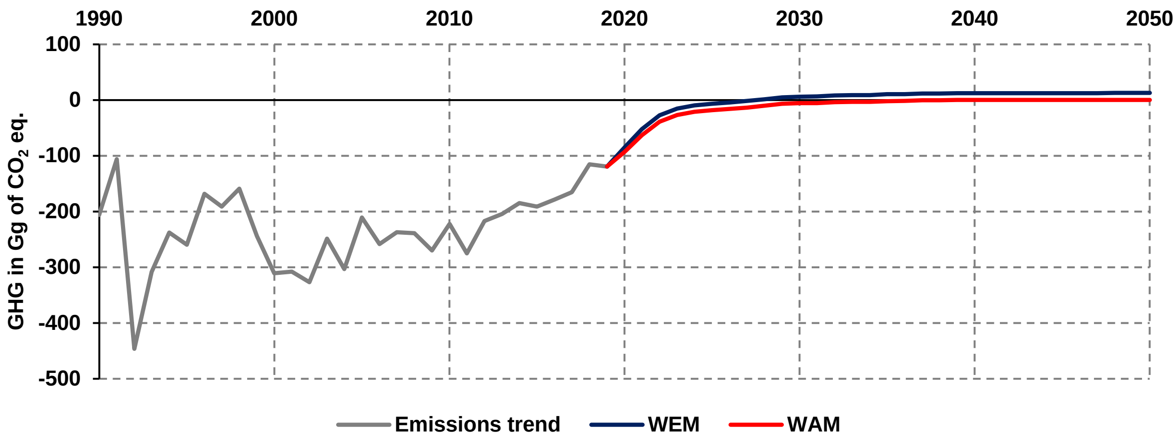


***Figure 6.50**: Trend and projections of CO_2 and N_2O emissions and removals in category 4.B.2 - Land converted to Cropland in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in Grassland - in this category, projections of CO_2 emissions and sinks (Gg) were determined for all scenarios, with the scenarios (***Figure 6.51***). Both scenarios show CO_2 sinks by 2050, but a significant decrease in sinks can be expected compared to historical data, mainly due to a decrease in acreage in this category. The **WEM** scenario shows slightly lower removals, due to lower areas of permanent grassland, higher CO_2 emissions from deforestation and N_2O from soil mineralisation, compared to the **WAM** scenario. However, the differences in removals between the two scenarios are minimal.

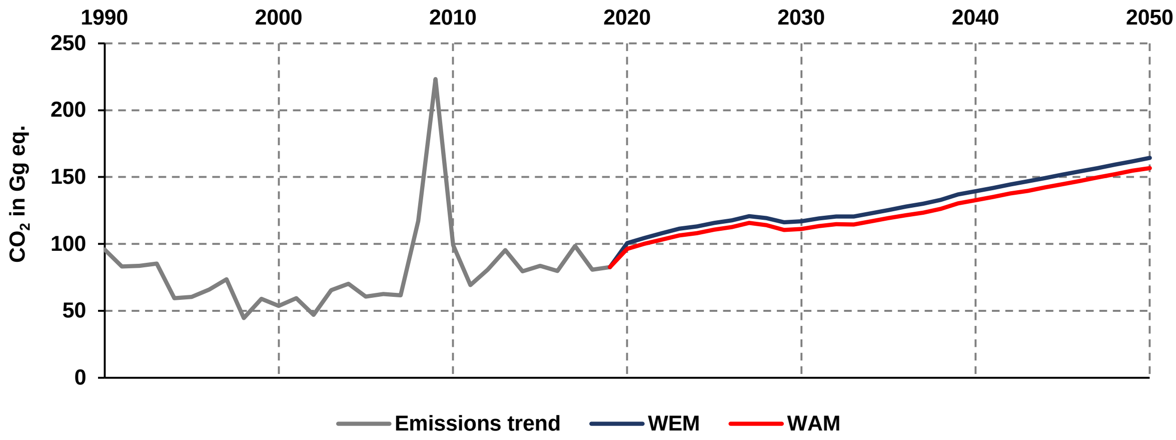
***Figure 6.51:** Trend and projections of CO_2 and N_2O emissions and removals in category 4.C - Grassland in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in Settlements - in this category, projections of CO_2 emissions (Gg) were determined for the **WEM** and **WAM** scenarios (***Figure 6.52***). Both scenarios show CO_2 emissions up to 2050 and can be expected to increase compared to historical data, mainly due to the increase in acreage in this category. This situation is mostly due to the development of transport infrastructure, industrial areas, urban and municipal development and the increase in the acreage of various infrastructure in the land. The **WEM** scenario shows slightly higher CO_2 emissions compared to the

WAM scenario. Higher CO_2 emissions from deforestation and N_2O emissions from soil mineralisation contribute to this.

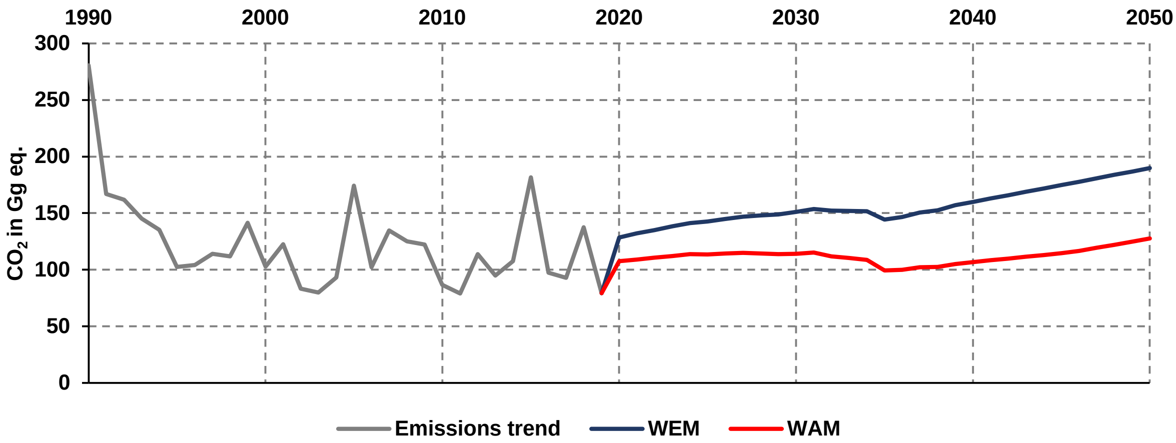
Figure 6.52: *Trend and projections of CO_2 emissions in category 4.E - Settlements in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in Other Land - in this category, projections of CO_2 emissions (Gg) were determined for the **WEM** and **WAM** scenarios (***Figure 6.53***). Both scenarios show emissions up to 2050, an increase in emissions can be expected compared to historical data, mainly due to the increase in acreage in this category. This situation is mostly due to degradation of cropland, but also to an increase in the acreage of various infrastructure in the land.

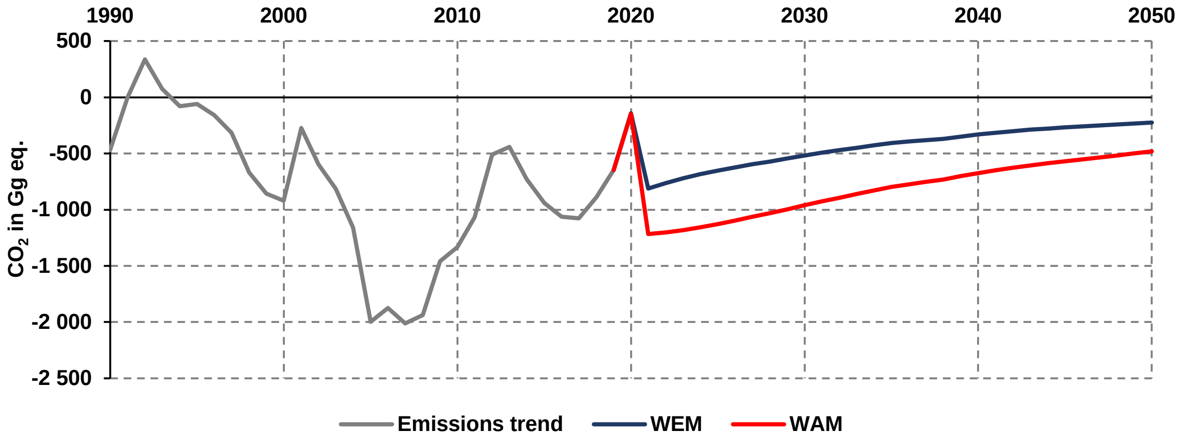
The **WEM** scenario shows higher CO_2 emissions compared to the **WAM** scenario. Higher CO_2 emissions from deforestation and N_2O emissions from soil mineralisation also contribute to this.

Figure 6.53: *Trend and projections of CO_2 emissions in category 4.F - Other Land in **WEM** and **WAM** scenarios up to 2050*



Projections of emissions/removals in Harvested Wood Products - increased sustainable use of harvested wood products can significantly reduce emissions through substitution effects and improve the removal of greenhouse gases from the atmosphere. This category shows CO_2 removals (Gg) for the **WEM** and **WAM** scenarios (***Figure 6.54***). CO_2 sequestration occurs through carbon sequestration in the different wood product groups. While the storage period for paper products is 2 years, it is 25 years in wood panels and up to 35 years in lumber. The **WEM** scenario shows lower removals compared to the **WAM** scenario, mainly due to the higher share of products with shorter carbon storage times.

Figure 6.54: *Projections of CO_2 removals in category 4.G - Harvested Wood Products in **WEM** and **WAM** scenarios up to 2050*



6.5.4 Methodology, Model Used and Sensitivity Analysis

Emission inventory	SVK_CRF_13-04-2022 (1990 – 2020)
Baseline year for projections	2018 – 2020
Baseline year for policies and actions	2020
Emissions projections for the period	2021 – 2050
Reduction targets	2030 and 2050
Expression of the reduction compared to the years	1990 (base year for greenhouse gas emissions)

Emissions projections were prepared in accordance with the 2006 Intergovernmental Panel on Climate Change Methodology, Chapter IV (IPCC 2006 Guidelines). The computational analytical tool is based on the MS Excel platform and the calculation includes various policies and measures (in numerical formulation) defined according to the **WEM** and **WAM** scenarios. The projections of emissions and removals in the Forest category used outputs from the FCarbon, model, which was developed in the context of the implementation of Regulation (EU) 2018/841 of the European Parliament and of the Council. The main reasons for the model development were the requirements for consistency with the reporting of GHG emissions and removals in national emission inventories and also the inclusion of forest dynamics through characteristics related to the age structure of the forest. The whole procedure of simulating the FCarbon model and calculating emission and sink projections is programmed in Python and the data are stored in a SQLite database.

In the context of a very exceptional situation in the LULUCF sector in 2020, caused by low extraction, dampened by anti-pandemic measures during the first wave of COVID-19, increased removals, and 2020 being an exceptional year outside of the long-term trend of high removals, the emission projections were calibrated to the 2014-2019 time period. This allowed to reduce the fluctuation of the emission projections and to relate them to the previous trend.

The model was calibrated using data for 2014-2019, as the first usable forest cover condition data from the reference period were valid at the end of 2013. The aim of the calibration was to increase the accuracy of the simulation process so that it is able to reproduce the resulting emissions and removals as faithfully as possible and to track the actual development of forest stands during the reference period. For each year of the simulation, deviations from the mean values of the thinning and harvesting percentages (both positive and negative, in %) were specified, so that the sum of the deviations over the calibration period was zero. After the first run of the model, total carbon stock gains and losses were calculated. It was found that the resulting average value of the increments (5 141.1 kt C) was higher by 2.68% and the average value of the simulated removals (-3 874.5 kt C) was lower by 0.05% compared to the average values of the national GHG emissions and removals inventory (5 006.9 kt C and -3 872.5 kt C, respectively). Carbon increments were compared by tree species and ratios of simulated to actual values were calculated. These ratios were used as multipliers to the volume increments determined from the tree-by-tree growth tables to adjust the total simulated biomass increments. The calibrated model was used to simulate the trend of forest age structure, increments and harvests over the period 2020-2050. Forest condition data valid at the end of 2019 were used as inputs to the model.

The "gains-losses" method was used to quantify emissions and removals in each category. This is based on estimates of the year-on-year change in biomass from the difference in biomass gains and losses, where gains represent the annual increase in carbon stocks due to biomass growth and losses represent the annual decrease in carbon stocks due to biomass removal (harvesting). The simulation results for each tree species are summarized within each step and the emissions and removals in living biomass are calculated from the summarized data. The annual increment of coarse biomass (m^3) is converted to biomass increment (dry weight) using wood density, Biomass Conversion Expansion Factor (BCEFI) and Root-to-Shoot Ratio (R). The annual carbon stock gain is calculated by multiplying the dry weight by the average dry carbon content (50% for conifers and 49% for broadleaves). The annual loss of carbon stocks due to biomass loss is calculated from the annual harvest volume (m^3), the conversion and expansion factor (BCEFR), the ratio of aboveground to belowground biomass (R), and the average dry carbon content. The resulting carbon stock changes (additions minus removals) are converted to CO_2 emissions and removals by multiplying the carbon mass by -44/12. More detailed information on the methodology for calculating emissions and removals is published in the National Inventory Report 2022.[147] For category 4.A.1 Remaining forest, the projections have been treated as a continuation of forest management in the so-called reference period 2014-2019 for all scenarios.

In the **WEM** scenario, the trend of increments - gains, modelled on the basis of a scenario with dynamically increasing forest area (1 996 677 ha in 2020 to 2 024 540 ha in 2040 and 2 035 643 ha in 2050) and dynamically changing tree species composition (a decrease of spruce from 22% in 2020 to 17% in 2040 and 15% in 2050), was assumed, beech increases from 35% in 2020 to 39% in 2040 and 41% in 2050, with the remaining tree species remaining at 2020 levels). As for the losses, these have been modelled through harvesting. In the **WEM** scenario, the so-called planned harvests were modelled (6-8% higher than the realised harvests).

- Category 4.A.2 Land converted to forest land (afforestation):

Acreage and tree species composition were projected as static - the average value from historical data 1990-2019 was used (GL/FL - 863 ha, CL/FL - 89 ha, OL/FL - 353 ha) sm - 34%, bo - 15%, bk - 44%, db - 8%.

- Category 4.A.2 Forest land converted to other land (deforestation):

Both area and tree species composition were projected as static - the average value from historical data 1990-2019 was used (FL/GL - 25 ha, FL/CL - 2 ha, FL/S 46 ha, FL/OL - 111 ha. The average hectare stock was modelled as a dynamic variable.

- Category 4.B.1 Cropland:

[147] https://oeab.shmu.sk/app/cmsSiteBoxAttachment.php?ID=105&cmsDataID=0

The acreage of CLA/CLP (annual stands/perennial stands) and CLP/CLA (permanent stands/annual stands) transfers was projected as static and the average value from 1990-2019 historical data was used (CLA/CLP - 6 ha, CLP/CLA - 385 ha). The acreage of each sub-category of permanent grassland (orchards, gardens, vineyards and hop gardens) was projected as dynamic - determined using the exponential smoothing function of MS Excel, in the Forecast tool. The areas in the remaining categories (permanent grassland, settlements, other land) were projected as dynamic. The harvested wood products (HWP) category was projected based on the volume of timber harvest calculated for the **WEM** and **WAM** scenarios, by the FCarbon model, with the distribution of harvest volume among the different product categories based on the current, realistic distribution (realistic model).

- Category 4.A.1 Forest land remaining forest land:

The projections were made as a continuation of forest management in the so-called reference period 2014-2019. In the **WAM** scenario, the projected development of gains was modelled on the basis of a scenario with dynamically increasing forest area (1 996 754 ha in 2020 to 2 027 654 ha in 2040 and 2 050 106 ha in 2050) as a result of afforestation (i.e. afforestation of formerly mainly cropland, its transfer to category 4.A.2 Land converted to forest land, after a 20-year period, to category 4.A.1 Forest land remaining forest land). The **WAM** scenario is also characterised by a dynamically changing tree species composition. As for the losses - losses, these were modelled through harvesting. In the **WAM** scenario, actual realised harvests were modelled (6-8% lower than planned).

- Category 4.A.2 Land converted to forest land (afforestation):

Acreage and tree species composition were projected as a combination of a static approach and a dynamic approach - the acreage determined by the exponential smoothing function of MS Excel was used, in the Forecast tool (GL/FL - from 1 322 ha in 2020 to 224 ha in 2050, CL/FL - from 65 ha to 122 ha in 2050, OL/FL - 718 ha), spruce - from 46% in 2020 to 32% in 2040 to 29% in 2050, pine - from 18% in 2020 to 13% in 2040 to 14% in 2050, beech - from 33% in 2020 to 49% in 2040 to 49% in 2050, oak - from 3% in 2020 to 6% in 2040 to 7% in 2050, beech - from 33% in 2020 to 49% in 2040 to 49% in 2050.

- Category 4.A.2 Forest land converted to other land (deforestation):

Both area and tree species composition were projected as dynamic - the value determined by the MS Excel exponential smoothing function in the Forecast tool was used (FL/GL - 0 ha, FL/CL - from 2 ha in 2020 to 1 ha in 2050, FL/S - from 36 ha in 2020 to 31 ha in 2050, FL/OL - from 62 ha in 2020 to 0 ha in 2050. The average hectare stock was modelled as a dynamic variable.

- Category 4.B.1 Cropland:

The acreage of CLA/CLP (annual stands/permanent stands) and CLP/CLA (permanent stands/annual stands) transfers was projected as dynamic - using the value determined by the exponential smoothing function of MS Excel, in the Forecast tool (CLA/CLP from 27 hectares in 2020, through 48 hectares in 2040, to 59 hectares in 2050, CLP/CLA from 162 hectares in 2020, through 99 hectares in 2040, to 67 hectares in 2050). The acreage of the individual subcategories of permanent crops (orchards, gardens, vineyards and hop gardens) was projected as dynamic - determined through the exponential smoothing function of MS Excel, in the Forecast tool (dynamic projections). Acreages in the remaining categories (permanent grassland, settlements, other land) were projected as dynamic. The harvested wood products (HWP) category was projected based on the timber harvest volume calculated for the **WAM** scenario by the FCarbon, model, with the distribution of harvest volume among the different product categories based on an ideal distribution.[148]

6.6 WASTE SECTOR

In general, the more waste we produce, the more we have to get rid of. Some waste disposal methods release both pollutants and greenhouse gases into the air. Recycling is one method of reducing the impact of waste disposal on the air and the climate. However, there are also ways of managing waste that are more environmentally friendly.

The waste management sector consists of the following categories:

- *5.A Solid waste Disposal Sites*
- *5.B Biological Treatment of Solid Waste*
- *5.C Waste Incineration*
- *5.D Wastewater Treatment*

The most common disposal methods are landfill and, to a lesser extent, incineration. When waste from landfills decomposes, non-methane volatile organic compounds (NMVOCs) and methane are released into the air, and particulate emissions are released when waste is handled (PM).

Incineration is the second most common method of waste disposal in the Slovak Republic. In the past, this energy was not often used and waste was only disposed of. Modern plants now use waste as a fuel in the production of energy or heat, and waste is also recovered in this way. In this case, the emissions from incineration are classified in the energy sector. In our country, waste incineration contributes significantly to the amount of dioxins and furans (PCDDs/PCDFs) that are emitted into the air. Since dioxins are virtually unbreakable in nature and can persist for hundreds of years, they are deposited in animal tissues and thus enter the human food chain. Dietary intake, especially of meat, fish, eggs, milk and fats, is the most important route of entry of dioxins into the human body. Incineration of waste also releases high levels of heavy metal emissions into the air. Modern waste incineration plants capture these pollutants efficiently, but this was not common practice in the past. Heavy metals are deposited in the soil and subsequently in organisms, from which they are difficult to break down. Through the food chain, contamination of organisms gradually increases. Animals at the end of the food chain, and therefore humans, are particularly at risk from heavy metals. The risk is particularly higher in coastal areas, where seafood consumption is generally higher.

Recycling is not the only sustainable way to recover waste. Composting any organic waste, such as food and garden waste, is one of them. Organic waste decomposes into mulch in a matter of weeks, which can be used as fertilizer for the soil. Many households practise small-scale composting and large-scale composting systems are also being developed with the collection of organic waste from parks and urban amenities. Similar types of organic waste can also be treated in biogas plants. Unlike composting, here the waste is decomposed anaerobically (without air access) and biogas is produced which can be further burned to generate energy that can be used for heating.

This sector also includes cremations of human and animal remains, which are also a source of air pollution through emissions of heavy metals and POPs.

[148] Forsell, N.; Korosuo, A.; Federici, S.; Gusti, M.; Rincón-Cristóbal, J.J.; Rüter, S.; Sánchez-Jiménez, B.; Dore, C.; Brajterman, O.; Gardiner, J. 2018. Guidance on developing and reporting Forest Reference Levels in accordance with Regulation (EU) 2018/841

Wastewater treatment also releases pollutants and greenhouse gases (both CH_4 and N_2O). In general, emissions of POPs as well as NMVOCs, CO and NH_3 occur in wastewater treatment plants, but in most cases these are negligible amounts.

The waste sector accounted for 4.6% of total greenhouse gas emissions in 2020. Methane emissions have increased by more than 100% since 1990 due to the use of cumulative methodology in the solid waste landfilling category. A similar trend, although not as pronounced, is expected in the coming years. The volume of emissions from landfills is also strongly dependent on the implementation of landfill gas capture and utilisation.

The trend in emissions from waste management has been balanced over the entire period under review since 1990. Methane is the most important gas, accounting for more than 91% of the sector's GHG emissions, followed by N_2O with almost 9%. Most emissions come from landfilling, followed by wastewater.

6.6.1 Parameters and PAMs Used in the Waste Sector

Emissions projections are based on the assumption of demographic development of the Slovak population according to the EU Reference Scenario sent in 2022 (EU REF 2022), according to EUROPOP2019 projections (***Table 6.30***).

Table 6.30: *Projections of demographic development in Slovakia up to 2050*

Year	Source	Scenario	2020	2025	2030	2035	2040	2050
Total (median state)	EÚ REF 2022	**WEM**	5 460 136	5 467 891	5 440 730	5 384 612	5 312 439	5 147 215

Municipal solid waste (MSW) production per capita/year in kg - for the purpose of calculating the specific municipal solid waste production, the standard OECD model of annual municipal waste increment (0.69% of GDP) was used. The MSW metrics for the projections are shown in ***Table 6.31***.

Table 6.31: *Specific production of MSW in Slovakia by 2050*

Year	*Unit*	2020	2030	2040	2050
Unit production MSW	*kg/capita*	446	484	547	608

Share of landfilled municipal solid waste in total MSW production - Slovakia is gradually reducing the share of landfilled MSW in total municipal waste production by introducing waste management policies. According to the targets set by the EU Landfill Directive, a maximum of 10% of MSW produced in Slovakia should be landfilled in 2035 (***Table 6.32***).

Table 6.32: *Projections of the development of the MSW landfill fraction in Slovakia until 2050*

Year	2020	2030	2040	2050
Proportion of landfilling from MSW	48.4%	22,4%	10%	10%

MSW composition and degradable organic carbon (DOC) content of landfilled waste - on the basis of the available data on the representation of these components in MSW in Slovakia as well as the trend of increasing separate collection and thus the diversion of some components (kitchen waste, textiles), the expected DOC values for the next period were determined. The calculated DOC values are presented in ***Table 6.33***.

Table 6.33: *Projections of the development of the MSW landfill fraction in Slovakia until 2050*

Year	2020	2030	2040	2050
DOC value	0.120	0.103	0.094	0.088

When projecting methane emissions from landfilling of ISW waste in Slovakia, the key calculation parameters are defined by the following indicators:

GDP (economic development of a country as an indicator of waste production) - trend in GDP is generally considered to be a basic indicator of waste production - as GDP increases, the amount of waste increases. According to the OECD it is characteristic for developing countries (where Slovakia still belongs) that for every 1% increase in GDP, MSW production increases by 0.69%. However, COVID-19 and its associated measures have apparently brought about a change in this paradigm. GDP growth has slowed to a halt over the last two years, yet for some types of waste (sanitary, medical, packaging) there has been a significant increase in their production or a change in the way they are managed (D1>R1). One possible explanation is that some recycling plants were not functioning properly, or that the sharp increase in specific wastes was dealt with in the cheapest economic way (landfilling instead of recycling).

It is very difficult to predict how GDP in Slovakia will develop in 2022-2025-2030 in the context of the current energy crisis or the change in the structure of the economy (automotive industry), as well as the consequences of some climate measures. According to the European Commission's DG Economic and Finance (ECFIN) GDP growth for 2021-2023 was estimated at between 3.03% and 5.13%. The National Bank of Slovakia recently revised its estimate for this period to only 0.5-1.9%. The ECFIN forecast for 2030 to 2050 estimates a gradual slowdown in annual GDP growth from 1.65% to just 0.95%. It is clear from these figures that the economic boom of 2015-2019, with GDP growth of +5%, is certainly not foreseen in the near term. Thus, the recession is likely to dampen the growth of industrial waste production, although on the other hand, the shift away from landfill to recovery is likely to slow down.

On the basis of these facts, we assume that ISW production in Slovakia will be stable or only slightly increasing in the coming years. From the current approx. 10.2 million tonnes, we expect an increase to 11.0 million tonnes by 2030 and to approx. 12.5 million tonnes by 2050.

SWDS (share of landfilled ISW in total industrial waste production) - SWDS is an indicator of how much of the waste generated ends up in landfills. In Slovakia, the share of landfilled ISW has been significantly reduced from 31-46% in 2005-2015 to less than 20% today. In terms of weight, this represents a decrease in landfilled ISW from the original 2.5 to 4.3 million tonnes to around 1.8 million tonnes today:

- Exactly half (50% = 901 628 t) of the landfilled ISW is EWC 10, i.e. waste from thermal processes (slag), and this waste group also has the lowest recovery rate (up to 85% of the waste generated still ends up in landfills) and we do not foresee a significant change in the total production or the proportion of landfilling for the time being. However, this group has a DOC < 0 and is therefore neutral in terms of the methane balance.

- one third of the landfilled ISW (33% = 620 000 t) is EWC 17, i.e. construction waste. This represents 13% of the total volume of construction waste generated, so the potential to reduce the landfilled amount to at least 10% (and optimally less than 5%) is still relatively significant. Achieving these levels of recovery of construction waste would reduce landfill by around 200-450 000 t/y.
- Less than 10% (167 320 t) is waste from EWC 19, i.e. waste from waste treatment, and only this group is expected to show a significant increase in total production in the near future. With the ban on landfilling of untreated mixed municipal waste from 1.1.2023 (which constitutes the majority of landfilled municipal waste = MSW), a gradual shift of this waste away from landfilling to mechanical-biological treatment plants (MBTs) can be expected over time. According to the availability of new MBU capacities, about 1.0 million tonnes of mixed municipal waste will thus end up in these facilities over time. In Germany, in 2010 (5 years after the MSW landfilling ban), 61 MBU facilities were in operation, treating 4.47 million t of residual waste per year, with 22% eventually ending up in landfills as the remainder of the process. In Poland, for 20 MBT plants, an average residue of up to 46% is reported to be destined for landfill. Depending on the technological level of individual plants in Slovakia, we can therefore expect about 25-45% of waste of category 19 EWC at the outlet. If no energy recovery or (co)incineration facilities are built in Slovakia, this output waste from MBTs will end up only in landfills. This will lead to a significant increase in landfilling of waste from Sc. 19 EWC from the current approx. 170 000 t by a further 250 to 450 000 t per year (∑420-620 000 t) in the 2025-2030 timeframe.
- The other three groups of industrial waste: en. 02 + 03 +15 EWC each contribute only about ±1.0% to the total amount of ISW landfilled, which is only about 10-30 000 t/year by weight. Given that for each of these groups the share of landfilled waste is less than 10% of the total production in the group (even only 1.2% for 02 EWC), we are probably approaching the technological limit of recovery for these wastes. More significant reductions in landfilling are likely to come only at the cost of greater financial investment, which is likely to be difficult to enforce and implement in the coming recession.

These six groups of industrial waste (10 + 17 + 19 +02 +03 + 15 EWC) together account for up to 96.5% of the total amount of landfilled ISW in Slovakia. Therefore, the other 13 groups of ISW, which have only a minimal contribution to landfilling (and methane production), are not further included in the preparation of the emission projections. In summary, the amount of landfilled industrial waste (ISW->SWDS) is steadily decreasing. In Slovakia, landfilling is "decoupling", i.e. despite relatively high economic growth in recent years, the production of ISW has increased only slightly and the share of landfilling of these wastes has declined significantly. However, due to the dominant share of landfilling of ISW in the 10 EWCs, a significant decrease in landfilling of ISW is not expected. Unless a suitable recovery method for waste from 10 EWCs (waste from thermal processes) is found, the share of landfilling of ISW in the total industrial waste production in that year is also expected to be around 15% by 2050 (approx. 1.5-1.8 million t/y). However, these wastes are neutral in terms of the methane emission balance and the EWC groups 17 and 19 are particularly important. Landfilling of EWC 17 is expected to decrease in the coming years (due to new policies and the increase in the landfill tax for construction waste). Conversely, landfilling of sc. 19 EWC is expected to increase (as an output from new MBT facilities).

SWDS + DOC>0 (share of landfilled industrial waste containing biodegradable carbon) - SWDS + DOC > 0 represents only that part of landfilled industrial wastes which, due to their organic degradable carbon content, contribute directly to methane emissions from landfilling. In Slovakia, these types of MSW represent only a relatively small proportion of the total amount of MSW produced. The maximum of 3.6% was in 2009, the share has fallen below 3% since 2012 and below 2% since 2014. It has remained just above 1% since 2017. In absolute terms, this represents a decrease from the original approx. 290 000 t/y to the current approx. 100-120 000 t/y. In terms of the weight of the different components according to the IPCC classification, mixed construction waste (50-60%) and mixed packaging (25-33%) have the largest share, followed by paper and sludge, and food, textiles and wood have the smallest share.

The different components of industrial waste (wood, paper, textiles, sludge, etc.) each contribute their individual share to the total methane emissions based on their content of organically degradable carbon (DOC) and decomposition rate constant (k). Therefore, the contribution of methane emissions from each component is different and the amount of landfilled waste in tonnes may not then correspond to the amount of emissions produced. The components wood, textiles and food do not represent a major source of emissions due to their share of landfilling (about 1-2%) and their contribution to the 2025-2050 emissions balance will remain minor.

Sludge production has fluctuated in previous years, but here again a long-term slight decline is expected rather than a significant increase in landfilling. The Mix_Pack component could decrease slightly due to beverage container backup, although it is not known what proportion of mixed plastics these containers account for. However, the first results of the backup have not yet confirmed this assumption and the volume of plastics recycled is not yet decreasing. By 2050, we foresee a decrease in landfilling of this component by approx. 1/3 from the current 35 000 t/y to approx. 20 000 t/y, due to the intensification of separate collection as well as to the re-sorting of separated plastics. Similarly, for mixed construction waste, we foresee a decrease of up to 1/2 (from 70 000 t/y to 30 000 t/y) due to the increase in landfill charges. Only for the paper component (which also includes waste from EWC 19 12 12) do we foresee a significant increase in landfill from less than 10 000 t today to up to 60 000 t/year by 2050. The total amount of landfilled ISW with DOC > 0 stabilises at around 110 to 120 000 t/y for the years 2025 to 2050.

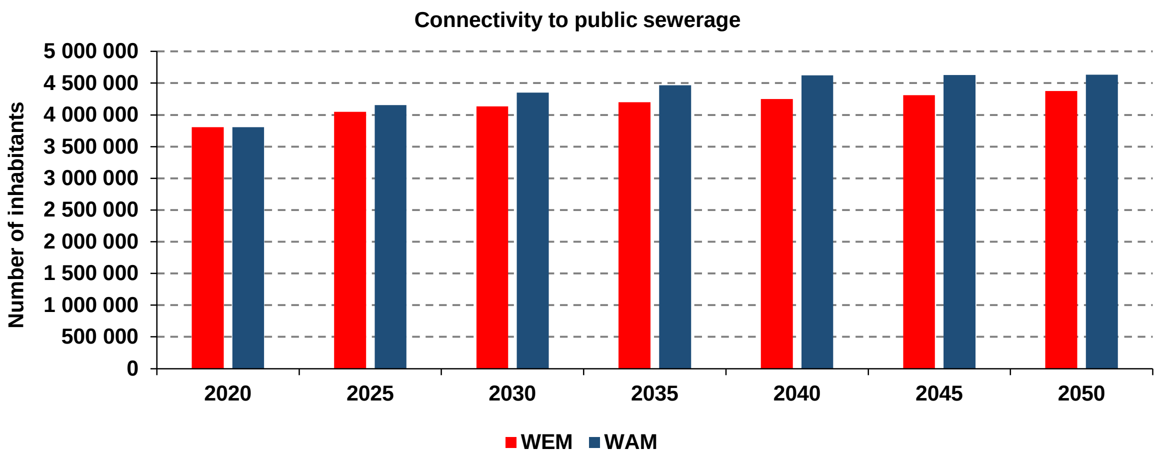
A very important input parameter for the correct estimation of GHG emissions projections from wastewater is the proportion of households connected to public sewerage and wastewater treatment plants (***Table 6.34***). These estimates under the two scenarios are shown in ***Figure 6.55***.

Table 6.34: *Projections of demographic development in Slovakia until 2050*

Year	Demography	Connected to public sewerage*	Connected to public sewerage and WWTP	Public sewerage (not connected to the WWTP)	Cesspools	Domestic WWTP	Latrines
Source	***EU REF 2022***	***Water Research Institute/Blue Report, expert estimates***					
WEM Real version							
2020	5 460 136.00	3 805 330.00	3 782 220.00	23 110.00	1 538 834.20	109 937.87	6 033.93
2025	5 467 891.00	4 046 239.34	4 018 899.89	27 339.46	1 298 624.11	117 559.66	5 467.89
2030	5 440 730.00	4 134 954.80	4 118 632.61	16 322.19	1 164 316.22	136 018.25	5 440.73
2035	5 384 612.00	4 199 997.36	4 186 535.83	13 461.53	1 032 230.12	148 076.83	4 307.69
2040	5 312 439.00	4 249 951.20	4 236 670.10	13 281.10	899 395.92	159 373.17	3 718.71
2050	5 147 215.00	4 375 132.75	4 362 264.71	12 868.04	589 356.12	180 152.53	2 573.61

Year	Demography	Connected to public sewerage*	Connected to public sewerage and WWTP	Public sewerage (not connected to the WWTP)	Cesspools	Domestic WWTP	Latrines
WAM Optimistic version							
2020	5 460 136.00	3 805 330.00	3 782 220.00	23 110.00	1 538 834.20	109 937.87	6 033.93
2025	5 467 891.00	4 155 597.16	4 133 725.60	21 871.56	1 183 798.40	123 027.55	5 467.89
2030	5 440 730.00	4 352 584.00	4 336 261.81	16 322.19	933 085.20	149 620.08	5 440.73
2035	5 384 612.00	4 469 227.96	4 455 766.43	13 461.53	751 153.37	161 538.36	2 692.31
2040	5 312 439.00	4 621 821.93	4 611 197.05	10 624.88	502 556.73	185 935.37	2 124.98
2050	5 147 215.00	4 632 493.50	4 622 199.07	10 294.43	255 816.59	257 360.75	1 544.16

Figure 6.55: *Trend of the number of connections to public sewerage in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*



Current policies of the MŽP SR (collection of biodegradable waste, advance packaging system, collection of kitchen waste, collection of textiles):

- Each of these policies will have an impact on some of the parameters affecting the calculation of emissions from landfilling in Slovakia. Separate collection of kitchen waste will reduce the share of the "FOOD" component in mixed municipal waste. A decrease of -40% is foreseen in the projections. Similarly, separate collection of textiles could reduce the share of this component in landfilled MSW by 50%. Continued separate collection will result in a decrease in the paper and garden waste components of around 20%. The deposit system for returnable packaging may also result in a reduction in the production of mixed packaging, which accounts for a significant proportion of landfilled waste. This could lead to a reduction in DOC of around 30% by 2050, which also represents an adequate reduction in landfilled bio-degradable carbon and ultimately a reduction in methane emissions from landfills.

Two scenarios have been prepared to model the emission projections for categories 5.A - Landfills and 5.D - Wastewater:

WEM – scenario with existing measures (realistic)

WAM – scenario with additional measures (optimistic)

For the modelling of emission projections from categories 5.B - Composting of non-biogenic waste and 5.C - Incineration of waste without energy recovery, only one scenario was prepared, namely **WEM** = **WAM**, due to the lack of relevant PAMs.

WEM scenario - the business-as-usual (realistic) scenario, or also called BAU = Business as Usual, is based on the expectation that developments in solid waste landfill management will continue as observed in other EU countries undergoing economic transition. GDP growth will be accompanied by growth in waste production, but this will gradually slow down. Conversely, in line with the "Environmental Kuznets Curve" (EKC) theory, the environmental behaviour of the population and firms will increase, leading to more sophisticated waste management practices - less landfilling, more recovery and, ultimately, waste prevention.

Municipal waste production (5.A.1) - the **WEM** scenario presents a projections of methane emissions from MSW with the continuation of current trends and policies in waste management in Slovakia without taking into account more significant externalities or radical economic collapses. The **WEM** scenario assumes that the landfilling target of a maximum of 10% of MSW is achieved in 2035 with a gradual diversion of about 1.0 million tonnes of MSW to new MBT facilities.

Table 6.35: *Trend and projections of parameters and methane emissions from MSW in **WEM** scenario up to 2050*

Year	*Unit*	2020	2030	2040	2050
MSW	*tonnes*	2 434 040	2 631 137	2 906 547	3 127 042
MSW->MBT	*tonnes*	0	330 000	660 000	1 000 000
MSW-> SWDS	*tonnes*	1 177 944	590 246	290 655	300 000
CH_4 Emissions	*Gg*	39.572	30.884	18.522	13.257

Production of industrial waste (5.A.2) - the **WEM** scenario represents a projections with a continuation of the current trends given by the policies and measures in the waste management in Slovakia without taking into account more significant externalities or radical economic collapses. The amount of landfilled industrial waste containing biodegradable carbon stabilises at around 115 000 t/year. Methane emissions from landfilling of industrial waste are shown in ***Table 6.36*** below.

Table 6.36: *Trend and projections of methane parameters and emissions from ISW in **WEM** scenario up to 2050*

Year	*Unit*	2020	2030	2040	2050
ISW -> SWDS	*tonnes*	129 265	115 862	115 722	119 547
CH_4 emissions	*Gg*	5.285	5.029	5.100	5.236

Municipal waste production (5.A.1) - the **WAM** scenario presents a projections of the future development of methane emissions from landfilling in Slovakia with the introduction and application of new policies in waste management without taking into account more significant external influences (economic crisis, impact of pandemics, etc.). This scenario assumes a significant decrease in the amount of landfilled municipal waste, i.e. diversion of mixed MSW, to new MBTs (gradually 330 000 t to 1.0 million t in 2050). In terms of the EC targets for waste management by 2035 (D1<10% MSW and R>60% MSW) and maintaining the current level of energy recovery of MSW (approx. 195 000 t/y), there is still approx. 850 000 t of MSW for which additional facilities or technological procedures are needed to divert MSW from landfilling and reduce emissions. Other policies and measures that, based on knowledge from abroad, can lead to significant changes in the parameters affecting the calculation of landfill emissions include:

- Construction and operation of new WtE (waste-to-energy plants = WEEE). All original EU countries ("old EU15") that have achieved a reduction of landfill emissions of about 60-80% in the past show a minimum share of MSW energy recovery above 40% (Slovakia shows only about 8% i.e. about 200 000 t/y).
- Increased use of LFG for energy production or combustion or oxidation of methane on biofilters. Slovakia is at the very bottom of the ranking according to the European National Greenhouse Gas Inventory Report 2022 (5%[149]) in the share of LFG use for energy production or "recovery methane" (EU28 average = 39%). Despite the relatively high similarity of landfilling in the V4 countries (landfill capacity, collection area, MSW composition), Slovakia shows only about one third (CR) to one half (PL) of the recovered methane per tonne of landfilled MSW. Alternatively, additional policies for LFG for electricity generation, flaring or oxidation on biofilters, (or active landfill aeration under the "2019 Refinement IPCC GL") have the potential to significantly increase this amount and thus further reduce final methane emissions.

Table 6.37: *Trend and projections of parameters and methane emissions from MSW in **WAM** scenario up to 2050*

Year	Unit	2020	2030	2040	2050
MSW	*tonnes*	2 434 040	2 631 137	2 906 547	3 127 042
CH_4 Emissions	*Gg*	39.572	30.884 – 10.0 = 21.0	18.522 – 8.0 = 11.0	13.257 – 5.0 = 8.0

Production of industrial waste (5.A.2) - the **WAM** scenario presents projections of the future development of methane emissions from landfilling of industrial waste in Slovakia under the introduction and application of new policies in waste management. Taking into account the development and experience with other EU countries, we foresee a significant strengthening of energy recovery of waste (R01) combined also with incineration (D10) for those industrial wastes that are incinerable (or calorific value exceeds 6 MJ/kg).

Table 6.38: *Trend and projections of methane parameters and emissions from ISW in **WAM** scenario up to 2050*

Year	*Unit*	2020	2030	2040	2050
Σ ISW	*tonnes*	129 265	115 862	115 722	119 547
Σ ISW > 6 MJ/kg	*tonnes*	55 508	66 131	75 298	86 675
ISW -> R01+D10	*%*	0%	20%	50%	75%
ISW -> SWDS	*tonnes*	129 265	102 636	78 073	54 540
CH_4 Emissions	*Gg*	5.285	4.454	3.388	2.367

Wastewater treatment (5.D) - the business-as-usual (realistic) scenario, or also called BAU=Business as Usual, is based on the expectation that wastewater management developments will continue as observed over the last decade. According to these assumptions, the development of the wastewater sector is characterized by an increase in the share of the population covered by sewerage systems, with the aim of reaching 85% coverage in 2050. This scenario corresponds with the information from the Envirostrategy 2030[150], as well as with the recently adopted document "Concept of water policy of the Slovak Republic until 2030 with a view to 2050"[151]. This development can be characterised by the

[149] European Union National Inventory Report EU27+UK, page 789, Figure 7.9

[150] https://www.minzp.sk/files/iep/03_vlastny_material_envirostrategia2030_def.pdf

[151] https://www.minzp.sk/files/sekcia-vod/koncepcia-vodnej-politiky/koncepcia-vodnej-politiky.pdf

continuous development of sewerage systems and the modernisation of wastewater treatment plants to meet the requirements of the EU water sector strategies.

The scenario assumes that the number of inhabitants using storage tanks (cesspools) will decrease (from the current 30% to 11.45% in 2050) due to the expansion of the sewerage network from the current 70% to 85% and also by increasing the number of domestic wastewater treatment plants from the current 2% to 3.5%.

WAM scenario is based on the expectation that developments in the waste management sector will continue with increased financial support from the Slovak government as well as EU support under the Recovery Plan for Europe. At the same time, some new knowledge and trends from other EU countries, which have led to a shift away from landfilling as well as a reduction in emissions from landfills, will be implemented in the Slovak waste management sector.

The scenario with additional measures (optimistic) is based on the expectation that developments in the wastewater sector will continue with increased financial support from the Slovak government as well as EU support under the Recovery Plan for Europe. This development is characterised by an accelerated increase in the share of the population connected to sewerage systems, with a target of 90% connection in 2050. This scenario corresponds to the aspiration to achieve a level of sewerage connection as high as in the developed Western European countries (at least 90% connection to sewers and wastewater treatment plants).

The scenario assumes that the number of inhabitants using septic tanks will decrease (from 30% today to 5% in 2050) as a result of the intensive expansion of sewerage from 70% today to 90% and the construction of decentralised domestic wastewater treatment plants from 2% today to 5%. This strategy corresponds to the strict requirement of the European Commission, as stated in procedure No 2016/2191, for non-compliance with certain articles of Council Regulation 91/271/EEC of 21 May 1991 concerning urban waste water treatment. These measures are expected to contribute to a reduction of methane emissions in the municipal sector by almost 86% and in the industrial sector by 69% in 2050 compared to 2005.

6.6.2 Projections of Emissions in Category 5.A - SWDS

Landfilling is a significant source of methane emissions, which are released as landfill gas. As very few landfills in Slovakia have sophisticated landfill gas capture and recovery systems, landfill gas is released directly into the atmosphere. Methane also escapes from closed landfills, from layers of waste stored for up to about 30 years, so it is very important to prevent landfilling. Methane from category 5.A - SWDS has an increasing trend year on year due to the cumulative approach to its calculation.

Total greenhouse gas emissions from landfills in the **WEM** scenario reach a reduction of 1.5% in 2030 compared to 2005 and 49.3% in 2050 compared to 2005 (***Table 6.39***).

