



MINISTRY OF ENERGY

**FIRST BIENNIAL TRANSPARENCY
REPORT OF HUNGARY**

Table of contents

Executive Summary	6
I. National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases	11
II. Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement	12
II.A. National circumstances and institutional arrangements	12
II.A.1. Government structure	12
II.A.2. Population profile	12
II.A.3. Geographical profile	16
II.A.4. Economic profile	16
II.A.4.1. Macroeconomic environment	17
II.A.4.2. Inflation	18
II.A.4.3. Employment	19
II.A.4.4. Financial assets and wealth of households	20
II.A.4.5. Entrepreneurial sector	21
II.A.4.6. Current account balance and financing	21
II.A.4.7. External trade	22
II.A.5. Climate profile	22
II.A.6. Sector details	24
II.A.6.1. Energy	24
II.A.6.2. Transport	34
II.A.6.3. Industry	41
II.A.6.4. Buildings and residential sector	46
II.A.6.5. Agriculture	48
II.A.6.6. LULUCF	52
II.A.6.7. Waste	56
II.A.7. Institutional arrangements	59
II.A.7.1. Institutional arrangements for tracking progress	59
II.A.7.2. Institutional arrangements for implementation of the NDC	61
II.B. Description of a Party's nationally determined contribution under Article 4 of the Paris Agreement, including updates	64
II.C. Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement	66
II.C.1. Indicator	66

II.C.2. Methodologies and accounting approach	67
II.C.3. Structured summary – status of progress	67
II.D. Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement	68
II.D.1. Policy-making process	68
II.D.1.1. European Union framework	68
II.D.1.2. National framework	69
II.D.2. Policies and measures and their effects	71
II.D.2.1. Cross sectoral policies	71
II.D.2.2. Energy	74
II.D.2.3. Transportation	93
II.D.2.4. Industrial Processes	101
II.D.2.5. Agriculture	102
II.D.2.6. LULUCF	108
II.D.2.7. Waste	110
II.D.2.8. Water management	115
II.D.2.9. Research	117
II.E. Summary of greenhouse gas emissions and removals.....	117
II.F. Projections of greenhouse gas emissions and removals	120
II.F.1. Greenhouse gas emissions and removals	120
II.F.1.1. ESR and LULUCF targets	120
II.F.1.2. Other national objectives and targets consistent with the Paris Agreement and existing long-term strategies	121
II.F.2. Renewable energy	123
II.F.2.1. Estimated trajectory for renewable share (RES)	123
II.F.2.2. Estimated national trajectories for the sectorial share of renewable energy in final energy consumption from 2021 to 2030 in the electricity, heating and cooling and transport sectors	124
II.F.2.3. Estimated trajectories by renewable energy technology	124
II.F.2.4. Electricity	125
II.F.2.5. Heating and cooling	126
II.F.2.6. Transport	127
II.F.2.7. Estimated trajectories for bioenergy demand	128
II.F.2.8. Biogas - Potential of agricultural raw materials	130
II.F.2.9. Biomass - Woody biomass supply potential	131
II.F.3. Current situation and forecasts with existing policies and measures	132

II.F.3.1. Projected evolution of key external factors affecting the energy system and greenhouse gas emissions	133
II.F.3.2. Projection of sectoral developments	156
III. Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement	168
III.A. National circumstances, institutional arrangements and legal frameworks	168
III.A.1. National circumstances relevant to its adaptation actions	168
III.A.1.1. Biogeophysical characteristics relevant to adaptation actions	168
III.A.1.2. Demographic situation relevant to adaptation actions	169
III.A.1.3. Economic and infrastructural situation relevant to adaptation actions	170
III.A.2. Institutional arrangements and governance	175
III.A.3. Legal and policy frameworks and regulations	175
III.B. Impacts, risks and vulnerabilities	176
III.B.1. Current and projected climate trends in Hungary	176
III.B.1.1. Current climate trends	176
III.B.1.2. Projected climate trends	178
III.B.1.3. Observed and potential impacts of climate change, including sectoral, economic, social and/or environmental vulnerabilities	184
III.B.1.4. Approaches, methodologies and tools, and associated uncertainties and challenges	192
III.C. Adaptation priorities and barriers	194
III.C.1. Domestic priorities and progress towards those priorities	194
III.C.2. Adaptation challenges and gaps, and barriers to adaptation	196
III.D. Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies	198
III.D.1. National Adaptation Strategy and the Carpathian Basin Report	198
III.D.2. National Adaptation Geo-information System (NAGiS)	199
III.E. Progress on implementation of adaptation	201
III.F. Monitoring and evaluation of adaptation actions and processes	202
III.F.1. Institutional background, responsibilities	202
III.F.2. Adaptation MRE tools, systems	203
III.F.3. Achievements, impacts, effectiveness and results	204
III.G. Cooperation, good practices, experience and lessons learned	211
III.G.1. Climate policy governance and background information	211
III.G.2. Information systems in Hungary	212
III.G.3. Relevant climate research institutions	213
III.G.4. Additional related international activities	214

III.G.5. Systematic observation	215
III.G.6. Atmospheric observation	217
III.G.7. Terrestrial observation and carbon balance	218
III.G.8. Funding and projects	221
IV. Information on financial, technology development and transfer and capacity building support provided and mobilized under Articles 9–11 of the Paris Agreement	229
IV.A. National circumstances and institutional arrangements.....	229
IV.B. Underlying assumptions, definitions and methodologies	230
IV.C. Information on financial support provided and mobilized under Article 9 of the Paris Agreement	230
IV.D. Information on support for technology development and transfer provided under Article 10 of the Paris Agreement	231
IV.E. Information on capacity-building support provided under Article 11 of the Paris Agreement	231
V. Annexes	232
V.A. Annex I: Common reporting tables for electronic reporting of information in national inventory reports of anthropogenic emissions by sources and removals of greenhouse gases by sinks (CRFs).....	232
V.B. Annex II: Common tabular formats on information necessary to track progress (CTF Tables)	232
V.C. Annex III: Common table formats for electronic reporting of information on financial, technology development, transfer and capacity-building support provided and mobilised, as well as support needed and received, under Articles 9-11 of the Paris Agreement (CTF Tables)	232

Executive Summary

National circumstances and institutional arrangements

The report provides general information on Hungary's government structure, population, geographical, economic and climate profile. Furthermore, the report introduces the state of play in different sectors: energy, transport, industry, buildings and residential sector, agriculture, LULUCF and waste.

Hungary is a landlocked country in Central Europe, in the Carpathian Basin, with an area of 93.033 km² and a population of 9.585 million. The capital city is Budapest, with 1.7 million inhabitants. Approximately half of Hungary's landscape consists of flat to rolling plains of the Carpathian Basin. There are three major geographical regions in Hungary: Transdanubia (beyond the Danube), *Duna-Tisza köze* (between the Danube and Tisza), and *Tiszántúl* (beyond the Tisza). The climate is highly variable since Hungary is situated in the transition area between three climatic zones: oceanic, continental and Mediterranean. The influence of the Carpathian ranges and the surrounding mountains is also reflected in the spatial distribution of the climatic elements.

The Hungarian Government is divided into 13 ministries, including the Ministry of Energy that was established in December 2022. Besides energy policy, the Ministry of Energy also deals with climate policy, environmental protection, waste management and water management. The country is a market economy with a highly internationalised and export-driven business sector. Due to its high level of integration into the global economic system, the Hungarian economy have been heavily affected by the negative consequences of the COVID-19 pandemic and the Russian-Ukrainian conflict.

The **energy sector** is significantly dependent on imports. Gas import dependency is close to 80%, however, domestic production is slowly increasing and gas demand has fallen by 18% during the last three years. Oil import dependency is also high, 82-84% while domestic production is falling. Since overwhelming majority of oil and gas is imported from Russia, key goal of the Hungarian energy policy is the diversification of source and transit routes. Energy saving and energy efficiency also play an important role in Hungarian energy policy. The Energy Efficiency Obligation Scheme was established in 2021. Thus, obliged entities must introduce such programmes and take measures that will result in proven energy savings on the end user side. Share of renewables in the energy mix is playing an increasingly important role, mainly due to the dynamic growth in photovoltaic production. The installed photovoltaic capacity in Hungary exceeded 7800 MW according to 2025 data. In 2023, share of renewable energy sources (RES) in the gross final energy consumption was 17.1%. According to the revised National Energy and Climate Plan, Hungary intends to reach a RES share of 30% by 2030 in gross final energy consumption. Besides, nuclear energy was the source of 47.14 % of domestically generated electricity in 2024 and will continue to play a major role in the power sector in the future, due to the ongoing construction of the new reactor units of the Paks Nuclear Power Plant.

The **transportation** sector continues to play a significant role in Hungary's GHG-emissions. The average age of the car fleet has been increasing constantly since 2007, its value is more

than 16.7 years in 2023. Alternative fuel vehicles (hybrid, electric and mixed combustion) exhibited significant growth, increasing a share of 6.5% in the total car stock in 2023.

Competitiveness of the **industrial sector** is based on an employment rate of around 75 %, a stable investment rate of over 20 %, and product exports of around 65-70 % of GDP. Industry plays a key role in the stability of our economy and accounts for 21-22 percent of the gross added value. However, the volume of industrial production in 2023 was 5.5 % below the high base of a year earlier. The New Competitiveness Strategy of Hungary was adopted at the beginning of 2024.

Thanks to its favourable natural endowments, Hungary has had a significant and internationally appreciated **agricultural sector** for centuries. Moderate climate, fertile soils and outstanding water conditions together with technology and knowledge enable agriculture to supply domestic citizens and foreign markets with safe, high-quality food. Thus, agriculture is of outstanding and strategic importance in the Hungarian national economy. Between 2019 and 2023, the share of agriculture in total gross value added was about 3.2-4.1 %, the share of total investment was 4.1-4.6% and the share of total employment was 4.2-4.6%. The output of agriculture increased further at current prices in 2023, continuing the trend, which started in 2011, and reached a new record.

Forests in Hungary have been managed sustainably already for about a century and, overall, have continued to be carbon sinks for decades so far. Of the total area of the country (9 303 thousand ha), 2074 thousand ha were under forest management in 2023. Altogether more than 800 thousand ha new forests were established in the last eight decades, and more than 202 thousand ha new forests have been established by 2023 since 1990. The new forests have added much to the services of the forests, including their sink capacity. The annual sink of the biomass of forests established since 1990 have been 1.0-1.2 million tCO₂ a year.

Tracking progress is based on the EU's Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (**Governance Regulation**). It established a governance mechanism and specific arrangements to track the progress of the EU and its Member States towards the implementation and achievement of the EU's climate and energy targets and commitments under the UNFCCC and the Paris Agreement. These arrangements include the monitoring of GHG emissions and removals, the reporting of policies and measures, projections of GHG emissions and removals and progress on adaptation to climate change. **On the national level**, relevant institutions are the Ministry of Energy, HungaroMet Hungarian Meteorological Service Nonprofit Ltd., Ministry of Agriculture, Forest Research Institute, Hungarian National Land Centre, the National Food Chain Safety Office and the Ministry of Construction and Transport.

Description of a Party's nationally determined contribution

Under their updated NDC, the EU and its Member States, acting jointly, are committed to a legally binding target of a domestic **reduction of net greenhouse gas emissions by at least 55 % compared to 1990 by 2030**¹. The NDC consists of a single-year target, and the target type

¹ The updated Nationally Determined Contribution of the European Union and its Member States is available [here](#)

is ‘economy-wide absolute emission reduction’. The scope of the NDC covers the 27 Member States of the EU. Implementation of the NDC is based on the 2030 Climate and Energy Framework that include the EU Emissions Trading System (EU ETS), the Effort Sharing Regulation (ESR) and the LULUCF Regulation. On the national level, Hungary has established a comprehensive framework to implement its NDC, by focusing on strategies outlined in its National Energy and Climate Plan (NECP) and the Second National Climate Change Strategy (NCCS-2)². The energy sector is governed by the long-term National Energy Strategy for 2030 that has been amended to incorporate a vision for 2040 that focuses on clean, smart, and inexpensive energy while increasing energy independence and security and decarbonizing energy production.

Mitigation policies and measures

As a Member State of the European Union, Hungary's efforts to mitigate climate change are largely guided by the policies and regulations set by the EU. In 2020, Hungary committed to achieving climate neutrality by 2050, in line with the EU's long-term climate objectives. In line with this commitment, Hungary intends to reduce its GHG emissions at least by 50 % compared to 1990 levels and to increase the share of renewable energy sources to at least 30 % within gross final energy consumption by 2030.

Therefore, all of the policies and measures introduced in the report aim to help to achieve the common goal. Hungary's commitment to its climate targets is demonstrated by the latest data that show a significant reduction of 9.5% in GHG emissions in Hungary in 2023 compared to the previous year. The domestic emissions reduction currently stands at 43% compared to 1990 levels, therefore, our previous 2030 climate target (-40 %) was already met in 2023.

Some other strategies that have been implemented are the following: Emissions Trading System (EU ETS), Effort Sharing Decision (ESD), the Kyoto Protocol, the Paris Agreement under the Convention, Kigali Amendment of the Montreal Protocol.

All national strategies are designed to achieve sectoral decarbonization goals and overall reductions in greenhouse gas emissions. This is exemplified by Hungary's updated National Energy and Climate Plan (NECP), updated in 2024. In the new document, Hungary commits to reducing GHG emissions by 50% compared to 1990 levels, an increase from the previous target of 40%, and to ensure that the country's final energy consumption does not exceed 740 PJ by 2030.

The goals will be achieved through several sub-programs, including Jedlik Ányos Plan 2.0 in the transportation sector, Jenő Kvassay Plan in the field of water management, and several Home renovation programs, where the focus lies on building renovation and energy efficiency development.

² The NCCS-2 is available [here](#)

Projections of greenhouse gas emissions and removals

The report provides a comprehensive summary and analysis of greenhouse gas emission projections and removals. Furthermore, the report provides insight into both historical emission inventories and projections of future emissions. Projections contain the WEM (with existing measures) and WAM (with additional measures) scenarios, if available, separately.

In order to achieve climate neutrality, in line with the currently planned progression, Hungary aims to reduce its gross GHG emissions by at least 50%, reaching 47.5 million tCO₂e by 2030 compared to the 1990 levels. Hungary's greenhouse gas emission reduction targets align with the EU's and other international commitments. Hungary has also set the goal of attaining climate neutrality by 2050, which was confirmed in Act XLIV of 2020 on climate protection.

Information related to climate change impacts and adaptation

This chapter is organized into thematic headlines, each offering insights into a specific area of focus and presenting key findings and results. It begins with a foundational introduction, outlining the scope and significance of the subject. It highlights the key drivers influencing the field, emphasizing the growing importance of regulatory alignment, technological advancements, and market evolution in shaping future strategies.

Climate change in Hungary is expected to bring about increased heatwaves, which will affect road users and potentially damage road infrastructure. The increased frequency of floods and storms also poses a threat to road transport. Similarly, heatwaves and extreme storms are significant climate challenges for rail infrastructure. Inland waterways face the dual impact of water abundance and scarcity, with floods and droughts disrupting water transport. Air transport is primarily threatened by extreme storms, which can damage infrastructure and hinder safe operations. Energy infrastructure is also at risk from extreme weather events, with a study in 2023 assessing the vulnerability of energy production and infrastructure to these events.

Hungary's climate policy administration is led by the Deputy State Secretariat for Climate Policy within the Ministry of Energy, with the Climate Policy Department responsible for legal and legislative decisions and the HungaroMet Hungarian Meteorological Service's National Adaptation Centre (NAC) Department which is supporting strategic planning, reporting, and monitoring. The National Adaptation Geo-information System (NAGiS) is a key tool for Hungary's adaptation policy.

Key laws governing climate adaptation in Hungary include Act LX of 2007, which mandates the development of a national climate change strategy and the establishment of a geo-information-based national adaptation decision support system. Act XLIV of 2020 aims to prevent and reduce the impacts of climate change, while Government Decree 94/2014 details the rules of the NAGiS system, which was modified in 2023 to assign its operation to HungaroMet.

Hungary has been experiencing rising average temperatures, with a 1.5°C increase since the beginning of the last century, which is higher than the global average. The most significant warming has occurred in the summer, and there have been changes in precipitation patterns, with a slight decrease since the 20th century but an increase in recent decades. The intensity of precipitation has increased, with more intense rain events and fewer rainy days.

Future climate projections indicate that Hungary will continue to experience an increase in mean temperature, with potential increases of 1.6 to 4 °C by the end of the century. Precipitation patterns are less clear, with models suggesting an increase in spring, autumn, and winter precipitation, but with varying projections for summer. There is also an expectation of more extreme temperature days, with a decrease in frost days and an increase in hot days and heatwave days.

Hungary is vulnerable to several climate change impacts, particularly concerning water management, forests and natural ecosystems, human health, and extreme weather events. Water bodies are affected by changes in temperature and precipitation patterns, with uneven temporal distribution of precipitation leading to both high precipitation days and prolonged dry periods.

Financial, technology development and transfer and capacity building support

Hungary is committed to contribute to the green transition of developing countries. Besides contributing to the Green Climate Fund, bilateral climate finance is also of very high importance. Knowledge transfer and technology export in the field of adaptive water management technologies and related sustainable agricultural practices is a priority in our support to developing countries. The Hungarian Government has bilaterally supported the implementation of several projects in developing countries in the form of non-reimbursable grants. In addition, the Hungarian Export-Import Bank has concluded tied aid loan agreements with a number of developing countries. In total, Hungary provided EUR 17.5 million in climate finance to developing countries in 2021, EUR 8.2 million in 2022, and EUR 8.67 million in 2023.

Financial support to developing countries are mainly provided by the Ministry of Foreign Affairs and Trade, for example, its Department for Hungary Helps Programmes and Department of Water Diplomacy. Tracking progress and reporting on climate finance are carried out by the Climate Policy Department of the Ministry of Energy. Furthermore, the Western Balkans Green Centre, as a background agency of the Ministry of Energy, contributed to the green transition of the Western Balkans region.

I. National inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases

National inventory document (NID) of anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs) and the Common Reporting Format Tables (CRF tables) have been reported by Hungary to the UNFCCC Secretariat and are available at: <https://unfccc.int/ghg-inventories-annex-i-parties/2024> and <https://unfccc.int/first-biennial-transparency-reports>.

II. Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement

II.A. National circumstances and institutional arrangements

II.A.1. Government structure

Hungary is a parliamentary republic. The Fundamental Law, which is the constitutional document of Hungary, was adopted in 2011 by the National Assembly ('Országgyűlés') and entered into force on the 1st January 2012. The unicameral 199-member National Assembly is the highest organ of state authority, it initiates and approves legislation. Members of the National Assembly are elected in every four years. The election threshold for political parties is 5 %.

The Prime Minister is elected by the National Assembly, serving as the head of the government and exercising executive power, selects cabinet ministers and has the exclusive right to dismiss them. Traditionally, the prime minister is the leader of the largest party in the National Assembly.

The president, elected by the members of the National Assembly in every five years, serves as the head of state. The president has primarily representative responsibilities and powers, for instance, serves as the Commander-in-Chief of the Armed Forces and formally nominates the Prime Minister to be elected by the National Assembly. Importantly, the president also has a veto power and may send legislation to the 15-member Constitutional Court for review. The Constitutional Court has the power to challenge legislation on grounds of unconstitutionality. The third most significant public position in Hungary is the Speaker of the National Assembly, who is elected by the National Assembly and responsible for overseeing the daily sessions of the body.

The Hungarian Government is divided into 13 ministries, including the Ministry of Energy that was established in December 2022. Besides energy policy, the Ministry of Energy also deals with climate policy, environmental protection, waste management and water management.

II.A.2. Population profile

On the 1st January 2024, the population of Hungary was 9.585 million, 16 thousand less than a year earlier. In 2023, natural population flows resulted in a decrease of 43 thousand persons, mitigated by an international immigration surplus of 27 thousand persons. The age structure of the population continued to age.

Life expectancy for men was 73.39 years and 79.58 years for women in 2023. Population density in 2023 was 103.2 inhabitants/km². Table 1 illustrates the age structure of the Hungarian population on the 1st January 2024.

Age groups	Male	Female	Total
0–4	236 014	222 595	458 609
5–9	242 033	229 335	471 368
10–14	233 966	221 236	455 202
15–19	252 685	239 512	492 197
20–24	264 902	251 716	516 618
25–29	287 219	267 439	554 658
30–34	320 454	297 406	617 860
35–39	320 697	301 149	621 846
40–44	349 047	335 213	684 260
45–49	435 301	420 241	855 542
50–54	358 348	352 065	710 413
55–59	303 618	314 545	618 163
60–64	253 918	290 529	544 447
65–69	273 926	352 937	626 863
70–74	215 428	315 491	530 919
75–79	142 457	239 137	381 594
80–84	84 573	173 040	257 613
85–89	35 202	93 568	128 770
90–94	11 483	35 981	47 464
95–99	1 875	7 321	9 196
100–	232	793	1 025
Total	4 623 378	4 961 249	9 584 627

Table 1. Number of population by sex, by age group on 1st January, 2024

Source: Hungarian Central Statistical Office

In 2023, a total of 85.2 thousand children were born, 3.7% less than a year earlier. The total fertility rate fell from 1.52 a year earlier to 1.51, in addition to a decline in the number of women

of childbearing age. In 2023, 128.2 thousand people died. The number of deaths decreased by 8.2 thousand persons, or by 6.0% compared to 2022.

International immigration and emigration incidents resulted in a population increase of 27.3 thousand people, which was about 10 thousand people fewer than in 2022. During 2023, 33.7 thousand Hungarian citizens moved abroad, and 21.8 thousand Hungarian citizens born in Hungary returned home.

Table 2 illustrates the population changes over the years. The population reached its peak in 1980, with 10.7 million inhabitants, and has since followed a consistent downward trend.

Years	Resident population (capita)	Number of resident population aged 0-14 years	Number of resident population aged 15-64 years	Number of resident population aged 65 years or over
1870	5 011 310	1 840 507	3 026 359	144 444
1880	5 329 191	1 875 652	3 261 358	192 181
1890	6 009 351	2 176 849	3 580 315	252 187
1900	6 854 415	2 391 601	4 158 669	304 145
1910	7 612 114	2 645 486	4 586 641	379 987
1920	7 986 875	2 446 309	5 095 142	445 424
1930	8 685 109	2 392 245	5 743 266	549 598
1941	9 316 074	2 420 401	6 244 560	651 113
1949	9 204 799	2 290 090	6 221 581	693 128
1960	9 961 044	2 529 453	6 541 330	890 261
1970	10 300 996	2 173 554	6 945 194	1 182 248
1980	10 709 463	2 341 173	6 918 844	1 449 446
1990	10 374 823	2 130 549	6 870 352	1 373 922
2001	10 198 315	1 694 936	6 957 129	1 546 250
2011	9 937 628	1 447 659	6 812 849	1 677 120
2022	9 603 634	1 393 232	6 230 959	1 979 443
2023*	9 599 744	1 393 055	6 235 157	1 971 532
2024*	9 584 627	1 385 179	6 216 004	1 983 444

* 1st January

Table 2. Change of population in Hungary, 1870-2024

Source: Hungarian Central Statistical Office

Table 3 below illustrates the share of different age groups in the total population over the years. The share of children under 14 years has been decreasing constantly since the 1970s, while the share of the age group over 65 years shows an increasing tendency. Therefore, ageing index of Hungary is steadily increasing.

The number of births fell significantly from the 1970s until 2011, then a slow growing tendency has started. The Hungarian Government is committed to reverse the negative population trends, therefore it has introduced several family-friendly policies and incentives.

Years	Resident population (capita)	Percentage of resident population aged 0-14 years	Percentage of resident population aged 15-64 years	Percentage of resident population aged 65 years or over	Ageing index
1870	5 011 310	36,7	60,4	2,9	7,8
1880	5 329 191	35,2	61,2	3,6	10,2
1890	6 009 351	36,2	59,6	4,2	11,6
1900	6 854 415	34,9	60,7	4,4	12,7
1910	7 612 114	34,8	60,3	5,0	14,4
1920	7 986 875	30,6	63,8	5,6	18,2
1930	8 685 109	27,5	66,1	6,3	23,0
1941	9 316 074	26,0	67,0	7,0	26,9
1949	9 204 799	24,9	67,6	7,5	30,3
1960	9 961 044	25,4	65,7	8,9	35,2
1970	10 300 996	21,1	67,4	11,5	54,4
1980	10 709 463	21,9	64,6	13,5	61,9
1990	10 374 823	20,5	66,2	13,2	64,5
2001	10 198 315	16,6	68,2	15,2	91,2
2011	9 937 628	14,6	68,6	16,9	115,9
2022	9 603 634	14,5	64,9	20,6	142,1
2023*	9 599 744	14,5	65,0	20,5	141,5
2024*	9 584 627	14,5	64,9	20,7	143,2

* 1st January

Table 3. Percentage of population by age groups and ageing index in Hungary, 1870-2024

Source: Hungarian Central Statistical Office

For historical reasons, significant Hungarian minority populations can be found in the surrounding countries, most of them in Romania (in Transylvania), Slovakia, Serbia (in Vojvodina) and in Ukraine (in Transcarpathia). Sizable Hungarian minorities live also in Austria (in Burgenland), Croatia (mainly Slavonia) and Slovenia. Approximately two million ethnic Hungarians live in the neighbouring countries.

II.A.3. Geographical profile

Hungary is a landlocked country in Central Europe; the neighbouring countries are Austria, Croatia, Romania, Serbia, Slovakia, Slovenia and Ukraine. Geographically Hungary is mostly flat terrain, with hilly and low mountain regions. The Danube and the Tisza are the two main rivers of the country, the largest lake is Lake Balaton. The capital city is Budapest, with 1.7 million inhabitants. Other major cities are Debrecen (which is the second largest city with 201 000 inhabitants), Miskolc, Pécs, Szeged, Győr, Nyíregyháza, Kecskemét and Székesfehérvár with around 100-200 thousand inhabitants. The official language is Hungarian.

The area of the country is 93 033 km². Main rivers are the Danube (*'Duna'*), Tisza, Dráva, Rába, Maros and Szamos. There are three major geographical regions in Hungary: Transdanubia (beyond the Danube), *Duna-Tisza köze* (between the Danube and Tisza), and *Tiszántúl* (beyond the Tisza). Transdanubia is a primarily hilly region with a terrain varied by low mountains. These include the very eastern stretch of the Alps (*'Alpokalja'*) in the west of the country, the Transdanubian Mountains, in the central region of Transdanubia and the Mecsek Mountains and Villány Mountains in the south. Lake Balaton, which is a major lake water body of the country, and Lake Hévíz, one of the largest thermal lakes globally, are also located in the Transdanubian part of Hungary. The second largest lake in the Carpathian Basin is the artificial Lake Tisza (*'Tisza-tó'*).

Approximately half of Hungary's landscape consists of flat to rolling plains of the Carpathian Basin: the most important plain regions include the Little Plain (*'Kisalföld'*) in the northwest and the Great Plain (*'Alföld'*) in the southeast. The highest elevation of the latter is 183 meters above sea level.

The highest mountains of the country are located in the foothills of the Carpathians that lie in the northern parts of Hungary (highest point is *Kékes* at 1014 metres).

Hungary's administrative division is based on a regional system of 19 counties (*'vármegye'*) and the capital city. Each counties are subdivided into districts (*'járás'*). Within the counties there are 25 towns with county rights of which local governments have extended powers and responsibilities.

II.A.4. Economic profile

Hungary is a market economy with a highly internationalised and export-driven business sector underpinned by a stable macroeconomic environment. A structural economic crisis began in the second half of the 1980s, leading to a comprehensive transformation of both the economic and political systems in 1990. This shift toward a market economy triggered a transformational recession and an economic downturn that persisted until 1995. Since then, Hungary's economy

has experienced steady growth, with its growth rate surpassing the EU average. In 2004, Hungary became a member of the European Union.

II.A.4.1. Macroeconomic environment

The financial crisis and recession of 2009 severely impacted the Hungarian economy, with economic activity and production plunging to their lowest point in mid-2009. While the economy began to recover slowly in 2010 and 2011, the Eurozone crisis created an unfavorable international economic environment, significantly slowing Hungary's growth and pushing the economy into a mild recession by 2012. From 2013 onward, the economy embarked on a path of steady recovery, bolstered by improving external and internal conditions.

The economic fallout from the COVID-19 pandemic led to a sharp decline in GDP in 2020 and a significant increase in the budget deficit. However, by 2021, Hungary's economy began to rebound, with GDP growing by 7.1%, followed by a further 4.6% growth in 2022, surpassing pre-pandemic levels. Hungary was among the EU member states with the strongest performance growth during this period.

In 2023, geopolitical tensions continued to affect economic developments, resulting in a 0.9% contraction in GDP. Although inflationary pressures gradually eased, the 17.6% annual increase in consumer prices eroded real wages and consumption, negatively impacting investment decisions. Despite these challenges, employment reached a record high. However, investment volumes fell by 8.5% compared to the previous year, partly due to high interest rates and the absence of EU funding, which also led to a reduction in public orders.

The negative effects on consumption and capital formation were significantly offset by a marked improvement in the external trade balance. Exports grew by 2.5%, while imports fell by 3.5% in 2023 compared to 2022, reaching an all-time high. Hungary generated a surplus of 9.2 billion euros, an improvement of 18.3 billion euros compared to the previous year. This was primarily driven by the stabilization of energy carrier import prices, alongside a reduction in imports—reflecting lower domestic demand—and a rise in exports. The growth in exports was mainly attributed to strong performance in export-oriented industries, particularly transport equipment and accumulator manufacturing.

Hungary's budget deficit remained high in 2023, at 6.7% of GDP. However, government debt as a percentage of GDP continued to decrease, falling to 73.5% by the end of the year.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
GDP volume index (previous year = 100%)	101,8	104,2	103,7	102,2	104,3	105,4	104,9	95,5	107,1	104,6	99,1
Unemployment rate (%)	9,8	7,5	6,6	5,0	4,0	3,6	3,3	4,1	4,0	3,6	4,1
Inflation rate (%)	1,7	-0,2	-0,1	0,4	2,4	2,8	3,4	3,3	5,1	14,5	17,6
Balance of general government /GDP (%)	-2,6	-2,8	-2,0	-1,8	-2,5	-2,1	-2,0	-7,6	-7,2	-6,2	-6,7

Table 4. Main economic indicators of Hungary in 2013-2023

Source: Hungarian Central Statistical Office

II.A.4.2. Inflation

In the 2020s, several consecutive waves of inflation hit the global economy that has not been seen in 50 years. The supply-demand imbalances stemming from the COVID-19 pandemic, the energy crisis, and the Russian-Ukrainian war affected countries worldwide. The European Union, and particularly its Eastern member states, including Hungary, were heavily affected.

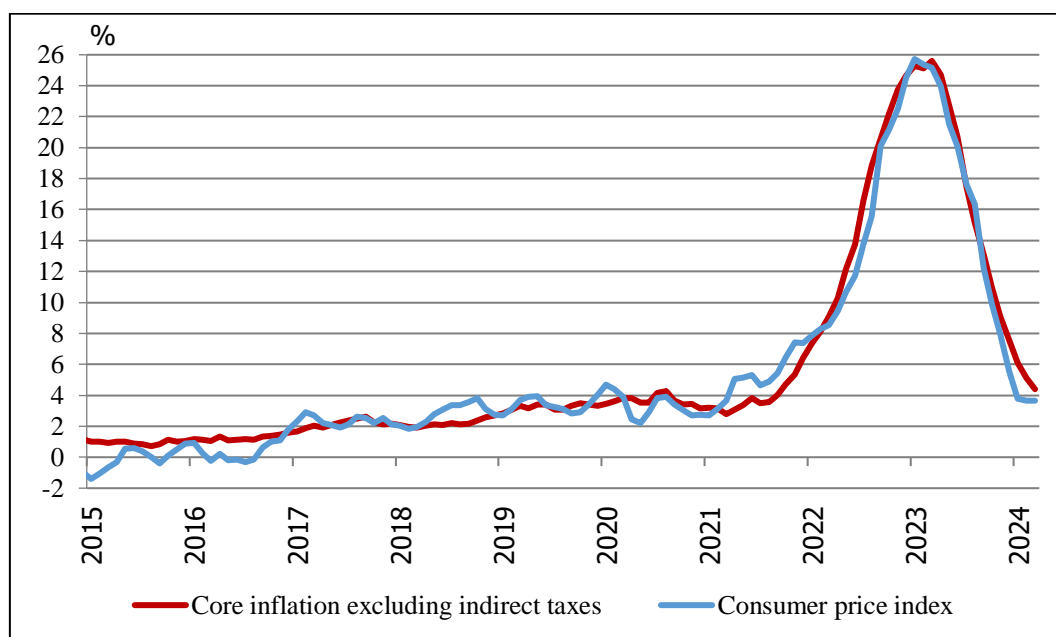


Figure 1. Inflation trends in Hungary

(Monthly core inflation and consumer price index, year-on-year)

Source: Central Bank of Hungary (MNB)

Price trends in Hungary aligned with broader European patterns, though with greater volatility. Nearly half of the cumulative price increase in Hungary between June 2021 and January 2024 can be attributed to global factors, with an additional one-third driven by regional influences. During the recent global inflationary wave, Central and Eastern Europe saw steeper price increases, largely due to the region’s heightened sensitivity to global energy price fluctuations, stemming from its higher energy intensity and reliance on Russian energy imports. In 2022, European gas prices surged eightfold, while electricity prices rose fivefold compared to the 2019 average.

Less than a quarter of Hungary’s cumulative price increase during this inflationary period was due to domestic factors, including competitiveness challenges and the highest profit-driven inflation across Europe.

Inflation peaked in January 2023, but since then, a successful disinflationary process has been underway. The decline in inflation has been supported by a disciplined monetary policy, government measures to enhance competition, subdued domestic demand, and a significantly improved external cost environment. Between January 2023 and March 2024, inflation decreased from 25.7% to 3.6%. The speed of this disinflation mirrors the most successful disinflation episodes of the past 50 years. Historical data from global high-inflation periods over the last five decades shows that inflation dropped below 10% from above 20% in just one-quarter of cases within the first year after the surge.

II.A.4.3. Employment

Hungary's employment indicators reached new record highs in 2023. The number of employed individuals aged 15–74 averaged 4.724 million, while the employment rate for those aged 15–64 rose to 74.8%, the highest since the introduction of the Labour Force Survey in 1992. The number of unemployed individuals aged 15–74 was 203,000, resulting in an unemployment rate of 4.1%, which was 27,000 higher (0.5 percentage points higher) than the previous year. In 2023, Hungary's employment and unemployment rates outperformed the EU average, placing the country in the top third of Member States for both indicators.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
European Union - 27 countries (from 2020)	9,3	10,1	10,1	11,1	11,6	11,0	10,2	9,3	8,3	7,4	6,8	7,2	7,1	6,2	6,1
Hungary	9,7	10,8	10,7	10,7	9,8	7,5	6,6	5,0	4,0	3,6	3,3	4,1	4,0	3,6	4,1

Table 5. Unemployment rate in Hungary and in EU27, 2009-2023 (15-74 years, percentage of population in the labour force)

Source: Hungarian Central Statistical Office

II.A.4.4. Financial assets and wealth of households

Since 2008, household gross wealth has grown steadily. Household savings represent potential financial resources for other economic actors, playing a crucial role in supporting macroeconomic stability. The rising value of financial assets can be attributed to several factors: in addition to the upward trend in wages—driven by increases in the minimum wage, guaranteed minimum wage hikes, and wage growth in both the public and private sectors—the higher savings rate during the COVID-19 lockdowns and the revaluation of financial assets also contributed.

Year	Year end data (billion HUF)	Year end data (billion EUR)
2008	16 138	60.9
2009	18 105	66.8
2010	19 189	68.8
2011	20 551	66.1
2012	23 318	80.1
2013	25 894	87.2
2014	29 246	92.9
2015	33 644	107.4
2016	36 916	118.7
2017	40 778	131.5
2018	45 481	141.5
2019	50 624	153.2
2020	56 797	155.6
2021	64 232	174.1
2022	70 626	176.5
2023	81 707	213.5

Table 6. Net financial assets of households

Source: Central Bank of Hungary (MNB)

II.A.4.5. Entrepreneurial sector

In 2022, the number of active enterprises in Hungary totaled 1.05 million, with 584,000 being private entrepreneurs and 466,000 consisting of companies with a legal entity. Small and medium-sized enterprises (SMEs) make up 99.9% of all businesses in Hungary, while the remaining 0.1% (6,963 entities) are large enterprises with more than 250 employees.

In 2023, the overall number of domestically registered enterprises remained largely stable. The number of entrepreneurs, particularly private entrepreneurs, increased, while the number of business partnerships declined. In 2022, SMEs contributed to 44% of the total value added by all enterprises. Foreign affiliates accounted for 50% of domestic investments that same year.

II.A.4.6. Current account balance and financing

After years of current account surpluses, the external balance of the Hungarian economy deteriorated significantly in 2022, primarily due to a surge in energy prices. However, the current account returned to surplus in 2023 as energy prices normalized and domestic demand was subdued by high inflation.

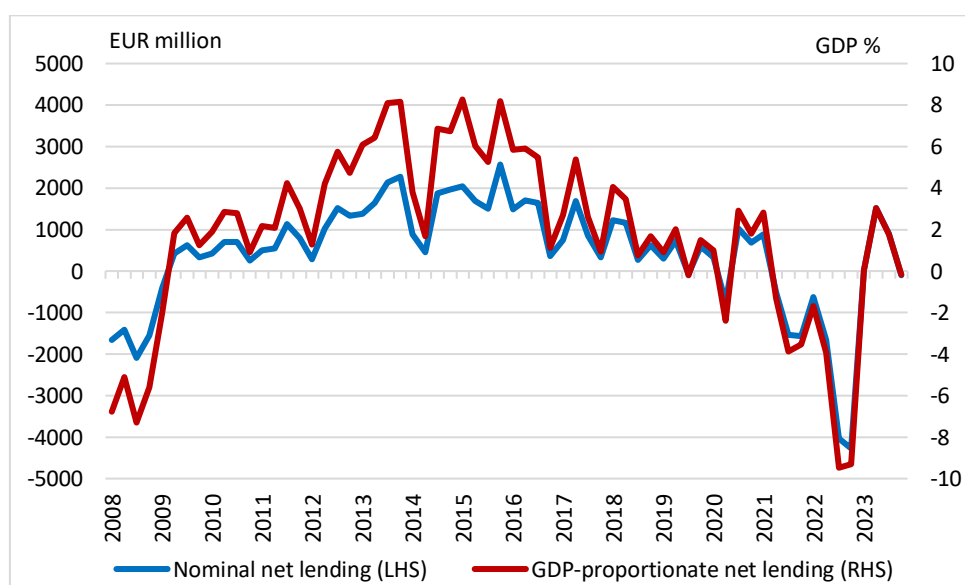


Figure 2. Net lending

Source: Central Bank of Hungary (MNB)

With the current account shifting to a surplus, Hungary's external vulnerability improved considerably across nearly all indicators. Gross and net external borrowing sharply declined, while external debt ratios and the foreign exchange (FX) debt ratio remained low. As a result of reduced net borrowing, net external debt stayed below 15% of GDP, approaching its historic low by 2023. International reserves reached a record high of over €46 billion in March 2024, significantly surpassing investor expectations, with short-term external debt standing below €34 billion at the end of 2023.

Sectoral saving developments also played a key role in improving the external balance. The private sector's net financial saving increased substantially, with household savings rising sharply, while reduced capital expenditure lowered the net borrowing requirements of the corporate sector. Although gross public debt increased during the COVID-19 period due to a high fiscal deficit, it has been steadily decreasing since 2020. By the end of 2023, it stood at approximately 73% of GDP.

II.A.4.7. External trade

Hungary's economy, driven by its export orientation, has become increasingly integrated into the global economic system. Following a period of improving trade balances that began in 2009 and culminated in record-high surpluses, this positive trend came to a halt in 2020-2021, when the pandemic crisis reached its peak. However, as the energy crisis began to ease, surpluses in the goods market resumed. At its peak, the total external trade balance accounted for 9.8% of Hungary's GDP. The key drivers of this external trade success include the transport equipment and related industries, as well as the strong performance of the services sector, which helped maintain a positive trade balance for many years. In recent years, 77% of Hungary's exports have been conducted with EU member states, while 70% of imports have come from the single market. Germany plays a central role in this trade relationship, accounting for 26.3% of both exports and imports in the last year. Other key export partners include Italy, Romania, Slovakia, Poland, the Czech Republic, and France. On the import side, Germany is followed by China, Austria, Poland, South Korea, and Slovakia.

The 2023 figures show modest growth, with exports increasing by 0.9% year-on-year and imports falling by 4.3%. Thanks to the stabilization of energy prices and a reduction in energy sector dependencies, the trade balance saw a notable surplus in 2023. The services sector has also demonstrated consistent growth, with the value of traded services increasing by 117% between 2010 and 2023, and more than doubling over the past decade.

II.A.5. Climate profile

Hungary is situated between latitudes **45°45' and 48°35' N in the temperate zone** according to the solar climatic classification. Its climate is highly variable. One of the main reasons for this variability is that its location in the transition area between 3 climatic zones: **oceanic, continental and Mediterranean**. The climate is influenced by mild oceanic air masses with high humidity, by continental air masses with more extreme temperatures and dry air masses, and by light air masses with high humidity from the Mediterranean. In the summer months, 60-70% of the air masses have oceanic origin, while in cold winters air masses of continental origin tend to predominate. Although Hungary is a relatively small country and there are no significant differences in topography, the influence of the **Carpathian ranges** and the surrounding mountains is also reflected in the spatial distribution of the climatic elements. The country is located in the zone of **westerly winds**, and due to its position, surrounded by the Alps and the Carpathians, the prevailing wind direction is north-westerly, while the southerly winds are at their second maximum.

As for the climate classification of Hungary, a large part of the country can be classified in the Köppen scheme as category Cfa - warm-moderate climate zone, with a uniform distribution of precipitation and hot summers. The Trewartha classification places our country in the continental climate type with a longer warm season. These classifications, however, fail to capture the subtle differences in climate between the various landscapes of Hungary. For this reason, **György Péczely has developed a method for Hungary**, which categorizes the heat and water supply on the basis of the average temperature of the growing season and the aridity index. Climate zones can be created as a combination of categories of these two conditions. Since the classification criteria have not changed, climate change can **be tracked by changes in the boundaries of the climate zones**. The impact of rising temperatures is reflected in the fact that while in the period 1961-1990 (Figure 3, left panel) most of Hungary belonged to the moderately warm - dry climate zone (coloured yellow), the warm and dry category (coloured red) became dominant in the period of 1991-2020 (Figure 3, right panel). In the earlier standard normal period, there were more areas with moderate cool and cool categories, but these have retreated to the high altitude areas in the last decades, with the Bükk Plateau being the only area with cool and wet climate conditions. The comparison of climate classes also shows that precipitation has changed much less than temperature over 30 years: the humidity part of the categories has remained unchanged in most places.

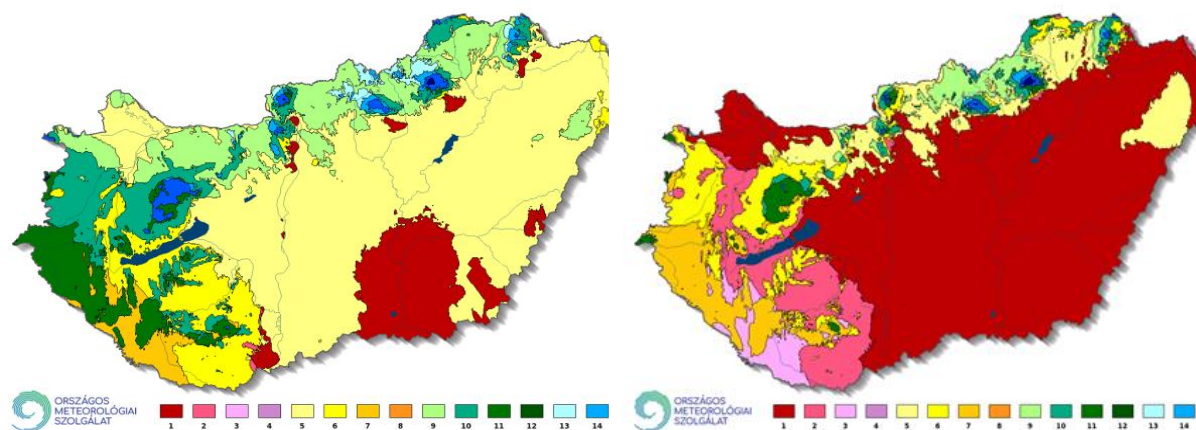


Figure 3. Climate zones of Hungary in 1961-1990 and 1991-2020 according to Péczely's classification. (1-warm and dry; 2-warm and moderate dry; 3-warm and moderate wet; 4-warm and wet; 5-moderate warm and dry; 6-moderate warm and moderate dry; 7- moderate warm and moderate wet; 8-moderate warm and wet; 9-moderate cold and dry; 10-moderate cold and moderate dry; 11-moderate cold and moderate wet; 12-moderate cold and wet; 13-cold and dry; 14-cold and moderate dry; 15-cold and moderate wet; 16-cold and wet)

II.A.6. Sector details

II.A.6.1. Energy

Security of supply

Hungary is significantly dependent on energy imports. Gas import dependency is close to 80%, however, domestic production is slowly increasing and gas demand has fallen by 18% during the last three years. Oil import dependency is also high, 82-84% and the domestic production is falling. It is not only the import dependency that causes vulnerability for Hungary, but also its unilateral character. The major part of the imported gas originates from Russia. The key goal of Hungarian energy policy is to seek ways out of this energy dependency, in particular in the case of natural gas and oil. To achieve this goal, Hungary intends to increase energy savings and the share of renewable energy sources to the greatest possible level, safe nuclear energy and the electrification of transport, diversification of source and transit routes safeguarding Hungary's natural gas and oil import, and utilising domestic fossil energy reserves (coal, lignite, unconventional natural gas) in an eco-friendly manner involving BATs and R&D (zero carbon power plants, carbon capture and reuse) for future power generation.

Energy and carbon intensity

These have undergone significant transformations in Hungary over the past 27 years following the dissolution of Communism. This period witnessed a profound structural shift in the economy, marked by a notable decline in energy-intensive industries and a regression in material and energy utilization to levels reminiscent of the 1970s. Concurrently, the establishment of the Paks Nuclear Power Plant in the late 1980s, replacing a majority of coal-fired power plants, coupled with the widespread adoption of natural gas for residential and public heating, further contributed to a substantial reduction in greenhouse gas intensity (by 40% from 1990 to 2015) and environmental pollution within the energy sector, persisting to the present day.

Moreover, heightened emphasis on cost-efficiency within the market-driven economic framework has propelled advancements in energy efficiency. Notably, from 1990 to 2013, Hungary witnessed an 18% decline in gross inland energy consumption, followed by a slight increase over the subsequent two years, resulting in a cumulative drop of 12.5% within this timeframe. Analysis of gross domestic product (GDP) data during the same period reveals a successful decoupling of economic growth from energy consumption trends in Hungary, as illustrated in Figure 4.

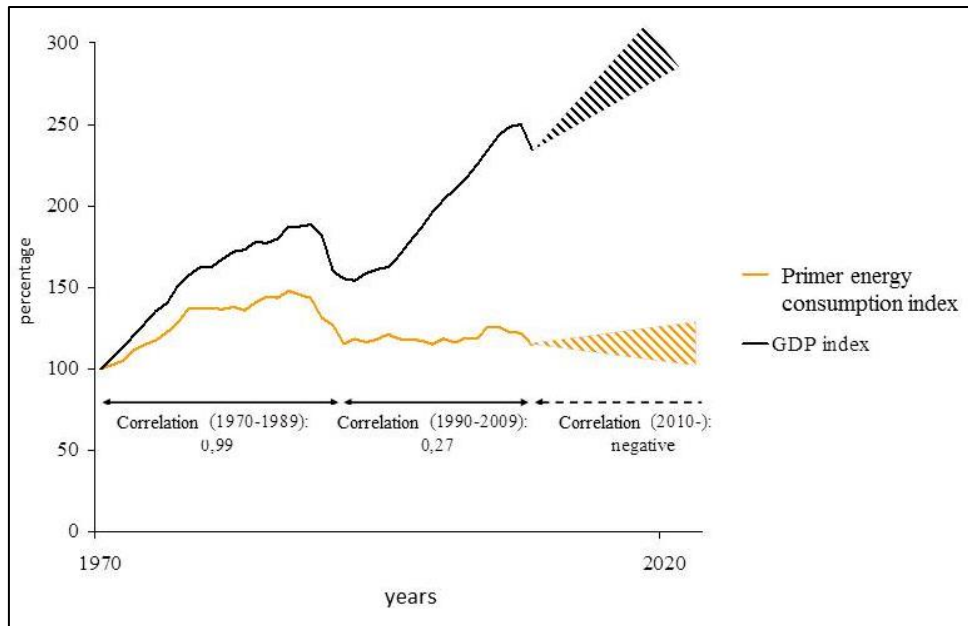


Figure 4. Economic growth and energy consumption is successfully decoupled in Hungary

Source: National Energy Strategy 2030

The decreasing tendency of energy consumption is accompanied by a 40.1% increase in GDP between 1990 and 2015, resulting in a decrease in energy- and carbon intensity (-20.8% between 2000 and 2015) that are now roughly equivalent to the IEA average.

Due to the nature of the Hungarian energy sector, the improvement of energy saving and energy efficiency should be treated as a priority, as it holds the greatest potential for maintaining the level of primary energy demand and reducing import dependency. The entire supply chain must be taken into consideration so that the level of primary energy use can be maintained through the improvement of energy efficiency, as the collective result of technological solutions, economic incentives and social awareness-raising. For taking actions, Hungary established the Energy Efficiency Obligation Scheme in 2021 in line with the demands of Energy Efficiency Directive. Thus, obliged entities must introduce such programmes and take measures that will result in proven energy savings on the end user side. In addition, several alternative policy measures are available with energy efficiency intention to generate final energy savings.

Renewables

Due to the targeted supporting schemes (METÁR, first large scale solar tender, Solar Energy Plus Program etc.) and other measures, the recent share (2023) of RES in the gross final energy consumption is 17.1%. According to data from the EMBER Institute, Hungary had the highest share of solar power in electricity generation in Europe in 2024.

According to the revised National Energy and Climate Plan, the share of RES in gross final energy consumption has to reach 30% by 2030.

The expected increase in the share of renewables in the electricity sector is based fundamentally on a dynamic growth in photovoltaic production. According to data from 1 March 2025, the

installed photovoltaic capacity in Hungary exceeded 7800 MW. The number of small household-scale solar power plants exceeded 298,000 on March 1, 2025. This result exceeds the targets (6000 MW and 200,000 household-scale solar power plants) set out in the previous National Energy and Climate Plan.

A significant part of renewable energy sources, which play an increasingly important role in our energy mix, are typically weather-dependent, such as wind and solar energy. The introduction of these capacities into the system requires a significant development of the electricity network, and on the other hand it also necessitates the increasing availability of flexible and balancing capacities. The Hungarian Government is devoting significant resources to further developing, improving the electricity network, making it more modern and resilient.

Hungary is planning to build energy storage facilities with a total capacity of around 500-600 MW by 2026, which could increase to 1 GW by 2030.

In the heating and cooling sectors, we see great potential both in biomass utilisation and in the utilisation of environmental heat through the use of heat pumps. In transportation is expected to be an increase in renewable electricity-based electromobility, the use of biogas, advanced biomass and biomass.

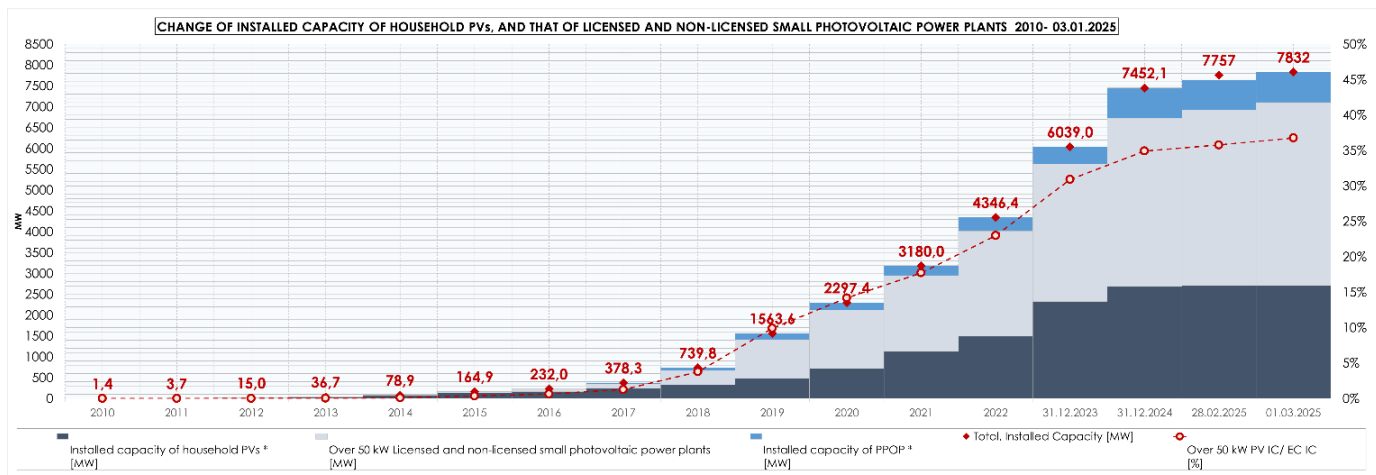


Figure 5. Change of installed capacity of household PVs, and that of licensed and non-licensed small photovoltaic power plants 2010-03.01.2025

Source: MAVIR Zrt.