Table 6.39: *Trend and projections of methane emissions from category 5.A - SWDS in* ***WEM*** *scenario up to 2050*

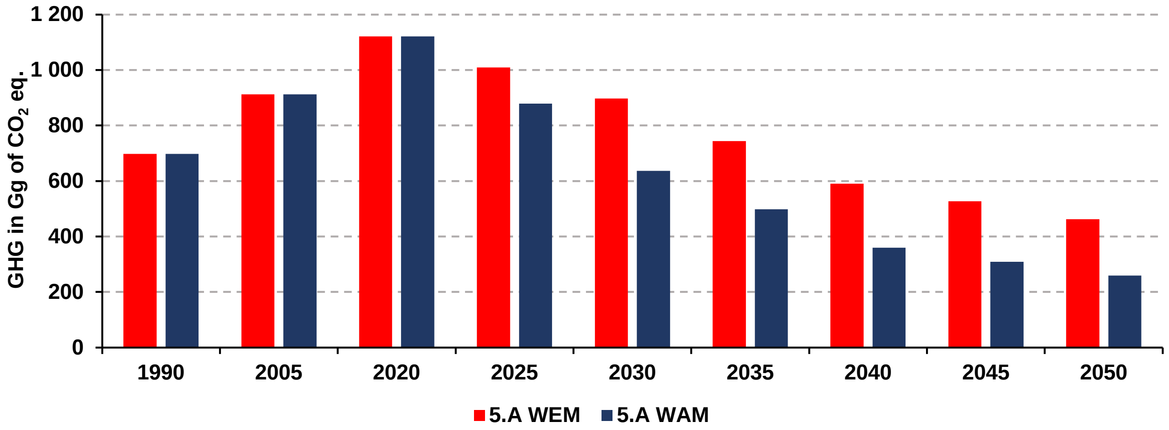
WEM Scenario	UNIT	2005	2020	2030	2040	2050
Emissions from MSW	*Gg*	29.690	39.572	30.884	18.522	13.257
Emissions from ISW	*Gg*	6.780	5.285	5.029	5.100	5.236
Emissions ΣCH_4	*Gg*	36.470	44.857	35.913	23.622	18.493
Change compared to 2005	*%*	-	+23%	-1.5%	-35.2%	-49.3%

Total greenhouse gas emissions from landfills in the **WAM** scenario reach a reduction of 30% in 2030 compared to 2005 and 72% in 2050 compared to 2005 (***Table 6.40***).

Table 6.40: *Trend and projections of methane emissions from category 5.A - SWDS in* ***WAM*** *scenario up to 2050*

WAM Scenario	*Unit*	2005	2020	2030	2040	2050
Emissions from MSW	*Gg*	29.690	39.572	21.000	11.000	8.000
Emissions from ISW	*Gg*	6.780	5.285	4.454	3.388	2.367
Emissions ΣCH_4	*Gg*	36.470	44.857	25.454	14.388	10.367
Change compared to 2005	*%*	-	+23%	-30%	-60%	-72%

Figure 6.56: *Trend and projections of GHG emissions in 5.A - SWDS in* ***WEM*** *and* ***WAM*** *scenarios up to 2050*



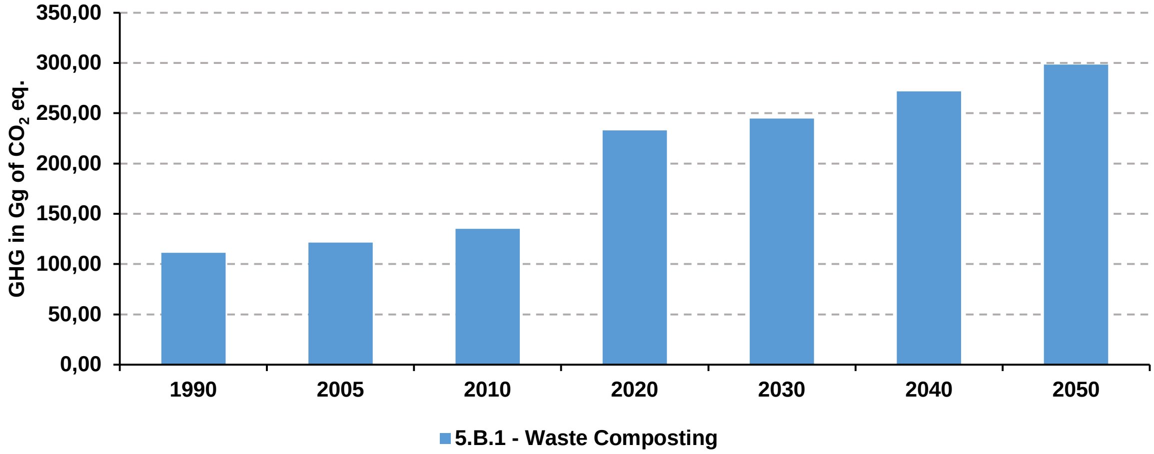
6.6.3 Emission Projections in Category 5.B - Composting

Total GHG emissions in the **WEM=WAM** scenario reach an increase of 50.43% in 2030 compared to 2005 and an increase of 59.35% in 2050 compared to 2005 (***Table 6.41***, ***Figure 6.57***). Compared to the 1990 base year, they will increase by 54.52% in 2030 and 62.70% in 2050.

Table 6.41: *Trend and projections of GHG emissions in 5.B - Waste Composting in* ***WEM=WAM*** *scenario up to 2050*

5.B – Waste Composting									
5.B.1	1990	2005	2020	2025	2030	2035	2040	2045	2050
	Gg CO_2 equivalents								
	111.3284	121.3230	232.8800	231.3374	244.7611	258.1847	271.6084	285.0320	298.4557
compared to 2005					+50.43%				+59.35%
compared to 1990					+54.52%				+62.70%

Figure 6.57: *Trend and projections of GHG emissions in 5.B - Waste Composting in* ***WEM=WAM*** *scenario up to 2050*



6.6.4 Emission Projections in Category 5.C - Incineration of Non-biogenic Waste

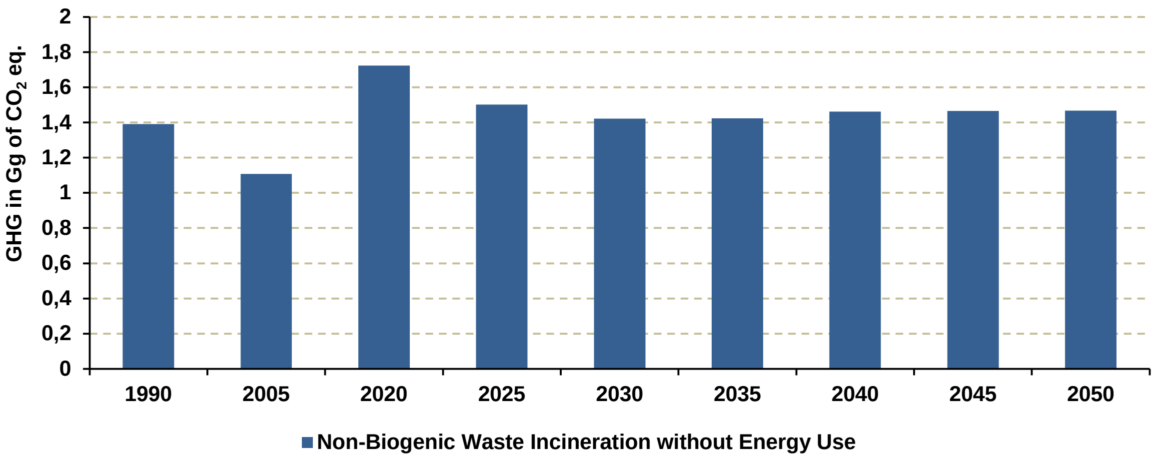
The **WEM=WAM** scenario will increase non-biogenic GHG emissions from waste incineration without energy recovery, with an expected increase of 22.14% in 2050 and 24.47% in 2050 after 2030 compared to 2005. However, similar to the composting category, the benefit to the entire waste management sector exceeds the increase in emissions in this category (***Table 6.42***, ***Figure 6.58***).

Total GHG emissions in the **WEM=WAM** scenario increase by 2.17% in 2030 compared to 1990 and by 5.10% in 2050.

Table 6.42: *Trend and projections of GHG emissions in 5.C – Incineration of Non-biogenic Waste without energy recovery in* ***WEM=WAM*** *scenario up to 2050*

5.C - Incineration of waste without energy recovery non-biogenic emissions									
5.C.1	**1990**	**2005**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	Gg CO_2 equivalents								
	1.3918	1.1078	1.7234	1.5025	1.4227	1.4238	1.4621	1.4659	1.4667
compared to 2005					22.14%				24.47%
compared to 1990					2.17%				5.10%

Figure 6.58: *Trend and projections of GHG emissions in 5.C – Incineration of Non-biogenic Waste without energy recovery in* ***WEM=WAM*** *scenario up to 2050*



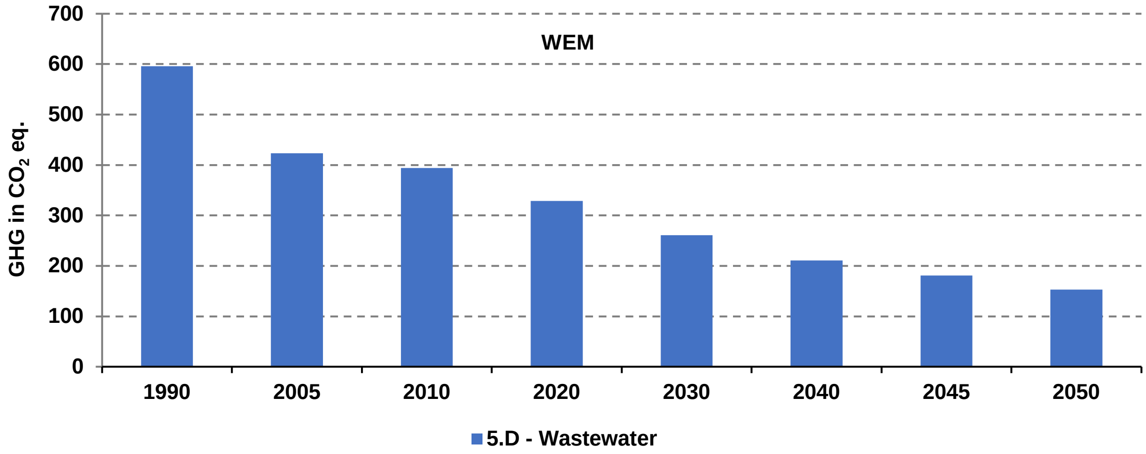
6.6.5 Projections of Emissions in Category 5.D - Wastewater

The **WEM** scenario reduces methane emissions from municipal wastewater (CRF category 5.D.1) by 40.5% in 2030 compared to 2005 and by about 69% in 2050 compared to 2005. Methane emissions from industrial wastewater (CRF category 5.D.2)) are currently significantly lower than methane emissions from municipal wastewater, yet we expect further reductions in methane emissions in 2030 of around 63% compared to 2005 and in 2050 of around 68% compared to 2005, mainly due to wastewater recycling and reduced production of organic pollution in industrial production. N_2O emissions from both the domestic and industrial wastewater sectors are relatively low, but here too we expect emissions to decrease by 22% in 2030 and by around 32% in 2050 compared to 2005.

Table 6.43: *Trend and projections of GHG emissions in 5.D - Wastewater in **WEM** scenario up to 2050*

5.D - Wastewater Treatment									
5.D	**1990**	**2005**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	Gg CO_2 equivalents								
	595.6145	423.3195	328.6576	294.6640	260.6704	235.6164	210.5624	181.7903	153.0183
compared to 2005					-38.42%				-63.85%
compared to 1990					-56.24%				-74.31%

Figure 6.59: *Trend and projections of GHG emissions from 5.D - Wastewater in **WEM** scenario up to 2050*



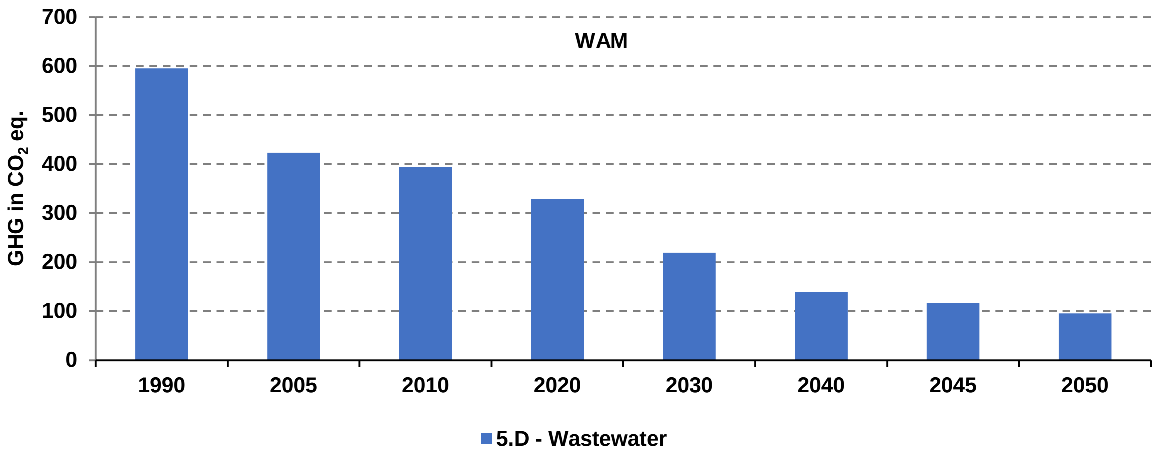
The **WAM** scenario will reduce GHG emissions from wastewater, and after 2020 we expect emissions to decrease by -48.20% in 2030 and by -77.37% in 2050 compared to 2005. Similar to the landfill category, the benefit for the entire waste management sector is the second highest as it is a significant source of emissions (***Table 6.44***, ***Figure 6.60***). Total GHG emissions in the **WAM** scenario achieve a 63.18% reduction in 2030 compared to 1990 and an 83.91% reduction in 2050.

This scenario (**WAM)** will reduce methane emissions from municipal wastewater (CRF category 5.D.1) by 52% in 2030 compared to 2005 and by about 86% in 2050 compared to 2005. Methane emissions from industrial wastewater (CRF category 5.D.2)) are currently significantly lower than methane emissions from municipal wastewater, yet we expect further reductions in methane emissions in 2030 of around 64% compared to 2005 and in 2050 of around 69% compared to 2005. N_2O emissions from both the municipal and industrial wastewater sectors are relatively low, but we also expect reductions of around 24% in 2030 and around 36% in 2050 compared to 2005.

Table 6.44: *Trend and projections of GHG emissions from 5.D - Wastewater in **WAM** scenario up to 2050*

5.D - Wastewater Treatment									
5.D	**1990**	**2005**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	Gg CO_2 equivalents								
	595.6145	423.3195	328.6576	265.7799	219.2838	185.4475	138.8982	117.0443	95.8083
compared to 2005					-48.20%				-77.37%
compared to 1990					-63.18%				-83.91%

Figure 6.60: *Trend and projections of GHG emissions in 5.D - Wastewater in **WAM** scenario up to 2050*



6.6.6 Emission Projections in Waste Sector

The Waste sector accounted for 4% of total greenhouse gas emissions in 2020. Methane emissions have increased by more than 100% since 1990 due to the use of cumulative methodology in the solid waste landfilling category. A similar trend, although not as pronounced, is expected in the coming years. The volume of emissions from landfills is also strongly dependent on the implementation of landfill gas capture and utilisation. According to the prepared **WEM** and **WAM** scenarios for each category, it can be concluded that after recalculating all four main waste treatment categories, there will be a 24.41% reduction in GHG emissions by 2030 compared to 2005 and a 21.65% reduction compared to 1990. The reductions by 2050 will be even more significant, with a 53.43% reduction in emissions from the waste sector compared to 1990 (***Table 6.45, Figures 6.61*** and ***6.62***).

Table 6.45: *Trend and projections of GHG emissions in 5 - Waste sector in **WEM** and **WAM** scenarios up to 2050*

Sector 5 - Waste									
WEM	**1990**	**2005**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	Gg CO_2 equivalents								
	1 406.3538	1 457.544	1 684.650	1 377.503	1 404.6791	1 239.4124	1 074.1829	994.7258	915.2657
compared to 2005					-3.62%				-37.20%
compared to 1990					-0.12%				-34.92%

Sector 5 - Waste									
WAM	**1990**	**2005**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
	Gg CO_2 equivalents								
	1 406.3538	1 457.544	1 684.650	1 377.503	1 101.818	943.081	771.669	712.980	654.906
compared to 2005					-24.41%				-55.07%
compared to 1990					-21.65%				-53.43%

Figure 6.61: *Trend and projections of GHG emissions in 5 - Waste sector by categories in **WEM** scenario up to 2050*

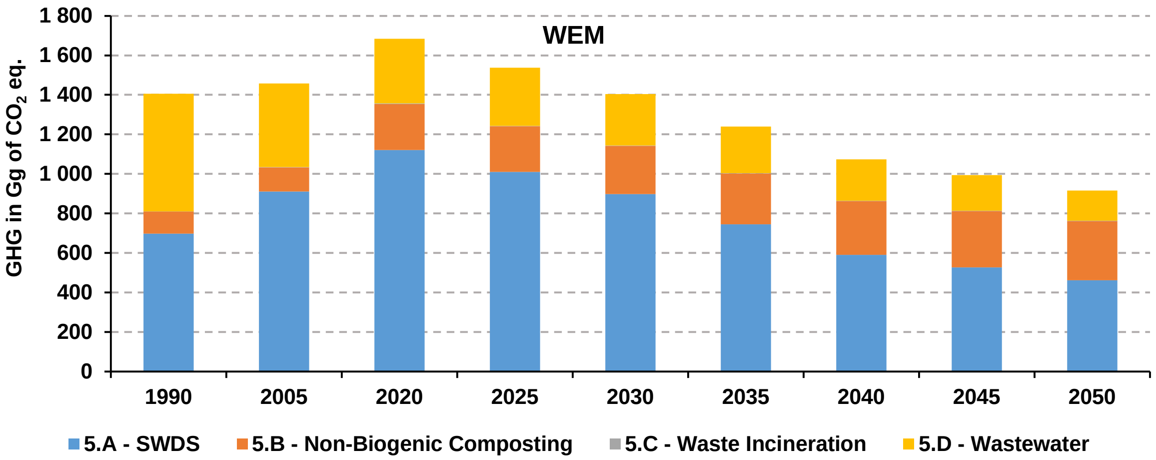
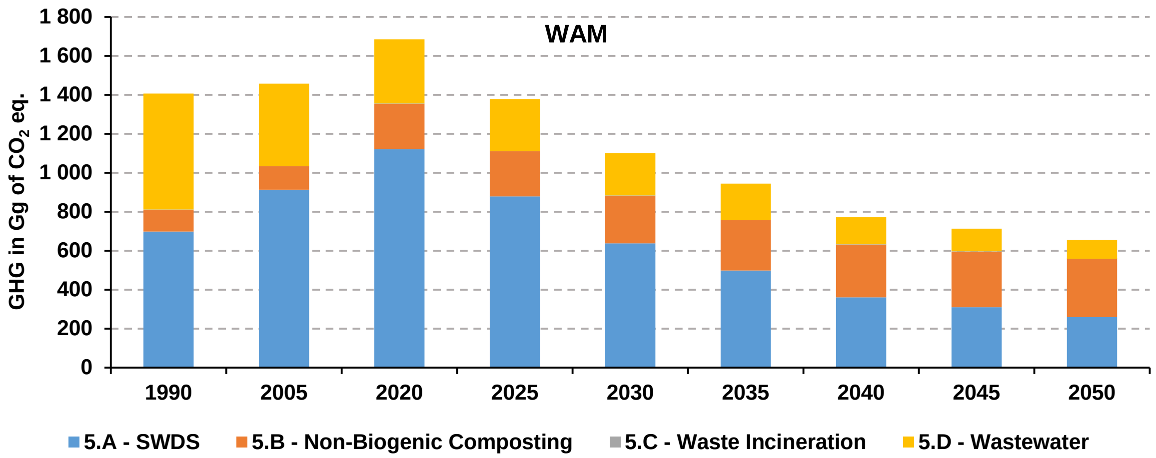


Figure 6.62: *Trend and projections of GHG emissions in 5 - Waste sector by categories in **WAM** scenario up to 2050*



6.6.7 Methodology and Model Used

Emission inventory	SVK_CRF_13-04-2022 (1990 – 2020)
Baseline year for projections	2020
Baseline year for policies and actions	2020
Emissions projections for the period	2021 – 2050
Reduction targets	2030 and 2050
Expression of the reduction compared to the years	1990 (base year for greenhouse gas emissions)
	2005 (the base year for emissions in the Regulation ESR[27])

The emission projections have been prepared in accordance with the IPCC 2006 Guidelines, the methodology is consistent with the methodology for estimating emissions under Article 26(3) of Regulation (EU) 2018/1999. The calculation analysis tool is based on MS Excel platform and the calculation includes different policies and measures (in numerical formulation) defined in **WEM** and **WAM** scenarios. The calculations of the emission projections of the individual gases have been carried out according to „2006 IPCC Guidelines for National Greenhouse Gas Inventories – Chapter 3 Solid Waste Disposal“.

There are a number of specially developed mathematical models for the preparation of emission projections, but due to the need for complex input data including economic and energy indicators, it is not currently possible to use them for the purpose of reporting national projections. The small Slovak economy would need its own model developed exactly for our conditions, or at least a refinement of the specific national parameters that enter into the calculations (ideally up to tier 3 level). Currently, we are still working partly at tier 1 level (default IPCC parameters 10-15 years old) and partly at tier 2 level (national data on waste production and management), as we lack the necessary statistical data specific to Slovakia.

Improvements in the quality and timeliness of input data as well as other improvements in the preparation of waste sector emission projections should allow the whole calculation process to be automated, which should reduce calculation time and create room for more scenarios to be created and sensitivity analysis to be carried out.

From the previous description of the key parameters for calculating methane emissions from landfilling, it is clear that two of them are of objective nature - the trend of the population over the period under consideration as well as the total waste production. These parameters are influenced by social and economic factors that we cannot yet regulate or direct to any great extent. Their future values for the period under review are therefore rather difficult to predict and burdened with a relatively high degree of uncertainty. The other three parameters (landfill fraction, waste composition, methane capture and use) are more or less subjective in nature and are influenced by external interventions and government policies. Some of these parameters may (or may not) also act synergistically and increase their impact on total methane emissions from landfilling. For example, the construction and operation of additional waste-to-energy facilities ("incinerators" = WtE) will in any case contribute to a decrease in the amount of landfilled waste, as we can see for example in the data from Bratislava Self-Governing Region and Košice Self-Governing Region. Increased separate collection of waste components will lead to a decrease of DOC in landfilled waste. The construction and operation of new MBT facilities will combine both of these parameters. However, it should be noted that the residue from MBT facilities (ending up in landfills) has a higher DOC > 0 than the residue from WtE (DOC < 0). The resulting impact of the measures on these parameters will depend on the capacity of the new facilities and their efficiency of operation. However, a time horizon of at least 5-10 years needs to be considered for these policies to be reflected in the output. The last parameter, 'Recovery methane', is probably also a very important and under-appreciated component. Based on evidence from European countries where landfill diversion has already taken place, it is evident that landfill gas production and thus the amount of recoverable methane from landfills will consequently decrease. On the other hand, according to the EEA report of May 2021, Slovakia is one of the EU27 countries with the lowest landfill gas use (only 5%), while the EU average is about 39%. Due to the lack of data, it is not possible to quantify more accurately what the total potential of recoverable methane from landfills is and what the current efficiency of its capture and treatment is.

When describing the preparation of the emission projections, it should be noted that emissions from landfilling are according to the IPCC 2006 Guidelines, calculated according to the components of landfilled waste (food, wood, paper, textiles, sludge) and not according to the type of landfill as defined in the Landfill Directive (2018/850 or 1999/31/EC). Due to the different development and production of municipal and industrial waste in Slovakia, as well as the requirement in previous revisions of the national inventory, emission projections were calculated separately with industrial waste = ISW (EWC items 01 to 19) and separately with municipal waste = MSW (EWC item 20). The resulting emission projections from the landfill waste category (5.A) are then the sum of the two sub-categories.

Further improvements to the preparation of waste sector emission projections should allow the whole calculation process to be automated, reducing calculation time and making room for more scenarios to be created and sensitivity analysis to be carried out.

6.7 AGGREGATED GHG EMISSIONS

This chapter describes in figures and tables the projections of total aggregate GHG emissions for all monitored sectors of the Slovak economy.

Figure 6.63: *Trend and projections of GHG emissions excluding LULUCF in **WEM** and **WAM** scenarios up to 2050*

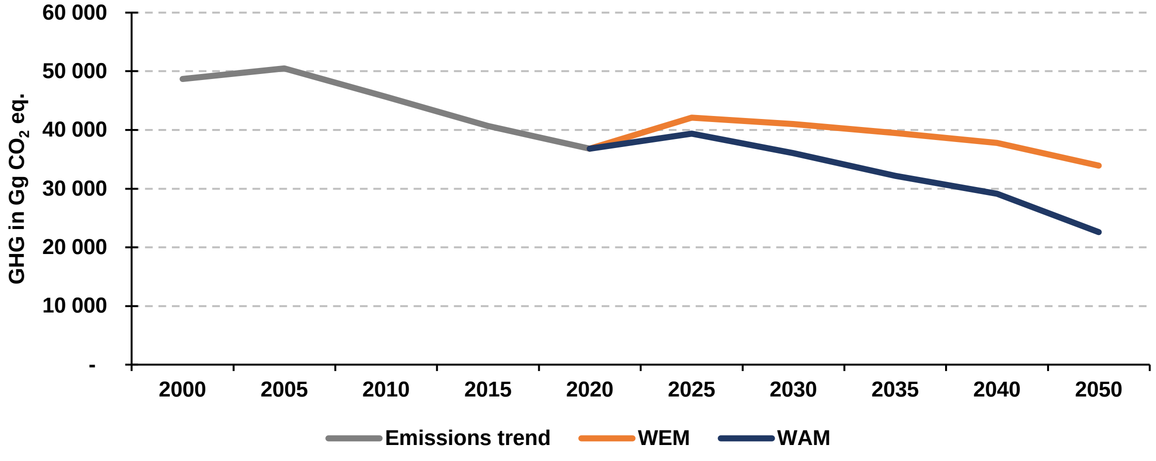


Figure 6.64: *Trend and projections of GHG emissions including LULUCF in **WEM** and **WAM** scenarios up to 2050*

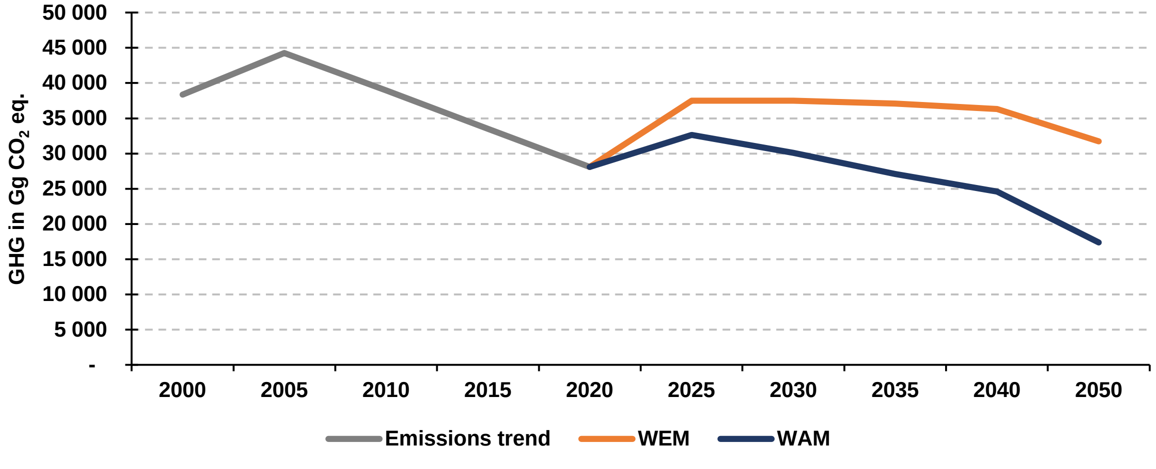


Table 6.46: Trend and projections of total aggregated GHG emissions (Gg CO_2 equivalents)

WEM	2020	2025	2030	2035	2040	2050
Total GHG emission projection without LULUCF	37 003	42 382	41 290	39 727	38 068	34 208
Total GHG emission projection with LULUCF	29 409	37 828	37 833	37 416	36 645	32 090
WAM	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Total GHG emission projection without LULUCF	37 003	39 664	36 327	32 437	29 395	22 872
Total GHG emission projection with LULUCF	29 409	32 980	30 422	27 416	24 928	17 703

Figure 6.65 and ***Table 6.47*** show a comparison across sectors in the GHG emission projections in **WEM** scenario (full line) and **WAM** scenario (dash line).

Figure 6.65: *Trend and projections of total aggregated GHG emissions by sectors in **WEM** and **WAM** scenarios up to 2050*

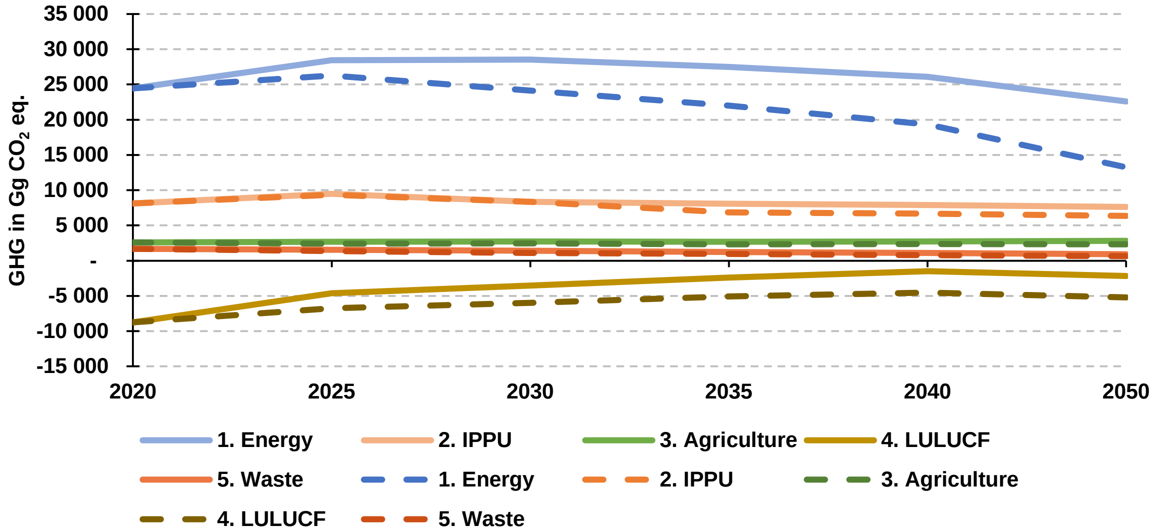


Table 6.47: Trend and projections of total aggregated GHG emissions by sectors (Gg CO_2 equivalents)

WEM	2020	2025	2030	2035	2040	2050
1. Energy	24 609	28 704	28 803	27 739	26 363	22 870
2. Industrial Processes	8 130	9 476	8 341	8 087	7 904	7 612
3. Agriculture	2 580	2 665	2 741	2 661	2 727	2 810
4. LULUCF	-7 593	-4 554	-3 457	-2 311	-1 423	-2 117
5. Waste	1 685	1 537	1 405	1 239	1 074	915
Total without LULUCF	37 003	42 382	41 290	39 727	38 068	34 208
Total with LULUCF	29 409	37 828	37 833	37 416	36 645	32 090
WAM	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
1. Energy	24 609	26 532	24 429	22 283	19 577	13 538
2. Industrial Processes	8 130	9 347	8 342	6 875	6 677	6 369
3. Agriculture	2 580	2 407	2 454	2 336	2 369	2 310
4. LULUCF	-7 593	-6 684	-5 906	-5 021	-4 466	-5 170
5. Waste	1 685	1 378	1 102	943	772	655
Total GHG without LULUCF	**37 003**	**39 664**	**36 327**	**32 437**	**29 395**	**22 872**
Total GHG with LULUCF	**29 409**	**32 980**	**30 422**	**27 416**	**24 928**	**17 703**

CHAPTER 7 VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

7.1 CLIMATE MODELLING, SCENARIOS AND PROJECTIONS OF FUTURE CLIMATE FOR THE TERRITORY OF SLOVAKIA

Scientific evidence from recent years (including IPCC reports and data from the SHMÚ) shows that increasing greenhouse gas concentrations due to human activities are having a major impact on the Earth's climate system. The latter responds to changes in greenhouse gas concentrations through global warming and rapid, complex changes to the whole system. The manifestations and impacts of climate change and global warming are significantly manifested in Slovakia. The observed upward trend in the Earth's surface temperature is the most noticeable manifestation of ongoing climate change, especially since the second half of the 1980s, and in Slovakia especially since the early 1990s.

Since 1881, the average annual air temperature in Slovakia has increased by 1.8-2.0°C (0.15°C/10 years), with the fastest temperature rise occurring in the summer months, when the average air temperature has risen by more than 2.0°C (almost 3.0°C in the southern regions of Slovakia). After 1991, the number of above-normal years increased significantly, with 2018 and 2019 being extremely warm - the average annual air temperature in Hurbanovo was 12.43°C. In the last two decades, the number of [high] extremes of maximum and minimum daily air temperature has increased significantly, and especially after 1991 there has been a rapid increase in the frequency of heat waves across Slovakia. In the period 2001-2022, dry, without precipitation periods have been shown to occur more frequently, which, combined with in average warmer climatic conditions, leads to more frequent and more widespread soil drought. A major problem in Central Europe and Slovakia is the significant change in the temporal and spatial distribution of precipitation and snow cover. Precipitation in the warm part of the year occurs more often in the form of intense torrential downpours and in the cold part of the year more often in liquid form. In particular, the intensities of 5- to 180-minute rainfall increase significantly, which can be explained by the more frequent occurrence of short-term convective precipitation and, on the contrary, by the less frequent occurrence of long-lasting, mostly stratiform precipitation. In the lowlands and middle mountain regions there is a rapid change in the temporal distribution of snow cover, with a significant decrease in the number of days with total snow cover and its total duration [for more details on the observed changes in climate conditions in Slovakia, see the Chapter III.

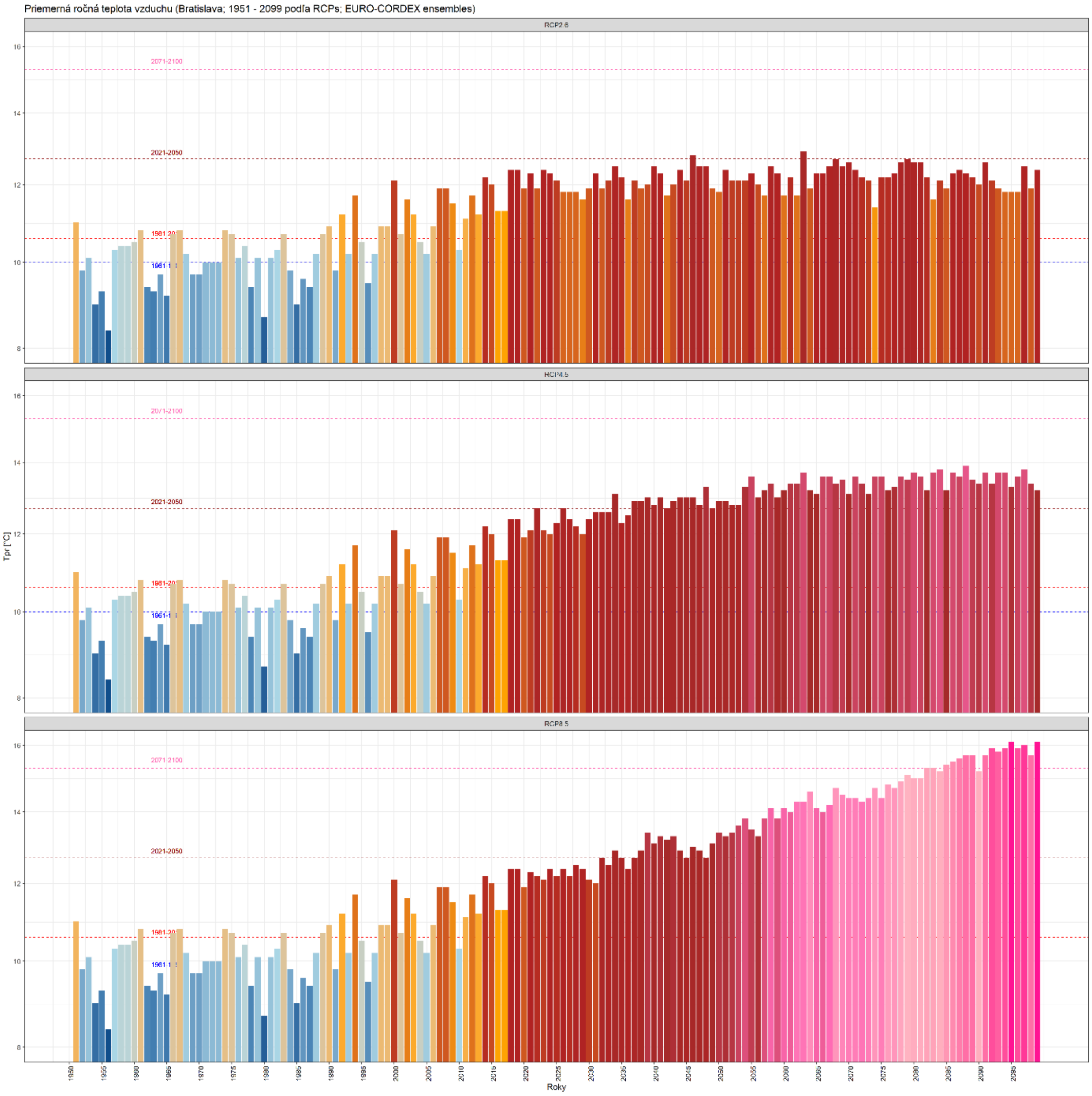
The rate of expected changes in climate conditions in the coming decades (up to 2 100) will depend on the amount of greenhouse gas emissions and the evolution of their concentrations in the atmosphere. This is also indicated by the outputs of the global (GCMs) and regional (RCMs) climate models, which take into account the projected trajectories of greenhouse gas emissions under the RCPs emission scenarios (RCP2.6 to RCP8.5) and, in the most recent versions of the models, the SSPs scenarios (SSP1-2.6 to SSP5-8.5). Global and regional climate models are now a major tool for studying the climate system and for developing scenarios of expected climate change during the 21st century. Although intensive development and improvement of global GCMs is currently under way, their spatial resolution still remains too coarse. Regional climate models represent one of the most widely used methods of downscaling the outputs of GCMs (through the use of dynamical downscaling). In this case, the model simulation does not run on the whole globe, but only on a limited area, but with a higher spatial and temporal resolution. A very important project within the European CORDEX domain is the EURO-CORDEX consortium, which offers RCMs outputs for eight sub-domains with more detailed horizontal resolution. Simulations of the current generation of RCMs, which have been prepared for Europe as part of the European part of the global CORDEX experiment, offer daily and sub-daily data with a spatial resolution of 10 × 10 km (or 12 × 12 km). The EURO-CORDEX RCMs are driven by the ERA-Interim global reanalysis (some also by the ERA5 reanalysis).

For the preparation of scenarios of expected future climate conditions in the regions of Slovakia, simulations of RCMs (regional climate models) available within the EURO-CORDEX project (https://www.euro-cordex.net/) were used, where ensemble averages of annual, seasonal and monthly mean air temperature (and other meteorological elements) from 15 to 20 members (models) were calculated for the selected RCP emission scenarios for the time horizons 2021 to 2050, or 2071 to 2100 (with a spatial resolution of 10×10 km). The models used in the simulations were validated against meteorological observations from the regional area (using gridded data from meteorological stations in Europe (EOBS)). Simulations of RCMs were driven by ERA-Interim reanalysis, and model outputs were validated using the 1961-1990 and 1981-2010 reference periods, respectively. The emission scenarios RCP2.6 (optimistic scenario), RCP4.5 (medium scenario), RCP6.0 (medium upper scenario) and RCP8.5 pessimistic scenario were used for the preparation of the climate change scenarios. RCPs (Representative Concentration Pathways) are emission scenarios that project the most likely path of greenhouse gas emissions to the atmosphere until around the end of this century. According to them, climate models calculate the total radiative forcing that results from the total achieved concentration of these gases in a given period.

- Due to continued warming, based on the outputs of the climate models, the annual average air temperature is very likely to increase by 0.7-0.9°C by 2030 (compared to 1991-2020), by about 2.0-3.0°C by 2050, and by 3.5-6.0°C by 2100 (depending on the chosen RCP scenario) in the southern Slovakia region.
- Daily minima are expected to rise faster than daily maxima in air temperature (minimum air temperature will increase between 6.0 and 10.0°C by 2100, maximum air temperature between 2.0 and 5.0°C), which may cause a decrease in the average daily amplitude of air temperature.
- The scenarios do not foresee significant changes in the annual pattern of air temperature, but the temperature increase in the autumn months should be smaller than in the rest of the year (the average air temperature will increase fastest in summer and winter, by 1.5 to 4.0°C in summer, and by 2.5 to 5.0°C in winter by 2100).
- Already by 2050, we foresee a significant increase in the number of summer days, tropical days, but a decrease in the number of frost days and ice days.
- The most important consequence in terms of thermal comfort is an increase in the frequency, length and intensity of heat waves, which may occur as early as May and will not be infrequent even by mid-September. In the warm half of the year, we expect heat waves or periods of very high daytime air temperatures (above 30 and 35°C, respectively) to be more frequent; heat waves similar to those of 2003, 2007 or 2015 will be 3 to 5 times more frequent in the period around 2050.
- A higher number of days with sultry weather is also predicted, due to an overall increase in atmospheric water content parameters. Warm and dry weather is expected to arrive more quickly in spring. In the warm part of the year, the variability of rainfall is expected to increase, with longer and more frequent low-rainfall (dry) periods on the one hand and more rainfall-intensive short rainy periods on the other.
- According to most RCMs simulations, precipitation totals in most of Slovakia should increase until the end of the century (it should be noted, however, that there is considerable uncertainty in the climate model outputs regarding changes in precipitation totals).

- In southern and south-western Slovakia, precipitation will increase by the end of the century, averaging up to 10% for RCP4.5 and up to 15% under RCP8.5 compared to the 1981-2010 reference period (in absolute terms, this implies an increase in the annual mean of 50 to 70 mm for RCP4.5, and 100 to 120 mm for RCP8.5 and at the end of this century).
- While winter and autumn precipitation will gradually increase, spring and summer precipitation will decrease, which, in combination with higher air temperatures, will have a negative impact on the precipitation balance and a more frequent occurrence of droughts, especially in the southern half of Slovakia.
- Torrential and intense short-term rainfall events are likely to be more frequent and intense - the bulk of the emission scenarios within the ensemble of models used confirm a general increase in intensities, most notably (albeit with greater uncertainty) for shorter rain periods. The increase in both totals and intensities is approximately +5 to +8% for RCP2.6 for the period 2021-2050, +3 to +5% for the period 2051-2100, +5 to +8% and +10 to +14% for RCP4.5, +10 to +20% and +15 to +30% for RCP6.0 and +18 to +25% and +25 to +35% for RCP8.5, respectively.
- Stronger and more intense storms are expected to become more frequent due to higher air temperature and humidity. The occurrence of extreme accompanying storm phenomena, such as wind gusts >25 m/s or hail 2-5 cm in diameter, will be significantly more frequent; for high wind gusts (>25 m/s) the occurrence may be 20-80% higher, for hail up to 5 cm in diameter it may be 40-150% higher by 2100 (depending on the emission scenario chosen).
- Changes in temperature and precipitation conditions in winter will be reflected in changes in snow conditions. These are expected to result both in a reduction in the number of days with snow cover and in a decrease in the average snow cover depth. However, with the increase in precipitation extremes, higher daily increments of new snow should be expected to occur more frequently in winter.
- As a consequence of an uneven increasing of air temperature in all regions of the world during the 21st century (e.g. the Arctic region is already warming up to three times faster than lower latitudes), planetary circulation systems and the long-term location of the centres of action and frontal zones will undergo fundamental changes. This is already evident in the increasing number of extreme weather conditions recorded in the Northern Hemisphere, which also been recorded in our area over the last two to three decades. This is probably related to the changing dynamics and location of the high-altitude jet stream in the polar frontal zone and the more frequent occurrence of persistent (blocking) pressure disturbances and weather conditions.

Figure 7.1: *Projected change in annual mean air temperature in Bratislava under the three selected RCP scenarios (RCP2.6 - top, RCP4.5 - middle and RCP8.5 - bottom); compiled from the outputs of the EURO-CORDEX RCMs [Source: Cordex, Copernicus]*

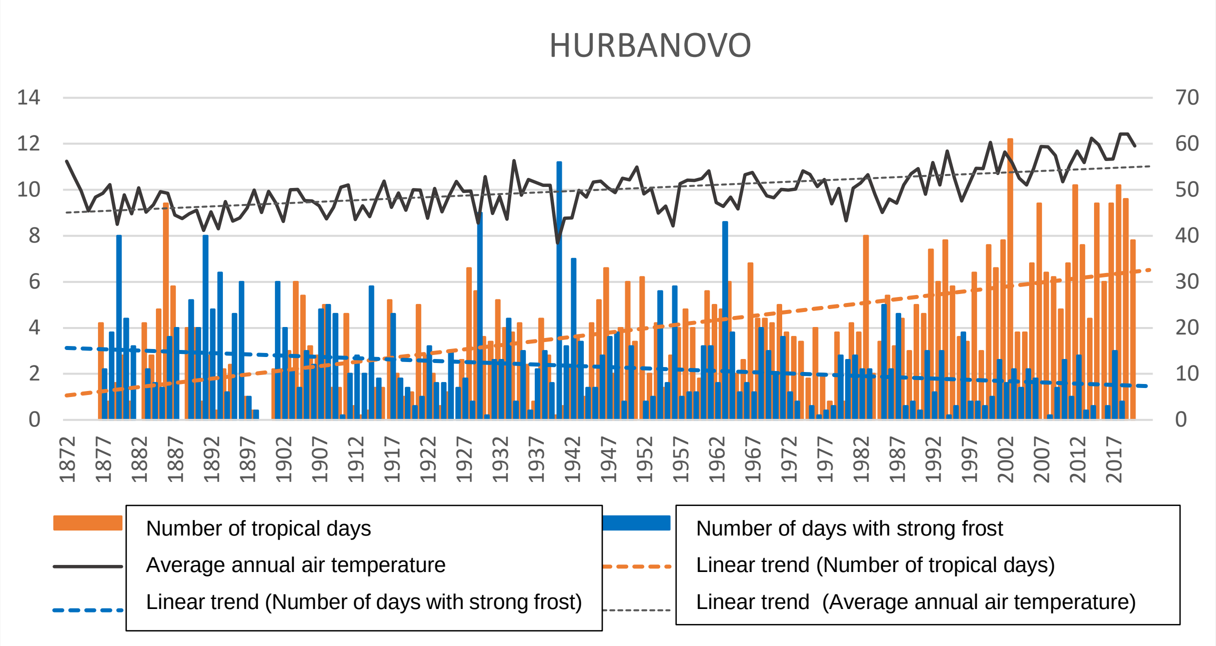


7.2 OBSERVED AND EXPECTED IMPACTS OF CLIMATE CHANGE

Climate change is noticeable throughout Slovakia, including in high mountain areas. It is mostly reflected in an increase in the average annual air temperature, a spatially varying trend of annual atmospheric precipitation averaging about 0.5% (in the south of Slovakia the decrease was sometimes more than 10%, in the north and north-east precipitation increased sporadically up to 3%), a decrease in relative air humidity and a decrease in all characteristics of the snow cover up to an altitude of 1000 m above sea level in almost the entire territory of Slovakia (at higher altitudes an increase was recorded). There is also an increase in potential evaporation and a decrease in soil moisture - the characteristics of soil and plant water evaporation, soil moisture, and solar radiation confirm that the south of Slovakia, in particular, is gradually drying out.

Over the last 15 years, there has been a significant increase in the occurrence of extreme daily and multi-day precipitation totals, which has resulted in an increase in the risk of localised flooding in various areas of the Slovak Republic. On the other hand, local or widespread droughts occurred much more frequently in the period 1989-2020 than before, mainly caused by long periods of relatively warm weather with low precipitation totals in some parts of the growing season. Drought was particularly pronounced in 1990-1994, 2000, 2002, 2003 and 2007, and in some regions in western Slovakia in 2015, 2017 and 2019.

Figure 7.2: *Course of temperature characteristics in Hurbanovo for the period 1872-2020*



Source: SHMÚ

The normal period 1991-2020, with the characteristics of air temperature, precipitation totals, evapotranspiration, snow cover, as well as other elements, approached the projected climate conditions around 2030, which were quantified in terms of climate change scenarios for our territory.

7.3 ASSESSMENT OF RISKS AND VULNERABILITY TO CLIMATE CHANGE IN SLOVAKIA IN SELECTED SECTORS

7.3.1 Impacts of Climate Change on the Agricultural Sector

Agriculture in the Slovak Republic has undergone fundamental changes over the last 20 years. The structure of crop production has changed through the application of some of the principles of the European Union's Common Agricultural Policy. Climate change is expected to have a major impact on the conditions under which agricultural production takes place. Various indicators give us an indication of the possible consequences that are already being felt and the trend that is continuing.

Agricultural production is mainly influenced by the following climatic factors: increase in average air temperature, change in precipitation and its distribution, increase in CO_2 concentration and the occurrence of weather extremes. Agriculture is very sensitive to climatic fluctuations and weather extremes such as droughts, storms, cloudbursts and floods. Crop production may benefit from a warmer climate, but the occurrence of weather extremes and an increase in their intensity will cause other problems.

The effects of climate change, in particular the occurrence of droughts and more frequent floods, are causing changes in agricultural production in the Slovak Republic. The summer season is getting longer due to the warming trend not only in the south but also in other regions of the Slovak Republic. Higher air temperature accelerates the intensity of physiological processes. The phenological phases change and the crops ripen faster. The changed climate affects not only the regional distribution of cultivated crops (the spread of thermophilic crops to the more northern parts of the Slovak Republic), but also the qualitative characteristics of the soil.

A negative change in the water status of the soil is reflected in the water capacity available for crops. As a result of the increase in soil aridity, there is a significant tendency for the groundwater reserves available for crop use to decrease, and this can be seen most markedly in the light soils. The decrease in soil water is caused by increasing evapotranspiration due to rising temperatures.

Climate change and the global rise in average annual temperatures will also affect livestock welfare. Rising temperatures in stables will also increase CO_2 and NH_3 levels. Similarly, we can expect to see the emergence of parasites and diseases in livestock, which need higher temperatures to exist. We also expect new crop pests to emerge, leading to increased pesticide use and a possible negative impact on bees. The effects of climate change on crop production will also affect food for livestock production. Warmer temperatures, drought periods and changes in rainfall can affect forage crops and the production of natural pastures. Climate change may also contribute to the loss of natural water sources for livestock. The increase in average annual temperature causes the number of summer days to increase and the period of consistently high air temperatures to become longer. Animals are expected to experience temperature stress.

We also expect positive effects of climate change in the northern regions of the Slovak Republic. A warmer climate will bring more favourable conditions for the production of thermophilic forage crops. This could have a positive impact on the economics of livestock farming, with farmers in northern areas no longer having to buy expensive feed and being able to grow it themselves. Increased CO_2 concentration can have an impact on phytomass production. The so-called fertilizing effect of CO_2 causes more intensive photosynthesis and consequently more water consumption in plants. A higher rate of photosynthesis brings an increase in phytomass.

7.3.1.1 Vulnerability Assessment in the Agricultural Sector

Climate change is affecting land cover in the Slovak Republic. There are obviously some regional differences, but in general we can say that winters will be milder and wetter, summers will be warmer and drier, and weather extremes will be more intense. The impacts of climate change on agriculture are related to water. Increased water and soil erosion is expected, as well as deterioration of soil structure, poorer water availability in the soil profile and intensified salinisation and sodification processes.

In dry and windy periods, wind erosion will occur on open ground. Increased water erosion is expected during torrential rains. As a result of more frequent occurrence and increased intensity of torrential rainfall and reduced anti-erosion effect of crop vegetation, the occurrence of gully erosion is also expected. In this respect, shallow soils in mountainous areas in particular are among the soil types at risk.

Climate change also fundamentally affects the direction and rate of accumulation and transformation of soil organic matter. Higher temperatures can affect the decomposition of soil organic matter and the mineralisation process will overwhelm the wetting processes. This can cause soil acidification. This will also affect the deterioration of the physical properties of the soil, such as its structure, and may also lead to soil compaction.

We can also expect a major impact of climate change on the country's water regime. Higher temperatures and increased evaporation, as well as a gradual increase in groundwater mineralisation, will cause an increased accumulation of salts in the middle and surface layers of the soil. Areas with saline soils are expected to expand.

Major impacts can be expected in intensive livestock production, where animals are more sensitive to changes in environmental conditions and less resistant to parasites and diseases. This causes losses in production as well as ill health. This type of production relies heavily on the production of high quality forage. Their availability can be problematic in areas where droughts are more frequent. Changes in rainfall will also affect extensive livestock production dependent on natural pastures. In the future, there will be an increased demand for cooling systems in livestock production, which is associated with higher costs and may cause high economic losses on farms.

7.3.1.2 Adaptation Measures in the Agricultural Sector

According to a recent survey carried out in the Slovak Republic, as well as according to general recommendations for agrotechnical measures, there are some effective ways of adapting to the current and future conditions of agricultural production:

Change in the structure of varieties of cultivated crops and species of animals reared in the Slovak Republic.

- Launching breeding programmes to support the development of new breeding or alternative options, continuing the cultivation of Slovak crops and the breeding of Slovak species and varieties with an emphasis on increasing their resilience.
- Application of integrated crop protection.
- Diversification of crop production and gradual incorporation of drought-resistant crops.

The change in crop structure represents a radical step in the region's agricultural production. This approach will be particularly effective in higher altitude regions, due to the increasing thermal comfort, which in the past was typical only for the lowlands. In Slovak conditions, this concerns in particular the expansion of maize and sugar beet production to higher altitudes. Producers are considering the introduction of new maize varieties. Varietal change is also expected in cereals, especially winter wheat. Current winter wheat varieties are maturing 3-4 weeks earlier than in the past. This will result in lower inputs and reduced revenue generation potential.

Adaptation of agrotechnical measures (especially sowing) to changed agro-climatic conditions.

The adjustment of agrotechnical conditions concerns in particular spring varieties of barley and wheat. Models have shown that maintaining fixed sowing days in spring can shift the ontogeny period to a period of high temperatures. This can reduce the number of germinating seeds. Later, high temperatures can have a negative effect on grain development.

Promoting the revitalisation of old irrigation systems and the construction of new ones, ensuring sufficient irrigation water in cooperation with the water management sector and promoting the efficient use of irrigation systems (micro-irrigation systems).
Irrigation depends not only on farmers but also on the water management sector. The effect of irrigation is well known in Slovak conditions and further modelling has shown the stabilising effect of irrigation.

Prefer and apply agrotechnical measures to promote soil conservation, cultivation technologies for soils threatened by erosion, use of a higher proportion of organic matter in the soil, improvement of soil retention capacity

Ensuring good land use practices, mosaic landscaping and soil segmentation, promoting maintenance of windbreaks, grass strips, terraces and perennial meadows.

On livestock farms, it is recommended to use well-ventilated stables with temperature control. To avoid heat stress in animals, cooling at critical times is recommended. This will require the installation of a cooling system on any efficient livestock farm. The balance of feed rations in relation to metabolic heat declines will be important. Breeding will need to focus on adaptability and resilience. Indigenous local species can have a great advantage in this respect as they maintain a sufficient level of adaptability.

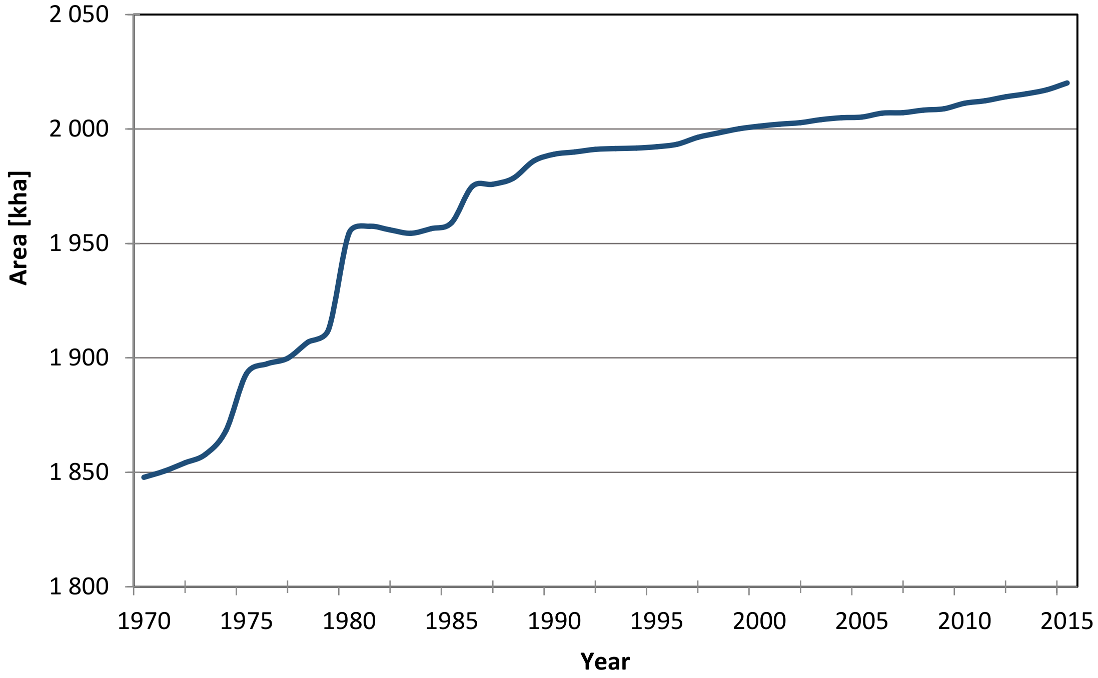
The application of the above measures will have to be selective and will produce different results in different regions.

7.3.2 Impacts of Climate Change on the Forestry Sector

The forested area in the Slovak Republic has increased steadily over the last decades, with an increase of almost 10% over the last 45 years. The species composition of trees has also undergone changes in recent times, which can be considered favourable for the inherent adaptation mechanisms of forests. The proportion of highly sensitive Norway spruce has declined by 2.9% (from 26.3% to 23.4%) over the last decade, the decline was caused by increasing damage from a range of biotic and abiotic factors. At the same time, the proportion of less sensitive broadleaved trees has increased, for example the recent increase in the proportion of beech by up to 2.2%.

Forest stands with higher diversity and better horizontal and vertical structure can be considered more adaptable to climate change. The proportion of single-species coniferous forest stands in the Slovak Republic is considerably lower than in other Central European countries and the composition of tree species is more natural. However, existing forest stands with inappropriate structure are more susceptible to the spread of pests and mechanical damage, especially by wind. The proportion of over-mature forest stands is also quite high and their susceptibility to damage is high.

Figure 7.3: *Development of forest area in the Slovak Republic (kha, ha[3]) in the period 1970-2015 (based on data from the Geodesy, Cartography and Cadastre Authority of the Slovak Republic)*



In recent decades, forest damage in the Slovak Republic has been steadily increasing, and this increase corresponds to increasing disturbances across Europe. In the Slovak Republic, most of the damage was caused by wind and bark beetle. In particular, the forests were significantly affected by two storms, in 2004 and 2014, as well as by subsequent secondary damage caused by biotic agents. High damage typically occurs especially in regions affected by the continuous retreat of spruce forests, namely in the regions of Kysuce and Orava (north-west of the Slovak Republic), Spiš, the Low Tatras and the High Tatras.

The impacts of climate change on forests are *direct impacts*, which are directly related to changes in air temperature, precipitation distribution, increased CO_2 concentrations or prolonged growing seasons, and *indirect impacts*, which are mostly manifested by changes in forest disturbance regimes.

Forest productivity is expected to be significantly affected by climate change and such change may have major implications for the quality of ecosystem services provided, including timber production, as well as for forest management.

7.3.2.1 Vulnerability Assessment in the Forestry Sector

We present a simplified vulnerability assessment using natural zonation of forest communities in the Slovak Republic. The zones addressed are:

- low to middle elevations, where deciduous species are predominant and the effects of drought are expected to be most pronounced;
- medium to high altitudes, which contain a high proportion of vulnerable secondary spruce forests and where accelerated forest dynamics can be expected;
- the mountainous area naturally dominated by conifers with protective and other regulating functions, and climate change can be beneficial to forest vegetation.

The assessment presented here takes into account all three components of vulnerability - climate exposure, ecosystem sensitivity and adaptive capacity. The latter component mainly takes into account adaptive capacity related to forest management, although the adaptive mechanisms of species and communities themselves are also taken into account.

The fact that forest communities in low-lying areas of the Slovak Republic are expected to face the highest climatic challenges in terms of increasing water scarcity and increasing frequency and intensity of hot spells increases the overall vulnerability of forests. On the other hand, the tree species and forest communities here show a high degree of heat and drought tolerance, but it is very likely that projected climate change will exceed these limits. The biotic vulnerability of the forests could be considered low, provided that no new pests emerge. In particular, forestry adaptation should include the promotion of drought-tolerant species and forestry interventions that maintain water and nutrient regimes. In the future, the introduction of drought-tolerant tree species with a higher drought tolerance than native species could be considered, but current legislation does not allow such action. The high vulnerability of these ecosystems is mainly determined by exposure to climate impacts and limited opportunities to promote drought tolerance of these ecosystems with new species from other areas. The relative sensitivity on the scale of the Slovak Republic can be considered *moderate*.

The vulnerability of mid- to high-altitude forests is mainly determined by the altered species composition and the high proportion of secondary stands of Norway spruce, which exhibit high biotic and mechanical vulnerability. It is likely that forests will be increasingly destroyed in the future in response to the physiological weakening of tree defences due to adverse climate and the potential influx of new pests. The adaptive capacity of forest management is likely to be insufficient to adequately cope with increasing damage. Adaptive capacity may also be undermined by a lack of awareness of climate change risks and adaptation options, as well as the persistent spruce-focused orientation of the economy. These facts can hinder timely, prudent and effective action. The relative vulnerability of these forests on the scale of the Slovak Republic can be considered *high*.

Mountain forests can be expected to benefit from a longer growing season, a shorter period of frozen ground and increased nutrient supply due to accelerated decomposition. It is likely that such processes, in addition to sufficient rainfall, will maintain the vitality of these forests. On the other hand, the increased frequency of storms and the spread of pests from lower elevations can undermine the vitality of these ecosystems. The spread of tree species from lower elevations may pose a risk to biodiversity. As large parts of these forests are unmanaged and provide protective and other regulatory functions, the ability of forest management to adapt these forests is uncertain. The relative vulnerability of these forests can be considered *moderate*.

7.3.2.2 Adaptation Measures in the Forestry Sector

Change in tree species composition

Changing the composition of dominant species in response to increasing drought and pest attacks is an essential measure in forest adaptation in many regions of the Slovak Republic. The measure focuses primarily on increasing the proportion of drought-tolerant species, reducing the proportion of species that require more irrigation and are sensitive to drought, increasing stand diversity (which promotes the inherent adaptive capacity of forests), and reducing the proportion of host trees within the range of climate-sensitive insect pests. The importance of such measures increases towards lower elevation (xeric) tree species where the adverse impacts of drought may be more pronounced. However, such measures entail considerable lead time and will only take effect gradually, underlining the importance of early and forward-looking adaptation steps.

The introduction of species that do not currently occur in Central Europe could be considered questionable, mainly because of the potential risks to biodiversity and the unclear prospects for their long-term viability. However, fundamental changes in climate may speak in favour of southern species and may ultimately provide an alternative to current species that may not be able to persist in drier and warmer climates, so adaptive steps such as assisted migration may be worth considering.

Assisted transfer of reproductive material

When it comes to sources of reproductive material, foresters and environmentalists alike still agree on the “local is always best” approach. However, current legislation specifies rules for the transfer of reproductive material and thus provides a good basis for adaptive changes in forest composition. As long as ongoing climate change is within the range of the expected stability potential of the provenance, adaptation can be achieved by exploiting phenotypic stability. For example, in the case of beech, field trials suggest that increasing water deficit, as expressed by increased Ellenberg’s climate quotient up to 5 units, can be compensated for by phenotypic stability (plasticity) of the local population.

Regeneration, breeding and dilution

Adaptive forestry interventions should minimise biotic risk, promote species and structural diversity of stands, support natural regeneration and facilitate water, carbon and nutrient cycling. For natural regeneration, long regeneration phases on smaller areas should be preferred. In case of deteriorating local conditions, enrichment planting, i.e. a combination of natural and artificial regeneration, may be applied. This approach has been found to have a positive impact on genetic diversity, thereby increasing the intrinsic adaptive capacity of forests.

Harvesting

Shortening the rotation period can be used to reduce the proportion of old growth with high susceptibility to insects and disease. Such a measure also has the potential to accelerate the transition to a more appropriate species composition. For example, a reduction by 10 to 30 years has been proposed for most of the Czech Republic's commercial tree species (except oaks); such a reduction has been found to be beneficial in terms of forest production, safety, and economics. As the ecological and economic environment in the Slovak Republic is similar, this approach could work here as well.

However, the reduction of the rotation period should be considered in combination with all relevant site- and species-specific factors, and must balance positive effects on climate risk with impacts on timber production, carbon storage or biodiversity. The negative impacts of reduced rotation length, such as unwanted temporary over-harvesting and surplus timber on the market, which could have a negative effect on the timber industry, also need to be considered.

Other steps

The importance of continuous and long-term forest monitoring increases with climate change, as early identification of trends in forests and the environment is a prerequisite for adaptive management under changing environmental conditions.

Adaptation of forest infrastructure also includes optimisation of forest road networks. Increasing the density and improving the quality of forest roads will provide access to areas in need of rehabilitation, stimulate small-scale management, and reduce overplanting in accessible locations. However, this measure must be applied with caution as there is strong evidence that inadequately constructed road networks can have a negative impact on the water regime and thus amplify the adverse effects of drought.

The forest planning infrastructure should also be improved, as many current planning tools such as yield tables and empirical models fail to take into account the effects of a changing environment. In this respect, it is important to explicitly consider climate-sensitive processes in alternative planning models. For example, financial support for economic practices that address climate change adaptation could be considered.

7.3.3 Impacts of Climate Change on the Biodiversity

It is now widely recognised that climate change and biodiversity are linked. Climate change affects biodiversity, with negative consequences for human well-being, but biodiversity also makes an important contribution to climate change mitigation and adaptation through the provision of specific ecosystem services. Therefore, the conservation and sustainable management of biodiversity is critically important in addressing climate change. Natural processes take place in ecosystems that provide benefits for both natural and human activities. The scale and nature of climate change may reach levels where natural adaptation of ecosystems will no longer be possible. The consequences of climate change on natural systems could therefore have far-reaching impacts, namely the loss of biodiversity in terms of species and habitats.

The basic document dealing with biodiversity is the National Strategy for Biodiversity Conservation in Slovakia, approved by the Government of the Slovak Republic in 1996, a new updated version of the National Strategy was approved in 2014.

It is generally assumed that biodiversity will be reduced by a number of factors, mainly as a result of increased intensity of land use and the associated destruction of natural habitats or natural sites. These pressures on biodiversity occur independently of climate change and it is therefore questionable to what extent climate change can enhance or exacerbate biodiversity loss.

All current evidence suggests that, in general, the impact on biodiversity will be negative, due to the increasing effect of global climate change on forest, agricultural and aquatic ecosystems. Vulnerable ecosystems such as pine forests in the mountains, swamp ecosystems in the foothills and mountains as well as aquatic systems are most at risk. Based on the changes in ecosystems that are already recognised and predicted, the following climate change impacts are expected:

- Increasing threats to climate-sensitive species with a narrow ecological niche.
- Changing climatic conditions of specific plant and animal species.
- Potential migration of species.
- Threats to autochthonous fauna and flora from invasive species.

Databases documenting the current status of ecosystems already exist and cover mainly forestry. National inventory and monitoring of Slovak forests was carried out in 2005-2006. The second round of inventory and monitoring took place in 2015-2016. The results are currently being analysed and should be published at the end of 2017. This allows us to quantify changes in the biodiversity of forest ecosystems in relation to the number of species, their abundance as well as the recognition of invasive species.

7.3.3.1 Vulnerability Assessment in the Biodiversity

The current global biota has been affected by fluctuating Pleistocene (last 1.8 million years) concentrations of atmospheric carbon dioxide, temperature, and precipitation, has undergone evolutionary changes, and has adopted natural adaptive strategies. However, such climate change took place over a longer period of time, in a landscape that was not as fragmented as it is today, and with little or no additional pressure from human activities. Habitat fragmentation has trapped many species in relatively small areas within their previous range, resulting in lower genetic variation.

The current rate and magnitude of species extinctions exceeds the standard course of evolution. Human activity has already caused losses in biodiversity and could therefore affect ecosystem services crucial to human well-being. The rate and magnitude of climate change caused by greenhouse gas emissions has affected and will continue to affect biodiversity, either directly or in combination with other factors.

Links between biodiversity and climate change

There is strong evidence that climate change is affecting biodiversity. According to the Millennium Ecosystem Assessment, climate change is likely to become one of the most important drivers of biodiversity loss by the end of the century. Climate change is already forcing biodiversity to adapt, either through habitat shifts, changes in life cycles or the evolution of new physical traits. The conservation of natural terrestrial, freshwater and marine ecosystems and the restoration of disturbed ecosystems (including their genetic and species diversity) is fundamental to the overall objectives of both the Convention on Biological Diversity and the UN Framework Convention on Climate Change, as ecosystems play a key role in the global carbon cycle and in adaptation to climate change, while also providing a wide range of ecosystem services essential for human well-being. The Slovak Republic has been a party to the Convention on Biological Diversity and the UN Framework Convention on Climate Change since 1994.

7.3.3.2 Adaptation Measures in the Biodiversity

Adaptation appears to be a critical tool for mitigating the impacts of climate change on biodiversity and maintaining existing levels of biodiversity at least at current levels. However, the system can also work the other way round. High levels of biodiversity also confer a relatively high level of resilience to some ecosystems (e.g. forest ecosystems), which ultimately increases the likelihood of a particular ecosystem being adaptive and mitigates the impacts of climate change on biodiversity as a whole. Adaptation measures in the biodiversity sector focus on protected areas. General proposals for adaptation measures should cover the following activities:

- completion of infrastructure and capacity building in institutional nature conservation;
- minimising negative impacts on biodiversity in cooperation with other sectors.

Adaptation based on the ecosystem principle

Ecosystem-based adaptation that integrates biodiversity use and ecosystem services into an overall adaptation strategy can be cost-effective and can deliver social, economic and cultural co-benefits and contribute to biodiversity conservation.

Conservation and management strategies that conserve and restore biodiversity can be expected to reduce some of the negative impacts of climate change. However, the pace and scale of climate change will be too challenging for natural adaptation. Options for increasing the adaptive capacity of species and ecosystems in the face of accelerating climate change include:

- reducing non-climatic stresses such as pollution, overexploitation of resources, habitat loss and fragmentation, as well as invasive and non-native species;
- wider adoption of conservation and sustainable use practices, including strengthening the network of protected areas;
- facilitating adaptive management by strengthening the monitoring and evaluation systems.

Adaptation based on an ecosystem approach uses biodiversity and ecosystem services in an overall adaptation strategy. It involves sustainably managing, protecting and restoring ecosystems so that they can provide services that help people adapt to the adverse impacts of climate change. Examples of ecosystem-based adaptation are:

- sustainable management of upland wetlands and floodplains to maintain flow and protect water quality;
- preservation and restoration of forests to stabilise slopes and regulate watercourses;
- the establishment of diversified agroforestry systems to cope with the increased risks arising from changing climatic conditions;
- conserving agrobiodiversity to ensure specific gene pools for crop and livestock adaptation to climate change.

7.3.4 Impacts of Climate Change in the Public Health

The public health implications of climate change are influenced primarily by environmental factors, but also by socio-economic developments and the implementation of effective adaptation measures.

The basic document in the field of environmental health within the public health system in the Slovak Republic is the National Environmental and Health Action Plan of the Slovak Republic (NEHAP IV). It is a national plan adopted by the Government of the Slovak Republic by Resolution No. 1012012. The main objective is to implement concrete actions to protect environmental health. One of the areas of focus is climate change and its impact in relation to public health. A national review of the implementation of the activities implemented under this Action Plan is prepared every two years.

Biometeorological conditions can significantly affect human health in specific situations, specifically for people suffering from cardiovascular problems. Long periods with high temperatures are almost critical. Days with maximum temperatures above 30°C are called tropical days and have the potential to adversely affect people. Large cities and urban agglomerations in southern Slovakia are particularly vulnerable to heat waves, due to the heat island effect in these urban zones. Air-conditioned spaces are still not a common feature of private or public buildings, and even rooms in hospitals are rarely air-conditioned.

Climate change is undoubtedly multiplying global human health problems and increasing cases of premature death due to natural phenomena. The type and nature of events depends on conditions in different parts of the world.

The findings of several studies, projects and national surveys on the effects of weather on human health suggest that people will be exposed to severe impacts of climate change in the form of extreme conditions in the next decade. Other forms of health impacts can be seen in worsened malnutrition in regions where people depend on crops and livestock production. Other forms of such effects include changes in the spread of infectious diseases, the spread of diseases caused by polluted water (especially in regions where personal hygiene and sanitation are very low), the spread of respiratory diseases due to air pollution and pollen distribution, etc. The most common impacts of climate change in Europe and their health consequences are described in ***Table 7.1***.

Table 7.1: *The most common climate change impacts expected in Europe and their health implications*

Phenomenon	**Health impacts**
Floods	Deaths, injuries, infectious diseases
Air temperature fluctuations (extremely high air temperature, very low air temperature) combined with polluted air and higher surface ozone	Deteriorating health in people with cardiovascular and respiratory diseases, asthma, premature death, dehydration
Vector for transmission of infectious diseases (mosquitoes, ticks)	Malaria, yellow fever, Lyme disease, encephalitis, West Nile fever
Waterborne diseases	Hepatitis, diarrhoea
UV radiation	Skin diseases
Pollen allergens	Allergic sensitivity, worsening of allergic symptoms, increased number of asthma attacks
Food	Cases of salmonellosis

According to the latest climate scenario in the Slovak Republic, we expect the population to suffer from the direct impacts of climate change, such as higher air temperatures in summer and heat waves at the end of the 21st century. Typical features of a heat wave are extreme air temperatures during the day and relatively high air temperatures at night. The more extremely warm days there are, the more their effects will be felt. The most at risk areas are cities, southern parts of the Slovak Republic and areas with higher concentrations of PM_{10} and $PM_{2.5}$. At times when there is an extremely warm day and at the same time a higher concentration of ground-level ozone, people who suffer from any disease are at least twice as likely to die. According to studies in many European cities, people aged between 75 and 84 are the most at risk. People in this group are usually lonely and do not have the means to ensure a basic standard of living.

Table 7.2: *Consequences of climate change and their impacts on public health predicted for the Slovak Republic at the end of 2100*

Phenomena	**Probability according to projections**	**Impact on human health**
Extreme air temperature, higher frequency of occurrence, length of heat waves	Very probably	Higher heat-related mortality and morbidity, especially among the elderly, chronically ill, very young and lonely
Increased number of warm days/nights	Very probably	General deterioration in health, the most affected will be elderly and lonely individuals aged over 75, children, the mentally and physically handicapped
Periods of high rainfall, torrential rain, thunderstorms, tornadoes, floods	Very probably	Higher risk of death, flood injuries, respiratory diseases, diseases from polluted water (hepatitis) and food (salmonellosis)
Droughts	Probably	Higher risk of infectious diseases caused by water and food
Occurrence of rapid weather changes/fluctuations	Probably	Higher risk of deaths, mental illnesses
Extension of the pollen season	Probably	Asthma, allergies, respiratory diseases
Prevalence of infectious disease transmission vectors	Probably	Malaria, Lyme disease, tick-borne encephalitis, West Nile fever
Higher UV radiation, surface ozone and PM_{10} concentrations	Very probably	Higher risk of cancer, deaths from respiratory diseases

7.3.4.1 Adaptation Measures in the Public Health

Reducing the adverse effects of climate change, including measures taken in non-medical sectors, will have a positive impact on public health. Therefore, the Department of Public Health at the Ministry of

Health of the Slovak Republic is invited to consult draft adaptation strategies and measures in cooperation with the Public Health Authority of the Slovak Republic pursuant to Act 355/2007.

There is currently no separate adaptation strategy for public health in the Slovak Republic. First steps towards adaptation in this area should include:

- an integrated response to heat waves, such as taking climate change scenarios into account before designing and constructing new buildings and new housing estates;
- new approaches aimed at reducing urban heat islands, ozone emissions and other air pollutants could be incorporated into energy efficiency and transport planning programmes.

Establishing and maintaining a public heat wave warning program is a fundamental requirement to protect public health from the effects of extreme heat. The population must be repeatedly informed and advised through all possible channels on the possibilities of individual protection from the heat.

The public health system in the Slovak Republic should accept the reality of climate change and develop a strategy to properly respond to it. The current situation in the health sector in Slovakia, especially in hospitals, is not favourable because almost no attention is paid to the consequences and prevention of extreme weather conditions.

The management of health institutions, in collaboration with their supervisory bodies, should develop both short- and long-term targets and create the conditions for achieving them so that extreme weather conditions can be responded to on a local scale and in real time.

It is important to focus on educating doctors and health professionals about the health impacts of climate change so that they can recognise the early symptoms of heat-related illnesses. The level of physician awareness of the risks of extremely high temperatures, warnings, social and emergency systems must work together to ensure that the patient is properly informed and knows how to behave in the event of a high risk.

7.3.5 Impacts of Climate Change on Water Management

Climate models indicate a change in the distribution of atmospheric precipitation on Earth and a change in the frequency and intensity of extreme weather events. It is expected that there will be a much more uneven distribution of precipitation totals throughout the year and in different regions of Slovakia. This will also be reflected in the development of runoff conditions in Slovakia. According to different climate scenarios, a change in the long-term average annual runoff can be expected over most of the territory, with a more pronounced decrease expected especially in the lowland area. In particular, changes in long-term monthly flows are expected, with an increase in winter and spring runoff and a decrease in summer and autumn runoff, especially in the growing season.

These scenarios suggest that prolonged periods of drought in the summer and autumn months, associated with water scarcity, may be an important manifestation of climate change in our area. This phenomenon can occur as a result of a significant loss of snow in winter and its earlier melting in spring, an earlier onset of the growing season and thus a more pronounced evaporation in the spring months, but also as a result of lower precipitation and higher temperatures in the summer period. The result is a significant lack of soil moisture in the second half of summer and early autumn.

Dry periods may be interrupted by several days of high rainfall, or by heavy storm activity with intense precipitation.

Key documents on the integration of the assessment of the impacts of climate change on water bodies include Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy and Directive 2007/60/EC on the assessment and management of flood risks, with an emphasis on the need to assess and predict water status, including the long-term management of water resources and the provision of flood protection.

The most important hydrological indicator is the average annual flow, which is the main hydrological characteristic of surface streams. The annual flow depends mainly on the amount of precipitation and evaporation, but its annual pattern is altered by several other factors, such as vegetation cover as well as the fraction of water that infiltrates below the surface of the ground and becomes groundwater. The presence of water in springs or streams during the winter and the winter runoff regime influence the retarding effects of the runoff process caused by the rocky and soil environment in individual river basins.

The most important conclusions that can be drawn from the current climate scenarios, and which may consequently have relatively significant impacts on water management, are as follows:

1. increased runoff in the cold half of the year and loss of winter precipitation naturally accumulated in the form of snow cover;
2. a decrease in soil moisture and a reduction in groundwater runoff during the warm half of the year;
3. Increased surface runoff during the warm half of the year during torrential rainfall (which can lead to increased soil erosion and faster silting of water reservoirs);
4. increase and extension of drought;
5. reduction of usable water resources.

7.3.5.1 Vulnerability Assessment in the Water Management

Based on the analysis of current knowledge and understanding of hydrological conditions of water management in the Slovak Republic, we estimated the level of risk of negative impacts of climate change on the water management sector for selected geomorphological units (***Table 7.3***).

Table 7.3: *Risk of negative impact of climate change on the water management sector for selected geomorphological units*

Region	Geomorphological units	Risk
1	Malé Karpaty (Little Carpathians), Biele Karpaty (White Carpathians), Považský Inovec Mountain Range, Záhorská nížina Lowland, Podunajská nížina (Danubian Lowland), Považské podolie Basin, Podunajská pahorkatina Hills, Pohronský Inovec Mountain Range	*
2	Lučensko-košická zníženina (Lučenec-Košice Depression), Krupinská planina (Krupina Plateau), Javorie Mountains, Matransko-slanská oblasť (Matra-Slanec Area) and adjacent basins	***
3	Východoslovenská nížina (Eastern Slovak Lowland), Vihorlatské vrchy (Vihorlat Mountains)	**
4	Poloniny Mountains, Nízke Beskydy (Low Beskids), Východné Beskydy (Eastern Beskids), Spišská Magura Mountain Range	**
5	Stredné Beskydy (Central Beskids), Západné Beskydy (Western Beskids), Javorníky Mountain Range	**
6	Tatry (Tatra Mountains), Nízke Tatry (Low Tatras), Chočské vrchy Mountains, Malá Fatra- Krivánska Mountains and adjacent basins	*
7	Slovenské Rudohorie (Slovak Ore Mountains), Branisko Mountain Range and adjacent basins	***
8	Veľká Fatra Mountain Range, Malá Fatra-Lúčanská Mountain Range, Kremnické vrchy (Kremnica Mountains), Štiavnické vrchy (Štiavnica Mountains), Starohorské vrchy (Staré Hory Mountains), Poľana Mountain Range and adjacent basins	*
9	Vtáčnik Mountains, Tríbeč Mountains, Strážovské vrchy (Strážov mountains), Žiar Mountain Range	*

Risk of negative impact of climate change
0 – minimum risk, *medium risk **high risk ***very high risk

Prolonged drought in the summer and autumn months associated with water scarcity may be a major consequence of climate change in the Slovak Republic. These dry periods may be punctuated by brief episodes of torrential rain or heavy storm activity with rain, causing flooding to occur.

Long droughts can cause significant water shortages. Based on current trends, climate change is likely to have a significant negative impact on local water resources with low water volumes, particularly in the southern regions of the Slovak Republic, depending on a wide range of other underlying factors (both natural and anthropogenic). Changes in the hydrological regime show an increased need for redistribution of runoff from areas between the north and south of the Slovak Republic (in other words, between higher and lower altitudes), i.e. redistribution of runoff inter-annually or over the course of the year. It is also important for water supply and electricity generation by exploiting hydropower potential. The measure will cover the decrease in yield from water resources, especially in the lowland parts of central and eastern Slovakia during the summer months.

Changes in precipitation and runoff patterns, and an increase in the number and intensity of extreme hydrometeorological and hydrological events due to climate change can have a major impact on the health and life of the population. In addition to the direct threat to life and health during floods, risks associated with the deterioration of the quality of water resources as well as epidemiological risks are expected to become more frequent. The effects of flooding can cause chemical contamination of water bodies and groundwater sources intended for human consumption. During periods of low water levels, the risk of eutrophication and increased water temperature can affect water quality.

7.3.5.2 Adaptation Measures in the Water Management

Adaptation in our country could be divided into two parts. One is to eliminate the effects of drought, e.g. increasing flow and water yields on the one hand and minimising the impacts of floods, especially flash floods in mountainous and foothill areas, on the other. Proper adaptation measures need to be prepared and implemented to eliminate the adverse effects of climate change. Most of the focus is on water resources, their conservation and efficient use. Water, as a vital component of the environment, is an irreplaceable raw material and natural resource of strategic importance for the security of the state, the lack of which may endanger the life and health of the population or jeopardize the performance of the basic functions of the state. This resource needs to be protected and its efficient and appropriate use needs to be managed to ensure the sustainable use and development of society. Adaptation to climate change in the water management sector should therefore focus on the implementation of measures to better manage runoff in individual river basins:

- completion of the system of multi-purpose water reservoirs, public drinking water sources and provision of the required quantity and quality of water for agriculture and industry;
- completion of the flood protection system for river basins, especially in the residential areas of municipalities;
- reconstruction of technical structures and gradual implementation of hydro-melioration measures in forestry and agriculture in order to increase flood protection in the most vulnerable “small” river basins in the area.

The following complementary measures have been proposed at national level for adaptation to climate change in the Water Plan of the Slovak Republic:

- revise the system for determining the maximum design flow and subsequent evaluation of the flood safety of dams;
- revise the prospective water demand;

- evaluate the provision of water withdrawal from water works for water supply, power generation and augmentation of minimum flows;
- develop a methodology to assess drought - use complementary indicators alongside current practice;
- investigate drought and its impact on the ecological status of water bodies;
- expand research on the impacts of climate change.

7.3.6 Impacts of Climate Change in the Tourism

In the Slovak Republic, the tourism sector is determined by the diverse topography and mild climatic conditions of the country. Several types of tourism can be recognised in Slovakia: summer tourism, winter tourism, spa and health tourism, cultural and urban tourism, conference tourism, rural tourism, agritourism, ecotourism or geotourism.

In the near future, according to experts, the vegetation zones are expected to shift towards the poles. Temperatures are expected to rise in winter. The decrease in the number of days with continuous snow cover will be felt by ski resort operators through lower revenues and higher costs for artificial snowmaking. Although on the one hand less energy will be used for heating, on the other hand there will be higher costs for air conditioning in the summer months. Tropical summers will occur more frequently. The years 2011-2016, with the exception of 2014, were characterised by heat waves. Lower rainfall is expected in the summer months, which will affect the scarcity of water, which is the most exploited raw material in the tourism sector.

Regional manifestations of climate change will affect both tourist destinations and tourists, as climate and weather conditions are a significant factor in tourists' destination choices. The climate primarily defines the length and quality of the tourist season. The tourism sector is highly dependent on seasonality and climatic conditions change the environmental setting of tourist destinations. Tourists choose the climate that matches their holiday plans. The gradual change in climate is causing a search for other destinations and travel in season.

While tourists can change their behaviour relatively easily, service providers in the tourism sector are less flexible and climate change will have the worst impact on their business. The highly competitive environment in the tourism sector and low margins must also be taken into account. The consequences of climate change require more costs for artificial snow, irrigation and air conditioning. Tourists and tour operators can adapt to climate change more easily than local tourism service providers and local economies dependent on tourism revenues.

Loss of snow cover - *A territorial study of climate change in the Slovak Republic* suggests that global warming in our area may be reflected in an average increase in air temperature of 2-4 °C in 2075. At altitudes below 1,100 metres above sea level, continuous snow cover is unlikely to occur. 76% of the ski resorts in the Slovak Republic are below 1,100 metres above sea level, 16% of them for the most part and only 6% are above this altitude. The construction and operation of ski resorts in most mountain areas is cost and energy intensive due to the need for artificial snow. Experts say a 1.8°C rise in temperature would mean that at an altitude of 1,500 metres above sea level, snow would remain on the ground for a period shorter by about 40 days. With a warming of 1 °C, there is a threat of up to a 60 % reduction in natural snow. The period of continuous snow cover will start later, the snow cover on mountain heights will be much lower, which also increases the amount of avalanches. In mountain resorts, winter can be shortened by up to three weeks. The cost of operating lifts is rising, especially for smaller companies investing in new technologies, and this could have a negative impact, especially with uncertain forecasts. Snow guns are priced in the hundreds of thousands of euros and have a huge energy and water consumption. Artificial snow melts more slowly and shifts the growing season of the local flora due to its unnatural composition, which enriches the soil differently compared to natural snow, affecting the species composition. Seasonal attractions are becoming increasingly important in mountain areas.

Increased number of tropical days - in 2015, the Slovak Hydrometeorological Institute issued the first temperature warning of the highest degree for the entire territory of the Slovak Republic for several consecutive days. By 2050, the occurrence and duration of heat waves is likely to expand by three days. The number of days with temperatures above 35-40°C is expected to increase in areas with drier conditions and lower vapour cooling. Temperatures above 40°C are not only uncomfortable but can also lead to heart attacks from the heat. Rainfall is expected to decrease in the summer months, which will be reflected in water scarcity.

Vacationers will therefore shift their travel to later or earlier in the year when the heat is not as intense. This is particularly reflected in domestic tourism, which will move to the fringes of the summer season. Overheated buildings require increased electricity and water consumption. Forest fires caused by heat waves can destroy natural attractions and tourist infrastructure.

Increased activity and intensity of rainfall - cities are at risk of flooding during heavy rainfall because the water does not dry out quickly due to impermeable surfaces. Old sewerage systems struggle to accommodate more water, causing damage to transport infrastructure, impairing traffic flow on closed roads and railways, and delaying services. Tourists react sensitively to information about floods. Over the last 10-12 years, extreme daily rainfall events have been on an increasing trend, causing localised flooding in different parts of the country, posing risks to tourist facilities and increasing insurance costs.

Storms - severe weather conditions can be expected to recur and will have a negative impact on tourist safety.

Changes in soil composition - erosion, changes in soil acidity and moisture can, in extreme cases, mean the destruction of archaeological sites and natural resources.

New diseases - warming causes the migration of animals that are not typical of our climate and are likely to spread diseases (e.g. malaria). Increased incidence of infectious diseases, tick-borne diseases and prolonged pollen season should also be expected. Increased numbers of pests that survive milder winters may cause an increase in the price of agricultural production and thus reduce household disposable income.