Energy supply

Fossil fuel production has declined significantly over 42 years, from 15 Mtoe in 1978 to almost 3 Mtoe in recent years. Coal production was 0.77 Mtoe in 2023, representing a decline of 54% since 2005. Natural gas dropped by 54% over the same period to record lows of 1.2 Mtoe in the years 2020–2023. Crude oil and natural gas liquid production was 1.09 Mtoe in 2023, which is a 26% increase compared to the 0.86 Mtoe production of 2015. In 2015, biofuel and waste production were 2.0 Mtoe, an increase of 75% compared to 2005. The 2015 value has not changed significantly since then, it remained the same in 2023. Other renewable energy

production is much smaller, with a total production of 0.25 Mtoe from geothermal, wind, solar and hydro in 2015.

Energy production has declined faster than energy demand in Hungary, which has led to increased import dependency, especially for oil and natural gas. In 42 years, Hungary has gone from being almost self-sufficient in natural gas production to importing around 85% of its needs in 2023. Oil import dependency increased from 80% in 2005 to 88% in 2015, it decreased to 86% in 2023. Domestic coal production still meets about two-thirds of demand.

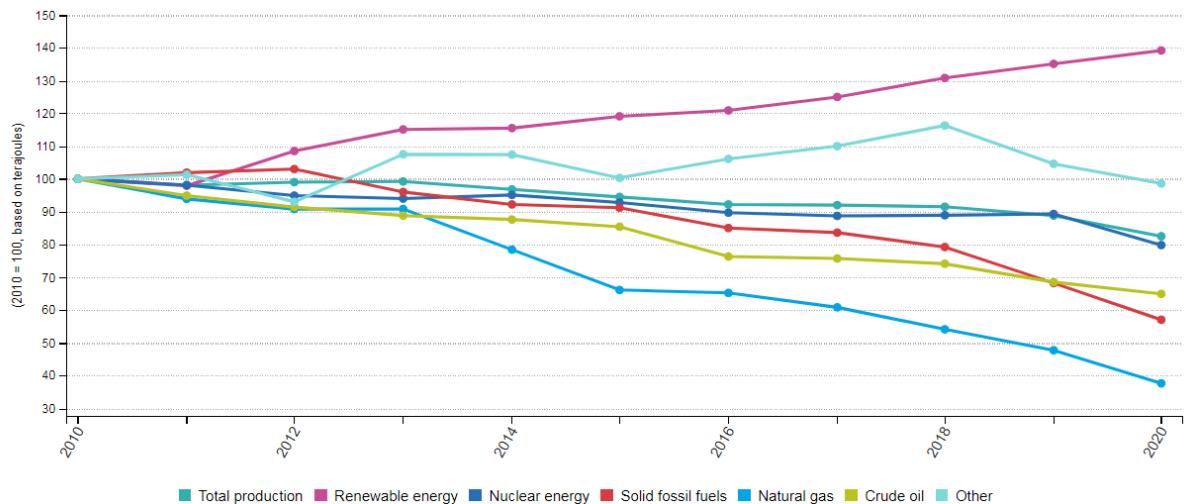


Figure 6. Primary energy production by fuel type, 2010-2020

Source: Eurostat (2020), *Energy Balances of Hungary*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_production_and_imports

Energy production peaked at 16.8 Mtoe in 1987 and has declined by 37% since. (Figure 6.) Energy production was 10.6 Mtoe in 2020. A major change to the production balance was the introduction of nuclear energy in the late 1980s. It has been the largest domestic energy source since 1996 and accounted for 44% of total production in 2021. The share of the nuclear energy production in the total energy production slightly decreased recently due to the peak of the renewable energy production. Renewables have taken a large part of the total primary energy production in Hungary since 2011, when their share in total energy production started to increase steadily.

Energy demand

Total final consumption (TFC) of energy experienced a slight upward trend from 2012 until 2022. In 2022, a moderate decrease was noticeable, hence the amount of TFC became 18 Mtoe. In 2023, due to high energy prices and lack of demand, TFC significantly decreased reaching its current amount of 16.5 Mtoe (Figure 6.). Industry accounts for one-fourth of TFC (Figure 7). The transport sector accounts for almost one-third of TFC and consumption in this sector

has been increasing heavily in the last decade. Households invariably accounts for more than one-third of TFC, hence it holds the highest potential for generate savings.

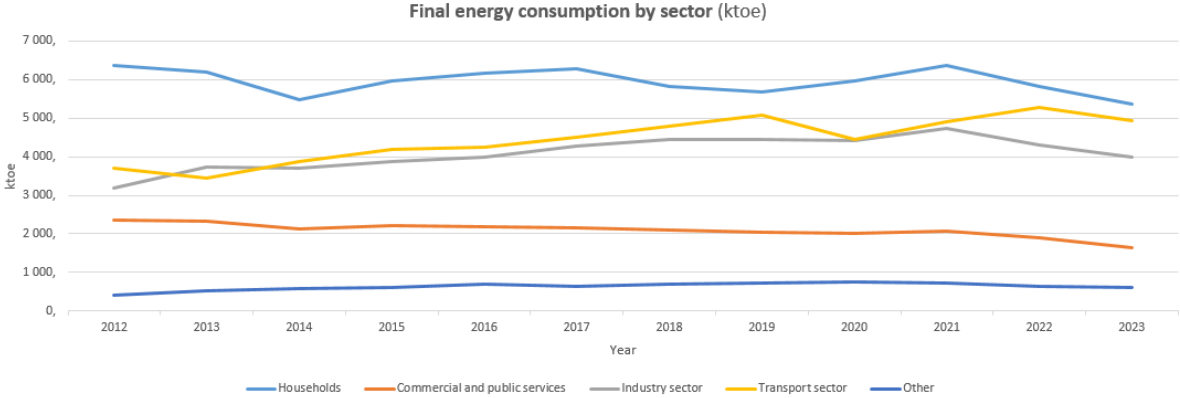


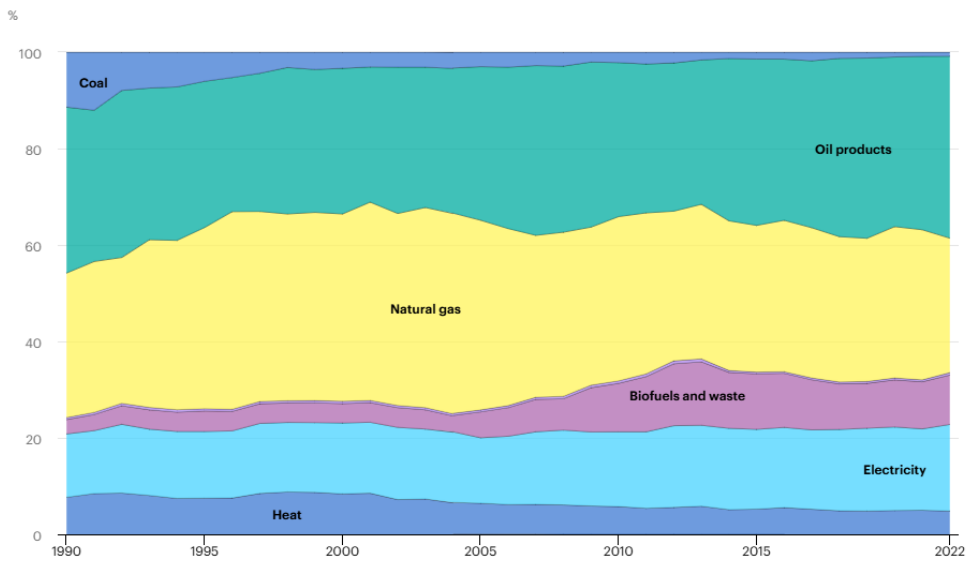
Figure 7. TFC by sector, 2012-2023

Source: EUROSTAT (2025) [Database - Eurostat](#).

* Other includes agriculture, fishing and forestry.

Oil and natural gas are the largest sources of energy in final consumption, accounting for roughly one-third of TFC each (33% for oil, and 27% for natural gas). The transport sector is the largest oil consumer accounting for 63% of oil in terms of TFC in 2023, followed by the industry sector, which uses oil as a fuel and as a feedstock (Figure 8.). Natural gas and electricity are the main energy sources consumed in the residential, commercial and industry sectors.

Total final consumption (TFC) by source, Hungary, 1990-2022



IEA, Licence: CC BY 4.0

● Coal ● Oil products ● Natural gas ● Geothermal, solar, wind, etc. ● Biofuels and waste ● Electricity ● Heat ● Crude oil

Figure 8. Total final consumption, by source, 1990-2022

Source: IEA (2024) <https://www.iea.org/data-and-statistics/>

Total final energy consumption by energy source in Hungary (2021 Estimate, TWh)

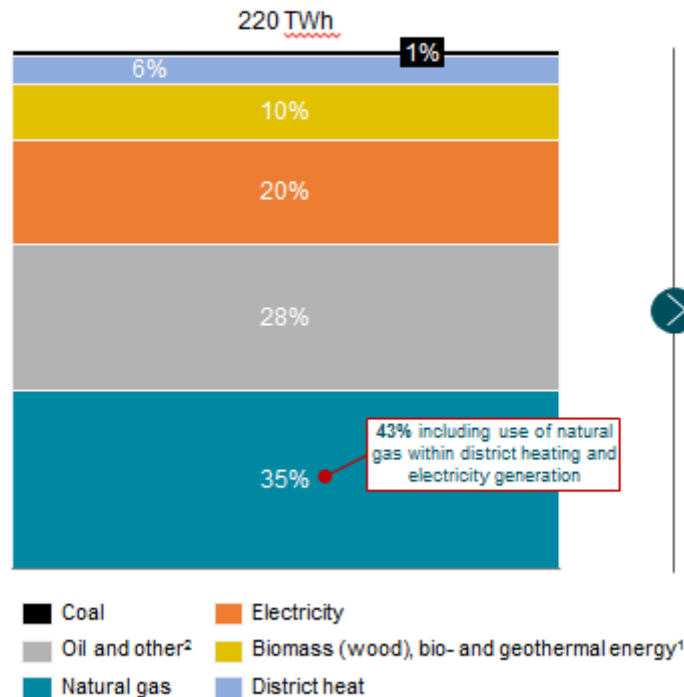


Figure 9. Fuel share of TFC by sector, 2021

Source: Eurostat, BCG analysis (2022)

Institutions

In Hungary, central governmental organisations and independent competent authorities (Hungarian Public Utility Regulatory Authority, Hungarian Atomic Energy Authority, Supervisory Authority for Regulated Activities), are involved in energy-related tasks. The Ministry of Energy is the lead energy policy institution. It is responsible for conventional energy resources (crude oil, natural gas, and coal), electricity and nuclear energy (except for the Paks II. Project). The Ministry of Energy is also responsible for renewable energy, climate policy and energy efficiency.

The Ministry of Foreign Affairs and Trade is the project owner of the capacity expansion at the Paks nuclear power plant also known as the Paks II. Project. The Ministry of Foreign Affairs and Trade is responsible for energy security and energy diplomacy.

MVM Group is a fully state-owned company that operates under the supervision of the Ministry of Energy. Its portfolio covers the total domestic energy system.

The Hungarian Energy and Public Utility Regulatory Authority (HEA) performs official supervision related to natural gas, electricity, district heating and water utility operation activities, and preparatory tasks for fee regulation related to waste management public services. Its detailed scope of activities and authority are described in detail in the sectoral legislation.

HEA is also responsible for reporting statistics (energy, climate, and stocks), exercising regulatory oversight in the sectors and issuing relevant permits. As the official statistical body, HEA also performs standard national energy-statistics-related tasks and complies with the data reporting obligations to various national and international bodies and organisations.

The Hungarian Atomic Energy Authority (HAEA) is an independent regulatory body that supervises Hungary's atomic energy matters and has regulatory oversight of nuclear facilities. The competence of the HAEA covers the security of nuclear materials and facilities, including primarily the Paks Nuclear Power Plant, the nuclear non-proliferation system created to prevent the spread of nuclear weapons, as well as the coordination and provision of state administration and official tasks related to nuclear accident prevention.

Supervisory Authority for Regulated Activities (SZTFH) is an independent regulatory body in Hungary that performs tasks defined by law. The Authority deals with the official control, supervision and regulation of several areas, including mine supervision, the conclusion of concession contracts, the supervision of geothermal activities and a list of natural gas/crude oil producers. It also provides statistics on energy research expenditures. SZTFH also serves as Hungary's ESG regulator.

The Hungarian Central Statistical Office is responsible for reporting of statistics. The National Research, Development and Innovation Office manages and supports public research, development and innovation funds and is responsible for Horizon Europe planning.

Energy security

Hungary's oil and gas production remains modest, with the country primarily depending on imports to fulfil its energy requirements. The Russian Federation is the major source for both oil and gas, but significant efforts have been made to diversify supply routes both along the north-south and east-west axes. Increasingly, greater diversity can be seen in the country's portfolio of crude oil sources. As a landlocked country, Hungary has a well-connected and developed energy infrastructure with its neighbouring countries, thus the diversification routes are established. But this does not necessarily mean that Hungary also receives supplies of certain energy products from multiple directions. (e.g. we have access to limited natural gas sources).³

Getting more involved in the common European oil and gas market, building new cross-border connections and/or amplification of the existing ones could mean a safer energy supply in the middle term. As an EU Member State, Hungary is part of the implementation of the EU's Energy Union Strategy aiming at a transformation of European energy supply through the establishment of a fully integrated energy market. This will certainly allow Hungary to diversify its energy import sources and transport routes providing a secure, sustainable, and affordable energy supply.

Oil represents roughly one-quarter of TPES and is expected to remain at this level until at least 2030. Domestic oil production, which was 1.09 Mtoe in 2023, is expected to continue to decline thereby increasing dependence on imports. Oil consumption increased from 6.6 Mt in 2014 to

³ Note: extra natural gas sources can be reached with additional infrastructure developments outside Hungary.

7.4 Mt in 2023. The transportation sector dominated oil consumption accounting for 63% of demand in 2023.

Natural gas demand has declined significantly since its 2005 peak of 15 billion cubic metres (bcm) but it retains the largest share of Hungary's TPES accounting for 34% in 2021. The decrease of demand can be attributed to the population's more conscious use of heating – which includes both the choice of different heating methods and the price-sensitivity of the population when it comes to natural gas. Currently Hungary receives about 8.5 bcm of natural gas yearly. According to the data from the Hungarian Transmission System Operator, in 2024, renewable energy sources accounted for 24.6% of electricity generation. Partly with the rise of renewables and partly with nuclear energy, Hungary will reduce electricity imports from the current 24% to 20% by 2030; in the district heat sector and in heat production in general, the country will replace natural gas by geothermal heat and biomass. In the optimal case, a quarter of the natural gas needs expected by 2030 are to be supplied from domestic sources.

The use of publicly held stocks is central to Hungary's emergency response policy for both oil and gas. The Hungarian Hydrocarbon Stockpiling Association (HUSA) is entrusted with public stockpiling of both oil and gas. HUSA was founded and is operated and financed by the domestic oil and gas industry and the government exercises special control rights over the association. Its public oil stocks are composed of gasoline, diesel and crude oil and remain comfortably above the IEA's 90-day requirement. The stored quantity (about half of it being gasoline) was equivalent to 219 days of net imports on February 14, 2025, based on the currently available stock amounts, and the respective refinery yield ratios. According to the Stockpiling Act, a minimum of one-third of the strategic stocks shall consist of petroleum products i.e. diesel and/or gasoline and the present ratio of petroleum products to crude is 60:40. When counted together with industry stocks, the total puts Hungary well beyond the IEA minimum stockholding obligation of 90 days of net imports. In an IEA co-ordinated response to a supply disruption, Hungary can respond with the release of public stocks.

Hungary has also developed strategic gas reserves, which are under government control. The strategic gas reserves in 2024 are the Special Natural Gas Stock, which is 739 mcm and the Security Gas Stock (which was previously reduced to 915 mcm in 2015) is 1200 mcm in 2024, totalling 1939 mcm. The level of stocks is determined by a ministerial decree.

Electricity production and consumption

It is in Hungary's interest to reduce its energy import needs. The share of net electricity imports in total internal consumption (excluding self-consumption by domestic power plants and grid losses) decreased from 31.44% in 2014 to 23.98% in 2024. Our electricity supply exposure is slowly but steadily decreasing.

Domestic electricity demand is expected to grow at a higher rate than previously expected over the next 6-10 years. This can be partly offset by the planned expansion of electricity generation capacity. However, relatively high import margins are expected in some periods.

Renewable energy sources, in particular solar energy, are playing increasingly important role in gross domestic electricity production and in total gross electricity flows.

These amounts are expected to continue to grow in the future as electricity consumption per capita is still relatively low compared to the OECD average. Hungary is a net electricity importer and also a major transit country, mostly to its southern neighbours. The Paks Nuclear Power Plant contributes significantly to domestic electricity production with a share of nuclear production of 47.14 %, with the remaining generation depending on renewables (24.6%), natural gas (20.4%) and coal. Hungary is part of the electricity system of Central Eastern Europe, and its wholesale electricity market has been coupled with the Czech Republic, Slovakia and Romania since 2014. The Hungarian electricity system is directly connected to all of our neighbours.

However, the current national arrangements for congestion management and bidding zone definition in Central Europe do not necessarily accurately reflect actual congestion, and this is leading to increasing limitations of cross-border flows of electricity. The country's TSO, MAVIR, is responsible for grid management and system security, under the supervision of HEA, the energy regulator. MAVIR has contracts for mutual assistance with neighbouring TSOs.

Nuclear energy was the source of 47.14 % of domestically generated electricity in 2024 and will continue to play a major role in the power sector into the foreseeable future. National Energy Strategy 2030 with an outlook until 2040 states that the long-term preservation of nuclear energy in the energy mix is not only one of the most important energy objectives. Maintaining/ preserving our nuclear objectives is crucial, see Government Resolution No. 1335/2022. (VII.15.) on taking the necessary measures to extend the operating time of the Paks Nuclear Power Plant, as well as the expansion of nuclear capacities – the Paks II project received the construction license of August 25, 2022, besides the construction permits for the reactor buildings of units 5 and 6.⁴ Paks II is considered as a flagship project by the government and the ownership rights are exercised directly by the Ministry for Foreign Affairs and Trade. Once Paks II commences operation, it will need to be integrated into the electricity market. The four Paks I units are planned to close down in sequence between 2032 and 2037, after 50 years of operation, but the competent authorities and the stakeholders began the preparatory work that would make a 10-20 year extension possible.

To ensure the timely replacement by new nuclear units after the shut down of the extended operation of Paks I (the shutdown is transferred to a later date by the extension of the operating time), the Paks II project received the construction license in the summer of 2022, and it will be operational by 2032, according to the current planning.

⁴ In January 2014, Hungary signed an Intergovernmental Agreement with the Russian Federation for the construction and technical support of two units of 1 200 MWe at Paks II. The units should start operation in 2032. In March 2014, Hungary and the Russian Federation signed a financial agreement providing for a EUR 10 billion credit line from Russia to cover 80% of the capital expenditure for the construction of the two units. The Hungarian State will financing the remaining 20%.

II.A.6.2. Transport

Infrastructure

Hungary's central location in Europe and the accordingly dense motorway network are one of its most important competitive advantages. Five vital European transport corridors (Rhine-Danube, Mediterranean, Baltic-Adriatic Sea, Baltic-Black-Aegean Sea, Western Balkans) pass through Hungary, providing unparalleled access to all parts of Europe, including major European ports and the fast-growing CIS (Commonwealth of Independent States) market. To exploit these benefits, Hungary is determined not only to preserve but also to enhance its infrastructural network and to improve its integration into the European network.

Road Network

As a result of intensive construction works along main transport corridors in the last 10 years, major motorways and trunk roads have reached national borders, ensuring faster and safer transportation. Hungary has an extensive road system, centred in Budapest, and the most developed highway network among new EU member states. Seven of the eight main roads start from Budapest (designated by single digit numbers, running clockwise from the Vienna motorway M1) and all of them link up with the European road network.

The road network is divided into roads and private roads. Roads are state-owned national roads and local public roads. The length of national roads is 32 629 km. Local roads have a total length of 183 156 km. The national road network accounts for about 75% of the country's total road traffic (Figure 10).

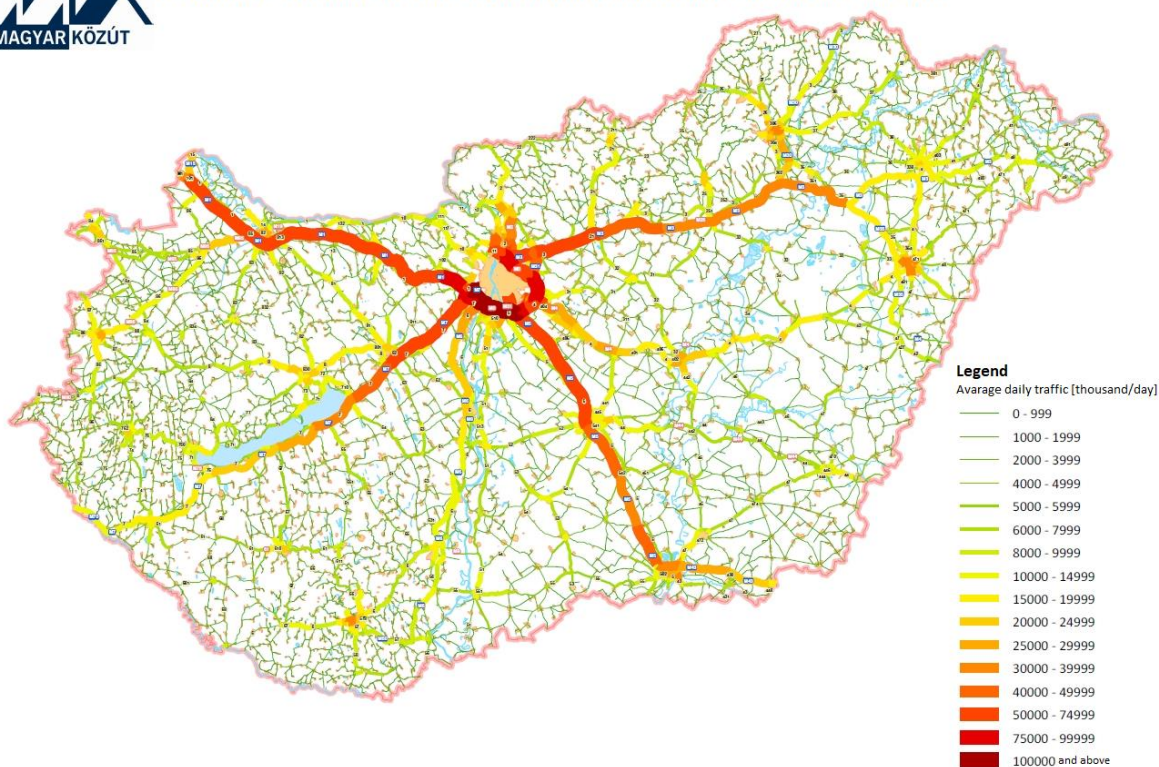


Figure 10. Traffic volumes (average daily traffic) on the Hungarian State Road network

Source: Hungarian Public Road Non-profit Plc. (based on 2021 data)

9456 km of national roads are the main network, of which 2 479 km are part of the European road network. The length of the expressway network (motorways, motor roads) is approximately ~1 883 km, and the length of motorways with node branches is 2 430 km. 26% of the length of the national roads pass through settlements, so they play a significant role in the local traffic. There are 8 276 bridges on the national roads, 1 860 road-rail crossings (of which 1 392 are level crossings, of which 76 are insured), 9,108 road junctions and 6 934 level pedestrian crossings.

The improvement of the highway network and four-lane motorways linking all the major cities in Hungary will result in an approximately 40% decrease in driving times on the main intercity routes. A top priority of the Hungarian government is to further extend and reconstruct the road network in Hungary. Since 2010, approximately 600 km of expressway with 2x2 lanes has been built. As a result of these developments, almost the entire TEN-T Core Network is covered by motorways nearly all major cities (mainly cities with county rights) are connected into the expressway network, and 9 motorways reach the national borders to improve mobility with the neighbouring countries. In Hungary, the motorway network could be reachable within 30 minutes for almost the 90% of the population and from near 2320 settlements.

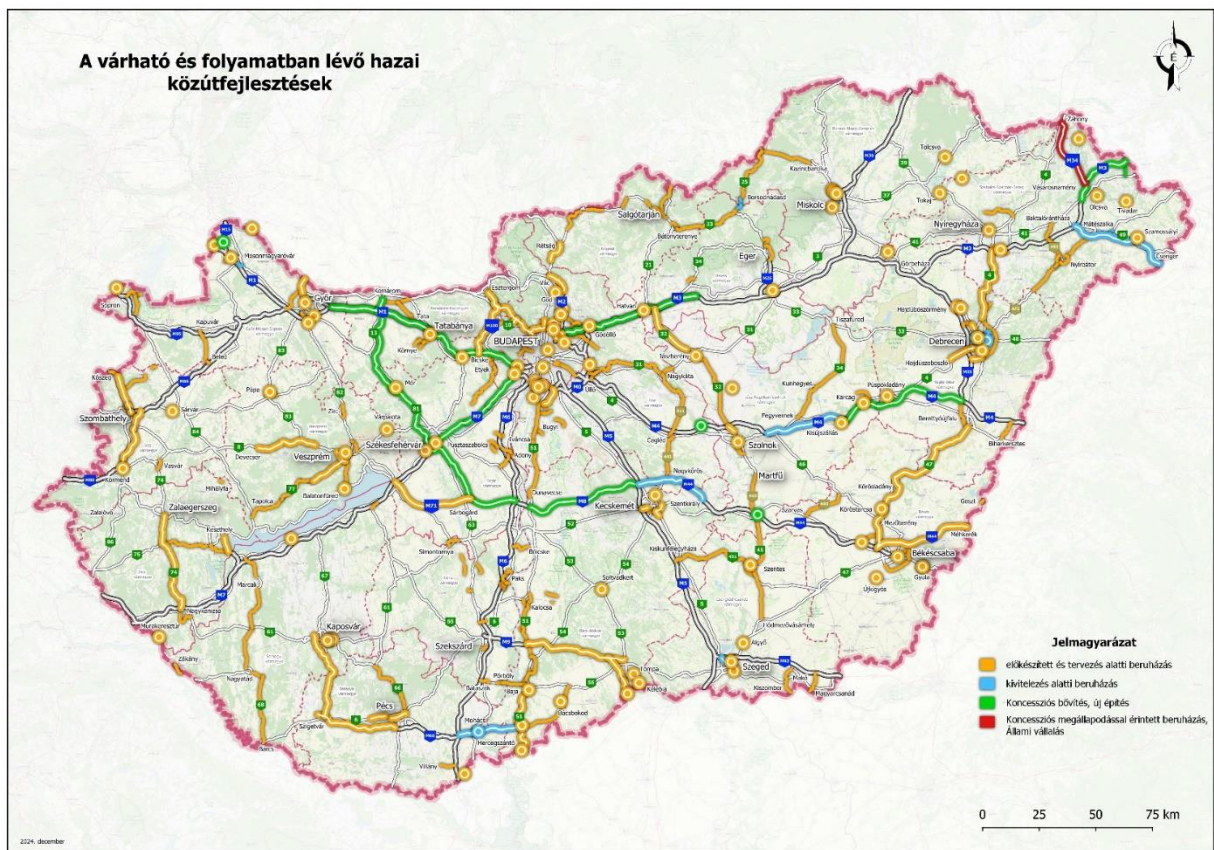


Figure 11. Road network in Hungary: existing and planned roads

Source: Ministry of Construction and Transport

Legend:

Orange – Project under planning phase

Blue – Project under construction

Green – Project under concession contract

Red - Project under concession contract, but the Hungarian State has to finance the planning and construction

Road transport and the transport network are in a contradictory and continuously changing situation in Hungary. This can be characterised by the following factors:

- the network of good quality and rapidly expanding expressways and almost 500 dead-end settlements are present at the same time in the country in the central and western,
- in the south-western and south-eastern parts of the country, the problem is caused by the saturation of the public roads and by delayed accessibility, respectively
- while traffic problems in large cities – congestions, parking difficulties, air pollution – remind us of developed countries, the access to peripheral areas has hardly improved in 50 years.

Railway Network

The 7400 km-long railway network covers the whole country and it is an integral part of the Trans-European network (TEN-T), thus providing easy access by international express trains from the neighbouring and numerous other European countries. 18% of the Hungarian railway is double-tracked, while 46% of it is electrified.

Fast connection to sea ports

Several scheduled block train lines connect Hungary with the seaports of Hamburg (D), Bremen (D) and Rotterdam (NL) on the North Sea, with Koper (SI) and Trieste (I) on the Adriatic and soon with Constanța (RO) on the Black-Sea. The Koper, Trieste and Constantza seaports also offer alternative shipping routes from Asia. Lead time from these ports to Hungary is within 16-36 hours by road or direct train.

Around 17% of freight is transported by rail in Hungary, well above the EU average. Záhony and its region at the Hungarian-Ukrainian border is the junction and reloading centre for European standard-gauge railways and the wide-gauge system of the CIS states.

Inland Waterways

Hungary is a landlocked country but it has access to the Black Sea and the North Sea via the river Danube. Major inland ports are located in Győr-Gönyű, Komárom, Budapest, Dunaújváros, Paks, Baja and Mohács. The opening of the Danube-Rhine-Main channel in 1992 made possible the performance of export-import traffic with the countries along the Rhine and the maritime ports in the North, too. In Hungary 2% of freight is transported by inland waterways.

Aviation/Air Transport

The aviation landscape of Hungary has gone through significant changes in the last couple of years. The Covid-19 pandemic had a devastating effect on the aviation industry, as air traffic went from all-time highs to all-time lows in a matter of days due to the imposed lockdowns. However, as the world started to re-open, the aviation market reinvigorated again from the summer period of 2022. Both passenger numbers and cargo volumes have steadily grown ever since worldwide. Passenger traffic at Hungary's largest airport, Budapest Liszt Ferenc International Airport, began to grow significantly. Although in 2023, passenger traffic was 9.1% lower than in the record year of 2019 (when 16.2 million passengers were recorded), in 2024, the airport saw a rise to 17.526 million passengers, marking an 8.7% increase compared to 2019. Cargo traffic figures were not suffering due to the pandemic – in compare to year 2019 a substantial increase of 30% was observed in 2021, followed by a subsequent annual increase of 6-7% due to the expanding Cargo City operations at the airport. The war in Ukraine has caused a rapid increase of air traffic in the Hungarian airspace due to the airspace closures in Ukraine and Belarus. The Hungarian Air Navigation Service Provider Hungarocontrol has concentrated all the efforts to meet these extra challenges in order to serve this extra traffic.

The other two international airports of Hungary – Debrecen International Airport in Debrecen and Hévíz-Balaton Airport in Sármellék - have also elaborated ambitious strategic plans to thrive and exploit the current positive trends of the industry.

Acknowledging the importance of the regional airports from the local communities' mobility and regional connectivity perspectives, the Hungarian aviation administration assists the worthwhile projects of these airports to help them to catch up and grow.

Factors affecting emissions from transportation

The average age of the car fleet has been increasing constantly since 2007. We arrived at the 2000 niveau of an average age of 12 years in 2011. The rate of growth has slowed down since 2012, but the average age is still increasing every year. The recent value is more than 16.7 years in 2023, and there is more than 2.5-year difference between diesel (14.8 years) and gasoline (17.4 years) passenger cars.

New registrations were at a low point in 2010. Statistics from the Central Statistical Office show that the stock of new registrations started to grow in 2010 after the continuous fall from 2003. The continuous growth lasted until 2019 (314,000 new registrations) and was interrupted by COVID-19. There is a continuous decline in newly registered cars, with a substantial decrease of 18% (259,000 fewer) in 2020 compared to the previous year, followed by further reductions of 1.7% (254,000) in 2021, 6.5% (238,000) in 2022, and 10.5% (213,000) in 2023.

The stock of cars has been increasing constantly in the last few years. Between 2018 and 2023, Hungary's passenger car stock increased steadily from 3 641 823 to 4 168 651 vehicles, reflecting a growth of approximately 14.5%.

Concerning the composition of the car stock, 64% were equipped with petrol engines in 2021 (in 2000 – 90%, in 2010 – 79% and in 2016 – 69%). The change in vehicle stock was therefore fundamentally due to the reduction of gasoline combustion vehicles, the number of petrol cars has been continuously reducing from 2003 to 2014 (2 266 198), but the number of gasoline passenger cars are increased in the last years (2015 – 2 272 447, 2016 – 2 301 168, 2021 – 2,581,637). During the last year, the proportion of gasoline-powered cars in the fleet experienced a marginal decline, growing only slightly from 2,445,468 (67.1%) in 2018 to 2,583,465 (62,0%) in 2023, indicating a relative decrease in their share within the total fleet.

Conversely, diesel cars saw moderate growth in their numbers, rising from 1 131 685 (31.1%) in 2018 to 1 315 322 (31.6%) in 2023, maintaining a relatively stable percentage share. In 2021 the stock of diesel-engine vehicles was 31% (1 272 218) of the whole fleet (in 2000 – 10% (230 855), in 2010 – 21% 619 807 and in 2016 – 29% 970,997). This is due to better consumption and increasing performance and happens despite the increasing cost from deNOx-measures already manifesting in (higher) consumer prices.

Notably, alternative fuel vehicles (hybrid, electric and mixed combustion) exhibited significant growth, increasing from 64 670 (1.8%) in 2018 to 269 864 (6.5%) in 2023.

According to the EU Green Deal, a decrease in the number of passenger cars with internal combustion engines is expected by 2030 since from 2035, there will be a ban on the sales of all new vehicles with internal combustion engines.

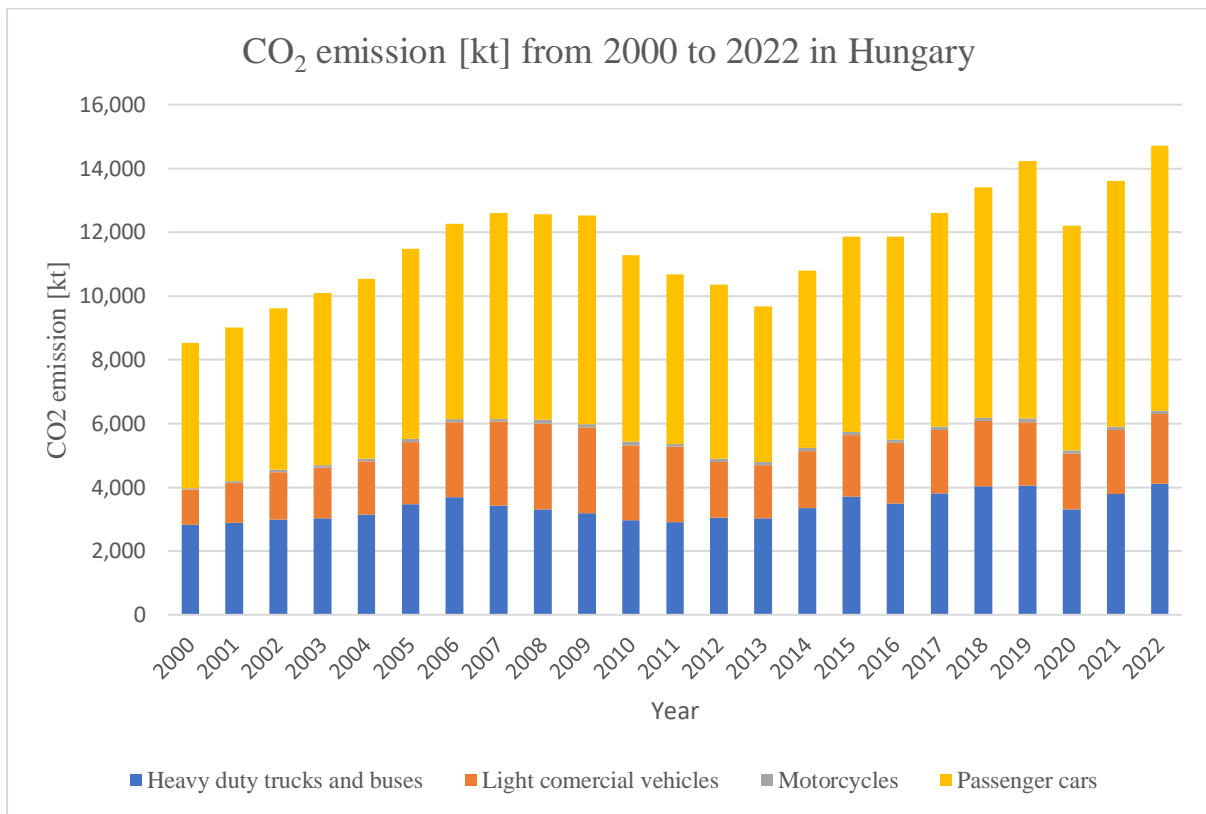


Figure 12. CO₂ emission (kt) trends of vehicle sectors from 2000 to 2022

Source: European Environment Agency, 2025, modified

Figure 12 shows the trends of CO₂ emission between 2000 and 2022. CO₂ emission is increasing again in these vehicle categories (passenger cars, heavy-duty trucks, light commercial vehicles, buses and motorcycles) since 2013. However, this upward trend was interrupted in 2020, when emissions dropped significantly to 12 196 ktons due to impact of the COVID-19 pandemic. Following this decline, emissions began to rise again in 2021 and 2022, reaching 13 601 ktons and 14 714 ktons, respectively. Passenger cars consistently contributed the largest share of CO₂ emissions.

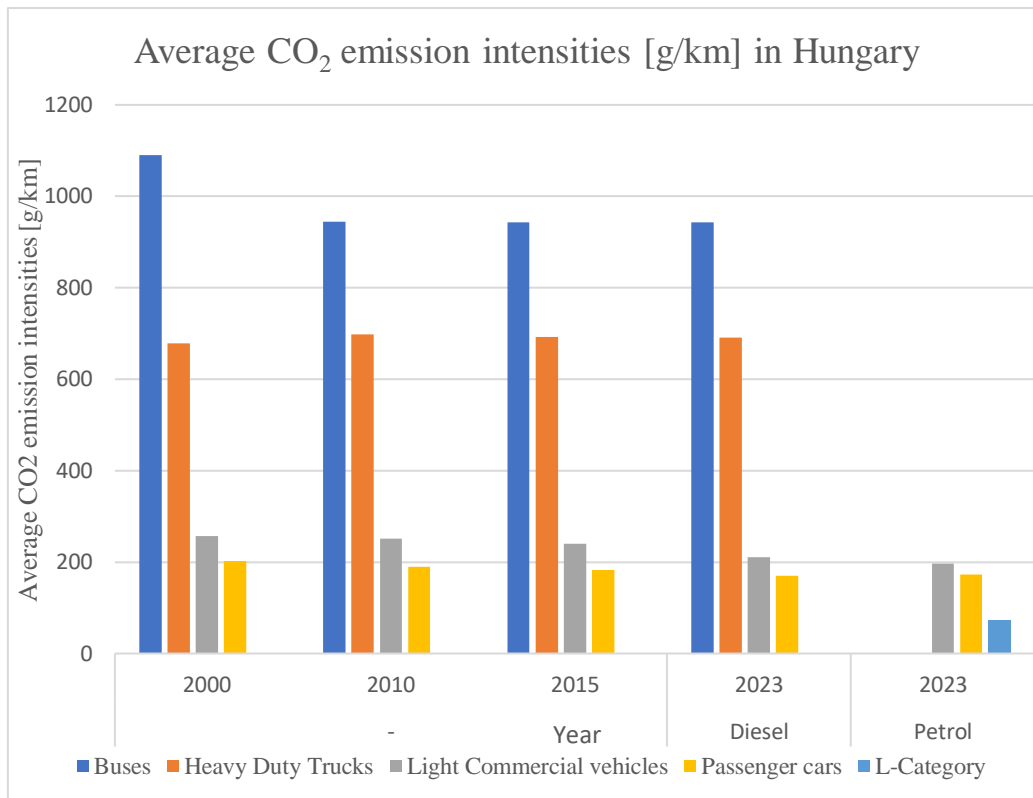


Figure 13. Average CO₂ emission intensities (g/km) in 2000, 2010, 2015 and 2023

Source: Institute for Transport Sciences (KTI), 2025

For CO₂ emission intensities (g/km) the average values of CO₂ emissions of vehicle categories were calculated in 2005, 2010, 2015 and 2023. Figure 13 shows the difference between vehicle categories. In 2023, the most common fuel types (diesel, petrol) of vehicle categories are represented.

Despite a consistent reduction in average CO₂ emission intensities since 2000 across all vehicle types—including passenger cars, light commercial vehicles, heavy-duty trucks, and buses—a significant decline has not been observed between 2015 and 2023. This stagnation occurs even as energy consumption and the number of vehicles on the road have increased. Several factors contribute to this phenomenon. While natural fleet turnover from older to newer emission standards (Euro norms) has played a role in past improvements, its effect has diminished. The importation of used vehicles has resulted in a lower number of more efficient Euro 6-compliant vehicles being registered in the national fleet. Additionally, there is an annual growth in energy consumption and in the total vehicle fleet size.

The increasing number of vehicles and the changing utilisation patterns have a significant impact on future fuel consumption and energy use. It can be also declared that the CO₂ emission intensity of a certain country greatly depends on several parameters, which include the number of vehicles from different vehicle segments, the different fuel types, the mean activity and the vehicle age etc.

II.A.6.3. Industry

The Hungarian economy has repeatedly demonstrated its competitiveness by building on its strong foundations and being able to react quickly to crisis situations and recover quickly from difficult times. The basis of our competitiveness is that we have achieved an employment rate of around 75 %, a stable investment rate of over 20 %, and product exports of around 65-70 % of GDP. Industry plays a key role in the stability of our economy and accounts for 21-22 percent of the gross added value. Against this background, there is no need for an economic turnaround, but for a fine-tuning of the objectives and instruments of the existing economic strategy.

Our goal is to further increase economic growth so that Hungary reaches 90 percent of the European Union's level of development by 2030. This requires an employment rate of 85 percent and an investment-to-GDP ratio of 30 percent, of which business investment accounts for 20 percentage points. To achieve these goals, competitiveness proposals were needed, a **New Competitiveness Strategy** adopted at the beginning of 2024, it is based on suggestions from companies, taking into account the problems and responses of nearly 1 300 companies in 6 priority sectors: automotive, food, creative industries, health, information and communication, chemicals, metals and plastics. The Competitiveness Strategy focuses particularly on the uptake of artificial intelligence in the corporate sector and the development of an advanced electromobility ecosystem. Under the pillars, the priority will be to develop domestic suppliers, strengthen research, development and innovation and develop closer links with companies, and finally to develop national champions. Hungary's industry is the key to our competitiveness, and increasing competitiveness is essential to restart economic growth.

THE PILLARS OF THE COMPETITIVENESS STRATEGY ARE DESIGNED TO INCREASE DOMESTIC ADDED VALUE

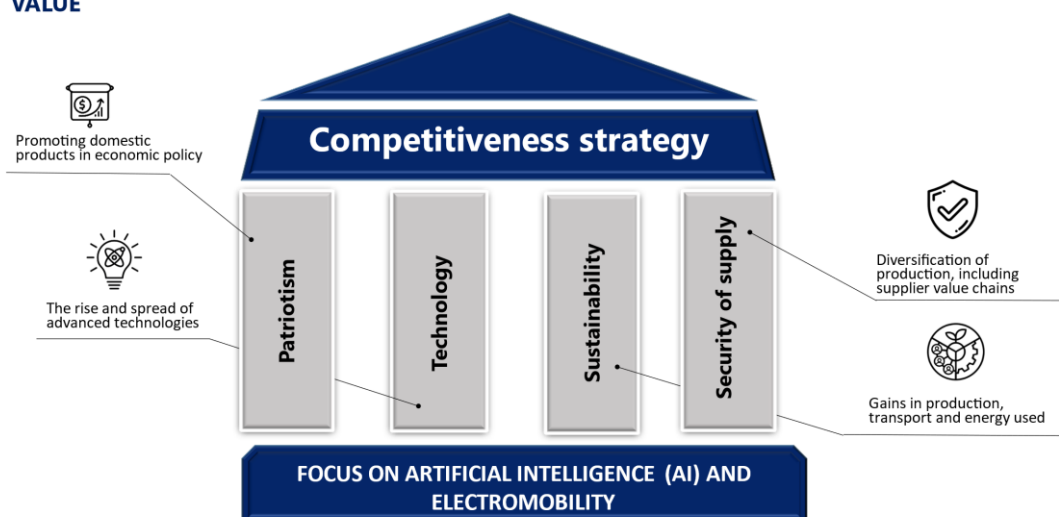


Figure 14. Source: Hungary's Competitiveness Strategy 2024-2030, Ministry for National Economy

The volume of industrial production in 2023 was 5.5 % below the high base of a year earlier. Only three manufacturing sub-sectors managed to increase their production volumes. Again, the largest expansion was in the manufacture of electrical equipment, which included battery production. With the easing of parts supply problems, the recovery in the most important

area, the manufacture of motor vehicles, which started in 2022, continued, with output reaching a record high in 2023. The demand-squeezing effect of high food inflation set back the performance of the food industry. The output in the largest manufacturing sector, which accounts for 26 % of manufacturing output, grew by 8.4 %.

Industrial production growth has stalled

Industry in Hungary is relatively significant, with water and waste management accounting for 22 % of gross value added in 2023. In our country, 32 % of investments in 2023 were in the manufacturing sector. The volume of sales on the external market in 2023 was 3.2 % lower than a year earlier, while domestic sales were 14.8 % lower. Among the manufacturing industries, output in manufacturing, which accounts for 96 % of production, fell by 4.3 %, with sales declining in both sales directions. As in recent years, the vast majority of manufacturing sub-sectors were dominated by sales to the rest of the world. Mining, which accounts for only 0.4 % of industrial output, saw its output fall by 31 % compared to 2022, while energy, which accounts for 4.1 %, saw its output fall by 23 %. Investments amounted to HUF 5,816 billion in 2023, 2.7 % more than a year earlier at comparable prices. Industrial producer prices were on average 7.6 % higher than in the previous year, mainly due to higher energy and raw material prices, as a result of higher domestic sales prices and lower export sales prices. In 2023, the number of persons employed in industry was nearly 774 thousand, 0.5 % more than in 2022.

Change in industrial production

(Monthly average of 2015 = 100.0%)

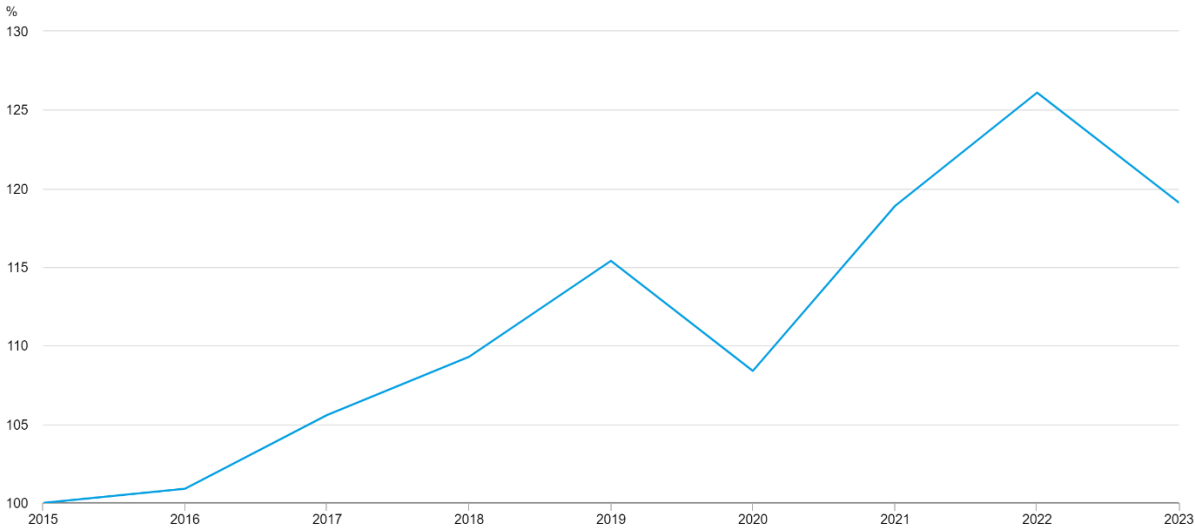


Figure 15. Source: Hungarian Central Statistical Office (KSH), 2023

Manufacture of electrical equipment is the most dynamically growing subsector

In Hungary, the manufacturing sector makes up the dominant part of industrial production. Production in 2023 was HUF 51,891 billion, 4.3 % below the 2022 value at comparable prices. The other two sectors of the economy, which are much less important than manufacturing, are energy and mining also fell by 23 % and 31 % respectively.

Only three manufacturing sub-sectors managed to increase their production volumes in 2023 compared to a year earlier. As in every year since 2019, the largest increase was again in **the manufacture of electrical equipment**, driven by the performance of companies producing vehicle batteries and electric motors. Output has surged with the commissioning of significant production capacities thanks to recent investments, with production volumes in 2023 up 9.3 % year-on-year, and the industry's output nearly tripling over the last five years (2019-2023), reaching 11 % of manufacturing output value.

The manufacture of transport equipment, which accounts for the largest share (26 %) of manufacturing output by sub-sector, also rebounded in 2023. The industry was severely affected by the coronavirus epidemic, with plant shutdowns causing significant production losses in 2020 and further production declines in 2021 due to disruptions in supply chains, notably the global chip shortage. As component supply problems eased, vehicle output in 2022 was up 15 % from the low base of a year earlier.

Production growth continued in 2023, with volumes up 8.4 % year-on-year. This brings the sector's performance to its peak so far, but ongoing investment is expected to further boost vehicle production output. **Other manufacturing**, which accounts for a small share, was the third sub-sector to increase its output (by 6.4 %) compared to 2022, driven by a significant increase in the volume of industrial machinery and equipment installed.

Within manufacturing, **the second-largest food sector**, with a share of almost 13 %, has seen its output growth since 2011 (except in 2013) halt in 2023, with output falling by 11 %, with the demand-squeezing effect of high food inflation playing a significant role. Domestic sales, which account for 57 % of food industry sales, fell by 8.6 % and exports by an even larger 12 %.

Production volume change in the sections and subsections of industry, year-on-year, 2023

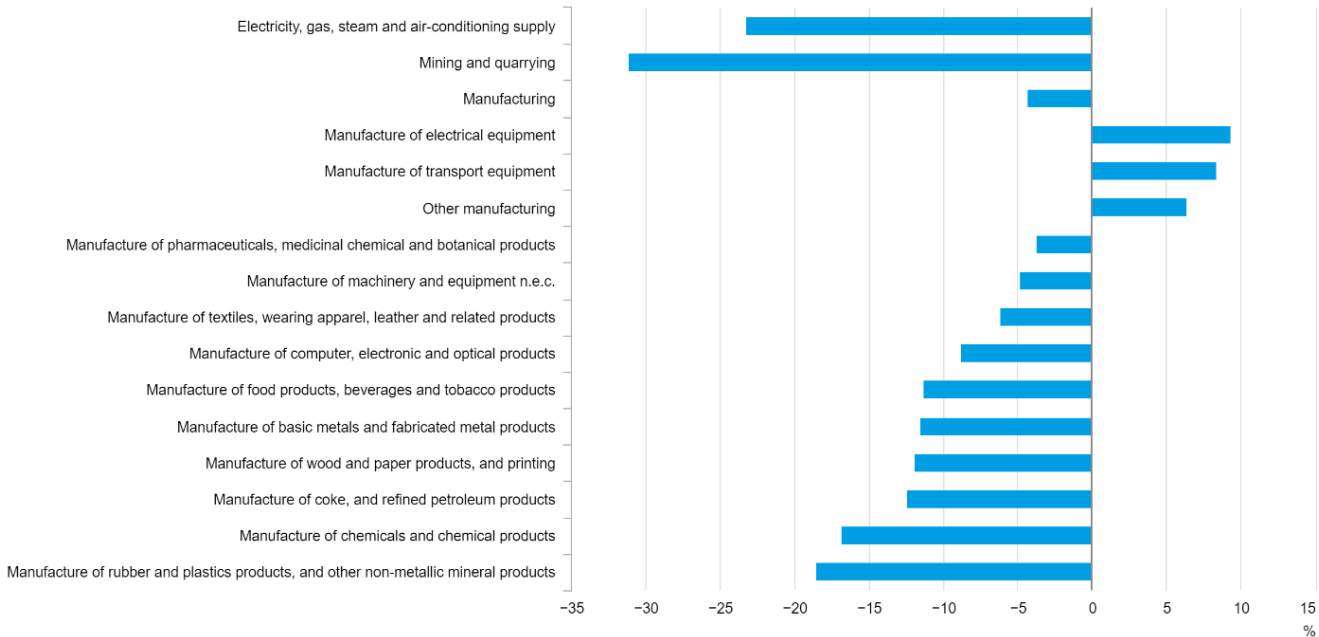


Figure 16. Source: Hungarian Central Statistical Office (KSH), 2023

Volume change and weight of investments in manufacturing subsections, 2023

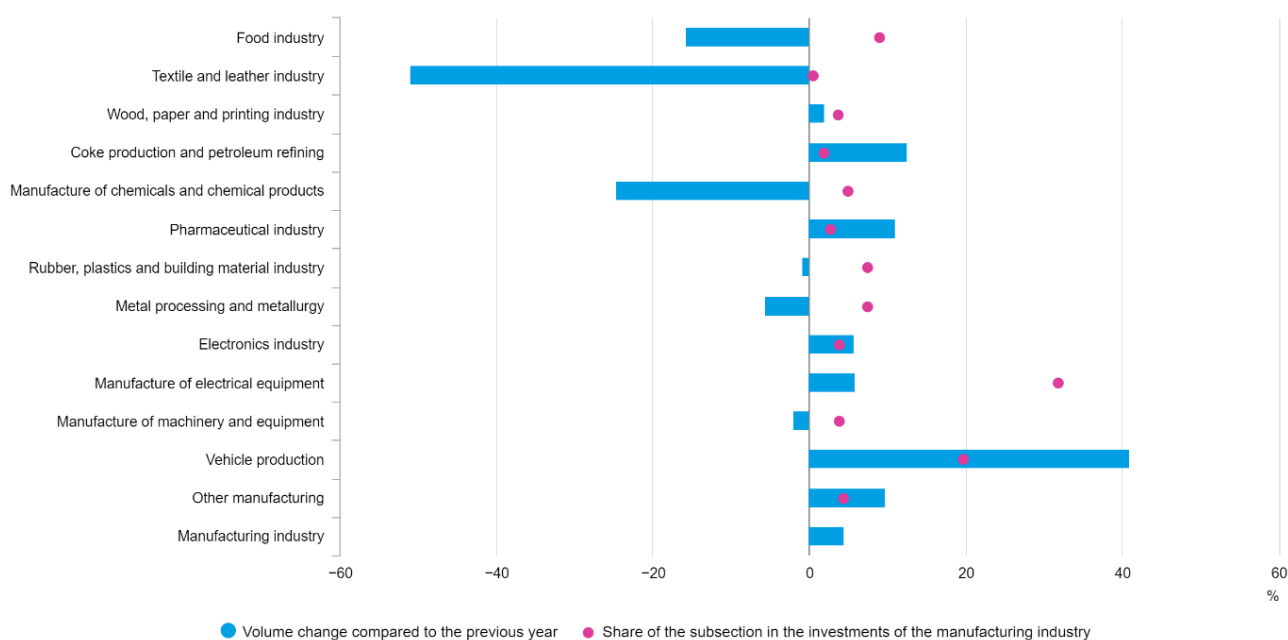


Figure 17. Source: Hungarian Central Statistical Office (KSH), 2023

In most food sub-sectors, production volumes in 2023 are significantly below those of a year earlier. Output in the meat industry, the largest contributor, fell by 12 %, driven by both domestic and export sales. In parallel, the production of animal feeds fell by 17 % and the production of vegetable and animal oils by 11 %. Only the production of bakery products and pasta increased (by 11 %). In addition to the production of electrical equipment and food, output in the **electronics industry** has also been rising steadily since 2014. However, the upward trend in output also broke in 2023, falling 8.8 % from the high base of a year earlier.