Threats to biodiversity - a reduction in environmental and aesthetic values automatically means a reduction in interest in a tourist destination.

The impact of tourism on climate change

The tourism sector has a significant impact on climate change. The biggest emitters of greenhouse gases are air transport and accommodation facilities that use heating and air conditioning. Tourists become both agents and victims of climate change. They contribute to climate change during transport to destinations, accommodation, meals, activities, excursions and shopping.

In the Slovak Republic, tourists use cars for transport to holiday destinations, although the intensity of car transport for other purposes (commuting, business trips, shopping, etc.) is much higher. The number of visitors to the Slovak Republic arriving by air is insignificant compared to the total volume of air transport. However, the increasing standard of living and purchasing power of the Slovak population predict an increased use of car and air transport for tourism purposes. The transport of raw materials (e.g. for food preparation) is particularly intensive in areas with limited local resources.

Tourism in general overuses water resources to operate hotels, water parks, swimming pools, golf courses, ski slopes with artificial snow and tourist consumption. The effects of climate change are exacerbated when mismanagement of a destination leads to incorrect location of facilities. Soil and vegetation erosion occurs, which greatly reduces plant vigour and changes the composition of the flora in the area.

7.3.6.1 Vulnerability Assessment in the Tourism

The impacts of climate change on the tourism sector could be both negative and positive, depending on the type of tourism.
Positive impacts:

- summer tourism - an increased number of summer days will help to develop summer tourism in areas with a suitable location.

Negative impacts:

- winter tourism - a reduction in the number of days with snow cover will push the boundary of ski resorts to higher altitudes and bring a shorter winter season to resorts at lower altitudes;
- summer tourism in the southern parts of the Slovak Republic - drought may affect summer water sports;
- spa and health tourism - extending the growing and flowering season will reduce the number of days suitable for this type of recreation, which may reduce the number of visitors due to unfavourable conditions;
- cultural and urban tourism - heat waves and extreme weather conditions will affect the climatic comfort of visitors;
- rural tourism and agritourism - this type of tourism indirectly reflects the impact of climate change on crop and livestock production.

7.3.6.2 Adaptation Measures in the Tourism

The following measures can contribute to sustainable tourism and development:

- responsible destination management based on sustainable tourism principles;
- shifting the focus of tourism activities towards environmentally innovative forms that strike the perfect balance between conservation and tourism development;
- development of ecotourism - including activities with relatively low impact on ecosystems. The development of geotourism, which not only preserves but also develops the natural, cultural and historical values of the area for future generations and allows visitors to actively experience the atmosphere of the area. As a result of the negative impacts of climate change, tourism operators will be forced to pay more attention to those groups of tourism products that are not dependent on the season (e.g. spa tourism, which has the highest occupancy in the summer, but also allows for year-round operation).

7.3.7 Impacts of Climate Change in the Transport

The geographical location of the Slovak Republic in Central Europe and its location in relation to most of the major economic centres and ports of Europe means that the Slovak Republic is a crossroads of major transcontinental transport routes:

- the north-south route, which connects the ports on the northern Adriatic coast with St. Petersburg and the Baltic Sea ports;
- west-east route, which connects traditional centres in Western Europe with centres in Russia and Ukraine;
- the connection between north-western Europe and the south-eastern part of the continent (connection between North Sea ports and ports on the Balkan peninsula).

The Slovak Republic is therefore a very important transit territory and its transit role is further strengthened by its peripheral location within the European Union, where it serves as the EU's gateway to the economically interesting part of Eastern Europe (Ukraine and other countries of the former Soviet Union).

Adverse weather phenomena can increase the transport time for goods and people and increase the risk of accidents. Extreme weather phenomena (high and low temperatures, severe storms, heavy snow) can cause serious difficulties in almost all types of transport. A comprehensive analysis of the potential consequences of climate change on various sectors, including the transport sector, has been prepared by the Ecological & Forestry Research Agency and is summarised in ***Table 7.4***.

Table 7.4: *Potential consequences of climate change on transport*

Transport	Impact of weather	Consequences
Road transport	Extreme weather (storms, floods)	Road closures, detours, damage to road infrastructure
	Adverse weather conditions (rain, snow, black ice, fog)	Reduced safety and traffic flow, traffic congestion
	Adverse weather conditions (rain, snow, black ice, fog)	Increased winter maintenance requirements, damage to road surfaces
Air transport	Extreme weather (storms, floods)	Disruption of airport services, damage to facilities, flight delays
	Adverse weather conditions (rain, snow, black ice, fog)	Flight delays
Railway transport	Extreme weather (storms, floods)	Disruption of traffic, damage to infrastructure
	Adverse winter conditions (frequent snowfall, wind, long winter)	Increased winter maintenance requirements, damage to rails and sidings
Water transport	Extreme weather (storms, floods)	Disruption of traffic, damage to infrastructure
	Frequent snowfall, wind, long winter	Freezing of rivers - disruption of waterways

Under the conditions of the Slovak Republic, the following impacts of climate change on transport are expected:

- the main road routes will be negatively affected in the future, especially in winter (e.g. by snow cover, ice, wind) and in mountain passes at higher altitudes, especially in the central and northern parts of the Slovak Republic (e.g. Donovaly, Čertovica, Besník, Šturec, Cesta Slobody (Road of Freedom) in the High Tatras - especially their western part from Smokovec to Podbanské);
- in the highest parts of the road corridors near Štrbské pleso and Čertovica we can expect a higher amount of precipitation in winter;
- a decrease in snowfall in the country's lowlands, in the number of days with frost and in the number of days with black ice;

- the variability of climate impacts on road transport will increase - from positive in the lowlands to negative at higher altitudes;
- positive impacts of climate change, such as increases in air temperatures, in the mountains and river basins, will be felt in railway transport. The negative impacts of climate change will occur during heat waves, especially in the lowlands in summer;
- as regards railway transport in relation to precipitation, higher precipitation in winter, in river basins and in the mountains, could have a negative impact;
- inland waterways on the Danube, Morava and Váh runoff will be adversely affected due to low flows in summer and freezing water levels in winter;
- aviation will be more sensitive to extreme weather conditions. Bratislava and Košice airports will be negatively affected by dangerous climatic phenomena in winter (e.g. black ice, snow cover);
- the predicted effects of climate change are not expected to affect underground transport (pipelines);
- the mode of transport most vulnerable to climate change is probably road transport (as it is today);
- the most vulnerable regions of the Slovak Republic in terms of transport are river basins and higher altitudes in the northern, central and eastern parts of the country;
- some shorter sections of roads above 1,200 m above sea level are likely to suffer from higher precipitations in winter and other modes of transport are also likely to be problematic in these sections.

7.3.7.1 Vulnerability Assessment in the Transport

Based on an analysis of current knowledge and information on transport in the Slovak Republic, we have estimated the level of risk for all modes of transport (with road transport being the most affected), including their infrastructure (with road and railway transport being the most affected). ***Table 7.5*** shows the level of risk expressed in four grades in each city region.

Table 7.5: *Risk of climate change impacts on transport in individual city regions*

Transport type	Higher territorial unit							
	BA-SK	TT-SK	NR-SK	TN-SK	BB-SK	ZA-SK	PO-SK	KE-SK
Road transport	**	*	*	*	**	**	**	**
Railway transport	*	*	*	*	*	**	**	**
Air transport	*	0	0	0	*	0	*	*
Water transport	*	*	*	0	0	0	0	0
Pipeline transport	0	0	0	0	0	0	0	0

Risk of negative impact of climate change on transport
0 – minimum risk, *medium risk **high risk ***very high risk

Table 7.6: *Summary information on vulnerability and adaptation to climate change in the Slovak Republic*

Area of vulnerability	Examples/comments/adaptation measures
Agriculture	Vulnerability: Gradual increase in aridity of maize-growing areas. Increased water, wind and soil erosion, as well as deterioration of soil structure, poorer water availability in the soil profile and intensified salinisation and sodification processes are expected. Occurrence and spread of pests and diseases of agricultural plants, trees and animals. Adaptation: • Change in the structure of species and varieties of crops grown in the Slovak Republic. • Adaptation of agrotechnical measures to changed agro-climatic conditions. • Support for the revitalisation of old and the construction of new irrigation systems.

Area of vulnerability	Examples/comments/adaptation measures
	• Applying agrotechnical measures to promote soil conservation, cultivation technologies for soils threatened by erosion, use of a higher proportion of organic matter in the soil, improvement of soil retention capacity • Ensuring good land use practices, mosaic landscaping and soil segmentation, promoting maintenance of windbreaks, grass strips, terraces and perennial meadows. • Promotion of organic farming. • Introduction of adaptation measures in agriculture to minimise temperature stress in animals.
Forestry	Vulnerability: • Increase in frequency and severity of droughts and heat waves with impacts on forest health, productivity and susceptibility to secondary biotic damage. It threatens particularly at low and medium altitudes. • Occurrence of new pests and diseases, development of several generations of spruce bark beetle. It threatens throughout the forest area. • Continued decline of secondary stands of Norway spruce, potentially exacerbated by climate change. Moderate, especially in the mid-altitudes. • Increased severity of storms impacting mountain forests in particular. Moderate, with impacts mainly on forests at high altitudes. • Increased risk of forest fires. Moderate, particularly at low and medium altitudes. Adaptation: Change in tree species composition, increasing the proportion of drought-tolerant species, reducing species requiring more water, increasing stand diversity, reducing the proportion of host trees within an increasing range of climate-sensitive pests, considering assisted migration in favour of southern species and origins with phenotypic stability. Adaptive forestry interventions to promote species and structural diversity of stands, natural regeneration and combination with artificial regeneration, long regeneration phases in smaller areas. Shortening the rotation period of tree species with high susceptibility to insects and diseases, in order to accelerate the transition to a more appropriate species composition. Support for forest monitoring aimed at early identification of adverse trends in forest development. Optimising the forest road network. Improvement of accessibility to areas requiring remediation measures and to stimulate small-scale farming. Financial support for economic practices that address climate change adaptation.
Biodiversity	Vulnerability: Invasions of certain insects as agricultural pests. Invasions of vector-borne diseases threatening to human health. Biodiversity decline. Vulnerable ecosystems such as pine forests in the mountains, swamp ecosystems in the foothills and mountains as well as aquatic systems are most at risk. Adaptation: Phytopathological measures in legislation and practice. Conservation of the original species spectrum of biodiversity in the Slovak Republic. Protecting critically endangered species and communities; preventing the drying up of wetlands and aquatic habitats. Completion of infrastructure and capacity in institutional nature conservation. Minimising negative impacts on biodiversity in cooperation with other sectors. Application of ecosystem-based adaptation measures.
Public health	Vulnerability: Extension of the pollen season and its distribution to new geomorphological areas. Adaptation: Pollen season monitoring and dissemination to the public. Impact of extreme air temperatures on cyanobacteria in bathing waters. Adaptation: Bathing water monitoring and quality assessment, dissemination to the public. Deterioration of health conditions of people with cardiovascular and respiratory diseases, asthma, premature death, dehydration due to extreme weather (increasing heat and cold waves, flooding). Adaptation: Outreach and dissemination of information in relation to prevention. Exposure to increasing UV radiation and its negative effects on the skin. Adaptation: Indirectly, through state health oversight of tanning salons. Spread of vector transmission of infectious diseases (mosquitoes, ticks) to new geographical areas. Adaptation: Collection of prevalence data, education and dissemination of prevention information. Effects of heat on population mortality and morbidity. Flood-related mortality and morbidity. Potential future spread of important disease species. Food safety at all stages, from production to consumption. Adaptation: Reducing the health impacts of heat through health protection and health education - changes to future housing standards and infrastructure, improving warning systems about the health effects of heat.

Area of vulnerability	Examples/comments/adaptation measures
	Programmes for disease surveillance and vaccination. National food safety monitoring and control.
Water management	Vulnerability: • Threat to water resources for water supply and power generation. • Decline of water sources in the south and east of the Slovak Republic. • Decline in electricity generation at large hydraulic power plants. • Increase in the incidence of droughts and floods. • Change in the hydrological cycle. Adaptation: • Protection of water resources. • Increased need for redistribution of runoff between north and south. • Identification of prospective and additional water sources and their exploitation. • Efficient water management in the country. • Reassessment of large and small flood control reservoirs.
Tourism	Vulnerability: Less snow and irregular occurrence of snow cover at lower elevations. Winter season shorter in some locations. Restriction of water tourism in the south of the Slovak Republic. Adaptation: Reorientation of endangered winter resorts to other activities. Development of sustainable tourism (ecotourism, geotourism). Diversifying tourism options to different seasons.
Transport	Vulnerability: Impact on road traffic in the form of higher precipitation and snow in the mountains. Impact on air transport in the form of hazardous meteorological phenomena. Negative impact of decreasing total precipitation on inland waterway transport. Adaptation: Support for railway transport. Improvement and widening of road corridors, construction of motorways and tunnels. Promotion and development of national air transport.
Power industry	Vulnerability: Impact on power plants in the form of severe weather events, tornadoes, severe storms. Higher energy demand in the summer season. Less water in rivers. Adaptation: Improving the safety of power plants.

7.4 NATIONAL ADAPTATION POLICIES AND STRATEGIES

As the contribution of IPCC Working Group II (WGII) to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) makes quite clear - the consequences of human-induced climate change, including the occurrence of increasingly frequent and intense extreme events, are widespread adverse impacts, loss and damage to nature and humanity worldwide, beyond the natural variability of the climate. Extreme climate and weather events have exposed millions of people to acute food insecurity and reduced water security, and despite progress in adaptation planning, there remains a growing gap between planning and implementation. There is no doubt that we need to strengthen our adaptive capacity and reduce our vulnerability to the impacts of climate change to ensure a resilient society for generations to come.

The Slovak Republic fully respects the reports of the Intergovernmental Panel on Climate Change (IPCC) and accepts the international commitments on climate change adaptation as defined in the UN

Framework Convention on Climate Change, the Paris Agreement and is also part of the implementation of the new EU Strategy on Adaptation to Climate Change of 24 February 2021[152].

The Slovak Republic defines adaptation to climate change as its priority in the strategic document Envirostrategy 2030. The main instrument for increasing the adaptive capacity of the Slovak Republic is the update of the Strategy for Adaptation of the Slovak Republic to the Adverse Impacts of Climate Change from 2014, called the Strategy for Adaptation of the Slovak Republic to Climate Change - Update (hereinafter referred to as the "NAS"), which was adopted in 2018. Another document is the Action Plan to address the impacts of drought and water scarcity in Slovakia - H_2ODNOTA JE VODA (Water is the Value, approved by Government Resolution of the Slovak Republic No. 110/2018).

The Ministry of Environment of the Slovak Republic has also prepared an Action Plan for the implementation of the Strategy for Adaptation of the Slovak Republic to Climate Change (hereinafter referred to as the "NAP"), which is an implementation document of the NAS.

7.4.1 Strategy for Adaptation of the Slovak Republic to the Adverse Impacts of Climate Change (2014)

The first more comprehensive document in this area, which sought to link scenarios and possible consequences of climate change with proposals for appropriate proactive adaptation measures in the widest possible range of areas and sectors, was the ***Strategy for Adaptation of the Slovak Republic to the Adverse Impacts of Climate Change***[153], which was approved by Government Resolution of the Slovak Republic No. 148/2014. The strategy considered the following to be priorities: dissemination of information and knowledge on adaptation issues at all levels of governance as well as for the general public; strengthening of the institutional framework for adaptation processes in the Slovak Republic; elaboration and development of methodologies for a comprehensive assessment of climate change risks from the national to the local level; development and application of methodologies for the economic assessment of adaptation measures (macroeconomic impacts); and elaboration and implementation of a tool for the selection of investment priorities on the basis of the assessment of cross-sectoral aspects of adaptation measures.

7.4.2 Strategy for Adaptation of the Slovak Republic to Climate Change - Update (2018)

Government Resolution of the Slovak Republic No. 148/2014 required the Slovak Government to submit an update of the National Adaptation Strategy to the Slovak Government for discussion, taking into account the latest scientific knowledge in the field of climate change. In 2017, the Ministry of Environment of the Slovak Republic started the preparation of an update of the strategy, which focused on assessing the current state of adaptation and planned activities in critical areas and sectors, defining a general vision for adaptation of selected areas and sectors, and updating the set of adaptation measures and the framework for their implementation. A *multi-ministerial working group for adaptation*, composed of representatives of ministries and their professional organisations, other central government bodies, academia, the non-governmental sector, was involved in updating the strategy, and the public was also given the opportunity to comment. The Commission for Climate Change Policy Coordination at the level of Secretaries of State has been kept informed of the process of updating the National Adaptation Strategy. The updated NAS has undergone a strategic environmental assessment process pursuant to Act No. 24/2006 Coll. on environmental impact assessment and on the amendment to certain

[152] https://eur-lex.europa.eu/legal-content/SK/TXT/PDF/?uri=CELEX:52021DC0082&from=EN

[153] https://www.minzp.sk/files/oblasti/politika-zmeny-klimy/nas-sr-2014.pdf

acts as amended. The Strategy for Adaptation of the Slovak Republic to Climate Change - Update[154] was approved on 17 October 2018 by Government Resolution of the Slovak Republic No. 478/2018.

The main objective of the updated NAS is to increase the resilience and improve the preparedness of the Slovak Republic to face the adverse effects of climate change and to establish an institutional framework and coordination mechanism to ensure effective implementation of adaptation measures at all levels and in all areas. The achievement of the main adaptation objective should be supported by the fulfilment of the sub-objectives, which are: ensuring active development of national adaptation policy, implementation of adaptation measures and monitoring of their effectiveness, strengthening the reflection of the objectives and recommendations of the adaptation strategy in the framework of multi-level governance and business support, raising public awareness of climate change issues, promoting synergies between adaptation and mitigation measures and the use of an ecosystem approach in the implementation of adaptation measures, and promoting the reflection of the objectives and recommendations of the 2030 Agenda for Sustainable Development, the UN Framework Convention on Climate Change and the Paris Agreement.

The Strategy tries to interconnect, to a maximum scope of areas and sectors possible, the scenarios and possible climate change consequences with the draft suitable adaptation measures. In terms of adaptation to the adverse impacts of climate change, the following are considered key areas and sectors: the rock environment and geology, the soil environment, the natural environment and biodiversity, the landscape water regime and water management, the residential environment, public health, agriculture, forestry, transport, tourism, industry, power industry and other business and risk management areas.

Based on the Government Resolution of the Slovak Republic No. 478/2018 - *the first information on the progress achieved in the implementation of adaptation measures in the Slovak Republic is to be submitted to the Government of the Slovak Republic for discussion by 28 February 2023.* This resolution also imposes the task of submitting *an update of the National Adaptation Strategy* to the Government of the Slovak Republic for discussion *by 31 December 2025*, taking into account the latest scientific knowledge in the field of climate change.

7.4.3 Action Plan for the implementation of the Strategy for Adaptation of the Slovak Republic to Climate Change (2021)

The preparation of the Action Plan for the implementation of the Strategy for Adaptation of the Slovak Republic to Climate Change[155] (hereinafter referred to as the "NAP"), which started in 2018, was covered by the MŽP SR in cooperation with the Prognostic Institute of the Slovak Academy of Sciences. Based on qualitative and quantitative analyses, adaptation measures were prioritised in the NAP. The prioritisation was based on the results of a participatory process involving all relevant stakeholders. The Action Plan identified short-term targets for the period 2021-2023 and medium-term targets for the period 2024-2027. Actions were prioritised according to importance, feasibility and availability of financial resources. The Action Plan should contribute to a better translation of adaptation measures into the sectoral policies of the ministries concerned. It also includes a proposal for a vulnerability monitoring system, a proposal for a system of mid-term evaluation of the adaptation process in the conditions of the Slovak Republic, including tracking the links between costs and benefits, and a proposal for a platform

[154] https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/strategia-adaptacie-sr-zmenu-klimy-aktualizacia.pdf

[155] https://www.minzp.sk/files/odbor-politiky-zmeny-klimy/akcny-plan-implementaciu-nas.pdf

for the publication and sharing of positive experience. The Action Plan was approved on 31 August 2021 by Government Resolution of the Slovak Republic No. 476/2021.

The Action Plan aims to increase Slovakia's preparedness for the adverse effects of climate change through the implementation of cross-cutting and specific adaptation measures and tasks. At the same time, an institutional framework and coordination mechanism will be supported to ensure effective implementation of adaptation measures at all levels and in all areas, as well as to raise overall awareness of the issue. To achieve the objective, 5 cross-cutting actions are identified:

- Cross-cutting action 1: Strengthening the policy and legislative framework for adaptation and effective setting up of financial mechanisms for the implementation of adaptation measures - Main responsibility: Ministry of Environment of the Slovak Republic together with other central government authorities;
- Cross-cutting action 2: Establishment of a national information system for the provision of climate information - Main responsibility: Ministry of Environment of the SR;
- Cross-cutting action 3: Efficient climate change risk management system - Main responsibility: Ministry of Interior of the SR;
- Cross-cutting action 4: Establishing a functional framework to support science, education and the development of awareness of adaptation issues - Main responsibility: Ministry of Environment of the SR, Ministry of Education, Science, Research and Sport of the SR, Slovak Office of Standards, Metrology and Testing in cooperation with the Ministry of Investments, Regional Development and Informatization of the SR;
- Cross-cutting action 5: Building green infrastructure and green networks - Main responsibility: Ministry of Environment of the SR, Ministry of Agriculture and Rural Development of the SR, Ministry of Transport and Construction of the SR.

These actions are followed up by 18 tasks. The NAP has 7 specific areas at its core: water protection, management and use, sustainable agriculture, adapted forestry, natural environment and biodiversity, health and healthy population, the residential environment, and technical, economic and social measures. Each of these 7 areas has a specific objective, each of which has defined its basic principles and specific measures that define the tasks in that segment. A total of 45 specific measures and 169 tasks have been identified for the period of validity of the NAP until 2027. These measures and their follow-up tasks are based on the NAS.

1. Specific objective on the protection, management and use of water: Improve the adaptive capacity of the country to protect, manage and use water through better management of water as a key challenge under climate change, while enhancing public safety, protection of critical infrastructure and the landscape, relying, inter alia, on the reform of landscape planning and the amendment of the Water Act;

   Basic principles that will need to be applied:

   • Apply good water management practices in integrated river basin management to cope with periods of excessive and low rainfall, floods and droughts

   • Apply the principle of equitable access to water resources for all users, including ecosystems and biota that facilitate adaptation

- Focus adaptation measures at the level of partial floods within an integrated approach to landscape management
- Improve coverage and availability of meteorological and hydrological data for all adaptation decision makers in sufficient detail to address implementation projects at the local level

The Manifesto of the Government of the Slovak Republic for the period 2021-2024 states that the Government of the Slovak Republic will propose a water policy to ensure the gradual restoration of damaged water bodies, to stop water pollution, to halt the decline in the quantity of groundwater and to ensure the sufficiency of drinking water in the regions. The Government of the Slovak Republic will focus on the protection and restoration of natural floodplains, wetlands, small reservoirs and ponds, the protection of natural, free-flowing stretches of watercourses and the revitalisation of regulated sections of streams wherever possible, especially in rural areas.

Resolution of the Government of the Slovak Republic No. 372/2022 of 1 June 2022 approved the Water Policy Concept until 2030 with a view to 2050[156]. Resolution of the Government of the Slovak Republic No. 319/2022 of 11 May 2022 approved the document Water Plan of Slovakia for the years 2022 - 2027[157]. The Ministry of Environment of the Slovak Republic approved the Case Study on Sustainable Use, Protection and Restoration of the Danube River.

2. Specific objective on sustainable agriculture: Increase the adaptive capacity of agricultural landscape management by applying measures aimed at protecting soil, natural resources and promoting the biodiversity of agricultural landscapes and encouraging sustainable crop and livestock production;

   Basic principles that will need to be applied:

   - Apply environmentally sound agricultural practices to protect the soil, including increasing soil organic matter
   - Support the creation of diverse structures in the agricultural landscape to address the increasing risks arising from changing climatic conditions, including the protection of biodiversity as well as genetic resources
   - Support the diversification of agricultural production, including plant protection, plant breeding and a balanced support for livestock production
   - Support adaptation measures to increase soil water retention as well as to address irrigation

On 10 February 2022, Government Resolution of the Slovak Republic No. 94/2022 approved the document “Strategic Plan of the Common Agricultural Policy for 2023-2027” (SP CAP)[158], which Slovakia was obliged to draw up in order to be able to draw support from the European Agricultural Guarantee Fund and the European Agricultural Fund for Rural Development. It is the basic programming document of the EU’s Common Agricultural Policy to support the sustainable development of agriculture, food industry, forestry and rural areas.

The Ministry of Agriculture and Rural Development of the SR based the preparation of the SP CAP on a thorough analysis of the strengths and weaknesses as well as the prospective branches of the sector,

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[156] https://www.minzp.sk/voda/koncepcne-dokumenty/koncepcia-vodnej-politiky-roky-2021-2030-vyhladom-do-roku-2050.html

[157] https://www.minzp.sk/voda/vodny-plan-slovenska/

[158] https://rokovania.gov.sk/RVL/Material/26898/2

which are defined in the *“Vision of common practices in building a modern agriculture in the horizon of the year 2035”* adopted by the Government of the SR. The vision contains targeted, focused and well-thought-out plans on how to make the Slovak countryside more efficient.

3. Specific objective on adapted forest management: Enhance the adaptive capacity of forests to ongoing climate change through a comprehensive and holistic approach;

   Basic principles that will need to be applied:

   • Approximation of tree species composition and exploitable genetic resources of forest tree species towards a state of maximum stability and resilience to climate change

   • Encouraging and promoting alternative management models that support the stability and resilience of forest stands

   • Updating and incorporating the latest knowledge on the impacts of climate change on forests into legislation and practice

The National Forestry Programme is a strategic national document through which the state implements its forestry policy objectives. The development of national forestry programmes results from international agreements in the implementation of which the Slovak Republic participates. The international debate on national forestry programmes began in 1992 at the United Nations Conference on Environment and Development. It further continued under the auspices of the Intergovernmental Panel on Forests, the Intergovernmental Forum on Forests, and is now prominent on the agenda of the UN Forum on Forests. The first National Forestry Programme was approved in 2007. In accordance with it, the Action Plan of the National Forestry Programme of the Slovak Republic for the years 2007 - 2013 was adopted and after the evaluation of the implementation of its measures, the framework objectives of the National Forestry Programme of the Slovak Republic for the period 2014 - 2020 were updated and the next Action Plan of the National Forestry Programme of the Slovak Republic for the years 2014 - 2020 was adopted. The Ministry of Agriculture and Rural Development of the Slovak Republic is currently preparing the document “National Forestry Programme for 2022 - 2030”.

4. Specific objective on the natural environment and biodiversity: Enhance the adaptive capacity and ecological stability of landscapes through better water management for biodiversity and improved adaptive management of all types of territories, taking into account the dynamics of ecosystem development;

   For effective steps to meet this objective, it will be necessary to:

   • Increase water retention in the landscape for nature and biodiversity

   • Support the creation of diverse and resilient landscape structures adapted to changing climatic conditions

   • Enhance the adaptive capacity of agricultural and forest landscapes by promoting biodiversity and ecosystems

   • Protect and revitalise ecosystems and promote the natural evolution of habitats using land-use planning and zoning tools

   • For reasons of energy security and in the context of the international commitments of the Slovak Republic (Integrated Energy and Climate Plan), respect ecosystem services to the extent necessary, including e.g. the use of hydropower, while at the same time ensuring the requirements for the ecological stability of the landscape, nature protection and biodiversity.

The Updated National Strategy for the Protection of Biodiversity to 2020 was approved by Government Resolution of the Slovak Republic No. 12/2014 of 8 January 2014. The main objective of the National Strategy 2020 follows from the EU's commitment to "stop the loss of biodiversity and degradation of ecosystems and their services in the Slovak Republic till 2020, to ensure the recovery of biodiversity and ecosystems to a suitable extent, and to increase our contribution to preventing the loss of biodiversity in global scope." The vision set by the SR in this document is that "The natural capital of the Slovak Republic – biodiversity, ecosystem services , and goods are sufficiently protected, assessed on a regular basis, reasonably utilised, and where suitable, also recovered till 2050 due to their internal values and for their non-negligible contribution to well-being and economic prosperity of the Slovak Republic. The adopted measures and policies at national level prevent adverse changes, which would be caused by the loss of natural capital." Subsequently, in 2014, the Action Plan for the implementation of measures resulting from the Updated National Biodiversity Conservation Strategy until 2020 was also approved.

Update of the Slovak Wetland Management Programme until 2024 and the Wetland Action Plan for 2019-2021: The Slovak Wetland Management Programme is the basic strategic document for the implementation of the commitments arising from the Ramsar Convention and is primarily based on its strategic plan. The programme includes the related Objective 11: Ongoing or completed restoration (revitalisation) in degraded wetlands, preferably in sites that are important for biodiversity conservation, disaster risk reduction, maintaining the standard of living of inhabitants and/or climate change mitigation and adaptation.

Tasks related to climate change include Task 11.2: Ensure the implementation of the proposed adaptation measures from the updated Strategy for Adaptation of the Slovak Republic to Climate Change (protection measures in infiltration areas and spring areas, solution of environmental burdens, increase of the inundation and retention capacity of the landscape, anti-erosion measures, changes in the use of agricultural land, sustainable grassland management, management and revitalisation of wetlands, including peat bogs, enabling the natural dynamics of streams, creation of wetlands, also in built-up areas, afforestation, building green infrastructure, etc.)

Prioritised Action Framework (PAF) for NATURA 2000 in the Slovak Republic in the Multiannual Financial Framework for 2021-2027: The PAF priority measures will not only contribute to the specific objectives of the EU Nature Directives, but will provide significant socio-economic as well as ecosystem service benefits to society. Benefits may include climate change mitigation and adaptation, or other ecosystem services such as those related to tourism and culture.

5. Specific objective on health and healthy population: Respond proactively and preventively to changing climatic conditions and ensure an adequate healthy environment for living, working, housing and recreation;

   To improve adaptation in health, it will be necessary to:

   • Promote measures to ensure a healthy environment in spatial planning and construction and in the management of protected and natural areas

   • Strengthen dialogue between institutions responsible for public health, nature and biodiversity conservation and emergency management and promote the development of joint strategies and plans

• Promote the protection of employees' health by ensuring appropriate working conditions in the event of weather extremes

Government Resolution of the Slovak Republic No. 3/2019 of 9 January 2019 approved the National Environmental and Health Action Plan of the Slovak Republic V (NEHAP V)[159]. The primary objective of NEHAP V is to minimise risks from the environment that may harm and endanger human health through the proposed activities of individual elaborated priority areas. The document says it is essential to strengthen efforts to address the main environmental determinants affecting individual and population health, which are air pollution, water pollution, inadequate drinking water supplies, hazardous chemicals, noise, waste, contaminated sites and climate change. Improving the quality of the environment is a prerequisite for creating a healthy residential environment for a good quality of life. NEHAP V is an important tool to strengthen processes In favour of improving environmental health with the involvement of relevant partners from different sectors.

6. Specific objective on the residential environment: Contribute to the creation of a quality legislative, institutional, professional and financial environment for systematic and comprehensive actions of local governments in the process of adaptation to climate change in the residential environment (in cities and municipalities);

   To improve adaptation in the residential environment, it will be necessary to:

   • Prepare an enabling legislative environment for achieving a suitable adaptation environment in settlements

   • Provide methodological and consultative support for municipalities in the field of adaptation of settlements

   • Ensure financial coverage for the implementation of adaptation measures in the residential environment

The new Act on Spatial Planning No. 200/2022 Coll. keeps in mind the protected interests of the state in the process of creating spatial planning documentation. A new feature is that the landscape plan, the flood risk map, or the principles for the protection of heritage sites will also become binding for the creation of spatial plans. Their use will be supervised by specialised authorities under the Ministry of Environment. A key role in implementation will be played by the Landscape Planning Act, which the Ministry of Environment will submit to the National Council of the SR later this year.

The new Construction Act No. 201/2022 Coll. ensures the participation of the affected public if the construction plan also concerns a protected part of nature. It also facilitates the permitting and implementation of water retention measures. The process of removing illegal structures is simplified.

Both Acts shall come into effect on 1 April 2024.

The link between adaptation and mitigation should also be borne in mind. The Recovery Plan - Roadmap to a Better Slovakia[160] considers it important not only to improve energy performance when renovating buildings, but to link existing instruments with measures to adapt to climate change, which is one of the biggest environmental challenges in today's society. It states that all spheres of life and economic sectors will be directly or indirectly affected by the adverse effects of climate change. As the effects of climate change are already manifesting themselves in Slovakia, it is necessary to adapt the planned projects in

[159] https://www.uvzsr.sk/docs/info/zp/nehap/NEHAP_V.pdf

[160] https://www.mfsr.sk/files/archiv/1/Plan_obnovy_a_odolnosti.pdf

the building sector to the changing situation and to take the necessary measures to increase their resilience to possible negative impacts (e.g. rainwater harvesting, implementation of vegetated roofs, as well as preparation for increasing the average outdoor temperature by passive interventions such as installation of shading technology).

Where technically feasible, the separation of “grey” water (water from sinks, showers that can be used for watering after dilution with rainwater or after pre-treatment in a retention pond) from “brown” sewage water would also be encouraged during restoration. Measures such as green roofs, separation of grey water from brown water, photovoltaics, heat pumps, measures to prevent overheating of buildings (green vegetation wall, external shading elements of windows and doors on façades - pergolas, external blinds, etc.), removal of asbestos or sorting of construction waste during renovation, or the provision of nesting opportunities for protected animals, rainwater harvesting and use for watering green spaces around the building would be appropriately supported financially as additional measures to be applied depending on the specific conditions of historic and listed public buildings and houses. The renovation would also include the reconstruction of the space around the public buildings (where technically and spatially feasible) to achieve adaptation to climate change - planting trees, shrubs, especially on the south and west side of the building, which is more overheated.

Climate risk screening will be carried out during construction and these risks will be taken into account (e.g. changes in floodplains due to climate change).

7. Specific objective on technical, economic and social measures: Strengthening the understanding of adaptation as an economic and social challenge, involving other affected sectors of the economy and improving the implementation framework for cross-cutting and specific actions;

   For effective steps to meet this objective, it will be necessary to:

   - Focus on adaptation to geological risks from climate change
   - Support climate resilience and adaptation of all types of infrastructure, including critical infrastructure
   - Promote the adaptation of the business environment in all types of enterprises, energy and tourism sectors
   - Support solutions to social problems related to climate change.

The main tasks during the NAP implementation period will focus on investments to reduce threats to drinking water sources, territorial stability and to address the issue of old burdens. In order to improve the adaptive capacity of the Slovak Republic, investments in geological surveys will be needed to identify deficit areas in terms of drinking water sources and to verify the yield of these sources, including the strengthening of their protection, as well as measures aimed at the prevention and management of landslide risks.

The starting point for improving the climate resilience of infrastructure is the incorporation of EU methodological recommendations into strategic and environmental assessment (SEA and EIA) processes. Consequently, it would be necessary to build the capacities of the concerned government entities, as well as the business environment, in the use of the methodological recommendations in the preparation of individual projects and activities.

The challenge for supporting the business environment in the context of climate change adaptation is to address the evolution of electricity consumption in relation to climate change but also with the emergence of new modern environmentally and climate friendly technologies (electromobility, smart grid, etc.). There is a need to promote the wider uptake of the smart concept in the energy sector, where, despite the adoption of various concepts and strategies, awareness of the benefits of the smart concept is not yet fully sufficient. Some partial so-called smart concepts already exist in Slovakia (electromobility, smart cities), others need to be created (smart grids, smart homes, smart buildings), it is important to support their interconnection and mutual communication of these concepts as a whole so that they can be called smart energy.[161]

In terms of securing critical infrastructure in the tourism sector, it is necessary to link early warning systems, agro-meteorological information systems, or to create an information system on the state of the weather and alerts, risks of floods or fires in tourism facilities and national park administrations. Furthermore, it is about creating a unified information system for organisers or approvers of different types of events to pass on information about the time, expected number and security of the event.

In terms of addressing the social challenges of climate change, there is a lack of information and data on how climate change will affect household budgets and how targeted interventions could help vulnerable populations. The social costs of adaptation will need to be addressed, in cooperation between central and local government, to develop support schemes to reduce the risks and address the needs of social groups related to the impacts of climate change. It will be necessary to increase the information base and seek optimal solutions within the framework of existing and other possible social policy instruments.

The financing of the NAP tasks is based on the principle of a combination of available resources and their complementarity.

For the purposes of the NAP, we define 6 main resources of funding:

- State budget
- Budgets of local governments
- European funds and the Common Agricultural Policy, including their compulsory national co-financing
- Complementary resources (e.g. Environment Fund, LIFE, EEA and Norway Grants and others)
- Funding of science and research (Horizon 2021-2027, Slovak Research and Development Agency, Scientific Grant Agency and others)
- Private resources

Within the framework of the Partnership Agreement and OP Slovakia for 2021-2027, adaptation to climate change is envisaged as one of the principles for planned interventions in the field of environment. Particular attention will be paid to the residential environment, measures will address the overheating of the landscape and the increasing risk of drought as well as the scarcity of drinking water sources, promote the untapped potential of water retention in the landscape and strengthen capacities to cope with the impacts of extreme weather events. Financing options for NAP measures and tasks in the framework of the programming period 2021-2027 will be continuously refined following the approval of key strategic documents and binding decisions on the distribution of financial allocations.

[161] Smart Industry Concept for Slovakia, https://www.mhsr.sk/inovacie/strategie-apolitiky/smart-industry

The investments of the Recovery Plan - Roadmap to a Better Slovakia in the field of biodiversity and climate are to be directed in particular towards the reform of landscape planning, the reform of nature conservation and water management in the countryside, and the reform of regional adaptation to climate change, with an emphasis on nature conservation and biodiversity development.

7.5 MONITORING, EVALUATION, PROGRESS AND RESULTS

The main responsibility for the implementation, monitoring and reporting on the Strategy for Adaptation of the Slovak Republic to Climate Change - Update and its implementation tool - the National Action Plan lies with the Ministry of Environment of the Slovak Republic, which has a coordinating function within the inter-ministerial and cross-cutting tasks. Inter-ministerial coordination at the highest level was through the Commission for Climate Change Policy Coordination at the level of Secretaries of State. Operational coordination of implementation is carried out through the Adaptation Working Group, whose members are nominated representatives of individual ministries and other central government bodies, other general government organisations, academia, NGOs, or other interested groups. After the approval of the NAP by the Government of the Slovak Republic, a joint coordination, monitoring and evaluation mechanism was prepared, which is an operational document of the Adaptation Working Group and will serve for the ongoing coordination of the work of the group in the implementation of the NAP. At the level of individual sectors, it is recommended that the responsible ministries incorporate the individual NAP tasks in which they will participate into their planning documents, including financial support, at the level of ministries and their organisations, and in the case of other general government organisations, into their planning procedures. It is advisable to prepare stacks of projects (which will be the elaboration of individual tasks in the form of projects) and applications for non-repayable financial contribution. Based on the monitoring of the indicators of individual areas and tasks, the Adaptation Working Group will continuously assess the risks to the implementation of the NAP and propose procedures to eliminate these risks. The Adaptation Working Group will also be regularly informed on the monitored NAP implementation indicators and will contribute to the preparation of the next National Adaptation Strategy and NAP.

Monitoring and analysis of the state of adaptation of the Slovak Republic to climate change will follow two main objectives. Primarily, it is an assessment of the effectiveness of the NAP and the results achieved, which will also serve as a basis for further actions and policies beyond the period of validity of the plan. At the same time, Slovakia's membership in the EU implies strict reporting obligations, monitoring and evaluation of the NAP implementation status, which will also serve for the preparation of evaluation reports. The Action Plan is prepared for the period up to 2027. The expected outcome is an improvement in the horizontal approach to adaptation (crosscutting priorities) and in each of the seven strategic priorities. The fulfilment of the specific objectives of all identified five crosscutting, 45 specific measures and 169 tasks within them will be subsequently evaluated. Cross-ministerial coordination and cooperation between all stakeholders will be key to achieving the objectives of the NAP. The inter-ministerial working group of the Ministry of Environment of the Slovak Republic for adaptation to climate change at the expert level will ensure coordination in the implementation of the plan and will serve for the needs of monitoring and evaluation. The Council of the Government of the Slovak Republic for the European Green Deal will also participate in the inter-ministerial coordination as appropriate. Cross-ministerial coordination will work towards integrating climate change into sectoral policies. This means strengthening the policy and legal framework for adaptation and incorporating adaptation themes and approaches into existing national and sectoral plans and programmes. An important fact of implementation will therefore be the need for clear coordination and leadership of the process, whereby all sectors and stakeholders need to be motivated to participate in the implementation of the identified actions and tasks.

The central government, as the coordinator of the overall implementation environment and the main source of funding, is crucial for the successful implementation of the NAP. A major part of the measures and future steps will take place in the residential environment. On the one hand, the local government is the implementer and guarantor of the measures; on the other hand, it needs political, legislative and financial support from the Government of the Slovak Republic for successful implementation. Other stakeholders that have and will have an impact on the achievement of the NAP objectives are the business sector, the academic sector, education, NGOs and the media. The task for all the concerned coordinators in fulfilling the tasks will be to ensure a detailed assessment of the submitted proposals in order to include (proposed) support schemes to compensate for their negative impacts on vulnerable population groups, if such impacts are identified. This may mean submitting proposals for measures, proposals for new policies or changes to them to meet the tasks and objectives of the proposed material that will have a more substantial negative impact on the economy of vulnerable households, or measures that, because of the high investment required, will be inaccessible to vulnerable groups and therefore will not have a positive impact on their quality of life. In line with EU requirements, the Ministry of Environment of the Slovak Republic will assess the overall situation in the field of adaptation at regular intervals based on the defined framework and the evaluation of the effectiveness and sustainability of the adaptation approach. For the NAP assessment, this means an aggregated assessment based on three criteria:

- How have the adopted and implemented measures and tasks increased the resilience of the Slovak Republic and reduced the adverse impacts of climate change?
- How effective were the measures and tasks adopted and implemented?
- In which areas are the measures and tasks adopted and implemented proving insufficient to avert adverse impacts?

Adaptation of the Slovak Republic to climate change is a challenging and long-term process. The focus of monitoring and evaluation will be at the level of strategic priorities, specific objectives and tasks. Each task is assigned an indicator(s) that will be evaluated on an ongoing basis. At the same time, based on the evaluation of these indicators and based on the assessment of the state in the field, a qualitative assessment will be made of the situation in the implementation of the strategic priorities and specific objectives. Based on the indicators and the results of the assessment, the situation will be evaluated in the context of trends in adaptation.

The following approach is chosen to quantify the proposed indicators: In the case of identifiers assigned to measures or tasks, which in adaptation terminology are called “soft approaches” (methodologies, information systems, information and awareness-raising activities, development of analysis, development of a documented procedure, etc.), it is appropriate to choose a binary classification, i.e. in case the baseline value of the indicator is 0 and the target value is 1 when a given “soft approach” has been implemented (methodology developed, information and awareness-raising activity implemented, information system put into operation, analysis carried out, documented procedure developed, etc.). In the case of identifiers assigned to other measures or tasks, e.g. related to elements of grey, blue or green infrastructure, the task coordinator shall propose a specific solution of the measure or task (a specific project) to meet the cost-effectiveness criteria and on the basis of the precisely defined substantive content of the project, its cost quantification and the specified time horizon of the solution they shall determine the baseline and target value of the indicator. In so doing, they will also take into account whether data relevant to the value of the indicator can be collected efficiently, as data collection should not be more costly than the value of the information it provides. On the one hand, there is a requirement for a transparent and straightforward methodology for calculating the indicator value, but on the other hand, objectively, there are a number of other influences, mainly related to the fact that it is not always possible to collect hard data and measurements. In this case, the use of indicator values in the form of linguistic variables or a Likert scale may be considered if possible or appropriate.

The National Action Plan is conceived as a document that focuses more on guiding the activities and investments towards the objectives increasing the adaptive capacity of the Slovak Republic and reducing the risks arising from climate change. The quantification of some outputs thus faces a high degree of uncertainty, which is related to the fact that it is not possible to decide or specify within the NAP how many investments and how targeted in adaptation will be supported by EU and SP CAP funds, which are key for the implementation of adaptation measures as sources of funding. The NAP thus provides a framework (as was the case with the Recovery and Resilience Plan) for targeting investments, where it is already possible to operate with quantifiable values linked to specific resource allocations.

At the task level, the achievement/non-achievement of the indicators will be assessed. These, together with an analysis of sector-specific contextual indicators, will then provide data for assessing the situation over time:

- Has there been an improvement or deterioration in the policy/legislative framework for adaptation and in the financial mechanisms for the implementation of adaptation measures?
- Is the situation with regard to an effective information system for the provision of climate information better than it was before the start of NAP implementation?
- Does the Slovak Republic improve the crisis management system at all levels of governance?
- Has there been improvement in support for science, education and awareness development on adaptation issues?
- Is the situation improving or worsening with regard to the specific objectives of water conservation, management and use, sustainable agriculture, forestry, natural environment and biodiversity, health and healthy population?
- Is the current state of implementation of technical, economic and social measures better or worse?

For the first time, the coordinators of the individual measures or tasks will also evaluate the quantitative implementation of these measures and tasks using the relevant indicators by 31 December 2022, and every two years thereafter by 31 December of the respective year, with the understanding that the Ministry of Environment has used and will continue to use these evaluations in the preparation and reporting to the EC on national adaptation measures pursuant to Article 19(1) of Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action (according to the wording of the regulation for the first time by 15 March 2021 and every two years thereafter). In accordance with this requirement, the Ministry of Environment of the Slovak Republic prepared a Report for the European Commission as of 15 March 2021, which was subsequently resubmitted in May 2021, using the Reportnet 3 tool prepared by the European Environment Agency (the report in English, including annexes, is available at the following address: https://reportnet.europa.eu/public/country/SK).

The coordinators will also monitor the effectiveness and efficiency of the measures implemented, with the possible development of relevant recommendations for practice. An important part of the evaluation will also be to assess the extent to which the public has been involved in the implementation process, the "co-ownership" of the topic by different stakeholders and the sustainability of the approaches at national and local government level.

Responsibility for individual measures and tasks in the NAP is directly determined in accordance with Act 575/2001 Coll. on the organisation of the activities of the Government of the Slovak Republic and the organisation of the central government of the Slovak Republic and also establishes the relevant timetable.

The National Action Plan, which is valid until 2027, has an obligation to submit information on the progress made in meeting the short-term objectives of the NAP to the Government of the Slovak Republic by 30 June 2024, as stipulated in Government Resolution of the Slovak Republic No. 476/2021.

CHAPTER 8 PROVIDING FINANCIAL, TECHNOLOGICAL AND CAPACITY-BUILDING SUPPORT TO DEVELOPING COUNTRIES

This chapter provides an overview of projects addressing the impacts of climate change, as well as an overview of similar activities that originally had a different purpose but also contribute to climate change mitigation or adaptation. Similar activities come from projects implemented with financial support from the Slovak Republic for developing countries in 2019-2020. The following activities were selected from the overall portfolio: climate change adaptation activities, climate change mitigation projects, support and capacity building projects in drinking water supply, waste management, organic farming, food security, afforestation and renewable energy development.

All financial support of the Slovak Republic at the bilateral and multilateral level, which was intended for developing countries in the field of climate in 2019 - 2020, went through official development assistance in accordance with the procedures of the OECD Development Assistance Committee. The Report on Development Cooperation of the Slovak Republic is submitted by the Ministry of Foreign and European Affairs of the Slovak Republic (hereinafter referred to as the "MFEA SR") to the Government of the Slovak Republic annually in accordance with Act No. 392/2015 Coll. on development cooperation and on the amendment to certain acts, as amended by Act No. 281/2019 Coll. (hereinafter referred to as the "Act on Development Cooperation").

Through Official Development Assistance (ODA), the Slovak Republic assists less developed countries, contributes to the implementation of the 2030 Agenda for Sustainable Development Goals and to addressing major global challenges, including conflict mitigation and post-conflict stabilisation. The starting point for the implementation of development cooperation is the Medium-Term Strategy for Development Cooperation of the Slovak Republic for 2019-2023. In 2020, the COVID-19 pandemic was added to the long-term challenges, particularly in the form of migration and climate change and its consequences. The development cooperation of the Slovak Republic was thus largely tailored to the need to address the humanitarian needs of partner countries resulting from the pandemic. Shortly after the outbreak of the pandemic, Slovakia demonstrated its solidarity and responded promptly to the acute needs of partner countries, in particular through humanitarian assistance. At the same time, the necessary changes in the setup of the instruments and in the implementation of SlovakAid activities were implemented in order to increase their usability in the changed conditions. Assistance was provided in both material and financial form, directly to partner countries, as well as in support of international initiatives and activities of international organisations. The total amount of development assistance from the Slovak Republic related to supporting partner countries in their fight against the COVID-19 pandemic disbursed in 2020 amounted to approximately 3.78 million EUR (ODA SR Annual Report 2020).

With its activities to support partner countries in the fight against the COVID-19 pandemic, Slovakia joined the EU and its Member States' initiative called Team Europe. The initiative aims to help less developed countries cope with the health crisis and the resulting humanitarian needs, strengthen health, water and sanitation systems, and mitigate the social and economic impact of the pandemic. The amount of development assistance contracted by the Slovak Republic until the end of 2020, which represents a contribution to Team Europe, amounted to approximately 11 million EUR[162].

[162] These are funds earmarked in the state budget of the Slovak Republic for various forms of development cooperation earlier and allocated after the outbreak of the pandemic to support partner countries in the fight against the spread of the COVID-19 disease.

The provision of material humanitarian assistance in support of the fight against pandemic COVID-19 involved a range of actors from the general government, non-governmental and private sectors. Material humanitarian assistance was provided to Kenya, Ukraine and North Macedonia. Financial contributions for the purchase of equipment and medical supplies were made to hospitals in Moldova, Montenegro, Serbia and Georgia. Slovakia's support for the fight against the pandemic was also implemented through financial contributions to several international organisations: World Health Organization (WHO), the International Committee of the Red Cross, the United Nations High Commissioner for Refugees (UNHCR) for activities in Ukraine, and the UN Multi-Partner Trust Fund.

In 2019, the Slovak Republic contributed to Green Climate Fund – 1 814 059 EUR and Intergovernmental Panel on Climate Change – 100 000 EUR. In 2020, the Slovak Republic did not contribute to the Green Climate Fund, but it is committed as follows:

- 2021 – 500 000 EUR
- 2022 – 1 000 000 EUR
- 2023 – 500 000 EUR

In 2019-2020 the Slovak Republic supported 22 capacity building and technology transfer projects in developing countries with capacity building as the main objective, for a total amount of 1 009 917 EUR. Of these, only one project focused on technology transfer (in 2020), five projects were combined - both capacity building and technology transfer. Other projects focused explicitly on capacity building.

The Slovak Republic does not possess of any information on climate related private finance mobilization in 2019-2020, therefore this report embraces only the financial support from public sources.

More information can be found in chapter 7 of the Fifth Biennial Report of the Slovak Republic.

Table 8.1: *Provision of public financial aid: summary information for 2019*

Channels for the allocation of funds	Year									
	In European currency - EUR					In American dollars – USD*				
	Core/general	Climate-specific				Core/general	Climate-specific			
		Climate change mitigation	Climate change adaptation	Cross-cutting	Other		Climate change mitigation	Climate change adaptation	Cross-cutting	Other
Total amount of contributions through multilateral channels:	1 638 010.60	1 424 797.10	91 127.19	1 914 059		1 597 715.50	1 389 747.09	88 885.46	1 866 973.14	
Multilateral sources of climate change finance		364 077.10	91 127.19	1 814 059			355 120.80	88 885.46	1 769 433.14	
Other multilateral sources of funding				100 000					97 540.00	
Multilateral financial institutions, including regional development banks	1 250 000.00	1 060 720.00				1 219 250.00	1 034 626.28			
UN specialised agencies, funds and programmes	388 010.60					378 465.53				
Total value of contributions through bilateral, regional and other channels		1 124 067.50	1 356 013.70				1 096 415.43	1 322 655.76		
Total value of funds earmarked for climate change financing	**1 638 010.60**	**5 910 064.51**				**1 597 715.53**	**5 764 676.92**			

Table 8.2: *Provision of public financial aid: summary information for 2020*

Channels for the allocation of funds	Year									
	In European currency - EUR					In American dollars – USD*				
	Core/general	Climate-specific				Core/general	Climate-specific			
		Climate change mitigation	Climate change adaptation	Cross-cutting	Other		Climate change mitigation	Climate change adaptation	Cross-cutting	Other
Total amount of contributions through multilateral channels:	661 638.19	379 241.80	93 549.98			645 361.89	369 912.45	91 248.65		
Multilateral sources of climate change finance										
Multilateral financial institutions, including regional development banks										
UN specialised agencies, funds and programmes										
Total value of contributions through bilateral, regional and other channels		603 425.00	796 461.00	30 323.00		588 580.74	776 868.05	29 577.05		
Total value of funds earmarked for climate change financing	**661 638.19**	**1 903 000.78**				**645 361.89**	**1 856 186.96**			

**The relevant values have been calculated using the Euro reference exchange rates (European Central Bank) of 23 September 2022; EUR 1 = USD 0.9754; Source: http://www.ecb.int/stats/eurofxref/*

Table 8.3: *Provision of public financial aid through multilateral sources in 2019*

Donor funding	Total amount				Status	Funding source	Financial instrument	Type of support	Sector
	Core/general		Climate-specific						
	European euro - EUR	USD	European euro - EUR	USD	Committed, Disbursed	ODA, OOF, other	Grant, Concessional loan, Non-concessional loan, Equity, Other	Mitigation, Adaptation, Cross-cutting, other	Energy, Transport, Industry, Agriculture, Forestry, Water and sanitation, Cross-cutting, other, Not applicable
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund			1 814 058.96	1 769 433.11	Disbursed	ODA	Other: One-off contribution	Cross-cutting	Not applicable
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds: World Meteorological Organisation			91 127.19	88 885.46	Disbursed	ODA	Other: Membership fee	Adaptation	Not applicable
8. Other multilateral climate change funds: Montreal Protocol Multilateral Fund			356 690.26	347 915.68	Disbursed	ODA	Other: Membership fee	Mitigation	Not applicable
9. Other multilateral climate change funds: Montreal Protocol Trust Fund			7 386.84	7 205.12	Disbursed	ODA	Other: Membership fee	Mitigation	Not applicable
10. Other multilateral climate change funds: The Intergovernmental Panel on Climate Change			100 000.00	97 540.00	Disbursed	ODA	Other: Membership fee	Cross-cutting	Not applicable
Subtotal			**2 369 263.25**	**2 310 979.37**					
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian development Bank									
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other: Council of Europe Development Bank			650 000.00	634 010.00	Committed	ODA	Grant	Mitigation	Water supply - large systems, wastewater

Donor funding	Total amount				Status	Funding source	Financial instrument*	Type of support	Sector
	Core/general		Climate-specific						
	European euro - EUR	USD	European euro - EUR	USD	Committed, Disbursed	ODA, OOF, other	Grant, Concessional loan, Non-concessional loan, Equity, Other	Mitigation, Adaptation, Cross-cutting, other	Energy, Transport, Industry, Agriculture, Forestry, Water and sanitation, Cross-cutting, other, Not applicable
									management/disposal energy conservation and demand-side efficiency
8. Other: AgriFI Challenge Fund	1 250 000.00	1 219 250.00			Disbursed	ODA	Other: Contribution	Adaptation	Agriculture
9. Other: International Investment Bank			410 720.00	400 616.29	Committed	ODA	Grant	Mitigation	Energy, Renewable energy resources
Subtotal	**1 250 000.00**	**1 219 250.00**	**1 060 720.00**	**1 034 626.29**					
Specialized United Nations bodies									
1. United Nations Development Programme (specific programmes)									
2. United Nations Environment Programme (specific programmes)									
3. Other: The United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	11 828.00	11 537.03			Disbursed	ODA	Other: Capital subscription	Cross-cutting	Agriculture
4. Other: The Food and Agriculture Organization of the United Nations (FAO)	349 492.6	340 895.08			Disbursed	ODA	Other: Capital subscription	Cross-cutting	Agriculture
5. Other: European and Mediterranean Plant Protection	26 690.00	26 033.43			Disbursed	ODA	Other: Capital subscription	Cross-cutting	Agriculture
Subtotal	**388 010.60**	**378 465.54**							
Total	**1 638 010.60**	**1 597 715.54**	**3 429 983.25**	**3 345 605.66**					

**The relevant values have been calculated using the Euro reference exchange rates (European Central Bank) of 23 September 2022; EUR 1 = USD 0.9754; Source: http://www.ecb.int/stats/eurofxref/*

Table 8.4: *Provision of public financial aid through multilateral sources in 2020*

Donor funding	Total amount				Status	Funding source	Financial instrument	Type of support	Sector
	Core/general		Climate-specific						
	European euro - EUR	USD	European euro - EUR	USD	Committed, Disbursed	ODA, OOF, other	Grant, Concessional loan, Non-concessional loan, Equity, Other	Mitigation, Adaptation, Cross-cutting, other	Energy, Transport, Industry, Agriculture, Forestry, Water and sanitation, Cross-cutting, other, Not applicable
Multilateral climate change funds									
1. Global Environment Facility									
2. Least Developed Countries Fund									
3. Special Climate Change Fund									
4. Adaptation Fund									
5. Green Climate Fund									
6. UNFCCC Trust Fund for Supplementary Activities									
7. Other multilateral climate change funds: World Meteorological Organisation			93 549.98	91 248.65	Disbursed	ODA	Other: Membership fee	Adaptation	Cross-cutting
8. Other multilateral climate change funds: Montreal Protocol Multilateral Fund			371 856.67	362 709.00	Disbursed	ODA	Other: Membership fee	Mitigation	Energy
9. Other multilateral climate change funds: Montreal Protocol Trust Fund			7 385.13	7 203.46	Disbursed	ODA	Other: Membership fee	Mitigation	Cross-cutting
10. Other multilateral climate change funds: The Intergovernmental Panel on Climate Change									
Subtotal			**472 791.78**	**461 161.10**					
Multilateral financial institutions, including regional development banks									
1. World Bank									
2. International Finance Corporation									
3. African Development Bank									
4. Asian development Bank									
5. European Bank for Reconstruction and Development									
6. Inter-American Development Bank									
7. Other: Council of Europe Development Bank									
8. Other: AgriFI Challenge Fund									

Donor funding	Total amount				Status	Funding source	Financial instrument*	Type of support	Sector
	Core/general		Climate-specific						
	European euro - EUR	USD	European euro - EUR	USD	Committed, Disbursed	ODA, OOF, other	Grant, Concessional loan, Non-concessional loan, Equity, Other	Mitigation, Adaptation, Cross-cutting, other	Energy, Transport, Industry, Agriculture, Forestry, Water and sanitation, Cross-cutting, other, Not applicable
9. Other: International Investment Bank									
Subtotal									
Specialized United Nations bodies									
1. United Nations Development Programme (specific programmes)									
2. United Nations Environment Programme (specific programmes)	100 000.00	97 540.00			Disbursed	ODA	Grant	Cross-cutting	Not applicable
3. Other: The United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa	11 310.00	11 031.77			Disbursed	ODA	Grant	Cross-cutting	Agriculture
4. Other: The Food and Agriculture Organization of the United Nations (FAO)	524 858.00	511 946.49			Disbursed	ODA	Grant	Cross-cutting	Agriculture
5. Other: European and Mediterranean Plant Protection	25 470.00	24 843.44			Disbursed	ODA	Grant	Cross-cutting	Agriculture
Subtotal	**661 638.00**	**645 361.71**							
Total	**661 638.00**	**645 361.71**	**472 791.78**	**461 161.10**					

*****The relevant values have been calculated using the Euro reference exchange rates (European Central Bank) of 23 September 2022; EUR 1 = USD 0.9754; Source: http://www.ecb.int/stats/eurofxref/*

CHAPTER 9 RESEARCH AND SYSTEMATIC OBSERVATION

9.1 DOMESTIC RESEARCH ACTIVITIES

The Ministry of Education, Science, Research and Sport of the Slovak Republic (MESRS SR) is the central body of central government for science and technology in Slovakia within the meaning of Act No.575/2001 Coll. on the organisation of government activities and the organisation of the central government, as amended; it manages research and development (R&D) in Slovakia in accordance with Act No. 172/2005 Coll. on the organisation of state support for research and development and on the amendment to Act No. 575/2001 Coll. on the organisation of government activities and the organisation of the central government, as amended.

Policy in the field of research and development is currently shaped also in the context of the European and international research area, which is translated at national level into key strategic documents and system measures such as the strategic document Research and Innovation Strategy for Smart Specialisation of the Slovak Republic 2021-2027 (SK RIS3 2021+), in which the topic of "climate change" is an important part of the identified domains, as well as the strategic material Recovery and Resilience Plan of the Slovak Republic, specifically the parts dedicated to research and innovation for decarbonisation of the economy as well as resilience and adaptation to climate change. In accordance with European documents, climate change is also a priority in strategic materials in the Slovak Republic. Another upcoming strategic document in this area is the National Strategy for Research, Development and Innovation, which will be a binding document for funding research, development and innovation from all public sources until 2030. The support for adaptation to climate change and disaster risk prevention as well as resilience, taking into account ecosystem approaches, is at the same time embedded in the material Programme Slovakia 2021-2027, which is an investment instrument for the growth of the living standards of the population and increasing the competitiveness of the Slovak Republic.

In 2021, the Slovak Republic adopted the Roadmap for Research Infrastructures - SK VI Roadmap 2020-2030. It is a key document of the Slovak Republic for the field of research infrastructures, which not only monitors the current development and current status of major public and private research infrastructure in the territory of the Slovak Republic, but also its interconnection with the economy, domains of smart specialisation, international cooperation in the context of ESFRI (European Strategy Forum on Research Infrastructures) and the European Union's framework programme for research and innovation Horizon Europe for 2021-2027. The material in question was prepared by the Ministry of Education, Science, Research and Sport of the Slovak Republic in cooperation with experts of the World Bank and representatives of the Research Agency and was discussed by the commissions for the coordination of the activities of the Slovak Republic in ESFRI research infrastructures at national level, acting as advisory bodies to the Minister of Education, Science, Research and Sport of the Slovak Republic. The material aims to highlight the importance and potential of the existing research infrastructure and its role as an engine of development and innovation tendencies of the Slovak Republic towards a knowledge-based society. The Roadmap for Research Infrastructures - SK VI Roadmap 2020-2030 monitors in particular the existing R&D infrastructure built from public resources, while building further necessary technical R&D infrastructure focused on industrial research and experimental development with active participation of the private sector is one of the key steps towards transforming the results and outputs of basic research into practice.

Research infrastructures in the Slovak Republic are mainly made up of university scientific parks, research centres and institutions associated in national research and development platforms. Research infrastructure also includes technology, equipment and highly qualified personnel in the private sector. Several research infrastructures are of international importance and individual research institutions are closely linked to international research infrastructures within the ESFRI. Their financing is based on resources from the state budget, resources obtained based on their own project activity and an important part of the financing of research infrastructures in the Slovak Republic are the resources of the European Structural and Investment Funds. The membership fees of the Slovak Republic in international research and development organisations are financed from the budget of the Ministry of Education, Science, Research and Sport of the Slovak Republic based on previous approval of membership by the Government of the Slovak Republic, which allocates funds for this purpose.

Status and funding of research and development

In the Slovak Republic, 6 main actors are involved in the system of public funding of research and development: MESRS SR, Slovak Research and Development Agency (SRDA), Scientific Grant Agency (VEGA), Cultural and Educational Grant Agency (KEGA), Slovak Academy of Sciences (SAS) and Research Agency (VA). In addition, research is also supported financially from the budgets of other ministries, central government bodies and the private sector.

The most important actor of the research and development funding system is the MESRS SR. As the central government body for science and technology, it creates the conditions for its development and is responsible for the efficient use of the state budget funds spent on science and technology.

In 2005, the MESRS SR established the Slovak Research and Development Agency (SRDA) as its state-budget funded organisation. The Agency was established for supporting research and development in Slovakia through the provision of state budget funds for the solution of projects. The main mission of the SRDA is to support cutting-edge basic research, applied research and development in individual groups of fields of science and technology. The Agency fulfils its core mission by providing funding for projects submitted under the Agency's general open calls, for projects submitted under the Agency's government-approved programmes, and for projects submitted under international science and technology cooperation agreements and programmes. Dozens of projects dealing with research on adaptation to the expected impacts of climate change have been and are being solved in the context of the general calls launched by the SRDA. The projects are solved by teams of institutions from various sectors of research and development, especially from the higher education sector and the state sector of research and development through institutes of the Slovak Academy of Sciences and ministerial research institutes, but also from the business sector of research and development.

The Scientific Grant Agency of the MESRS SR and the SAS (hereinafter referred to as the "VEGA") is an internal grant system for the Ministry of Education and the Slovak Academy of Sciences, which ensures a mutually coordinated procedure for the selection and evaluation of basic research projects solved at the workplaces of universities and scientific institutes of the SAS. The VEGA also assesses scientific projects in the field of research aimed at mitigating the adverse impacts of climate change. To support the integration of climate change adaptation into relevant research supported by the VEGA grant scheme, projects were funded in 2021 at public universities, in particular at the Technical University in Zvolen, the Slovak University of Agriculture in Nitra and the Slovak University of Technology in Bratislava, as well as at institutes of the Slovak Academy of Sciences.

The Cultural and Educational Grant Agency of the MESRS SR (hereinafter referred to as the "KEGA") is an internal grant system aimed at the financial support of applied research projects in the field of education, pedagogy and creative and performing arts, initiated by researchers from public universities or the MESRS SR in specified thematic areas from the institutional funds of public universities.

The Research Agency ensures the process of implementation of assistance from the European Structural and Investment Funds of the EU, it is a managing, communicating and coordinating institution operating in the field of education, research and development and as regards competences, it is a part of the MESRS SR (it has the function of an intermediary body).

The SAS has an important place in the system of financing research and development in Slovakia; it is a self-governing scientific institution focused on the development of science, education, culture and economy. In terms of the state budget, it represents a separate budget chapter. It allocates funds from its own resources to finance VEGA projects, as together with the MESRS SR it forms an internal grant system for basic research.

Among the ministerial research institutions operating within the Ministry of Environment of the Slovak Republic, the Slovak Hydrometeorological Institute (SHMÚ) also carries out significant scientific and research activities in the field of climate change under Act No. 201/2009 Coll. (as amended by Act No. 39/2013 Coll.) on the state hydrological service and the state meteorological service. In connection with hydrological and meteorological activities, the SHMÚ supports the improvement of its own professional level:

- it develops research and scientific activities,
- it monitors scientific progress in relevant fields,
- it uses domestic and foreign results of science and research,
- it implements the development of database systems, prediction systems, methods and applications for various fields of human activity,
- it supports the publication of the results of research and scientific activities.

In 2019, the Government of the Slovak Republic took note of the informative material of the MESRS SR on the state of research and development in the Slovak Republic. Underfunding is a long-term problem of Slovak science and research. Research and development expenditure was 0.83% of GDP in 2019, which puts the Slovak Republic behind the EU average of 1.65% of GDP in that period and falls short of the 1.2% target set for 2020 in the Research and Innovation Strategy for Smart Specialisation of the Slovak Republic. This follows from the Report on the State of Research and Development in the Slovak Republic and its comparison with abroad in 2019, which was approved at its meeting by the National Council Committee on Education, Science, Youth and Sport.

In 2020, the share of research and development spending in GDP rose to 0.92% (from 0.83% in 2019). In 2021, the SR spent a total of EUR 918.346 million on research and development, which corresponded to 0.95% of GDP. This amount of expenditure represents in absolute terms an increase compared to 2020 of almost EUR 79 millions. However, we are the sixth worst country in the EU (2020) in terms of both public and total research and development spending. Expenditure on research and development in 2021 from public sources amounted to EUR 404.743 million, expenditure from private sources amounted to EUR 513.603 millions. The aim is to increase private spending on research and development to 1.2% of GDP by 2030 from 0.53% of GDP today.

For the economy of the SR, support for research and development is essential to ensure technological development and products with higher added value. Despite this, the SR has made little progress in innovation. To improve the state of science and research in Slovakia, the following is recommended (based on the findings) in the following periods:

- increase business investment in research and development in the SR,
- support cooperation between the academic environment and the private business sector,
- continue to implement existing R&D support schemes,
- create conditions to support Slovakia's participation in EU framework programmes,
- systematically develop human resources in science and technology,
- support the activities of excellent science,
- create conditions to support the return of experts from abroad to the Slovak Republic,
- increase participation in the Horizon Europe programme compared to the outgoing Horizon 2020 programme.

9.2 INTERNATIONAL RESEARCH ACTIVITIES

There has been some increase in domestic and international activities compared to the previous period. Human-induced and natural climate change and its variability and impact on natural ecosystems and various societal and economic sectors is the focus of scientific interest of several institutions, national and international projects and programmes. A large number of different activities have been carried out mainly in the framework of joint European research, i.e. the COST projects (Cooperation in Science and Technology) of the framework programmes (FP7: 2007-2013, FP8: 2014-2020). Some projects were partly financed by the state budget and European structural funds. Internationally, the most requested projects were national projects dealing with climate change, vulnerability and impacts of climate change. This includes a large number of projects that did not directly address climate change, but rather the physical, chemical and biological processes associated with the kind of impacts that climate change undoubtedly represents.

Research and development in the field of climate change and adaptation to its impacts is a key part of the EU framework programme for research and innovation Horizon Europe 2021-2027, and Slovak R&D organisations are also involved in projects supported under its calls.

The challenges are implemented on the basis of Horizon Europe's first work programme for 2021-2022, which aims, among other things, to contribute to the EU's ambition to become the first climate-neutral continent by 2050. The work programme includes a commitment to invest at least 35% of the allocated funds in calls to meet the climate goals and to support projects that will seek new solutions to reduce emissions, for the transition to clean energy, circular economy and sustainable mobility and food systems, as well as adaptation to the impacts of climate change.

The aim is to promote new products, services and business models and create new markets for climate-neutral products.

It includes the so-called New European Bauhaus concept, which should show the positive impacts of the green transformation on the everyday lives of EU citizens. To support Bauhaus activities, a pilot call will be implemented with a budget of EUR 25 million.

Support for the participation of Slovak research and development organisations in Horizon Europe calls, including in the field of climate change, is ensured in cooperation between the MESRS SR and the Slovak Centre of Scientific and Technical Information through the established network of National Contact Points (NCPs) (including the NCP for Cluster 5 focused on climate).

New Horizon Europe instruments, such as missions addressing current societal challenges and European Research and Innovation Partnerships, also aim to support climate goals and increase resilience.

National experts appointed by the MESRS SR actively participate in the activities of the committees of individual missions:

- Adaptation to climate change and societal transformation - supporting 150 European regions and communities on the path to increased climate resilience
- 100 climate-neutral and smart cities by 2030

As part of the Climate Mission, the European Commission, in cooperation with the MESRS SR, the Slovak Liaison Office for Research and Development in Brussels (SLORD) and the Slovak Academy of Sciences (SAS), organised a kick-off event for the new mission on adaptation to climate change on 23 July 2020, which included a discussion with the public and an opportunity for citizens to present their expectations regarding measures and challenges in the field of climate change.

The MESRS SR is also involved in the new European research and innovation partnership Driving Urban Transitions to a Sustainable Future (DUT) focusing on sustainability in cities and communities, including their ecosystems. Slovak universities (University of Žilina, Slovak University of Technology in Bratislava, University of Economics in Bratislava) will be involved in research and innovation activities.

Based on the request of the European Commission, the interest of the Slovak Republic was also indicated in the preparation and subsequent implementation of further partnerships under the second wave in the period 2023-2024, which also include partnerships focused on climate impacts and agricultural objectives, with the Ministry of Agriculture and Rural Development of the Slovak Republic as the coordinator: European Partnership for Accelerating Farming Systems Transition: Agroecology living labs and research infrastructures MP SR a European Partnership for Safe and Sustainable Food Systems for People, Planet and Climate

9.3 RESEARCH IN THE FIELD OF CLIMATE CHANGE

For the time period including the submitted 8th National Report, 225 research, development and innovation projects have been identified through a qualified process and have been carried out during the period 2017-2021. Of these projects, 181 were domestic and 44 foreign. ***Table 9.1*** shows the institutions and colleges where climate change-related research has been recorded. The largest number was recorded at the entities dealing directly or indirectly with the most vulnerable and at the same time focal sectors within Slovakia, which are forestry, agriculture and water management.

In many cases, the selection of projects was quite challenging, as many of the projects examining the previous 30-40 year period include global change directly or indirectly. At the same time, projects dealing with the implementation of the National Adaptation Strategy or adaptation projects for individual cities or parts of cities as well as regions are not included in the above overview.

Most projects focused on the impacts of climate change now or in light of projected climate change projections over future time horizons. This was followed by projects related to research and development of approaches to mitigation and adaptation. Socio-economic analyses of the impacts of climate change were the next most represented project subject.

Table 9.1: *List of institutions involved in climate change research and number of projects*

No.	Institution	Number of projects in 2017-2021
1	Slovak Hydrometeorological Institute, Bratislava (SHMÚ);	3
2	Faculty of Mathematics, Physics and Informatics of CU in Bratislava (FMFI UK);	1
3	Faculty of Natural Sciences, Comenius University in Bratislava (PriF UK);	15
4	Slovak University of Technology in Bratislava (STU)	20
5	Technical University in Zvolen (TUZVO)	28
6	National Forest Centre in Zvolen (NLC);	11
7	Slovak University of Agriculture in Nitra (SPU)	31
8	Earth Science Institute of the SAS (ÚVZ SAV);	8
9	Institute of Parasitology of the SAS (PAÚ SAV);	4
10	Institute of Landscape Ecology (ÚKE SAV);	9
11	Institute of Forest Ecology of the SAS (ÚEL SAV)	12
12	Institute of Zoology of the SAS (ÚZo SAV);	1
13	Institute of Hydrology of the SAS (ÚH SAV);	22
14	Institute of Geography of the SAS (GEU SAV)	3
15	Institute of Philosophy of the SAS (FiÚ SAV)	2
16	Centre of Social and Psychological Sciences of the SAS (CSPV)	3
17	Botanical Institute of the SAS (BÚ SAV)	4
18	University of Veterinary Medicine and Pharmacy in Košice (UVLF);	2
19	Matej Bel University in Banská Bystrica (UMB);	7
20	Constantine the Philosopher University in Nitra (UKF)	2
21	University of Prešov (PU)	6
22	Pavol Jozef Šafárik University in Košice (UPJŠ)	4
23	National Agricultural and Food Centre (NPCC)	12
24	Water Research Institute (VÚVH)	3
25	University of Žilina (ŽU)	2
26	Technical University of Košice (TUKE)	7
27	Catholic University in Ružomberok (KU)	1
28	Capital City of Bratislava (HM Ba)	1
29	University of Economics in Bratislava (EU Ba)	1

Studies of climate processes and the climate system, including paleoclimatic studies

- Modelling of the hydrological cycle is important, including interaction with the biosphere and the pedosphere Particular emphasis on processes influenced by land cover;
- Paleoclimatic studies are devoted to the research of lake sediments, but also to the study of climate in older geological periods in Slovakia and abroad;
- Slovak researchers are involved in EU-funded European research projects;

Modelling and prediction, including global and regional climate models

No specialized research centre for global climate change modelling has been established in Slovakia. Outputs from several GCMs and RCMs were used in the preparation of national and regional climate change scenarios.

- Statistical and dynamical downscaling of GCM and RCM projections of basic climate variables for the territory of the Slovak Republic is performed. The other variables are obtained by applying the physical equations from the baseline scenarios, especially for the water balance components;
- GCM models are not being developed in Slovakia, but research activities are under way that contribute to the improvement of GCMs. These are carried out by SHMÚ staff for the ECMWF (European Centre for Medium-Range Weather Forecasts);

Research on the impacts of climate change

- The research focuses mainly on sectors and topics that are vital for Slovakia, e.g. water management (floods and droughts), forests (future species composition and production), agriculture (biodiversity and crop yields);
- Research on the impacts of climate change is often interdisciplinary. Physical impacts are examined together with socio-economic factors and potential impacts, and with different types of mitigation and adaptation;

Socio-economic analysis, including analysis of climate change impacts and response options

- Research on impacts and measures in the important sectors of agriculture and forestry predominated;
- Vulnerability of ecosystem services of agricultural landscapes and forests and also their use as a tool for assessing the socio-economic potential of an area;
- Focus on sustainable landscape and urban development and its management;

Research and development of approaches to mitigation and adaptation, including technologies

- Research on mitigation and adaptation options in Slovakia covers a wide range of topics;
- Water management adaptation practices in water conservation, irrigation use and flood protection are important;
- In forestry, the emphasis is on forest management, including new cultivation practices;
- There is a strong focus on protecting soils from degradation and erosion, including increasing its carbon content;
- Suggestions for adaptation solutions were also made in energy technologies, in particular the use of biomass and solar energy;
- Research in Slovakia is not focused on the private sector or SMEs;

Support for developing countries

The Slovak Agency for International Development Cooperation (SAIDC) ensures the implementation of official development assistance of the Slovak Republic in accordance with binding EU, UN and OECD documents. The Agency implements development cooperation, including development education and capacity building. Research plays a relevant role in some projects, such as the project to build capacity and strengthen drought adaptation in Georgia.

The exchange of information on research results is ensured mainly by publication in scientific journals or in the form of final project reports as well as by annual reports of research organisations or funding institutions. The exchange of scientific and technical information is not subject to any regulation. Basic data provided by the SHMÚ is generally available for a fee, according to the current price list, for student education and research purposes it is generally freely available.

Examples of domestic projects

Impact of impervious land cover on urban climate in the context of climate change (pedo-city-climate) project APVV-15-0425; research organisation: Soil Science and Conservation Research Institute of the National Agricultural and Food Centre in Bratislava, collaborating organisations: Institute of Geography of the SAS Bratislava, Slovak Hydrometeorological Institute Bratislava (2016-2020).

The project analysed and evaluated the impact of the built-up area, the quality of land cover and green infrastructure, as well as the occurrence of urban heat islands in the summer months on the formation and distribution of U-ESA (Urban Environmentally Sensitive Areas) elements. The delimitation of these areas is an output whose materials can be used for the construction and development of cities and megacities from an environmentally sustainable perspective in the context of climate change adaptation. The documents provided by this project will constitute a very important tool for spatial planning and decision making in terms of environmental design and management of urban areas.

Impact of natural hazards on forest ecosystems in Slovakia under changing climatic conditions, project APVV-15-0136, research organisation Faculty of Forestry, Technical University of Zvolen, collaborating organisation Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Institute of Forest Ecology, Slovak Academy of Sciences in Zvolen (2016-2019).

The subject of the research was the study of natural risks and their impacts on forest ecosystems under the conditions of emerging climate change in the most important forest ecosystems in Slovakia. It addressed the increase in the extremes of climatic conditions, manifested mainly by increased frequency of torrential rainfall, floods, landslides, droughts, forest and landscape fires, wind and snow calamities, and population explosions of harmful insects and pathogens. It addressed the modelling of changes in ecosystem growth processes under changing environmental conditions, as well as the responses of forest tree species to increasing natural hazards, the profitability of forest land management, and potential changes in the water management and societal functions of forests.

Detection and modelling of changes in hydrometeorological time series under conditions of climate change, Project VEGA1/0891/17, research organisation Faculty of Civil Engineering STU (2017-2020).

The project developed a new methodological procedure for detecting changes in the internal structure of measured and derived hydrometeorological series and interdependencies of their characteristics caused by climate change. In selected river basins in Slovakia, the picture of ongoing changes in the runoff regime was confirmed. To model the expected changes in the internal structure of the time series, a rainfall-runoff model (TUW model) was designed and tested in a daily time step with a switching mode. The proposed TUW model can eliminate uncertainties in hydrological regime change scenarios, which is important for future assessment of climate change impacts on runoff. The obtained outputs of runoff regime change detection from both measured and modelled water balance components provide sufficient insight into the ongoing changes in the selected river basins.

The impact of climate change in eastern Laurasia on the evolution of Mesozoic vertebrates: a high-resolution analysis of uniquely fossilised tissues from China. Project APVV-18-0251, research organisation Centre for Interdisciplinary Biosciences, Pavol Jozef Šafárik University in Košice (2019-2022).

The aim of this multidisciplinary research project is to understand the evolutionary dynamics of the Laurasian climate and vertebrate fauna using modern quantitative analytical and imaging techniques and biostatistical processing of fossil tissues and abiotic structures. The geological environment to be explored in this research includes Middle Jurassic to Upper Cretaceous deposits in remote areas of Inner Mongolia and the Liaoning provinces of China, where new palaeontological discoveries of regional and global significance are expected. The dynamics of changes in the vertebrate paleofauna determines the main research activities in palaeoclimatology, palaeogeography, palaeobiology and paleogenomics. This project was organised in collaboration with the Inner Mongolia Museum of Natural History and the Japan Synchrotron Radiation Research Institute (JASRI Spring-8).

The publication **Scenarios of Development in the Environment 2020+. Sustainable Growth, Biodiversity and Climate Change** (2017) was prepared in cooperation with the Slovak Environment Agency, the Ministry of Environment of the Slovak Republic and the Centre of Social and Psychological Sciences of the Slovak Academy of Sciences. The output of the report is 3 scenarios for the possible evolution of environmental trends in the short term.

The publication **Scenarios for the nature of Slovakia until 2050: Alternative scenarios and implications for public policies** (2020) was prepared in cooperation with the Ministry of Environment of the Slovak Republic, the Slovak Environment Agency and other experts from the academy of sciences and universities. It is a comprehensive forward-looking study focusing on environmental policy in Slovakia in the medium (up to 2030) and long term (up to 2050). The result is the elaboration of a baseline scenario and four alternative scenarios, which include the impact of climate change on the nature and biodiversity of Slovakia.

Examples of international projects

The project DriDanube (Drought Risk in the Danube Region) was a project of Interreg (2017-2019). 23 institutions from 10 countries in the Danube basin worked on it. The Slovenian Environment Agency was the project leader, the SHMÚ was the partner for Slovakia.

The main objective of the project was to increase the adaptive capacity of the Danube region to climate variability by strengthening resilience to drought through the use of newly developed tools and data. The specific objectives of the project were focused on the development of a new drought monitoring system - Drought Watch, the unification of drought risk and impact assessment methodologies (prepared in accordance with EU directives under the Civil Protection Mechanism) and the improvement of drought crisis management in the Danube region. The target groups of the project were national hydrometeorological institutes, authorities responsible for crisis management, water and agricultural associations and non-governmental organisations.

The results of the project were one of the key inputs for the development of the Action Plan to address the impacts of drought and water scarcity in Slovakia (H2ODNOTA JE VODA) - Water is the Value - in 2018.

Process-based models for climate impact attribution across sectors (PROCLIAS) COST Action 19139

The project leader is PIK Potsdam, the Slovak partner is the Institute of Landscape Ecology of the Slovak Academy of Sciences, (2020-2024).

The project seeks to bridge the lack of coordination between climate change impact models and the attribution of climate impacts in Europe is also an under-researched area. Therefore, it focuses on the development of common protocols, harmonised datasets and a common understanding of how to conduct cross-sectoral, multi-model climate impact studies at regional and global scales. These would make it possible to attribute the impacts of recent climate change and produce robust projections of future climate impacts. Therefore, the project focuses on the key interactions of climate impacts across sectors, their cumulative effect, particularly extreme events, and attribution of impacts to climate change and quantification of uncertainties.

Water temperature simulation during summer low flow conditions in the Danube basin

This project is part of the UNESCO programme, the project leader is the Institute of Hydrology of the Slovak Academy of Sciences (2020-2023).

The project focuses on the investigation of long-term variability and long-term trends of water temperature of selected rivers in different regions of the Danube basin (mountains, highlands, lowlands) and also along the course of the Danube. A multiple regression technique is used to analyse the relationships between water temperature and influencing factors (low and high flow conditions, increasing atmospheric temperature, anthropogenic activity in the river basin, etc.). Multi-regression simulation and stochastic water temperature prediction models will be developed for selected rivers. These will be used to simulate the water temperature of selected rivers according to different flow and air temperature scenarios. One of the expected results is a scientific basis for a water quality classification method according to water temperature of water bodies in the Danube basin for the implementation of the WFD 2000/60/EC.

9.4 SYSTEMATIC OBSERVATION

Hydrological monitoring and meteorological monitoring as well as air quality measurements in Slovakia are guaranteed by Act No. 201/2009 Coll. on the state hydrological service and the state meteorological service. According to this Act, the observation networks and structures of the SHMÚ are the property of the state. The SHMÚ has in place a Quality Management System according to STN EN ISO 9001:2016 for monitoring, evaluation and interpretation of data and ISO/IEC 17025:2017 for the Water Quality Testing Laboratory. The system is properly maintained and operated.

The framework for comprehensive environmental monitoring in Slovakia is established by Government Resolutions of the Slovak Republic No. 623/1990 Coll., No. 449/1992 Coll. and No. 620/1993 Coll. The basic units of the National Monitoring System of Slovakia are the partial monitoring systems (PMS). Some of these partial monitoring systems are operated by the SHMÚ.

In addition to the national observing network, observations of the climate system are also carried out by other institutions. However, these are carried out for their own sake and for a limited period of time, usually for the purposes of specific projects.

9.4.1 Atmospheric Climate Observing Systems

Most of Slovakia has complex, mountainous terrain, so monitoring requires a dense station network. In the previous 5-year period, the meteorological and climatological station network underwent extensive automation. Today, almost the entire network is automated. The rain gauge network has automatic measurements at more than half of all stations. Automation required a new methodology for data quality control, also using the products of remote observation systems.

The monitoring also includes a set of baseline climate variables pursuant to Decision FCCC/SBSTA/2007/L.4/Add.1. The SHMÚ manages data according to the Quality Management System in accordance with STN EN ISO 9001:2016.

Slovakia has a long tradition in instrumental climatological observations. Some climatological stations have series of regular observations and measurements for more than 100 years (7 meteorological stations, 203 stations measuring atmospheric precipitation). In 2020, the World Meteorological Organisation granted the status of Centennial Observing Station to the Hurbanovo meteorological station. Since 2005, the SHMÚ has been implementing a data rescue programme, which digitises archived records of climatological, precipitation and phenological stations. The obtained data are used for a more accurate analysis and description of climate change and climate variability in Slovakia over the last 140 years.

The atmospheric climate observation systems are operated by the SHMÚ and include the following subsystems

- 27 climatological stations (traditional manual measurements and observations),
- 56 automatic meteorological stations with additional observations (automatic stations with an observer who makes additional measurements and observations of meteorological phenomena, cloud cover, type and duration of precipitation, snow cover and water equivalent of the total snow cover),
- 96 automatic meteorological stations (automatic stations without an observer),
- 356 rain gauge stations (traditional manual measurements and observations),
- 162 automatic rain gauge stations with additional observations (automatic rain gauge stations with an observer who makes additional measurements and observations of meteorological phenomena, type and duration of precipitation, and parameters of snow cover),
- 198 automatic rain gauge stations (automatic rain gauge stations without an observer),
- 45 totalizers (cumulative measurement of atmospheric precipitation in inaccessible terrain),
- 196 phenological stations (monitoring of seasonal and inter-seasonal dynamics of the development of selected species of fauna and flora in relation to the weather),
- 55 agro-climatic stations for measuring soil temperature (at depths of 2, 5, 10, 20, 50 and 100 cm, up to 7 metres at selected stations),
- 8 agro-climatic stations for measuring soil moisture,
- 4 Doppler radars,
- 7 stations to measure solar radiation,
- 22 automatic stations with global radiation measurements,
- 1 station for measuring total atmospheric ozone (Brewer ozone spectrophotometer),
- 200 m and 40 m high meteorological mast for measurements in the surface layer of the atmosphere,
- 1 upper-air station,
- lightning detection system.

The Regional Instrument Centre (RIC) for WMO RA VI is based at the SHMÚ in Bratislava and assists the members of the Association in calibrating their national instrument standards for the measurement of the five meteorological variables. It is accredited according to ISO/IEC 17025 and provides services to maintain the high quality of meteorological measurements.

Membership of EUMETSAT allows Slovakia to receive satellite imagery in real time. Access to EUMETSAT satellite and image products is also important. The DAWBEE (Data Access for Western Balkan, Eastern European and Caucasian Countries) project supports access to EUMETSAT data and products to 11 countries. The SHMÚ succeeded in the selection of software for satellite data processing and preparation of image products, including visualisation of satellite images. The SHMÚ software (MSGProc and ViewMSG) was installed on computers purchased by EUMETSAT. The SHMÚ provides software maintenance and enhancements. The software and the products it generates are used to monitor cloud cover, weather, precipitation, vegetation index and drought.

The monitoring subsystem "Air" provides air quality monitoring with continuous measurement of gaseous pollutants and atmospheric aerosols. This subsystem also monitors atmospheric precipitation chemistry. The SHMÚ provides data collected through monitoring subsystems for decision-making, management, research and development, as well as for the general public. The air quality network consists of 48 automatic stations in the most polluted regions and 4 stations for monitoring background air pollution.

Slovakia cooperates in the World Climate Programme (WCP WMO) and the Global Climate Observing System (GCOS WMO). The cooperation is mainly based on the provision of observed data to relevant databases and in the form of international exchanges. It sends solar radiation data to the World (WRDC, St. Petersburg) and European Data Centre (EDUCE, Finland) and ozone measurements to WOUDC, Toronto. It provides phenological data to the Pan European Phenological database PEP725. Measured and observed data as well as data from the outputs of research projects are also provided for international projects.

The online international exchange involves hourly data from 25 synoptic stations. Monthly data from 5 stations are included in CLIMAT Reports.