Two of its two largest sub-sectors are electronic components, circuit cards and components for the automotive industry output fell by 8.4 % and the production of electronic consumer goods by 12 %.

Within manufacturing, the largest declines were recorded in the **rubber, plastics and construction materials, chemicals and chemical products, coke and refined petroleum products sub-sectors** (by 18, 17 and 12 % respectively). The performance of these largely chemical activities was hit hard by the sharp rise in the cost of natural gas and oil due to the Russian-Ukrainian conflict. Within the rubber, plastics and building materials industries, the rubber sector, which also supplies the automotive industry, failed to improve its performance despite the expansion of vehicle production.

The decline in the production of chemicals and products was driven by the decline in the production of plastic raw materials and fertilizers and nitrogen compounds, while the decline in the production of coke and petroleum refining was mainly due to the tightening regulatory and tax environment, in addition to macroeconomic difficulties. To a lesser extent than the former, but still significantly (by 12 %) below the previous year, production in energy-intensive metal processing and metallurgy fell, reflecting the shutdown of production due to the low world steel price. 73 % of manufacturing sales revenue came from exports and 27 % from

domestic sales. The weight of exports was particularly high (over 90 %) in electronics, electrical equipment and transport equipment, while coke, petroleum refining and foodstuffs were largely produced for domestic markets.

Change in production at the six most significant manufacturing subsections

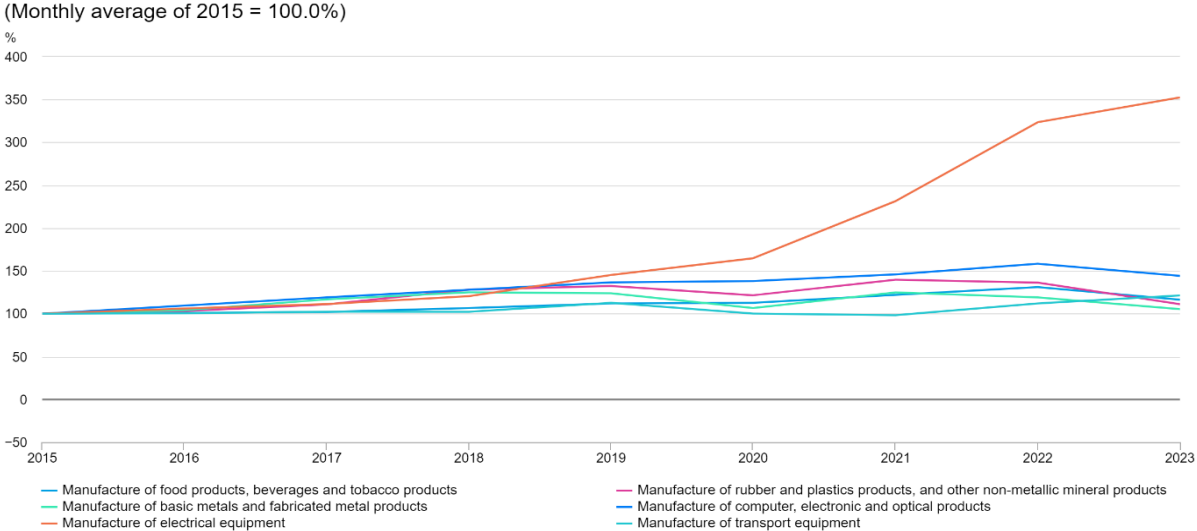


Figure 18. Source: Hungarian Central Statistical Office (KSH), 2023

Distribution of industrial domestic and export sales in the sections and significant subsections of industry, 2023

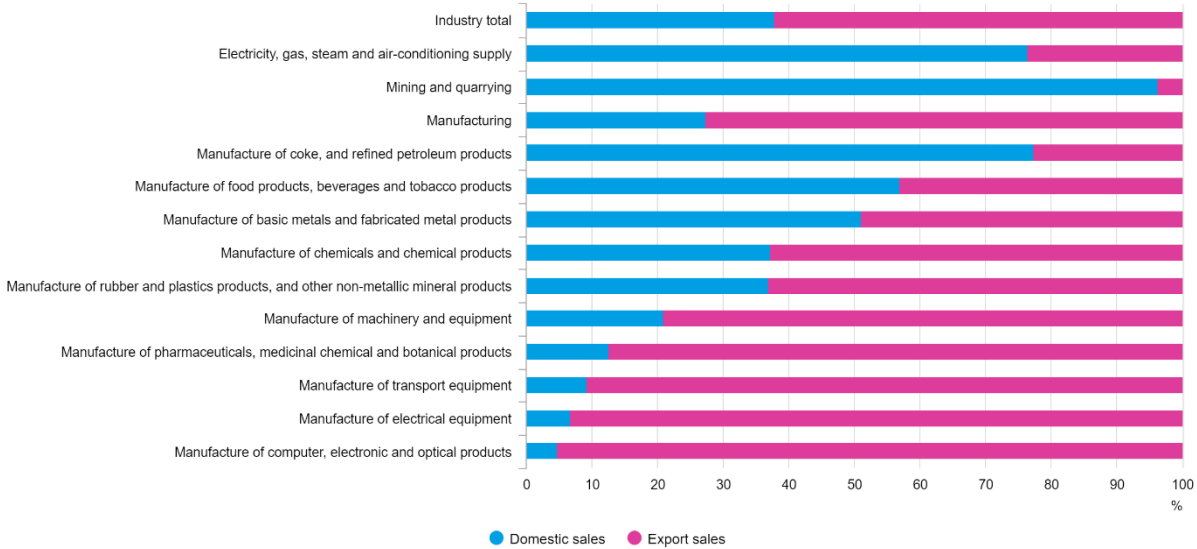


Figure 19. Source: Hungarian Central Statistical Office (KSH), 2023

Industrial production fell in most counties

In 2023, nearly two-thirds of the country's industrial output were produced in the capital and six counties (Pest, Győr-Moson-Sopron, Komárom-Esztergom, Borsod-Abaúj-Zemplén, Bács-Kiskun and Fejér).

Only the counties of Baranya, Komárom-Esztergom, Bács-Kiskun and Pest saw an increase in output compared to a year earlier. In Komárom-Esztergom and Pest counties, the production of electrical equipment, including batteries, contributed to the increase in production, while in Bács-Kiskun the automotive industry helped.

Among the regions with a strong industrial tradition, production volumes declined in Győr-Moson-Sopron, Borsod-Abaúj-Zemplén and Fejér, in addition to the capital. Among the counties, Fejér recorded the largest decrease in industrial output (19 %), mainly due to the decline in metal processing and metallurgy in 2023, rubber, plastics, construction materials and foodstuffs. The value of output per capita remained highest in Komárom-Esztergom and Győr-Moson-Sopron counties, three times and twice the national average (HUF 5.7 million) respectively, while Somogy and Békés counties were below half the national level.

Value of industrial production per capita in the counties and in Budapest, 2023*

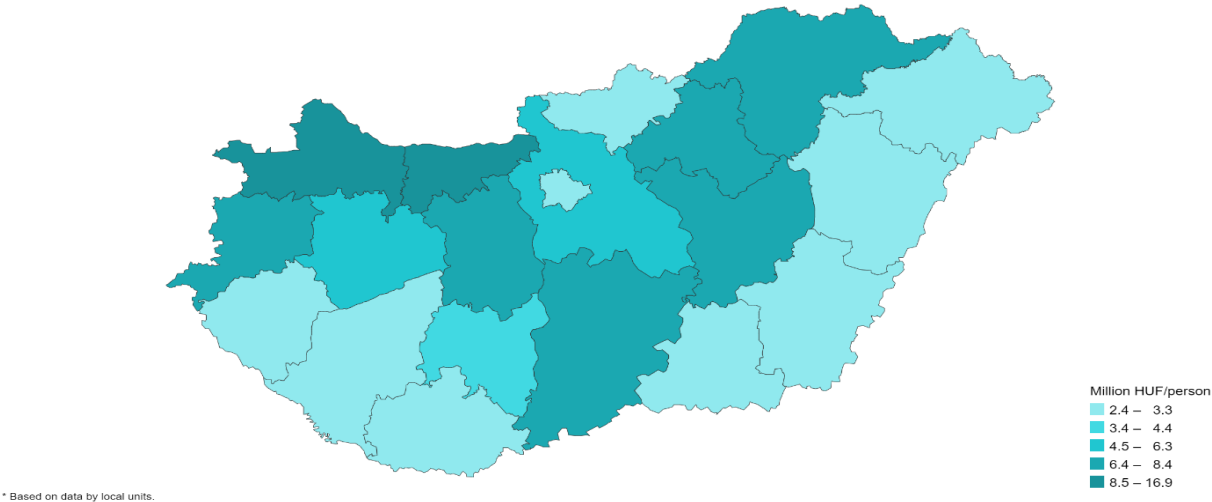


Figure 20. Source: Hungarian Central Statistical Office (KSH), 2023

II.A.6.4. Buildings and residential sector

Besides the capital city Budapest, there are 3,155 municipalities in Hungary, which are responsible for the provision of most local services, including the operation of kindergartens, welfare and some healthcare facilities, and maintenance of some cultural institutions and museums. The operation of these institutions includes supplying energy, except for some hospitals where the running costs are paid for by the central social security fund. Many of Hungary’s district heating systems are also owned by municipalities, as well as some cultural institutions and museums. Of the 3,155 municipalities, 25 are cities with county rights and over 2,800 are villages. The type and number of buildings owned by local municipalities are shown in Table 7 below.

	Total 2023	1900 and Pre 1900 (%)	1901-1959 (%)	1960-1989 (%)	After 1989 (%)
<i>Educational</i>	12 656	12,0	30,5	45,5	12,0
<i>Cultural</i>	5 866	16,5	35,7	36,1	11,7
<i>Sport</i>	2 669	n.a.	n.a.	n.a.	n.a.
<i>Health Service</i>	4 111	7,4	26,3	48,9	17,4
<i>Social</i>	2 664	9,9	30,7	32,4	27,0
<i>Health + Social Service</i>	6 775	8,4	28,0	42,4	21,2
<i>Trade, Service and Administration</i>	9 719	12,5	30,8	42,0	14,7

Table 7. Type and number of buildings owned by local municipalities by age, 2023

Source: Hungarian Central Statistical Office (KSH)

Residential flats

The data available on the residential housing stock is from the Housing Survey census undertaken in 2015 by the Hungarian Central Statistical Office.

The number of inhabited flats in dwellings was 3.9 million, of which approximately 20-20% were found in the capital cities and the larger urban areas, 33% in other smaller cities and 26% in villages and smaller settlements. Proportion of flats in houses was 63%, in block houses 20% and 17% in building associations 17%, respectively. 27% of the dwellings were built before 1960, 7% originates from before World War I. The major part of the present dwellings, approximately 1.5 million flats were built between 1960 and 1980. Privately owned dwellings ratio is 92%, the number of municipality owned flats is decreasing, and around 500,000 flats are in mixed ownership buildings (private-municipal building management). More than 2/3 of the families live in individual buildings (family houses, conventional rural houses). The decreasing population and the receding number of newly built dwellings result in the decrease of inhabitation intensity, which is reflected in the number of dwellers per 100 flats. This indicator decreased from 274 in 1990 to 221 in 2015.

The share of flats built in new family houses decreased to 41.4% by 2021 from 69.3% in 1990 and the share of dwellings in new multi-storey buildings increased to 52.2% by 2021 from 13.9%.

	1999	2003	2005	2012	2015	2022
Total number dwellings (1000)	3980	4134	4209	4402	4428	4581
Number of municipality- owned dwellings (1000)	213	181	117	106	123	110
Privately rented (1000)	119	113	129	129	233	268
Dwellings inhabited by owner (1000)	3494	3450	3641	3582	3431	3614
Empty private dwellings (1000)	135	313	212	354	545	534
Empty municipal dwellings (1000)	19	14	14	11	15	15
Other(1000)		91	38	37	61	55
Population (1000 souls)		10117	10077	9909	9830	9604
Number of inhabitants/dwellings		2,45	2,39	2,26	2,21	2,1

Table 8. Statistics on residential flats

Source: Hungarian Central Statistical Office (KSH)

The construction of new dwellings and the widespread appearance of modern household appliances (e.g. air-conditioning) are important factors towards increasing energy consumption. However, the growing number of newbuilt dwellings supplied with energy-efficient technologies may outweigh this effect: in 2021, 20% of new dwellings was equipped with heat pump and 6% with solar collector.

According to the 2022 census results, 1 216 thousand dwellings are equipped with air conditioning, 76 thousand dwellings are equipped with heat pump, 179 thousand dwellings are equipped with solar cell, 30 thousand dwellings are equipped solar panel out of the total of 4 581 thousand dwellings.

II.A.6.5. Agriculture

Thanks to its favourable natural endowments, Hungary has had a significant and internationally appreciated agricultural sector for centuries. Moderate climate, fertile soils and outstanding water conditions together with technology and knowledge enable agriculture to supply domestic citizens and foreign markets with safe, high-quality food. Thus, agriculture is of outstanding and strategic importance in the Hungarian national economy, which is shown by its contribution to GDP, international trade, its role in the production of safe and healthy food, in sustainable

and efficient management of natural resources, in rural employment, as well as its contribution to the maintenance of rural landscapes.

Since Hungary's accession to the EU, its agricultural sector has undergone significant development, with notable improvements in efficiency, competitiveness and profitability, gradually converging toward the performance levels of the older Member States. As a result, the significance of Hungarian agriculture has increased in terms of production and income indicators. Nevertheless, there are still many reserves in the agriculture of the country; its role in the EU's agricultural production and trade can be further increased in the future, with a better utilization of its capabilities. Hungarian agriculture has a good environmental performance in EU comparison.

However, in recent years, climate change affects agriculture significantly, since extreme weather conditions (e.g. hot weather, drought and uneven distribution of precipitation, spring frost) reduces production.

Economic significance

Between 2019 and 2023, the share of agriculture in total gross value added was about 3.2-4.1 %, the share of total investment was 4.1-4.6% and the share of total employment was 4.2-4.6%.

The output of agriculture increased further at current prices in 2023, continuing the trend, which started in 2011, and reached a new record. According to the Economic Accounts of Agriculture, the output was HUF 4409.5 billion at current basic prices in 2023, 8.4% more than in 2022. Output volume increased by 25.6% (after 4 years of weather induced contraction), while producer prices dropped by 14.0 %. The good performance in 2023 was driven by crop production, however, the volume of animal output remained stable.

Between 2019 and 2023, the output of agriculture at current basic prices increased by 56.4 percent, and both crop production (+52.4%) and animal output (+63.5%) contributed to this achievement. Calculated at constant prices, the output of agriculture has decreased by 2.5% in the last five years: crop output decreased by 9.1%, while the animal sector experienced 4.7 % growth.

Exports and the trade balance of agro-food products have expanded significantly in recent years, gaining a major macroeconomic role. Following the trend of the last five years, exports of agro-food products increased further and reached EUR 13385.7 million, EUR 173.7 million more than in the previous year and EUR 4037.2 million more than in 2019. Imports of agro-food products were EUR 9866.2 million (up EUR 122.8 million compared to 2022), and the trade balance was EUR 3519.5 million (EUR +50.9 million). In 2023 the share of agro-food products in total exports was about 9.0%, from imports was about 7.0%, and from the trade surplus was 38.4%.

Land use

In Hungary, the share of utilised agricultural area and arable land in the total land area is considered to be high in international comparison. Out of the total 9.3 million hectares land, 54.3% is under agricultural cultivation. The most significant forms of land use are arable land (four-fifths of the total agricultural area) and grassland (15.7% of the agricultural area). By comparison, in the EU, 38.8% of the total area is agricultural area, and 23.4% is arable land. In Hungary the share of agricultural area out of the total area is the eighth highest, and of the arable land out of total area is the seventh highest in the EU.

In the period 2020-2023, the agricultural area increased by 148.9 thousand hectares, of which arable land by 95.2 thousand hectares and grassland increased by 61.5 thousand hectares, whereas the size of kitchen gardens decreased by 0.8 thousand hectares, vineyards and orchards decreased by 2.2-4.7 thousand hectares.

Crop production

The natural and climatic conditions of Hungary are very favourable for agricultural production. Owing to the various advantages of the growing areas, crop production is very diverse, but cereals and oilseeds dominate.

Wheat was produced on 1053 million hectares in 2023, with a 5.6 tons/hectare average yield. The 5.6 million tons harvested production was 36.4% more than in the previous year (2022 was characterised by historical drought). The production area of maize was 771 million hectares. The average yield in 2023 8.2 tons/hectare. The production dropped to 6.3 million tons (-125.7%) compared to the weak performance of 2022. The harvested area of sunflower seed was 674 thousand hectares, the harvested area of rapeseed amounted to 189 thousand hectares. The production of sunflower seed reached 1970 thousand tons (+53.2%), while 626 thousand tons of rapeseed were harvested (+24%).

Horticulture (production of vegetables, fruits and grapes)

Vegetable and fruit production has a long tradition in Hungary, thanks to the favourable natural conditions. Horticulture is a very labour-intensive sector and plays a significant role in agricultural employment.

The area of vegetables was 79.1 thousand hectares in 2023, the main vegetables were sweet corn, green peas, tomatoes, sweet pepper, cucumber and water melon. The volume of production increased by 13.1%.

The area of orchards is 76.8 thousand hectares in 2023. The most important fruits were apple, sour cherry, plum, peaches and apricots. The volume of production increased by 1.2%.

Over the past five years, cut-outs and weather have determined the volume of grape and wine production, and the weather has significantly influenced the quality. Hungary currently produces wine grapes in 22 wine regions on nearly 58.7 thousand hectares. In 2023 411 thousand tons of grape was produced.

Animal husbandry

Hungary's agricultural production decreased dramatically between 1990 and 2000 and the drop in livestock reached 50% which has continued after the EU accession as well. In recent years, due to the Government's aims to reverse these trends, several measures were introduced which has resulted in slight positive changes in the animal husbandry sector.

The stock of cattle has increased since 2011 and this trend continued until 2020, which was primarily attributable to the expansion of the beef stock and the favourable market conditions. The stock of cattle (862 thousand heads) increased by 36.8% between 2010 and 2020. However, the number of cattle decreased between 2020 and 2023 by 7.6% due to the market conditions and high input prices. The stock of cows (403 thousand heads) has increased by 33.9 per cent between 2010 and 2020 and decreased by 2.6 per cent between 2020 and 2023.

The pig stock is declining for decades with small fluctuations. It amounted in December 2023 to 2.608 million, which was about 1.9% higher than in the previous year and 13.2 per cent lower than 10 years before. The number of sows fell by 4.1%.

The poultry stock was 35.573 million in 2023, 1.7% more than in 2020. During the last years, the poultry stock fluctuated but the number of slaughter increased significantly.

The sheep stock was 907 thousand in 2023, 4.1 per cent increase compared to the previous year, but 25.3 per cent drop in 10 years. The number of ewes (694 thousand) remain stable in 2023 but decreased by 20.6% in 10 years.

The data above differ from the information available in Table 5.2.1 'Livestock populations and trends BY and 1990-2021 (1,000 head)' of the Hungarian National Inventory Report 1985-2021.⁵ The reason for the discrepancy is that livestock data in the NIR calculates the annual average livestock data from the data of the Hungarian Central Statistical Office reported on the 1st December and 1st June.

Pesticide use

The pesticide use per hectare is lower than in the EU-27. The total pesticide consumption per hectare was 127 kg in 2023, which is 11 per cent less than the value of the EU-27. In the past 5 years pesticide use fluctuated depending on the weather conditions.

Mineral fertiliser use is higher than the EU-27 aggregate, but shows a decreasing trend. Fertiliser consumption per hectare was 57 kg in 2023, which exceeds the 46 kg of the EU, but in the last two years a significant drop was observed, which was influenced mainly by the high fertiliser prices, but the green measures of the Common Agricultural Policy (CAP) contributed as well.

Greenhouse gas intensity of the agriculture is lower than the EU aggregate and decreased in the past years. GHG emission per gross value added was 1.47 kg/euro at current prices in 2023, which is less than the 1.62 kg/euro of the EU-27. Since 2019 the indicator decreased from 1.93

⁵ Please find the National Inventory Report 1985-2021 here: <https://unfccc.int/documents/627849> and the CRF Tables here: <https://unfccc.int/documents/627846>

kg/euro, but shows high volatility depending on the weather conditions (which influences crops production).

Manure and fertiliser use

Areas fertilized with farmyard manures amounted to 254 thousand hectares in 2023, the tendency is increasing (2019: 191 thousand hectares). Areas fertilized with chemical fertilizer amounted to 3236 thousand hectares in 2022 (2019: 3056 thousand hectares). Amount of fertilizer use was 342 kg/ha (379.8 kg/ha in 2019).

There are significant differences in the case of organic nitrogen applied as fertilizer to soil between the data above and the data included in the Hungarian National Inventory Report 1985-2021 (Table 5.5.7). The difference between the two figures is due to the fact that the Hungarian Central Statistical Office and Institute of Agricultural Economics use different methodologies to calculate the amount of organic nitrogen applied to the soil as fertiliser. The "loss" (evaporation) is deducted at a different stage in the data production.

II.A.6.6. LULUCF

There is a sophisticated system in Hungary to continuously collect data on forests and forestry, run by the Department of Forest Management Planning of the Ministry of Agriculture. The data is collected in a cadastre-type system. All data produced by this system is stored in the National Forestry Database (NFD) A detailed description of forestry-related databases of this system in English can be found at https://www.foldalap.am.gov.hu/download.php?id_file=40461.

A general description of another data collection system, i.e., the National Forest Inventory, can be found in English at <https://nfi.am.gov.hu/>.

All statistical data on forests and forestry that are reported in this document were taken from the official statistics of the NFD as well as the National Inventory Document, if not reported otherwise.

In general, forests in Hungary have been managed sustainably already for about a century (Ministerial reports 2006-2017; Forest Europe 2020⁶) and, overall, have continued to be carbon sinks for decades so far. Concerning forest area, the fact that the management has been sustainable is well-demonstrated by the constant increase of the area covered by trees and forests. Of the total area of the country (9 303 000 ha), 2074 thousand ha were under forest management in 2023. This area includes forest sub-compartments, which are covered by trees, and other sub-compartments, which include forest roads and other areas serving forest management. Both forest area and standing volume have been increasing for decades in the main forest-related land-use and land-use change categories (Figure 20.). The area of sub-category land converted to forest land (L-FL) started to decline a bit due to the reduction of the afforestation rate recently. However, altogether more than 800 thousand ha new forests were

⁶FOREST EUROPE, 2020: State of Europe's Forests 2020. URL: <https://foresteurope.org/state-of-europes-forests/>

established in the last eight decades, and more than 202 thousand ha new forests have been established by 2023 since 1990.

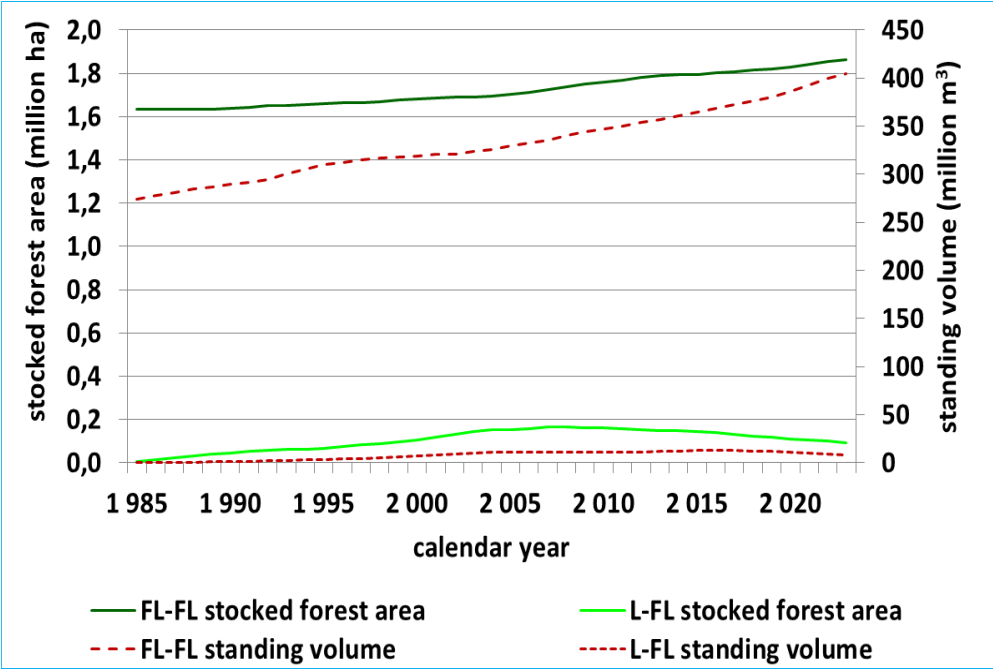


Figure 21. The development of the area and volume of stocked forests since 1985

Source: National Inventory Document of Hungary, 2025

The new forests have added much to the services of the forests, including their sink capacity. The annual sink of the biomass of the forests established since 1990 have been 1.0-1.2 million tCO₂ a year. Considering that the sink of the forests that existed already before 1990, which have ten times as large area than that of recent afforestations, have had only three-four times as much sink recently, one can see how effective afforestations can be to remove carbon from the air.

Also, there is not much pressure on our forests concerning deforestations. We have deforestations each year (Table 9), but both their area and the emissions from them are small and conversions can only occur in exceptional cases (such as building or roads or other infrastructure etc.).

Inventory year	Conversions from FL to other land use					
	Annual area (ha): AA _t		Cumulative area (ha) calculated as: AC _t = AC _{t-1} + AA _t - AA _{t-20}		CO ₂ emissions (ktCO ₂)	
	forest subcompartments	forest and other subcompartments	forest subcompartments	forest and other subcompartments	from biomass	from soils
1985	326	326	326	326	38	1
1990	613	613	2 243	2 243	63	4
1995	358	358	3 514	6 412	44	11
2000	719	1 187	5 898	10 586	71	18
2005	411	859	8 678	16 911	48	29
2010	208	2 351	8 467	22 667	26	38
2015	1 383	1 699	12 061	27 551	106	45
2020	1 191	1 503	19 220	37 593	123	61
2021	1 531	1 659	20 230	37 955	245	61
2022	1 225	1 225	20 817	37 323	114	60
2023	2 417	3 067	22 640	39 138	119	63

Table 9. The area of deforestations and resulting emissions from biomass cleared in Hungary in selected years

Source: National Inventory Document Hungary, 2025

No major changes have taken place in the ownership structure of the forests for the last decade. Most of the changes in the ownership structure have been due to afforestation, as by far the most new forests are established in the private sector., i.e., by private land owners. The share of private forests amounts to about 43%, whereas forests owned by local governments amount to 1%. Thus, most forests (56%) are still owned and managed by the state.

Most forests (approx. 59%) are classified as production forests. The share of protection forests is 40%, whereas forests serving predominantly social, touristic, educational and scientific purposes amount to 1%.

The sustainability of forest management in Hungary, as also demonstrated above (Figure 21.), has resulted in the fact that the stock volume of the Hungarian forests has continuously increased in the last several decades (from 257 million m³ in 1981 to over 412 million m³ in 2023). This increase is partly due to the fact that forests have been predominantly young, but partly also due to the continuing afforestation programmes, which have substantially increased forest resources since 1930 when they started. A third reason for the continuous increase of our forest resources is that for the last several decades, the wood increment of the forests has always topped the sum of all harvests and mortality (Figure 22.), i.e., the amount of harvests has only been some 60% of the current annual increment (CAI). Although the health monitoring of the forests indicates a slight increase in mortality and forest damages for the last three decades, the amount of salvage loggings (1995: 552 thousand m³; 2000: 427 thousand m³; 2005: 530 thousand m³; 2011: 393 thousand m³; 2015: 513 thousand m³ 2023: 233 thousand m³) has not shown any increasing (or decreasing) trend.

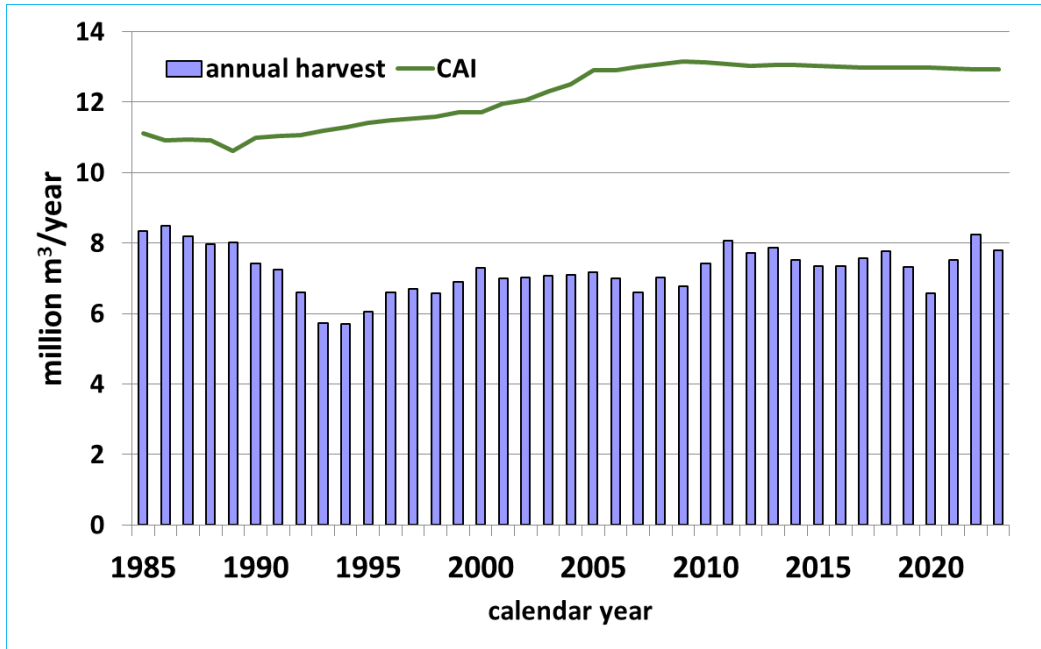


Figure 22. The total amount of annual harvest and the estimated current annual increment (CAI) over time in Hungary.

Source: National Inventory Document Hungary, 2025

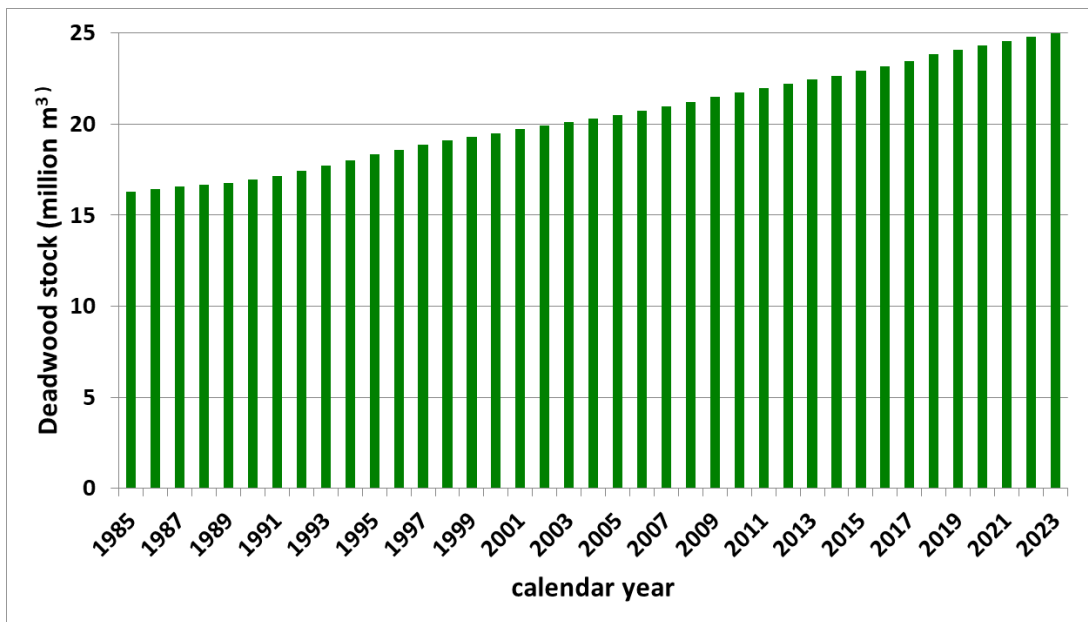


Figure 23. Deadwood stock

Source: National Forest Inventory

II.A.6.7. Waste

To describe situation of waste management, three basic indicators are used: the change in annual waste generated, the amount of municipal waste generated, and the amount of municipal waste landfilled are presented in respect of kg/person/year.

Over the past period the amount of the waste generated shows slight fluctuation in time series analysis and an increase on the long term, Municipal waste has increased slightly, with a parallel slight increase in the amount of municipal waste landfilled from 2021 onwards. The most significant displacement was the rate of the material recovery, which increased significantly.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Total waste (kt/year)	15167	14766	15731	15526	15453	17890	18233	19057	20154	20500	20431	19865
Change in waste from previous year	96,8	97,4	106,5	98,7	99,5	115,8	101,9	104,5	105,7	101,7	99,6	97,2
Generated of municipal waste kg/person/year	408	382	380	380	382	384	383	388	402	415	404	429
Disposed of by landfill of municipal waste kg/person/year	263	244	221	202	192	186	189	196	217	212	223	233

Table 10. Tendency of waste generation and relevant indicators, 2012-2023*

Source: Ministry of Energy EHIR

After the entry into force of Act CLXXXV of 2012 on Waste, the total amount of waste no longer includes the amount of municipal liquid waste.

Total waste and its main sectoral breakdown show relative stability over the period 2012-2015. Construction production has shown a steady increase since 2016, which has led to an increase in the amount of waste generated.

Possible cause of differences are analysed below via production volume of waste streams:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Agricultural and food industry waste	797	933	890	681	645	613	623	790	749	713	493	513
Industrial and other business waste	5 797	5 759	6 189	5 900	5818	5951	5965	5644	5307	5073	4516	4598
Construction and demolition waste	3 809	3 772	4 205	4 738	4718	6942	7240	8158	9543	9947	10840	10001
Hazardous waste	776	565	653	498	551	616	658	674	623	725	670	639
Municipal waste	3987	3 738	3795	3712	3721	3768	3746	3791	3931	4042	3911	4115

Table 11. Waste generated by source (ktons), 2012-2023

Source: Ministry of Energy EHIR

Based on time series analysis the amount of agricultural waste is changing in a significant way. The range of agricultural and food waste is wide, it includes the agricultural waste, the waste generated in the forestry sector, the waste of the hunting and fishing sectors, and also the waste of the food processing industries. Most of these wastes are biodegradable waste, but it also includes the waste generated in the processing technologies, which is not biodegradable waste (for instance sludge, preservative waste). The amount of the agricultural and food waste on the one hand depends on the size of the agricultural land in Hungary. On the other hand it depends on the size of the food processing capacities, and on the fact that over the past period, only a small part of the food by-products appears as waste.

The proportion of industrial and agricultural waste is more than a quarter of the total waste generated. The generated amount of this waste stream has typically stagnated and significantly decreased in the recent years.

Generated volume of construction and demolition waste reflect the industry's performance. Construction industry has expanded, partly due to infrastructural investments, partly due to home building programmes. There is 111% change in volume from 2015 to 2023 concerning the generated construction and demolition waste.

The amount of hazardous waste generated has stagnated overall in recent years. It can show smaller or greater differences in each year, so the deduction of long term conclusions is cannot be grounded solely by analyzing the quantity generated annually. It can be stated that the amount of hazardous waste generated in the country is 3-5% of the total amount of waste generated.

After a few years of stagnation, the amount of municipal waste generated has been slightly increased in recent years. According to our forecasts there is not expected a radical change in the amount of municipal waste generated.

	2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		2023	
	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%
Amount of waste (kt)	15167		14766		15731		15526		15453		17890		18233		19057		20154		20500		20431		19865	
Material recovery	6721	44	6561	44	8042	51	7776	50	7906	51,2	10365	57,9	11112	60,9	12443	65,3	13537	67,1	14054	68,6	14347	70,2	14203	71,5
Energy recovery (Incineration with energy recovery)	980	6	1191	8	1215	8	1211	8	1409	9,1	1617	9	1363	7,5	1044	5,5	1079	5,4	1136	5,5	1014	5,0	1099	5,5
Incineration	92	1	87	1	95	1	89	1	93	0,6	70	0,4	76	0,4	91	0,5	141	0,7	114	0,6	95	0,5	100	0,5
Disposal (Landfill)	6978	46	6426	44	5932	38	6257	40	5838	37,8	5445	30,4	5049	27,7	5310	27,9	4954	24,6	4928	24,0	4802	23,5	4276	24,5
Other	395	3	501	3	365	2	192	1	220	1,4	291	1,6	633	3,5	168	0,9	442	2,2	269	1,3	173	0,8	188	0,9

Table 12. Generation and treatment of wastes (without sludge) 2012-2023

Source: Ministry of Energy-HIR

Table 12 shows that a significant shift can be observed in the treatment of total waste in the recent years. The proportion of the landfilled waste has slightly decreased, whereas the amount of material recovery has increased.

The introduction of the mandatory door-to-door separate collection of household paper, metal and plastic waste in 2015 and the separate collection of green waste helped to reduce the amount of waste going to landfill and to increase recycling rates. In the treatment of waste, significant changes have occurred in the past years, the amount of waste material recovery has increased. In the treatment of waste, significant changes have occurred in the past years, the rate of waste material recovery has increased. Compared to the total amount in 2012, the amount recovered in its material was 44%, in 2023 this rate reached 71.5%. The amount of disposal decreased from 46% in 2012 to 24.5% by 2023. The decrease for disposal has been significantly affected by the introduction of the landfill tax by 1 January 2013. The amount of landfill tax is HUF 6 000/ton.

II.A.7. Institutional arrangements

II.A.7.1. Institutional arrangements for tracking progress

Institutional arrangements for tracking progress in the European Union

The EU's Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (Governance Regulation) established a governance mechanism and specific arrangements to track the progress of the Union and its Member States towards the implementation and achievement of the EU's climate and energy targets and commitments under the UNFCCC and the Paris Agreement. These arrangements include the monitoring of GHG emissions and removals, the reporting of policies and measures, projections of GHG emissions and removals and progress on adaptation to climate change.

Under the Governance Regulation, the EU has established a Union Inventory System to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of the data reported by the EU and its Member States. This inventory system includes a quality assurance and quality control programme, procedures for setting emission estimates, and comprehensive reviews of national inventory data to enable the assessment of compliance towards climate goals.

Each EU Member State compiles its GHG inventory in accordance with the requirements of the Paris Agreement and the relevant Intergovernmental Panel on Climate Change (IPCC) guidelines.

Inventory data on GHG emissions and removals, including information on methods, are submitted electronically using a reporting system managed by the European Environment Agency (EEA). The submitted data are subject to quality control procedures and feed into the compilation of the GHG inventory of the EU. Net GHG emissions, calculated from emissions and removals reported in the GHG inventory of the EU, are the key information used for tracking progress towards the EU NDC target of a least -55 % net emission reduction by 2030 compared to 1990.

Given the scope of the EU NDC related to international aviation and navigation, a specific share of international aviation and navigation emissions as reported in the GHG inventory data is calculated based on the Joint Research Centre's Integrated Database of the European Energy System (JRC-IDEES). Details on the methodology applied to identify GHG emissions from international aviation and navigation in the scope of the EU NDC, which are added to the national totals from the EU GHG inventory, are given in Annex 2 to this BTR.

Under the Governance Regulation each Member State must report to the Commission biennially on the status of implementation of its NECPs. This process allows the Commission to ensure that the EU and the Member States remain on track to achieve the climate-neutrality objective and progress on adaptation. Under the Governance Regulation, Member States further operate national systems for policies and measures and projections and submit and report standardised information, which is subject to quality and completeness checks. Based on the submitted data, the EEA compiles projections of GHG emissions and removals for the EU. The EU-wide

information is summarised annually in the Climate Action Progress Report by the European Commission and in the ‘Trends and projections’ report by the EEA. Both the Union and the national systems are subject to continuous improvements.

Institutional arrangements for tracking progress in Hungary

The national system is operated by the ministers responsible for the environment, energy policy, forest management, agricultural policy and national budget. The *Ministry of Energy* is responsible for energy and climate policy, environmental protection, waste management and water management. Within the Ministry of Energy, the Climate Policy Department plays a coordinating and supervisory role in the national system. The Head of Unit for International Climate Policy is the current UNFCCC and IPCC Focal Point of Hungary.

The *Ministry of Agriculture* is responsible for agricultural and forestry policy development and nature conservation. It also manages agriculture and rural development, as the second pillar of the Common Agricultural Policy (CAP) of the European Union, as well as the related research and development, while specifying short, medium and long-term goals.

The *Ministry of Construction and Transport* is responsible for transport-related measures in Hungary. It oversees transport infrastructure development, road and railway projects, and urban mobility planning. The ministry also manages strategic transport policies, ensuring alignment with EU regulations and sustainability goals while setting short, medium, and long-term objectives.

The Governmental Decree 278/2014. (XI. 14.) regulates the preparation of the national inventory reports and the procedure of the obligatory data provision necessary for the inventories. This decree designates the HungaroMet Hungarian Meteorological Service Nonprofit Ltd. (that took over the tasks of the Hungarian Meteorological Service that operated until 31 December 2023) as the main compiler institute. In addition, it formalizes the participation of the University of Sopron (that incorporates the former Forest Research Institute), the Hungarian National Land Centre (that has a Forestry Department), and the National Food Chain Safety Office in the inventory preparation process. The latter three institutes are responsible for the LULUCF sector.

HungaroMet as the national meteorological service provider is a 100 percent state owned nonprofit company. Its duties are specified in a Governmental Decree 547/2023 (XII.12.). These duties include, among others, the preparation of GHG and air pollutants emission inventories for the fulfilment of reporting obligations arising from international treaties. A greenhouse gas inventory division was already established in 2006 within the Meteorological Service for the preparation and development of the GHG inventory. The name of the division was changed to Unit of National Emissions Inventories in 2015 to reflect the fact that this unit is also responsible for the compilation of air pollutant emission reports. This division is responsible for most inventory-related tasks and compiles the greenhouse gas inventories and other reports with the involvement of external institutions and experts, partly on a contractual basis. Most parts of the inventory (energy, industrial processes, and waste) are prepared by the experts of the Unit of National Emissions Inventories themselves. The agriculture sector is prepared with the involvement of the Institute of Agricultural Economics Nonprofit Kft. (AKI).

The whole LULUCF sector is compiled by the institutes listed in the above-mentioned Governmental Decree 278/2014.

Regarding reporting requirements under Article 5 of the Kyoto Protocol, information is provided in the National Inventory Document (NID) of Hungary.⁷

II.A.7.2. Institutional arrangements for implementation of the NDC

Institutional arrangements for implementation of the NDC in the European Union

The EU and its Member States have set up a comprehensive system for the implementation of the EU climate change mitigation targets. The European Climate Law sets the goal of climate neutrality by 2050 and the intermediate target of reducing net greenhouse gas emissions by at least 55 % by 2030 compared to 1990 levels. These targets cover emissions and removals that are regulated in EU law.

To ensure that the EU and its Member States achieve their target, the 2030 Climate and Energy Framework was put in place. The main policies of this framework are the EU Emissions Trading System (EU ETS), which caps GHG emissions in energy, industry, aviation and maritime transport; the LULUCF Regulation which includes national net removal targets for the LULUCF sector; and the Effort Sharing Regulation (ESR) which establishes national reduction targets for GHG emissions not covered by the EU ETS or the LULUCF Regulation i.e. domestic transport (excluding aviation), buildings, agriculture, small industry and waste.. The legislative acts under the 2030 Climate and Energy Framework require the European Commission and the EU Member States to set up the institutional arrangements for implementing the specific policies and measures.

The revised EU ETS Directive increases the level of ambition in the existing system from 43 % to 62 % emissions reductions by 2030, compared to 2005 levels and extend the system to also apply to international maritime transport. The amended Effort Sharing Regulation (ESR) increased, for the sectors that it covers, the EU-level GHG emission reduction target from 29 % to 40 % by 2030, compared to 2005, which translates in updated 2030 targets for each Member State. The new LULUCF Regulation sets an overall EU-level objective of 310 Mt CO₂ equivalent of net removals in the LULUCF sector in 2030.

The ESR sets national targets for the reduction of GHG emissions in the Member States by 2030. Member States are also subject to gradually decreasing annual emission limits for each year from 2021 to 2030. The annual progress towards the national targets under the Effort Sharing Regulation is assessed by comparing GHG emission levels from the sectors covered by the ESR with the relevant annual emission allocations under the legislation (AEAs). To achieve compliance under the ESR, Member States are permitted to use flexibility options to a certain extent.

Progress in the implementation of these policies and measures is monitored under the Governance Regulation. Relevant information which is reported regularly and archived at the

⁷ Please find NID 2024 here: <https://unfccc.int/ghg-inventories-annex-i-parties/2024>

EEA include GHG inventories, approximated GHG inventories for the previous year, information on policies and measures, projections, and progress towards the implementation of the National Energy and Climate Plans - NECPs). This information helps the EU and its Member States to correct their course if progress towards the targets of the 2030 Climate and Energy Framework is behind schedule. As an example, the European Commission assesses the drafts of new or updated NECPs and provides recommendations for improved planning and implementation. In addition, the reported information is subject to quality checks, and the GHG inventories reported by EU Member States are subject to comprehensive reviews in 2025, 2027 and 2032.

All EU legislation, including the legislation under the 2030 Climate and Energy Framework, is subject to a stakeholder engagement process. So-called 'better regulation tools' ensure that policy is based on evidence and the best available practice. During the preparation of legislative proposals, the European Commission invites citizens, businesses and stakeholder organisations to provide their views on the subject of the new legislation. These comments are documented in a dedicated portal, and the European Commission reports on how it considers these comments in the development of the legislative proposals. Furthermore, the Governance Regulation sets requirements for Member States to ensure that the public is given early and effective opportunities to participate in the preparation of the NECPs.

Institutional arrangements for implementation of the NDC in Hungary

Hungary has established a comprehensive framework to implement its Nationally Determined Contribution (NDC) under the Paris Agreement, focusing on strategies outlined in its National Energy and Climate Plan (NECP) and the Second National Climate Change Strategy (NCCS-2)⁸. The energy sector is governed by the long-term National Energy Strategy for 2030 that has been amended to incorporate a vision for 2040 that focuses on clean, smart, and inexpensive energy while increasing energy independence and security and decarbonizing energy production. As laid down in the final updated NECP, Hungary intends to reduce its GHG emissions at least by 50 % compared to 1990 levels and to increase the share of renewable energy sources to at least 30 % within gross final energy consumption by 2030.

The NECP serves as a roadmap for Hungary's energy and climate objectives up to 2030, with a perspective extending to 2040. The plan emphasizes reducing greenhouse gas emissions, increasing the share of renewable energy sources, and improving energy efficiency. In response to evolving international dynamics, the NECP has been revised to further decrease emissions and elevate the proportion of renewables in the energy mix. These revisions aim to diminish Hungary's reliance on energy imports and advance its goals of climate neutrality and sustainability.

The updated NECP⁹, submitted to the European Commission in October 2024, outlines enhanced targets for emission reductions and green energy production, reinforcing Hungary's commitment to the European Union's climate objectives.

⁸ The NCCS-2 is available [here](#)

⁹ The final updated NECP of Hungary is available [here](#).

During the preparation of the updated NECP, **Hungary carried out wide-ranging professional and public consultations, as well as an international strategic environmental assessment**, in order to ensure that the NECP can be implemented with the support of the parties concerned. An abridged version of the draft updated NECP could be consulted in summer 2023, while its conciliation documentation and environmental assessment could be consulted in summer 2024 in an open public consultation. In addition, face-to-face discussions with NGOs and industry took place between May and June 2023 and from the beginning of July 2024. Among the neighbouring countries, Austria requested the results of the environmental assessment.

On 20 February 2024, representatives of Austria, Croatia, Italy, Slovenia and Hungary held a regional meeting in the Slovenian capital to discuss the progress of the NECPs and the opportunities for regional cooperation, with the participation of the European Commission. The discussions provided an opportunity to discuss the progress of the NECP update in the Member States and to get acquainted with the evolving plans of the Member States. Meetings of the coordination groups DG ENER and DG CLIMA regularly focus on reconciling a component of the NECP with the related tasks, challenges and opportunities for improvement, presenting them in the NECPs and mapping the planned policy measures.

The Ministry of Energy oversees the development and implementation of Hungary's energy and climate policies.

[The National Climate Protection Authority](#)

The National Climate Protection Authority (hereinafter "the Authority") is an autonomous department integrated into the Ministry of Energy, established as a result of the entirely redefined EU and international fluorinated greenhouse gas legislation.

The main tasks of the Authority in relation to F-gases are the following:

- Doing inspections and monitoring owners and operators of businesses and applications using F-gases.
- Verification of the accuracy and veracity of the data in the Climate Gas Database (typical types of cases: data reporting, leakage testing, leakage monitoring installation, verification of compliance with the obligation to keep records of climate gas movements).
- Carrying out on-site inspections.
- Liaising with EU bodies, in particular the Commission.
- Liaising with the various partner authorities - cooperation with the National Tax and Customs Administration (in order to ensure the efficient data flow for successful joint actions), and cooperation with other investigative authorities (prosecution, police).
- Contributing to the development of the professional approach, incorporating feedback from the sector into the legislative process.

- Carrying out the training and testing necessary for the performance of activities related to applications containing or operated with F-gases.

In 2022, the Authority conducted around 300 proceedings against companies involved in fluorinated greenhouse gas activities. The total amount of climate protection fines imposed in these proceedings was around HUF 30 million. The most common infringements are failure to comply with leakage testing obligations and recording incorrect data in the Climate Gas Database. The most serious infringement was an illegal refrigerant trade in spring 2022, a joint operation with the Counter Terrorism Centre and the Police.

The Authority is also responsible for the administration of EU Emission Trading System (ETS). Furthermore, from 2024, the Authority will be the designated competent authority in Hungary pursuant to Article 11 of Regulation (EU) No 2023/956 of the European Parliament and of the Council of 10 May 2023 establishing a mechanism to offset the carbon intensity of imported goods (CBAM Regulation).

The Authority is committed to continuing its efforts to serve Hungary's emission reduction targets in the coming years, with a view to keeping its customers up to date and promoting compliance.

II.B. Description of a Party’s nationally determined contribution under Article 4 of the Paris Agreement, including updates

Under their updated NDC, the EU and its Member States, acting jointly, are committed to a legally binding target of a domestic reduction of net greenhouse gas emissions by at least 55 % compared to 1990 by 2030¹⁰. The term ‘domestic’ means without the use of international credits.

The NDC consists of a single-year target, and the target type is ‘economy-wide absolute emission reduction’. The scope of the NDC covers the 27 Member States of the EU.

The 17 October 2023 updated NDC scope is supplemented by additional information to clarify the precise amount of international aviation and maritime emissions which are covered under the EU NDC. Details on the EU NDC can be found in Table 13. and in Annex 1.

Information	Description
Target and description	Economy-wide net domestic reduction of at least 55 % in greenhouse gas emissions by 2030 compared to 1990. The term ‘domestic’ means without the use of international credits.

¹⁰ The update of the Nationally Determined Contribution of the European Union and its Member States is available [here](#)

Target type	Economy-wide absolute emission reduction
Target year	2030 (single-year target)
Base year	1990
Base year value	Net greenhouse gas emissions level in 1990: 4,699,405 kt CO ₂ e
Implementation period	2021-2030
Geographical scope	EU Member States: Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, the Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland and Sweden
Sectors	Sectors as contained in Annex I to decision 5/CMA.3: Energy, Industrial processes and product use, Agriculture, Land Use, Land Use Change and Forestry (LULUCF), Waste.
	International Aviation: Emissions from civil aviation activities as set out for 2030 in Annex I to the EU ETS Directive are included only in respect of CO ₂ emissions from flights subject to effective carbon pricing through the EU ETS. With respect to the geographical scope of the NDC these comprise emissions in 2024-26 from flights between the EU Member States and departing flights to Norway, Iceland, Switzerland and the United Kingdom.
	International maritime Navigation: waterborne maritime navigation is included in respect of CO ₂ , methane (CH ₄) and nitrous oxide (N ₂ O) emissions from maritime transport voyages between the EU Member States.
Gases	Carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF ₆), nitrogen trifluoride (NF ₃)

LULUCF categories and pools	The included LULUCF categories and pools are as defined in decision 5/CMA.3.
Intention to use cooperative approaches	The EU's at least 55 % net reduction target by 2030 is to be achieved through domestic measures only, without contribution from international credits.
	The EU will account and report for cooperation with other Parties in a manner consistent with the guidance adopted by CMA1 and any further guidance agreed by the CMA.
Any updates or clarifications of previously reported information, as applicable	The information on the NDC scope contains clarifications/further details compared to the information provided in the updated NDC of the EU.

Table 13.

Source: Updated NDC of the EU

II.C. Information necessary to track progress made in implementing and achieving nationally determined contributions under Article 4 of the Paris Agreement

II.C.1. Indicator

For the tracking progress towards implementing and achieving the NDC of the EU, an indicator is used which has the same unit and metric as the NDC base year and target values. The chosen indicator is 'annual total net GHG emissions consistent with the scope of the NDC in CO_{2e}'. Table 14 provides more information on this indicator.

Information	Description
Selected indicator	Annual total net GHG emissions consistent with the scope of the NDC in CO _{2e} .
Reference level and base year	The reference level is total net GHG emissions of the EU in the base year (1990). The reference level value for the EU is 4,699,405 kt CO _{2e} .
Updates	This is the first time the reference level is reported, hence there are no updates. The value of the reference level may be updated in the future due to methodological improvements to the EU GHG inventory and to the determination of

	international aviation and navigation emissions in the NDC scope.
Relation to the NDC	The indicator is defined in the same unit and metric as the target of the NDC. Hence it can be used directly for tracking progress in implementing and achieving the NDC target.
Definitions	<p>Definition of the indicator ‘annual total net GHG emissions in CO₂e:</p> <p>Total net GHG emissions correspond to the annual total of emissions and removals reported in CO₂ equivalents in the latest GHG inventory of the EU. The totals comprise all sectors and gases listed in the table entitled ‘Reporting format for the description of a Party’s nationally determined contribution under Article 4 of the Paris Agreement, including updates.’ Indirect CO₂ emissions are included from those Member States that report these emissions.</p>

Table 14. Description of the indicator

II.C.2. Methodologies and accounting approach

The EU and its Member States use the following accounting approach for tracking progress towards the joint EU NDC: annual GHG data from the national GHG inventory of the EU, complemented for international aviation and navigation with estimations from the Joint Research Centre’s Integrated Database of the European Energy System. The total net GHG emissions are provided in the scope of the EU NDC and are compared to the economy-wide absolute emission reduction target as defined in the NDC. The EU will account for its cooperation with other Parties in a manner consistent with guidance adopted by the CMA.

As far as emissions and removals from the LULUCF sector are concerned, net emissions are used for tracking progress towards the 2030 target of the NDC based on all reported emissions and removals.

II.C.3. Structured summary – status of progress

An important purpose of the BTR is to demonstrate where the EU and its Member States stand in implementing their NDC, and which progress they have made towards achieving it. The most recent information on GHG emissions and removals in the scope of the NDC constitutes the key information for tracking this progress. Table 15 summarises the current status of progress.

Total net GHG emissions	Unit	Base year value	Values in the implementation period			Target level	Target year	Progress made towards the NDC
			2021	2022	2030			

consistent with the scope of the NDC	the EU	kt CO _{2e}	4,699,405	3,272,650	3,205,223	NA	(at least 55 % below base year level)	2030	The most recent level of the indicator is 31.8 % below the base year level
--------------------------------------	--------	---------------------	-----------	-----------	-----------	----	---------------------------------------	------	--

Table 15. Status of progress in implementing the EU NDC

Based on the GHG inventory data and data on international aviation and navigation for 2022, the EU and its Member States reduced net GHG emissions by 31.8 % compared to 1990. The EU and its Member States made progress towards implementing and achieving their NDC. The legal and institutional framework is in place to make further progress in the years ahead and to achieve the NDC target by 2030.

II.D. Mitigation policies and measures, actions and plans, including those with mitigation co-benefits resulting from adaptation actions and economic diversification plans, related to implementing and achieving a nationally determined contribution under Article 4 of the Paris Agreement

II.D.1. Policy-making process

II.D.1.1. European Union framework

2050 EU climate target

The EU’s long-term climate objective is to reach climate neutrality by 2050. This target was adopted by the European Council in December 2019, forms a part of the EU long-term strategy submitted for the UNFCCC, and is legally binding due to the adaptation of (EU) 2021/1119 Regulation (‘European Climate Law’).

2030 EU climate target

In October 2014, the European Council adopted the EU’s climate and energy target for 2030. Based thereon, the EU has adopted a series of climate- and energy-related legal acts between 2015 and 2020. These prescribe the following key targets for 2030:

- At least gross 40% cuts in greenhouse gas emissions (from 1990 levels) – this served as the EU’s Intended Nationally Determined Contribution under the Paris Agreement in 2015,
- At least 32% share for renewable energy,
- At least a 32.5% improvement in energy efficiency.

The EU’s 2030 climate ambition was raised by the December 2020 European Council conclusions and the adoption of (EU) 2021/1119 Regulation (‘European Climate Law’) which entered into force in July 2021. The new 2030 climate target is at least 55% reduction of the net EU greenhouse gas emissions compared to 1990, where only 225 million tCO₂e sink can be taken into account. The at least net 55% reduction target was submitted to the UNFCCC as the EU’s Nationally Determined Contribution under the Paris Agreement in December 2020. The process of updating the EU’s climate and energy legislation to the new target was started on the 14th of July 2021 when the European Commission published its proposals in a package titled ‘Fit for 55’. The legislative process of adopting these legal acts is still ongoing, so at the moment most legislation in force still belongs to the previous, gross 40% target.

The 2030 EU climate target is divided into three pillars – all of which are under revision at the moment to increase their ambition:

- EU Emissions Trading System (EU ETS) an EU-wide harmonized scheme covering large emitters, which currently covers around 40% of gross EU emissions. As in effect, it shall reach a 43% emission reduction by 2030 compared to 2005.
- Effort Sharing Regulation (ESR), which covers most gross emissions out of the scope of the EU ETS like buildings, transport, agriculture, waste management etc., and prescribes legally binding targets for Member States. This covers around 60% of gross EU emissions. As in effect, it shall reach a 30% emission reduction by 2030 compared to 2005.
- Land Use, Land Use Change and Forestry: as in effect, it ensures the fulfillment of a ‘no-debit rule’.

II.D.1.2. National framework

Hungary’s mitigation actions, as a member state of the European Union, are determined primarily by the policies and regulations of the EU. Therefore, Hungary has also deposited its ratification documents concerning the Kyoto Protocol (including its Doha Amendment), the Paris Agreement under the Convention and the Kigali Amendment of the Montreal Protocol aiming for the reduction of emissions of F-gases.

Rules for the implementation of the Kyoto Protocol and the mitigation of F-gases are ruled by 2007 Climate Change Act (no. LX). The EU ETS and ESD policies were transposed by the law on emission trading (CCXVII. of 2012).

Furthermore, Hungary, as an EU Member State, fulfills its commitments for 2030 and 2050 jointly with the whole EU. The **Emissions Trading System (EU ETS)** and Effort Sharing

Decision (ESD)¹¹ policies of the EU, serving this purpose, were transposed to the national law by the act on emission trading (CCXVII of 2012). Concerning the EU ETS, it should be noted that since the start of 2013, the system works in an EU-wide harmonized manner. Therefore, Hungarian authorities are bound by the EU law in the operation of the system, including auctioning and free allocation of emission allowances (the latter used to be carried out via adopting national allocation plans before 2013).

Directive 2003/87/EC is transposed by Law 2012/217 which defines the National Emission Trading Registry (2§ 7.) as the registry system defined by Article 4 of Regulation 389/2013/EU, and the National Administrator (2§ 25.) as defined by Article 3 (22) of Regulation 389/2013/EU. Governmental decree 410/2012 is an implementing regulation of Law 2012/217 (government is mandated to establish the implementing regulation by 39§ 1. g. of Law 2012/217). Decree 410/2012 nominates NCPA as the National Administrator of the Hungarian Emission Trading Registry, serving as the EU-ETS and the KP registry. Separate Ministry of Energy (responsible for climate and environmental protection) has been created on the 1st of December 2022.

National Climate Change Strategy

The 2007 Climate Change Act (no. LX) provides a mandate for the Government to develop a strategy on climate change in Hungary. In 2008, the First National Climate Change Strategy for 2008-2025 (NCCS-1) has been developed, reviewed in 2013. Later, the second National Climate Change Strategy (NCCS-2) for 2014-2025 has been elaborated, but after the adoption of the Paris Agreement, NCCS-2 has been updated again. The updated NCCS-2 for 2018-2030 (NCCS-2) was published and opened to public consultation in the spring of 2017. It was adopted by the Government and submitted to the Parliament in May 2017.

The NCCS-2 includes:

- analysis of the expected effects of climate change in Hungary, its natural and socioeconomic consequences and the climate vulnerability of ecosystems and sectors;
- a Hungarian **Decarbonisation Roadmap** on the transition into a competitive, low carbon economy until 2050 and comprising the goals, priorities and action lines of the reduction of greenhouse gas emission, considering the strategic documents of similar timescale of the European Commission;
- a **strategic framework for national adaptation**, with special regard to the prevention and risks and mitigation of damage related to climate change and climate security; the strategic framework is supported by the National Adaptation Geoinformatics System and the results of the territorial and sectoral climate vulnerability studies based on that;
- a target system of **awareness-raising** activities to prevent the climate change and to prepare and adapt to the climate change.

¹¹ Its successor, the Effort Sharing Regulation (ESR), covers the years from 2021 up to 2030.

National Environmental Programme until 2026 (NEP-V)

The National Environmental Programme (NEP) is the comprehensive strategy of environmental issues in Hungary. The Programme is consistent with the 8th Environmental Action Programme of the European Union, and closely linked to the National Framework Strategy on Sustainable Development approved by the Hungarian Parliament. The recent National Environmental Programme (NEP-V) was adopted by the Parliament in 2022 (Resolution of the Parliament 62/2022 (XII. 9) OGY), and aims to improve the environmental condition in order to protect the health and quality of life of families and communities in Hungary, and to contribute to the assurance of environmental conditions of sustainable development.

It also ensures the continuation of the tasks started earlier and also takes into account the new international and EU objectives, for example to; (1) improve the quality of life and the environmental conditions of human health, reducing the effects of environmental pressure, (2) protect and recover the natural values and resources and their sustainable use, (3) improve resource efficiency and making steps toward a green and circular economy, (4) improve environmental safety and (5) society's environmental awareness, and to (6) strengthen the ability to adapt to climate change.

II.D.2. Policies and measures and their effects

The following section will summarize key national strategic documents and cross-sectoral regulations that influence greenhouse gas (GHG) emission reductions and climate protection efforts. All listed projects started in 2020 or earlier, and are currently ongoing. The objectives and categorization of each initiative will be detailed in the sector breakdown. Planned, adopted, and implemented policies and measures are also included in EXCEL TABLE 5.

II.D.2.1. Cross sectoral policies

Law on Climate Protection

Hungary has set a climate neutrality goal for 2050. The Law no. XLIV 2020 on Climate Protection, also set out a reduction of GHG emissions by at least 40% by 2030 compared to the 1990 levels. From 2030, in the case of final energy consumption going beyond 2005 levels, the increased consumption will be provided from carbon neutral energy sources. By 2030, the share of renewable energy sources in the gross final energy consumption should be at least 21%.

It aims to help to achieve the:

- Member State's binding national target for greenhouse gas emissions and the annual binding national limits pursuant to Regulation (EU) 2018/842 (Decarbonisation: GHG emissions and removals),
- with the binding target of at least 42% renewable energy in 2030 as referred to in Article 3 of Directive (EU) 2018/2001 (Decarbonisation: Renewable energy),
- the indicative national energy efficiency contribution to achieving the Union's final energy consumption target of at least -11,7 %.

- Other national objectives, including long-term targets or strategies and sectoral targets, and national objectives in areas such as energy efficiency in the transport sector and with regard to heating and cooling (Energy efficiency);
- National objectives with regard to addressing constrained or interrupted supply of an energy source, for the purpose of improving the resilience of regional and national energy systems (Energy security);
- National objectives related to other aspects of the internal energy market such as; increasing system flexibility - in particular related to the promotion of competitively determined electricity prices in line with relevant sectoral law-, market integration and coupling; aimed at increasing the tradeable capacity of existing interconnectors, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment, and real-time price signals (Internal energy market).

National Energy Strategy 2030

Timeline: 2020-2030

The second National Climate Change Strategy published in 2020 relates to the 2018-2030 period, and is a comprehensive policy document of the energy sector, which sets climate objectives until 2030. The main goal of the strategy is to provide clean, smart and affordable energy, and contains of the National Decarbonisation Road Map, the National Adaptation Strategy and the ‘Climate Partnership’ Awareness Raising Plan. It describes the planned measures in 6 flagship projects: 1. Climate friendly, flexible electricity production, 2. Improving the energy efficiency of the economy, 3. Transport greening, 4. Energy-conscious and modern Hungarian homes, 5. Energy innovation projects, 6. Program to establish an energy and climate-conscious society. Since this is a framework strategy, consecutive 3-year Action Plans – to be approved in the future – will specify the concrete measures. It aims to help to achieve the same binding targets as the Law of Climate Protection.

National Air Pollution Reduction Program

Timeline: 2024-2030

The National Air Pollution Control Programme (NAPCP) (Article 6 of Directive (EU) 2016/2284 – ‘the NEC Directive’) is the main governance instrument by which EU Member States must ensure that the emission reduction commitments for 2020-2029 and 2030 onwards are met. The strategic goal is to maintain ambient air quality where it is good and to improve it where it is not appropriate. It covers all emissions sectors.

The air pollution reduction goals and measures of the National Energy and Climate Plan (NECP) are often related, providing the opportunity to identify these measures: the two program’s goals could strengthen each other’s.

The NAPCP has a Subprogram for the agricultural sector which contains measures to reduce ammonia emission (in Hungary ca. 92% of the ammonia emission comes from the agricultural sector). In the Subprogram, there are measures concerning manure treatment, storage, and

application on animal farms and on the field as well. Furthermore, it contains regulations related to reduction of chemical fertilizers to prevent air pollution and nutrient loss. These measures contribute to the reduction of GHG emissions (CH₄, N₂O) from fertilizer usage, too.

National Energy and Climate Plan (NECP)

Re-submitted: 2024

The 2024 National Energy and Climate Plan, updated within the framework of integrated planning, covers the decarbonization, energy efficiency, energy security, internal energy market, and research, innovation and competitiveness dimensions of the Energy Union.

The most important objective of the NECP is to strengthen energy sovereignty and energy security, as well as decarbonization, while maintaining public support. The security of energy supply and increasing energy sovereignty have become a matter of national security, so reducing energy import dependence is a key energy policy issue. Hungary aims to have the largest part of Hungarian electricity production come from two sources: nuclear energy and renewable energy, the latter primarily from solar power plants in accordance with domestic conditions. These are not mutually exclusive, but rather mutually supportive solutions, and both can be considered clean energy sources.

Objectives in numbers:

- Reduce gross GHG emissions of Hungary by 50% until 2030 compared to 1990 levels (47,5 million tonnes CO₂e);
- Increase the share of renewables in gross final energy consumption to 30% by 2030, from 14% in 2021.
- Ensure that the country's final energy consumption does not exceed 740 PJ in 2030;
- Reduction of natural gas import through the transition to alternative heating solutions in residential buildings (appr. 2 billion m³ reduction per year);
- Increase the share of electricity interconnections to around 60% by 2030 (mandatory level according to EU obligations: 15%).

National Clean Development Strategy

Timeline: 2021-2050

As Hungary's long-term strategy, it presents the roadmap, sets out targets and principles to reduce gross GHG emissions by 95% by 2050 compared to the 1990 level, according to Regulation (EU) No. 2018/1999 and the Paris Agreement promulgated in Act L of 2016.

The final version of the Strategy, - which was submitted to the UNFCCC in September 2021 -, includes the following elements compared to the previous draft: (1) in-depth modeling to assess the complex interlinkages between sectors, (2) low-carbon, economy-wide, and sectoral scenarios, (3) analysis of their costs and impacts on the economy.

EU Emissions Trading System (EU ETS)

Implemented: 2005

The EU Emissions Trading System (EU ETS) has been a crucial part of EU climate policy since 2005. Its current framework aims to reduce emissions from significant sources of greenhouse gases, in the energy and industry sector, including power plants above a certain size, district heating systems, manufacturing facilities, aviation, and, starting in 2024, maritime transport. The goal is to ensure that emission reductions also generate revenue for the participating installations. To comply with the system, participants must cover their emissions with allowances. Some allowances are allocated for free by national enforcement authorities, while others must be purchased on the stock exchange or secondary market. The sale of these allowances on the European Energy Exchange generates between HUF 100 and 200 billion for Hungary each year.

Carbon Border Adjustment Mechanism (CBAM)

Implemented: 2023

The Carbon Border Adjustment Mechanism (CBAM) is a new climate policy tool introduced by the European Union as part of the Fit for 55 package. Its primary goal is to reduce the risk of carbon leakage in a WTO compatible way, continue international cooperation and outreach to partners to lower carbon emissions in production processes.

Reduction of emissions in the non-ETS area / Effort Sharing Regulation (ESR)

Adopted: 2018, 2023 According to the EU Effort Sharing Regulation (2023/857/EU), each Member State is required to contribute to the joint emission reduction goals established for the period between 2021 and 2030. These contributions are part of the overall EU target. Annually, GHG emissions from non-ETS sectors—such as transport, agriculture, waste, buildings, and industries outside the EU ETS—are verified by the EU for each Member State. Each country is then required to account for these emissions against its allocated annual limits for allowances, known as AEA units. Hungary must achieve an 18.7% reduction in sectors not covered by the EU Emissions Trading System (ETS)—including buildings, transport, agriculture, waste, and small industrial installations—by 2030 compared to 2005 levels.

II.D.2.2. Energy

European Union policies

Hungary's energy efficiency policies are guided by several EU regulations and directives. The Directive on Energy End-use Efficiency and Energy Services (2006/32/EC) seeks to encourage energy efficiency through the development of a market for energy services and the delivery of energy efficiency programmes and measures to end-users. The Directive requires member countries to create action plans and meet an indicative target to reduce final energy use in the sectors outside of the EU ETS by 9% from the early 2000s to 2016. The EU has also adopted a

non-binding target for 2020 to reduce primary energy use in the Union by 20% from baseline projections. The Directive also sets the framework for measures such as financing, metering, billing, promotion of energy services, and obligations for the public sector. In addition, it requires member countries to place energy efficiency obligations on energy distributors or retailers.

The revised Energy Efficiency Directive (EU/2023/1791) significantly raises the EU's ambition on energy efficiency. It establishes 'energy efficiency first' as a fundamental principle of EU energy policy, giving it legal-standing for the first time. In practical terms, this means that energy efficiency must be considered by EU countries in all relevant policy and major investment decisions taken in the energy and non-energy sectors. The 2023 revision of the directive follows a proposal for a recast directive on energy efficiency put forward by the Commission in July 2021, as part of the EU Green Deal package. Full implementation of the Energy Efficiency Directive will be key for the EU to comply with the commitment of the Global Pledge to double the global rate of energy efficiency improvements by 2030.

The Directive on the Energy Performance of Buildings (EPBD, 2002/91/EC) sets requirements for energy efficiency in building codes, including minimum energy performance standards and energy certificates. A recast of the EPBD (2010/31/EU) was adopted in May 2010 to strengthen the energy performance requirements and to clarify and streamline some provisions.

Requirements for energy labelling of household appliances are based on several directives adopted over the past 15 years which also include compulsory minimum energy efficiency requirements (2009/125/EC). The recast Directive Establishing a Framework for Setting Ecodesign Requirements for Energy-related Products (Ecodesign, 2009/125/EC) aims to improve energy efficiency throughout a product's lifecycle. It applies to products that use energy and to products that have an impact on energy use, such as building components.

Aiming to achieve a fully decarbonised building stock by 2050, the Energy Performance of Buildings Directive contributes directly to the EU's energy and climate goals. The revised Energy Performance of Buildings Directive (EU/2024/1275) entered into force in all EU countries on 28 May 2024 and helps increase the rate of renovation in the EU, particularly for the worst-performing buildings in each country. It also supports better air quality, the digitalisation of energy systems for buildings and the roll-out of infrastructure for sustainable mobility. Recognising the differences across EU countries in factors such as the existing building stock, geography and climate, the directive allows governments to decide on the renovation measures best-suited to their specific national context. Countries can also exempt various categories of buildings from the rules including historical buildings and holiday homes. Crucially, the revised directive facilitates more targeted financing to investments in the building sector, complementing other EU instruments and fighting energy poverty by supporting vulnerable consumers. EU countries also must ensure that there are safeguards for tenants, such as through rent support or caps on rent increases.

The Hungarian Long-Term Renovation Strategy objective is to achieve a renovation rate of 3% per year for the total housing stock by 2030. This will reduce the total energy consumption of residential buildings and CO₂ emissions by about 20%. Over the same period, the objective is to reinforce the renovation rate for public buildings at 5% per year. If this is gradually achieved, the total energy consumption of public buildings and CO₂ emissions can be reduced by 18%.

The aim is to achieve a higher proportion of buildings reaching or approaching the level of nearly zero energy buildings. The target is to reach 90% of near-zero energy buildings by 2050. This can be achieved by deep renovation of the existing building stock. As this implies a significant cost for the owner, it is necessary to create the possibility for phased renovation.

As for the revision of regulation on CO2 emissions standards for cars and vans (EU) 2019/631, the Commission is proposing to significantly tighten the carbon dioxide emission limits for new passenger cars and light commercial vehicles, encouraging the uptake of electric vehicles. New passenger cars will be allowed to emit 55% less carbon dioxide than the 2021 reference target from 2030 (instead of 37.5% today) and 100% less in 2035. New light-duty trucks will be allowed to emit 50% less carbon dioxide from 2030 (instead of 31% today) and 100% less in 2035 compared to their 2021 baseline, i.e. no carbon dioxide at all. Under the proposed legislation, taking into account the neutrality of the technology, only zero emission vehicles would effectively be allowed on the EU market from 2035, so the Commission envisages that new passenger cars and light commercial vehicles powered by internal combustion engines will have to be phased out of the EU market by that date. Another EU transport development is related to tire labeling requirements. Regulation (EU) 2020/740 seeks to harmonize information on the energy performance of tires, wet braking and external rolling noise. It will apply to EU member countries from May 2020.

Within the framework for the Energy saving programme for public buildings, starting from 2017, all public institutions must register their energy consumption and report it to the offices of the National Energy Efficiency Advisory Network and, at the same time, they must prepare energy saving plans and report annually on their implementation. An awareness-raising campaign is also needed to be launched targeting the employees of public institutions.

From 1 January 2018, buildings after renovation have to meet the following requirements as per the New requirements on energy performance of buildings: maximum 110-140 kWh/m² for residential buildings, maximum 132-160 kWh/m² for commercial and office buildings and maximum 90-150 kWh/m² for educational buildings, where new requirements are defined in terms of the heat transfer of the outer delimiters (U-value), the building engineering systems and the energy certificates of buildings.

[Establishment of the National Energy Efficiency Advisory Network](#)

Adopted: 2017

The National Energy Efficiency Advisory Network was established in 2017 and consists of 76 offices within the institutional framework of County Government Offices and District Offices. Their tasks, among others, are: to collect and monitor energy consumption data of municipal and state-owned public buildings; to provide assistance in awareness-raising activities targeting the users of municipal public buildings; to support the preparation and development of energy-saving action plans of municipalities and public institutions; to contribute to the conclusion of energy supply contracts and to provide free energy consultation and advice for SMEs.

Mandatory energy audit

Adopted: 2015

According to Directive 2012/27/EU on Energy Efficiency, since 2015 it has been obligatory for non-SME enterprises to have an energy audit every 4 years (or to operate an energy management system).

Mandatory employment of an energy rapporteur

Adopted: 2015

Since 1 January 2017 for enterprises and other institutions with high energy consumption, (where the annual energy consumption is higher than 400 000 kWh electricity or 100 000 m³ natural gas or 3 400 GJ heat energy), it is compulsory to employ an independent energy expert. The main task of the energy expert is to promote the introduction of energy-efficient approaches and behaviors within the operation and decision-making of the organization.

Operating aid for the production of renewable energy (METÁR)

Timeline: 2017-2026

The METÁR (Hungarian support scheme for renewable electricity) system was introduced on January 1, 2017. Important elements of the new system are that in the premium system the producer sells the electricity himself and receives the aid above the market reference price. Producers must bear the costs of deviating from the schedule. At present, support for new investment in METÁR can only be applied for in the form of a green premium-type entitlement awarded through a tender procedure. From 2017, a total of five lenders could be used to support renewable energy production. However, renewable energies are weather-dependent, so there is also a need to install storage capacities to help balance the amount of electricity available. That is why the fifth call, in March 2022, specifically supported the installation of renewable energy power plants with battery-powered energy storage.

Furthermore, the METÁR support scheme includes a so-called brown premium which was introduced in 2017 to incentivize the maintenance of electricity production from existing biomass or biogas power plants, these existing plants are benefiting from operating aid under the scheme.

Expansion of the Paks Nuclear Power Plant

Timeline: 2022-2032

In line with the National Energy Strategy, two new 1200 MW units will be added to the Paks Nuclear Power Plant. The new blocks could enter the system around 2030. The 4 units currently in operation (total power of 2006 MW) were expected to shutdown in 2032, 2034, 2036 and 2037.

In addition to supporting the newly built Paks II. Nuclear Power Plant investment (with the issued permits, the project's second authorization conditions for entering the construction phase were met), the Hungarian Government decided in the summer of 2022 to extend the operating time of the four units of the Paks Nuclear Power Plant, a decision confirmed by the Parliament's decision with a large majority. The lifetime of the Nuclear Power Plant can be extended by another 10-20 years.

LIFE-IP North-HU-Trans project

Timeline: 2019-2029

The LIFE-IP North-HU-Trans integrated project, part of the "Programme for the Environment and Climate Action (LIFE)," aims to enhance the successful implementation of the Hungarian National Energy and Climate Plan (NECP). It focuses specifically on the decarbonization and the sustainable, equitable transition of the Mátra Power Plant and its surrounding region. The LIFE-IP (LIFE Integrated Project) project type was introduced in 2014. In the 2014-2020 period Hungary – as all Member States – had an indicative national allocation of 3 LIFE-IPs, which the country has used successfully and managed to receive co-financing for 3 IPs, (1 in Nature, 1 in Environment and 1 in Climate Action). Within the 2021-2027 LIFE programme, IPs will be called Strategic Integrated Projects with the same scope and objective. The project has a planned budget of about HUF 6 billion.

Detailed¹² project objectives:

- ***Decarbonisation, GHG emission reduction:*** Roadmap for the gradual phase-out of MPP's lignite-fired units.
- ***Develop, test and evaluate renewable-based and innovative flexibility solutions at the post-mining sites.***
- ***Capacity-building*** – recruitment and training of decarbonisation and coal phase-out experts.
- ***Sustainable and just transition for lignite-sector employees:*** contribution to the Territorial Just Transition Plans of Heves and Borsod-Abaúj-Zemplén counties, complex training programmes for MPP workers.
- ***Recultivation of post-mining sites:*** repurposing of the post-mining sites for sustainable (preferably touristic and outdoor sports) use.
- ***Mobilization of complementary funds*** – for the region and Hungary and for the implementation of decarbonisation measures.
- ***Assessment and removal of legal barriers – creating a favourable regulation environment for the full implementation of the NECP:*** establishment of a national Coal Commission, establishment of an NECP Working Group within the Ministry for Technology and Industry.

¹² [Igazságos Átmenetért LIFE-IP North-HU-Trans hivatalos honlapja Introduction](#)

- ***Economic diversification in the post-coal region:*** mitigating the negative social effects of decarbonisation, supporting the transition of enterprises currently dependent on lignite sector.
- ***Reduction of energy poverty in the (low-income) households using lignite for heating:*** assessing resilience and emissions of households, implementation of energy efficiency and energy community measures.
- ***Greening public transport in the region and preparing for nation-wide replication.***
- ***Dissemination of results, awareness-raising and knowledge sharing:*** Replication Strategy, Best Practice Toolkit, workshops and conferences.

One of the special features of the project is the Coal Commission; the first permanent consultative forum on coal transition in Hungary. Its mission is to support the decarbonisation of MVM Máttra Energia Zrt. and lignite-based electricity production and the sustainable and equitable transition of the North Hungarian region, involving all relevant organisations.¹³

Renewable-based electricity production Program

Timeline: 2023-2029

It not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Renewable heat production Program

Timeline: 2023-2029

Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Development of the geothermal regulatory framework

Timeline: 2023-2026

¹³ <https://igazsagosatmenet.eu/>

The reform measure will evaluate and review the existing regulatory framework to ensure transparent and competitive regulation for the exploitation of geothermal energy resources. The REPowerEU chapter enhances the Recovery and Resilience Plan by incorporating essential reform measures. Most of these measures are legal adjustments related to electricity consumption and production, designed to effectively address domestic needs and the increasing use of renewable energy.

Supporting the use of renewable energy in bio-economy

Timeline: 2014-2025

The goal is to facilitate the supply and use of renewable energy sources, by-products, waste, residues, and other non-food raw materials for the bio-economy. Also, by promoting resource efficiency and supporting the shift towards a low-carbon and climate-resilient economy in the agriculture, food, and forestry sectors, we can reduce GHG emissions.

Developing a strategy for biogas/biomethane

Timeline: 2023-2026

The REPowerEU chapter enhances the Recovery and Resilience Plan by incorporating essential reform measures. Most of these measures are legal adjustments related to electricity consumption and production, designed to effectively address domestic needs and the increasing use of renewable energy. In this project, we aim to prepare a strategy document for biogas and biomethane by exploring the availability of feedstock and potential uses of biogas and biomethane.

National Hydrogen Strategy

Timeline: 2021-2030

Hungary's National Hydrogen Strategy (accepted in 2022) is ambitious but provides a realistic vision of the future as it opens the way for the establishment of a hydrogen economy, therefore contributing to the achievement of decarbonization goals and providing an opportunity for Hungary to become an active participant of the European hydrogen sector. Supporting the creation of sustainable and environmentally friendly transport and industry. Hydrogen will support the decarbonization of the hard-to-abate industry and heavy-duty transport.

Ensuring the legal framework for hydrogen

Timeline: 2023-2026

Enactment of a legislative amendment to support which, - in collaboration with stakeholders, - it is necessary to assess relevant legislation and identify barriers to the development of the hydrogen ecosystem. The REPowerEU chapter enhances the Recovery and Resilience Plan by incorporating essential reform measures. Most of these measures are legal adjustments related

to electricity consumption and production, designed to effectively address domestic needs and the increasing use of renewable energy.

Promotion of the use of Hydrogen Program

Timeline: 2023-2029

Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but also supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility. The elements of the program (planned measures) will help to reduce energy use and GHG emissions and contribute to an increase in renewable energy use.

Review and development of energy efficiency regulations

Timeline: 2023-2026

The development of energy efficiency regulation is necessary in order to implement the provisions of the new EED (Energy Efficiency Directive) and to increase energy efficiency. The reform improves energy efficiency, will help to reduce energy consumption, contribute to an increase in share of renewable energy and will help to reduce GHG emissions.

Energy efficiency for companies Program

Timeline: 2023-2029

Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems, but supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Within the framework of the Modern Cities Programme, energy efficiency-improving measures implemented with budgetary support

Timeline: 2015-2025

The target group of the Modern Cities Program, announced in 2015, is the 23 cities with county status, with which the agreements were signed in 2017. The program aims to support the implementation of large, complex investments of regional significance, whose development

goals could be determined by the persons concerned - the cities themselves - according to their own needs. Of the 270 development goals, 133 have already been fully realized, and according to the plans, a large proportion of the investments will be completed by 2025. More than half of the program's total budget - two-thirds of which is a domestic budget source - has already been paid to the project managers. Modern Cities scheme provided Hungarian cities with more than 150 billion HUF in 2018. The program is scheduled to be completed in 2025, by which time the total used for development, including European Union funds, may reach 3,750 billion HUF. The program also includes energy investments.

Climate-friendly county Program

Timeline: 2022-2029

The main lines of intervention are to (1) promote energy efficiency, and reduce greenhouse gas emissions, and (2) promote renewable energy in line with sustainability criteria. The first action supports investments in energy modernization and energy saving in buildings and in energy modernization and energy saving in bathing facilities, while the second point focuses on energy modernization of municipally owned buildings. In more detail:

- Installation of equipment that utilizes the energy content of solar radiation, and related structural and support elements.
- Design and expansion of small photovoltaic power plants with a connection capacity of up to 500 kVA.
- Decentralized renewable energy source-based incentive to meet local heat and cooling and electricity needs.
- Establishing a connection to an existing local community heating plant or waste heat utilization system powered by renewable energy sources.

Energy Efficiency Obligation Scheme:

Implemented: 2021

In order to improve energy efficiency, support energy saving as well as encourage energy efficiency investments in Hungary, we introduced the Energy Efficiency Obligation Scheme (EEOS) in 2021. The scheme obliges energy traders to implement energy efficiency measures in proportion to the energy sold. These measures result in proven energy savings on the end users' side.

Long-term renovation strategy

Timeline: 2021-2030

One of the main objectives of the Strategy is to enable the national stock of residential and non-residential buildings, both private and public, to become a highly energy-efficient and decarbonized building stock through renovation by 2050. The achievement of the objectives of the Strategy and the implementation of the measures have a significant impact on economic

development and employment. The milestones and the effectiveness of the Strategy are decisive for the sustainability of both the built environment and the construction economy. At the same time, an update has become timely, which we plan to implement from 2025 with the National Building Renovation Plan.

Home renovation programs

Implemented: 2021

In addition to the EEOS, the Government is devoted to continuing the most effective alternative policy measures and launching new specific programs, like home renovation programs. The newest program supports the energy efficiency modernization of single- and multi-family detached houses built before 1990, offering interest-free loans and non-refundable support to replace doors and windows, upgrade the heating and hot water system and insulate the building.

In accordance with the EU requirements, the supported renovation must achieve an energy saving of at least 30%, certified by an energy performance certificate. Since this kind of program contributes to the country's energy-saving objectives, the energy efficiency modernization of the residential building stock, while improving the quality of life and comfort of the households as well as significantly reducing the monthly utility bills, it is extremely important to make both EU and national resources available.

The program includes the following sub-programmes:

1.) Framework for energy efficiency development of residential buildings

Timeline: 2023-2026

The subject of the reform measure: Develop a framework for the energy efficiency development of residential buildings, the results of which can be used to incorporate the requirements into the relevant support systems. Its purpose is to ensure the proper preparation of grant applications and effective support for renovations, as well as the operation of an effective monitoring system. The REPowerEU chapter complements the Recovery and Resilience Plan with additional important and necessary reform measures. The majority of these are legal measures related to electricity consumption and production, aiming to provide an effective response to domestic needs and the higher prevalence of renewable energy use.

2.) Family Home Creation Discount (CSOK) Program

Timeline: 2016-2024

The Családi Otthonteremtési Kedvezmény (CSOK) is a non-refundable state subsidy, worth up to HUF 10 million, which can be claimed for an existing or adopted child, and which can be used for the purchase, construction, or extension of a new or used apartment or residential building.

3.) Village Family Home Creation Discount (CSOK) Program

Timeline: 2019-2024

The village CSOK subsidy can be used for the purchase of a used property and for its simultaneous expansion and modernization, as well as for the modernization and expansion of an existing property. An important condition is that half of the claimable amount can be spent on purchases, and the other half must be used for modernization or expansion. Support is available in 2,631 preferred small settlements.

Residential Energy Efficiency Program

Timeline: 2023-2029

The goal is to implement a just energy transition plan for Baranya, Heves, and Borsod-Abaúj-Zemplén counties. Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but also supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Smart cost-sharing Program

Timeline: 2019-2029

There are still 200 district-heated dwellings in Hungary where the technical solutions used do not allow the provision of heat to be regulated. In addition, the use and uptake of smart cost-sharing to enable continuous monitoring of energy consumption is an effective tool to strengthen the awareness of users. The goal is to continue the projects implemented in 2019 and 2020: the "*Spreading the application of smart cost sharing, radiator replacement program*" was a non-refundable subsidy in 2021, the maximum amount of which was 50% of the eligible, gross heating modernization costs of a given apartment building. HUF 3 billion was available to complete the entire tender. The minimum amount that can be won per condominium is HUF 150,000.

Transformation of the regulation of consumption meters and the intelligent functions and devices connected to them

Timeline: 2023-2026

Implementation of legislative amendments in the field of transformation of the regulation of consumption meters and related intelligent functions and devices, making data more transparent and easier to access for users and other market players, especially aggregators. The REPowerEU chapter complements the Recovery and Resilience Plan with additional important and necessary reform measures. The majority of these are legal measures related to electricity consumption and production, aiming to provide an effective response to domestic needs and the higher prevalence of renewable energy use.

Energy efficiency of Public Buildings Program

Timeline: 2023-2029

Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Smart networks: Danube Ingrid' Project

Timeline: 2020-2025

The Danube InGrid Project (Danube Intelligent Grid) is part of the European Commission's Project of Common Interest, in the intelligent grid category. The goal is to strengthen cooperation and integration in the Slovak and Hungarian energy markets. The project promotes the development of modern energy infrastructure by applying smart grid technologies, both within and across borders.

Network development in the areas of JTP (Just Transition Platform) involvement

Timeline: 2023-2029

Enabling regions and people to manage the social, economic, and environmental impacts of the transition to a climate-neutral economy by 2050, based on the Paris Agreement, to meet the EU's 2030 climate goal. In this context, the goal is to implement a just energy transition plan for Baranya, Heves, and Borsod-Abaúj-Zemplén counties.

Network development

Timeline: 2023-2029

Similarly to other initiatives, it not only promotes overall energy efficiency measures, measures across various sectors, including small and medium-sized enterprises (SMEs), residential buildings, public buildings, and other systems but supports the increase of renewable energies at both community and power plant levels. It aims to improve district heating and cooling systems, encourage hydrogen use, reinforce the development of smart energy systems, networks, and storage opportunities, and also establish transmission and distribution network flexibility.

Hi-tech and green transition

Timeline: 2023-2029

The share of renewable energy sources is increasing, but the electricity grid systems needed to support them are not flexible enough and need to be improved. Above-average temperature rises reduce the resilience of ecosystems, so the development of disaster management systems is urgently needed to ensure the sustainable use of natural resources, too. The issue of waste management also has an impact on climate change and it is therefore important that the circular economy is also addressed by digital developments. The Operational Programme would create digital solutions in these and related areas to ensure that improvements in living standards can be sustained without increasing emissions: developments include the digitalization of building energy, IT services for energy communities, and digital sensor systems to support climate change monitoring.

Key elements of the action include:

- Promoting energy efficiency and reducing greenhouse gas emissions
- Developing smart energy systems, networks and storage outside the TEN-E network
- Promoting climate change adaptation and disaster risk prevention and resilience, taking into account ecosystem-based approaches
- Promoting the transition to a circular and resource-efficient economy

Grid Development Plan of the Hungarian Electricity System

Timeline: 2022-2024

Pursuant to Act LXXXVI of 2007 on electricity (VET), Section 25(1), the transmission system operator (Mavir) shall:

. “Distributors are responsible for preparing the electricity system network development plan for networks of 132 kV and above, taking into account the plans submitted by licence holders. The final decision regarding the installations included in the Hungarian electricity system network development plan has subsequently been adopted.” The implementation projects can be completed on time.

Max 1.65 GW of new CCGT capacity expansion to support electricity system flexibility needs

Timeline: 2023-2029

The Tiszaújváros and Visonta sites of the Tiszaai Power Plant and the Mátra Power Plant will have the capacity to generate 1500 MW of modern power to meet the growing demand for electricity. The MVM Group has launched open, conditional public procurement for the construction of combined cycle gas turbine power plant units at the sites in Borsod and Heves counties. The developments will strengthen Hungary's energy sovereignty by increasing domestic electricity production. The state-of-the-art facilities will allow for more efficient use of natural gas and hydrogen and a higher share of renewables.

Program for support for investments in grid-integrated energy storage

Timeline: 2022-2025

The call for proposals "Support for network integrated energy storage projects" aims to increase grid flexibility, in line with the objectives of the National Energy and Climate Plan. The HUF 33 billion tenders provides non-reimbursable support jointly financed by the government and the Modernisation Fund for enhancing the national electrical distribution and transmission networks with energy storage equipment, making it more resilient and able to incorporate higher degrees of weather-variable renewable production. The application deadline was 3 October 2022.

Legal incentives for the spread of energy storage

Timeline: 2023-2026

Implementation of legislative amendments regarding storage, development, and development of a transparent, unique regulatory framework, in order to facilitate the rapid integration of storage capacities into the network. We intend to increase the size of the energy storage market (currently a very low installed battery capacity of around 20 MW) through a combination of legislative and financial incentives. The REPowerEU chapter complements the Recovery and Resilience Plan with additional important and necessary reform measures. The majority of these are legal measures related to electricity consumption and production, aiming to provide an effective response to domestic needs and the higher prevalence of renewable energy use.

Strengthening the role of aggregators

Timeline: 2023-2026

Implementing legislative amendments to strengthen the role of aggregators, and developing tools that encourage beneficiaries of universal service to contract with one or more community service providers. It is part of the REPowerEU Recovery and Resilience Plan.

Expanding energy communities

Timeline: 2023-2026

Implementation of legislative amendments and creation aimed at increasing the number of energy communities by simplifying the creation and operation of energy communities as legal entities. It is part of the REPowerEU Recovery and Resilience Plan.

Harmonization of the network connection procedure

Timeline: 2023-2026

Implementation of legal amendments related to the harmonization of the grid connection procedure (MEKH, Hungarian Energy and Public Utility Regulatory Authority) and methodological review, ensuring consistency between distribution system controllers in the interpretation of the rules, and issuing grid connection permits for weather-dependent renewable energy sources up to a total output of 12,000 MW per second. It is part of the REPowerEU Recovery and Resilience Plan.

Establishing network tariffs

Timeline: 2023-2026

Development of a new methodology for determining the network tariff by MEKH (Hungarian Energy and Public Utility Regulatory Authority). It is part of the REPowerEU Recovery and Resilience Plan.

Sludge Treatment and Recovery Strategy

Timeline: 2014-2023

The Strategy sets out a 10-year (2014-2023) development plan concerning sludge management in Hungary. Its first stage (Sludge Treatment and Recycling Programme 2014-2017) mainly addresses the preparation of development tasks and treatment equipment. The second stage (2018-2023) involves the implementation of the above, and the preparation and implementation of additional development. The Strategy also provides a conceptual outlook until 2027.

The main areas of action:

1. Capacity building corresponds to sludge utilization and, the application of more up-to-date technologies first in demonstration projects and then more widely.
2. Organizing the efficient management of territorial sludge treatment.
3. Incentivizing agricultural use of sludge through improving the tools of farmers and management tools.
4. Enforcing strategic level planning when using recultivation areas
5. Ensuring and gradual building of energy recovery capacities
6. Management tools.

Factory rescue program for large enterprises

Timeline: 2022-2023

The Factory Rescue Program provides large companies with non-refundable support for energy efficiency and energy production investments. With a support intensity of up to 30% in Budapest and up to 45% in rural areas, a total of 15 million euros (approx. HUF 6.2 billion) per

company is available. The Government has allocated HUF 150 billion in budget resources for implementation in 2022. The measure improves the energy efficiency of companies.

SME energy cost and investment support program

Timeline: 2022-2023

SMEs can apply for subsidies by undertaking energy efficiency investments. The measure improves the energy efficiency of companies.

Amendment of the rules on the determination and certification of the energetic characteristics of buildings

Implemented: 2023

The government decree 176/2008. (VI. 30.) on the rules of certification of energy characteristics of buildings has been amended. As a result from November 2023, the energy certificates of the buildings in the future are prepared in a modern system and contain more detailed renovation proposals than before. 9/2023 on determining the energetic characteristics of buildings. ÉKM decree (revised TNM decree 7/2006) stipulates that the "near-zero energy building" level ("BB") requirement, which is 76 kWh/m²a, applies to newly built properties and properties that have undergone significant renovation after 2024 characterized by a specific primary energy consumption and an emission of 20 kg CO₂e/m²/year, which encourages the further growth of small household-sized power plants.

As a result of the regulations, energy certificates for buildings in the future will be prepared in a modern system and contain more detailed renovation proposals than before. The transparent certificate, with sample classifications, graphically shows the energy consumption of the entire building (or an independent part of the building) and the individual mechanical systems. The certificate records detailed renovation and modernization proposals in stages, with a schedule and cost plan. The recommendations can also help the staff of public buildings to use energy in a profitable way.

The advantages of the new certification regulations:

1. Stricter significant renovation requirement
2. Commonly understood qualification of the building and individual architectural and building technical elements.
3. Comprehensible renovation proposals.
4. Renovation roadmap
5. The new methodology approaching the standards increases reliability.
6. Operational CO₂ emission based on life cycle was methodologically developed and new requirements were created.

Home Renovation Grant

Timeline: 2021-2023

Residential housing modernization support program with the aim of energy modernization and economic revitalization. The special feature of the program is that its budget expenditure effect is neutral/positive on the central budget. In support of the spread of HMKE, from January 1, 2021, the Home Renovation grant could also be applied for the installation of solar systems in the case of households raising at least 1 child, with the grant a non-refundable amount of HUF 3 million could be settled. The request for support could be submitted after the completion of all renovation work on the apartment, within 60 days after the payment of the invoices, but no later than December 31, 2022.

The program covered 50% of the renovation costs, with a maximum available amount of HUF 6 million. In this framework, the Government supported the renovation of the homes of around 300,000 families with children, for a total of more than HUF 700 billion. The program encompasses demographic, housing, energy, construction industry, and credit market objectives, contributing to GDP growth as well.

Regulation of measures to preserve the security of natural gas supply

Implemented: 2023

The Government Decree regulates the detailed rules for performing the natural gas distribution service, maintaining the security of the natural gas supply, as well as the responsibilities and powers of organizations entitled to take action in a natural gas supply crisis situation, detailed provisions on restrictions, and regulations on the use of the safety stock. The purpose of the new legislation is to reconsider the restriction categories, to create consistency with European regulations and to create a national-level electronic emergency classification register in order to effectively manage the gas supply crisis and prepare for the next winter. Due to the transformation of the Hungarian natural gas market, it was necessary to modernize the natural gas supply emergency restriction classification and registration system in order to maintain the security of supply and to ensure continuous supply to consumers. An essential element of preparing for natural gas supply crisis situations is the updating of the restriction categories and the construction of the IT background of the uniform restriction classification system. In view of the preparation for the construction of the IT system, the relevant part of the regulation will enter into force later.

The agreement on cooperation with natural gas transmission lines crossing the Hungarian-Romanian state border, as well as electricity transmission lines

Implemented: 2020

The Hungarian Parliament authorizes the Government of the Republic of Hungary to enter into an agreement with the Government of Romania on cooperation in natural gas transmission lines and electricity transmission lines crossing the Hungarian-Romanian state border. It contributes to strengthening the internal energy market and security of supply, improves the conditions for electrification, and indirectly has a positive impact on GHG emissions.

NTC-based market coupling initiatives

Timeline: 2018-2024

The Interim Coupling project was launched in December 2018 following the request of the relevant national regulatory authorities (NRAs) in order to further develop regional integration of day-ahead organized electricity markets. The project aimed to connect the borders of 4M MC (Czech-Slovak-Hungarian-Romanian market coupling) with the Multi-Regional Coupling (MRC) by introducing Net Transmission Capacity (NTC) based implicit capacity allocation on the abovementioned six borders. The new market interconnection was successfully launched on 17 June 2021, when for the first time the day-ahead cross-border capacity was implicitly allocated on the abovementioned six borders: HU-AT, CZ-AT, CZ-DE, DE-PL, PL-CZ, and PL-SK.

Development of the legal background of dynamic pricing

Timeline: 2023-2026

Bringing into force a legislative amendment to develop the legal background for dynamic pricing, so that households with a suitable consumption meter can voluntarily enter into an electricity purchase contract with both dynamic pricing and within the framework of a universal service. It is part of the REPowerEU Recovery and Resilience Plan.

Renewal of the product structure of regulatory reserve markets

Timeline: 2023-2026

Enactment of legislative amendments and amendments to contract models to renew the product structure of the regulatory reserve markets, in order to facilitate the market entry of new types of flexibilities. It is part of the REPowerEU Recovery and Resilience Plan.

Intraday market coupling project (XBID)

Timeline: 2020-2026

The XBID project – established for coupling the pan-European intraday market – was initially made up of the members of 14 European countries, which has since been expanded with all Member States subject to the CACM Regulation. The XBID Market Project aims to implement cross-zonal continuous trading and to improve efficiency on the pan-European single cross-zonal intraday market. Integration was taking place in several stages, and the founding members were successfully connected on June 2018 and the system became operational. On 19 November 2019, HUPX and MAVIR successfully joined XBID, the Single European Market Interconnection Solution.

Company Development Program

Timeline: 2023-2029

Enabling regions and people to manage the social, economic, and environmental impacts of the transition to a climate-neutral economy by 2050, based on the Paris Agreement, to meet the EU's 2030 climate goal. In this context, the goal is to implement a just energy transition plan for Baranya, Heves, and Borsod-Abaúj-Zemplén counties.

Developing green skills

Timeline: 2023-2026

Development of a detailed national-level strategy for micro-certificate training programs supporting the green transition, as well as related regulations and other regulatory documents, in line with the framework-level regulation of the Adult Education Department of the Ministry of Culture and Innovation, to develop and launch micro-certificate training programs that ensure the acquisition of targeted green skills, so that facilitate the smooth and efficient implementation of the green transition. It is part of the REPowerEU Recovery and Resilience Plan.

Promoting a just transition

Adopted: 2021

Territorial Just Transition Plans have been created for Heves, Borsod-Abaúj-Zemplén, and Baranya Counties to promote the Just Transition in the regions where the transition to a clean energy economy would endanger the jobs in fossil fuel-intensive sectors. It includes the regional development for the Matra power plant by creating a more diversified economy, and more stable, long-term, more sustainable jobs.

The plans aim to:

- provide an opportunity to monitor labour market developments with energy transitions and to reverse possible adverse trends;
- to help improve the employability of the workforce in the green economy sectors, thereby improving the competitiveness of the area;
- provide support for the upskilling and reskilling of vulnerable workers;
- extend certain opportunities for development policy support to vulnerable social groups and regions.

For the programming period 2021-27, KEHOP Plus (Priority 5) will support the Just Transition with EUR 294,836,732 (EU share: 250,611,222). Other quantified objectives include: 3518 pieces of more energy-efficient housing by 2027, and a decrease in primary energy consumption by 478,409 MWh/year until 2027, where the base year was 2020.

Promoting green roofs and green facades

Timeline: 2021-2023

A crucial aspect of the decarbonization process involves significantly reducing energy consumption and associated CO₂ emissions from buildings. This objective can be accomplished through sustainable and climate-friendly strategies, such as implementing sustainable urban water management and utilizing green infrastructure, specifically green building tools like green roofs, green walls, and green facades. These solutions have a positive impact on the urban microclimate, including the reduction of heat islands, shading, and provision of recreational opportunities. So far, the number of training courses held: 6 in total (2 per year), and the number of information materials produced: 1.

II.D.2.3. Transportation

As one of the highest emitters, it is crucial to focus on the transportation sector for GHG reduction. Hungary submitted the CORSIA State Action Plan in September 2022 to the International Civil Aviation Organization (ICAO), which lists the domestic actions to reduce CO₂ emissions based on ICAO decisions. In addition, Hungary is currently exploring national options for further emission reductions in the field of sustainable aviation fuels in the framework of its Sustainable Aviation Fuel (SAF) Project, which could contribute to the achievement of the ICAO long-term global aspirational goal (LTAG) at both national and regional level.

As for the International Maritime Organization (IMO) decisions, implementation of these decisions is regulated by EU rules that are applicable to Member States, thus it is applicable to Hungary, too. According to the reporting obligations under the EU rules, there are limited effects on Hungary since there is no vessel in our registry that would exceed the respective thresholds of Gross Tonnage (5000 GT).

Installation of electric charging stations along the trans-European transport network

Timeline: 2022-2025

It promotes the use of electric vehicles by installing charging stations along the transportation routes. The measure improves the energy efficiency of the transport sector, helps to reduce energy consumption, contributes to an increase in the share of renewable energy and will help to reduce GHG emissions. Some of the CEF projects are: NEXT-E, MVM-Ultra, Connect-E, Ultra-fast Charging Network, NEAT, Expand-E Cohesion; and OMV. Altogether, 220 chargers will be installed.