9.4.2 Terrestrial Climate Observing Systems

Cryosphere

The systematic measurement of snow cover is included in the observation programme of rain gauge stations (around 500 stations), where total and new snow cover as well as the water equivalent of the snow cover has been measured for over 100 years.

The Avalanche Prevention Centre of the Mountain Rescue Service (https://hzs.sk/slp/) operates a network of stations to observe the development of snow cover and meteorological conditions of avalanches in mountains in Slovakia.

Hydrosphere

The monitoring subsystem "Water" monitors the quantity and quality of surface and groundwater in Slovakia and includes monitoring of:

- quantitative indicators of surface waters,
- quantitative indicators of groundwater,
- groundwater quality,
- surface water quality,
- natural healing and natural mineral waters (monitoring is operated by the Inspectorate of Spas and Springs under the authority of the Ministry of Health of the Slovak Republic)

- irrigation water (monitoring is operated by the Soil Science and Conservation Research Institute under the authority of the Ministry of Agriculture and Rural Development of the Slovak Republic)
- recreational waters (monitoring is operated by the Public Health Authority of the Slovak Republic under the authority of the Ministry of Health of the Slovak Republic)

The hydrological network consists of 415 water gauging stations (automatic stations with on-line data transmission), which measure quantitative parameters of surface water (water level, flow rate, water temperature, and at 16 stations, suspended load is also evaluated from daily samples). Surface water quality monitoring is carried out annually in accordance with an approved monitoring programme. Approximately 350-400 monitoring sites are monitored annually. According to the requirements of the EU Water Framework Directive (WFD) in the Slovak Republic, the types of monitoring are: surveillance, operational, exploratory and monitoring of protected areas. Surface water quality monitoring is for various purposes e.g. status assessment, boundary waters, reporting, protected areas (drinking water)...etc. Depending on the purpose, individual determinants are also monitored.

The quantity of groundwater and springs is monitored at 1507 sites (groundwater levels at 1147 sites and spring yields at 360 sites) and groundwater quality is monitored at about 760 sites.

CHAPTER 10 EDUCATION, TRAINING AND AWARENESS RAISING OF THE POPULATION

This chapter provides an overview of the activities of the Ministry of Education, Science, Research and Sport of the Slovak Republic (MESRS SR), the Ministry of Environment of the Slovak Republic and other institutions of the Slovak Republic in the field of education, training and awareness-raising of the population on climate change and relevant policies since? Education in general is the responsibility of the MESRS SR, but the Ministry of Environment of the Slovak Republic also plays an important role in the field of non-formal and informal education and awareness-raising of the population, either directly or through its directly managed organisations, such as the Slovak Environment Agency (SEA), the State Nature Conservancy of the Slovak Republic (SNC SR), the National Zoo Bojnice, the Slovak Mining Museum (SMM), the Slovak Museum of Nature Protection and Speleology (SMNPS), the Slovak Hydrometeorological Institute and others. Education and information on this issue is also provided by selected universities and scientific institutions, interest groups and professional and non-governmental organisations.

10.1 LEARNING ACTIVITIES

Climate change is a professionally challenging and cross-cutting topic that goes beyond educational programmes for primary and secondary schools. The issue of climate change and its adverse impacts cuts across a wide range of subjects in environmental education in primary and secondary schools. Its importance has also increased in recent years at the level of colleges and universities. Climate issues can be studied at Comenius University in Bratislava and partly at the University of Economics in Bratislava - in terms of economic and political implications.

The Ministry of Environment implements a number of educational events focused on climate change education. Together with the SEA, it has set up a portal for environmental education, learning and edification EWOBOX (www.ewobox.sk), which serves the general public, from kindergarten pupils to university students, NGOs, the professional public, and educators. Climate education is one of the areas of education. The Ministry of Environment of the Slovak Republic supports environmental education projects through the Environmental Fund, from which subsidies can be drawn by natural persons, legal persons, civic associations, non-profit organisations and municipalities. Such areas include the Green Education Fund, the Village Recovery Programme and the Nature Conservation Programme. Also from the Norwegian funds, projects focusing on climate change have been supported through the call ACC03 Raising Awareness on Climate Change Mitigation and Adaptation in Schools (ClimaEdu) and ACC05 Raising Awareness on Climate Change Mitigation and Adaptation (ClimaInfo).

The National Institute for Education, as a state budget-funded organisation directly managed by the MESRS SR, has introduced a national environmental action programme “Environmental Education and Learning” for the 1st and 2nd level of primary schools, secondary schools and grammar schools.

Environmental education and learning covers the following areas related to climate change: renewable resources and non-renewable natural resources, rational use of natural resources in the context of sustainable development, the use of alternative energy sources, means of energy transfer and their impact on the environment, industry and sustainable development of society, recycling, energy consumption, quality of life, a wide range of environmental impacts on health, ways and means of protecting health or life under volatile conditions on Earth (different environmental conditions and different degrees of societal development on Earth, causes and consequences of global environmental problems (and the principles of sustainable development).

In secondary schools, the topic of the environment in environmental education and learning is part of more comprehensive educational areas such as “Man and Society” and “Man and Values”, which focus on the links between environmental, technical, economic and societal approaches to problem solving and highlight other principles of sustainable development that relate to climate policy (cooperation in diversity, eradication of poverty, elimination of disease, inequalities between people, ensuring a life of dignity for all).

10.1.1 Slovak Republic Youth Strategy 2021-2028.

The Slovak Republic Youth Strategy 2021-2028 defines key areas, objectives, measures and indicators aimed at improving the situation of young people. It is based on knowledge and evidence of the real needs of young people and is the result of a constructive dialogue between young people and representatives of general government, regional and local government and the non-governmental sector. The strategy places particular emphasis on youth work and non-formal youth education in the individual measures.

The Sustainable and Green Future chapter is mainly concerned with people’s quality of life, which depends directly on the quality of the environment in which people live. Many of the decisions and behaviours people make affect the quality of the environment only after many years, the impacts are cumulative and mutually reinforcing. The result is not only the long-term deterioration of the local environment in which we live, but also the emergence of global problems such as climate change, biodiversity loss, pollution and others that threaten the survival of humanity as a global community.

10.1.2 Educational Programmes in Schools

The Ministry of Education, Science, Research and Sport of the Slovak Republic annually allocates funds from the school budget for the implementation of successfully developed development projects aimed at the promotion and development of environmental education and learning in primary and secondary schools under the name “Enviroprojekt”, healthy lifestyle, health and safety in schools under the name “Health and Safety in Schools”, “Healthy Nutrition” and others. The practical outputs of the projects are various seminars, competitions, workshops or methodological materials, workbooks and worksheets. Pupils in different parts of Slovakia build nature trails, clean up protected areas, watercourses, protect cultural heritage, implement social care and healthy eating programmes, or solve problems related to energy use, renewable resources or waste disposal.

The Ministry of Environment has established the following training programmes:

Ekostopa (Eco-Footprint) is an innovative educational programme currently implemented through the web portal www.ekostopa.sk. Its main objective is for students to correctly identify how our daily activities affect the environment.

A practical demonstration - the so-called “Ecometer” is an interactive model of Earth with an average width of 3.5 m, which is used to calculate the ecological footprint we leave behind.

Učenie hrou (Learning through Play) is a pilot environmental programme for the general public and primary and secondary school pupils.

The Enersol Project was launched in 2000 and is a joint programme of six European countries - the Czech Republic, Slovakia, Germany, Slovenia, Poland and Austria. Its importance lies mainly in the international exchange of teaching experiences and the introduction of technical, ecological and environmental ideas and texts to secondary schools.

Žiť energiou v školách (Living Energy in Schools) is an educational programme that includes educational materials, interactive games and recommendations on how to save energy in schools: https://www.siea.sk/bezplatne-poradenstvo/kamaratka-energia/.

Lesná pedagogika (Forest Pedagogy) (National Forest Centre) is an environmental education activity that serves to gain knowledge about nature and life in the forest through games and experiences. Through its activities, Forest Pedagogy expands knowledge about the environment, its protection and sustainable development: http://www.lesnapedagogika.sk/. The programme is also intended for the general public.

Program učenie hrou (The Learning through Play programme) is an inspiration for inventing activities, it has an informative and educational dimension. It aims to raise environmental awareness in the field of environmental protection based on interactive games. The target groups are children in kindergartens and pupils in primary and secondary schools. The emphasis is on interactive and experiential learning.

Separujem, separuješ, separujeme (I Separate, You Separate, We Separate) is a programme that motivates and engages pupils in waste sorting based on practical environmental education and promotes the lowest possible waste production. Primary school pupils are the target group.

Tajomstvo hmyzu (The Mystery of Insects), pupils investigate what would happen if there were no insects in the world. They will learn interesting facts about this miniature but diverse world, learn about its importance and its significance in nature, and build an insect hotel.

Preč s odpadom (Waste Away), the aim of the programme is to raise awareness of what waste is, where it is produced and where it goes from our rubbish bins.

Príbeh plastu (The Story of Plastic) takes pupils through the life of a plastic bottle, from its creation to its end in a landfill or in the sea.

Pod dekou (Under the Blanket) is a programme aimed at showing how we contribute to climate change, how to change it or how to adapt to it.

10.1.3 National Environmental Competitions

Múdra príroda (Wise Nature) is a literary competition with three categories: poetry, description and prose. Primary school pupils are the target group.

EnvirOtázniky is a national knowledge competition for pupils of the 2nd level of primary schools. Its aim is to awaken an interest in science and environmental issues in primary school pupils.

Zelený svet (Green World) is an international children's art competition.

Hodina s ekostopou (An Hour with Eco-Footprint) is a national competition for kindergarten, primary and secondary school teachers with an environmental theme.

Hypericum is a natural science competition for primary school pupils of 2nd level.

ProEnviro is a competition for the best environmental project organised by a school. Its main objective is to promote and support projects towards sustainable development and to support environmental activities in schools.

Úsmev pre strom (Smile for a Tree) is a national competition with three categories: Collect and recycle, Plant a tree and Create your own eco-project. Primary and secondary school pupils are the target group.

The national ETM (European Mobility Week) prize is awarded to the local government that has done the most to raise awareness of sustainable mobility during European Mobility Week.

Enviróza is a school competition for pupils of the 2nd level of primary schools and of secondary schools. It takes place as a game outdoors and its aim is to gather and disseminate information about environmental burdens in Slovakia. Players search for and identify environmental burdens and publish their results on the internet.

Invázne druhy rastlín (Invasive Plant Species) is a school competition organised as part of the school programme “Na túre s NATUROU (Hiking with NATURA)”. The main objective is to establish observation and research groups that focus on mapping areas of invasive plants and animals in the environment.

Envirospektrum – the mission of the competition is to teach children to connect with nature through photography.

10.1.4 International Activities

Schools are involved in various international, national and regional projects independently or in cooperation with non-governmental organisations.

Roots & Shoots is a programme for young people of all ages founded by Dr. Jane Goodall in 1991. It aims to cultivate respect and compassion for all living creatures, to promote and foster understanding between cultures and faiths, and to encourage individuals to take action to make the world a better place for people, animals and the environment. In 2016, a pilot educational project based on the Global Action Programme - Jane Goodall’s Roots & Shoots - was launched. The SEA’s participation in this project starts in 2016.

GLOBE - an international education programme in which pupils explore nature and actively improve the environment around their school. A specific feature of the GLOBE programme is the creation of an alternative community that goes beyond the borders of Slovakia, which significantly supports and develops learning processes at the level of pupils and teachers. Participation in the programme provides access to a global database of measured data on the Earth’s environment, managed by NASA, as well as the opportunity to participate in current global campaigns, competitions, international projects, research expeditions, meetings, etc. GLOBE’s areas of expertise in which we are conducting research include:

Meteorology - the day-to-day measurement and observation of erratic phenomena in the atmosphere.

Hydrology - measuring the properties of water and observing life in water.

Vegetation cover - a new way of looking at the landscape and vegetation around us.

Phenology - the unrepeatable observation of recurring changes in nature throughout the year.

The Junior Festival is a unique part of the EKOTOPFILM festival (international film festival on sustainable development) with a special programme for primary and secondary school children. It brings real environmental education to selected cities in Slovakia. Children learn to sort waste, conserve forests, save energy and protect the environment.

ENVIROPROJEKT is a development project funded by the MESRS SR and serves to promote and support practical environmental education in primary and secondary schools. Pupils in different parts of Slovakia build nature trails, clean sections of watercourses or carry out activities related to renewable energy sources and waste disposal.

Eco-Schools is an international environmental programme organised by Spiral - a nationwide network of organisations dedicated to environmental education and learning. The challenge of meeting the requirements of this programme has forced schools to introduce the principles of environmental education and learning throughout the curriculum and the actions of students, pupils and teachers.

10.1.5 Colleges and Universities

The MESRS SR does not prescribe the content of courses offered by higher education institutions. Detailed statistics on higher education are publicly available on http://www.cvtisr.sk/cvti-sr-vedecka-kniznica/informacie-o-skolstve/statistiky/statisticka-rocenka-publikacia/statisticka-rocenka-vysoke-skoly.html?page_id=9596. In Slovakia, the following faculties undertake studies related to climate change:

Comenius University in Bratislava

Faculty of Mathematics, Physics and Informatics - the Department of Astronomy and Astrophysics, the Department of Earth Physics, the Department of Environmental Physics and the Department of Meteorology and Climatology are involved in comprehensive research and education in the field of climate change at the faculty.

Slovak University of Agriculture in Nitra

Faculty of Horticulture and Landscape Engineering - the Department of Biometeorology and Hydrology deals with climate change issues.

Faculty of Agrobiology and Food Resources - the impact of climate change on agriculture is addressed by the Department of Plant Protection and the Department of Sustainable Agriculture and Herbology.

Technical University in Zvolen

Faculty of Forestry - research conducted by the Department of Natural Environment includes climate change issues.

Faculty of Ecology and Environmental Sciences - research activities of the Department of Applied Ecology and the Department of Biology and General Ecology also focus on the impacts of climate change.

Technical University in Košice

Faculty of Civil Engineering - the faculty's research includes the impact of a changing climate on the construction of infrastructure.

Slovak University of Technology in Bratislava

Faculty of Civil Engineering - the activities of the Department of Land and Water Resources Management and the Department of Sanitary and Environmental Engineering also focus on climate change adaptation.

Faculty of Chemical and Food Technology - the faculty is engaged in research and development of environmental engineering technologies.

10.2 CONFERENCES

10.2.1 Periodic Conferences

Enviro-i-fórum is a conference in the field of environmental science, organised annually since 2005 by the SEA and the Ministry of Environment of the Slovak Republic. Its main objective is to create, share and access environmental data.

The Green Infrastructure Conference - a scientific symposium focusing on healthy ecosystem networks provides cost-effective alternatives to traditional “grey” infrastructure and offers additional benefits for the population and biodiversity.

Environmental Protection Technology is a conference focusing on the development of techniques and technologies in various environmental sectors.

Air Protection is an international conference, held annually since 1985, dealing with current air protection techniques, options for reducing air emissions, problems and experience with the measurement of tradable emission allowances.

The National Emission Allowance Register SR is a conference that has been organised since 2005 for participants in the emission allowance trading scheme, operators and verifiers of CO_2 emission reports, experts and state administrators.

The conference for young scientists and experts up to 35 years of age from the Czech Republic and Slovakia is organised annually at the headquarters of the SHMÚ in the field of meteorology, climatology, hydrology and water management. The conference is combined with a competition for the best three projects.

Environment - Conditions and Options for Solutions is a conference aimed at presenting and solving problems in the field of environment and waste management.

Bioclimate is an international conference organised annually since 1960 by the Slovak Bioclimate Society of the Slovak Academy of Sciences and the Czech Bioclimate Society of the Czech Academy of Sciences. This conference addresses the scientific aspects of climate in relation to the natural environment and socio-economic sectors. Several of the presentations given at the Bioclimate conference dealt with the issue of climate change. Some of the presentations that have appeared at the last five Bioclimate conferences have been included in the Web of Science database.

10.2.2 Other Important Conferences and Workshops

Transition to a Green Economy - T2gE The aim of the conference is to attract the attention of all relevant stakeholders and to create a space for an informed debate on the key issues of the transition to a green economy. Discussions mainly focused on the actions of key stakeholders, including financial and investment ones.

Eco-innovation Slovakia 2016 is an international forum designed to present and showcase examples of eco-innovation and best practices.

The Urban Environment Conference addresses environmental problems in cities and seeks to find ways *to make our cities* “greener” and sustainable.

Other conferences covering a variety of topics, organised by different institutions and organisations in many cities.

10.3 OTHER EVENTS

10.3.1 Festivals, Workshops, Fairs, Exhibitions and Other Educational Programmes

Ekotopfilm-Envirofilm – the largest educational event of the Ministry of Environment of the Slovak Republic for the general professional and lay public. The International Environmental Film Festival, together with other cultural and professional events, aims to raise public environmental awareness by organising environmental activities, performances and exhibitions of works on the theme of the Green World, which take place after the festival. An accompanying event of the Envirofilm Festival is the Junior Festival.

ŠIŠKA - a fair for environmental education programmes - designed for those working in the field of environmental education and learning. Every year 100 educators and supporters of environmental education participate in this fair. The main theme of the 23rd year of the environmental education fair ŠIŠKA 2021 was devoted to environmental burdens.

Important environmental days and events (in cooperation with the Ministry of Environment of the SR) - World Wetlands Day, International Day of Forests, World Water Day, World Earth Day, International Day for Biological Diversity, World Environment Day, International Day of Trees, European Mobility Week and International Buy Nothing Day.

Exhibitions - exhibitions with different themes, which are held every week in the atrium of the main building of the Ministry of Environment of the Slovak Republic (winners of the Green World competition).

Covenant of Mayors - The Covenant is a major initiative of several European governments and the European Commission, working together to achieve the Europe 2020 objectives. By signing the Covenant, the signatories have committed to increase energy efficiency in their territory, increase the use of renewable energy sources and contribute to the targets adopted by the EU in its 2020 Strategy, along with a 20% reduction in CO_2 emissions by 2020. The main national coordinator of the Covenant in Slovakia is the Ministry of Environment of the Slovak Republic. The Ministry of Environment of the Slovak Republic has been cooperating intensely with the Ministry of Economy of the Slovak Republic on the implementation of the objectives of the Covenant for a long time.

Open day for the general public on the occasion of World Meteorological Day, World Water Day and World Environment Day (including seminars and promotional material on climate change).

Day of Forests - April - the month of forests.

Olympiads - Biology Olympiad, Geography Olympiad and Chemistry Olympiad.

10.4 TRAINING

10.4.1 Training of Staff Working in the Field of State Administration of Environmental Protection

Training of state administration staff in the field of environmental protection - implemented based on Act No. 525/2003 Coll. on state administration of environmental protection and on the amendment to certain acts and Decree 462/2004 Coll. laying down details of special qualification requirements for the performance of certain activities in the field of environmental protection.

Green public procurement training - designed for employees of municipal, local and governmental authorities and their subordinate organisations working in the field of green public procurement.

Continuous teacher education - an accredited educational programme called Ekostopa - education in the field of sustainable development for teachers of kindergartens, primary and secondary schools.

Innovative education, its aim is to develop the professional knowledge, didactic skills and competences of pre-primary, primary and secondary teachers in the field of environmental education with a view to integrating it into the compulsory content of education and learning in schools.

10.4.2 Other Relevant Voluntary Learning

Granting of accreditation to verifiers according to Act No. 572/2004 Coll. on emission allowance trading - on the basis of Article 24 (1) of Act No. 414/2002 on economic mobilisation and on the amendment to certain acts. The Slovak National Accreditation Service is responsible for granting accreditation to the authorised verifier. On 1 January 2014, the transitional period during which authorised verifiers could carry out verification on the basis of successful completion of an examination at the Ministry of Environment of the Slovak Republic and registration in the register of authorised verifiers expired. More information on accreditation is published on the website www.snas.sk.

The SHMÚ organised a training session on the amendment to certain acts, where practical issues that arose during the training session were discussed. The training took place on 30 October 2017 and its aim was to provide participants with comprehensive information on the change in legislation and the issue of demonstrating compliance with sustainability criteria in the field of biofuels and bioliquids in Slovakia. During the discussions, participants had the opportunity to get answers to questions on various practical matters and problems related to this issue.

10.5 SOURCES OR INFORMATION CENTRES

10.5.1 Making Information Accessible through the Use of Communication and Information Technologies

Enviroportal – the main source of information and information hub for climate change is also the portal www.enviroportal.sk, an information portal that focuses on communicating environmental information from one central location operated by the SEA. Not only professionals but also the general public are the target group.

In addition, the environmental assessment indicators are regularly assessed and published on the Enviroportal portal, where other important information is also published, e.g. on erosion, landslides, floods, waste management, etc. (www.vuvh.sk, www.sguds.sk, www.shmu.sk, www.sazp.sk, www.svp.sk)

Facebook - the website contains a wealth of information, news, inspiration, activities and events organised by the SEA.

(www.facebook.com/Slovenský-hydrometeorologický-ústav, www.facebook.com/vuvh.sk, www.facebook.com/svp.sk, www.facebook.com/SAZPBB)
Official website of the Ministry of Environment of the Slovak Republic - comprehensive information on climate change published and regularly updated on the official website of the Ministry of Environment of the Slovak Republic (http://www.minzp.sk/sekcie/temy-oblasti/ovzdusie/politika-zmeny-klimy/medzinarodne-zmluvy-dohovory).

Greenhouse Gas Emissions Information System - a separate website www.ghg-inventory.shmu.sk has been operated by the SHMÚ since 2007 and it contains detailed data on greenhouse gas emissions and projections of these gases.

NIPI Geoportal - in order to build a national infrastructure for spatial information based on the INSPIRE Directive, a portal has been built and launched, which can be accessed via the website http://geoportal.sazp.sk. The portal provides access to spatial data and spatial data services through network services.

enviro.sk – www.enviro.sk is a unique database of professional solutions in the field of waste management and environmental science. The main part of this database contains more than 2000 professional articles.

www.dmc.fmph.uniba.sk – The Department of Astronomy, Earth Physics and Meteorology of Comenius University in Bratislava provides scientific information on climate change and the physics of Earth's climate system within the accredited study programmes of the 2nd and 3rd level of higher education as well as on the website, which is often visited by readers from abroad.

Because of its cross-cutting nature, climate change also cuts across other disciplines. Ministries also publish information, data, studies, reports dealing with climate change issues, mainly through their specialised agencies. In particular the National Forest Centre - www.nlcsk.org the portal on forests www.forestportal.sk Soil Science and Conservation Research Institute - www.vupop.sk a Slovak Innovation and Energy Agency - www.siea.sk. In addition, scientific information on climate change and Earth's climate system is published on the website of the Faculty of Mathematics, Physics and Informatics - www.fmph.uniba.sk. Non-governmental organisations such as Greenpeace also contribute to the dissemination of information to the public (http://www.greenpeace.org/Slovak Republic/sk/kampane/klimaticke-zmeny).

EWOBOX – a portal for environmental education, learning and edification. (www.ewobox.sk).

10.5.2 Periodicals

Enviromagazín (Enviromagazine) – is a journal published by the Ministry of Environment of the Slovak Republic and the SEA since 1996. It performs its information and promotional function in a popular way. Some of the articles concern the issue of climate change, the content of others is closely related to the issue of climate change.

Parlamentný Kuriér (The Parliamentary Courier) – in 2016, an interview was published in the magazine of the National Council of the Slovak Republic, in which the area of climate change policy was addressed "Last year, the Slovak Republic spent almost EUR 2 million on climate change-related issues". In 2014, it was the interview "Implications and solutions to climate change".

21. storočie (21st century) - a journal focusing on industrial ecology that has been published for 15 years. This journal is the only nationwide periodical focused on the economic context of environmental policy with an emphasis on the protection of individual components of the environment in corporate practice. In addition to focusing on the individual components of the environment, the journal also focuses on energy and the rational use of energy, especially in the context of the climate and energy package, which Slovakia will also have to adopt. Promotion of the development of renewable energy sources and emission allowance trading are also regular topics.

Meteorologický časopis (Meteorological journal) – is a specialised scientific and professional journal published by the SHMÚ and dealing with topics in meteorology, climatology, hydrology, air pollution and some other related fields. The journal publishes original scientific studies by Slovak and foreign authors mainly in English, reviews and short professional papers in the Slovak or Czech language. All articles are peer-reviewed.

Časopis o stredoeurópskom lesnom hospodárstve (Journal of Central European Forestry) - National Forest Centre - the Forest Research Institute in Zvolen publishes a scientific journal on forests (SAP publishing house, Bratislava).

Les a letokruhy (Forest and Tree Rings) – the magazine is published by LESMEDIUM SK, s.r.o. and is devoted to tree planting in the forest, forest protection and commercial timber.

Quark - a magazine with the latest information about science, research, discoveries and new technologies in Slovakia and the world, published once a month.

Odpad (minimalizácia, zhodnocovanie a zneškodňovanie) (Waste (minimization, recovery and disposal)) - a magazine on waste generation, minimization, recovery and disposal and related areas. Published by Miroslav Mračko - EPOS.

Vodné hospodárstvo (Water Management) - a journal of current and emerging knowledge and experience in the field of water policy. It is published by the Association of Employers in Water Management in Slovakia.

The journal EA / Energetika on renewable energy sources and energy savings – publishing house / ST s.r.o.

10.5.3 Scientific, Professional and Educational Journals Dealing with Climate Change.

Vodohospodársky časopis (Water Management Journal) - published by the Water Management Institute of the Slovak Academy of Sciences and the Institute for Hydrodynamics. This journal is the most important scientific journal with sixty years of tradition and is included in the Web of Science database.

Acta Meteorologica Universitatis Comenianae – the journal is published by the Faculty of Mathematics, Physics and Informatics.

Acta Hydrologica Slovaca – the journal is published by the Institute of Hydrology of the Slovak Academy of Sciences.

Geografický časopis (Geographical Journal) - published by the Geographical Institute of the Slovak Academy of Sciences.

Contributions to Geophysics and Geodesy (Zborník príspevkov z oblasti geofyziky a geodézie) – is published by the Institute of Earth Sciences of the Slovak Academy of Sciences and is also one of the most important scientific journals included in the Web of Science (Scopus) database. This journal has a 42-year tradition of delivering original scientific studies and relevant information in the fields of meteorology, climatology and the water cycle, including the implications of climate change.

Životné prostredie (the Environment journal) – published by the Institute of Landscape Ecology of the Slovak Academy of Sciences.

Časopis Ekologické štúdie (the Ecological Studies journal) - is a domestic peer-reviewed scientific journal published by the Institute of Landscape Ecology of the Slovak Academy of Sciences in cooperation with the Slovak Ecological Society at the Slovak Academy of Sciences (SEKOS) and the Department of Ecology and Environmental Science of the Faculty of Natural Sciences of Constantine the Philosopher University in Nitra. The journal presents original scientific studies in the fields of ecology, landscape ecology, environmental science, ecological and environmental education as well as other related disciplines.

Publication of the State of the Environment Report - published regularly since 1993. Together with an assessment of the quality of the environment in Slovakia, the report highlights trends in environmental indicators. The report includes a chapter on climate change.

Report on air quality and the share of individual sources of air pollution in Slovakia - issued annually by the SHMÚ. The report provides information on emissions and the air pollution situation in Slovakia, the most significant stationary sources of air pollution in previous years and the development in the production of pollutants and greenhouse gases.

10.5.4 Important Information Centres

From a legal point of view, the collection, assessment and dissemination of environmental information in Slovakia to the public, including information on climate change, is covered by Act No. 211/2000 Coll. on free access to information, Act No. 205/2004 Coll. on the collection, storage and dissemination of environmental information and Act No. 478/2002 Coll. on air protection and CO_2 emission allowance trading. These regulations ensure the dissemination of information to the public.

Ministry of Environment – the publication of climate change information is the responsibility of the national focal point of the Ministry of Environment. It provides information on climate change, international negotiations and the development of specific instruments, including legislation, to address the issue.

Slovak Hydrometeorological Institute – provides information on the causes and consequences of climate change, adaptation and mitigation measures, emissions of pollutants and greenhouse gases.

Slovak Environment Agency (SEA) – updates and provides information and educational programmes for professionals and the general public on the state of the environment, including climate change.

Slovak Innovation and Energy Agency - provides free advice on new energy technologies and energy savings for households and businesses.

Environmental education is offered by most Slovak universities as an overall Master's degree programme or as individual subjects. Lecturers or scientists from these universities also give lectures and convey highly specialised knowledge to the general public and the mass media.

Green Line (Ministry of Environment of the Slovak Republic) - through the Green Line it is possible to anonymously report violations of laws designed to protect the environment. It is used to record complaints from citizens related to environmental crime or to provide information related to the environment. It addresses complaints about illegal felling of trees or cutting them down during bird nesting and other issues.

10.5.5 Media

Various mass media have been used to inform the public about climate change, its potential impacts and climate change policy in general.

RTVS (Slovak Television) - RTVS broadcasts the programme Meteoklub, where meteorologists discuss, for example, the topic of climate change. Reports, discussions or documentaries such as "Slovak Forests - Climate Change" or the six-part documentary series "Climate Change and Animals" are commonly broadcast on television.

The TV station TA3 broadcasted live several discussions with Slovak scientists and experts, which lasted from 10 to 90 minutes. For example, the programme "Climate Change: "What lies ahead?" was aired on the programme Interviews over Midnight; information about the "Climate Summit and the Slovak Republic's position" was presented on the programme Topic of the Day. Similar themes were discussed in the programmes "So Like This?" The television station Spectrum aired the documentary "The Climate Fallacy".

Radio Slovakia 1 regularly broadcasted 15 to 90 minute programmes ("To the point", "At first hand" and "Night pyramid" - live discussions with Slovak experts) on topical issues (the topic of climate change appeared in the programmes approximately five times a year). Climate-related topics have become the focus of the Spektrum and Magnes programmes, which bring the latest news in science and technology.

Every month, the Slovak Academy of Sciences organises a scientific discussion on current scientific issues (also for the general public) together with well-known scientists from Slovakia and abroad. Climate change was addressed in discussions on "Is the environment warming or can we use science effectively to reduce its temperature? How does space weather affect climate change?" or "Global change - navigation and adaptation". In 2015, the Slovak Academy of Sciences collaborated in the development of the "Climate Atlas of Slovakia", which shows the development of the climate in Slovakia over the last 50 years.

big fut: big steps for the future – big fut is a series of lively discussions that seek answers to the pressing questions of our time. In addition to the technological background, they provide an economic, social and moral perspective. Big fut is always held at a Slovak university. The discussions also cover climate topics such as "If we were all plants?", "Are we at risk of a global blackout in 2030?" (including the topic of nuclear vs. alternative energy), "What if there were only electric cars on the road?", "When will we stop driving cars?", and festivals on smart electricity and electromobility are organised.

The newspapers SME, Denník N, Pravda, Hospodárske noviny, Nový Čas, Plus Jeden Deň and the internet newspapers Aktuálne.sk, Aktuality.sk, Euractiv.sk regularly report on the current situation in the field of climate change after consulting with experts.

Ekotopfilm – this film festival with 44 years of tradition is the oldest event of its kind in the world. The festival is an exceptional space that brings together the public, private and third sectors through the themes of sustainable development.

10.6 PARTICIPATION IN INTERNATIONAL ACTIVITIES

The Slovak Republic has been a member of the European Environment Agency and the European Environment Information and Observation Network since 2001. Coordination on behalf of Slovakia is provided by the SEA. National Reference Centres are being set up within the European Environment Information and Observation Network, whose activities directly address climate change:

National Reference Centre for Air Pollution and Climate Change Mitigation,

National Climate Change Reference Centre - Impacts, vulnerability and climate change adaptation scenarios (including SHMÚ representatives).

The issue of climate change is also relevant to other activities of the National Reference Centre:

National Reference Centre for Agriculture and Forestry (including representatives of the Ministry of Agriculture and Rural Development of the Slovak Republic, the National Forest Centre and the SEA), National Reference Centre for Energy (including representatives of the Ministry of Economy and the SEA),

National Reference Centre for Soil (including representatives of Matej Bel University and the SEA),

National RC Reference Centre for Waste (including representatives of the SEA and the Statistical Office of the Slovak Republic).

The following reports are outputs of the European Environment Agency in the field of climate change:

Climate change, impacts and vulnerability in Europe 2016;

https://www.eea.europa.eu//publications/climate-change-impacts-and-vulnerability-2016

Trends and projections for Europe in 2016 - monitoring Europe's climate and energy targets;

https://www.eea.europa.eu//publications/trends-and-projections-in-europe

Approximate EU greenhouse gas emissions statistics: early estimates for 2015.

https://www.eea.europa.eu//publications/approximated-eu-ghg-inventory-2015

In 2003, the "European Network of the Heads of Environment Protection Agencies" was established, of which the SEA and the SHMÚ are members for the Slovak Republic. The network creates an independent space for the exchange of views on various environmental issues as well as for the formation of common positions in their further development.

The activities of the OECD Climate Change Expert Group, the Working Party on Environmental Information and the Joint Working Party on Agriculture and the Environment regarding method development and assessment have established criteria that are relevant to climate change issues.

ANNEX 1: THE FIFTH BIENNIAL REPORT OF THE SLOVAK REPUBLIC

1 INTRODUCTION

In accordance with decision 6/CP.25), developed country Parties shall submit their Fifth Biennial Reports (BR5) no later than 31 December 2022. By the decision 2/CP.17 it was decided that the developed country Parties should enhance reporting in national communications and submit biennial reports outlining their progress in achieving emission reductions and the provision of financial, technology and capacity-building support to non-Annex I Parties, building on existing reporting and review guidelines, processes and experiences.

This Fifth Biennial report was prepared as a part (annex) of the Eight National Communication of the Slovak Republic (8NC). Most of required information are included in the 8NC.

Tabular information as defined in the common tabular format (CTF) for the UNFCCC biennial reporting guidelines for developed country Parties (UNFCCC decision 19/CP.18) are submitted separately attached to this submission. For the CTF submission to the UNFCCC, the electronic reporting facility provided by the UNFCCC Secretariat has been used as required by UNFCCC decision 19/CP.18 and decision 9/CP.21 (replace tables 7, 7(a) and 7(b)).

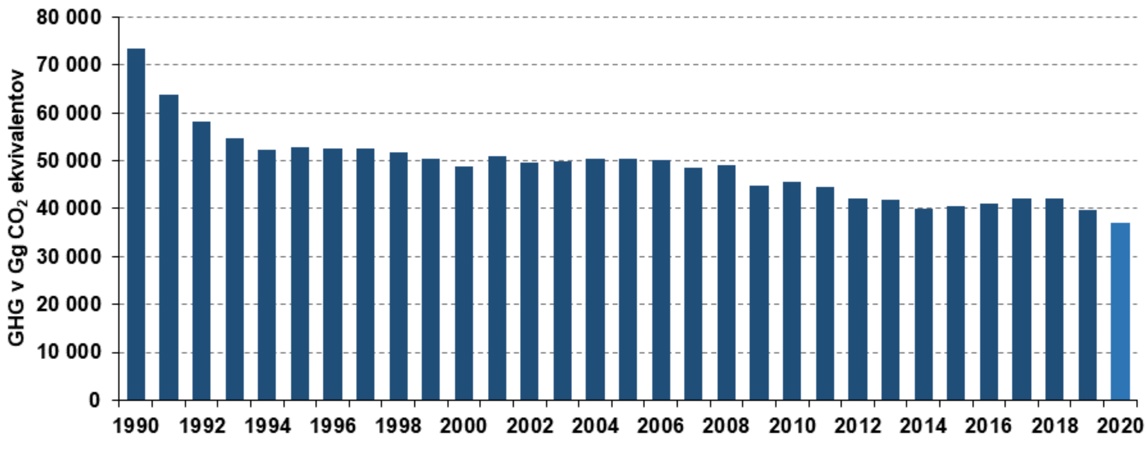
Tabular information and list of tables can be found in the **Annex 2** of the 8NC.

2 INFORMATION ON GREENHOUSE GAS EMISSIONS AND TRENDS

Total greenhouse gas (GHG) emissions in the Slovak Republic (without LULUCF) decreased by 49.6% from 1990 to 2020. The largest relative change was in the agricultural and energy sectors, where GHG emissions decreased substantially by 57% and 56%, respectively, compared to 1990. The reduction was due to changes in agricultural management practices and increases in energy efficiency and fuel consumption reduction.

In the following figure, the trend of GHG emissions is shown.

Figure A1.1: *The aggregated GHG emission trends*



More and detailed information can be found in the **Chapter 4** of the Eight National Communication of the Slovak Republic.

2.1 INFORMATION ON CHANGES IN THE NATIONAL INVENTORY SYSTEM

Small changes in the arrangement or structure of the National Inventory System of the Slovak Republic occurred since the Fourth Biennial Report:

- Strengthening capacity in the Waste sector, which was divided between 4 sectoral experts focusing separately on categories in the sector (composting, incineration, wastewater and SWDS) instead of one sectoral expert in previous year;
- Several new institutions were involved in the inventory, among others in transport (Control and Testing Body for road vehicles), Ministry of Transport and Construction of the Slovak Republic – Section of Buildings (for buildings energy balance mostly focusing of residential heating and cooling), State Nature Protection Body (for wetlands identification);
- New internal (SHMÚ) expert on emission projections was hired;
- The uncertainties calculations were previously based on external cooperation, since the year 202, an internal expert is responsible for all sectors across inventory;
- New expert was involved in the cropland category to strengthen new calculations on land-based matrix and new expert was involved into agricultural team.

The SVK NIS is operational, functioning and fulfilling all main tasks and obligation in the line with the approved plans. Standard actions regarding the personal and financial capacity took place and the activity is guarantee. Description of the National Inventory System of the Slovak Republic can be found https://oeab.shmu.sk/o-nas/dokumenty.html, document is in Slovak language.

More information can be found in the **Chapter 4.3** of the Eight National Communication of the Slovak Republic and relevant chapters in SVK NIRs.

3 QUANTIFIED ECONOMY-WIDE EMISSION REDUCTION TARGET

The Slovak Republic, as a one of the EU Member State, participate in the EU 2020 and EU 2030 emission reduction targets under the UNFCCC and the compliance architecture set up within the EU in order to meet that targets, and gives an overview of other EU environmental targets. The Slovak Republic also inform about the national circumstances and the progress in the fulfilment of the national mitigation policy.

3.1 THE EU TARGET UNDER THE CONVENTION

Under the UNFCCC, the EU and its Member States committed to achieving a joint quantified economy-wide greenhouse gas emission reduction target of 20 per cent below the 1990 level by 2020 ("the Cancun pledge"). It is therefore 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.

In 2010, the EU submitted a pledge to reduce its GHG emissions by 2020 by 20% compared to 1990 levels in order to contribute to achieving the ultimate objective of the UNFCCC: to stabilise GHG concentrations at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system, or, in other words, to limit the global temperature increase to less than 2°C compared to temperature levels before industrialization (FCCC/CP/2010/7/Add.1). The EU had also committed to raising this target to a 30% emission reduction by 2020 compared with 1990 levels, provided that other developed countries also commit to achieving comparable emission reductions, and that developing countries contribute adequately, according to their responsibilities and respective capabilities. This offer was reiterated in the submission to the UNFCCC by the EU-28 and Iceland on 30 April 2014.[163]

The definition of the Convention target 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" (FCCC/SB/2011/INF.1/Rev.1 of 7 June 2011). 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 (FCCC/AWGLCA/2012/MISC.1).

The EU's accounting rules for the target under the UNFCCC are more ambitious than the current rules under the Kyoto Protocol, for example, including international aviation, and adding an annual compliance cycle for emissions under the Effort Sharing Decision or higher Clean Development Mechanism (CDM) quality standards under the EU Emissions Trading System (EU ETS) (FCCC/TP/2013/7). Accordingly, the following assumptions and conditions apply to the EU's 20% target under the UNFCCC:

- The EU Convention pledge does not include emissions/removals from Land Use, Land Use Change and Forestry, 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 Kyoto Protocol.
- The target covers the gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.
- The target refers to 1990 as a single base year for all covered gases and all Member States. Emissions from international aviation to the extent it is included in the EU ETS are included in the target.[164]
- A limited number of CERs, ERUs 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. International credits will no longer be used fot EU ETS compliance in the system´s fourth trading period (2020-2030). In the ESD sectors, the annual use of international credits is limited to up to 3% of each Member State's ESD emissions in 2005, with a limited number of Member States being permitted to use an additional 1% from projects in Least Developed Countries (LDCs) or Small Island Developing States (SIDS), subject to conditions.
- The Global Warming Potentials (GWPs) used to aggregate GHG emissions up to 2020 under EU legislation were those based on the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) when the target was submitted. For the implementation until

[163] European Union, its Member States and Iceland submission pursuant to par 9 of decision 1/CMP.8 http://ec.europa.eu/clima/policies/international/negotiations/docs/eu_submission_20140430_en.pdf

[164] In the EU, the sum of emissions covered by categories 1.A.3.a 'domestic aviation' and memo item "international bunkers – aviation" go beyond the scope of the EU target, as emissions from international aviation are included in the EU Climate and Energy Package and the EU target under the UNFCCC to the extent to which aviation is part of the EU ETS

2020, GWPs from the IPCC's fourth assessment report (AR4) will be used consistently with the UNFCCC reporting guidelines for GHG inventories.

In 2015, the Paris Agreement was adopted and provides a framework to revisit and raise ambition in the future. Countries will now have to come together regularly to review their climate plans and collectively ensure that the necessary action is being taken to tackle climate change and limit global temperature rises to below 2°C, and pursue efforts for 1.5°C; and countries strive to prepare long-term low GHG emission development strategies. European Union has ratified the Paris Agreement on 5 October 2016. In pursuit of the temperature goals in the Paris Agreement, the Union should aim to achieve a balance between anthropogenic GHG emissions by sources and removals by sinks as early as possible and, as appropriate, achieve negative emissions thereafter.

The European Union has adopted Regulation 2018/1999 on the Governance of the Energy Union and Climate Action in December 2018. This Regulation sets out the necessary legislative foundation for reliable, inclusive, cost-efficient, transparent and predictable governance of the Energy Union and Climate Action (governance mechanism), which ensures the achievement of the 2030 and long-term objectives and targets of the Energy Union in line with the Paris Agreement. In this line, EU endorsed a 2030 Framework for Energy and Climate for the Union based on four key Union-level targets:

- a reduction of at least 40 % in economy-wide greenhouse gas (GHG) emissions;
- an indicative target of improvement in energy efficiency of at least 27%, to be reviewed by 2020 with a view to increasing the level to 30% - 32,5%;
- a share of renewable energy consumed in the Union of at least 27% with a view to increasing the level to 32%;
- and electricity interconnection of at least 15%.

3.2 THE EU TARGET COMPLIANCE ARCHITECTURE

The EU has jointly committed to its UNFCCC target and implemented it internally through EU legislation in the 2020 EU Climate and Energy Package. In this 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). Binding national targets were set for Member States under the Effort Sharing Decision. The achievement of EU internal compliance under the 2020 Climate and Energy Package including the national targets under the ESD is not subject to the UNFCCC assessment of the EU's joint commitment under the Convention.

The Global Warming Potentials (GWPs) used to aggregate GHG emissions up to 2020 under EU legislation were those based on the Second Assessment Report of the IPCC when the target was submitted. In accordance with the CMP Decision to revise the GWPs to those from the IPCC Fourth Assessment Report (AR4) revised GWPs from AR4 were adopted for the EU ETS. The revised GWPs were taken into account for the revision of the ESD target. For the implementation until 2020, GWPs from AR4 will be used consistently with the UNFCCC reporting guidelines for GHG inventories.

Table A1.1: *Key facts of the Convention 2020 targets of the EU-28*

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 it is included in the EU ETS.
Land Use, Land-Use Change, and Forests (LULUCF)	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.
Other	Conditional offer to move to a 30% reduction by 2020 compared to 1990 levels as part of a global and comprehensive agreement for the period beyond 2012, provided, that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.

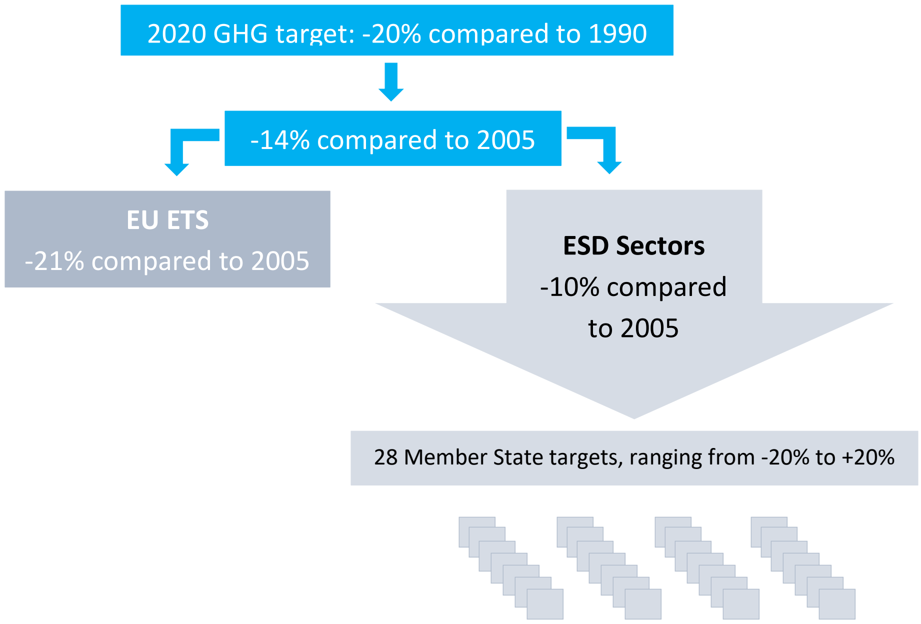
As this 2020 target under the Convention has only been submitted by EU-28 and not by each of its Member States (MS), there are no specified Convention targets for single MS. Due to this, Slovakia as part of the EU-28, takes on a quantified economy-wide emission reduction target jointly with all Member States.