Promoting public procurement of clean road transport vehicles to support low emission mobility

Timeline: 2021-2030

The purpose of the legislation is to transpose the provisions of Directive 2019/1161 (CVD), amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles. The regulation imposes a certain percentage of clean and energy-efficient vehicle procurement in specified procurement categories for member states in two phases, with emission limit tightening (2021-2025; 2026-2030). In the domestic regulation, the target values set for buses are higher (in line with the Government's new bus strategy concept and the tasks related to the Green Bus Pilot Project). The decision requires the preparation of an impact assessment to consider the possibility of setting stricter targets, such as 100% for purely electric (battery, fuel cell) propulsion, beyond the provisions of the transposed regulation.

Strengthening clean urban-suburban transport

Timeline: 2023-2029

The goal is to enhance suburban rail systems in major cities. This involves focusing on two main areas: (1) developing electric charging stations and facilities, as well as promoting zero-emission public transport vehicles such as electric buses, trolleybuses, and trams; and (2) investing in Park and Ride (P+R), Bike and Ride (B+R), and intermodal transportation hubs.

Support (aid) for single car freight transport by rail

Timeline: 2021-2025

The Government, in its decision outlined in Resolution No. 1414/2020 (VII. 16.), has established a support system for the freight transport of individual railcars and the development of the related transport sector. Starting from the year 2021, state support will be provided for a period of five years. The annual amount allocated for this support is up to HUF 3,842,000,000 in 2021 and up to HUF 6,407,000,000 for each year from 2022 to 2025. This state support allows railway freight companies to participate in the support system through non-discriminatory application procedures. The essence of individual railcar transport is that it facilitates the transportation of smaller quantities of goods, even as little as the capacity of a single railcar, with significant manual labor ("car sorting") and relatively high costs. However, compared to road transport, it achieves freight operations with much lower pollutant emissions.

The development of TEN-T railway and regional intermodal transport

Timeline: 2023-2029

The aim is to develop a resilient, smart, safe, sustainable, and intermodal TEN-T to cope with the impacts of climate change by (1) TEN-T (international) rail international infrastructure development (stations, railway track, and safety equipment), and electrification, (2) purchasing motor trains and (3) through TEN-T port investments.

National Cycling Strategy 2030

Timeline: 2023-2030

In order to define long-term goals and find proper actions the Hungarian Government adopted the National Cycling Strategy in 2030. It sets ambitious goals and establishes guidelines to follow in order to make our country a better place for cycling by 2030. It aims to achieve the Member State's binding target for GHG emissions, the final energy consumption target, and improve the resilience of regional and national energy systems. It also promotes cycling campaigns (Bike to Work! campaign, Cycling across 7 borders, Cycle to Green!), and gives out Cyclist Friendly Awards (Cyclist Friendly Municipality and Cyclist Friendly Workplace). Within its framework, the development of bicycle traffic and the amendment of legislation to increase the share of bicycle traffic are implemented.

Improvement of the bicycle transportation network

Timeline: 2021-2030

The government aims to increase the length of bicycle roads by an additional 1000 km by 2020, to increase the share of daily bicycle users to up to 27% of the total population, and to increase the share of recreational bicycle users by 30.000 persons/year. A group of measures are meant to achieve these targets, such as the development of bicycle infrastructure, the support to the establishment of cycling facilities (e.g. bicycle racks, B+R parking), the establishment of cyclist public transport systems, and the awareness-raising campaigns. These measures are planned to be introduced between 2010 and 2020. The trend continued in 2021 with an additional 95 km. The construction and the preparation of about 850 kilometers of cycle paths are supported nationwide. By 2030, bicycle roads are expected to reach 15,000 km.

HET_G Sustainable Green Transport

Adopted: 2020

The goal for the coming decades, - up to and including 2040, - is to facilitate the green transition of Hungary's transport system. This involves achieving systemic results to create a low-emission transport system that is uniformly reliable. All core network elements will be installed in compliance with relevant European technical standards; bottlenecks will be eliminated, and rail-based transport will be effectively integrated with urban networks for passenger transport.

Elements of the investments include (1) Increasing the capacity of the metropolitan/suburban rail network (HÉV), (2) rail network bottleneck replacement on the TEN-T corridor, (3) development of zero-emission bus transport, (4) Deployment of centralized traffic management on TEN-T railway lines and (5) awareness-raising measure.

Deployment of an integrated tariff and timetable system

Implemented: 2023

The lack of an integrated tariff system is still an obstacle to better cooperation between rail and bus transport and thus a more efficient public transport, therefore new area-based passes will be introduced on 1st May 2023, which will be valid for all rides interurban transport providers (except for trains with mandatory seat reservation). It is important to note, that this level of tariff integration has never existed before in domestic public transport. From now on, the bus and rail timetables will be mutually interpretable, which will create an opportunity to continue timetable coordination, and rationalization and further increase efficiency.

[Extension of exemption from excise tax in the case of water and rail passenger transport and goods transport](#)

Timeline: 2023-2029

In its decision number C(2023) 5276 dated August 4, 2023, the European Commission granted approval to Hungary's request for state aid under the title "*Scheme on excise duty exemptions and refunds for fuel used in railway and inland waterway transportation 2023-2029.*" This approval extends the system until April 3, 2029, for an additional six years, allowing Hungary to support environmentally friendly modes of transportation through the maintenance of excise duty exemptions and refunds.

The total estimated budget for the entire duration is approximately EUR 214.2 million over six years, corresponding to an annual budget of approximately EUR 35.7 million. The estimated budget for the inland waterway sector is approximately EUR 124.8 million, representing 58.3% of the estimated total budget. Within this budget, approximately EUR 30 million will be provided to inland waterway freight transport (24%), while approximately EUR 94.8 million will be provided to inland waterway passenger transport (76%).

[Budapest infrastructure developments program](#)

Timeline: 2023-2029

By creating a more liveable urban environment through integrated urban development interventions, opportunity services, social urban regeneration, and improving the energy-efficient infrastructure of the building stock, Hungary can achieve improvement in GHG emissions target, final energy consumption, and resilience in national energy systems. Furthermore, the below measures will contribute to an increase in the share of renewable energy.

Elements of the intervention (similarly to the Climate-friendly county Program):

- Energy modernization of municipally owned buildings.
- Installation of equipment that utilizes the energy content of solar radiation, and related structural and support elements.
- Design and expansion of small photovoltaic power plants with a connection capacity of up to 500 kVA.
- Decentralized renewable energy source-based incentive to meet local heat and cooling and electricity needs.
- Establishing a connection to an existing local community heating plant or waste heat utilization system powered by renewable energy sources.

Targeted measures:

- GHG emission from heating and cooling systems switched from solid fossil fuels to natural gas estimated (additional), tCO₂eq/yr: reference yr (2021): 1, Target (2029): 16000 tCO₂eq/yr;
- Supported targeted cycling infrastructure (additional): baseline (2021): 0. Target (2029): 23 pieces;
- Population affected by protection measures against climate-related natural disasters: reference yr (2021): 0, target (2029): 750,000 persons;
Annual users of new or upgraded public transport (users per year): reference yr (2021): 0, Target (2029): 500 000 users /yr.

Green Bus Program

Timeline: 2020-2029

The Green Bus Programme aimed at making local transport more sustainable, therefore, a greater number of environmentally friendly buses will be in service in local public transport by 2030. Initially, municipalities could purchase EURO VI, CNG, and electric buses, however, starting from January 1, 2022, only electric buses are available for purchase.

As part of the project, Volánbusz Zrt. has purchased more than 100 new environmentally friendly electrically powered buses since 2022. Thanks to the development, a significant part of the local vehicle fleet of the metropolitan agglomeration and six county seats has been renewed, thanks to which the level of harmful material burdening the air in the affected areas has decreased.

CEF2-funded projects supporting the expansion of national electric charging infrastructure

Under implementation: 2021

The further development of the electric charging network is facilitated not only through self-funded charging installations and governmental support but also through Hungarian projects funded under the Connecting Europe Facility's (CEF 2) transport segment.

Improvement of the railway vehicle fleet

The priority projects under the Integrated Transport Development Operational Programme Plus (IKOP+) focus on acquiring 18 new single-current suburban railway vehicles, as well as 15 zero-emission electric multiple units with 200 seats.

Replacement of vehicle of public transport service companies

Timeline: 2020-2026

The replacement of public transport service companies' vehicles has decreased in recent years. The average age of the Hungarian public bus fleet was 14.46 years at the end of 2015. Between 2016 and 2020, 1813 buses were required to be replaced, and after 2020 additional 6000 bus replacements became necessary. A total of 1000 new, modern buses will be purchased by 2026. The average age of buses is currently under 10 years, while the upgrade will bring it down to under 8 years.

The Government of Hungary is contributing to mitigating the damage caused by global climate change through a number of measures in the field of domestic transport, which will reduce the use of fossil fuels in the short term and reduce its use in the long term. In the area of public transport, a number of tariff measures have been introduced in recent years, with the primary aim of reducing the demand for private motorized transport. As a result of the fare reform, there has been a visible increase in the number of people using public transport. Operators are also paying particular attention to increasing the share of alternative propulsion vehicles in their new vehicle purchases.

National policy framework for alternative fuels infrastructure development

Timeline: 2016-2030

In order to achieve decarbonization, fossil fuel consumption needs to be reduced with alternative solutions. Therefore, the National Framework Plan for the Development of Alternative Fuels Infrastructure (adopted by 1782/2016. Government Decision in 2016) identifies national targets for the deployment of alternative fuel infrastructure (CNG/LNG, biofuels, electricity, hydrogen regarding the transport sector) and number of expected vehicles by 2020, 2025 and 2030 and summarizes the legal and financial incentives allocated for the deployment and R&D concerning these types of fuels. The revision of the target was carried out in 2020.

National Mobility Strategy – Jedlik Ányos Plan 2.0

Timeline: 2019-2030

Ányos Jedlik Plan 2.0 is the main policy document for the promotion of e-mobility in Hungary. It was adopted in 2019 and defines targets for the number of electric cars and charging points. In accordance with the plan, the institution of green license plates was introduced in 2015, providing many benefits to owners of environmentally friendly vehicles. The plan determines goals, policies, and measures in the following fields: formation of the detailed market model; charging infrastructure development; promotion of battery electric vehicles (BEVs); deploying charging infrastructure and expanding the electric vehicle fleet of the central and local governments; decarbonization of public transportation and development of electric buses; energy production of local governments and development of smart grid solutions; utilizing the cost reduction possibilities in charging; awareness-raising related to electric mobility.

The other main objective is to make coherence with other strategies and policy measures including the National Bus Strategy, which focuses on the spread of environmentally friendly buses, including electric buses.

Financial support for the purchase of electric vehicles for companies

Timeline: from 2016

This is a sub-program of the Jedlik Ányos Plan (1.0.) that provides support to private persons and companies to buy electric cars and trucks under 3.5 tonnes. The maximum contribution rate is 21% of the price and a maximum of 1.5 million forints/vehicle. The sub-program was launched in 2016. In order to promote environmentally friendly transport, the Hungarian Government supports the full range of electromobility, including the purchase of electric scooters, cars, buses, and electric bicycles. In order to increase the proportion of electric vehicles in the vehicle fleet, the Government has announced several calls for tenders since 2016, thereby supporting the purchase of battery electric vehicles for several target groups.

In the framework of the latest call for proposals RRF-REP-10.10.1-24, the Government provides HUF 30 billion in grants to enterprises for the purchase of battery electric cars, light commercial vehicles, and vans.

Tax allowances after environmentally friendly vehicles

Timeline: 2015-2024

To increase the popularity of electromobility, the institution of green license plates was introduced in 2015, providing many benefits to owners of environmentally friendly vehicles. For these vehicles, several tax advantages, exemption from costs or expenses, and other forms of support have been introduced in recent years, such as exemption from the vehicle tax, from the taxation of company cars, from the registration tax, and from the transcription tax. Furthermore, municipalities may provide free parking and entry to these vehicles. In 2024, the institution of the green license plate has been revised to promote truly environmentally friendly cars. From 1 September 2024, only battery electric cars and zero-emission cars are eligible to obtain a green license plate. This revision will also affect tax incentives, with battery electric and zero-emission cars retaining their exemption.

Moreover, for buses, lorries, and trucks the rate of the motor vehicle tax is dependent on the environmental classification of the vehicle. Trucks also receive tax allowance for using combined transportation. The rate of company car tax and registration tax also depends on the environmental classification of the vehicle.

Usage-based road toll on heavy duty vehicles

Implemented: 2013

A road toll was introduced for heavy-duty vehicles in 2013 and helped to achieve a final energy consumption of at least 740 PJ for 2030. Vehicles with a permissible gross weight of more than 3.5 tonnes are obliged to pay a mileage-based road toll. The toll applied in the road toll system consists of two elements, the infrastructure charge and the external-cost charge. The infrastructure charge is intended to recover the costs incurred in constructing, maintaining, operating, and developing road infrastructure, depending on the infrastructure element used

(expressway or main road) and the number of axles of the vehicle (J2-J5). The external-cost charge introduced in 2024 is set in relation to the costs caused by traffic-based air pollution, noise pollution, CO₂ emissions, or any combination. The system represents the user and the polluter pays principle. It gives incentives for better organization of freight delivery, better use of payload capacity, and for using vehicles with lower emissions.

Livable County Program

Timeline: 2022-2029

Building a livable county through Sustainable Urban Development, which involves constructing reliable local transport infrastructure and services, municipal green and blue infrastructure, creating brownfield regeneration, local community and cultural, sports and leisure spaces and services, ICT and smart city development, and social urban regeneration by focusing on climate adaptation. The supported targeted cycling infrastructure is planned to increase to 728,1 km by 2029; the length of additional inland and stormwater protection facilities to 1,845,366 m by 2029, and the newly built or renovated green infrastructure to 24,44 ha by 2029, compared to 2021.

National Transport Infrastructure Development Strategy

Timeline: 2014-2050

The National Transport Infrastructure Development Strategy is the main policy document in the transport sector, however, it is not primarily designed for climate protection purposes but focuses on the strategic objectives of transport infrastructure development and considers its climate protection and many other (environmental, energy efficiency, employment, spatial inequalities, economic, social welfare, etc.) impacts. In terms of climate and environmental objectives, it has not changed the main lines of action previously identified, which are:

- the development and regulatory responsibilities of the EU transport and climate policy for Hungarian transport (placing on the market and operation of vehicles, fuel quality, renewable and alternative energy sources),
- favoring public transport over private transport in passenger transport, encouraging non-motorized transport, and improving the safety and comfort of walking and cycling,
- in freight transport, encouraging rail and waterborne transport and combined transport.

In addition, the strategy aims to reduce the environmental impact of transport through increased energy efficiency, and demand management. The implementation period of the plan is between 2014 and 2050. Implementation of the plans could increase the length of road infrastructure equipped with ITS by 480 km by 2050 and reduce average annual greenhouse gas emissions from transport by 17 kt CO₂eq by 2050.

Budapest Rail Node Study

Timeline: 2021-2040

Budapest has a strategic location in the heart of Europe at the crossroads of national Trans-European and international transport corridors. The Hungarian capital is one of the most important economic centers of Central Europe; easily accessible by rail, road, water, and air, therefore occupying a significant passenger and freight transit traffic on its transport networks. To make a long-term strategy that corresponds to the aims of the country and the city, the Rail Node Study addresses future rail-based developments in the capital and its agglomeration, such as:

- Advancing a sustainable traffic system, maximizing the usage and the efficiency of the railways, including both passenger and freight traffic,
- Improving the environmental performance of the traffic sector on the national and municipal levels,
- Reducing the effects of climate-changing by mitigating the sector's emission of greenhouse gases,
Increasing the quality of life of the urban population through effective and comprehensive traffic planning and urban design.

II.D.2.4. Industrial Processes

F-gas Regulation

At their 28th Meeting on 15 October 2016, the Parties to the Montreal Protocol adopted the Kigali Amendment to add hydrofluorocarbons (HFCs) to the list of controlled substances and approved a timeline for their gradual reduction by 80-85 percent by the late 2040s, and phase out F-gas import and production by 2050. The Kigali Amendment came into effect on 1st January 2019, and Hungary, as a developed country alongside the EU took measures to implement the phase-down.

To ensure that the EU can meet its obligations under the Kigali Amendment, Regulation (EU) No. 517/2014 has been adopted (hereinafter "F-gas Regulation"), which repealed Regulation (EU) No. 842/2006. Applying from 1 January 2015, the F-gas Regulation aimed to reduce fluorinated greenhouse gas emissions by two-thirds of 2010 levels by 2030, by improving the leak-tightness of equipment, promoting the use of more environmentally friendly alternatives to F-gases and capping sales of HFCs on the EU market through an HFC phase-down.

The Regulation layed down the following rules:

- Operators of equipment that contains fluorinated greenhouse gases shall take precautions to prevent the unintentional release ('leakage') of those gases.
- Operators of equipment that contains fluorinated greenhouse gases in quantities of 5 tonnes of CO₂ equivalent or more (10 tonnes of CO₂ equivalent in case of hermetically sealed equipment) and not contained in foams shall ensure that the equipment is checked for leaks. The frequency of the obligation is set by the F-gas Regulation (1 year/6 months/3 months or 2 years/1 year/6 months in case of leakage detection system equipped).

- Operators of equipment containing more than 500 tonnes of CO₂ equivalent of F-gases shall ensure that the equipment is provided with leakage detection system.
- National authorities are responsible for establishing training and certification programs for businesses and individuals involved in the installation, providing the service, maintenance, and repair or decommissioning of equipment containing F-gases, and recovery.
- Operators of stationary equipment or of refrigeration units of refrigerated trucks and trailers that contain fluorinated greenhouse gases not contained in foams shall ensure that the recovery of those gases is carried out by natural persons that hold the relevant certificates.
- The placing on the market of products and equipment listed in Annex III of the F-gas Regulation shall be prohibited from the date specified in that Annex. Only a very limited scale of exceptions remain in existence.
- It set a quota system for reducing the HFC production and the amount of HFC's placed on the market (the HFC phase-down sets reduction steps by percentage from 2015 to 2030).
- It obligates the producers, importers, exporters and companies carrying out activities involving destruction or feedstock usage of F-gases to report annually via the BDR System, which is operated by the EU Commission.
- Directive 40/2006/EC (MAC Directive) on emissions from air conditioning systems of motor vehicles provides the gradual replacement of air-conditioning systems using HFC-134a. It also limits the possibility of retrofitting motor vehicles with air conditioning systems designed to contain fluorinated greenhouse gases with a global warming potential higher than 150 and prohibits the charging of air conditioning systems with such gases. Automotive manufacturers must provide the competent authority with all relevant technical information regarding activities involving servicing, and maintenance of mobile systems operating with F-gases.

Hungary ensured the enforcement of the F-gas Regulation by adopting Act LX of 2007 on the implementation framework for the UN Framework Convention on Climate Change and its Kyoto Protocol and Government Regulation No. 14/2015.

In addition, Hungary established an IT system (Climate Gas Database - "Klímagáz Adatbázis") to collect certain data from the operators, producers, importers, and certified companies carrying out servicing and maintenance. All companies, that on behalf of another person or organization, install, commission, label, maintain, service, test for leaks, repair, as well as decommission an application containing F-gases which are required to undergo a leak test, are obliged to register in the system.

II.D.2.5. Agriculture

As an EU member state, the policies and measures implemented in the agricultural sector are based on the **Common Agricultural Policy (CAP)** of the European Union. To increase the

efficiency of measures aiming at climate protection the European Commission published more strategic documents (Green Deal, Farm to Fork Strategy, Biodiversity Strategy, Soil Strategy, Carbon farming, etc.) in the last years. The implementation of these new strategies proceeds in Hungary. From 2023 the agricultural policy and the support system will be based on the new CAP strategic plan.

Protection against soil erosion

Timeline: from 2023

Soil plays an important role in carbon capture, so the loss of soil is a major threat, as soil formation is a very slow process. That is why great emphasis should be put on the fight against erosion, which also has a bearing on climate change. Erodibility is determined by the grain size, humus content, structure, moisture state, and water absorption of the soil. (The greater the water absorption capacity of a soil, the less eroded.) The erosion work of the rain is greatly increased by the slope of the hill, which increases the destroying energy of the water.

From 2023 onwards, the Conditionality provides a set of binding standards for Good Agricultural and Environmental Condition (GAEC) and Statutory Management Requirements (SMR). The rules on conditionality are laid down in the AM Decree No. 14/2023 of 19 April 2023 on the conditions for the use of aid from the European Agricultural Guarantee Fund and the European Agricultural Fund for Rural Development (hereinafter the Conditionality Decree). Regulation No. 5 of GAEC lays down rules for soil cultivation to reduce the risk of soil degradation and soil erosion, including the consideration of slope angles. It is prohibited to grow certain crops (e.g. maize, sunflower) on land with a slope greater than 12% unless the farmer implements the erosion control measures in Regulation 5 of the GAEC. In addition, the requirements of SMR 1 include qualification cases for soil erosion. Exercise specifically related to erosion control in the agroecological program (mulching of plantations on slopes below 12% by mulching, cultivation of annual row cover crops).

Regulation No. 5 of GAEC lays down rules for soil cultivation to reduce the risk of soil degradation and soil erosion, including the consideration of slope angles. It is prohibited to grow certain crops (e.g. maize, sunflower) on land with a slope greater than 12% unless the farmer implements the erosion control measures in Regulation 5 of the GAEC.

The Decree 50/2008 of the Ministry of Agriculture and Rural Development was modified in 2013 to implement regulations in Common Agricultural Policy (CAP). The Decree contains regulations on "Good agricultural and environmental condition". It bans cultivating certain cultures with high erosion risk on steep slopes (more than 12%). It prescribes practices for maintaining cover on agricultural land after harvest.

The Act No. CXXIX of 2007 on the protection of arable land contains general rules on soil erosion control and preserving soil organic matter content. Providing a set of measures from which farmers can choose to apply according to the characteristics of their land to control soil erosion if appropriate for example contour ploughing, cover crops, preserving soil structure, avoiding overgrazing, covering intersections in orchards. Another set of measures helps prevent the loss of soil organic matter, for example, appropriate nutrient management, reduced tillage, protection of layers with high organic matter content, and utilizing of plant residues on the plot.

The Soil-protection Action Plan (SAP) – which contains recommended actions by FAO – is a supplementation of the Act No. CXXIX of 2007 was adopted in 2021 and will be taken into force from 2026. The SAP as an agri-political document, deals with the issue of soil protection and mineral resources management and is coherent with the EU’s common policies such as the Farm to Fork Strategy as part of the Green Deal. To decrease soil degradation, the SAP aims to raise farmers’ awareness of the good practices that can contribute to climate adaptation. From 2026 farmers shall make soil protection plans at the farm level. Guidelines provide concrete and clear support for soil protection planning and consultancy, good practice of tillage and soil management. Green consulting program has the possibility to help land managers in the better application of currently available technologies via knowledge transfer. The consultancy system will be based on a detailed soil database.

Decree 59/2008 (IV. 29.) FVM on the detailed rules of the **action program for the protection of waters against nitrate pollution of agricultural origin** and on the procedure for data provision and registration (hereinafter: Nitrate Decree) continues to contain the procedural rules for nitrate pollution of agricultural origin. The GAECs include by name nitrate pollution of agricultural origin in GAEC 2 of the Regulation on Conditionality, which is based on the requirements of the Nitrate Regulation. In addition, the Regulation contains a requirement for the establishment of water protection zones along surface waters in its Regulation GAEC 4. According to Good Agricultural Practice, the maximum application rate of nitrogen from slurry and manure is 170 kg/ha. It is also forbidden to take manure and slurry to the field between the 31st of October and the 15th of February. There are certain regulations concerning storing, and treating manure or slurry on the livestock farm and on the field as well.

Protection of biodiversity and protected areas

Timeline: 2014-2025

Restoring, preserving, and enhancing biodiversity, including in Natura 2000 areas, in areas facing natural or other specific constraints, and high nature value farming, as well as the state of European landscapes. By 2025, the following objectives are set in place:

- Percentage of agricultural land under management contracts supporting biodiversity and/or landscapes: 11,79%;
- Agricultural land under management contracts supporting biodiversity and/or landscapes 552 748 ha;
- Percentage of forest/other wooded area under management contracts supporting biodiversity: 5,08%;
- Forest/other wooded area under management contracts supporting biodiversity: 104 100 ha.

Greening payment (Eco-Scheme)

Implemented: 2020

Since 2015, farmers entitled to payment under the single area payment scheme shall observe, on all their eligible hectares, the agricultural practices beneficial for the climate and the environment. In return, they receive the so-called greening payment. The agricultural practices beneficial for the climate and the environment are the following:

- Crop diversification – for improved soil quality,
- Maintaining existing permanent grassland – for carbon sequestration and protection of environmentally sensitive grasslands,
- Having a certain amount of ecological focus area (EFA) on or adjacent to the arable land of the farm – for safeguarding and improving biodiversity on farms.

Greening has been replaced by the Eco-Scheme as part of the Common Agricultural Policy from 2020, which is largely the same in its basic principles as the previous greening support and aims to help farmers address climate and environmental challenges. The program offers various sustainable farming practices that allow producers to optimize production according to their land use category while protecting the soil and reducing the effects of climate change.

Practices against soil erosion:

Mulching on arable land: ensuring that the soil is covered for as long as possible, increases the carbon sequestration capacity of the soil, protects the soil from the adverse effects of erosion, and helps to preserve soil moisture. Soil cover which is maintained even during the winter months reduces leaching of substances from pesticides and fertilizers, especially on slopes, thereby improving the quality of water bodies. Mulching in permanent crops in areas with a slope of less than 12%: mulching in permanent crops also protects the soil from the adverse effects caused by erosion, while contributing to preserving soil moisture.

Mulching permanent crops by maintaining cover crops or grass in the alleys: maintaining the soil surface with perennial herbaceous crops for a longer period facilitates carbon sequestration while reducing erosion processes and soil drying.

Practices to reduce greenhouse gas emissions and/or enhance environmental protection:

- Non-rotational tillage: this practice helps to preserve soil carbon and reduce greenhouse gas (GHG) emissions from arable land.
- Use of urea fertilizer in arable land: allowed only with immediate incorporation of the fertilizer or the use of inhibitor which significantly reduces ammonia emissions, thereby contributing to improving air quality.
- Use of urea fertilizer in permanent crops: allowed only with immediate incorporation of the fertilizer or the use of inhibitor which reduces ammonia emissions, thereby contributing to reduced environmental pressure.

CAP for "Contributing to halting and reversing biodiversity loss, enhancing ecosystem services and conserving habitats and landscapes"

Timeline: 2023-2027

The CAP-SO6 objectives in the field of "Contributing to the halting and reversal of biodiversity decline, enhancement of ecosystem services, and conservation of habitats and landscapes" include the following measures for the adaptation and risk management of agriculture:

- Agro-ecological program
- Rural development collaboration for the development of a biomass-based economy
- Payments encouraging agro-ecological land use change
- Long-term commitments to forest genetic resources
- Long-term commitments to forest environmental protection
- Support for organic farming
- Agri-environmental management payments (AKG)
- Compensation payments for Natura 2000 agricultural areas
- Compensation payments for Natura 2000 forest areas
- Support for tree planting and afforestation investments
- Agro-ecological non-production investments
- Ex-situ conservation of animal genetic resources
- In vitro conservation of animal genetic resources
- In situ conservation of animal genetic resources
- In situ conservation of plant genetic resources
- Ex-situ conservation of plant genetic resources and microorganisms
- Animal welfare support in the beekeeping sector
- Support for regional active and ecotourism developments

Long-term conservation of Pannonian grasslands and associated habitats through the implementation of the strategic measures of the National Natura 2000 Priority Action Plan at an appropriate pace

Timeline: 2021-2026

The existence and restoration of healthy habitats and ecosystems through ecosystem services contribute significantly to influencing climate change through mitigation and increased adaptation options. The extent of restored grasslands: 2997 ha.

Soil protection program

Timeline: 2014-2025

Preventing soil erosion and improving soil management. By 2025, the following objectives are set in place:

- Percentage of agricultural land under management contracts to improve soil management and/or prevent soil erosion: 8,39%;
- Agricultural land under management contracts to improve soil management and/or prevent soil erosion: 393,071 ha;
- Percentage of forestry land under management contracts to improve soil management and/or prevent soil erosion: 0,77%;
- Forestry land under management contracts to improve soil management and/or prevent soil erosion: 15,800 ha.

CAP for "Supporting sustainable development and efficient management of natural resources such as water, soil and air, including by reducing dependence on chemicals"

Timeline: 2023-2027

The CAP-SO5 objectives in the field of "Supporting sustainable development and efficient management of natural resources – such as water, soil, and air – in part through reducing dependence on chemicals" include the following measures for the adaptation and risk management of agriculture:

- Agro-ecological program
- Investment within agricultural enterprises to improve water use efficiency
- Payments encouraging agro-ecological land use change
- Support for organic farming
- Agri-environmental management payments (AKG)
- Support for tree planting and afforestation investments
- Agro-ecological non-production investments
- Support for regional active and ecotourism developments

National strategy for biodiversity conservation

Timeline: 2023

The current national biodiversity strategy in place expired at the end of 2020 and needs to be reviewed and renewed in line with the EU Biodiversity Strategy to 2030 (COM(2020) 380 final) and the Global Framework Strategy for Biodiversity Conservation for the next decade. The Global Framework Strategy has been adopted by the 15th Conference of the Parties to the Convention on Biological Diversity in 2021. This is Hungary's 3rd National Biodiversity Strategy, which aims to restore preserve, and enhance ecosystems related to agriculture and forestry, and improve capacity for adaptation.

CAP interventions

Implemented: 2023

As a continuation of the rural development program, the CAP includes the same objectives as the interventions mentioned in the previous paragraph, with the addition of two important new environmentally ambitious elements, such as:

- Agro-Ecological programs (Eco-schemes)
- Conditionality: Good agricultural and environmental conditions, abbreviated as GAEC 1-8, refer to a set of conditions set out by the European Union aiming to achieve sustainable agriculture.

Includes:

- CAP interventions to develop animal husbandry farms (aims to improve energy efficiency and competitiveness and reduce emissions)
- CAP interventions to improve the condition of the environment (aims to increase climate-friendly farming practices and carbon sequestration)

Irrigation Development

Timeline: 2018-2030

The Hungarian Government started an irrigation development program in 2018 to increase the irrigated area by 100,000 hectares by 2030. Irrigation contributes to safe farming and yield increase. New irrigation systems will be built, and the irrigation drainage system will be renewed. In the framework of the Rural Development Program and the CAP farmers may apply for support to invest in irrigation (water efficiency is important). In 2020 a new law, the Act CXIII. on irrigation, farming took into force, and administrative burdens concerning irrigation were decreased.

II.D.2.6. LULUCF

National Forest Strategy

Timeline: 2016-2030

The National Forest Strategy's main goal is to continue the track on reaching goals for 2050 of the earlier National Forest Program 2006-2015, which was presented in the previous national communication. Its main goal is to reach at least 27% forest coverage in Hungary in 2050, which requires an annual afforestation of around 15 thousand ha. The Strategy refers to climate change mitigation by promoting forest biomass and protection of forests which directly affects CO2 emission reduction targets.

Country Afforestation Program

Timeline: 2020-2030

Under the national afforestation program, the Ministry of Agriculture and the Ministry of Innovation and Technology (its successor is the Ministry of Energy) agreed on a multi-annual afforestation program financed by the national CO₂-commerce surplus. The program organizes and finances the afforestation activity of the state-owned forestry companies as their afforestation activities are excluded from the EAFRD program financing. It increases the sink capacity of the country. Lower net GHG emissions through the development of forestry.

Climate and Nature Protection Action Plan - We plant ten trees for every newborn.

Timeline: 2020-2030

The fifth action point of the Climate and Environment Action Plan is: "We will plant ten trees for every newborn baby. It means one million trees a year". In 2020, the Ministry for Innovation and Technology handed over 2 billion HUF to the Ministry of Agriculture from the former Green Economy Financing System to support certain forest cover increasing measures of the action point and implementation of some measurements of the first National Climate Change Strategy. The overall aim is to plant one million trees per year (at least ten for every newborn baby) in order to increase the forest cover ratio to 27% by 2030. This action will effectively contribute to increasing the country's natural carbon-absorbing capacities. The expected implementation of the post-newborn afforestation program in a given year by 2030 is 11,755 tons of CO₂.

CAP for "Contributing to climate change mitigation and adaptation and promoting sustainable energy by, inter alia, reducing greenhouse gas emissions and increasing carbon sequestration"

Timeline: 2023-2027

The CAP-SO4 measures in the field of "Contribution to the mitigation of and adaption to climate change, as well as the promotion of sustainable energy, in part through the reduction of greenhouse gas emissions and increased carbon sequestration" include the following for the protection and development of the natural environment and natural carbon sinks:

- Agro-ecological program
- Payments encouraging agro-ecological land use change
- Maintenance and income support for tree planting investments
- Support for organic farming
- Agri-environmental management payments (AKG)
- Support for tree planting and afforestation investments
- Agro-ecological non-production investments
- For-profit investments supporting competitive forest management
- Non-profit investments promoting the environmental sustainability of forest management

- Collaboration-based support for the prevention and risk reduction of forest fires
- In situ conservation of plant genetic resources
- Ex-situ conservation of plant genetic resources and microorganisms
- Support for green investments in agricultural operations
- Development of agricultural enterprises to reduce ammonia emissions
- Support for green investments related to the value enhancement of agricultural products
- Rural development collaboration for the development of a biomass-based economy (Regional)
- Investment within agricultural enterprises to improve water use efficiency
- Support for agricultural irrigation communities to enhance water use efficiency
- Support for individual wastewater treatment solutions (municipal)
- Agricultural Risk Management System (MKR Pillar III): Digital transformation of the National Agricultural Hail Damage Mitigation System
- Support for rural infrastructure development in farmsteads
- Infrastructure development in rural areas (municipal)

The measure supports the measure "Methodological development of the measurement of agricultural emissions" (M16) of the National Climate Change Strategy.

Use of climate-resilient forest reproductive material

Timeline: 2021-2024

The National Afforestation Programme aims to increase and maintain forest cover, as well as improve the resilience of existing forests and restore them after damage. Priority will be given to natural regeneration and the use and promotion of indigenous reproductive material, including forest reproductive material from drier climatic regions south of Hungary, to adapt to changes in soil conditions caused by climate change. Additionally, more drought-tolerant species and ecotypes will be supported. It increases the sink capacity of the country, and lowers net GHG emission through the development of forestry.

II.D.2.7. Waste

Waste Legislation

The EU's 2008/98/EC directive on waste (Waste Framework Directive) defines the basic regulatory framework for waste management in the Member States. It prescribes the preparing for re-use and recycling rate of paper, metal, plastic, and glass waste from households to be at least 50% in mass by 2020, for construction waste the re-utilization preparing for re-use, re-utilization recycling, and other material recovery rate should be at least 70%. Diversion of waste

from landfills should be aided by the implementation of a separate waste collection system for glass, metal, plastic, and paper generated in households.

The Directive (EU) 2018/851 on the amendment of Directive 2008/98/EC on waste added new targets regarding waste management. The target value for the preparation for reuse and recycling of municipal waste until 2025: 55% (with derogation 50%), until 2030: 60% (with derogation 55%), until 2035: 65% (60% with derogation). In addition to the above, the basic requirements for the extended producer responsibility (EPR) system had to be met by January 5, 2023, and the mandatory separate collection of bio-waste from December 31, 2023, and textile waste and household hazardous waste from January 1, 2025 must be ensured.

According to the 31/1999/31/EC directive on the landfill of waste, the biodegradable municipal waste going to landfills must be reduced to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 should have been reduced by 1 July 2016 to 35 %. This meant a maximum of 820 000 tonnes for Hungary, which was successfully achieved.

Based on Directive (EU) 2018/850 on the amendment of Council Directive 1999/31/EC on landfills, the permitted disposal rate of municipal waste may be a maximum of 10% by 2035 (25% with derogation, 10% by 2040). Directive (EU) 2018/852 amending Directive 94/62/EC on packaging and packaging waste requires a compliance rate of 65% by 2025 and 70% by 2030 for the recycling of all packaging waste.

The current Hungarian regulations consider both the EU regulations and the international conventions, as well as the domestic strategic ideas and objectives. In line with the EU's objectives, the basic strategic objective of the domestic sector is to prevent the generation of waste and to increase the material recovery of all waste streams.

The Act CLXXXV of 2012 on waste became effective on the 1st of January 2013, which has implemented many concepts, principles, goals, and measures by transposing the Waste Framework Directive and renewing the Hungarian waste management sector. According to the law, by the implementation of waste management activities the waste hierarchy must be taken into account, in accordance with the principles of circular economy as well. The primary goal of the legislation is prevention, however – if under certain circumstances it is not possible – then preparing for re-use or recycling shall be applied, and waste may only be incinerated or disposed of if there is no other way around.

A landfilling tax is levied on almost all kinds of waste landfilled. The tax was increased to 6000 HUF per tonne in 2016 from 3000 HUF. Revenues from this tax are allocated for waste management purposes. In 2021, the directive provisions on the circular economy were transposed and the framework rules for the concession system (see below) were established at the legislative level:

- Act II of 2021 on the amendment of certain energy and waste management laws, which also includes amendments to stricter sanctions for illegal waste disposal and the establishment, tasks, and powers of the waste management authority, and
- Act LXVIII of 2021 on the amendment of certain energy and public service laws.

As regards the level of regulations, aiming to implement the circular economy is included in Government Decree No. 158/2021. (III. 31.) on the amendment of certain government decrees

in order to transition to a circular economy, and in ITM Decree No. 16/2021. (IV. 9.) on the necessary amendment of certain ministerial decrees in order to transition to a circular economy. The comprehensive review and transformation of the Hungarian waste management system aimed to facilitate the transition to a circular economy, and to create a waste management that promotes waste prevention, reuse, preparation of waste for reuse, recycling, and recovery.

Hungary has already implemented the extended producer responsibility provisions under the Waste Framework Directive in previous years. It promotes the design and manufacture of products that facilitate the efficient use of resources throughout their life cycle, including repair, reuse, dismantling, and recycling, thereby contributing to the circular economy objectives. The extended producer responsibility system in Hungary, which has been modified in line with the minimum requirements and expanded in terms of product scope set in the Waste Framework Directive, was launched in 2023.

A deposit-return system (DRS, in the framework of the concession system) has been introduced from January 1, 2024, for glass and plastic bottles, as well as metal cans. The aim of the system is to achieve the highest possible collection and recycling rate for waste generated from beverage packaging in order to meet EU targets.

Similarly to other EU countries, a separate collection of biodegradable waste (green kitchen waste and food waste) has begun in Hungary as of January 2024, based on the Waste Framework Directive. The aim of the regulation is to promote the production of compost and biogas from biodegradable waste that meets quality requirements and its use in a larger proportion and of high quality, thereby contributing to the transition to a circular economy.

National Waste Management Plan

Timeline: 2021-2027

The elaboration of the National Waste Management Plan (hereinafter: NWMP) is required by Directive 2008/98/EC on waste and Act CLXXXV of 2012 on waste, which transposes the directive into Hungarian legislation. The NWMP has been approved by the Government Decision No. 1704/2021. (X. 6.). Pursuant to the law, the national planning of waste management is carried out by creating the NWMP and the National Prevention Program (hereinafter: NPP) which is a part of it.

The NWMP for the period 2021-2027 is prepared for 7 years, in line with the financial programming period of the EU, given that eligibility conditions will be introduced in the next EU budget cycle. According to the Government Decision 2060/2019 on measures necessary to meet the eligibility conditions for the payment of EU cohesion funding for the period 2021-2027, the NWMP is the right condition for up-to-date waste management planning. The NWMP introduces the status quo of waste management in Hungary, describes the current state of treatment per waste stream, and defines the objectives to be achieved, as well as the instruments and measures necessary for their implementation. The targets set out in the NWMP contribute to reducing the amount of plastic waste generated annually, to the economic management of natural resources and to the promotion of the use of secondary raw materials.

In Hungary, a new concession model has been introduced in the waste management sector from July 1, 2023. According to the new model, a concession holder has a country-wide exclusive right and a public service obligation to receive, collect, transport, and pre-process municipal waste, together with those kinds of non-municipal waste streams that are covered by extended producer responsibility (EPR) systems or deposit-refund schemes. In the concession model, the concession holder is responsible for the fulfillment of the waste management targets set by the European Union, as well as for the establishment of separate collection systems for certain priority waste streams (biowaste, textile waste, household hazardous waste).

The main purpose of the introduction of a new concession model was to ensure the continuity of supply in the field of waste management by guaranteeing a smooth transition to a circular economy, in order to fully meet the waste management targets set by the European Union and the targets laid down in the EU waste directives for their concrete implementation.

The NWMP includes an analysis of the situation, a progress report based on the experience of the period 2010-2018, a policy strategy for waste management for the period 2021-2027, identifies the main problems related to waste management, sets out a vision for the future, the priorities based on this vision, and the areas of intervention, directions, and instruments. The main elements of the document are the Situation Assessment, the Action Programme, and the National Prevention Programme.

The Situation Assessment presents the current waste management situation in Hungary by waste stream, with a particular focus on the progress achieved during the period 2014-2020. The situation assessment covers the historical development of the volumes and treatment methods of the waste streams concerned, the expected changes in the planning period, the identification of typical, mainly general problems and shortcomings, and finally the definition of objectives (lines of action) in the light of the mandatory targets.

In line with the areas of intervention and lines of action identified based on the situation assessment, the Action Programme sets out the objectives and the short and long-term measures to achieve them, in many cases supported by target indicators, with an indication of the estimated resource requirements and possible funding opportunities.

Measures to prevent waste generation play a key role in the shift towards a circular economy. The National Prevention Programme provides a comprehensive overview of the current state of practice in waste prevention in the country and presents some good practice examples. Its main objective is to identify waste prevention objectives and propose measures and indicators for their implementation.

A separate set of measures for waste prevention is - as part of the NWMP - the National Waste Prevention Programme. This strives to achieve the goals of waste reduction by setting goals and proposing measures defined in such a way as to facilitate the realization of the desired condition as effectively as possible, thus setting indicators for traceability. The Programme aims to provide a comprehensive overview of the current state of domestic waste prevention practice and to present some good practices to be followed.

The National Waste Management Public Services Plan for 2022 (hereinafter: NWMPSP) was published with the ITM Regulation No. 1/2022. (I. 7.). The NWMPSP describes the current status of public waste management service in Hungary, and the related regulations, and also

lists the tasks of the public service providers. It also sets out the minimum requirements for the provision of a public waste management service that must be met by public service providers. The NWMPSP contains the objectives and development directions affecting the public service area, and the conditions for the development of the public service system components. The NWMPSP also has an impact on the municipalities and their associations responsible for providing public waste management services.

Extended producer responsibility (EPR) fee

Implemented: 2023

Extended producer responsibility (EPR) fee paid by producers gives the financial background for the collection and treatment of wastes from products under EPR (packaging, certain single-use plastic products, electric and electronic equipment, batteries, tires, vehicles, office paper, advertisement paper, cooking oil and fat, textiles, wooden furniture). It is also an incentive for producers to make their products produce less or less harmful waste.

Environmental Product Fee

Implemented: 2011

Hungary's environmental product fee was introduced in 2011, and it is perceived as an effective environmental management tool, which has favorable effects on domestic waste management processes. The regulatory advantage of this tool is its ability to stimulate the manufacture and marketing of environmentally favorable products and to restrict environmentally undesirable products. It is levied on batteries, packaging, other petroleum products, electronic equipment, tires, promotional flyers, other plastic products, other chemical products, and office paper. The generated revenue provides funding for the state to achieve EU targets related to recovery, and it supports the development of domestic waste recovery. Government Decree no. 343/2011 (XII. 29.) and Act LXXXV. of 2011 regulate the environmental product fee.

Sewage Sludge Treatment Strategy

Timeline: 2014-2023

Outlook period: until 2027

The strategy includes a 10-year (2014-2023) development plan for Hungary's sewage sludge management. It is divided into two phases. The first phase (National Sewage Sludge Treatment and Recovery Programme 2014-2017) primarily deals with the preparations for the different development tasks and management tools. The second phase (2018-2023) includes the implementation of these and the preparation and implementation of further developments. The strategy also gives a conceptual outlook until 2027. The main areas of action: 1. Capacity building corresponding to sludge utilization, application of more up-to-date technologies first in demonstration projects and then more widely. 2. Organising the efficient management of territorial sludge treatment. 3. Incentivising agricultural use of sludge through improving the

tools of farmers and management tools. 4. Enforcing strategic level planning when using recultivation areas 5. Ensuring and gradual building of energy recovery capacities 6. Management tools.

Operation of the extended producer responsibility system

Implemented: 2023

The aim of Government Decree 80/2023 (III.14.) on the detailed rules of the operation of the extended producer responsibility system is to increase the separate collection and recovery of circular products (packaging, certain single-use plastic products, electrical and electronic equipment, batteries, vehicles, tires, office paper, advertising paper, cooking oil, textile products, wooden furniture). It helps with the creation of a circular economy, and with the lower emission rate of GHGs through the development of the waste sector.

II.D.2.8. Water management

Jenő Kvassay Plan

Timeline: 2017-2030

As Hungary increasingly experiences the impacts of climate change on its water resources, prevention has an important role to play in the integrated management of agriculture, agrotechnology, industry, and water management issues, which, based on the division of responsibilities between government departments, involve several ministries. The Jenő Kvassay Plan, which was published in 2017, describes action until 2030, that aims to improve water management, including public utility sewage systems, the sewerage of settlements and regions and to increase the recovery rate of water in the settlement water management.

Water Protection Program

Timeline: 2014-2025

Focuses on restoring, preserving, and enhancing ecosystems related to agriculture and forestry, improving capacity for adaptation, and achieving the Member State's binding target for GHG emissions. By 2025, the following objectives are set in place:

- Percentage of agricultural land under management contracts to improve water management: 3,57%.
- Agricultural land under management contracts to improve water management: 167,257 ha.
- Percentage of forestry land under management contracts to improve water management: 0,59%.

Forestry land under management contracts to improve water management (ha)

Improving decision support for surface and groundwater resources: modelling, forecasting and risk analysis

Implemented: 2021

Water resources are distributed unevenly in space and time, which can lead to conflicts among water users, particularly due to climate change. Currently, some areas are experiencing pressure on water resource management. Water is a publicly-owned, renewable but finite resource, and its responsible management requires decision-support systems. Modeling water resources is a useful tool for maintaining a balance between water demand and supply. We currently have 48 operating surface and 6 underground model areas.

Development of agricultural water supply works

Timeline: 2021-2023

The temporal and spatial variability and extremes of water balance continue to gradually increase due to climate change, making our country increasingly exposed to the risk of inland water and drought, especially since barely more than 2% of its arable land is covered by water recharge systems. Irrigated farming is an effective response to one of the biggest challenges to agricultural production, the effects of climate change, and offers the possibility of growing crops with higher production value. Therefore, the Government will continue to prioritize the dissemination and promotion of irrigated farming and better use of existing opportunities. The development of irrigation also contributes significantly to the ecological water replenishment of the areas under development.

Further development of a water scarcity monitoring system

Implementation: 2021

The most significant projected consequence of climate change for agriculture is the projected reduction in average rainfall during the growing season. The Operational Water Scarcity Assessment and Forecasting System is primarily for water management purposes, but its data can also be used by farmers. It provides information on the extent of water scarcity, predicts its evolution and helps to plan irrigation. We expand the network according to available resources. In 2023, we expanded the number of stations by 5 stations. Focuses on restoring, preserving, and enhancing ecosystems related to agriculture and forestry, improving capacity for adaptation.

Reducing climate-related risks to natural bathing waters

Timeline: 2021-2023

Climate change-induced weather events such as flash floods, extreme rainfall events, droughts, and rising summer water temperatures can have a detrimental impact on the quality of natural bathing waters. Flash floods and extreme rainfall events have the potential to wash pollution

from the shore or cause sewage overflows into combined sewage collection systems. During periods of drought, dilution and natural self-cleansing are reduced. This, combined with rising water temperatures, can lead to the emergence and survival of new pathogens in the water. To protect bathers' health, it is necessary to better understand the risks and events that trigger them. Based on this knowledge, a water quality prediction system should be developed. The current system, which is based on water quality testing, is only suitable for detecting pollution after it has occurred. The evaluation of the tests is also in progress.

II.D.2.9. Research

Pilot projects for climate adaptation in cooperation between cities and local industries

Timeline: 2021-2024

In Hungary, large areas of cities were transformed into industrial zones during the 20th century and in recent decades. However, there is no cooperation between city administrations and industrial enterprises beyond the economic linkages, and this is particularly true for mitigation and adaptation to climate change. In order to adapt to, prepare for, and mitigate the already unavoidable impacts of climate change, there is a need to identify opportunities for action and to take exemplary steps through concrete cooperation.

- Number of joint adaptation plan documents developed: 2
- Number of small-scale nature-based adaptation measures implemented: 6
- Number of smart adaptation tools developed and tested: 5

II.E. Summary of greenhouse gas emissions and removals

Hungary has submitted a stand-alone national inventory report. In line with paragraph 91 of the Annex to Decision 18/CMA.1, a summary of our GHG emissions and removals is provided in tabular format.

Base year = average of 1985-1987

IPPU = Industrial processes and product use

	ENERGY	IPPU	AGRICULTURE	LULUCF	WASTE	TOTAL
Base year	80,633	14,563	11,971	-2,360	3,519	108,327
1990	69,481	11,387	9,968	-3,293	4,079	91,622
1991	68,138	7,851	8,538	-2,458	4,177	86,246
1992	60,947	6,222	7,315	-2,986	4,236	75,734

1993	61,470	7,018	6,422	-5,626	4,303	73,587
1994	59,705	8,439	6,239	-6,243	4,351	72,491
1995	59,089	8,076	5,961	-6,260	4,407	71,274
1996	61,015	8,372	5,968	-2,608	4,429	77,176
1997	60,208	7,738	5,928	-3,067	4,491	75,299
1998	59,883	7,330	6,097	-4,156	4,554	73,709
1999	60,186	7,197	6,163	-1,930	4,632	76,249
2000	56,594	7,980	6,053	-1,051	4,724	74,300
2001	58,367	7,889	6,193	-2,701	4,743	74,492
2002	57,149	7,375	6,212	-2,002	4,861	73,596
2003	60,015	7,540	6,062	-4,382	4,960	74,196
2004	58,036	8,210	6,286	-3,425	4,938	74,044
2005	57,516	8,906	5,985	-5,953	4,965	71,419
2006	56,476	8,555	5,929	-4,026	4,921	71,854
2007	54,967	8,416	5,908	-4,313	4,916	69,896
2008	54,053	7,335	5,918	-6,022	4,852	66,136
2009	49,348	6,371	5,587	-4,545	4,852	61,614
2010	49,861	6,579	5,518	-4,636	4,848	62,170
2011	48,031	6,758	5,700	-4,124	4,657	61,022
2012	44,929	6,485	5,755	-4,674	4,704	57,200
2013	42,408	5,869	6,110	-4,027	4,496	54,856
2014	41,894	6,589	6,335	-5,054	4,405	54,169
2015	44,443	7,132	6,547	-5,653	4,280	56,749
2016	45,259	6,732	6,857	-4,534	4,185	58,499
2017	46,910	7,248	6,865	-5,314	4,197	59,906
2018	46,604	7,486	6,912	-4,784	4,175	60,394
2019	46,482	7,384	6,901	-5,363	4,167	59,572
2020	44,336	7,384	7,098	-7,076	4,121	55,863

2021	45,652	7,161	7,120	-7,171	4,083	56,846
2022	43,507	5,965	6,186	-6,773	4,070	52,955
2023	38,744	5,543	5,998	-5,811	4,028	48,502

Table 16.1. Greenhouse gas emissions and removals, by sector (with LULUCF, kt CO₂-eq)
Source: HungaroMet

	CO₂	CH₄	N₂O	HFCs	PFCs	SF₆	TOTAL
Base year	85,974	14,484	9,889	0	333	8	110,687
1990	73,427	13,694	7,438	0	338	18	94,915
1991	69,825	13,508	5,047	14	291	19	88,704
1992	62,281	12,291	3,939	23	162	25	78,720
1993	62,991	11,880	4,106	24	175	36	79,213
1994	61,880	11,632	4,958	28	191	45	78,733
1995	61,464	11,563	4,216	33	200	58	77,534
1996	63,083	11,662	4,738	39	191	71	79,784
1997	61,676	11,615	4,741	55	191	88	78,366
1998	61,255	11,516	4,674	84	234	101	77,864
1999	61,575	11,588	4,524	155	254	82	78,179
2000	58,244	11,711	4,853	197	254	92	75,351
2001	59,828	11,542	5,246	247	240	91	77,193
2002	58,842	11,447	4,649	341	244	74	75,598
2003	61,611	11,572	4,612	469	229	85	78,578
2004	59,985	11,209	5,319	611	243	102	77,470
2005	60,142	11,011	5,086	780	253	100	77,372
2006	59,529	10,449	4,851	935	4	112	75,880
2007	58,449	10,198	4,383	1,063	5	111	74,209
2008	57,184	9,920	3,750	1,203	6	95	72,158
2009	51,458	9,817	3,492	1,298	6	88	66,158

2010	51,993	9,827	3,476	1,400	6	103	66,806
2011	50,156	9,696	3,646	1,553	6	88	65,146
2012	46,720	9,818	3,596	1,645	6	88	61,873
2013	43,487	9,660	3,900	1,720	6	109	58,883
2014	43,639	9,455	4,118	1,920	6	86	59,223
2015	46,567	9,490	4,213	2,010	6	117	62,403
2016	47,039	9,416	4,477	1,962	6	133	63,033
2017	49,424	9,434	4,477	1,764	1	121	65,220
2018	49,366	9,357	4,544	1,806	2	103	65,177
2019	49,159	9,283	4,538	1,848	2	105	64,935
2020	47,105	9,190	4,673	1,853	2	116	62,939
2021	48,326	9,034	4,701	1,847	2	107	64,017
2022	45,267	8,674	3,890	1,784	2	110	59,728
2023	40,344	8,334	3,819	1,698	3	116	54,313

Table 16.2. Greenhouse gas emissions and removals, by gas (without LULUCF, kt CO₂-eq)
Source: HungaroMet

II.F. Projections of greenhouse gas emissions and removals

This chapter is based on the final updated **National Energy and Climate Plan of Hungary** submitted to the European Commission in October 2024.¹⁴

II.F.1. Greenhouse gas emissions and removals

II.F.1.1. ESR and LULUCF targets

Within the set EU and domestic targets, the **Effort Sharing Regulation (ESR)** sets national emission reduction targets¹⁵ in the so-called ESS sector (for non-ETS emissions) in proportion to GDP per capita. Hungary should **achieve a GHG emission reduction of at least 18.7%** by

¹⁴ *Final updated National Energy and Climate Plan of Hungary:*

https://commission.europa.eu/publications/hungary-final-updated-necp-2021-2030-submitted-2024_en

¹⁵ Regulation (EU) 2018/842 (<https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:02018R0842-20230516>)

2030 compared to 2005 as the base year **for the ESR sector**: domestic transport (excluding aviation), buildings, agriculture, "small industry" and waste management.

This means that it will have to reduce its emissions from **47.2 million tonnes of CO₂e to 38.3 million tonnes of CO₂e**, keeping a linear reduction trajectory in line with the Regulation.

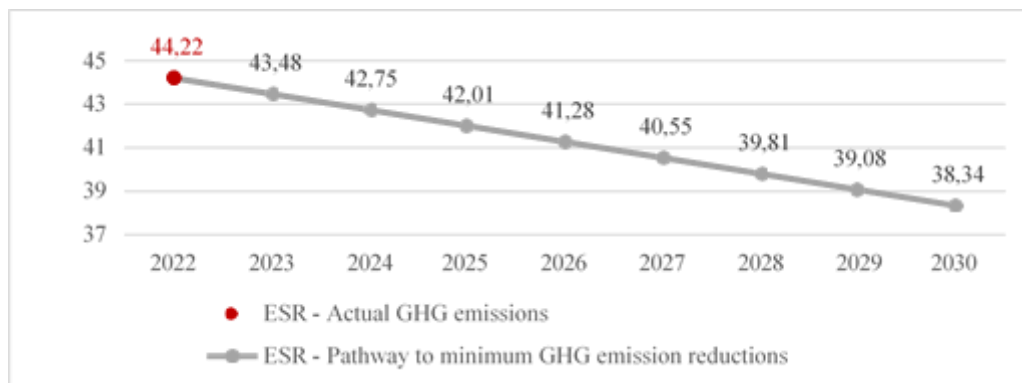


Figure 24. Calculated GHG emission limits in the ESS sector up to 2030 (based on 2022 actual data; million tonnes (CO₂e/year)

Facts: [Greenhouse gas emissions under the Effort Sharing Legislation \(europa.eu\)](https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&plugin=1)

The LULUCF Regulation requires each Member State to ensure that greenhouse gas emissions do not exceed removals in the land use, land use change and forestry (LULUCF) sector and, taking into account flexibilities, to meet its 2030 greenhouse gas removal target. Hungary has set a target for GHG removals to reach -5.724 Mt CO₂e per year by 2030 in the LULUCF sector. Absorption in 2021 was an outlier (-7.2 million t CO₂e), meaning that it is necessary to maintain and improve removals compared to the average capacity of natural sinks (~5 Mt). The decreasing absorption capacity is partly due to natural processes in vegetation, which have increased due to the negative effects of climate change. In order to maintain and enhance our natural CO₂ sinks, in line with the National Forest Strategy and taking into account the Do No Significant Harm (DNSH) principle, we intend to significantly increase the share of forest and other woodland cover by 2030 (to 27%) where it does not cause adverse impacts in other directions, such as water balance, soil strength and biodiversity.

II.F.1.2. Other national objectives and targets consistent with the Paris Agreement and existing long-term strategies

Hungary's greenhouse gas emission reduction targets are in line with EU and international commitments. Hungary has set itself the objective of achieving climate neutrality by 2050, which was confirmed in *Act XLIV of 2020 on climate protection*. Alternative avenues for achieving climate neutrality in 2050 are outlined in the *National Clean Development Strategy (NTFS)*¹⁶. In order to achieve climate neutrality, following the scheduled progress, Hungary aims to reduce its gross GHG emissions by at least 50%, to 47.5 million t CO₂e¹⁷, by 2030 compared to 1990.

¹⁶ https://unfccc.int/sites/default/files/resource/LTS_1_Hungary_2021_EN.pdf

¹⁷ Without international aviation. Including aviation, 47.75 million t CO₂e.

In the case of Hungary, carbon dioxide (CO₂) is the most significant (~76% in 2021) and the most widely emitted greenhouse gas affecting all sectors, which is why we focus our actions predominantly on this GHG. These measures will also help to reduce emissions of non-CO₂-GHGs incidentally and to further reduce them through additional measures, e.g. fluorinated gas emissions linked to industrial processes (F-gases; 3% of GHG emissions), nitrous oxide emissions primarily related to agriculture (N₂O; 7% of GHG emissions) and methane emissions (CH₄; 14% of GHG emissions), which are almost equally linked to waste management, agriculture and the energy sector. On the demand side, the *National Hydrogen Strategy* focuses not only on certain segments of transport, but also on industry. One of the objectives is to use a significant part of the produced – 16 000 tonnes of carbon-free and 20 000 tonnes of low-carbon hydrogen in industry, primarily to replace grey hydrogen, thus contributing to the decarbonisation of processes in ammonia production, petroleum refining, petrochemicals and possibly the steel industry. According to REDIII, 42% of hydrogen used as industrial feedstock needs to be replaced by RFNBO by 2030 and 60% by 2035. To meet this demand for hydrogen, there is a significant need for imports, for which supply chain needs to be established as soon as possible, taking into account the long-term cost-effective modes of transport.

Our goal is to reduce the GHG intensity of the Hungarian economy, i.e. to further reduce the GHG emissions associated with the production of unit of GDP, from 1.37 tCO₂e/million HUF in 2021. The reduction and offsetting of GHG emissions by businesses is also directly encouraged by the EU Emissions Trading Scheme (EU ETS) and the ESG law stemming from EU law¹⁸. In the case of installations covered by the EU ETS, the expected rising price of the carbon quota and, in the case of undertakings subject to the ESG Act, the establishment and implementation of emission reduction action plans are encouraged on the one hand by reputation and, on the other hand, by making activities more transparent according to sustainability, in addition to which investors are guided by the directions set by the national energy and climate policy target system.

To reduce GHG emissions and GHG intensity, the decarbonisation of the energy industry is of paramount importance. One of the most important decarbonisation tasks is the transformation of the lignite-fired Mátra power plant based on low-carbon technologies, thereby phasing out coal and lignite combustion from domestic electricity generation by 2029 at the latest. The Mátra Power Plant is a strategically important basic power plant of the Hungarian electricity system, but it is also one of the largest greenhouse gas emitters in Hungary (3.2 million t CO₂e/year), which in 2021 accounted for 33% of the total energy production sector's emissions, thus 5% of the total domestic greenhouse gas emissions.

In December 2022, a decision was taken to further extend the operating time of the existing units of the Paks Nuclear Power Plant (Paks I.)¹⁹, which serves the country's energy sovereignty, climate protection and security of supply objectives. On this basis, the preparatory activities necessary for the administrative authorisation procedure for the further extension of the operating time can start. Preparatory activities can take 9-10 years, based on the experience of previous service life extensions. In addition, in the next decade, the Paks II. A nuclear power plant can also produce two units with a capacity of 1.2 GW per unit, so the six units together

¹⁸ Act CVIII of 2023 on the rules of corporate social responsibility taking into account environmental, social and social aspects and amending other related acts to promote sustainable finance and unified corporate responsibility

¹⁹ 56/2022. (XII. 8.) OGY resolution

represent 4.4 GW of power and a huge decarbonisation potential for Hungary. In addition to the above, we plan to reduce the share of natural gas in the energy mix.

Significantly increase the share of forest and other tree cover. However, it is not expected that we will be able to meet the increasing GHG emission reduction targets at a later stage without artificial neutralisation tools. Currently, the most mature technology capable of artificial absorption/neutralisation is the CCS group (CC(U)S). Without CCUS, or its future alternative, climate neutrality does not seem feasible at present. There are activities and industries of particular importance, such as energy production, metals, petroleum or mineral industries, which, both in terms of their energy use and industrial processes, are, according to current knowledge, unsuitable for decarbonisation and full implementation of decarbonisation, but at the same time are indispensable for decades from the point of view of the economy and society. CCUS, according to our current knowledge, is the technology that should be planned in the future for capturing GHG emissions that will remain after the implementation of all emission reduction and removal options that are more cost- and energy-efficient than CCUS. However, this goal is influenced by the regulation-level legislation *on Net Zero Emission Industry* (NZIA) and the *strategy on carbon farming*, in connection with which it will be necessary to prepare surveys and analyses based on domestic opportunities and constraints in the future. In the interest of efficient pore space utilization, in the case of given geological formations, it is necessary to take into account the utilization options, surface possibilities and limitations. Priority can be the utilization of geothermal energy, storage of carbon dioxide, storage of hydrogen, mining of dissolved metal fluid (and in the case of other porusters, this also includes the increased efficiency of hydrocarbon extraction). The choice between different technologies to be used for climate neutrality is necessary, also in view of the difficulties in developing new markets and supply chains. In view of this, it is essential to plan the development of complex solutions, which can be achieved by targeted regulatory and financial means.

In addition to the above, it is particularly important for Hungary to promote adaptation to the effects of climate change, the global goal of which and the balance between mitigation and adaptation measures are determined by the Paris Agreement. The module of the NCCS-2 *National Adaptation Strategy (NAS)* defines an adaptation vision, comprehensive and specific strategic goals in connection with the domestic climate adaptation, which include, among others, protecting and restoring ecosystems, the sustainable utilization of natural resources, helping the specific adaptation of vulnerable areas, managing increasing risks, mitigating the expected social impacts, and supporting research and innovations.

II.F.2. Renewable energy

II.F.2.1. Estimated trajectory for renewable share (RES)

Increase the share of renewables in gross final energy consumption to 30% by 2030, from 14% in 2021. The indicative trajectories calculated on the basis of the *Governance Regulation* are set out in the following chapters, along the cornerstones of the WAM projections corresponding to the sectoral discussions.

	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
--	-------	-------	------	------	------	------	------	------	------	------

RES appropriation	14%	15%	17%	20%	22%	23%	25%	26%	28%	30%
--------------------------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 17. Indicative timeline: Estimated national trajectory for the share of renewable energy in gross final energy consumption 2021-2030 (%)

(Data: MEKH, Eurostat)

Hungary plans to meet the 30% target by achieving the sub-targets for the electricity sector, heating and cooling and transport described in the following chapters.

II.F.2.2. Estimated national trajectories for the sectorial share of renewable energy in final energy consumption from 2021 to 2030 in the electricity, heating and cooling and transport sectors

The indicative trajectories calculated under the Governance Regulation for the electricity (RES-E), heating and cooling (RES-H) and transport (RES-T) sectors are as follows.

	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Appropriation RES-E	14%	15%	17%	19%	20%	23%	25%	27%	29%	32%
RES-H&C appropriation	18%	20%	22%	23%	24%	25%	27%	29%	30%	32%
RES-T allocation with multiplier**	10%	10%	13%	16%	17%	19%	20%	22%	24%	25%

Table 18. Indicative timeline: Estimated national trajectory for the share of renewable energy in gross final energy consumption by sector from 2021 to 2030 (%)

(Actual data: MEKH, Eurostat)

II.F.2.3. Estimated trajectories by renewable energy technology

The indicative trajectories calculated under the Governance Regulation are as follows for the electricity, heating and cooling and transport sectors.

Renewable energy consumption (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	0,6	0,6	0,8	1,0	1,2	1,3	1,3	1,4	1,5	1,5
Heating and cooling	1,9	2,0	2,1	2,3	2,4	2,5	2,6	2,8	2,9	3,0

Transport**	0,3	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,5	0,5
Total	2,8	2,9	3,3	3,6	3,9	4,1	4,4	4,6	4,9	5,1

Table 19. Indicative timeline: Use of renewable energy sources by sector, 2021-2030 (Mtoe/year)
(Actual data: MEKH, Eurostat)²⁰

II.F.2.4. Electricity

Taking into account domestic conditions and needs, as well as the future regional capacity portfolio, Hungary focuses on the expansion of solar power generation, among other small renewable capacities, as illustrated in the table below.

Renewable electricity generation (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Solid biomass	0,14	0,13	0,16	0,19	0,23	0,21	0,18	0,16	0,14	0,11
Waste	0,01	0,01	0,01	0,02	0,02	0,02	0,02	0,01	0,01	0,01
Biogas	0,01	0,01	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,03
PV	0,33	0,41	0,52	0,63	0,75	0,82	0,90	0,98	1,06	1,14
Wind	0,06	0,06	0,08	0,10	0,13	0,14	0,16	0,18	0,19	0,21
Other**	0,02	0,02	0,03	0,03	0,04	0,04	0,04	0,05	0,05	0,05
Total	0,6	0,6	0,8	1,0	1,2	1,3	1,3	1,4	1,5	1,5

Table 20. Indicative timeline: Renewable electricity generation, by technology (Mtoe/year)
(Actual data: MEKH, Eurostat)²¹

The previous solar capacity target for 2030 (6 GW) was met 5 years earlier than expected, allowing us to increase solar capacity from around 6.8 GW today to nearly 12 GW by 2030. An expansion is also expected for wind turbines, with capacity expected to increase from around 0.33 GW to 1 GW. In addition, we will increase the volume of hydro- and geothermal electricity generation capacities, while reducing biomass capacities. This is illustrated in the following table.

Renewable electricity generation capacity (MW)	2021*	2022*	2 023	2 024	2 025	2 026	2 027	2 028	2 029	2 030
Biomass	438	424	437	450	464	417	371	324	278	232
Biogas	85	84	97	111	124	124	124	124	124	124

²⁰ Note: *Your Fact **Without Multiplier

²¹ Note: *Your fact, **Other than: Water and geothermal

PV	2 968	4 235	5 456	6 676	7 897	8 718	9 538	10 359	11 179	12 000
Wind	324	324	434	545	655	740	825	910	995	1 080
Other**	63	63	70	78	85	90	95	100	105	110
Total	3 878	5 130	6 495	7 860	9 225	10 089	10 953	11 817	12 681	13 546

Table 21. Indicative timeline: Electricity generation capacities installed for the use of renewable energy sources, by technology (MW)

(Actuality: Eurostat)²²

II.F.2.5. Heating and cooling

In the heating and cooling sector, in line with the *Renewable Energy Directive (REDIII)*, we will increase the share of renewable energy (RES-H/C) by 1% points between 2021 and 2025 and by at least 1.3% points per year between 2026 and 2030, by increasing the amount and share of biomass and geothermal, including waste heat and renewable electricity.

For district heating, the share of renewable energy, including renewable electricity, and waste heat and cold (RES-DH) in heating and cooling is increased by an average of 2.2% per year. We plan to achieve the reduction of the share of covered gas in the source mix of district heating by using biomass and by exploiting geothermal heat energy more and more extensively (preferably cascade-based), as well as in an environmentally sustainable manner. Furthermore, we intend to encourage the use of heat pumps in district heating if the systems are also adapted to integrate the technology. Our goal is to reduce the share of natural gas in district heating to 50% by 2030. This is where the utilization of the energy content of shallow-geothermia (areas below 30 °C close to the surface) and deep-geothermia (thermal waters above 30 °C) provides support for both individual and district heating services.

We support the efficient use of biomass in households and see a high potential for the use of ambient heat and shallow geothermal energy through heat pumps, therefore we plan to continue to provide incentives for the deployment of heat pumps – and complementary small renewable power plants – and for the efficient replacement of biomass boilers, in particular through our modernisation and greening programmes. Heat pump utilization of shallow geothermal energy (e.g. with soil probes) can serve not only heating, but also cooling and domestic hot water production for both the population and businesses.

Renewable based heating and cooling (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Biogas	0,02	0,03	0,03	0,03	0,03	0,04	0,05	0,07	0,08	0,10
Solid biomass	1,72	1,66	1,73	1,80	1,87	1,90	1,92	1,95	1,96	1,97

²² Note: *Your fact, **Other than: Water and geothermal

Geothermal	0,14	0,15	0,18	0,20	0,22	0,24	0,25	0,27	0,28	0,29
Solar thermal energy	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Renewable waste	0,03	0,04	0,04	0,04	0,04	0,03	0,03	0,03	0,03	0,02
Heat pump - Ambient/Ground Heat**	0,02	0,08	0,15	0,22	0,30	0,36	0,41	0,47	0,52	0,58
Total	1,9	2,0	2,1	2,3	2,5	2,6	2,7	2,8	2,9	3,0

Table 22. Indicative timeline: Use of renewable energy sources in heating and cooling (Mtoe/year)

(Actual data: MEKH, Eurostat)²³

In the case of capacities required for renewable-based heat supply, we encourage new deployment for all technologies, however, we expect solar thermal capacities to decrease, considering that its efficiency is questionable compared to other systems.

With regard to district heating, our aim is that, in the longer term, the majority of domestic district heating services and, in the medium term, at least the district heating systems of municipalities where the amount of district heating supplied to the network at municipal level reaches 100 000 GJ should fall into the category of ‘efficient district heating and cooling under the EU Energy Efficiency Directive. This can substantially reduce primary energy consumption and GHG emissions associated with buildings. Efficiency already in the short term under the Directive requires district heating/cooling using at least 50% renewable energy, 50% waste heat, 75% cogeneration heat or a 50% combination of such energy sources. From 2027 onwards, the shares will be progressively tightened.

II.F.2.6. Transport

Hungary has set a target to increase the share of renewable energy in the transport sector by 2030. To achieve this target, Hungary will increase the share of second generation (or advanced) biofuels and biogas to at least 4.5% and the share of renewable transport fuel of non-biological origin to at least 1% in the final energy consumption of transport by 2030. The share of first-generation food and feed crop-based biofuels will not increase beyond 2020 levels (2030: 3%). Furthermore, we plan to collect and use used cooking oil more efficiently, thus increasing its share in transport. The remaining part needed to reach the target of at least 25% renewable share is planned to be achieved through a significant increase in the use of electricity and hydrogen for transport. The indicative transport fuel consumption schedule is shown in the table below.

²³ Actual data, **Average total heat output calculated at 3.5 COP. Taken into account for electricity consumption

Renewable transport (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Used cooking oil	0,16	0,12	0,13	0,13	0,14	0,13	0,13	0,12	0,12	0,11
First generation biofuels	0,13	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12
2nd generation biofuels	0,00	0,04	0,04	0,04	0,04	0,09	0,12	0,19	0,24	0,29
Renewable-based hydrogen	-	-	-	-	-	0,00	0,01	0,01	0,02	0,02
Renewable road electricity**	0,001	0,001	0,002	0,003	0,004	0,014	0,024	0,034	0,044	0,054
Renewable-based railway electricity**	0,010	0,01	0,02	0,03	0,03	0,03	0,04	0,04	0,04	0,04
Total (without mult.)	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,5	0,6	0,6
Total (with multiplier)	0,3	0,3	0,4	0,4	0,4	0,5	0,6	0,8	1,0	1,1

Table 23. Renewable energy consumption in transport by fuel (Mtoe/year) (Data: MEKH, Eurostat)²⁴

In 2021, Hungary's *National Hydrogen Strategy* was adopted, which sets a target of producing 16 000 tonnes of 'carbon-free' and 20 000 tonnes of 'low-carbon' hydrogen by 2030, with 240 MW of water-dissolving capacity to be installed. The draft Renewable Fuel Directive foresees a significantly higher demand for *so-called renewable fuels of non- biological origin* (RFNBO) by 2030, which the country would cover to a significant extent from imports, through the pipeline system(s) planned to be built in the future. On the demand side, the Hydrogen Strategy focuses on hard-to-decarbonise transport segments and industry (mainly, but not exclusively, grey hydrogen industries). In order to reduce GHG emissions from the transport sector, a target of 4 800 fuel cell vehicles, mainly buses and vans, will be included in domestic road transport by 2030. The development of on-road recharging infrastructure is also planned to support hydrogen supply.

II.F.2.7. Estimated trajectories for bioenergy demand

Demand

In 2021, Hungary's primary bioenergy consumption (solid biomass, biogas and transport biofuels) amounted to 2.7 Mtoe, while the final bioenergy consumption at the same time was

2.3 Mtoe, two thirds of which was household consumption (1.4 Mtoe direct combustion and 0.12 Mtoe secondary energy use). Overall, considering the total stock of bioenergy, Hungary is a net exporter, so in terms of its supply, the amount of domestic resources is suitable to meet the current bioenergy needs.

²⁴ Note: Data plate without taking into account multipliers; *Your fact; **Included in electricity consumption

The use of bioenergy is essential for the scheduled increase in the share of renewable energy. According to our calculations, sustainable bioenergy use could increase by 2030, driven by the increasing role of biofuel in heat production and transport fuel use, according to the above schedules.

The field of energy and climate policy, in coordination with the fields of agriculture and forestry, concluded, with regard to bioenergy, that the potential of the available domestic bioenergy sources is suitable for meeting the higher energy resource demand in the future, taking into account the natural environment and the maintenance of the sink capacity of the LULUCF sector, the nutrient supply of the soils and the multifaceted energy needs.

Accordingly, in addition to the projections taking into account this limit, the bioenergy consumption rate for 2030 was adopted, as shown in the table below.

Bioenergy consumption (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Electricity sector	0,2	0,1	0,2	0,2	0,3	0,3	0,2	0,2	0,2	0,2
Heating and cooling sector	1,8	1,7	1,8	1,9	1,9	2,0	2,0	2,1	2,1	2,2
Transport sector	0,3	0,3	0,3	0,3	0,3	0,4	0,4	0,5	0,5	0,6
Total	2,2	2,2	2,3	2,4	2,5	2,6	2,7	2,7	2,8	2,9

Table 24. Bioenergy consumption by sector based on the WAM scenario (Mtoe/year)²⁵

The use of bioenergy is beneficial for Hungary in several respects, mainly in terms of the possibilities of biogas. Biogas plants can be suitable for the recovery of a number of types of waste, while providing a renewable energy source suitable for the production of electricity lines (balancing energy sources), and their by-products can count as valuable nutrient substitutes. Biomethane is also suitable for other, versatile industrial uses. By increasing the importance of biogas/biomethane use, the share of biomass use in electricity production may decrease. In this way, inter alia, forest growth can continue to provide the amount of biomass planned to be harvested in the context of sustainable forest management, including those used for energy purposes.

Supply

Determining the supply parameters for projections of bioenergy use is essential given the supply constraints of resources and their multi-purpose potential. Potential estimates of bioenergy

²⁵ Note: Resource-disaggregated data on final energy consumption are provided in the previous chapter; *Your fact (MEKH; Eurostat)

resources and related agri-economic and forestry plans and strategies include targets and measures for sustainable management that meet regulatory requirements and natural constraints for agriculture, animal husbandry, forestry and land use.

Most of the primary solid biomass used for energy purposes is provided by our forests. In addition to woody biomass, herbaceous agricultural biomass (typically cereal straw) accounts for only a few percent of energy recovery, and the amount of raw materials used is decreasing. These resources can be used as feedstock for biogas plants.

II.F.2.8. Biogas - Potential of agricultural raw materials

Based on the related agricultural economic scenarios, between 16 % and 32 % of the total estimated technical potential of primary resources, mainly animal manure and, to a lesser extent, crop by-products and manufacturing by-products, and possibly energy crops and secondary crops, can be used to produce biogas according to current knowledge. During the anaerobic fermentation of these raw materials, it is estimated that they may allow the production of ~300-800 Mm³ biogas, which is illustrated in the figure below. It has a total biomethane content of 150-400 Mm³. The wide intervals, i.e. the ‘realistic’ and ‘optimistic’ scenarios, are due to differences in the intensity of support policy, circular economy and, above all, agro-economic opportunities and measures. Therefore, the national conceptual treatment of biogas production is significant, according to which it is possible to produce ~600 Mm³ of biogas per year by 2030. Of this, 260 Mm³ is expected to increase direct biogas use and ~340 Mm³ biogas can be used to produce ~184 Mm³ biomethane.

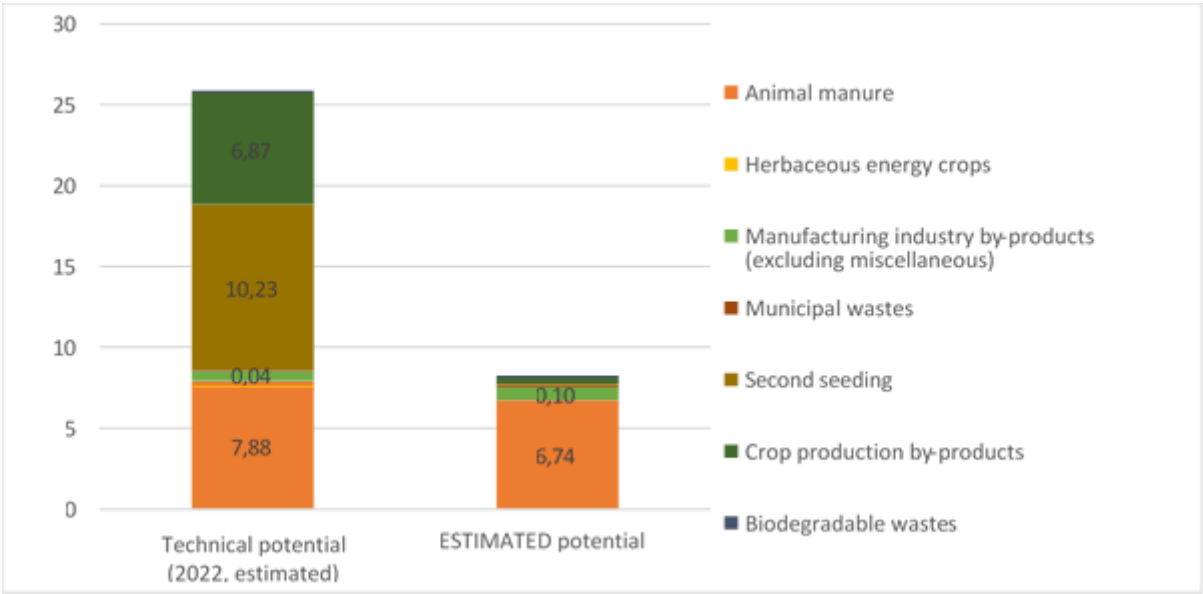


Figure 25. Potential of agricultural and other feedstocks for use in biogas plants (Mt/year)

Source: Based on AKI (Insitute of Agricultural Economics) and IFUA estimates

The applicability of the technical potential of the biogas feedstock is therefore limited. The optimal input of raw materials determined on the basis of the raw material potential assessment is influenced by the demand of agricultural management beyond the territorial limit of the raw

material. In the case of certain feedstocks, it is necessary to include the optimistic quantity (according to expert estimation, based on our current knowledge, with appropriate financing support) by 2030, in order to achieve the share of renewable energy in a diversified manner as soon as possible. However, due to the limited feedstock, it is necessary to review the availability of biogas feedstock and the potential for additional feedstock input from 2030 onwards, in the light of demand and supply conditions and technological developments, with the agreement of the agricultural and energy fields.

II.F.2.9. Biomass - Woody biomass supply potential

Determining the annual logging volume of state forest holdings is an ecological issue. The planning of logging in accordance with the objectives of forest maintenance and forest management and ensuring the sustainability of forest management, which generates the need for their resources, is carried out in several stages. The basis is ten-year forest plans, on the basis of which three-year strategic plans and annual plans are drawn up.

The sustainable supply of biomass to the domestic forest stock, taking into account the sink capacity of the LULUCF sector, is ensured in accordance with the current regulations. In the forests of our country, in the framework of district forest planning, the possibilities of utilization bearing in mind the requirement of sustainability are determined, with the exception of freely disposable forests. The related information is provided in the following tables.

Stock types (ha)	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050
Acacia	2 504	2 550	1 800	2 450	2 450	2 350	2 200	2 050	1 900	1 750
Oak	2 309	4 143	2 200	1 750	1 750	1 750	1 625	1 500	1 375	1 250
Domestic summer and other soft leafy	787	705	380	1 400	1 400	1 400	1 300	1 200	1 100	1 000
Shrubs and other hard leafy	1 633	1 689	1 400	1 050	1 050	1 050	975	900	825	750
Noble summers and white willow	325	432	710	1 050	1 050	950	900	850	800	750
Pine and black pine	16	6	10	-	-	-	-	-	-	-
Spruce and other pine and beech	-	-	-	-	-	-	-	-	-	-
Total	7 574	9 525	6 500	7 700	7 700	7 500	7 000	6 500	6 000	5 500
Net GHG balance (Mt CO₂/year)	-0,01	-0,03	-0,09	-0,16	-0,25	-0,82	-1,23	-1,55	-1,62	-1,87

Table 25. Expected annual evolution of afforestation by tree stand type and removals by WAM (hectares/year, Mt CO₂e²⁶)

Source: SOE-ERTI (University of Sopron, Forest Research Institute)

²⁶ Including plantations for traditional forestry and industrial purposes

	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050
Logging	6 580	7 523	7 598	7 598	7 598	7 598	7 598	7 598	7 598	7 598	7 598
GHG balance of existing forests and withdrawals	- 6,64	- 6,86	- 6,01	- 5,82	- 5,66	- 5,51	- 4,97	- 4,69	- 4,46	- 4,22	- 3,98

Table 26. Extent of logging and projection of future net carbon balance of existing forests according to WAM (thousand m³/year and Mt CO₂e)²⁷

Source: SOE-ERTI (University of Sopron, Forest Research Institute)

However, it is necessary to point out that, on the one hand, climate change has already caused unprecedented damage to forests in the region, which disrupts the planned course of forest management. Although the Hungarian deciduous stands and the measures already introduced in forest management and forestry holdings contribute to the prevention of greater damage to forests, it cannot be excluded that such damage may occur, which may result in a temporary, sharp increase in the availability of wood biomass due to the renovation of forests extinct over a large area, and is expected to decrease. On the other hand, the amount of biomass that is actually extracted and can be extracted depends on the market and any restrictions on forest management that can be inferred from the above. These include changes expected under the *EU Biodiversity Strategy* under discussion, such as the extent of protected areas in relation to the designation of additional forest areas, and the type and extent of related restrictions.

Finally, sustainable forest management and the effectiveness of forest protection are hampered by small-scale management resulting from private forest management. In *line with the National Forest Strategy*, it is therefore necessary to properly integrate and, where possible, improve the fragmented farming structure by modifying the regulatory environment and other state measures. Appropriate regulation of associated forest management can contribute to this²⁸.

II.F.3. Current situation and forecasts with existing policies and measures

This chapter presents Hungary's historical energy and decarbonisation trends along the 5 dimensions of the Energy Union, as well as the relevant projections available with existing measures compared to 2019, i.e. the expected progress under the WEM scenario, in view of the outliers driven by the crisis situations of recent years, but also taking into account their impacts.

²⁷ Note: * FRL: under the logging assumptions of the Forest Reference Level required under the so-called LULUCF Regulation; ** Increased logging: a scenario of increased logging compared to current levels; *** Low-level logging (i.e. approximately the level of logging maintained at the current level of logging)

²⁸ National Forest Strategy (https://2015-2019.kormany.hu/download/a/1a/d0000/National_Erd%C5%91strat%C3%A9gia.pdf)

II.F.3.1. Projected evolution of key external factors affecting the energy system and greenhouse gas emissions

In the WEM scenario, including the additional measures (WAM) scenario, the projection assumptions are set out in the chapter below. The projections are based on the data provided in the Commission Recommendation of March 2024.

Macroeconomic projections (GDP and population growth)

GDP and population change are very important factors in terms of energy use and GHG emissions. In addition to oil prices, these factors are the ones that most determine the future performance of each sector. For the key inputs, the values recommended by the Commission were used. These include population and GDP, while exchange rates have been taken to be constant throughout the period.

	2019	2025	2030	2035	2040	2045	2050
USD/EUR exchange rate	1,12	1,1	1,1	1,1	1,1	1,1	1,1
HUF/EUR exchange rate	325	400	400	400	400	400	400
Population, persons*	9 772,7	9 632,9	9 515,4	9 413,2	9 334,2	9 276,9	9 226,5
Average annual growth rate of real GDP*	-	3.61%	2,08%	1.78%	1.62%	1.74%	1.69%

Table 27. Key input data used to project GHG emissions

Source: COM (March 2024): Annex II GHG projection parameters 2025

Sectoral changes expected to affect the energy system and greenhouse gas emissions

In the following, the most important factors determining the performance of a given sector, and therefore its energy use and GHG emissions, are summarised by sector.

Factors affecting residential energy consumption

Household energy use can be divided into two main groups: on the one hand, the energy needed for cooling, heating and hot water in the building and, on the other hand, the energy used for the use of household appliances, lighting and cooking. Different factors determine the development of energy demand in the two areas.

Factors affecting energy use related to the production of heating, cooling and hot water

The energy use of residential buildings is mainly determined by three factors: i) the floor area of the total occupied building stock; the energy performance of buildings and (iii) the fuel mix of the energy used. While the first factor, i.e. the evolution of the building stock, is the exogenous input parameter of the model used, the other two are the result of modelling.

The modelling of the Hungarian residential building stock was based on the most commonly used residential building typology, which includes 23 building types, of which 12 are family houses and 11 are condominiums. In the case of building types, the construction method, the construction time and the size of the building are decisive.²⁹ Based on a number of studies, questionnaires and other data sources, we have determined the typical technical parameters and fuel consumption of these 23 building types. The following table summarizes the Hungarian building typology and its main characteristics.

Type of building	Characteristics of the building	Year of construction	Size	Number of dwellings occupied, pcs	Average dwelling size, sqm
1	Abscess without foundation		-	150 023	66
2	With abscess foundation		-	385 772	66
3	family	-1944	-	213 256	74
4	family	1945-1959	-	190 106	75
5	family	1960-1979	Below 119 nm	532 069	75
6	family	1960-1979	Above 120 nm	87 245	148
7	family	1980-1989	Below 119 nm	247 816	74
8	family	1980-1989	Above 120 nm	91 987	153
9	family	1990-2005	Below 119 nm	198 028	75
10	family	1990-2005	Above 120 nm	102 110	166
11	family	2006 - 2020	Below 119 nm	44 464	80
12	family	2006 - 2020	Above 120 nm	90 576	161
13	condominium, 4-9 flats	-1945	-	72 027	55
14	condominium, 4-9 flats	1945-1989	-	100 247	57
15	condominium, 4-9 flats	1990-2005	-	41 607	65
16	condominium, 4-9 flats	2006 - 2020	-	24 150	64
17	large condominium (10+ flats)	-1944	-	179 424	58

²⁹ Sources: REKK (2023): *Possibility of phasing out Russian gas in Hungary*; Multicontact Kft., Hungary: *Modernisation of public and residential buildings - Definition and development of support programmes*, 2020; T. Csoknyai, J. Farkas, L. Formanek, M. Horváth, *Building typology study*, KEOP-7.9.0/12-2013-0019 project, Budapest, 2015

18	large condominium (10+ flats)	1945-1989	-	241 509	50
19	large condominium (10+ flats)	Block	-	163 771	50
20	Panel	-1979	-	290 941	50
21	Panel	1980-	-	163 780	50
22	large condominium (10+ flats)	1990-2005	-	68 772	53
23	large condominium (10+ flats)	2006 - 2020	-	47 484	54

Table 28. Building typology of Hungary

The development of the number of dwellings is influenced by the number of newly built and the number of demolished dwellings. The development of new constructions has been hectic over the past two decades. The number of new constructions reached its highest level in the mid-2000s – between 40 000 and 45 000 dwellings per year – while it reached its lowest level – less than 10 000 dwellings – in the mid-2010s, before increasing again and approaching 30 000 by 2020. By contrast, the number of dwellings disappearing is on a stagnating trend, with around 2 500 dwellings disappearing each year from the mid-2010s. In the case of both values, we assumed that the average level of the Hungarian building stock over the next three decades over the past 20 years, so we calculate with the construction of 23,500 dwellings and the disappearance of 3,000 dwellings each year.

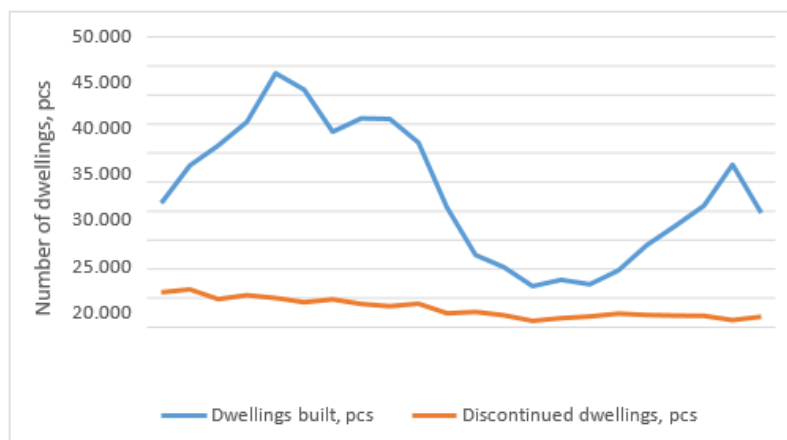


Figure 26. Housing construction and demolition developments 2000-2021 (pcs/year)

Source: KSH

Although there is a downward trend in the number of inhabitants, the number of new dwellings built exceeds the number of demolished dwellings, resulting in an overall increase in the number of inhabited areas per inhabitant, as can be seen from past trends. In the case of new dwellings, we assumed that the number of dwellings is evenly distributed among small family houses, large family houses, condominiums with few and many flats. They have different average floor areas, which are the same as the average floor area per category.

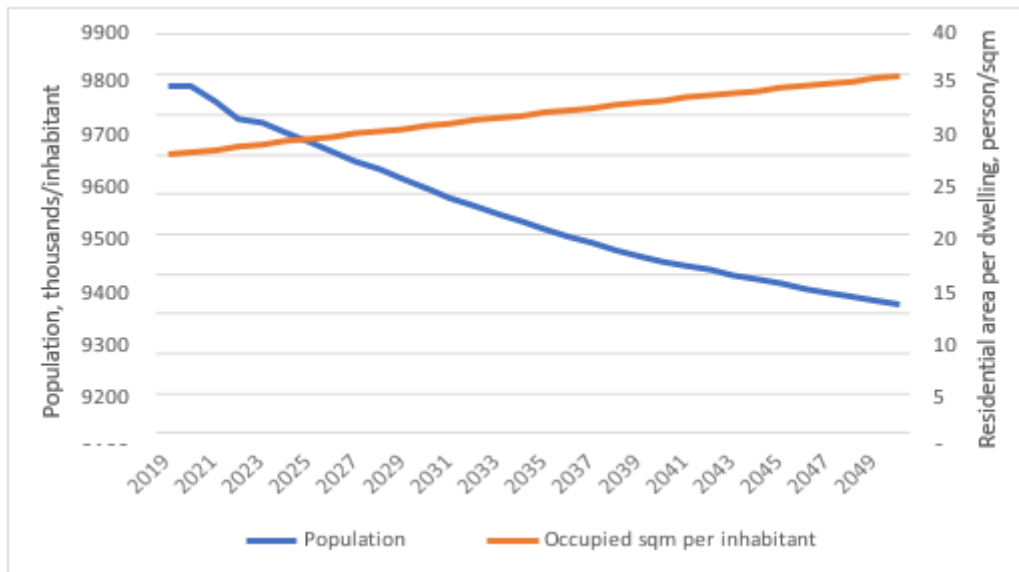


Figure 27. Population and population per inhabitant (m2) projections, 2019-2050

Source: KSH, REKK (Regional Energy Economy Research Centre) estimate

Factors affecting energy use in household appliances

Household appliances are divided into six different types: (1) Refrigerators; (2) Freezers; (3) Washing machines; (4) Lighting; (5) Cooking; (6) Other electrical appliances.

For each subtype, we determined their future demand separately. The population, the change in the floor area of buildings, the current penetration rate and its assumed evolution play a role in this. As a result, the demand for refrigerators and freezers and the demand for lighting will increase by 7% by 2030, 14% by 2040 and 21% by 2050 compared to 2019. For other instruments, this increase is 15% by 2030, 33% by 2040 and 53% by 2050 compared to the base year. For cooking and washing machines, due to the decreasing population, a reduction of 1.5-2.6% (2030) is calculated as a minimum of 2.5-5.6%.

Within each subcategory, 5-6 new technology options are defined – for other assets, one type of new technology has been defined – whose investment costs and energy use needs are included in the model. Exchange is possible at any time, but at the latest at the end of the lifetime of the given asset. The model may ‘decide’ to replace the device, as the transition to the new technology pays off and/or helps to achieve the objectives set.

Public and commercial buildings

For public and commercial buildings, there is no detailed data on the type and area of buildings that can be used directly for modelling. Unlike residential buildings, there is no representative survey for this sector. Although there are many databases, they have very different structures, are not homogeneous and are contradictory. In many cases, specific energy consumption is unrealistically low, sometimes too high. The total floor area of the total non-residential building stock for each source varies between 52 and 125 million m2. Most information can be found

on state-owned buildings (public buildings), but it does not come from surveys based on a representative sample.

In view of the limited availability of energy data on buildings other than public buildings, our estimates were based on the building types included *in the Long-term Renovation Strategy*, supplemented by an ‘other’ building type, the specific consumption of which was determined by the nationwide floor-weighted consumption of the typology used. The total floor area of the ‘other’ type is determined in such a way that it gives the measured, aggregated energy consumption from the energy balance. The resulting value is 70 million m². This gives a total floor area of 126 million m² for the total stock, which is a good approximation of the official EU statistics on the building stock in the services sector, which is 125 million m². As we have little information about these buildings, we started from the investment options for residential buildings and determined the renovation options and their costs based on them.

For public and commercial buildings, taking into account the above, a total of 15 sub- categories are distinguished, as shown in the following table.

Building type	Year of construction	Number of units, pcs	Average size, nm	Total nm	Insulated
OTHER BUILDINGS	Every Period	33 958	2 179	74 000 000	No
Health, social and residential buildings	Before 1990	4 381	1 263	5 533 203	No
Health, social and residential buildings	1990 -	619	1 263	781 797	Yes
Administrative and office buildings	Before 1990	5 282	1 060	5 598 920	No
Administrative and office buildings	1990 -	539	1 060	571 340	Yes
Commercial buildings (e.g. warehouses, shops, stores, warehouses)	Before 1990	529	1 097	580 313	No
Commercial buildings (e.g. department store, shop, warehouse)	1990 -	111	1 097	121 767	Yes
Cultural buildings (e.g. museum, theatre, library, community centre)	Before 1990	826	1 097	906 120	No
Cultural buildings (e.g. museum, theatre, library, community centre)	1990 -	97	1 848	179 262	Yes
Educational buildings (e.g. kindergarten, school, college, university)	Before 1990	9 150	3 066	28 053 900	No
Educational buildings (e.g. kindergarten, school, college, university)	1990 -	954	3 826	3 649 688	Yes
Hospitals	Before 1990	725	5 068	3 674 300	No
Hospitals	1990 -	82	3 442	282 245	Yes
Sports facilities	Before 1990	524	767	401 908	No
Sports facilities	1990 -	1 546	1 263	1 952 598	Yes

Table 29. Typisation of public and commercial buildings

Source: HTFS (Long Term Renovation Strategy), REKK (Regional Energy Economy Research Centre) estimation

As in the residential building typology, renovation options have been distinguished for all types of public and commercial buildings. As a result, a total of 71 renovation options need to be cost-determined.

We made the following assumptions about the future increase in floor space. In the case of buildings that have not been fully renovated, a loss rate of 2% per year has been assumed³⁰, while within each category (e.g. hospitals, educational buildings, etc.), the change in the floor area of new buildings is proportional to the change in population. The exception to the latter is other buildings, where the increase in the floor area of new buildings increases by 30% of GDP growth. Thus, with the current GDP trajectory, the increase in the total surface area of public and commercial buildings between 2019 and 2050 is 9.3%.

Transport

In order to be able to compare the results of the modelling of transport emissions with domestic greenhouse gas emission trends, it is necessary to use data consistent with the national GHG inventory to determine³¹ transport demand, so we started from transport statistics based on the so-called territoriality principle, which contains data monitored and published³² by Eurostat and DG MOVE. However, the available transport performance time series are incomplete for several categories and only available for a few years, which makes it impossible to estimate future demand on the basis of historical data. Therefore, in some cases the forecast was made on the basis of the statistical data of domestic companies, i.e. not according to the principle of territoriality, which was corrected by an estimate.³³

Data were calculated for passenger-kilometres (ukm) for passenger transport and tonne-kilometres for freight transport (tkm). For the modelling, a separate prognosis was made for each mode of transport. The ukm and tkm values were³⁴ predicted using the Cochrane-Orcutt econometric method. Based on these projections, the initial baseline scenario without modal shift is modelled. By incorporating modal shift, the demand defined per mode of transport may

³⁰ This affects 97% of the initial building stock

³¹ Territoriality principle – takes into account the transport performance on the territory of the country, regardless of the nationality of the operator of the transport vehicle. These statistics serve, for example, as a basis for the definition of the modal split in transport (Eurostat).

³² EC (2022a): EU transport in figures, Statistical pocketbook 2022, DG Mobility and Transport, https://transport.ec.europa.eu/media-corner/publications/statistical-pocketbook-2022_en and Eurostat transport measurement data

³³ KSH, Transport sector situation, 2020, <https://www.ksh.hu/docs/hun/xftp/temporary/jelszall/2020/index.html>

³⁴ The method incorporates the delayed value of the random factor as an explanatory variable using an iteration procedure to eliminate residual autocorrelation in the time series.

vary to a certain extent, so modelling may result in a more efficient modal split. The data used and assumptions used to forecast demand are presented below.

Passenger transport

The development of the public transport segment of local passenger transport was projected with the help of regressions. For the baseline scenario without modal shift, the future demand for each mode was assumed to be similar to the starting year in terms of share of public transport.

Of the individual modes of transport, the number of passenger-kilometres associated with **the use of passenger cars** was predicted by means of a regression, and the proportion of the passenger-kilometres related to local transport was determined in proportion to the vehicle-kilometres reported in the Eurostat ‘traffic flow’ tables for ‘built-in areas’.

In the case of **motorcycles**, a similar approach was taken with regard to the share of local transport, but no basic statistical data were available to determine future demand, i.e. the passenger-kilometre value for the starting year had to be estimated. Three sources were used for this. For motorcycles, only stock data are available in the KSH database, and based on our studies, these stock data do not include vehicles with an engine capacity of less than 50 cm³ and an engine power of less than 4 kW, i.e. mopeds. The **national GHG inventory** provides annual energy consumption data for two-wheeled motor vehicles. However, statistics on mopeds are not available in either the KSH or Eurostat databases, so the number of mopeds has been estimated³⁵ on the basis of the latest *TRACCS (2013)* stock data for 2010, which are closest to current estimates.³⁶ Based³⁷ on *the National Transport Strategy (NKT) Transport Energy Efficiency Improvement Action Plan (KEHCsT)*³⁸ and *EC (2022b)*, we took the average consumption of motorcycles to be around 3 l/100 km and the average number of people transported to be 1.1. The trend in future demand (ukm) is assumed to be mainly determined by the development of the number of motorcycles and mopeds, therefore we estimated the development of the vehicle fleet based on the trend of the 16 years after the crisis. The average annual run calculated from the energy consumption in the GHG Inventory was 2,102 km. The values obtained in this way were used to predict future passenger-kilometre values for motorised two-wheeled vehicles.

Consolidated statistics on **local bus, suburban train, metro, tram and trolleybus** transport were available for a few years. Since we did not see any significant change in their temporal trend, except for a one-off increase due to the entry of a new metro line, we assumed that by default their future share of local transport would be the same as in the starting year³⁹.

³⁵ *TRACCS (2013): Transport data collection supporting the quantitative analysis of measures relating to transport and climate change*, <https://tracccs.emisia.com/index.php>

³⁶ https://hvg.hu/cegauto/20190416_robogo_safety_accident_karesemeny

³⁷ *EC (2022b): Study on New Mobility Patterns in European Cities Task C*, <https://transport.ec.europa.eu/system/files/2022-12/2022%20New%20Mobility%20Patterns%20in%20European%20Cities%20Task%20C%20Final%20Report.pdf>

³⁸ *National Transport Strategy, Transport Energy Efficiency Action Plan 2013-2020 (2050)*

³⁹ *KSH Stadat, local passenger transport data KSH Stadat*, https://www.ksh.hu/stadat_files/sza/hu/sza0021.html

When forecasting long-distance or **interurban passenger transport**, we acted similarly to local transport. From *the EC (2022a)*⁴⁰ area-based bus transport statistics, we deduced local bus transport performance data and calculated the future demand for interurban bus transport assuming similar proportions. For rail transport, statistics follow the territorial principle from the outset. Passenger-kilometre data for passenger cars and motorcycles are calculated as a proportion of traffic statistics for extra-urban vehicle-kilometres, similar to local transport.

Among the other sectors, waterborne, airborne and pipeline transport, the availability of historical passenger-kilometre data for domestic statistics only on the performance of local businesses and the data reported by Eurostat are also incompatible with energy consumption and GHG emissions data make it difficult to predict demand for air passenger transport⁴¹. Therefore, we accepted the estimate of the *EU 2020 Reference Scenario*.

Transport of goods

For freight transport, broken down by required vehicle size, data on the activity of freight vehicles on the national territory is not available, but only for the total (foreign and domestic) performance of transport undertakings. Therefore, based⁴² on Eurostat statistics and *EC (2022a)*, we estimated the distribution of tonne-kilometre data for the size categories based on the maximum payload. Another obstacle is that for LCVs only information on the number of vehicles is available, and the statistical data collection on freight transport performance ignores this category. Therefore, as for motorcycles, we estimated the tonne-kilometre data for **LCVs** based on GHG inventory energy consumption data, assuming an average annual mileage of 22 000 km, an average capacity utilisation rate of 70% and an empty road share of 50%. The short- and long-term transport performance was determined on the basis of Eurostat traffic data as a proportion of vehicle-kilometres measured in built-up areas and other roads.⁴³

The transport performance of **larger vehicles – heavy goods vehicles** – on domestic roads was determined on the basis⁴⁴ of tonne-kilometre ratios estimated on the basis of KSH and Eurostat transport performance data, *Eurostat traffic data and average occupancy (EC, 2022b)*. The tonne-kilometre data for short- and long-distance transport were determined on the basis of Eurostat transport statistics broken down by distance, taking into account transport performances below 50 km for short-distance transport.⁴⁵

⁴⁰ *EC (2022a): EU transport in figures, Statistical pocketbook 2022, DG Mobility and Transport, https://transport.ec.europa.eu/media-corner/publications/statistical-pocketbook-2022_en and Eurostat transport measurement data*

⁴¹ *EUROSTAT, https://ec.europa.eu/eurostat/cache/metadata/en/avia_tp_esms.htm*

⁴² *EC (2022a): EU transport in figures, Statistical pocketbook 2022, DG Mobility and Transport, https://transport.ec.europa.eu/media-corner/publications/statistical-pocketbook-2022_en and Eurostat transport measurement data*

⁴³ *EUROSTAT, https://ec.europa.eu/eurostat/databrowser/view/ROAD_TF_ROAD/default/table?lang=en*

⁴⁴ *EC (2022b): Study on New Mobility Patterns in European Cities Task C, <https://transport.ec.europa.eu/system/files/2022-12/2022%20New%20Mobility%20Patterns%20in%20European%20Cities%20Task%20C%20Final%20Report.pdf>*

⁴⁵ *EUROSTAT, https://ec.europa.eu/eurostat/databrowser/view/ROAD_GO_TA_DC/default/table?lang=en*

The future demand for **waterborne and pipeline transport** was estimated by means of a regression, the trend of which was mainly determined by the development of economic activity – the change in GDP.⁴⁶

The following table shows the transport demand projections, broken down by 10 years. The 2019 and 2020 values are based on fact-based values and also reflect the impact of the pandemic on transport performance, which was taken into account in the forecast. (It should be noted that current data show a faster increase for passenger rail transport than the estimate was based on).

	2019	2020	2030	2040	2050
Passenger transport, local (million ukm)					
Bus (local)	4574	3116	3407	3354	4115
Tram	1284	844	956	942	1155
Trolleybus	206	140	153	151	185
Subway	1523	1001	1134	1117	1370
WEEK	474	316	353	348	426
Motorcycle (local)	594	601	670	746	822
Car (local)	15176	14 651	18527	21988	25198
Passenger transport, interurban (million ukm)					
Bus (interurban)	14147	9309	9810	9231	8888
Car (interurban)	51857	50066	61532	72317	84462
Passenger train	7752	4854	5382	5064	4876
Motorcycle (interurban)	1135	1147	1279	1425	1570
Freight transport, short distance (million tkm)					
LCV (up to 3.5 t)	1114	1055	1540	1826	2173
Truck (max. 12 t)	206	195	285	338	402
Truck (over 12 t)	1595	1510	2204	2615	3111
Freight transport, long distance (million tkm)					
LCV (up to 3.5 t)	4808	4551	6645	7882	9378
Truck (max. 12 t)	655	629	919	1090	1297
Truck (over 12 t)	25230	23883	34868	41361	49210
Freight train	10625	11595	13935	16299	18493
Other Demands					
Waterborne transport (million tkm)	2120	1998	2950	3645	4397
Pipeline transport (million tkm)	8901	6739	7413	5272	2740

⁴⁶ KSH Stadat: ksh.hu/stadat_files/sza/sza/sza0002.html

Air transport (million ukm)	3285	2193	6147	7500	8802
-----------------------------	------	------	------	------	------

Table 30. Forecast of transport demand

Source: Eurostat, Hungarian Central Statistical Office (KSH), REKK estimation

Industry

The industrial energy sectors are broken down into a total of 31 sub-sectors, which also provide a more detailed breakdown than the energy balance. For each subsector, we estimated the volume indices of each sector up to 2050 using econometric methods, using Cochrane- Orcutt or the Prais-Winsten algorithm based on similar principles, using explanatory variables defined by the European Commission, such as GDP, population and oil prices. While strong growth can be observed for some sectors (e.g. construction), stagnation is expected for some subsectors (e.g. textile production). The following table summarises the dependent variables of the regression estimates and their units, the explanatory variables and their parameters – the variables belonging to the cells containing the parameter estimates – as well as the correction parameters determined by the method, the coefficient of determination expressing the explanatory power of the models (R^2 , %) and the empirical values of the Durbin-Watson (DW) statistics or Durbin h statistics for testing residual autocorrelation.