With the 2020 climate and energy package the EU has set internal rules which underpin the implementation of the target under the Convention. 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 (ESD).

These two sub-targets are:

- 21% reduction target compared to 2005 for emissions covered by the ETS (including domestic and international aviation);
- 10% reduction target compared to 2005 for ESD sectors, shared between the 28 MS through individual national GHG targets.

Figure A1.2: *GHG targets under the 2020 climate and energy package*



Under the revised EU ETS Directive[165], 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 decreases by 1.74% annually, starting from the average level of allowances issued by Member States 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 the EU-BR.

Non-ETS emissions are addressed under the Effort Sharing Decision (ESD).[166] 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 land use, land-use change and forestry (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 Member State (***Figure A1.2***). In the Effort Sharing Decision national emission targets for 2020 are set, expressed as percentage changes from 2005 levels. For Slovakia, this percentage changes from 2005 levels are +13%. These changes have been transferred into binding quantified annual reduction targets for the period from 2013 to 2020 (EC 2013),[167,168]

[165] Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community

[166] Decision No 406/2009/EC

[167] Commission Decision of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No. 406/2009/EC of the European Parliament and of the Council (2013/162/EU).

[168] Commission Implementing Decision of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No. 406/2009/ EC of the European Parliament and of the Council (2013/634/EU).

expressed in Annual Emission Allocations (AEAs). The quantified annual reduction targets 2013 – 2020 of Slovakia are set from 24.02 million AEAs in 2013, and increasing to 25.95 million AEAs in 2020. In the year 2020, verified emissions from stationary installations covered under the EU-ETS in Slovakia summed up to 18.2 Mt CO_2 eq. With total GHG emissions of 37.0 Mt CO_2 eq. (without LULUCF), the share of EU ETS emissions is around 49 %.

The monitoring process is harmonized for all European MS, especially laid down in the Monitoring Mechanism Regulation.[169] The use of flexible mechanisms is possible under the EU ETS and the ESD. For the use of CER and ERU under the EU ETS, please refer to the Fourth Biennial Report of the European Union.

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.[170] The emission reduction target is a pledge to reduce emissions by at least 55% (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).[171]
- 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 Slovak Republic is 12% emissions reduction against 2005. This has been agreed under the Effort Sharing Regulation (2018/842).[172] 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. Slovakia has approved the Slovak EviroStrategy 2030, which sets a voluntary increase of the legislative target up to 20% emission reduction target for Slovakia until 2030 against 2005.
- 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).[173] 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.

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[169] Regulation (EU) No. 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

[170] Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee of the Regions. A policy framework for climate and energy in the period from 2020 to 2030 COM(2014) 015 final.

[171] Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814

[172] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on 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.

[173] REGULATION (EU) 2018/841 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No. 525/2013 and Decision No. 529/2013/EU.

Table A1.2: *Key facts of the Convention 2030 targets of the EU-28*

Parameters	Target
Base Year	1990
Target Year	2030
Emission Reduction target	-55% in 2030 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 it is included in the EU ETS.
Land Use, Land-Use Change, and Forests (LULUCF)	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.
Other	Conditional offer to move to a 45% reduction by 2030 compared to 1990 levels as part of a global and comprehensive agreement for the period beyond 2020.

For Tabular summary of the information provided in this Chapter, please see **CTF Tables 2**.

3.3 OTHER EMISSIONS REDUCTION TARGET

In addition to the EU target under the Convention, the EU also committed to a legally binding quantified emission reduction commitment for the second commitment period of the Kyoto Protocol (2013-2020).

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. For details, see the EU's BR5.

In the ***Table A1.3***, all relevant GHG reduction targets for the EU and their key facts are displayed in an overview. First table includes the international commitments under the Kyoto Protocol and the UNFCCC. Second table includes the Slovak Republic commitments under the EU Climate and Energy Package until 2020 and the Climate and Energy Framework until 2030.

Table A1.3: *Overview and comparison of international, and EU targets for Slovakia*

Item	International Commitment			
	Kyoto Protocol		UNFCCC	Paris Agreement
Target year or period	First Commitment Period (2008-2012)	Second Commitment Period (2013-2020)	2020	2030
Emission reduction target	-8%	-20%	-20%	-55%
Further targets	-	-	Conditional target of -30% if other Parties take on adequate commitments	-
Base year	1990 KP Flexibility rules (Art 3(5)) regarding F-Gases and Economies in Transition	1990, 2000 used as the base year for NF_3	1990	1990
LULUCF	Included ARD and other activities not elected	Includes ARD and forest management, other activities if elected (new accounting rules)	Excluded	LULUCF in the scope of the LULUCF Reg. included
Aviation	Domestic aviation included. International aviation excluded.	Domestic aviation included. International aviation excluded.	Aviation in the scope of the EU ETS included. In practice total aviation emissions considered.	Aviation in the scope of the EU ETS included

Item	International Commitment			
	Kyoto Protocol		UNFCCC	Paris Agreement
Use of international credits	Use of KP flexible mechanisms subject to KP rules	Use of KP flexible mechanisms subject to KP rules	Subject to quantitative and qualitative limits	No contribution from international credits
Carry-over of units from preceding periods	Not applicable	Subject to KP rules including those agreed in the Doha Amendment	Not applicable	Not applicable
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3
Sectors included	Annex A of KP (Energy, IPPU, agriculture, waste), LULUCF according to KP accounting rules for CP1	Annex A of KP (Energy, IPPU, agriculture, waste), LULUCF according to accounting rules for CP2	Energy, IPPU, agriculture, waste, aviation in the scope of the EU ETS	Energy, IPPU, Agriculture, Waste, LULUCF
GWPs used	IPCC SAR	IPCC AR4	IPCC AR4	IPCC AR4

Item	EU Domestic Climate and Energy Framework Legislation Climate and Energy Package		EU Domestic Legislation Climate and Energy Framework	
	EU ETS	ESD	EU ETS	ESR
Target year or period	2013-2020	2013-2020	2020-2030	2020-2030
Emission reduction target	-21% compared to 2005 on the EU level	Annual target +13% target in 2020 for Slovakia (-10% for EU) compared to 2005 for non-ETS emissions	-43% compared to 2005 on the EU level	Annual targets trajectory with the -12% for Slovakia target in 2030
Further targets	Renewable Energy Directive: 14% share of renewable energy of gross final energy consumption in 2020; Energy Efficiency Directive: indicative target to decrease Final Energy Consumption to 378 PJ and Primary Energy Consumption to 686 PJ in 2020		Renewable Energy Directive: 32% share of renewable energy of gross final energy consumption in 2030; Energy Efficiency Directive sets a 32,5% energy efficiency target for 2030	
Base year	1990 for overall emission reduction target; 2005 for renewable energy and energy efficiency target; as well as for targets broken down into ETS and non-ETS emissions		1990 for overall emission reduction target; 2005 for renewable energy and energy efficiency target; as well as for targets broken down into ETS and non-ETS emissions	
LULUCF	Excluded		Included (LULUCF Regulation)	
Aviation	Domestic and international aviation, as in the scope of EU ETS	Aviation generally excluded, some domestic aviation included (operators below ETS de Minimis thresholds)	Domestic and international aviation, as in the scope of EU ETS	Aviation generally excluded (CO2 emissions from IPCC sources category '1.A.3.A civil aviation' shall be treated as zero)
Use of international credits	Subject to quantitative and qualitative limits, as set in EU Regulation 1123/2013.	The annual use of credits by Slovakia shall not exceed a quantity equal to 3 % from 2005 levels.	International credits are no longer compliance units within the EU ETS	Use of credits by Member States without quantitative limit
Carry-over of units from preceding periods	EU ETS allowances can be banked into subsequent ETS trading periods since the second trading period	No carry-over from previous period	EU ETS allowances can be banked into subsequent ETS trading periods since the second trading period	No carry-over from previous period
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6		CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	
Item	EU Domestic Climate and Energy Framework Legislation Climate and Energy Package	EU Domestic Legislation Climate and Energy Framework	Item	EU Domestic Climate and Energy Framework Legislation Climate and Energy Package
Sectors included	Power & heat generation, energy-intensive industry	Transport (except aviation), buildings,	Power & heat generation, energy-	IPCC source categories of energy, transport (except

	sectors, aviation (Annex 1 of ETS directive)	non-ETS industry, agriculture (except forestry) and waste	intensive industry sectors, aviation (Annex 1 of ETS directive)	aviation), non-ETS industry, agriculture (except forestry) and waste
GWPs used	IPCC AR4		IPCC AR4	

4 PROGRESS TO QUATIFIED ECONOMY-WIDE EMISSION REDUCTION TARGET

The EU has substantially overachieved its reduction target under the Convention, which means that also its Member States and the United Kingdom have fulfilled their emission reduction obligations. As stated in the 2022 EU GHG inventory submission to the UNFCCC, the total GHG emissions, excluding LULUCF and including international aviation, decreased by 34% in the EU-27 + UK compared to the base year 1990 or 1.94 billion tons of CO_2 eq. (carbon dioxide equivalent).

For the quantification of the progress to 2020 targets, the development of GHG emissions is the key indicator. The Convention target of a reduction of emissions by 20% from 1990 to 2020 only refers to the emissions of the EU-28 as a whole. GHG emissions of EU-28 are calculated as the sum of MS emissions. The development of GHG emissions in Slovakia is reported in CTF Table 4. Emissions in the sector of LULUCF are not included under the convention target, therefore they are not included in CTF Tables 4 and 4(a). The latter shall be filled with "NA" for not applicable, with the explanation "Numbers for LULUCF are not reported because this sector is not included under the Convention target". The use of flexible mechanisms takes place on the one hand by operators in the EU ETS, on the other hand by governments for the achievement of ESD targets. For information on the use in the ETS please see the Fourth Biennial Report of the European Union (Chapter 4.4.1). The use of flexible mechanisms in Slovakia currently takes place only by operators in the EU ETS. Slovakia is not planning to use international credits in the ESD/ESR scheme for meeting the annual trajectory target.

Slovakia fulfilled its emission reduction targets resulting from international and EU commitments in 2020. In 2020, anthropogenic GHG emissions decreased by 45.56% compared to 1990. Considering EU commitment for sectors covered by the EU ETS and sectors not covered by the EU ETS and covered by the ESD to decrease its emissions by 20% compared to 1990, Slovakia met its commitments. GHG emissions in the EU ETS decreased in 2020 by 27.99% compared to 2005 and ESD emissions, even Slovakia has positive target of 13% up to 2020, decreased in 2020 by 18.41% compared to 2005.

Table A1.4: *Total GHG emissions distribution between the EU ETS and ESR for the years 2013 – 2020*

YEAR	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**
	Gg of CO_2 equivalents							
Total greenhouse gas emissions without LULUCF	37 002.71	39 776.35	42 081.77	42 215.29	41 126.85	40 657.98	39 959.81	41 915.25
Total verified **EU ETS** emissions	18 170.00	19 903.84	22 193.40	22 063.23	21 264.05	21 181.22	20 918.07	21 831.83
CO_2 emissions from 1.A.3.A civil aviation	0.88	1.83	2.85	3.42	3.56	3.66	3.44	3.40
Total verified **ESR** emissions	19 062.12	20 087.96	21 065.07	21 249.80	19 758.69	20 084.62	19 782.14	21 080.25

According to the emissions inventory submitted in April 15, 2022, the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by 45.56% without LULUCF, compared to the base year 1990.

This achievement is the result of impacts of several processes and factors, mainly:

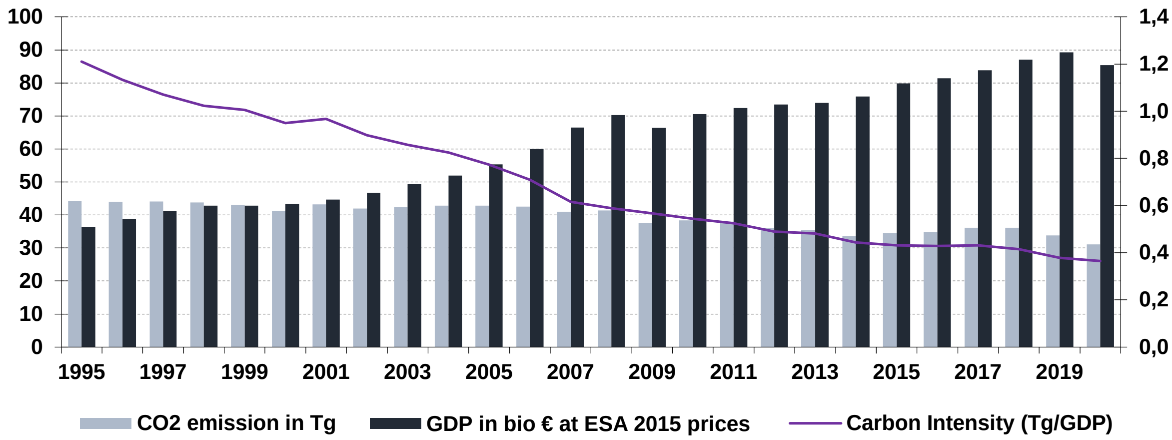
- Covid-19 pandemic impacts on transport, industry and services.
- Higher share of services on the GDP.
- Technological restructuring and change in structure of industries.
- Higher share of gaseous fuels on consumption of primary energy resources.
- Gradual decrease in energy consumption for certain energy intensive sectors.
- Impact of air protection legislation, which regulates directly or indirectly generation of greenhouse gas emissions.
- Global economic and financial crises started in 2009 and the short-term crises in oil and natural gas supply from Ukraine at the beginning of 2009 (January-February).
- Increase of energy efficiency and share of the renewable energy sources on final consumption.
- Phased-out one of three furnaces in the US Steel company (iron and steel producer) in June 2019 mostly caused decrease of EU ETS emissions in comparison with the ESR emissions (non-EU ETS). Re-introduction of the phased-out furnace took place in beginning of 2021, so the decrease of emissions will continue also in 2020 inventory. This caused the opposite the share of allocated emissions in the EU ETS (48%) and the ESR (52%) emissions (***Table A1.4***).
- Implementation of strict policies and measures in climate change and international agreements up to 2030 focused mostly on the EU ETS categories.
- Less intensive winter seasons, lower fuel consumption for heating.
- Higher share of biomass in the residential heating sector.

Table A1.5 and ***Figure A1.3*** show the most significant trend indicator of GDP and GHG emissions decoupling which was achieved in Slovakia in past years. In addition, development in the last inventory year (2020) is an evidence of continuation of decoupling process started in the 1997 and continuing after economic crises in 2009. With the recovery of economy, carbon emissions did not follow GDP growth. This is a signal of total reconstruction of Slovak economy and industry. It is also expected, that similar trend will continue in the future, while there are planned investments in energy saving and efficiency and step by step building a carbon neutral economy.

Table A1.5: *Decrease of carbon intensity per GDP in the Slovak Republic in 2005 – 2020*

YEAR	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 emission *in Tg*	42.79	42.55	40.97	41.36	37.62	38.40	37.98	35.91
GDP *in Bio €* **at ESA 2015 prices**	55.33	60.03	66.53	70.24	66.41	70.59	72.45	73.43
Carbon Intensity *in Tg/GDP*	0.77	0.71	0.62	0.59	0.57	0.54	0.52	0.49
YEAR	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CO_2 emission *in Tg*	35.57	33.66	34.47	34.91	36.11	36.10	33.78	31.09
GDP *in Bio €* **at ESA 2015 prices**	73.91	75.93	79.89	81.43	83.86	87.04	89.31	85.42
Carbon Intensity *in Tg/GDP*	0.48	0.44	0.43	0.43	0.43	0.41	0.38	0.36

Figure A1.3: *Comparison of CO_2 emissions per GDP (carbon intensity) in 1995 – 2020*



The Slovak Statistical Office, Dpt. of National Accounts. Within the revision of annual national accounts (base year 2015).

5 POLICIES AND MEASURES

The activities of the Slovak Republic on the development of policies and measures to mitigate GHG emissions have intensified since the publication of the Seventh National Climate Change Report of the Slovak Republic. Ministry of the Environment of the Slovak Republic (MŽP SR) and the Slovak Hydrometeorological Institute have taken all necessary steps to improve mechanisms for monitoring, evaluating and improving tools and measures to meet national reduction commitments under the UNFCCC. All relevant policies and measures at EU level shall be strengthened to meet the 2030 objectives of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Achieving these emissions reduction over the next decade is key to making Europe the world's first climate-neutral continent by 2050 and to making the European Green Deal a reality. With the proposals, the Commission is presenting the legislative tools to achieve the objectives agreed in the European climate legislation and the fundamental transformation of Slovak economy and society for a fair, green and prosperous future. As can be seen from recent GHG inventories, the Slovak Republic is on track to meet its commitments.

For the relevant information, please refer to Chapter 5 of the Eight National Communication of the Slovak Republic.

5.1 INFORMATION ON EFFECTS OF THE MITIGATION ACTIONS

This chapter provides information on general strategy documents as well as national key policies and measures implemented or under discussion to reduce GHG emissions in Slovakia. The information in this Chapter present sectoral policies and measures for the „With Measures“ scenario (WEM) and the „With Additional Measures“ (WAM) scenario. Both scenarios are used in the GHG projections presented in Chapter 6 of this report.

5.1.1 Policies and Measures to Reduce Greenhouse Gases

The main policy choice was emissions trading with a resulting price per tonne of emissions. Complementary policies adopted objectives to reduce greenhouse gas emissions in non-trading sectors, increase the share of renewable energy, increase energy efficiency as well as new legislation setting stricter quality standards for fuels and cars. The policies adopted may have had some implications for third countries, either through basic carbon market pricing mechanisms or requirements to comply with new and more stringent environmental regulations. CO_2 emissions trading (either EU ETS or Kyoto emissions trading) and increasingly stringent fuel quality standards may have had some impact. The main example of indirect impact on third countries is the integration of the aviation sector into the trading system. Among indirect effects, the main example is the concern about possible carbon leakage. Most of the impacts of carbon leakage (shifts of industrial activity to countries without any GHG reduction commitments, potential downward pressure on oil prices, etc.) on third countries could be rather positive for them.[174] Measures in place to minimise potential carbon leakage include ensuring that economic sectors facing an imminent threat of carbon leakage continue to receive free CO_2 allowances under the circumstances. Furthermore, increasingly stringent fuel quality standards in Europe could actually prove to be a positive influence, as they could trigger an increase in investment in the fuel processing industry in third countries. Rising fuel prices in Europe as a result of the carbon price (or tax) and quality improvements could play against rising oil prices, particularly as a result of the growing scarcity of this commodity. Such effects could on the one hand negatively affect the returns of oil exporting countries, which on the other hand may still be offset by rising demand from the rest of the world. The ultimate net impact will depend on the benefits derived from the expansion of industrial production and the costs required to clean up higher levels of pollution, including dealing with the consequences. Apart from emissions trading, the Slovak Republic has not used any other flexible instrument under the Kyoto Protocol to meet its GHG reduction targets, therefore no impact on third countries is reported in this sense. The actions considered in the development of the Climate Change Adaptation Strategy are local in nature with no implications for third countries.

5.1.2 General Strategy Documents

National Reform Programme – is a national and regularly updated programme with the main objective of meeting the structural policy objectives of the EU 2020 Strategy. It also contains an Action Plan with target policies for specific sectors, including identified financial allocations.

National Reform Programme 2022[175] – is a national and regularly updated programme with the main objective of meeting the goals of the 2030 Agenda for Sustainable Development (Agenda 2030) and the European Pillar of Social Rights (EPSP), thus replacing the Europe 2020 strategy that has been the backbone for the past decade. It also contains an Action Plan with target policies for specific sectors, including identified financial allocations.

Slovakia's Vision and Development Strategy 2030 (Slovakia 2030)[176] **–** this long-term sustainable development strategy, approved by Government Resolution No. 41 of 20 January 2021, also fulfils the role of the National Strategy for Regional Development of the Slovak Republic. It thus integrates sectoral priorities and regional and territorial development priorities, thus linking the public administration (the Central Government Authorities) and the local government authorities (cities, municipalities, higher level territorial units). It is based on four principles: the principle of sustainability,

[174] In some specific cases where a polluter seeks a site in a developing country, thereby causing an increase in local pollution, the increased environmental harm may outweigh the economic benefit.

[175] https://rokovania.gov.sk/RVL/Material/27183/1

[176] https://rokovania.gov.sk/RVL/Material/25655/1

i.e. the balance between available resources and their use, the priority of quality of life over economic growth, efficiency based on synergies and the integration of policies and their instruments.

Its objectives in the field of air include:

- Reduce air emissions by 82%, NO_X by 50%, NMVOC by 32%, NH_3 by 30% and $PM_{2.5}$ by 49% by 2030 compared to 2005 by implementing adequate environmental measures across all sources of pollution (industry, energy, transport, agriculture, domestic heating) and ensuring adequate monitoring of air pollutants, supported by the establishment of new air quality monitoring stations.

- Reduce air pollution, especially from industry, energy, local heating and transport, and encourage the establishment of new air quality monitoring stations as part of the development and information of the population In terms of environmental objectives, Slovakia 2030 is to ensure the protection, restoration and enhancement of natural resources, including ensuring the stability and health of ecosystems and their services, and the reflection of adaptation and mitigation measures to the adverse effects of climate change in all departmental strategic documents and municipal and regional development documents as an overriding public interest (e.g. in transport planning, energy, spatial planning, spatial planning, water management, land management, forestry, sustainable tourism, overall care of the countryside, etc.).

Environmental Policy Strategy of the Slovak Republic until 2030 - Greener Slovakia (or Envirostrategy 2030) – was adopted in February 2019, defines a vision for 2030, taking into account possible, probable and desired future developments, identifies key systemic issues, sets targets for 2030, proposes framework measures to improve the current situation, and includes key outcome indicators to verify the results achieved. As part of climate change mitigation, Slovakia will reduce greenhouse gas emissions in emissions trading sectors by 43% and outside these sectors by at least 20% compared to 2005. An effective emissions trading system will continue. Adaptation measures in the regions will reflect their specificities and be sufficiently responsive to climate change.

Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050 (NUS SR) – was approved by the Government of the Slovak Republic on 5 March 2020. The NUS SR responses to the commitments in the fight against climate change resulting from its membership in the European Union and the United Nations and the associated obligation to develop a long-term strategy with a scope of at least 30 years. The objective of the strategy is to identify existing and propose new additional measures within the SR to achieve climate neutrality by 2050. The primary objective of the NUS SR is to identify all measures, including additional ones that will lead to achieving climate neutrality in the Slovak Republic by 2050.

Integrated National Energy and Climate Plan 2021-2023 (NECP) was adopted by Government Resolution No. 606/2019. The Integrated National Energy and Climate Plan is a broad conceptual material, which is based on existing or upcoming strategic materials of several ministries, sets the framework for the implementation of legislative and non-legislative measures aimed at climate protection and long-term sustainable energy. The main quantified targets of the NECP in the framework of the Slovak Republic by 2030 are the reduction of GHG emissions for non-ETS sectors by 20% (the share has been increased from the originally declared level of 12%). Taking into account the EC's recommendation to increase the ambition in renewable energy sources (RES), the current draft of the NECP foresees an objective of 19.2% RES in 2030. Ministry of Economy SR will take all available steps to accelerate the development of RES especially in heat production during 2021-2030 and to bring Slovakia closer to a higher share of RES in 2030. The elaborated measures for achieving the national energy efficiency contribution of the Slovak Republic show values slightly lower (30.3%) than the European target of 32.5%. The industrial and buildings sectors will be key to achieving the objectives. Electricity interconnection is already above 50% and will remain so until 2030, so the objective of at least 15% interconnection will be met.

National Emissions Reduction Programme Directive (EU) 2016/2284 on the reduction of national emissions of certain air pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC sets emission reduction targets for sulphur oxides, nitrogen oxides, non-methane volatile organic compounds, ammonia and $PM_{2.5}$ by 2030. Government Resolution No. 103/2020 of 5 March 2020 approved the National Emission Reduction Programme, which proposes policies and measures to achieve the above-mentioned national commitments in two phases, for the period from 2020 to 2029 and for the period after 2030. The National Emission Reduction Programme contributes to achieving the air quality objectives under Directive 2008/50/EC, as well as ensuring consistency with plans and programmes set out in other relevant policy areas, including climate, energy, agriculture, industry and transport. At the same time, it will encourage a shift of investment towards clean and efficient technologies.

5.1.3 Sectoral Policies and Measures

Cross-sectoral and sectoral policies and measures in place as well as planned are presented in ***Table A1.6***. Additional information on these policies and measures can be found in CTF Table 3. attached to this submission. Policies and measure reported in BR5 have either a direct effect on GHG emissions or support the implementation of WEM/WAM scenario.

Table A1.6: *Summary of policies and measures considered into emission projections modelling*

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
SECTORAL POLICIES AND MEASURES – ENERGY						
Impact of European legislation - Ecodesign Framework Directive	CO_2	Efficiency improvement of appliances (Energy Consumption); Efficiency improvements of vehicles (Transport)	Regulatory, Economic	Implemented	2005	Ministry of Environment of the Slovak Republic (National Government)
Impact of European legislation - Energy Labelling Directive for Products (Directive 2010/30/EU)	CO_2	Efficiency improvement of appliances (Energy Consumption)	Regulatory, Economic	Implemented	2011	Ministry of Economy of the Slovak Republic (National Government); Slovak Office of Standards. Metrology and Testing
Impact of European legislation - Energy Performance of Buildings Directive (2010/31/EU)	CO_2	Efficiency improvements of buildings (Energy Consumption)	Regulatory	Implemented	2012	Ministry of Economy of the Slovak Republic (National government); Ministry of Transport and Construction of

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
						the Slovak Republic. (National Government)
Impact of European legislation - Energy Efficiency Directive (Directive 2012/27/EU)	CO_2	Efficiency improvements of buildings (Energy Consumption)	Regulatory	Implemented	2012	Ministry of Economy of the Slovak Republic (National Government)
Impact of European legislation - Directive 2009/73/EC, Directive 2009/72/EC, Regulation (EC) No. 715/2009. Regulation	CO_2	Decarbonisation of the internal gas market	Regulatory	Implemented	2009	Ministry of Economy of the Slovak Republic (National Government)
Impact of European legislation - Directive on the Promotion of the use of Energy from Renewable Sources - Renewable Energy Directive - including the amendment on ILUC (Directive 2009/28/EC as amended by Directive (EU) 2015/1513)	CO_2	Decrease of CO_2 emission (Other energy supply); Increase in renewable energy (Energy Supply); Efficiency improvement in the energy and transformation sector (Energy Supply).	Regulatory	Implemented	2009	Ministry of Economy of the Slovak Republic (National government); Ministry of Environment of the Slovak republic (National Government)
Impact of European legislation - "Clean Energy for All Europeans"	CO_2	Increase in renewable energy (Energy Supply)	Regulatory, Economic	Implemented	2016	Ministry of Economy of the Slovak Republic (National Government)
National Renewable Energy Action Plan, Government Resolution No. 677/2010	CO_2	Efficiency improvement in industrial end-use sectors (Energy Consumption); Efficiency improvement in sen/ices/tertiary sector (Energy Consumption); Efficiency improvement in the energy and transformation sector (Energy Supply).	Regulatory, Economic	Implemented	2011	Ministry of Economy of the Slovak Republic (National Government); Regional energy agencies(Regional entities) ; Commercial sector (Companies / businesses / industrial associations)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Impact of European legislation - EU EPS Directive 2003/87/EC as last amended in 2018 (Directive (EU) 2018/410)	CO_2	Decrease of CO2 emission (Other energy supply); Increase in renewable energy (Energy Supply); Efficiency improvement in the energy and transformation sector (Energy Supply); Efficiency improvement in industrial end-use sectors (Energy Consumption).	Regulatory, Economic	Implemented	2013	Ministry of Environment of the Slovak Republic (National Government)
Act No. 137/2010 Coll. on Air Protection as amended	CO_2	Prevention and control of air pollution and reduction of air pollution.	Regulatory, Economic	Implemented	2010	Ministry of Environment of the Slovak Republic (National Government)
Increasing Energy Efficiency with a number of measures in force since 2014 on the energy consumption side, according to which energy savings show up as a reduction in final energy consumption	CO_2	Efficiency improvements of buildings (Energy consumption); Efficiency improvement in industrial end-use sectors (Energy consumption); Efficiency improvement in services/ tertiary sector (Energy consumption); Efficiency improvement in the energy and transformation sector (Energy supply).	Regulatory, Economic	Implemented	2014	Ministry of Economy of the Slovak Republic. (National Government); Regional energy agencies; Commercial sector (Companies/ businesses/ industrial associations)
Optimisation of a district heating systems	CO_2	Switch to less carbon-intensive fuels (Energy supply); Demand management/reduction (Energy consumption).	Regulatory, Economic	Implemented	2015	Ministry of Economy of the Slovak Republic (National Government); Commercial sector (Companies / businesses / industrial associations)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Closure of solid fuel heating plants	CO_2	Increase in renewable energy (Energy supply)	Regulatory, Economic	Implemented	2015	Ministry of Economy of the Slovak Republic (National Government); Commercial sector (Companies / businesses /
Low-Carb on Development Strategy of the Slovak Republic until 2030 with a view to 2050	CO_2 CH_4 N_2O	To identify measures, including additional measures, to achieve climate neutrality in Slovakia by 2050	Regulatory, Economic	Implemented	2020	Ministry of Environment of the Slovak Republic (National government); Ministry of Economy of the Slovak Republic (National government); Ministry of Transport and Construction of the Slovak Republic (National government); Ministry of Interior of the Slovak Republic (National Government); Ministry of Agriculture and Rural Development of the Slovak Republic (National government); Commercial
Increasing carbon prices under the EU ETS after 2020	CO_2	The increase in carbon prices can accelerate the Slovak Republic ' s transition to a green economy by stimulating investment and innovation; Efficiency improvement in the energy and transformation sector (Energy supply)	Economic	Adopted	2020	Ministry of Finance of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Early decommissioning of solid fuel power plants	CO_2	Switch to less carbon-intensive fuels (Energy supply)	Regulatory, Economic	Planned	2023	Ministry of Economy of the Slovak Republic (National Government)
Decarbonising electricity generation after 2020 through RES and nuclear development	CO_2	Increase in renewable energy (Energy supply)	Economic	Planned	2022	Ministry of Economy of the Slovak Republic. (National Government);
Renewable energy support scheme	CO_2	Facilitate the deployment of renewables	Economic	Planned	2022	Ministry of Economy of the Slovak Republic (National Government)
Increasing the share of nuclear energy in the energy mix of the Slovak Republic	CO_2	Enhanced non-renewable low carbon generation (nuclear) (Energy supply)	Regulatory, Economic	Planned	2023-2035	Ministry of Economy of the Slovak Republic (National Government)
Continued reduction of final energy consumption in all sectors after 2020	CO_2	Efficiency improvement in the energy and transformation sector (Energy supply); Efficiency improvements of buildings (Energy consumption); Efficiency improvement in industrial end-use sectors (Energy consumption)	Economic, Regulatory	Planned	2022	Ministry of Economy of the Slovak Republic (National Government); Commercial sector (Companies / businesses / industrial associations)
Assessment of the future structure of appliances used for domestic heating based on survey data	CO_2	Improvement of air quality and lower greenhouse gas and pollutant emissions in the local area of cities and municipalities.	Regulatory, Economic	Planned	2022	Ministry of Environment of the Slovak Republic. (National Government)
Green Households II	CO_2	To increase the share of RES use in households and the associated reduction of greenhouse gas emissions replacement of old solid fuel heating equipment (boilers) in households with	Regulatory, Economic	Implemented	2015	Ministry of Economy of the Slovak republic (National Government); Regional centres of the Slovak Innovation and Energy

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
		low-emission systems.				Agency; Commercial sector (Companies / businesses / industrial associations)
Recovery and Resilience Plan - Restore Home Project	CO_2, CO, NO, N_2O, PM_{10}, $PM_{2.5}$, NMVOC	Reducing the energy demand of homes will positively affect household management, and reducing CO_2 emissions will contribute to improving the quality of the environment and the health of Slovakia's	Regulatory, Economic	Implemented	2022	Ministry of Environment of the Slovak Republic (National Government); Slovak Environment Agency (Regional entities)
Awareness campaign and education on good coal and biomass burning practices - LIFE IP -Improving Air Quality (Populair)	CO_2, CO, NO, N_2O, PM_{10}, $PM_{2.5}$, NMVOC	Promoting air quality measures and raising awareness of the importance of air quality; Enhancing effective air quality management and implementation of Air Quality Management Plans; To minimize negative impacts of household heating and transport on the air quality Supporting the exchange of heat sources (boilers) in households; Improving air quality monitoring and reporting on at regional and local	Regulatory, Economic	Implemented	2020	Ministry of Environment (National Government)
SECTORAL POLICIES AND MEASURES – ROAD TRANSPORT						
Act No. 277/2020 on the Promotion of the Use of Energy from RES	CO_2	Efficiency improvements of vehicles (Transport); Low carbon fuels/electric cars (Transport)	Regulatory, Economic	Implemented	2007	Ministry of Economy of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Impact of European legislation - Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO_2 Emission Performance Standards for New Passenger Cars and Light Commercial Vehicles	CQ_2, CH_4, N_2O	Low carbon fuels/electric cars (Transport); Efficiency improvements of vehicles (Transport)	Regulatory	Implemented	2019	Ministry of Environment of the Slovak Republic (National Government); Ministry of Economy of the Slovak Republic (National government); Ministry of Transport and Construction of the Slovak Republic (National government); Ministry of Interior of the Slovak Republic (National government)
Impact of European legislation - Regulation (EU)2019/1242 of the European Parliament and of the Council 20 June 2019 Setting CO_2 Emission Performance Standards for New Heavy Duty Vehicles	CQ_2, CH_4, N_2O	Low carbon fuels/electric cars (Transport); Efficiency improvements of vehicles (Transport)	Regulatory	Implemented	2019	Ministry of Environment of the Slovak Republic (National Government); Ministry of Economy of the Slovak Republic (National government); Ministry of Transport and Construction of the Slovak Republic (National government); Ministry of Interior of the Slovak Republic (National government)
Energy efficiency in road transport	CO_2, CH_4, N_2O	Increase of cars efficiency and decrease of GHG emissions from passenger cars, vans and trucks.	Regulatory	Implemented	2019	Ministry of Economy of the Slovak Republic (National Government); Ministry of Transport and

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
						Construction of the Slovak Republic (National government)
Promotion of the sale of low- and zero-emission vehicles	CQ_2, CH_4, N_2O	Strong uptake of electric cars and fuel cell cars, replacing internal combustion engine cars.	Regulatory, Economic	Planned	2023	Ministry of Economy of the Slovak Republic (National Government)
Long-term financial mechanism to support the development of charging infrastructure for electromobility	CQ_2, CH_4, N_2O	Development in charging infrastructure, smart grids and energy storage should progress in line with the growth of electromobility.	Regulatory, Economic	Planned	2023	Ministry of Economy of the Slovak Republic (National Government)
Setting stricter requirements for periodic technical inspections of vehicles	CQ_2, CH_4, N_2O	Efficiency improvements of vehicles (Transport)	Regulatory	Planned	2023	Ministry of Interior of the Slovak Republic (National government); Presidium of the Police Force (National Government)
Vehicle registration fee based on grams of CO_2/km emissions	CQ_2, CH_4, N_2O	Low carbon fuels/electric cars (Transport)	Regulatory, Economic	Planned	2023	Ministry of Finance of the Slovak Republic (National Government)
Modal shift to public transport - Strategic Transport Development Plan 2030	CQ_2, CH_4, N_2O	Modal shift to public transport or non-motorized transport (Transport)	Regulatory, Economic	Planned	2023	Ministry of Transport and Construction of the Slovak Republic (National Government)
Modal shift in the transport of goods	CQ_2, CH_4, N_2O	Improved rail; infrastructure transport (Transport)	Regulatory, Economic	Planned	2025	Ministry of Transport and Construction of the Slovak republic (National Government)
Introduction and promotion of hydrogen powered vehicles (FCEv)	CQ_2, CH_4, N_2O	Low carbon fuels/electric cars (Transport)	Regulatory, Economic	Planned	2023	Ministry of Economy of the Slovak Republic (National government); Ministry of

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
						Transport and Construction of the Slovak Republic (National Government); Ministry of Environment of the Slovak Republic (National government)
Blending biomethane into CNG and LNG fuel	CQ$_2$, CH_4, N_2O	Low carbon fuels/electric cars (Transport); Efficiency improvements of vehicles (Transport)	Regulatory, Economic	Planned	2023	Ministry of Economy of the Slovak Republic (National Government)
SECTORAL POLICIES AND MEASURES – INDUSTRY						
Best Available Techniques (BAT) for servicing electrical equipment	SF_6	To prevent and control the emission of industrial pollutants.	Regulatory, Economic	Implemented	2015	Ministry of the Environment of the Slovak Republic (National Government)
New mandatory parameters for fluorinated gases	HFCs	Decrease of F-gases emissions; focus on high GWP gases	Regulatory, Economic	Planned	2025	Ministry of Environment of the Slovak Republic (National Government); Commercial sector
Impact of European legislation - Regulation (EU) No. 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated GHG	HFCs, PFCs, SF_6	Replacement of fluorinated gases by other substances (Industrial Processes)	Regulatory	Implemented	2015	Ministry of Environment of the Slovak Republic (National Government); Commercial sector
Implementation of the EU ETS in the industrial sector processes	HFCs, PFCs, SF_6	To limit the CO_2 emission from the energy industries, manufacturing industries and from industrial processes, as well as nitrous oxide emissions from the chemical industry and perfluorocarbons from production of aluminium.	Regulatory	Implemented	2013	Ministry of Environment of the Slovak Republic (National Government); Commercial sector(Companies / businesses / industrial associations)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Further reduction of N_2O content in aerosol cans	N_2O	T0 reduce nitrous oxide emission	Regulatory, Economic	Implemented	2017	Ministry of Environment of the Slovak Republic (National Government); Commercial sector (Companies / businesses / industrial associations)
Impact of EU legislation - Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on Binding Annual GHG Emission Reductions by Member States from 2021 to 2030 to Contribute to Climate Action to Meet their Commitments under the Paris Agreement and amending Regulation (EU) No. 525/2013	CO_2, CH_4. N_2O, HFCs, PFCs, NF_3, SF_6	Contribute to the achievement of the objective under the EFF Regulation (SR -12%)	Regulatory	Implemented	2015	Ministry of Environment of the Slovak Republic (National Government); Commercial sector
SECTORAL POLICIES AND MEASURES – AGRICULTURE						
Common Agricultural Policy Strategic Plan 2023-2027	N_2O, CH_4	T0 support farmers in the transition towards increased sustainability in our food systems.	Regulatory, Economic	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Decree of the MŽP SR No. 410/2012 Coll.	NF_3, N_2O	Improved animal waste management systems (Agriculture)	Regulatory, Economic	Implemented	2012	Ministry of Environment of the Slovak Republic (National Government). Ministry of Agriculture and Rural Development of the Slovak Republic
National Emissions Reduction Programme	CH_4, N_2O	Improvement of air quality; to reduce nitrogen oxides by 50 percent, ammonia by 30 percent and dust	Regulatory, Economic	Implemented	2021	Ministry of Environment of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
		particles with a diameter of less than 2.5 micrometre's by 49 percent by2030 year.				
Impact of European legislation - Methane Strategy	CH_4, N_2O	To reduce methane emissions in the energy, agriculture and waste sectors, as these areas account for almost the entirety of anthropogenic methane emissions.	Regulatory, Economic	Implemented	2021	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government); Ministry of Environment of the Slovak Republic
Impact of European legislation - The Farm to Fork Strategy	N_2O	Improving food security and preventing tampering product; Reducing the environmental impact of food production.	Regulatory, Economic	Planned	2025	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Impact of European legislation - Code of Good Agricultural Practice	N_2O, CH_4	To minimise ammonia emissions from the storage and application of organic manures, the application of manufactured fertilise.	Regulatory, Economic	Implemented	2020	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government); Ministry of Economy of the Slovak Republic (National Government)
Low Carbon Strategy of the Slovak Republic	N_2O, CH_4	Improved livestock management (Agriculture); Improved animal waste management systems (Agriculture)	Regulatory, Economic	Planned	2025	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Impact of European legislation - Fit for 55	N_2O, CH_4	To modernize the agricultural sector with an emphasis on good farming practices, soil quality and food security; Sustainability criteria for	Regulatory, Economic	Planned	2025	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
		bioenergy will be strengthened.				
SECTORAL POLICIES AND MEASURES – WASTE						
Act No. 79/2015 Coll. on Waste and on amendments and additions to certain ads. as amended	CO_2, CH_4, N_2O	Minimizing the negative impacts of waste generation and management; Enhanced recycling (Waste management waste); Reduced landfilling (Waste management waste)	Regulatory, Economic	Implemented	2015	Ministry of Environment of the Slovak Republic (National Government)
Waste Management Programme of the Slovak Republic for 2021 - 2025	CO_2, CH_4, N_2O	Improved wastewater management systems (Waste); Enhanced recycling (Waste); Improved treatment technologies (Waste)	Regulatory, Economic	Implemented	2021	Ministry of Environment of the Slovak Republic (National Government)
Concept of Water Policy of the Slovak Republic until 2030 with a view to 2050	CH_4, N_2O	Improved wastewater management systems (Waste); Improved treatment technologies (Waste)	Regulatory	Adopted	2022	Ministry of Environment of the Slovak Republic (National Government)
Act No. 302/2019 on the Back-up of Disposable Beverage Packaging and on amending and supplementing certain acts	CH_4	Prohibiting of single use plastic products and tableware to consumers for the consumption of food and beverages at the point of sale, both in stores and at public events	Regulatory, Economic	Implemented	2019	Ministry of Environment of the Slovak Republic (National Government)
SECTORAL POLICIES AND MEASURES – LAND USE, LAND-USE CHANGE AND FORESTY SECTOR (LULUCF)						
Impact of European legislation - EU Forest Strategy 2030	CO_2	To deliver growing, healthy, diverse and resilient EU forests.	Regulatory	Implemented	2021	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Impact of European legislation - Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the Integration of GHG Emissions and Removals from LULUCF into the 2030 Climate and Energy Policy Framework	CO_2	Enhanced forest management (LULUCF); Afforestation and reforestation (LULUCF)	Regulatory	Implemented	2020	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Rural Development Programme 2014-2020 extended until 2022	CO_2	Enhanced forest management (LULUCF); Afforestation and reforestation (LULUCF)	Economic	Implemented	2022	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Slovak Rural Development Programme for the period 2023-2027	CO_2	Enhanced forest management (LULUCF); Afforestation and reforestation (LULUCF)	Economic	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
National Forestry Programme of the Slovak Republic 2022-2030	CO_2	Improvement quality of life including by conserving and improving protective functions of forests; Support ecological forest management by supporting the development and use of environmentally friendly technologies; Improvement and enhancement of biodiversity.	Economic	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Motivating forest managers to implement forest protection measures in the most threatened stands within the National Forestry Programme	CO_2	Improving the effectiveness of the implementation of forest protection measures against biotic and abiotic harmful agents (mainly bark beetles and wind) in the most threatened stands.	Regulatory	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Motivating forest managers to introduce future climate target tree species into stands where natural regeneration cannot be expected (within the National Forestry Programme)	CO_2	Strengthening protection against natural disturbances (Land use. land use change and forestry); Reduce vulnerability to biotic and abiotic factors; support for the use of alternative management models to adjust tree species composition, use of suitable provenances.	Regulatory	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Motivating forest managers to start the process of conversion to nature-friendly forms of forest management within the National Forestry Programme	CO_2	Afforestation and reforestation (Land use, land use change and forestry); Maintenance and restoration of permanent grasslands.	Regulatory	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Expansion of areas under strict protection	CO_2	Protection of the national park by means of a measure known as a ' zoning ' of the national park.	Regulatory	Implemented	2019	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Transfers of unused agricultural land to forest land	CO_2	Enhanced forest management (LULUCF) Afforestation and reforestation (LULUCF).	Regulatory	Planned	2024	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Increasing the share of long-life wood products (HWP), including for construction purposes	CO_2	Increased total sustainable production and consumption of longer-lived HWPs; Promotion of the sustainable use of terrestrial ecosystems	Regulatory	Planned	2024	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)
Implementation of measures to increase carbon sequestration in agricultural soils and maintain high levels of organic carbon in carbon-rich soils	CO_2	Improving sustainable forest management; Afforestation and reforestation (Land use. land use change and forestry)	Regulatory	Planned	2023	Ministry of Agriculture and Rural Development of the Slovak Republic (National Government)

Name of policy or measure	GHGs affected	Objective and/or activity affected	Type of instrument	Status	Implemen-tation year	Implementing entity or entities
Grassland maintenance and restoration	CO_2	Maintenance and restoration of permanent grasslands.	Regulatory	Planned	2024	Ministry of Agriculture and Rural Development of the Slovak (National Government)

Table A1.7: *Indicators of policies and measures used in the GHG emission projections*

Name of PaM or group of PaMs	Indicators used to monitor and evaluate progress over time (ex-post or ex-ante)						Comments
	Indicators used	Unit	2020	2025	2030	2035	
Impact of European legislation - Energy Labelling Directive (Directive 2010/30/EU)	White Appliances	GWh	14 095	15 009	15 983	16 269	GWh useful energy - Household thermal
	Black Appliances	number of appliances	20 783	25 143	27 724	30 534	in thousands appliances
Impact of European legislation - Energy Efficiency Directive (Directive 2012/27/EU)	Energy Savings	GWh	365	606	925	966	CPS Energy Model
	Energy Efficiency Indicator - of Final energy demand (Unit: %)	in %	76.48	78.62	81.24	82.09	
Impact of European legislation - "Clean Energy for All Europeans"	Net Installed Capacity	GWhe	2.138	2.139	2.255	2.521	Renewables
National Renewable Energy Action Plan, Government Resolution No. 677/2010	Electricity Generation by Renewable plants	GWhe	5 015	5 109	5 291	5 687	CPS Energy Model
Impact of European legislation - EU ETS Directive 2003/87/EC as last amended in 2018 (Directive (EU) 2018/410)	Gross Electricity Generation by Biomass plants	GWhe	498	391	314	550	CPS Energy Model
Impact of European legislation - Regulation (EU) 2019/631 - setting CO2 Emission Performance Standards for New Passenger Cars and Light Commercial Vehicles	Share of new BEVs in total sales of new passenger cars	%	8.38	37.05	62.69	64.22	CPS Energy Model
	Stock of electric vehicles in the passenger car fleet	thousand vehicles	2 644	41 844	157 304	357 644	
Impact of European legislation - Regulation (EU) 2019/1242 - setting CO2 Emission Performance Standards for New Heavy Duty Vehicles	Stock of Zero-emission trucks (BEVs, FCEVs)	number of cars	10	981	2 869	5 921	CPS Energy Model
Promotion of biofuels in road transport	Final Energy Demand	GWh	2 066	2 132	2 316	2 480	CPS Energy Model
Implementation of the EU ETS in the industrial sector processes	Direct Use of Fuels in Industry (1)	GWh	50 767	51 738	50 969	50 516	Direct Use of Fuels in Industry - for all industry sector (1) Including steam and
	Steam Production by Industrial CHP	GWh	5 787	5 774	5 758	5 814	

Name of PaM or group of PaMs	Indicators used to monitor and evaluate progress over time (ex-post or ex-ante)						Comments
	Indicators used	Unit	2020	2025	2030	2035	
	Gross Electricity Production by Industrial CHP	GWh	1 458	1 402	1 399	1 415	self - produced electricity by CHPs and boilers
Optimisation of district heating systems	District Heating Losses	GWhth	1147	989	865	746	CPS Energy Model
	Heat Plant Biomass	GWhth	715	666	757	684	
	Heat Plant Gas	GWhth	2 386	2 378	2 242	2 179	
Closure of solid fuel heating plants	Fuel Consumption in Heat Solid Plants	GWh fuel	38	26	0	0	CPS Energy Model
Increasing carbon prices under the EU ETS after 2020	Carbon price	$\$/tCO_2$	20.9	31.3	46.6	102.9	CPS Energy Model
Early decommissioning of solid fuel power plants	Gross Electricity Generation by Coal plants	Gwhe	1274	851	20	0	CPS Energy Model
Decarbonising electricity generation after 2020 through RES and nuclear development	Net Electricity Generation by Solar PV plants	Gwhe	0.523	0.523	0.523	0.848	CPS Energy Model
	Net Electricity Generation by wind onshore turbines	Gwhe	0.028	0.132	0.259	0.344	
	Net Electricity Generation by Biomass plants	Gwhe	465	1 157	3 056	4 432	
Increasing the share of nuclear energy in the energy mix of the Slovak Republic	Net Installed Capacity (Nuclear energy)	Gwhe	2.632	2.632	2.632	2.632	CPS Energy Model
	Net Installed Capacity by Nuclear plant	Gwhe	20 793	20 793	20 793	20 793	
Continued reduction of final energy consumption in all sectors after 2020	Energy Savings	GWh	365	650	2 440	2 836	Residential sector
	Energy Savings	GWh	275	510	1 484	1 802	Tertiary sector
Modal shift to public transport - Strategic Transport Development Plan 2030	Reducing the mileage of passenger cars	mil.vehkm	30 258.77	29 630.15	29 979.50	26 099.88	CPS Energy Model
Promoting the sale of low- and zero-emission vehicles	Stock of electric Vehicles	thousand vehicles	2 644	100 427	141 265	189 613	CPS Energy Model
	Share of electric cars in the passenger car fleet	%	0.11	3.80	5.20	6.86	

Name of PaM or group of PaMs	Indicators used to monitor and evaluate progress over time (ex-post or ex-ante)						Comments
	Indicators used	Unit	2020	2025	2030	2035	
Promotion of biofuels in road transport	Final Energy Demand	GWh	2 066	2 132	2 316	2 480	CPS Energy Model

Source: NUS SR

5.2 INFORMATION ON CHANGES IN DOMESTIC INSTITUTIONAL ARRANGEMENTS FOR MITIGATION ACTIONS AND THEIR EFFECTS

The Slovak Republic has not made changes in the domestic institutional, legal, administrative and procedural arrangements for domestic compliance, monitoring, reporting and archiving of information and evaluation of the progress towards Slovakia's emission reduction obligations and targets since the latest National Communication and Biennial Report (2020). The national inventory system of Slovakia and changes in national inventory arrangements are described in **Chapter 2.1** and can be found also in the National Inventory Report 2022.[177]

In the comparison with the Fourth Biennial Report of Slovakia, numbers of reported PaMs has been increased. None of the PaMs with a significant effect on GHG emission reduction have been cancelled without replacement.

Methodology used for emission projections and PaMs reporting was aligned with the Low-Carbon Development Strategy of the Slovak Republic. The strategy was created under the leadership of the Ministry of the Environment in cooperation with experts at the national (Ministry of Interior of the Slovak Republic, MF SR, STU, SAS) and international level (World Bank), with the Low-Carbon Growth Study for Slovakia[178] as the starting document for the preparation of the strategy. Through this cooperation, it was possible to develop modelling of the development and impact of individual policies and measures on the national economy, using the Compact Primes and ENVISAGE Slovakia (CGE) models.

5.3 ASSESSMENT OF THE ECONOMIC CONSEQUENCES OF RESPONSE MEASURES

5.3.1 Economic Impacts

Although the Slovak economy has decarbonized significantly in the last thirty years, further decarbonization is needed. Slovakia went through a period of abrupt decarbonization in the 1990s and 2000s that was caused by the changing structure of the economy, and technology improvements. Regardless of the improvements achieved so far, further decarbonization is needed to contribute to the EU-wide decarbonization goals in 2030 – decrease greenhouse gases by 55% compared to 1990 levels. This equals to abating an additional 6.3 million tonnes of CO_2 equivalent annually by 2030 (approximately 15% of current gross emissions). To model the most cost-effective path of decarbonization, the first Slovak marginal abatement cost curve (MACC) was constructed.[179] MACC compares various decarbonization measures from all sectors of the economy by their price for a ton of

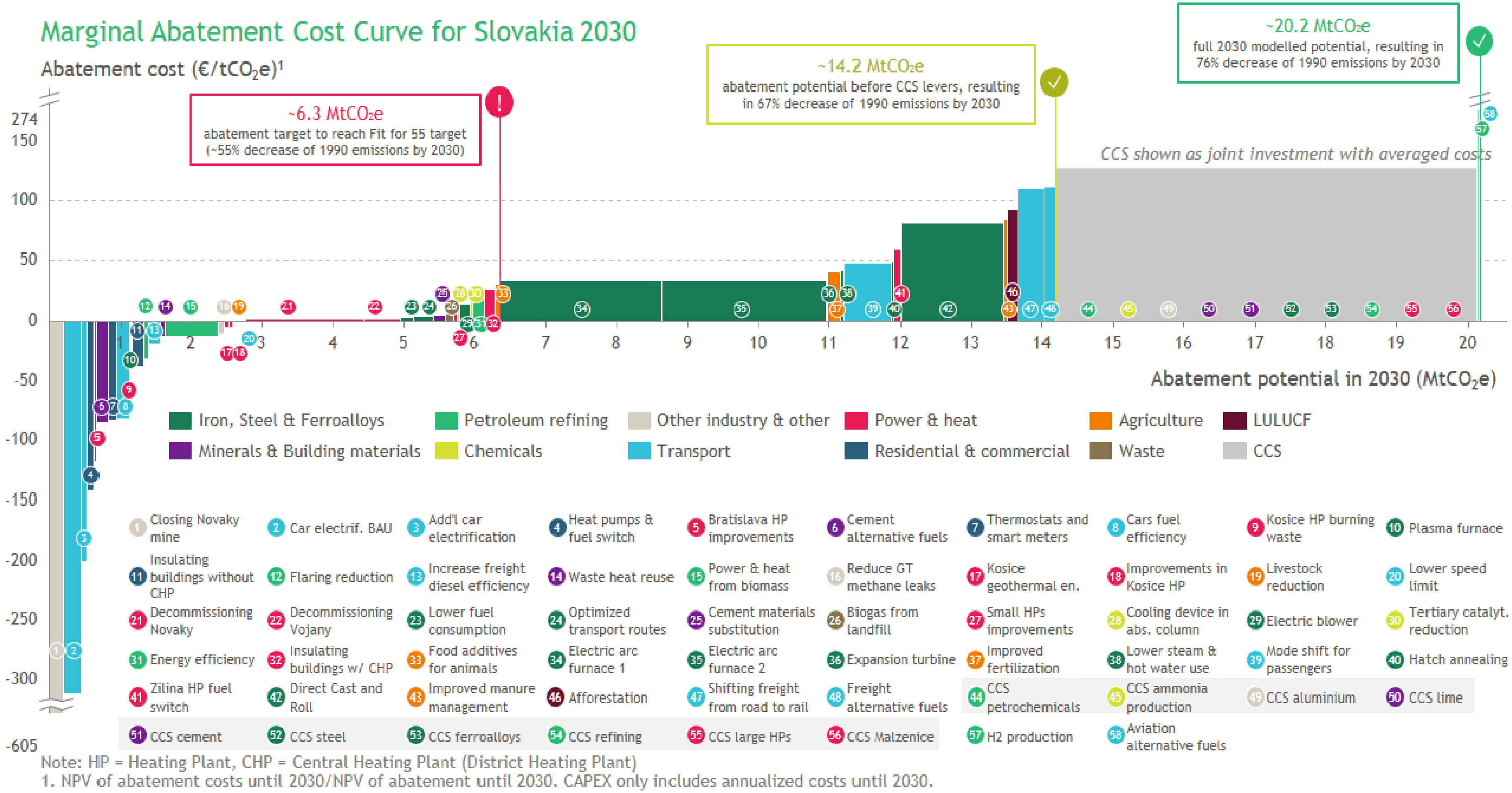
177 https://unfccc.int/ghg-inventories-annex-i-parties/2022

178 https://www.minzp.sk/files/iep/2019_01_low-carbon-study.pdf

179 https://www.minzp.sk/files/iep/decarbonization_of_the_slovak_economy_by_2030_study_062022.pdf

CO_2 equivalent abated, and their abatement potential in 2030. Three emission-reduction goals were identified as follow: 55%, 67%, and 76% based on the MACC. These goals together with needed levers are discussed below in turn. Slovakia is close to achieving the EU-wide "Fit for 55" target to reduce emissions by 55% (6.3 Gg of CO_2 equivalents) in 2030 compared to the 1990 levels. While there is not yet an official target for Slovakia, a 55% reduction is achievable at a societal net cost (including public and private spending) of 2.7 billion EUR by 2030, via cost-effective levers below 30 EUR per ton of CO_2 equivalent (many of which have a negative price). Nevertheless, these levers are individually small and require complex implementation efforts across many stakeholders. Therefore, Slovakia should aim also beyond the 55% target and implement additional levers. Electrification of the steel sector is the key in the push for decarbonization beyond the "Fit for 55" target. Currently the most polluting industry, it has many levers available that enable deep decarbonization even without implementing carbon capture and storage (CCS). Electrification and efficiency improvements of the steel sector can abate in total of 6.2 Gg of CO_2 equivalents per year, additional levers across industries before the CCS could abate 1.7 Gg of CO_2 equivalents by 2030. The societal net cost would reach approximately 5 billion EUR by 2030. In total, this would lead to a 67% decrease compared to 1990. Reaching the full 2030 decarbonization potential requires significant CCS investments. The key lever beyond 14.2 Gg of CO_2 equivalents abatement is the carbon capture and storage technology implemented across key point emitters to capture their remaining emissions. However, investing in CCS is CAPEX-intensive and would require significant political and societal efforts, including implementing supporting regulations. Total abatement compared to 1990 after implementing all the available levers would be 76% at a societal cost of over 13.5 billion EUR. Slovakia has a low-carbon electricity mix and expected electricity oversupply to support decarbonization. Slovak low emissions intensity electricity creates suitable conditions for decarbonization via electrification of the key sectors (e.g. transport and steel) as it will not result in significant secondary GHG emissions. With the decommissioning of Nováky and Vojany coal power plants, and the opening of nuclear power plants Mochovce 3 & 4, Slovakia will decarbonize its electricity generation even further (achieving ~90 ton of CO_2 equivalent/GWh) and will secure sufficient electricity supply to fulfill an increased demand from decarbonization levers (e.g. electric arc furnaces). The MACC was constructed before the Russian invasion of Ukraine, but its conclusions remain relevant. The invasion motivated the EU to rapidly reduce dependence on Russian fossil fuels by increasing energy efficiency, which is fully in line with the measures suggested by this study. Importantly, as outlined in the REPowerEU plan, the EU climate targets are not jeopardized by the new geopolitical situation. The study was prepared in a joint collaboration of Value for Money Department, Ministry of Finance (ÚHP), Institute for Environmental Policy (IEP), and Boston Consulting Group (BCG) during October and November 2021. The work was conducted via a joint project team composed of the authors of this study. During the MACC modelling, the authors used various internal and external benchmarks (including BCG proprietary databases and tools).

Figure A1.4: *2030 MACC curve for Slovakia*[17]



5.3.2 Total Costs of Decarbonization

To estimate the total costs of decarbonization, the sectors were divided on point and decentralized emitters. The former emit emissions at one or few sources and predominantly fall into the ETS sectors. The abatement cost in their case represents an immediate change of production technology, associated with one-off CAPEX (Capital Expenditures). Therefore, the abatement of point emitters can be implemented relatively quickly.

On the other hand, emissions of decentralized emitters are spread across numerous sources (individual cars, houses, farms) in sectors such as transport, residential & commercial buildings, agriculture, and LULUCF. These sectors cannot be abated as quickly and need a gradual change of consumers' behavior and incentivization for such change. Therefore, the costs of decarbonization of decentralized emitters are not counted as CAPEX, but rather as a total net cost (cost-benefit). ***Table A1.8*** provides information on the costs for each of the three targets, as discussed earlier (**Chapter 5.3.1**, ***Figure 5.1***). Although the levers may have negative costs over the lifetime (as shown in the MACC curve), their societal costs may still be positive by 2030. For example, electric cars have higher CAPEX than the ICE cars and this cost is returned gradually by the lower cost of fuel (OPEX). Nevertheless, by 2030, most of the cars bought by then will not have sufficient mileage to outweigh a higher CAPEX of EVs. This causes relatively high decentralized emitters' net costs in the first target in ***Table A1.8.***

Table A1.8: *Estimated total societal costs by individual goals (by 2030)*

Activity	Fit for 55 EU target	Target without CCS levers	Full 2030 potential
Reduction target	6.3 Gg of CO_2 eq.	14.2 Gg of CO_2 eq.	20.2 Gg of CO_2 eq.
	(55% reduction since 1990)	(67% reduction since 1990)	(76% reduction since 1990)
Point emitters' one-off CAPEX	EUR 764 millions	EUR 2.3 billions	EUR 10.9 billions
Decentralized emitters' net costs	EUR 1967 millions	EUR 2.7 billions	EUR 2.7 billions
Levers	Up to but excluding electric	All levers cheaper	All levers
implemented	arc furnaces (lever 33)	than the CCS	

Source: BCG (Boston Consulting Group), ÚHP (Value for Money Department, Ministry of Finance)

For the 55% reduction target, the societal costs exceed 2.7 billion EUR, the majority of which is for decentralized emitters. Comparing 55% and 67% targets, additional societal costs for 67% target are primarily invested into point emitters (additional 1.5 billion EUR), instead of decentralized emitters (additional 700 million EUR). The costs rise more than two fold in the last target (comparing 67% and 76% targets) due to the CCS infrastructure that is considered to be a part of the point emitters.

Comparison of MACC with A Low-Carbon Growth Study for Slovakia

In January 2019 the World Bank published a paper - The Low-Carbon Growth Study for Slovakia, which aimed to estimate Slovak costs of decarbonization. The study contained reference scenario (includes all national climate measures and obligations on climate action by 2020, but only ETS after 2020) and four decarbonization scenarios that were designed to contrast various combinations of share of renewables and energy efficiency targets and their trade-offs. The results are described in ***Table A1.9***.

Table A1.9: *Comparison of the results of Slovak MACC by 2030 with A Low-Carbon Growth Study*

Activity	Slovak MACC (Fit for 55 target)	Decarbonization scenarios 1-4
Baseline	Static average of 2016-2019	Dynamic referential scenario
Additional net costs by 2030	EUR 2.7 billions	EUR 1.2 - 9 billions
Total GHGs decrease 1990-2030	55%	47%
Environmental targets taken into account	Only total GHGs by 2030	Share of renewables, GHGs outside and within the ETS, primary energy savings, others
Scope	All sectors	All sectors except the LULUCF
Source	*Decarbonization of the Slovak economy by 2030*	*A Low-Carbon Growth Study for Slovakia*
Authors	ÚHP, BCG, IEP	World Bank, IEP
Year of publication	2022	2019

Source: World Bank, 2019; Institute for Environmental Policy (IEP) MŽP SR

Out of the four scenarios, scenario 2 is the most balanced in its focus on both energy efficiency and renewables in roughly equal measure and reached a 47 % decrease of GHGs in 2030, compared to 1990. This reduction is, therefore, somewhat less ambitious than the targets outlined in MACC. This is primarily because the 55% target was not adopted at the time of writing the World Bank paper.

Compared to the referential scenario, the costs of decarbonization scenario 2 were estimated to be 8 billion EUR by 2030. This is significantly higher than the estimates modeled in MACC, even if these have somewhat higher reduction targets. This can be explained by the different scopes of the two papers. Whereas MACC is preoccupied only by the total GHGs produced, the World Bank paper was preoccupied also with other environmental targets of Slovakia, such as the share of renewables in electricity generation or CO2 reduction in ETS sectors. Renewables in electricity generation was significantly less important in MACC due to the low emissions of the power & heat sector. Therefore it is understandable that the decarbonization scenario 2 was more costly as a result of its extensive investments into renewable energy, primarily biomass, and combined cycle power plants. Methodologically, the two papers differ as well. The World Bank paper used top-down economic modelling, whereas MACC used rather a bottom-up approach. In this sense, MACC offers greater precision in predicting the GHGs decreased by 2030, but is limited in its scope and does not analyze other environmental targets. These papers should therefore be understood not as complementary to each other.

More and detailed information can be found in chapter 3 of the Decarbonization of the Slovak economy by 2030.[17]

6 PROJECTIONS

Since the publication of 7th National Climate Change Report of the Slovak Republic, some of the measures mentioned in this report have been implemented to varying degrees and have affected the level of GHG emissions in the projected base year 2019.[180] The basic development of the activities determining the level of projected emissions resulted from the assumptions of macroeconomic development and the concepts of the relevant sectors of the national economy. Dynamic changes in global politics as well as economic developments in recent months have also significantly complicated the preparation of GHG emission projections, especially in view of the constant changes in the estimated development of macroeconomic indicators for the near future. The long-term development of greenhouse gas emissions also depends on other parameters, such as energy market developments, technological developments and the trading of CO_2 emission allowances. The EU ETS is one of the measures that was implemented before the projected base year, but the new trading period will continue to have an impact in the future. Nevertheless, the additional impact of this measure is limited due to the technical and economic potential. Despite the existing constraints resulting from dynamic changes in critical parameters, it is possible to reach a state of actual compliance with the emission reduction targets, as well as to create the conditions for further emission reductions after 2022. The table below shows trends of the projections.

Table A1.10: *Trend and projections of total aggregated GHG emissions (Gg of CO_2 equivalents)*

WEM	2020	2025	2030	2035	2040	2050
Total GHG emission projection without LULUCF	37 003	42 382	41 290	39 727	38 068	34 208
Total GHG emission projection with LULUCF	29 409	37 828	37 833	37 416	36 645	32 090
WAM	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Total GHG emission projection without LULUCF	37 003	39 664	36 327	32 437	29 395	22 872
Total GHG emission projection with LULUCF	29 409	32 980	30 422	27 416	24 928	17 703

More and detailed information can be found in chapter 6 of the Eight National Communication of the Slovak Republic.

6.1 DIFFERENCES BETWEEN BR4 AND BR5 EMISSION PROJECTIONS

Several differences occurred in comparison of Fourth (BR4) and Fifth Biennial Report of the Slovak Republic (BR5). Differences are caused by changes in input inventory data and significant differences by geopolitical development in these years. This chapter provides brief overview of the differences as it was encouragement provided in the review report of Third Biennial Report of the Slovak Republic.

As in BR4, data from the CPS were also used in the last Biennial Report. This has impact on emission projections of energy sector, including transport and industry sector.

A detailed description of methodologies, models and projection results was expanded in the **Chapter 6** of the Eight National communication of the Slovak Republic

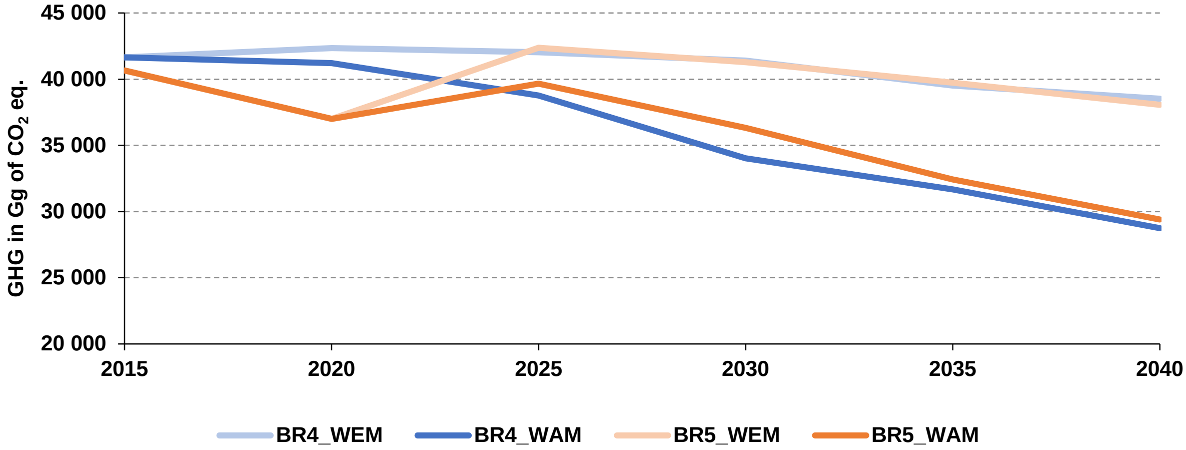
Information on models and assumptions was improved and strengthen as part of the improvement process.

[180] year 2020 was not representative as a base year for GHG emission projection due to COVID-19 and lock-down situation and therefore wasn´t use for emission projections

6.1.1 Comparison of Total Aggregated GHG Emission Projections

Figure A1.5 below shows only small differences between previous and new emission projections. It was caused by small changes in input parameters in key sectors. Big difference in 2020 was caused by impact of pandemic and the geopolitical situation. More information can be find in sectoral view.

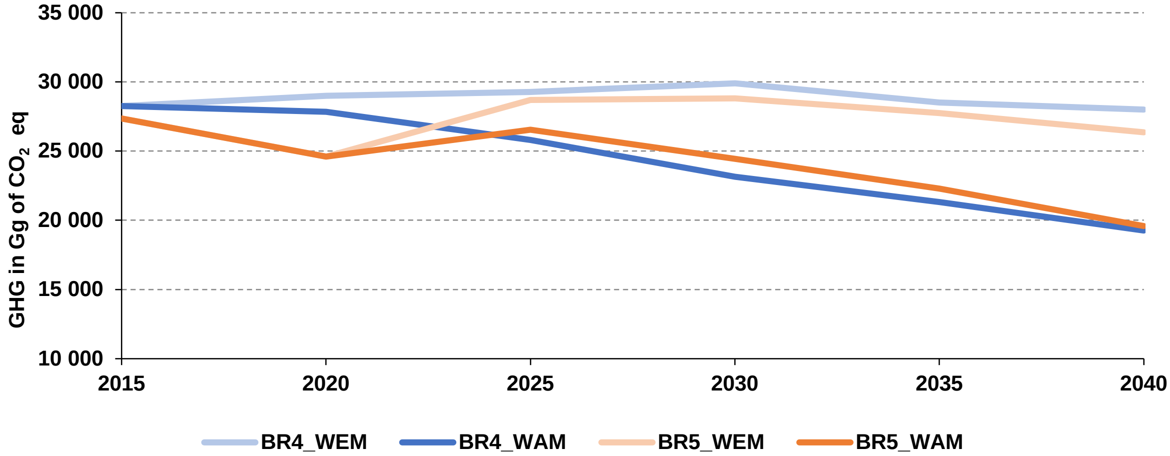
Figure A1.5: *Comparison of BR4 and BR5 aggregated GHG emission projections*



6.1.2 Comparison of Aggregated GHG Emission Projections in the Energy Sector

Changes in the Energy sector have the big impact on total changes between BR4 and BR5. In fact there is no significant changes, but the Energy sector covers by far the largest part of total emissions.

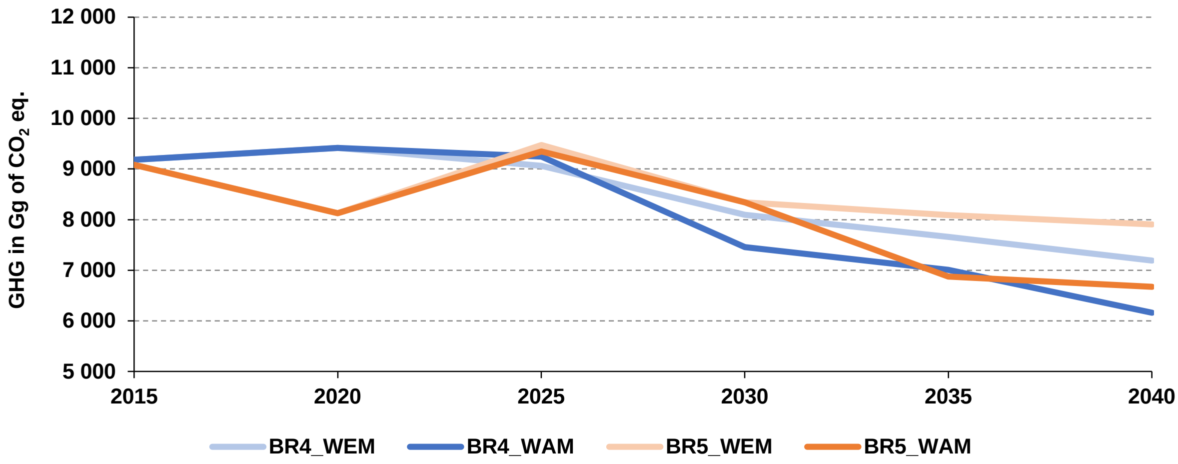
Figure A1.6: *Comparison of BR4 and BR5 GHG emission projections in the Energy sector*



6.1.3 Comparison of Aggregated GHG Emission Projections in the IPPU Sector

Changes in the IPPU sector have also impact on total changes of the emission projections between BR4 and BR5. Implementing of more effective measures was postponed to 2030 from 2025.

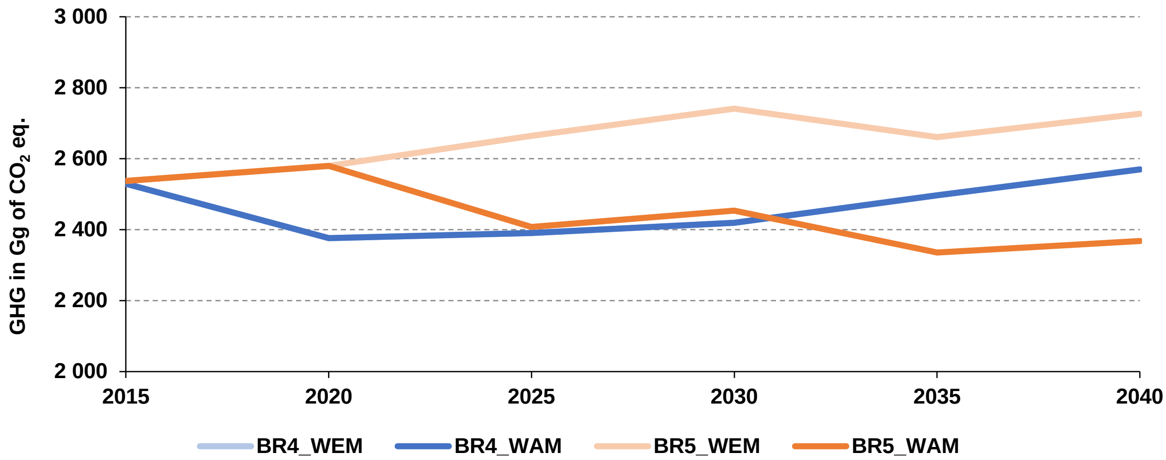
Figure A1.7: *Comparison of BR4 and BR5 GHG emission projections in the IPPU sector*



6.1.4 Comparison of aggregated GHG emission projections in the agriculture sector

In the agricultural sector, a significant difference can be seen between the BR4 and BR5 projections. It is caused by the improvement of the methodology. Some parameters, such as the trend of the livestock numbers did not change, but new and more detailed data and parameters were available for more detailed modelling and better results.

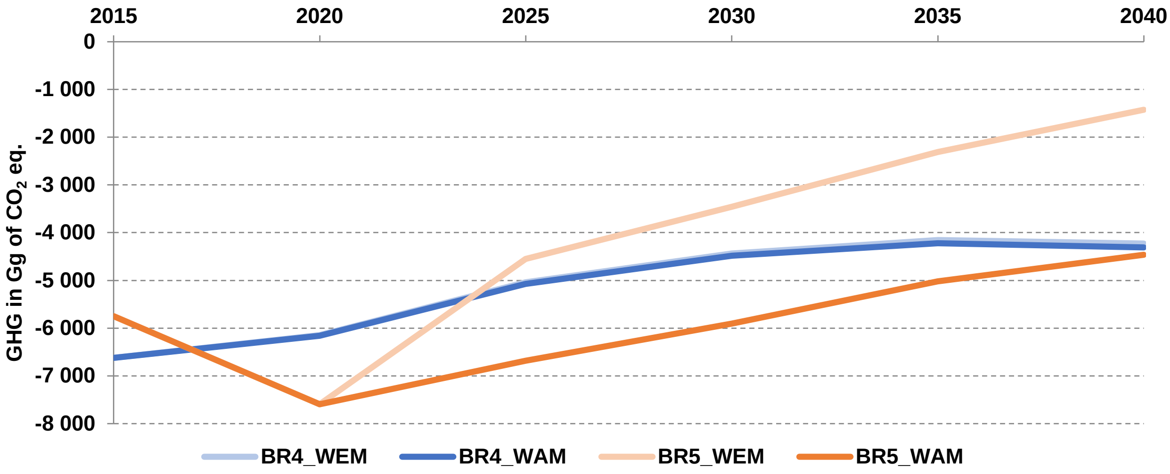
Figure A1.8: *Comparison of BR4 and BR5 GHG emissions projection in the Agriculture sector*



6.1.5 Comparison of Aggregated GHG Emission Projections in the LULUCF Sector

The trend of emissions in the LULUCF sector remains similar to the previous BR. However, scenarios, which were created, has significantly different results compare to very similar scenarios in BR4. It was caused by the latest plans in land and forestry management, which were taken into account.

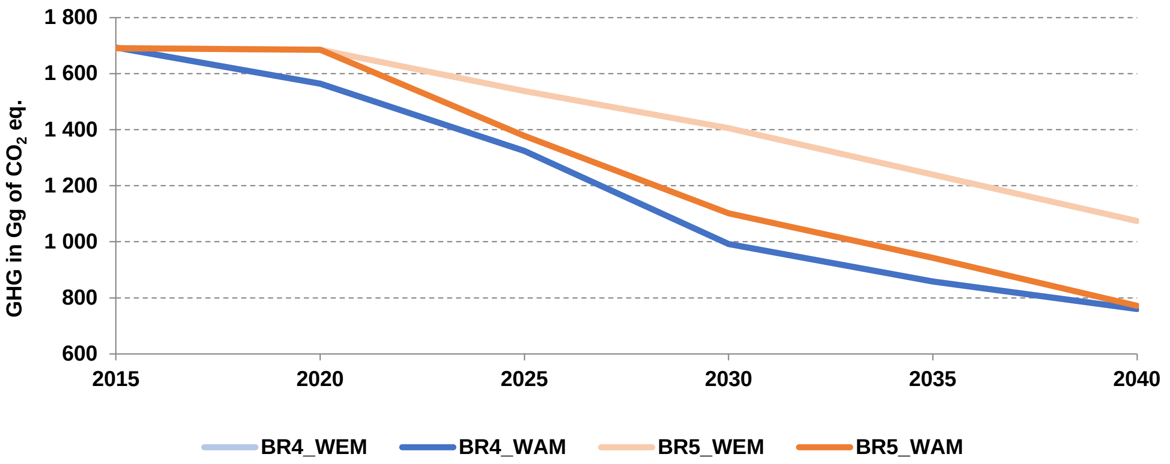
Figure A1.9: *Comparison of BR4 and BR5 GHG emission projections in the LULUCF sector*



6.1.6 Comparison of Aggregated GHG Emission Projections in the Waste Sector

Figure A1.10 shows visible differences between BR4 and BR5 emission projections, but they have very small impact on overall comparison. They were caused also by new information about expected future development in this sector.

Figure A1.10: *Comparison of BR4 and BR5 GHG emission projections in the Waste sector*



7 PROVISION ON FINANCIAL, TECHNOLOGICAL AND CAPACITY BUILDING SUPPORT TO DEVELOPING COUNTRIES

The chapter provides information on the provision of financial, technological and capacity-building support to developing countries. It embraces information on climate related financial support, which Slovakia provided to developing countries during the years 2019 and 2020. It also gives the overview of relevant climate related projects specifically aimed at addressing climate change or related activities that were primarily designed for other purposes, but are also contributing to the area of mitigation or adaptation process. Of the total portfolio, following activities were selected: activities in the field of climate change adaptation, mitigation projects, technology transfer support and capacity building projects for water, waste management, ecological agriculture, food security, afforestation and renewable energy sources development. Slovakia used the UNFCCC Common Tabular Formats (CTF) as the template for provision of public financial support attached to this submission.

More information can be found in chapter 8 of the Eight National Communication of the Slovak Republic.

7.1 APPROACH OF SLOVAKIA TO PROVISION OF CLIMATE FINANCE, INCLUDING THE PROVISION OF NEW AND ADDITIONAL RESOURCES

Slovakia became a member of the community of donors providing assistance to developing countries with its accession to the OECD (2000), European Union (2004) and the OECD Development Assistance Committee – DAC (2013). Preparatory process and the Membership in these organizations have made a significant contribution to the creation of the mechanism for the Slovak Official Development Assistance (ODA). The policy of development assistance is in legislation governed by Act No. 392/2015 Coll., on ODA, on the Organization of Activities of the Government and Central State Administration, as amended. Official development assistance has become an integral component of the foreign policy of the Slovak Republic. More than 400 projects in nearly twenty countries in Africa, Asia and Europe have been implemented over the past decade under the SlovakAid logo.

For the period 2019-2023 (Medium-Term Strategy for Development Cooperation of the Slovak Republic for 2019-2023[181]) there have been territorial priorities of the Slovak ODA within eight main SlovakAid programmes:

1. Development Interventions Programme;
2. Transformation Experience Sharing Programme;
3. Business Partnership Programme;
4. Humanitarian Aid Programme;
5. Governmental Scholarships Programme;
6. Programme for Sending Development Workers and Civil Experts to Developing Countries;
7. Development Education and Public Awareness Programme;
8. Capacity Building Programme.

The Slovak Republic cooperates with the following partner countries:

1. programme countries: Kenya, Moldova, Georgia;

[181] https://slovakaid.sk/wp-content/uploads/2021/01/strednodoba_strategia_rozvojovej_spoluprace_eng_2019-2023_644_stran_final.pdf

2. Western Balkans (Albania, Bosnia and Herzegovina, Montenegro, Kosovo*, North Macedonia, Serbia),
3. countries of the Eastern Partnership of the EU (Belarus, Georgia, Moldova, Ukraine),
4. Eastern sub-Saharan Africa (Burundi, Ethiopia, Eritrea, South Sudan, Kenya, Rwanda, Somalia, Tanzania and Uganda)
5. Middle East (Iraq, Jordan, Lebanon, Syria),
6. Afghanistan.

Slovak development cooperation will generally focus on the following seven areas:

- education – training focusing on access to the labour market and self-employment, education of teachers and equipment of educational facilities;
- healthcare - basic healthcare, nutrition programmes, education of the population and public awareness of prevention and healthcare, education of healthcare personnel;
- good governance and building of civil society - public finance management, public sector reform, enhancement of rule of law and public participation in democratic processes, security sector reform, activities of civil experts within international crisis management;
- agriculture and forestry - implementation of new techniques and methods, processing of agricultural products with focus on their marketing and sales, food security, soil protection;
- water and sanitation - drinking water supply, water and waste management;
- energy – with focus on energy security and alternative resources;
- support of market development of the environment, small and medium enterprises.

Cooperation instruments for main programmes are:

- block grants;
- small grant scheme;
- financial contributions (micro-grants);
- supply of goods and services;
- CETIR;
- start up;
- trilateral cooperation;
- earmarked contributions to international organisations;
- Slovak Republic - UNDP cooperation;
- Slovak Republic - EBRD Technical Cooperation Fund;
- loans with a grant element;
- financial contributions;
- financing scholarships.

Since 2019, the Slovak Republic has applied a regional approach more prominently - support thematically similar projects in several countries of the same region. The goal is to evaluate the experience gained and share examples of successful projects between partner countries.

The Slovak Republic also participates in development activities of the international community through the EU and international organisations and institutions. Multilateral development cooperation can be perceived as an instrument for support of those developing countries and sectors in which it is not effective for the Slovak Republic to act on a bilateral basis. Assistance in the form of multilateral contributions has made up approximately 75% of the total Slovak ODA. Priority of the Slovak Republic in multilateral development assistance is to increase the engagement of Slovak entities in the programmes and projects of the EU, UN and other international organisations and international financial institutions. The goal of the Slovak Republic is to actively participate in the decision-making process of the EU, multilateral organisations and institutions to which it contributes, and which reflect Slovak attitudes, values and priorities of foreign policy and development cooperation in specific activities of these international organisations.[182]

7.2 FINANCIAL RESOURCES

All the Slovak bilateral and multilateral climate financial support provided to developing countries in 2019 and 2020 was channelled through the Official Development Assistance (ODA) in accordance with the OECD DAC methodology.

7.2.1 Provision of Financial Support through Multilateral Channels

Slovakia defines those financial contributions as being climate specific, which funded climate relative activity defined as mitigation, adaptation, cross-cutting or other climate specific activity. If there are climate specific contributions reported in Fourth Biennial Report, core/general and climate specific data should be mutually exclusive – funds should only be reported in one of the categories. Slovakia concerns some of the multilateral as well as bilateral contributions as climate specific. Climate specific category concerns contributions to multilateral climate funds and dedicated projects managed by multilateral institutions, for instance in 2019 and 2020 Slovakia contributed to the Montreal Protocol Multilateral Fund, the Montreal Protocol Trust Fund, the International Finance Corporation, the World Meteorological Organisation (WMO), International Investment Bank and funded projects through the European Bank for Reconstruction and Development (EBRD).

The total climate specific financial contribution provided by the Slovak republic to developing countries through multilateral channels in the years 2019-2020 was 6 202 426.63 € (6 049 844.01 USD). Of this support, 1 804 038.9 € (1 759 659.54 USD) was directed to mitigation and 184 677.17 € (180 134.11 USD) to adaptation. In 2019-2020 Slovakia provided 2 299 648.6 € (2 243 077.24 USD) core/general finance contributions to multilateral organizations. Detailed financial support provided through multilateral channels is included in the CTF Table 7a attached to this submission.

7.2.2 Provision of Financial Support through Bilateral Channels

With respect to bilateral contribution, Slovakia funded climate related study programmes for foreign students and capacity building projects in different developing countries. The total support by the Slovak Republic to developing country Parties to the UNFCCC through bilateral channels in 2019 and 2020 was 3 910 470.22 € (3 814 272.65 USD). Of this support, 1 727 492.5 € (1 684 996.18 USD) was directed to mitigation, 2 152 654.72 € (2 099 699.41 USD) to adaptation and 30 323 € (29 577.05 USD) to crosscutting activities. Detailed financial support provided through bilateral channels is included in the CTF Table 7b attached to this submission.

7.3 TECHNOLOGY DEVELOPMENT AND TRANSFER

In 2019 and 2020, the Slovak Republic did not financially support any technology transfer project.

[182] https://www.mzv.sk/web/en/foreign_policy/slovak_aid

7.4 CAPACITY BUILDING

In the years 2019-2020, the Slovak Republic supported 22 capacity-building projects, mainly in the form of bilateral cooperation - see CTF Table 7a and 9 attached to this submission. All of them have been realized under the Official Development Assistance based on open calls of the Slovak Agency for International Development Cooperation. Another form of support is scholarships that Ministry of Education, Science, Research and Sport of the Slovak Republic provided to students from developing countries, which represent territorial priorities for ODA. All of the scholarships were provided to students whose study programme was environmental oriented, for example processing of agricultural products, environmental science, geodesy and cartography, land protection and land use, environmental planning and other. In addition, there were also projects implemented through multilateral channels, in particular through the European Bank for Reconstruction and Development. Their reports are presented in the CTF Table 7a attached to this submission.

At the moment Slovakia does not possess any information on climate related private finance mobilization, therefore this Biennial Report embraces only the financial support from the public sector.

ANNEX 2: CTF TABLES FOR THE FIFTH BIENNIAL REPORT OF THE SLOVAK REPUBLIC

Overview on CTF tables provided with the Fifth Biennial Report:

CTF Table 1:	Emission trends
CTF Table 2:	Description of quantified economy-wide emission reduction target
CTF Table 3:	Progress in achievement of the quantified economy-wide emission reduction target: information on mitigation actions and their effects
CTF Table 4:	Reporting on progress
CTF Table 4(a)I:	Progress in achieving of the quantified economy-wide emission reduction targets – further information on mitigation actions relevant to the counting of emissions and removals from the land use, land-use change and forestry sector
CTF Table 4(a)II:	Progress in achievement of the quantified economy-wide emission reduction targets – further information on mitigation actions relevant to the counting of emissions and removals from the land use, land-use change and forestry sector in relation to activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol
CTF Table 4(b):	Reporting on progress
CTF Table 5:	Summary of key variables and assumptions used in the projections analysis
CTF Table 6(a), (b), (c):	Information on updated greenhouse gas projections under a 'with measures' scenario, under a 'without measures' scenario and under a 'with additional measures' scenario
CTF Table 7:	Provision of public financial support: summary information
CTF Table 7(a):	Provision of public financial support: contribution through multilateral channels
CTF Table 7(b):	Provision of public financial support: contribution through bilateral, regional and other channels
CTF Table 8:	Provision of public financial support: provision of technology development and transfer support
CTF Table 9:	Provision of public financial support: capacity – building support