The parameters were used to forecast the trend of the estimated values for the period 2019-2050 under review.

the Dependent Variable	R2	Constant	GDP Volume Index	Populatio n Number Thousand s	Oil Price Dollar/Ba rrel	Delay	Correctio n Paramete r	DW	Durbin h
Volume index of agricultural production 1995=100	54,6	576,856		-0,045689	-0,230205		0,002	1,75	
Construction output volume index 1995=100	90,8	-4140,33	4,15	0,37294			0,106	1,78	
Cars at the end of the year	97,9	126231	19936,8		-177,915		0,024	1,9	
Total transport capacity (M freight tonne)	97,5	-14233,7	262,782		56,5807	0,39198	0,087		2,347
Rail transport capacity (M freight tonne)	83,3	2482,82	49,0334		-4,3949		0,05	1,88	
Road transport capacity (M freight tonne)	96,8	-1287,85	206,55		46,8		0,54	0,91	
Water transport capacity (M freight tonne)	58,1	-169,479	5,657			0,626	0,051		0,449

Pipeline transport capacity (M freight tonne)	63,4	1440,32	28,8242			0,264	1,29	
Passenger transport interurban (passenger-kilometre M)	29,1	-45276,4		7,02873		0,085	1,8	
Passenger transport local (Passenger-km M)	86,3	-145693	56,6511	14,552		0,45	1,096	
Passenger-kilometre passenger car (Passenger-kilometre M)		5309,99	201,675			0,3476	-0,16	-1,44
Volume index of mining and quarrying 1995=100	45,5	-1740,8	1,34729	0,161873		0	1,88	
Production volume index of food, beverages and tobacco products 1995=100	83,8	142,621		-0,0136095		0,92811	0,12	0,9
Production volume index of textiles, clothing, leather and leather products 1995=100	80	-1260,21	0,524149	0,127556		0,47	1,05	
Manufacture of wood and paper products, volume index of printing activities 1995=100	97,1	-77,5294	1,98393			-0,155561	0,088	0,718
Volume index of coke production and petroleum processing 1995=100	75,3	-1147,54	0,5547	0,115	0,111	0,01	1,975	
Volume index of production of chemicals and products 1995=100	83,7	15,9486	0,623331			-0,005	1,97	
Pharmaceutical production volume index 1995=100	90	1445,9		-0,132996	0,374	-0,13	2,258	
Production volume index of rubber, plastic and non-metallic mineral products 1995=100	98	-276,788	3,61595			0,15	1,67	
Production volume index of basic metals and fabricated metal products 1995=100	86,7	-1971,37	2,28898	0,179108		0,124	1,744	
Volume index of manufacture of computer, electronic and optical products 1995=100	89,5	-2131,43	2,19964	0,189409		0,667942	-0,135	-0,749

Volume index of electrical equipment production 1995=100	84,4	-1561,64	19,2646			0,47	1,05	
Volume index of the manufacture of machinery and equipment 1995=100	96,6	10244,5	-3,84133	-0,954288	1,21699	0,426724	-0,2	-4,77
Volume index of vehicle production 1995=100	97,3	-630,919	12,0555		-1,30935		0,386	1,2
Other manufacturing; volume index of installation and repair of industrial machinery and equipment 1995=100	97,8	2411,18		-0,231217		0,589196	-0,0038	-0,062
Manufacturing Volume Index 1995=100	98,6	-216,65	3,8544				0,0666	1,8
Electricity, volume index of gas, steam and air conditioning supply 1995=100	72,9	-680,016	0,44322	0,0682883		0,425674	-0,026	-0,358
Volume index of industry without water and waste management 1995=100	98,7	-162,289	3,12173				0,057	1,83

Table 31. Parameter estimates for fitted models and model characteristics

Based on the above parameter estimates and the projected changes in oil prices, population and GDP, it is possible to determine the production or the amount of energy used for production in the individual subsectors. The table below summarises the projected factor for each subsector, the baseline and the evolution of emissions in 2030 and 2050. In the case of certain industrial sub-sectors characterised by high GHG emissions penetration but homogeneous product production, which are treated in a ‘bottom-up’ manner in the HU TIMES model, i.e. with technological detail, demand-side values expressed in terms of naturalities (million tonnes, Mt) and energy consumption (PJ) were calculated for the other sectors.

Industrial sector	Subsector	Unit of measurement	2019	2030	2050
Iron and steel industry	Iron and steel production - blast furnace	Mt	1,15	0	0
	Manufacture of iron and steel - electric arc furnaces (EAF)	Mt	0,35	1,57	1,77

	Other	PJ	5,37	6,45	9,38
Chemical and pharmaceutical industry	Manufacture of ammonia	Mt	0,51	0,60	0,77
	Olefin production	Mt	0,91	1,07	1,37
	Manufacture of chlorine	Mt	0,27	0,32	0,41
	Other	PJ	27,51	32,37	41,62
Manufacture of basic non-ferrous metals		PJ	4,88	4,88	5,38
Manufacture of non-metallic mineral products	Cement / clinker	Mt	2,43	3,29	4,88
	Glass - Flat glass	Mt	0,30	0,41	0,60
	Glass - Hollow glass	Mt	0,14	0,18	0,27
	Glass - Light source, lamp	Mt	0,08	0,11	0,16
	Glass - insulation material	Mt	0,05	0,07	0,10
	Ceramic - Brick	Mt	0,67	0,91	1,35
	Ceramics - Tiles	Mt	0,02	0,03	0,04
	Ceramics - Sanitary	Mt	0,02	0,03	0,04
	Ceramics - Fireproof	Mt	0,01	0,01	0,02
	Other	PJ	13,02	17,59	26,11
Manufacture of vehicles		PJ	9,70	9,70	12,42
Manufacture of machinery		PJ	18,71	18,71	27,33
Mining and quarrying		PJ	1,57	1,57	1,81
Manufacture of food, beverages and tobacco products		PJ	27,81	27,81	39,28
Manufacture of paper and paperboard	Paper ETS	Mt	0,71	0,88	1,22
	Pulp, pulp ETS	Mt	0,02	0,03	0,04
	Paper and pulp NETS, printing	Mt	2,91	3,63	5,03
Manufacture of wood (excluding furniture)		PJ	5,05	6,49	9,00
Construction		PJ	12,24	17,24	26,88
Textile and leather industry		PJ	1,69	1,35	1,35
Other industrial sector		PJ	12,79	16,65	22,48
Material use		PJ	41,81	49,18	63,24

Table 32. Production or energy use of industrial subsectors in 2019, 2030 and 2050⁴⁷

Source: REKK estimate

⁴⁷ Unit of measurement: Mt: million tonnes production volume, PJ: petajoule energy consumption

Primary solid biomass

In the case of primary solid biomass, it was necessary to include in the modelling process a natural resource that is renewable on the one hand, but not available indefinitely on the other. In other words, during the modelling of the use of energy carriers, it was necessary to define the **biomass capacity limit**. The biomass capacity limit is determined as a result of the following steps. (1) We modelled the supply of forest firewood with the specified control parameters, then (2) we fixed the historical ratio of primary solid biomass of non-forestry origin, which can be calculated from Hungary's energy balance, and finally (3) we established the biomass capacity limit by summing these two sources.

The supply of forest firewood was modelled using the *bio-economy (FOX) model developed by REKK*.⁴⁸ This was based on the *National Forest Data Repository* and Sopp's increment tables and forest management statistics published by the *National Land Centre (NFK)*, such as harvests, tree selections, assortment prices and operating costs. We also assumed that the forestry sector, as part of the LULUCF sector, would have to play a significant role in meeting the CO₂removal target set by the European Union in April 2023. Compared to the reference period (2016-2018), the average value of -4 791 kt CO₂e reported in the emissions inventory⁴⁹ under the LULUCF Regulation should be increased by almost one million tonnes (-5 724 kt CO₂e by 2030). Therefore, during the modelling, we assumed a climate policy regulation that ensures that the Hungarian forestry sector approaches this target by 2030.

Based on the above, we modelled the supply limit of forest firewood for 2030, 2040 and 2050. This capacity limit has been significantly increased by the supply ratios of primary solid biomass sources of non-forestry origin observed in statistics and also considered typical for the modelled period. From this market segment, official data releases were used for recoverable slaughter area waste (NFK data), herbaceous primary solid biomass (MEKH individual data release) and net imports of wood assortments suitable for energy recovery (Eurostat data). Further data sources (KSH, NAV) were used for woody biomass harvested from non-forest-classified agricultural areas, the total estimated quantity of which was included in the biomass capacity limit available for energy purposes.

The following table summarises the capacity limit for the supply of primary solid biomass as estimated above.

⁴⁸ The FOX (Forest Carbon Sink Optimization) model is a quantitative model that optimizes the carbon sequestration of forests taking into account economic parameters. A dynamic linear mathematical optimisation model that determines optimal forest harvest cycles at national level based on exogenous harvest functions, forest management costs, timber market prices and optionally applicable carbon prices. For a more detailed description of the FOX model, see: https://rekk.hu/modellezes/karbon-megkotes-modellezese/?mobile_view=0

⁴⁹ Consolidated: REGULATION (EU) 2018/841 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018

	Estimated Primary Solid Biomass		
	Capacity Limit (PJ)		
	2030	2040	2050
Forest firewood (modeled) capacity cap	39	35	32
Other primary solid biomass (non-modeled) capacity cap	65	58	52
Total estimated primary solid biomass capacity cap	104	94	84

Table 33. Estimates of capacity limits for primary solid biomass in the heel years considered

Source: REKK

Taking into account the period 2010-2020, on average 31% of the primary solid biomass use included in Hungary's energy balance is covered by domestic firewood production. In addition, 7% of the biomass used is provided by the presumably utilised part of the biomass waste generated during harvesting (cutting field waste), 2-5% by the net imports of firewood and other energy wood assortments, 7% by the quantity of primary agricultural biomass of herbaceous origin (straw, husk, etc.) and 6-8% by the estimated quantity of woody biomass that can be harvested each year from non-forest agricultural areas.

Agriculture

In the case of energy modelling of the agricultural sector (REKK modelling), the volume index of agricultural production was predicted using the randomly adjusted least squares principle – *the Cochrane-Orcutt regression method* – mentioned earlier, taking into account changes in population and oil prices as explanatory variables.

In addition to the IPCC methodology, the 2023 EMEP/EEA Guidance was used as a basis for GHG emission modelling (AKI modelling). For the agricultural sector, *2020 is taken as the base year* so that the projection is in line with the forecast for air pollutants (NEC Directive). The WEM projection assumes the continuation of the measures for the period 2014-2022, the WAM projection builds on the measures of the CAP Strategic Plan, complemented by additional measures for the period after 2030. The CAP Strategic Plan defines the agricultural development directions for the period 2023-2027, which provides support based on a complex set of objectives, serving both economic, social and environmental objectives. Measures are in the process of being imposed.

Waste management (including sewage treatment)

We used the Tier 2 methodology to project GHG emissions from waste management, such as the calculation of methane emissions from waste disposal in the IPCC Waste Model (2019). With regard to activity data, i.e. the amount of waste disposed of, measures taken in the field

of waste management have the effect of reducing the amount of waste landfilled, which is also supported by the Biogas Concept. In addition, on the input side, biological treatment of waste, composting of municipal waste and sewage sludge were taken into account. Tier 1 methodology was used with default emission factors, the trend was determined by changes in activity data. (HungaroMet WEM modelling).

Industrial processes and material use

In the Hungarian IPPU sector, compliance with air quality standards and the *Methane Ordinance* provides the most important regulatory framework, and the replacement of grey hydrogen also has a significant impact. The GHG and air pollutant forecasting systems have been harmonised. The input data used to predict IPPU emissions⁵⁰ comes from the National Clean Development Strategy 2020-2050. The calculation of the forecasts is based on the HU-TIMES model.

In the case of material uses, in the mineral sector according to IPCC codes, cement was calculated using the GAINS model. Additional emissions from the mineral sector have been calculated on the basis of time series for energy use in non-metallic mineral production. In the case of ammonia and nitric acid, natural gas use in the WEM scenario was used as a non-energy trend for the calculation of activity data. The CO₂ and N₂O emissions have been calculated using the plant-specific emission factors. In the petrochemical sub-sector, because of the wide range of substances involved, CO₂ and CH₄ emissions have been calculated on the basis of fuel consumption trends. The calculation of the metal sector was based on the production of steel calculated on the basis of the production forecast. CO₂ and CH₄ emissions have been calculated based on the use of natural gas, coke and COG in pig iron and sinter production.

Land use, land use change

The project describes the GHG emissions of the LULUCF sector. In the land sector, CO₂ emissions are predominant. The WEM projection assumes the continuation of measures under the Common Agricultural Policy for 2014-2022, taking into account FAO forecasts for 2018. The assumptions of the WAM projection until 2027 are based on the measures of the CAP Strategic Plan, and in the following period we assume further changes due to the development of carbon farming incentives (certification schemes, carbon markets). Depending on the emission category, a Tier 1 and Tier 2 methodology was used for the projection.

The projection was based on the GHG inventory data submitted in 2022, as the inventory submitted in 2023 included a methodological change to calculate carbon sequestration in the soil, which makes the impact of individual farming methods (soil cultivation, nutrient supply) less projectable. The historical data have not been corrected, so the baseline values are in several cases different from what we would consider realistic on the basis of our current knowledge, but we tried to approximate the estimation of the spread of farming practices to reality during the projection period. However, after the completion of the LULUCF-Matrix development

⁵⁰ https://unfccc.int/sites/default/files/resource/LTS_1_Hungary_2021_EN.pdf

project, when the retrospective data are recalculated according to the new methodology, we consider it necessary to update and recalculate the projection as well (AKI modeling).

Forestry

Forests are characterised by a trend-increasing annual GHG balance between 1990 and 2020 according to the GHG inventory, with relatively large annual fluctuations. Among the many reasons for the latter, the methods used to monitor forests and to update the data stored *in the Forest Stock Repository* also play a role. In line with the methodological requirements to achieve the climate targets set out in the relevant EU regulations, estimates limited to carbon emissions have been supplemented with estimates for all emission sources included in the GHG inventory, such as forest fires, burning of waste, forest abandonment and carbon dioxide from organic soils. For the projection of existing forests, both scenarios were based on the state of the areas considered as forests in the Forest Stock Database under the Forest Act as known at the end of 2021. Every year we simulated the processes that take place in the forests that change the carbon stock of the individual carbon pools of the forests, and with the help of the CASMOFOR model⁵¹ we quantified the effect of these processes on the amount of carbon sequestered. Assumptions have been developed for the application of the model, for the modelling of processes directly related to forest management, and for the amount of logging. A trend line has been added to the time series of values for 2020, 2021 and 2022 reported for the carbon balance of our forests in the GHG inventory, thus projecting the value of carbon sequestration in 2023. Subsequently, taking into account the afforestation, the projected value of the CASMOFOR and CASMOFOR-NFD model results for 2023 was adjusted to the value of the trend line for 2023.

The difference between the WEM and WAM scenarios is that WAM assumes a gradual reduction in logging with higher planting rates. We also assume that mortality will not increase significantly due to climate change or any other reason, but will follow the trends so far, and the growth of trees will continue at the pace of the recent past. The effects of climate change may increase over time and take different forms, but due to the uncertainty of the occurrence of damage, we use the assumption that their extent will remain at the same level as before (SOE modeling).

Global energy trends, international fossil fuel prices, EU ETS allowance price

The most important independent variables used for modelling include **the oil price, the price of natural gas, the price of coal, the price of biomass or the price of the carbon quota**, which have a significant impact on modelling values, i.e. total energy use and/or GHG emissions. For these values, we used the values recommended by the Commission. There was no such recommendation for biomass, so we used the current price level for the future.

⁵¹ <https://www.scientia.hu/casmofor/index.php>

	2019	2025	2030	2035	2040	2045	2050
Oil price, \$/barrel	64,3	76	85	94	97	105	121
Natural gas price, €/MWh	16	33,8	32,4	29,5	36,4	35,6	34,6
Coal price, €/GJ	2,1	4,1	3,1	3,8	3,8	4,0	4,0
CO₂quota price (ETS), €/t	25	95	95	100	100	160	190
Biomass price, HUF/GJ	1 940	2 200	2 200	2 200	2 200	2 200	2 200

Table 34. Factor price forecasts

Source: EC (2023) and REKK analysis and estimation

In addition to wholesale prices, the extent of **other retail price components** – taxes, network charges, wholesale and retail margins – also has a significant impact on the results of the modelling. They are defined individually for each fuel and each sector. We assumed that the extent of these changes does not change in the examined time horizon. Excise duties are an exception. Here we assumed that the new EU minimum taxes would be applied if they exceeded the current level of excise duty applied.

Evolution of technology costs

With the development of technologies, we are faced with three types of effects: i) reducing the unit cost of the same technology, ii) increasing the efficiency of the same technology, and iii) introducing a completely new technology with a different cost structure, i.e. investment and operating costs. The energy use of agriculture has not been analysed at the technological level, but only in an aggregated way, so the development of technology cannot be presented either. Due to the structural, organisational and technological complexity of the sectors, only a few industrial sub-sectors could be analysed in detail at technology level. In the case of electricity and heat production and the transport sector, we describe in detail the future technological costs and their development over the period under review, as well as the renovation costs for the building sector.

Building sector

In the case of the population, the 23 building typology categories defined have been further subdivided into a total of 54 categories, according to the level of renovation of the given building type.

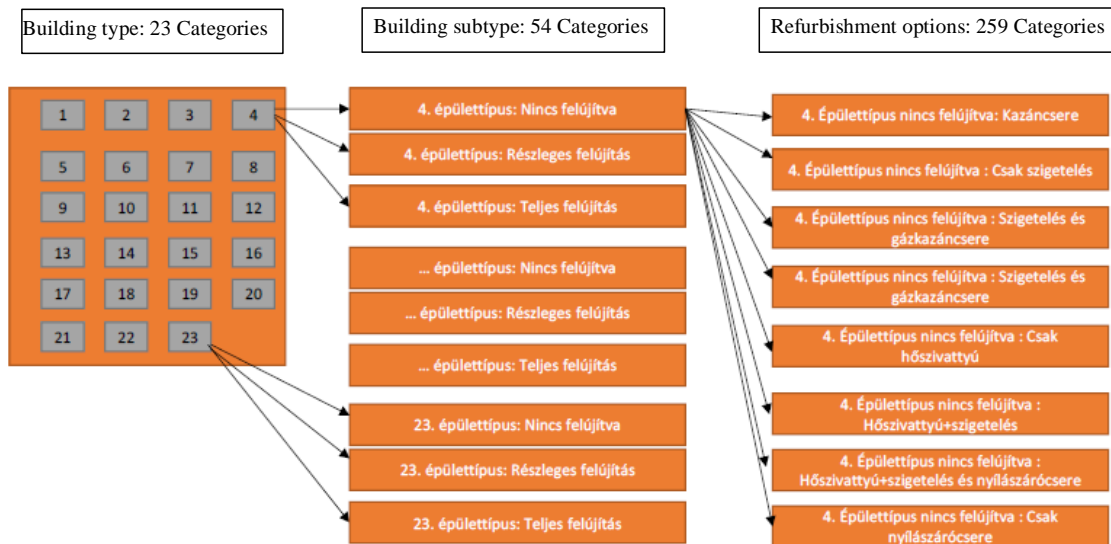


Figure 28. Renovation options for building types

Source: REKK

For each of them, we have determined which renovation options exist. Typically, we ordered 5-8 renovation options for each building type: gas boiler replacement, switch to heat pump (shallow geothermal, ambient heat recovery), insulation and window replacement, or a combination thereof. This may vary for each building type and sub-type, resulting in an overall cost of 259 renovation options.

Épülettípus	Homlokzat	Padlásfödém	Ablakcsere	Kazáncsere	Hőszivattyú
1	22 739 Ft	9 731 Ft	25 134 Ft	32 008 Ft	87 294 Ft
2	21 850 Ft	9 770 Ft	27 978 Ft	28 628 Ft	78 076 Ft
3	20 372 Ft	8 142 Ft	28 876 Ft	20 798 Ft	56 721 Ft
4	20 360 Ft	8 088 Ft	27 215 Ft	22 548 Ft	61 494 Ft
5	21 647 Ft	9 233 Ft	30 429 Ft	26 467 Ft	72 183 Ft
6	17 324 Ft	5 972 Ft	29 789 Ft	14 910 Ft	40 664 Ft
7	19 646 Ft	7 000 Ft	30 322 Ft	23 210 Ft	63 300 Ft
8	16 152 Ft	3 606 Ft	25 866 Ft	12 395 Ft	33 805 Ft
9	20 618 Ft	7 629 Ft	34 654 Ft	22 550 Ft	61 501 Ft
10	14 524 Ft	3 983 Ft	26 679 Ft	11 179 Ft	30 489 Ft
11	20 414 Ft	7 848 Ft	33 209 Ft	20 685 Ft	56 413 Ft
12	13 838 Ft	4 886 Ft	26 609 Ft	9 570 Ft	26 099 Ft
13	19 598 Ft	3 880 Ft	28 321 Ft	36 792 Ft	58 215 Ft
14	16 808 Ft	3 663 Ft	31 288 Ft	33 667 Ft	52 332 Ft
15	17 931 Ft	3 944 Ft	31 201 Ft	30 249 Ft	46 434 Ft
16	12 759 Ft	1 760 Ft	32 212 Ft	30 021 Ft	46 665 Ft
17	15 122 Ft	2 226 Ft	26 226 Ft	18 011 Ft	55 891 Ft
18	12 914 Ft	6 025 Ft	26 221 Ft	23 069 Ft	64 057 Ft
19	11 884 Ft	6 025 Ft	36 860 Ft	21 203 Ft	63 925 Ft
20	9 074 Ft	6 025 Ft	24 741 Ft	13 355 Ft	64 559 Ft
21	11 599 Ft	4 408 Ft	31 483 Ft	16 904 Ft	64 536 Ft
22	10 453 Ft	4 592 Ft	23 810 Ft	20 779 Ft	60 733 Ft
23	15 687 Ft	2 070 Ft	38 695 Ft	16 543 Ft	60 063 Ft

Table 35. Specific cost per floor area of each renovation element (HUF/m²)

Source: BME (Budapest University of Technology and Economics)

Renovation costs were determined on the basis of the 2022 Construction Cost Estimation Tool for each type, but specific offers from contractors were also taken into account. When determining the costs for each renovation option, the cost of the main materials and equipment, as well as the cost of labour, was taken into account. The costs have been converted to the floor area of each apartment, so the cost per floor area of each renovation option is different for each type.

In the case of the building sector, neither changes in renovation costs nor their efficiency gains were taken into account, so the change in technology costs is not reflected in this sector.

Electricity and heat generation

A total of 24 different technologies were distinguished for the electricity and heat production sectors. Of these, 16 technologies relate only to electricity generation, 5 to combined heat and power (CHP) installations and three to heat-only technologies. With the exception of six technologies, they are already available on the market, so they can be used in modelling as early as the first year. Renovation of wind power plants can only be achieved by the end of the lifetime of the 330 MW wind power plant capacity currently in operation, while power plants with carbon sequestration (CCUS) have only been made available from 2030 onwards.

	Technology	Lifetime	Efficacy, %			
			2020	2030	2040	2050
Renewable electricity producers	Geothermal	30	36%	36%	36%	36%
	Wind power plant - new	25	-*	-*	-*	-*
	Wind power plant - renovation	25	-*	-*	-*	-*
	Solid biomass	40	47%	49%	51%	53%
	Solid biomass - CCUS	40	42.3%	44.3%	46.3%	48.3%
	PV - household size	25	-*	-*	-*	-*
	PV - medium size < 1 MW	25	-*	-*	-*	-*
	PV - large > 1 MW	25	-*	-*	-*	-*
	Coal power plant, without CCUS	55	42%	44%	46%	48%
	Coal power plant using CCUS	55	42%	44%	46%	48%

Conventional power plants	OCGT, without CCUS	40	47%	49%	51%	53%
	Using OCGT, CCUS	40	47%	49%	51%	53%
	CCGT, without CCUS	30	56%	58%	60%	62%
	Using CCGT, CCUS	30	56%	58%	60%	62%
	Nuclear	50	33%	33%	33%	33%
Combined heat and power plants (electricity efficiency)	Natural gas	15	32%	33%	34%	35%
	Solid biomass	15	20%	20%	20%	20%
	Biogas - landfill	25	57%	57%	57%	57%
	Biogas - wastewater	25	46%	46%	46%	46%
	Biogas - agricultural	25	50%	50%	50%	50%
Heat producers	Gas boiler	30	92%	92%	92%	92%
	Geothermal	20	100%	100%	100%	100%
	Biomass boiler	15	85%	85%	85%	85%

Table 36. Estimated lifetime and change in efficiency of electricity and heat generation installations between 2020 and 2050 (Source: (REKK)⁵²)

	Technology	Investment cost, €/kW				Fixed annual cost, €/kW	Annual variable cost, €/GJ
		2020	2030	2040	2050		
Renewable electricity producers	Geothermal	5 217	5 217	5 217	5 217	95,7	0,0
	Wind power plant - new	1 670	1 572	1 480	1 398	35,0	0,0
	Wind power plant - renovation	1 069	1 006	947	892	35,0	0,0
	Solid biomass	870	870	870	870	34,8	0,0
	PV - household size	1 332	1 080	891	750	10,0	0,0
	PV - medium size	922	747	616	519	7,0	0,0

⁵² Note: * Not relevant, no transformation loss in energy balance, no fuel cost

	PV - large	717	581	479	404	5,0	0,0
Conventional power plants	Coal power plant, without CCUS	2 586	2 460	2 339	2 225	28,3	1,3
	Coal power plant using CCUS	5 726	5 726	5 726	5 726	66,2	1,3
	OCGT, without CCUS *	879	877	876	874	6,7	0,7
	Using OCGT, CCUS *	1 700	1 700	1 700	1 700	13,8	0,7
	CCGT, without CCUS *	922	918	913	909	14,0	1,3
	Using CCGT, CCUS *	1 827	1 827	1 827	1 827	28,9	1,3
	Nuclear	7 000	7 000	7 000	7 000	108,0	2,2
Cogeneration plants	Natural gas	820	816	812	808	19,3	5,6
	Solid biomass	3 000	3 000	3 000	3 000	3,3	4,9
	Biogas - landfill	1 750	1 750	1 750	1 750	262,5	0,0
	Biogas - wastewater	5 625	5 625	5 625	5 625	281,3	0,0
	Biogas - agricultural	3 008	3 008	3 008	3 008	423,8	0,0
Heat producers	Gas boiler	94	94	94	94	5,8	0,3
	Geothermal	1 400	1 400	1 400	1 400	17,2	0,0
	Biomass boiler	281	281	281	281	10,6	0,3

Table 37. Typical cost data for electricity and heat generation installations

Source: REKK data collection⁵³

Transport

When defining transport technologies and costs for **motorcycles**, we assumed that the **current and expected future role of diesel propulsion** for powered two-wheelers (three-wheelers) would be very limited. Hybrid vehicles also exist, but their uptake is currently very slow, mainly concentrated in Asia, and their future role is questionable. The reason for this is that in the case of relatively smaller vehicles, the doubled drive system can mean extra weight and complexity, which is also reflected in the service costs. In addition, especially in the higher-performance segment, some models are expected to appear, as the range of electric propulsion for shorter-distance vehicles in local traffic will mostly meet demand, and the range is likely to increase

⁵³ Note: * For OCGT, only variable costs other than fuel costs are included in the table. As OCGT is a significantly simpler technology than CCGT, it has lower operating costs. Source: REKK data collection

further in the future. For this reason, only gasoline and electric technologies are currently considered as options in the model. Technological progress is reflected in the increased efficiency of motorcycles and the cost reduction potential of electric vehicles, in line with the expected reduction in battery costs of 25% of the value of the vehicle.

As a **new technology for passenger cars**, hydrogen fuel cell passenger cars will appear in the model, which will be available from 2025. In addition, current technologies are constantly evolving until 2030, which means lower consumption and changes in procurement costs. In line with the literature, the cost of electric and hydrogen fuel cell vehicles is slightly decreasing and the cost of vehicles equipped with internal combustion engines is increasing, as increasingly complex technological solutions need to be used to meet the ever-increasing emission requirements.

In addition to **modern diesel, hybrid, CNG and electric vehicles for buses**, hydrogen fuel cell vehicles for long-distance transport and new diesel buses for long-distance transport, hybrid and fuel cell vehicles were also expected. Of the hybrid technologies, only conventional hybrid propulsion was considered. This is because, in long-distance transport, the distance travelled in the electric shift may be low due to the time lost due to charging time, and in local transport, the increase in range and new charging solutions, such as fast chargers at stops, may make the installation of two types of propulsion systems unnecessary over time.

According to information provided by transport service providers (BKK, MÁV-Start), no alternative fuel technology (e.g. hydrogen) is expected to be available for **track-based vehicles** by 2030, and no substantial reduction in consumption is expected for more modern electric technologies compared to current young (0-5 years old) vehicles. As a result, no new tram and metro technology will appear in the model, instead the use of devices equivalent to those currently in circulation (CAF, Alstom) is expected. In the case of suburban railways, a new fictitious technology will be available, which will be more efficient than the older suburban railway technology in the case of other railway vehicles. The new technology will be available in the model from 2025, as no new vehicles have yet been purchased in 2023. In the case of new rolling stock, the consumption of rolling stock will not change until 2030, and in the case of suburban railways, the improvement observed for other rolling stock is expected. Analog technology with KISS multiple units will be available in the model from 2020. Since diesel passenger trains aged 0-5 years are not in circulation, it was necessary to define a new technology that consumes less energy in line with the observed efficiency gains in track-based vehicles.

The new vehicles that can be entered by the model can be petrol, diesel, electric, plug-in hybrid, hydrogen fuel cell and CNG powered vehicles for the light commercial vehicle category, and petrol, diesel, electric and hydrogen powered vehicles for short-distance and long-distance transport. For the higher load categories, the rechargeable (diesel) hybrid version is not included in the options, for the reasons mentioned for buses, but is calculated using conventional hybrid technology. As far as natural gas propulsion is concerned, CNG propulsion was taken into account in the category below 12 tonnes, while LNG propulsion was taken into account for vehicles above 12 tonnes. Following the emergence of new models in the heavy goods vehicle category, it was assumed that electric and hydrogen propulsion could also appear as possible alternatives in the future for vehicles above 3.5 tonnes.

Industrial sectors

The table below shows the industrial sub-sectors where technology-level analysis was carried out. This approach has been applied in sectors where existing data has made this possible. For cases not included in the table, the subsector was examined on an aggregate basis. The table below shows how many different technologies the model can choose as an investment option for the sectors analysed in detail.

		Standard technology	Advanced technology
Iron and steel industry	Blast furnace	1	5
	Electric arc furnace	1	2
Chemical and pharmaceutical industry	Ammonia	2	3
	Olefi	2	2
	Chlorine	2	1
Manufacture of non-metallic mineral products	Cement	1	1
	Glass - Flat glass	1	4
	Glass - Hollow glass	1	4
	Glass - Light source, lamp	1	3
	Glass - insulation material	1	2
	Ceramic - Brick	1	5
	Ceramics - Tiles	1	5
	Ceramics - Sanitary	1	2
	Ceramics - Fireproof	1	4
Manufacture of food, beverages and tobacco products		1	0
Manufacture of paper and paperboard	Paper ETS	2	5
	Pulp, pulp ETS	1	3
	Paper and pulp NETS, printing	1	1

Table 38. Number of new technology options for the industrial sectors analysed in detail

Source: REKK

II.F.3.2. Projection of sectoral developments

The detailed results of the GHG projections are presented in Annex. For the energy, LULUCF and agriculture categories, a scenario taking into account the effects of existing measures (WEM) and a scenario taking into account the effects of additional measures (WAM) has been prepared. For industrial processes and product use, only existing measures have been taken into

account.

Hungary's total gross GHG emissions excluding the land use, land use change and forestry sector are expected to decrease to 53.7 Mt CO₂e by 2030 in the WEM scenario, representing a 17% reduction compared to 2019 and a 43% reduction compared to 1990.

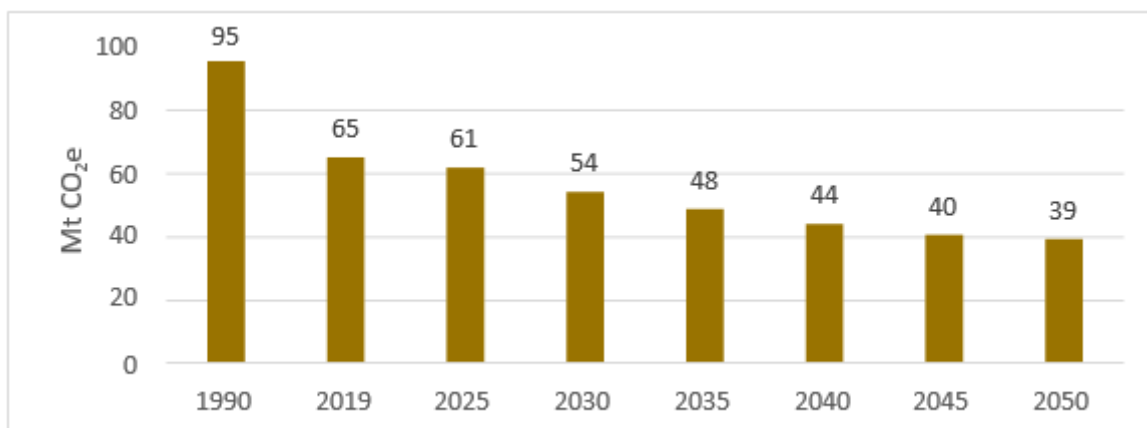


Figure 29. Total gross GHG emissions with existing policies and measures (1990-2050, Mt CO₂e/year)

Emissions under the EU ETS will be reduced by 35% by 2030 compared to 2019, while emissions under the ESD/ESR will be reduced by 10%.

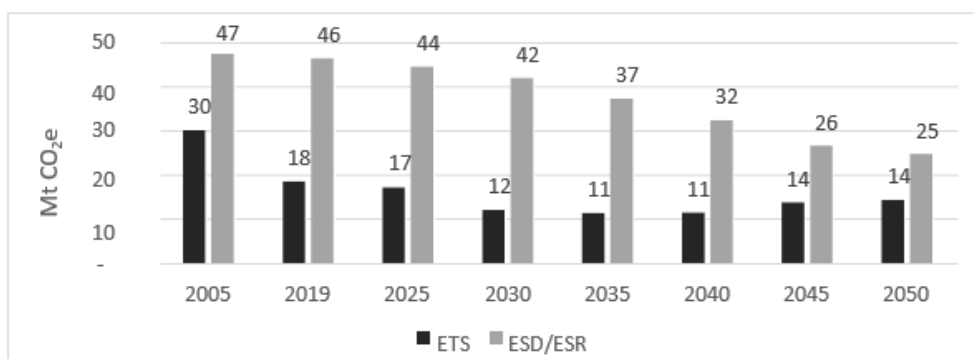


Figure 30. ETS and ESS emissions with existing policies and measures (2019-2050, Mt CO₂e/year)

Source: REKK, Eurostat

In the WEM scenario, CO₂ remains the most significant GHG. CO₂ emissions will be reduced by 18% by 2030 compared to 2019, while CH₄ emissions will be reduced by 17% and F-gases by 21%. Meanwhile, N₂O emissions increase by 0.02%. NF₃ emissions are not among the domestic emissions and are not expected to appear in the Hungarian GHG inventory.

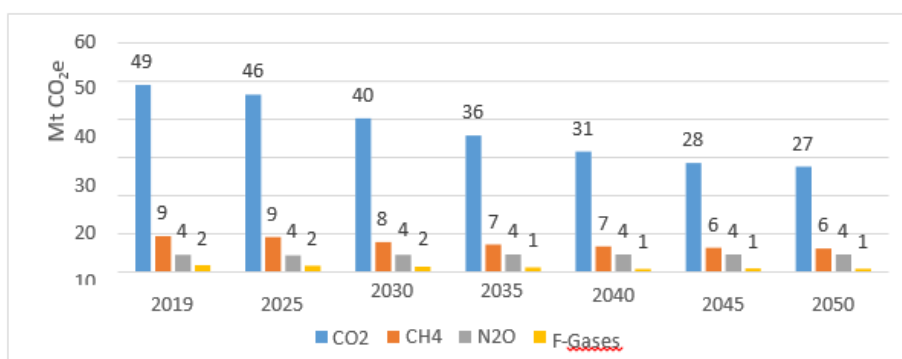


Figure 31. Evolution of net greenhouse gas emissions in the WEM scenario, by gas (2019-2050, Mt CO₂e/year)

Source: REKK, AKI, HungaroMet, Eurostat

Energy sector

Greenhouse gas emissions from the energy sector will change significantly by 2050, including in the WEM scenario. Compared to 2019 (gross), the reduction will be close to 21% by 2030 and 49% by 2050.

Transport (29%), energy (22%), population (17%) and manufacturing and construction (12%) were the main contributors to energy-related emissions in the base year. By 2050, the contribution of each sector to total emissions will change significantly. By 2030, although with reduced emissions, transport will retain its weight (30%), while the energy industry will only be responsible for 18% of energy-related emissions. Industry will play an increasingly important role in emissions across the energy sector by 2030 and 2050, accounting for 18% by 2030 and 29% by 2050. Emissions from the residential sector will be reduced by ~60% by 2050 and its share of total energy emissions will be 14%, compared to 19% in 2030. By contrast, the services sector's emissions will decrease by 19% by 2050, compared to 2019, and its share will be 7% by 2030 and 9% by 2050.

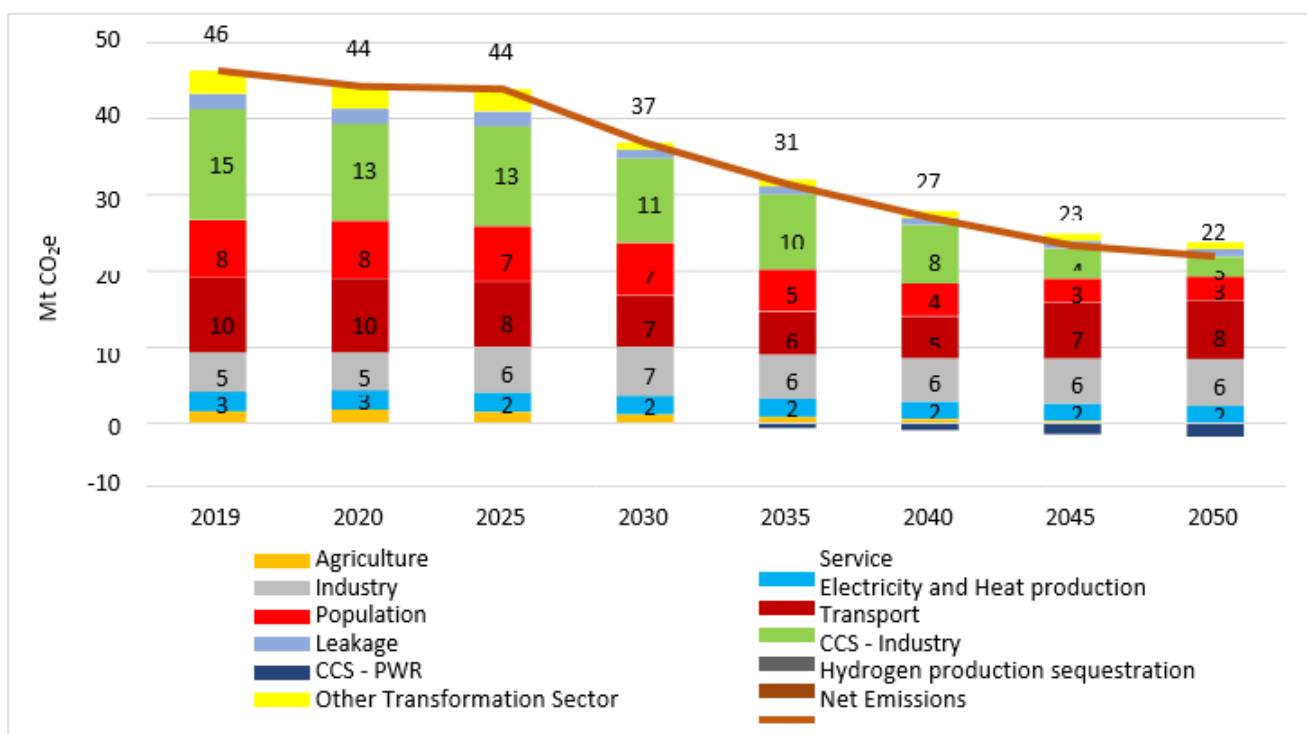


Figure 32. Sectoral composition of greenhouse gas emissions in the energy sector, WEM scenario (Mt CO₂e/year)

Source: REKK, Eurostat

Industrial processes and product use

Based on existing measures, total GHG emissions from the industrial processes and product use sector (IPPU) show a larger reduction of 7% by 2030 compared to 2019, followed by a further 7% reduction over the next 20 years.

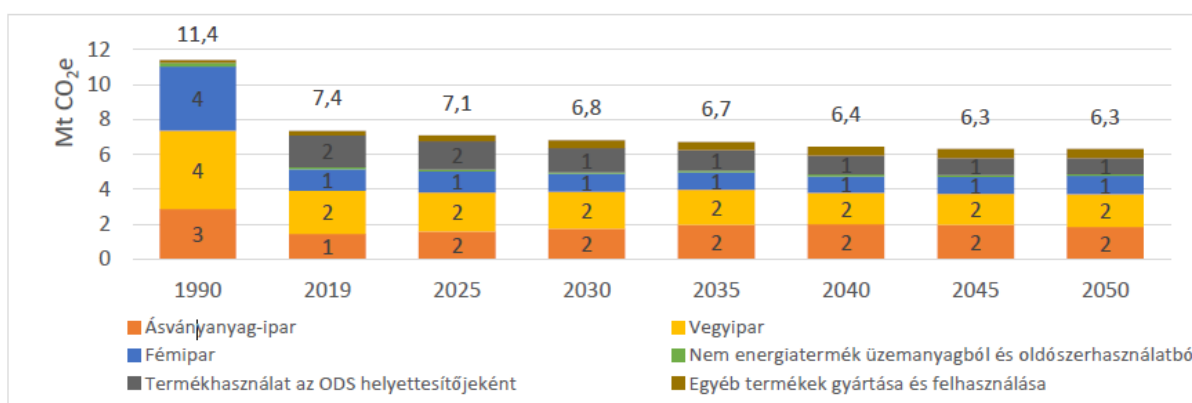


Figure 33. Composition of IPPU greenhouse gas emissions, WEM scenario (Mt CO₂e/year)

Total GHG emissions from the categories ‘Non-energy products from the use of fuels and solvents’ and ‘Use of products replacing ODS’ are expected to be halved by 2050. While GHG emissions from the minerals industry are on an increasing trajectory until 2030, emissions from these sectors, as well as from the chemical and mainly metals sectors, are projected to decline

more significantly, leading to an overall reduction in industrial (non- energy) emissions. At the same time, the reduction will slow down between 2030 and 2050, as mature industrial emission reduction solutions currently available will have been implemented by then.

Non-energy emissions from agriculture

Agricultural GHG emissions under the WEM scenario are expected to be 7 Mt CO₂e in 2030 and 6.9 Mt CO₂e in 2050. Emissions are slightly reduced (-0.6%) between 2019 and 2030, which translates into reductions of 30.9% and 31.9% between 1990-2030 and 1990-2050. Significant emission reductions are due to the livestock digestion and manure treatment categories, both of which fell by 45.1% and 50.1%, respectively, between 1990 and 2050.

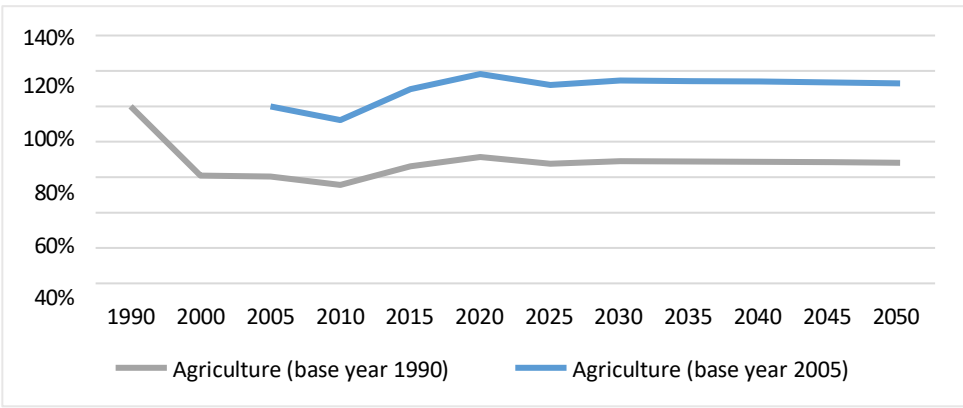


Figure 34. Greenhouse gas emissions from the agricultural sector compared to 1990 and 2005 levels in the WEM scenario between 2000 and 2050

Source: AKI, Eurostat

Emissions **from soil use** account for 48.4% (3.3 Mt CO₂e) of total GHG emissions from the agricultural sector in 2050. Emissions from tillage in the WEM scenario will be slightly below 1990 levels in 2050 as a result of reduced livestock and livestock manure use, compensated by increased fertiliser use. These emissions are 4% lower in 2030 than in 1990, while an increase of 26.3% is expected over the period 2005-2030 due to increasing fertiliser use. Emissions **from the digestion of farmed animals represent a significant share (32.7%) of the total sector’s** GHG emissions in 2050 and are expected to be 2.3 Mt CO₂e. Emissions from this category will decrease significantly (-45.1%) over the period 1990-2050. Emissions are 43.2% lower in 2030 than in 1990 and slightly increasing between 2005 and 2030 (+10.5%). GHG emissions **from manure treatment** in 2050 are only 1 Mt CO₂e, which is 50.1% less than in 1990. This is expected to decrease by 47.7% between 1990 and 2030 and by 9.8% between 2005 and 2030. The significant decrease is due to changes in dairy cow and pig herds. GHG emissions **from the use of urea-based** fertilisers will be reduced by 24.2% by 2050 to 0.13 Mt CO₂e, compared to 1990. Emissions are expected to increase one and a half times between 2005 and 2030.

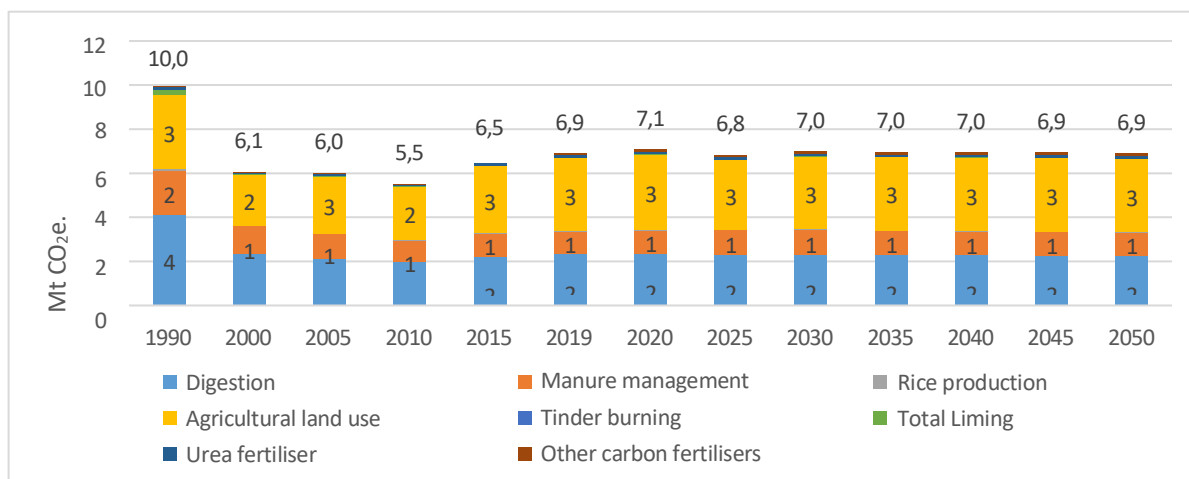


Figure 35. Greenhouse gas emissions from the agricultural sector in the WEM scenario between 1990 and 2050

Source: AKI, Eurostat

Total agricultural **CH₄ emissions** in the WEM scenario are 3 Mt CO₂e in 2050, which is 46.3% less than in 1990. CH₄ emissions will slightly increase between 2005 and 2030 (+5.5%). Digestion **emissions** account for more than 75% of the sector's total CH₄ emissions, i.e. 2.3 Mt CO₂e in 2050. CH₄ emissions from animal digestion, although decreasing by 45.1% between 1990 and 2050, are expected to increase slightly between 2005-2030 and 2005-2050 (+10.5% and +6.8% respectively). **CH₄ emissions from manure treatment** also represent a significant proportion. Despite increasing emission levels from poultry farming, the decline in pig population has led to a 48% reduction over the period 1990-2050, i.e. a 7.8% reduction over 2005-2030 and an 11.8% reduction over 2005-2050.

In the WEM scenario, **N₂O emissions** from the agricultural sector are expected to decrease by 12.3% to 3.7 Mt CO₂e between 1990 and 2050 and increase by 21.1% between 2005 and 2050. By 2030, emissions are 12.5% lower than in 1990 and 20.8% higher than in 2005. Despite the decrease in livestock, the slight decrease can be explained by the negligible reduction due to tillage. Soil **use accounts** for more than 90% of N₂O emissions in 2050, 3.3 Mt CO₂e. The CO₂ emissions of the agricultural sector under the WEM scenario are expected to decrease by 37.5% between 1990 and 2050 to 0.24 Mt CO₂e. However, due to the **increase in the use of urea and other carbon fertilisers**, emissions will increase by 65.8% between 2005 and 2030. However, emissions from the use of urea fertilisers are still 23.5% lower in 2030 than in 1990.

Waste management sector (including waste water treatment)

GHG emissions from the waste management sector are expected to be halved by 2050 compared to 1990 and reduced by 18% by 2030.

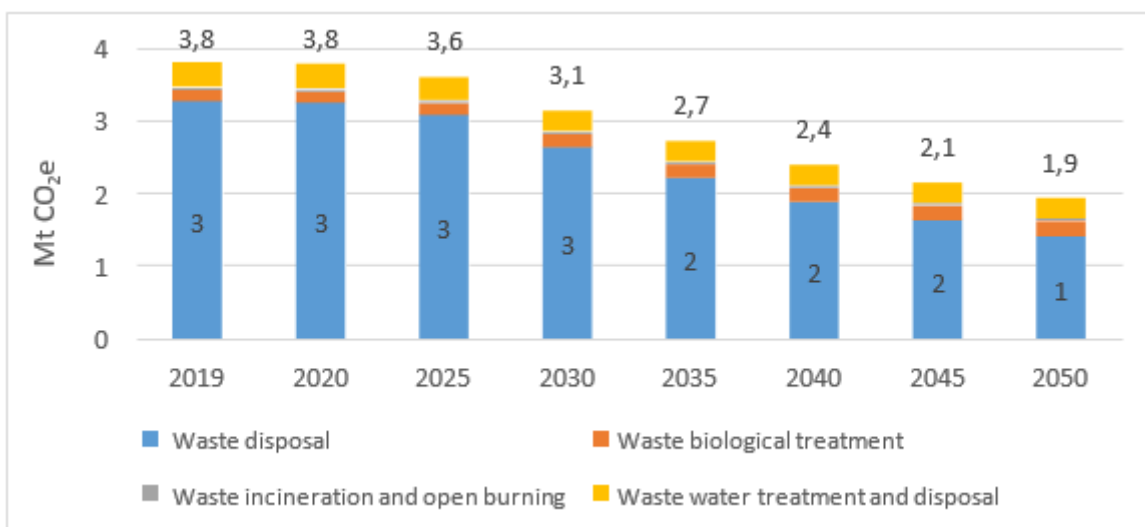


Figure 36. GHG emissions of the waste (and waste water) sector under the WEM scenario (Mt CO₂e/year)

Source: Eurostat, HungaroMet

Although methane emissions **from landfilling** are expected to decrease the most (-57% from 1990 to 2050), this source category remains the most important for emissions from the waste management sector. Its shares are 86%, 84% and 73% in 2019, 2030 and 2050. Both the expected increase in composting and biogas production will lead to increased emissions in the source category of **biological treatment of waste**. In the current WEM scenario, emissions are already increasing by 21% by 2030 and by 43% by 2050 compared to 2019. As regards waste water treatment, we expect a steady increase in the energy recovery of sewage sludge, which could increase methane leakage, and on the other hand, a higher connection speed to centralised, tertiary treated waste water treatment plants would result in higher nitrogen removals and thus lower N₂O emissions. As a result, greenhouse gas emissions **from wastewater treatment** would be reduced by 18% between 2019 and 2050, most of which (i.e. 17%) would already be achieved by 2030.

For municipal waste, landfilling will be reduced from over 2 million tonnes to 0.8 million tonnes in 2030 and 0.4 million tonnes in 2040. One of the reasons for this is the improvement of the separate collection of waste and the pre-treatment system of waste, thus reducing the amount of waste disposed of by landfilling and shifting it towards recycling, biogas production and recovery in thermal incineration (with increased capacity). The planned amount of disposal by landfill of the main types of degradable waste (food, paper, etc.) and the resulting CH₄ emissions are as follows.

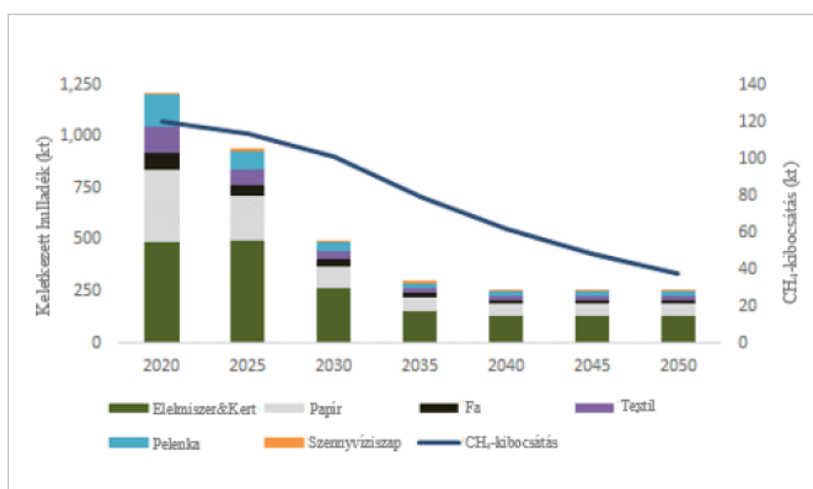


Figure 37. Quantity of waste disposed of by landfilling (kt)

Source: HungaroMet

The sources included biological treatment of waste, composting of municipal waste and sewage sludge. The amount of **composted municipal waste** is assumed to increase from 0.4 Mt in 2020 to 0.6 Mt in 2030 and to remain unchanged thereafter. Incineration **without energy recovery currently** accounts for only 1% of emissions in the waste sector and no significant change is expected. We assumed an increase of 4.4% in **the composting of sewage sludge** every 5 years, taking into account leaks from other biogas production. Methane emissions from wastewater treatment and discharges are largely determined by the proportion of dwellings connected to the public sewerage network, which is expected to increase further by 2030 (by 4-8% points). In parallel, the utilization of sewage sludge gas would increase by 11% and overall by about 30% by 2050.

In terms of **N₂O emissions**, no significant change in per capita protein consumption is expected. However, tertiary treatment would reach 99% by 2035 (from the current 89%), which would increase the removal of nitrogen from waste water and consequently reduce N₂O emissions.

LULUCF sector

In order to model the CO₂ sink capacity of the LULUCF sector, existing forests, afforestations⁵⁴ and non-forest land uses have been modelled using different methodologies reflecting the domestic situation, due to their different nature and different projection data needs⁵⁵.

For forest land remaining forest land, biomass carbon stock changes have been estimated based on traditional yield tables and information on past harvesting practice (these together were used to derive net growth, i.e., gross growth minus thinnings minus mortality for 22 species/species groups and 6 yield classes. Final harvest was modelled for specific age for each species and yield class. Biomass carbon stock changes due to a specific harvest scenario is modelled at the above species level by adding or deducting any differences between the harvest levels assumed in the model's reference run and in the scenario analysed. Below-ground biomass and HWP

⁵⁴ CASMOFOR (2001; 2023) and CASMOFOR-NFD (2019): Dr Z. Somogyi, SOE-ERTI (<http://www.scientia.hu/casmofofor>)

⁵⁵ Institute of Agricultural Economics (AKI)

stock changes are calculated as in the GHG inventory. Deadwood is modelled using reverse modelling based on species-specific stocks (measured by the National Forest Inventory) and first-order decay functions. Just like in the GHG inventory, changes in the litter and soil pools were assumed to be zero, i.e., these pools are assumed to be in equilibrium. Non-CO₂ emissions and emissions from organic soils were modelled as linear extrapolation of historical emissions. Definitions and methodologies are in general the same as in the GHG inventory.

To estimate biomass carbon stock changes in afforestations, gross growth functions are applied by age classes (1-20 years) in annual steps. Thinnings are modelled based on data estimated by analysing data collected in forestry practice for the above species together with expert judgment applied at the yield class level. For afforestations, no non-standard harvest scenarios were modelled, only the different afforestation area scenarios. Below-ground biomass and HWP stock changes as well as changes in the soil and litter pools were calculated as in the GHG inventory.

For non-forest projections definitions, equations and model parameters are the same as in the GHG inventory. The model in this respect is driven differently from the GHG inventory by the assumptions applied in the various land use and land use change scenarios.

In the WEM scenario, the LULUCF sector remains a net sink, with a projected sink of -5.3 MtCO₂/year in 2030. However, this value gradually declines to -4.2 MtCO₂/year by 2050. In contrast, under the WAM scenario, the sector maintains its sink status through 2050, sustaining a steady net sink level of -6 MtCO₂/year.

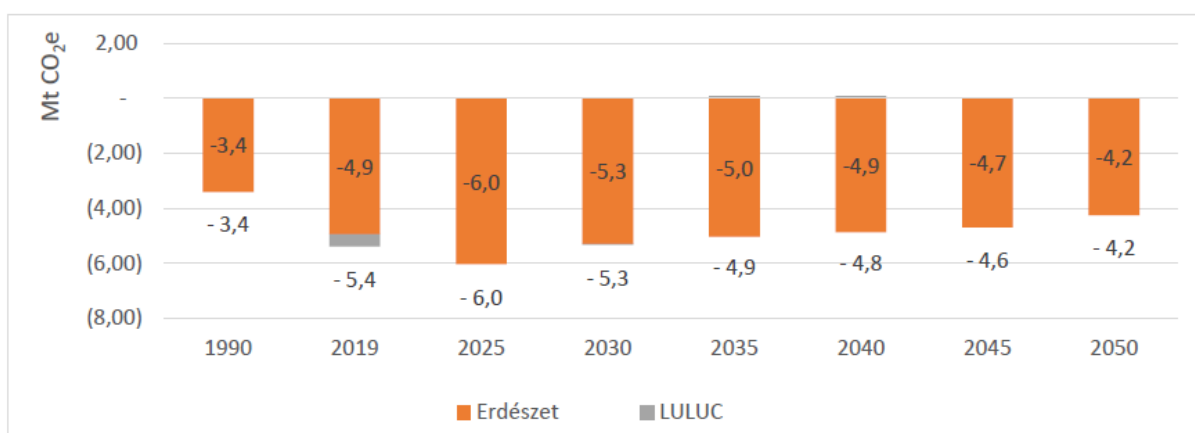


Figure 38. Net GHG removals of the LULUCF sector under the WEM scenario, 1990-2050 (Mt CO₂e)

Source: AKI, SOE, ERTI, Eurostat

For forestry, net removals of 4.9 Mt CO₂e are projected by 2030 based on the WEM scenario. In addition, in terms of land use and land use changes, the WEM project projects low GHG emissions (94.21 kt CO₂e) by 2030, which will be gradually reduced and balanced by 2050.

Forestry

A CASMOFOR-NFD model was used to predict the carbon absorption capacity of existing

forests in order to determine the so-called forest reference level. The projection of changes in the carbon stock of individual forest carbon pools is based on the state of forests as known at the end of 2021, followed by a quantified simulation of annual natural and forest management processes. The model is compatible with the methodology of the IPCC (2006, 2019) and the Hungarian GHG inventory, which can be found in the National Forest Stock Database (OEA; It manages forests registered in the National Forestry Database (NFD) and some of its parameters have been determined based on its data. CASMOFOR-NFD is a dynamic growth model that estimates woody biomass (above and below ground) and deadwood carbon pool for all forests in Hungary. The following data and assumptions were applied during the modelling.

During the modelling, the characteristics of the forest area are recalculated annually. The data required for quantification are available at varying depths. Most measurement data are available **for above-ground wood biomass** and more recently **for dead wood quantity**, while the magnitude of carbon stock change for **underground wood biomass** can be calculated using the scale factor used in the GHG inventory. However, we do not have adequate data for the avar and **soil** carbon pools, so in the case of avar, we assume that the amount of carbon captured in the avar correlates with that of woody biomass, i.e. it grows slowly, while in the case of the soil of existing forests, we assume a carbon stock change of 0.⁵⁶ Emissions from forests, which are accounted for in the GHG inventory, such as CH₄ and N₂O emissions from the incineration of slaughterhouse waste or forest fires, and CO₂ emissions from organic soils, are assumed to be the same and perpetuated at the 2020 level.

In connection with forestry, the **reduction in the stock of live trees associated with nursery cuttings and end-use** and the planned tree species for forest regeneration have been established. With **regard to logging**, we assume that the average annual upward trend in recent years remains unchanged.

	2021	2025	2030	2035	2040	2045	2050
Logging (e m³/year)	7523	8032	8280	8528	8776	9024	9272

Table 39. Scale of logging assumed in the WEM scenario (thousand m³/year, 2021-2050)

Source: SOE ERTI

As the annual increments will be much higher than the total logging resulting from this increase by 2050, the assumed annual logging shown in the table above meets the criteria for **sustainable wood use**. The same assumption is used for the development of forests, i.e. the growth rate of trees is based on recent trends.

The forest area used in the model is the same as the areas identified as forest parcels in the OEA at the end of 2021, for which data on **area (ha) and stocks of live trees (m³) were available by age group (150), group of tree species (22) and harvest class (6-6 FTO)**. The characteristics of tree stands (area and stock of live trees) and their changes over time are

⁵⁶ According to the demonstration carried out under the Kyoto Protocol, the soil of domestic forests is not carbon-emitting.

described in the model as a function of these three groups. The areas affected by the final use are placed in the minus three-year age group determined by experts before the first age group, thus mapping the assumed average time needed to start forest restoration. From these basic data, the parameters of the annual timber stock and the 132 Chapman-Richards function can be calculated, from which the differential factors of the timber volume can be derived.⁵⁷

Although the carbon sequestration capacity of the 2021 living wood stock is much higher than that of the deadwood carbon pool, this capacity may decrease significantly over time. This decrease is due to (1) an increase in the volume of logging, (2) a significant change in the age distribution of forests over time. The reason for the change in age distribution is, on the one hand, the different types of end-uses and the distribution of past afforestations by time, tree yield classes and tree species. **Net carbon sequestration is not a permanent** feature of forests. From this, the forestry sector still needs to find a way to at least postpone the reduction of carbon sequestration in order to approximate the carbon neutrality targets. **In addition to reduced logging, increasing afforestation**, among other things, can help.

In addition to the CO₂ absorption capacity of existing forests, WEM forecasting of **the LULUCF sector requires forecasting of the CO₂ absorption capacity of afforestations resulting from existing policies**. The projection of afforestation was made with CASMOFOR model, which is compatible with the currently used IPCC (2006, 2019) guidelines and the methodology of the domestic greenhouse gas (GHG) inventory (NIR, 2023).

The model calculates, in an annual step, **the changes resulting from the modelled processes for each forest carbon pool – living wood, dead wood, mulch cover, soil – and for wood products carbon pool**, based on harvesting tables, literature and expert estimates, according to the data and methods presented below. The best estimate can be made for above-ground biomass because most and most accurate data are available in this area. The growth of the above-ground carcass is modelled using standard tree yield tables. The forest management model tables have been updated on the basis of forest economic calculations and expert estimates. Mortality is calculated based on forest inventory and other information using an expert-estimated rate (mortality at a given age is equal to the current stock of trees multiplied by that rate). The decomposition of dead organic matter is modelled with simplified functions based on literature data. The dynamics of foliage and root system are modelled on the basis of literature data, the IPCC (2006) Guidelines and expert estimates.

It should also be borne in mind that the implementation of projects designed to neutralise emissions is affected, inter alia, by climate change. The growth and death of trees, as well as all other forest processes that are important for forest carbon turnover, depend on how environmental factors, including some climatic factors, change. Few results have yet been achieved in this field under domestic circumstances, so the projection was made on the assumption that no significant changes in forest processes and growth laws will occur – they will develop in line with those modelled in the tree yield tables. In the case of afforestation, the amount of carbon sequestered in the soil can be significant and has been estimated based on the methodology and carbon stock change factors of the GHG inventory (NIR, 2023).

In view of the fact that there is no separate tree production or forest management model

⁵⁷ The R program was based on the so-called robustbase module, e.g. on this website: <https://blogg.slu.se/forest-biometrics/2017/03/11/the-chapman-richards-growth-function/>.

available for each domestic tree species, it was necessary to use models derived for each tree species or group of tree species specified in the scenario, as shown in the table below.

Purpose of afforestation	Tree species – groups of tree species	Model of applied tree species
<i>Conventional forest management</i>	Black locust	Acacia (timber class 4)
	Unsedged oak (KTT)	SAC (timber class 4)
	Cherry and other hard leafy (Cser + EKL)	Shrub (timber class 3)
	Forest pine and Black pine (EF + FF)	EF (timber class 3)
	Domestic Poplar and Other Soft Leafy (HNY + ELL)	HNY (timber class 4)
	Noble poplar and white willow (NNY + DDA)	NNY (timber class 3)
<i>Industrial (cylindrical wood plantations)</i>	Black locust	Acacia (timber class 3)
	Noble poplar and white willow (NNY + DDA)	NNY (timber class 2)

Table 40. List of tree species and groups of tree species used in afforestation and the tree yield table and tree yield class used for them, according to the purpose of planting

Source: SOE-ERTI

The settings of the model tree species used also determine other required model parameters (e.g. tree density). The area of plantation of industrial plantations accounts for one tenth of total afforestation. The planting of plantations further increases the area of tree species that are also dominant in traditional forestry forests – acacia, poplar and white willow.⁵⁸ The above is illustrated in the diagram below.

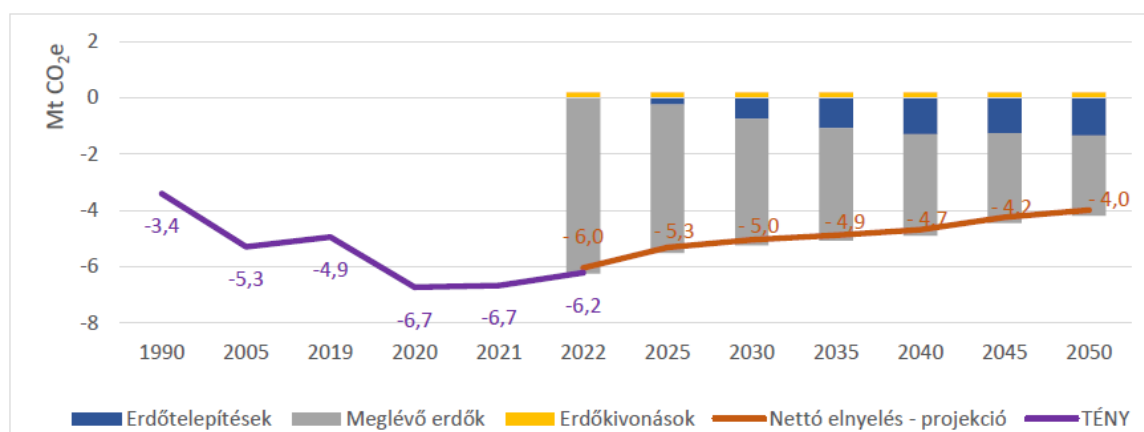


Figure 39. Expected evolution of CO₂ emissions and removals (net carbon balance) of the forestry sector, based on the WEM scenario (Mt CO₂e, 1990-2050) Source: SOE-ERTI

⁵⁸ The results are always interpreted as net sequestration, because it is true for every carbon pool that there are processes that increase the size of the given carbon pool, but there are also processes that decrease it, so the presented quantities are always the result of these processes with opposite effect.

III. Information related to climate change impacts and adaptation under Article 7 of the Paris Agreement

III.A. National circumstances, institutional arrangements and legal frameworks

III.A.1. National circumstances relevant to its adaptation actions

III.A.1.1. Biogeophysical characteristics relevant to adaptation actions

Hungary is situated in the middle of the Carpathian basin on 93 036 km². Due to its location (plain region surrounded by mountains), its territory is more **vulnerable to climate change's given negative effects**. The majority of the country's terrain lies under 200 meters (84%), and only 2% of the country is located above 400 meters. The country's territory belongs to the catchment area of the Danube (417 km). The fact that 95% of the surface water arrives from the neighbouring countries has a huge influence on Hungary's water management. As a remarkable consequence, floodplains covered 25% of the territory. Lake Balaton, the largest lake in Central Europe, also located in Hungary. Together with Fertő Lake, Velencei Lake and the Lake Tisza (the former Kisköre reservoir) these large and shallow lakes, particularly their water quantity and quality are really vulnerable to the effects of climate change.

The country had a forest coverage of 21.1% in 2023. Forests are mostly located in the northern and Transdanubian hilly/mountainous areas and in some parts of the Great Plain. Their most vulnerable stocks to climate change are the beech, spruce and black pine stocks of Alpokalja, Bakony, Mátra, Börzsöny and Bükk mountains and acacia/oak forests of the Nyírség.

Most of the territory of the Carpathian basin is covered by the **Pannonian biogeographical region**. Due to its isolation from other geographical regions, **unique flora and fauna evolved in the area**, including several endemic and relictum endemic species. Many of these species cannot be found in any other places in the world. Around 42 000 animal species and 3 000 plant species are identified in the territory.

Hungary has a moderate climate with a significant continental influence. According to the HungaroMet Hungarian Meteorological Service's (HungaroMet), long-term statistics and the National Adaptation Geo-information System's (NAGiS) data, **the average mean annual temperature of the region increased by 1.23 °C between 1901 and 2018. This increase is far higher than the estimated 0.9 °C mean annual temperature on the global scale**. Nowadays, the mean annual temperature in Hungary is 10.3 °C on average. Any differences from that temperature are typical only in smaller areas where topographical factors determine that. **The biggest increase can be experienced in the summer months and in the Southern Great Plain**.

Annual precipitation is 616 mm on average, considering the period of 1991–2020. Even the precipitation dispersion shows a really diverse pattern in space and time. On a seasonal scale, the average precipitation is 140 mm in spring, 200 mm in summer, 145 mm in autumn, and 110 mm in winter. The spatial distribution of precipitation is determined by the seas' distance, primarily the Mediterranean Sea and topology. In the driest parts of the Hungarian Great Plain,

some areas have annual precipitation less than 500 mm, and there are vast regions that have multiannual average precipitation of 500-550 mm. The typical annual precipitation in the southwestern border region and the Bakony Mountains is higher than 700 mm. Higher, nearly 800 mm precipitation occurs in small spots only in the vicinity of the Mátra and Bükk mountains' summits and the Kőszeg Mountains.

No clear change can be demonstrated in the amount of annual precipitation, even in a period of half a century- however, the spatial and temporal precipitation patterns are changing. **Intensity of rain events are constantly increasing, while the number of rainy days is in decline.** In the last more than fifty years, the series shows a slight, approximately 5% non-significant increase on the country average between 1961 and 2018.

Information about vulnerability of natural resources in Hungary is available in the **National Adaptation Geo-information System (NAGiS)**⁵⁹. The NAGiS is a source of information on the climate trends of Hungary; effects of strategic risk factors like climate change and other issues affecting long-term natural resource management, and the possibilities of adaptation to the changes.

III.A.1.2. Demographic situation relevant to adaptation actions

According to the Hungarian Central Statistical Office (KSH), **Hungary has 9.67 million inhabitants in 2023.** They are living in 3155 settlements, including 348 cities and 2807 municipalities in 2023. Every third municipality has less than 500 inhabitants. At the same time, only 3 % of the population lives in these small villages. Around 17.9% of the population, 1.70 million inhabitants live in Budapest. Hungary's capital is a primate city and far larger than the second-largest city Debrecen (201 704 inhabitants in 2023). Meanwhile, Szeged, Miskolc, and Pécs also had more than 140 thousand inhabitants in 2023. According to the 2022 census, the urbanization level was 70.22%. **Regarding vulnerability, urban areas are among the most affected areas of climate change (e.g., heat waves, urban heat islands, municipal rainwater inundations).**

Hungary's society is aging, there is an increasing rate of people over 65 years in society, **which results in a higher vulnerability to climate change's negative effects** (e.g., heat waves, cold waves). The life expectancy of men was 73.39 and women's life expectancy 79.58 years in 2023. There are regional differences in life expectancies between the more developed districts in western counties and the less developed northeastern and southeastern peripheries.

There are also significant spatial differences in income conditions (and in other general socio-economic indicators), **which also effects adaptive capacity.** Differences within the country can be described partly by geographical factors: Northern-Hungary and Southern Transdanubia typically have worse socio-economic indicators than Central and Western Hungary, but also the distance from regional centres and Budapest is an important factor (usually, the more peripheral a municipality is the worse are their socio-economic indicators). Socio-economic disadvantage is typically associated with lower adaptive capacity.

⁵⁹ <https://nater.mbfisz.gov.hu/en>

III.A.1.3. Economic and infrastructural situation relevant to adaptation actions

Macroeconomic situation

The 2023 annual overview volume of the Hungarian Central Statistical Office concludes the following on the social, economic and environmental characteristics of Hungary:

- In 2023, both the **number of people in employment and their share of the population increased** to a record high, while at the same time the **unemployment rate also increased**.
- Hungarian economic output to fall by 0.9% in 2023.
- High inflation and the interest rate environment have negatively affected consumption and investment decisions.
- **The sharp rise in consumer prices has led to a fall in real earnings**, a fall in household consumption and, as a result, a fall in retail sales.
- **The volume of investment was lower than in the previous year, partly due to the high interest rate environment and partly due to the lack of EU funding**. The slowdown in construction investment also affected construction output and housing starts.
- **The reduction in the debt-to-GDP ratio continued in 2023**.
- As in industry, the performance of the vast majority of economic sectors was below that of a year earlier. **The economic slowdown was most strongly held back by the favourable performance of agriculture, with yields well above the previous year's very low base due to a severe drought**.
- **The country's energy use continued to fall in 2023 after 2022**, reflecting high energy prices, a downturn in many economic sectors and milder weather earlier in the year.
- **In 2023, the number of deaths and births fell further compared to the previous year, while the number of women of childbearing age also declined**. The total fertility rate, which is an indicator of fertility propensity, has fallen slightly but remains above 1.5. International migration inflows have slowed the rate of population decline.

Title	2015	2019	2020	2022	2023
Macroeconomic environment					
Gross domestic product (GDP) volume index, 2015 = 100,0	100,0	117,7	112,5	125,9	124,8
GDP per capita, EU27_2020 average = 100,0 ⁶⁰	70,0	73,0	74,4	76,1	76,4
Investment volume index, 2015 = 100,0 ⁶¹	100,0	144,8	140,9	151,6	138,8
Balance of trade in goods, billion euros	8,6	4,3	5,6–	9,1	9,2

⁶⁰ Calculated at purchasing power parity.

⁶¹ Quarterly data for 2023 and annual data for earlier years are calculated on the basis of annual data collection.

Government sector balance as a percentage of GDP	-2,0-	-2,0	-7,6	-6,2	-6,7
SME sector share of business value added, %	43,2	45,6	44,6	43,9	..
R&D expenditure as a percentage of GDP	1,34	1,47	1,59	1,39	..
Consumer Price Index, 2015 = 100,0	100,0	109,3	112,9	135,8	159,8
Labour market situation					
Employment rate, % ⁶²	65,9	72,2	71,9	74,4	74,8
Unemployment rate, % ⁶³	6,6	3,3	4,1	3,6	4,1
Vacancy rate, %	6,6	3,3	4,1	3,6	4,1
Sectoral overview					
Industrial production volume index, 2015 = 100,0	100,0	115,5	108,8	126,0	119,2
Goods transport performance index, 2015 = 100,0 ⁶⁴	100,0	105,7	94,8	99,5	89,9
Volume index of retail trade turnover, 2015 = 100,0 ⁶⁵	100,0	125,7	125,4	136,6	125,9
Volume index of sales turnover in restaurants and catering, 2015 = 100,0 ⁶⁶	100,0	136,9	93,7	132,3	129,1
Volume index of construction output, 2015 = 100,0	100,0	153,9	138,9	158,2	150,3
Agricultural output volume index, 2015 = 100,0 ⁶⁷	100,0	107,5	105,0	86,7	108,5
Digital world					
Number of fixed internet subscriptions, 2015 = 100,0	100,0	119,1	122,6	131,1	132,9
Share of e-commerce in business turnover, % ⁶⁸	19	24	23	20	23
Percentage of households with internet connection, %	76	86	88	91	93
Demographic situation					
Live births, thousand persons	91,7	89,2	92,3	88,5	85,2

⁶² Within the population aged 15-64.

⁶³ Within the population aged 15-74.

⁶⁴ On a per tonne-kilometre basis.

⁶⁵ Calendar-adjusted volume index.

⁶⁶ Seasonally and calendar adjusted volume index.

⁶⁷ Standard price.

⁶⁸ Excluding financial institutions for enterprises with 10 or more employees.

Number of deaths, thousand persons	131,7	129,6	141,0	136,4	128,2
Total fertility rate	1,44	1,49	1,56	1,52	1,51
Living condition					
Index of change in real earnings, 2018 = 100,0 ⁶⁹	..	107,6	114,4	121,6	118,4
Percentage at risk of poverty or social exclusion, %	28,6	19,4	19,4	19,6	..
Average life expectancy at birth, years	75,44	76,16	75,52	75,84	76,60
Number of students in tertiary education, thousands	295,3	285,1	287,5	290,0	310,4
Environment and energy management					
Greenhouse gas emissions index, 2015=100.0 ⁷⁰	100,0	102,5	97,1	97,0	..
Total energy use in national economy, PJ	1 049	1 100	1095	1056	1001

Table 41. Summary data on the performance of the Hungarian economy, 2023

Source: Magyarország 2023, Hungarian Central Statistical Office (KSH)

Further information on macroeconomic environment is available in Chapter II.A.4 (Economic profile).

Infrastructure

Detailed information on infrastructure is available at Chapter II.A.6. – Sector details-Transport. This chapter focuses on the risks and climate adaptation issues related to infrastructure.

Road Network

Heatwaves are one of the climate impacts on road transport that affect road users (drivers and passengers alike) **the most**. Temperatures inside vehicles can be several degrees higher than outside. For private transport modes, high temperatures can also cause safety problems (e.g. distraction). In addition, **prolonged high temperatures can lead to increased asphalt deterioration** (drastic increase in rutting) **in the summer months**, which can have a negative impact on traffic, in extreme cases requiring the closure of certain sections and restrictions on traffic, and on the other hand, the warming roads can further heat up the already hot air in cities.

⁶⁹ Calculated on net earnings. Data for the full range of employers are available from 2019.

⁷⁰ Based on Eurostat data.

In addition, **road transport is also threatened by the increased frequency of floods and storms**. In lower-lying urban areas, floodplains and along watercourses, surface transport infrastructure may be submerged. **Sudden rainfall can undermine road embankments and embankments, sometimes leading to landslides, while prolonged drought can reduce the stability of the same structures** (subsidence). Climate change can also adversely affect the biodiversity of vegetation and habitats along roads and highways. Storms with stronger, more violent gusts of wind damage road safety equipment, traffic lights and road signs.

Railway Network

As with the road infrastructure, **heatwaves are one of the biggest climatic challenges for rail infrastructure**. **Rail tracks can be deformed by the heat**, causing delays on many lines, and there is an increased need for adequate ventilation and cooling of wagons to ensure the comfort of passengers. In addition, extreme storms can cause problems, both in terms of overhead line ruptures (e.g. due to tree felling, lightning strikes) and the **large amounts of sudden rainfall that can flood or undercut railway embankments**.

Inland Waterways

From a climatic point of view, **inland shipping routes are exposed to the double squeeze of water abundance and water scarcity**. The **floods** that time to time descend on our main rivers (e.g. Duna; Tisza) disrupt water transport and can endanger countless settlements. At the same time, the **flood protection infrastructure has been renewed in the last 10-15 years in the most endangered river sections**, thus reducing damages and the costs of protection. In addition to floods, **drought is also a significant climate effect**. In **2022**, as a result of the flood raging all over Europe, the **water level of our rivers suitable for domestic water transport dropped to a record low**, which also caused disruptions in water transport.

Aviation/Air Transport

Among the effects of climate change in Hungary, **air transport is primarily threatened by damage from extreme storms**. Hail and lightning can damage the infrastructure of airfields and the planes themselves. In addition, large amounts of precipitation can flood the runways, and strong gusts of wind can prevent the safe landing and take-off of airplanes. Although these effects are not yet significant in Hungary, but they are expected to increase in the future.

Energy infrastructure networks

Increased extreme weather events due to climate change will also have a major impact on **energy infrastructure elements in Hungary**. By 2023, the research "**Assessment of climate and geological vulnerability of energy infrastructure elements (electricity, gas, district heating systems)**" was completed, the results of which were also included in the NAGiS system. The research examined the **demand-side vulnerability of energy production in the**

electricity, natural gas and district heating sectors, and the vulnerability of energy infrastructure to extreme weather events and geological hazards. The main findings of the study are:

- Studies of the **high-voltage transmission network indicate that in the medium term (2021-2050), most domestic transmission lines are expected to have low climate and geological impacts on infrastructure**. Exceptions are several sections in the Southern Transdanubian region and in the southern foothills of the North Hungarian Mountains.
- Changes in **temperature also affect the evolution of demand for electricity, natural gas and district heating**, but many **other factors besides climate change can also affect energy demand**. The most important of these are **improvements in energy efficiency, population change, economic growth and economic structure**. There are real regional differences in these areas.
- **Cooling demand is expected to increase across the country in the future, and heating demand to decrease**, but the extent of this will also vary from area to area. **The Budapest agglomeration is expected to see a smaller decrease in energy demand than the rest of the country**, and electricity consumption is expected to increase more significantly.
- At the same time, **energy demand in the Northern Hungarian Mountains is expected to decrease more significantly due to the high climatic exposure**, so the average temperature of the heating season will increase more than in the rest of the country. In addition, **depopulation is a serious problem, especially in small rural areas**, which will also lead to a reduction in demand, and economic growth will be below the national average. **As a result, electricity consumption is less likely to experience high peak loads**, but the deterioration in the utilisation of natural gas and district heating systems could still be a major problem in the future.

Urban areas

Metropolitan areas such as **Budapest and its functional urban area**, as well as **regional urban centres** are more **exposed to climate change impacts due to the concentration of population, economy and infrastructure**. Due to the effect of **urban heat islands cities are more affected by the heat waves, which has negative consequences on human health** especially for the elderly and young children, and for outdoor workers. Besides that as it is mentioned above an increasing frequency of **asphalt damage** can also be expected in the summer months. In Hungary, the **frequency and intensity of extreme storms** and their accompanying phenomena (e.g. wind gusts, hail, intense precipitation) are increasing, significantly affecting urban areas. Extreme storms can **cause power cables to burst, trees to fall on roads**, rainwater **inundations** due to capacity limitations in the stormwater drainage system, **flash floods** in hilly settlements that sometimes lead to **landslides**. As a consequence, cities' transport systems can be paralysed and energy infrastructure networks can be interrupted.

III.A.2. Institutional arrangements and governance

The structure of the Hungarian climate policy administration has undergone a number of organisational changes (ministerial and background institutional changes) in recent years. At present, the Hungarian climate policy management organisation is the **Deputy State Secretariat for Climate Policy within the Ministry of Energy and its Climate Policy Department**, which is primarily responsible for **creating the legal background and taking legislative decisions. It also coordinates the climate policy-related efforts of the different ministries.** In addition to the ministry, the **National Adaptation Centre (NAC) Department of the HungaroMet Hungarian Meteorological Service** is also an important actor, acting as a climate adaptation-related **background institution of the ministry since 2012. The NAC has been part of the HungaroMet since January 2024.** Its main task is to **support strategic planning** in the fields of adaptation to the expected impacts of climate change (through the National Climate Change Strategy and its Action Plans, regional and municipal adaptation strategies) as well as **conducting international and domestic reporting, monitoring and evaluating activities on domestic climate adaptation processes, and operating and developing the National Adaptation Geo-Information System (NAGiS) system, the primary decision support tool of the Hungarian adaptation policy.** Furthermore, the department regularly participates in **adaptation-related international and domestic research projects.**

The Hungarian adaptation policy framework is determined by the development directions, identified by the relevant international, EU and Hungarian policy documents and strategies. The **Second National Climate Change Strategy (NCCS-2)** was adopted in 2018 by the Hungarian Parliament. It comprises **3 sub-documents (sub-strategies)** in line with the 3 pillars of climate policy: the **National Decarbonization Roadmap** for mitigation; the **National Adaptation Strategy** for adaptation; and the **Climate Change Awareness Raising Action Plan** for awareness raising. The implementation of NCCS-2 was planned to be supported by **Climate Change Action Plans (CCAP).** The **first CCAP was adopted in 2020 by the Government,** and covered the period 2018-2020. In early 2020 an additional document, the **Governmental Report on the current and expected impacts of climate change on the Carpathian Basin (RCB) was also adopted by the Government.** The document consist among other things of sectoral and thematic development directions in given vulnerability topics. During 2022-2023, the NCCS-2's **revision process (justified by the Parliamentary Decree 23/2018. (X. 31.) on the Adoption of the NCCS-2) occurred; an Evaluation Report was developed by the NAC.** This was justified by the 2012 amendment of Act LX of 2007 on the implementation of the UN Framework Convention on Climate Change and its Kyoto Protocol, which **requires Hungary to develop a national-level climate strategy, to be reviewed and updated regularly.**

III.A.3. Legal and policy frameworks and regulations

In the following, key laws governing Hungarian climate adaptation efforts are listed:

- **Article 3(1) of Act LX of 2007 on the Framework for Implementation of the UN Framework Convention on Climate Change and its Kyoto Protocol** declares the following:

Hungary shall develop a national climate change strategy and review and update it regularly.

This Act was modified in 2012 with the obligation to establish a geo-information-based national adaptation decision support system in Hungary.

- **Act XLIV of 2020 on climate protection** aims to prevent where possible or reduce the impacts of climate change and promote adaptation to the increase in the frequency and intensity of extreme weather events. The law states that **it must provide a response that is valid for the whole Carpathian Basin and quantifies emission reduction targets.**
- **Government Decree 94/2014 (21.III.)** on the detailed rules of the **National Adaptation Geographical Information System (NAGiS)**, which defines the purpose and tasks of the NAGiS system. **This Government Decree is under modification in 2023 by Government Decree 591/2023 (XII.),** which assigns the operation of the NAGiS system to **HungaroMet Hungarian Meteorological Service Nonprofit Ltd.**

III.B. Impacts, risks and vulnerabilities

III.B.1. Current and projected climate trends in Hungary

III.B.1.1. Current climate trends

By analyzing meteorological measurement data series, we can understand and continuously monitor the characteristics of Hungary's climate and detect signs of long-term climate change. The data stored in the archive of the Hungarian Meteorological Service (HungaroMet) - previously recorded in yearbooks and now digitally organized - provide a reliable basis for climate research and other environmental assessments.

Since the beginning of systematic meteorological measurements, instruments, measurement conditions, and observation times have changed multiple times. These varying measurement conditions can introduce unjustified breaks, known as inhomogeneities, in the recorded data series, which cannot be explained by the natural variability of the climate. Therefore, raw data series must be homogenized before conducting climate analyses. We carried out the completion of missing data, data homogenization, and quality control using the MASH (Multiple Analysis of Series for Homogenization; Szentimrey) system. Its use makes it possible to analyze the data series of a given station as if the measurements had always been conducted at the current measurement site under identical conditions.

Besides data quality, an important characteristic of measurement networks is how accurately we can reproduce the spatial distribution of meteorological fields based on data from the measuring stations. Using measurements from the network, we can estimate the values of various meteorological parameters at locations without measurements through interpolation. This allows us to create accurate maps covering the entire country.

The MISH (Meteorological Interpolation based on Surface Homogenized Databases; Szentimrey and Bihari) method, developed at the Hungarian Meteorological Service, is

specifically designed for the interpolation of meteorological elements. For example, the national series of annual mean temperatures is produced by interpolating the quality controlled and homogenized annual mean temperatures onto a nationwide grid using the MISH procedure and then averaging these values across all grid points for each year. This method provides a more accurate estimate of the annual mean temperature than a simple average of station values. In our analyses, the application of the MASH procedure ensures temporal representativeness, while the MISH procedure guarantees spatial representativeness.

The countrywide changes are in well accordance with global trends. The 1.5°C increase of the national average temperature since the beginning of the last century until 2023 (Figure 2.3) is higher than the global change estimated at 1.2°C. Over the period 1901-2023, summers warmed the greatest (1.8°C), the spring and autumn changes are similar 1.3°C and winters have seen 1.6°C temperature increase.

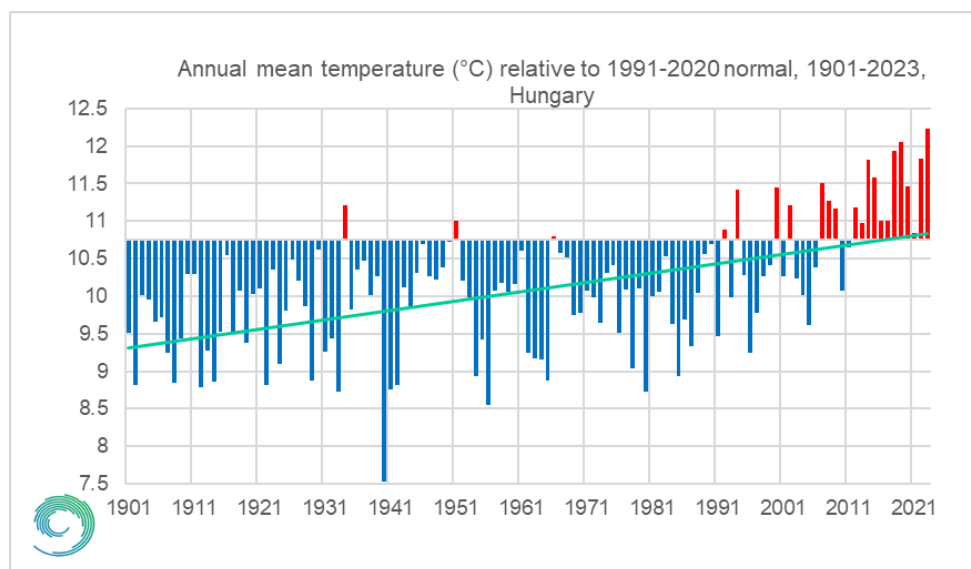


Figure 40. Annual mean temperature anomalies (°C) in Hungary between 1901 and 2023 relative to the average of the 1991-2020 normal period.

(Countrywide averages are based on homogenised and interpolated national averages)

Source: HungaroMet

Over the last forty years, the warming intensified. The regions of the Great Plain, particularly the Southern Great Plain in Hungary experienced the greatest increase of the heatwave days (when the daily mean temperature is higher than 25°C), with an increase of about 3 weeks in those areas since 1981.

The precipitation is a highly variable meteorological element in our region, both the spatial distribution and the amount of precipitation in a given period can vary greatly from the average. Annual precipitation in Hungary has been decreasing slightly since the beginning of the 20th century, but has been increasing in recent decades. Spring precipitation decreased by 17% since the beginning of the last century, but the autumn precipitation decrease is also over 10% since 1901.

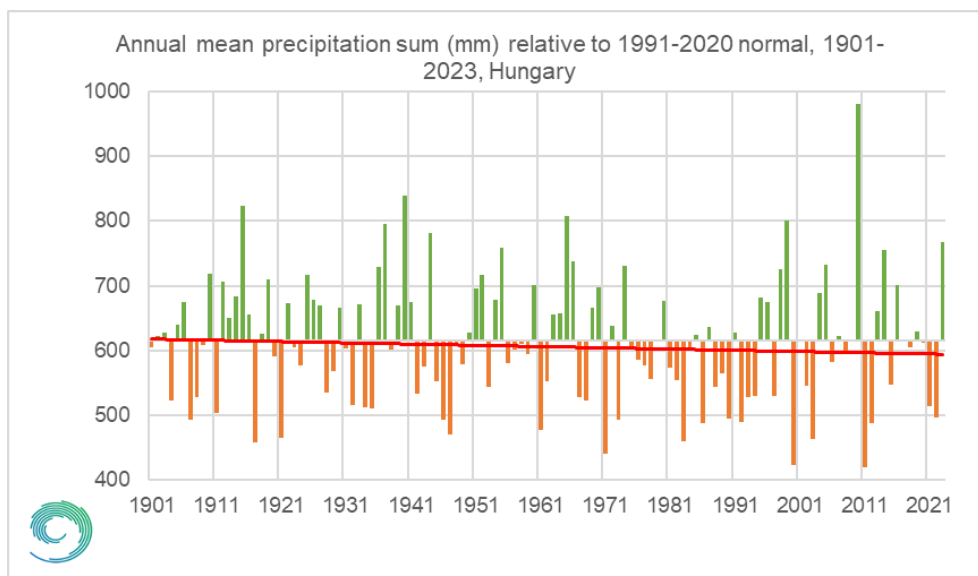


Figure 41. Annual mean total precipitation anomalies (mm) in Hungary between 1901 and 2023 relative to the average of the 1991-2020 normal period.

(Countrywide averages are based on homogenised and interpolated national averages)

Source: HungaroMet

The precipitation became more intense in the recent decades. The daily precipitation intensity (the ratio of the amount of precipitation and the number of wet days) has increased, especially in summer. The increase is 1.7 mm in countywide average, which indicates that precipitation is falling largely during intense weather events through short duration showers and thunderstorms. The likelihood of extremely dry years or longer periods in a year is increasing, but there are large deviations in annual rainfall totals. Consequently, both rainfalls causing flooding and drought-inducing rainfall deficits need to be prepared for.

III.B.1.2. Projected climate trends

In order to properly prepare for future climate conditions, numerical models can serve solid bases for impact studies and vulnerability assessments. Global climate models (GCMs) simulate the behaviour of the climate system components (i.e. atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere) together with their interactions and provide information about the planetary features of the climate change. Regional climate models (RCMs) are used to amend the large-scale global information with the desired fine scale details over the area of interest. In climate models, the impact of the human activity is taken into account as external forcings through the atmospheric concentration of greenhouse gases. Since the future anthropogenic activity is highly uncertain, several pathways (anthropogenic scenarios) of the future socio-economic developments are constructed. Climate models provide the possible evolution of the climate as response to a certain anthropogenic scenario.

Future climate projections include uncertainties deriving from chaotic nature of the climate system, from imperfections of the numerical models and from the ambiguous evolution of the future anthropogenic activity. The proper interpretation of the climate projections contains information about their likelihood. This can be achieved with joint evaluation of several climate model experiments based on multiple climate models and emission scenarios.

For subserving adaptation to climate change in Hungary, the National Adaptation Geo-information System (NAGIS; <https://nater.met.hu/en>) was established in 2013. The basis of impact assessments is past and future climate information provided by observations and climate modelling achieved in Hungary, extended with European climate model projections. The HungaroMet Hungarian Meteorological Service (former OMSZ) implemented open data policy for meteorological data in January 2021. As a result, climate measurements (including station data and gridded dataset) are available online (<https://odp.met.hu>). Regarding the future climate projections, the results of four regional climate model simulations (based on the ALADIN and REMO models and the RCP4.5 and RCP8.5 scenarios) executed at HungaroMet are organized in a database and the KLIMADAT visualization platform was developed and opened to the public (<https://klimadat.met.hu>). The aim of the platform is to aid impact researcher, planners, decision makers with regional and urban information produced from measurements and climate simulation data, which can be visualized in the form of maps and graphs. Currently, 22 regional and 11 urban climate variables are calculated for temperature and precipitation. In climate studies, characteristics and changes are investigated along multiple decades, thus 30-year periods with 10-year shift can be selected from the time range covering 1971–2100.

Future evolution of the mean temperature

Similarly to the global average, the mean temperature of Hungary will increase in the XXI. century. Mean annual temperature increase of less than 2 °C is expected in Hungary in 2041–2070, which is significant (i.e. the change exceeds the natural variability) for the whole country. By the end of the century, the increase averaged over Hungary is expected between 1.6 and 4 °C, The highest warming is obtained in the experiments with RCP8.5 scenario. The largest changes are projected in summer and winter, with a considerable spatial variation in winter, where the north-northeastern parts are warming more, compared to summer time, when such spatial differences cannot be observed. The coldest month will remain January in the future, however, its mean temperature will be above 0 °C already in 2041–2070 in contrast to the -1.1 °C observed mean temperature in 1971–2000. Out of four, three simulations project a one month shift in the warmest month (from July to August) by the end of the century.

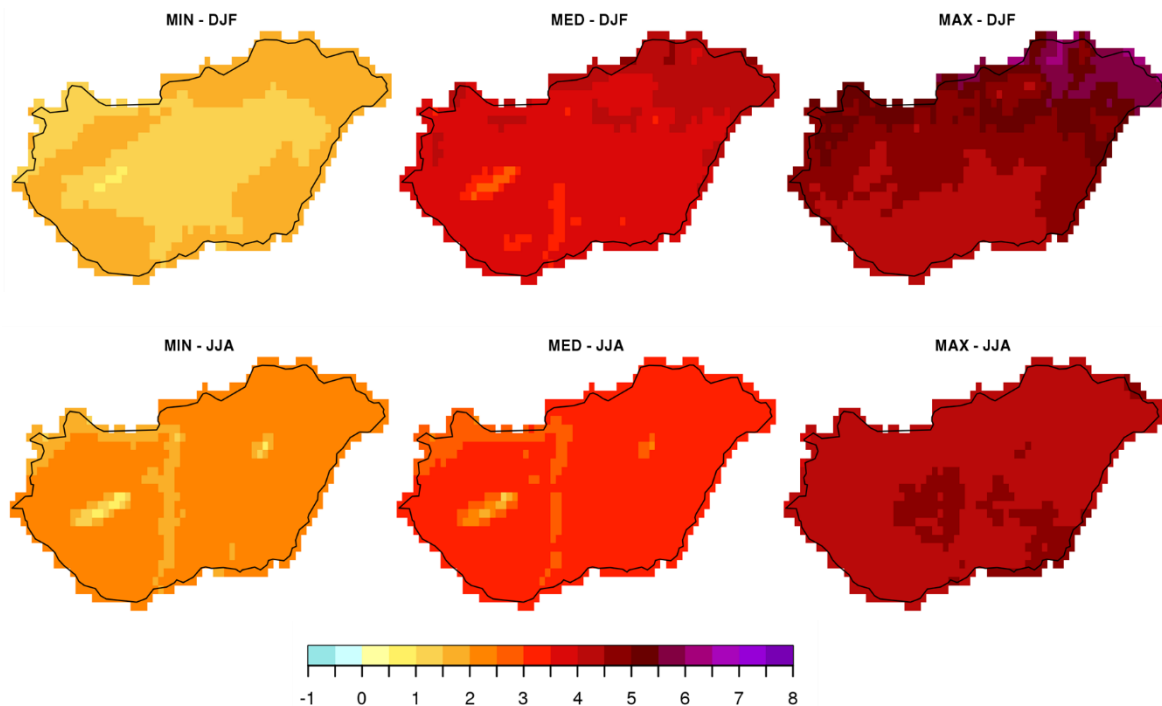


Figure 42. Winter and summer mean temperature change [°C] in 2071–2100 based on the results of the ALADIN and REMO regional climate models and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Model uncertainty is taken into account by presenting minimum, median and maximum values of the 4 simulations. Reference period: 1971–2000

Source: HungaroMet

Future evolution of the mean precipitation

The direction and extent of the expected change in precipitation is much less clear than that of temperature and indicates no correlation with the anthropogenic emission scenario used in the simulations. The projections show precipitation increase over Hungary in spring, autumn and winter. In summer, two model simulations project an increase from the beginning of the century (especially over the eastern and central parts of the country) and two ones show a decrease, with a degree around 20% by the end of the century. The current European model results suggest, that the probability of summer precipitation reduction is slightly larger even considering also the low emission (RCP2.6) scenario (Fig. 6.3). The main characteristics of the seasonal cycle seem to be unchanged: the most rain is expected in June, the annual minimum is foreseen in February or March. The secondary maximum in autumn will be less pronounced in the future. More years with completely dry months can occur in the future, especially in February, March, October or December.

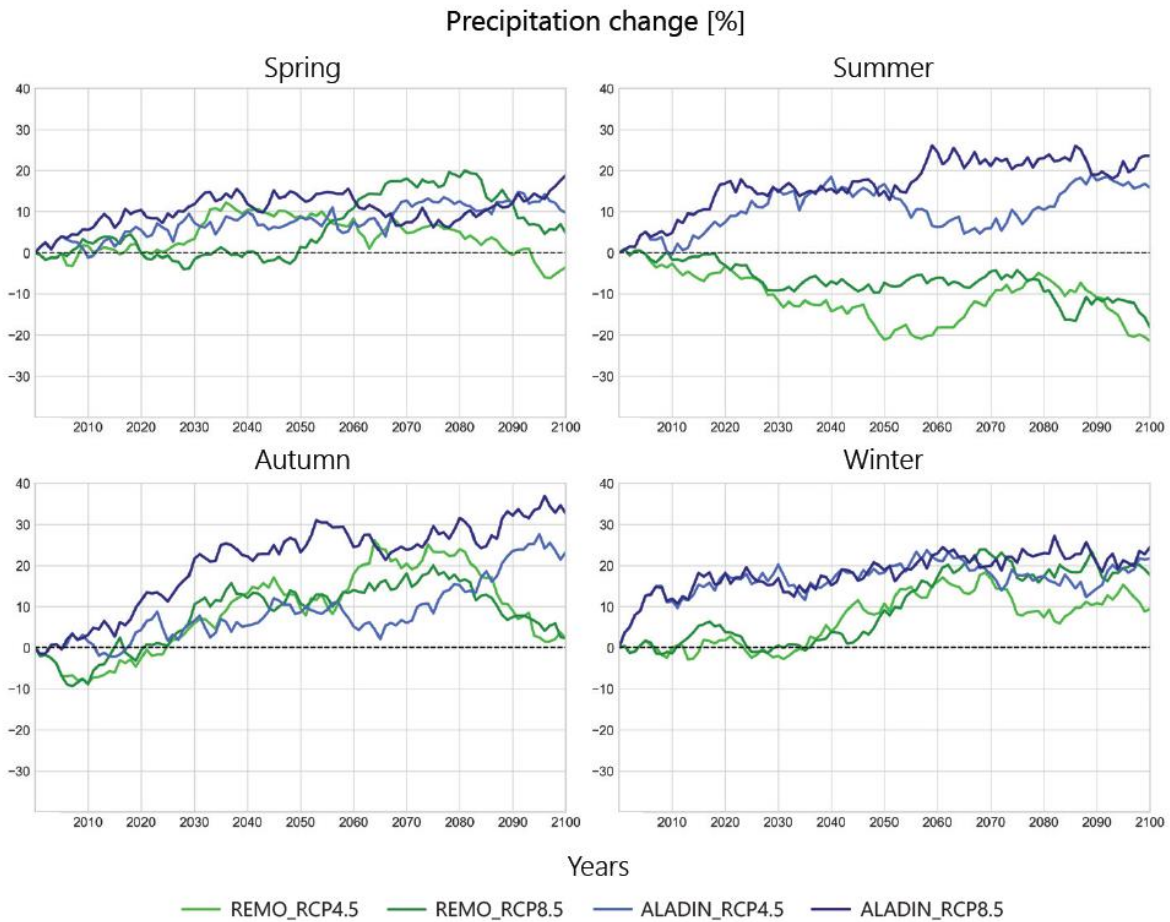


Figure 43. 30-year moving average of the seasonal mean precipitation change [%] in Hungary based on the results of the ALADIN and REMO regional climate models and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Reference period: 1971–2000.

(Source: HungaroMet)

Probability of decrease in summer precipitation [%]

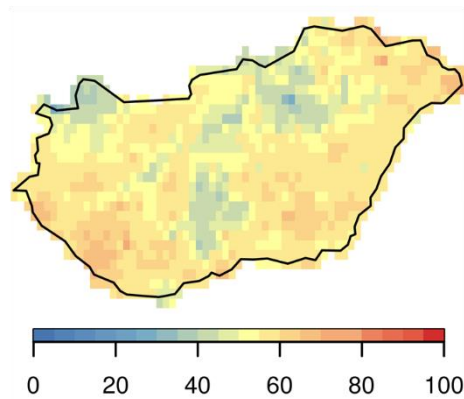


Figure 44. Probability of a decrease in summer precipitation [%] by 2071–2100 based on 9 European model experiments using low (RCP2.6), moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios on one composite figure. Reference period: 1971–2000.

(Source: HungaroMet, source of basic data: EURO-CORDEX)

Future evolution of daily temperature characteristics

As a consequence of the mean temperature increase, the occurrence of the low temperature days may decrease, while the frequency of high temperature days may increase. The number of frost days (when daily minimum temperature is below 0 °C) may decrease with 12-23 days compared to the observed average value of 97 days in 1971–2000. By the end of the century the uncertainty is substantially growing, since the projected decrease is 14-58 days. It means that up to 78% less frost days may occur in 2071–2100, what is more, on the western part of the country the reduction may reach 90-100%.

Regarding the high temperature days, in the past 17 hot days (when daily maximum temperature reaches 30 °C) were counted in Hungary in 1971–2000. It may increase by 3-8 days in the near future, while by 6-27 days at the end of the century.

Second degree heatwave days (when the daily mean temperature reaches 25 °C for at least 3 days) are especially demanding for society and the National Public Health Service orders second degree alarm. While in 1971–2000 on average only 3 days were counted, its number has already more than doubled by 1991–2020. All models project that the increase in the southern part of the country exceeds 10 days in 2041–2070, while by the end of the century two simulations project 30 days more second degree heatwave days in this area. All these suggest that Hungary is especially exposed to heat related risks, which may be further exacerbated in cities.

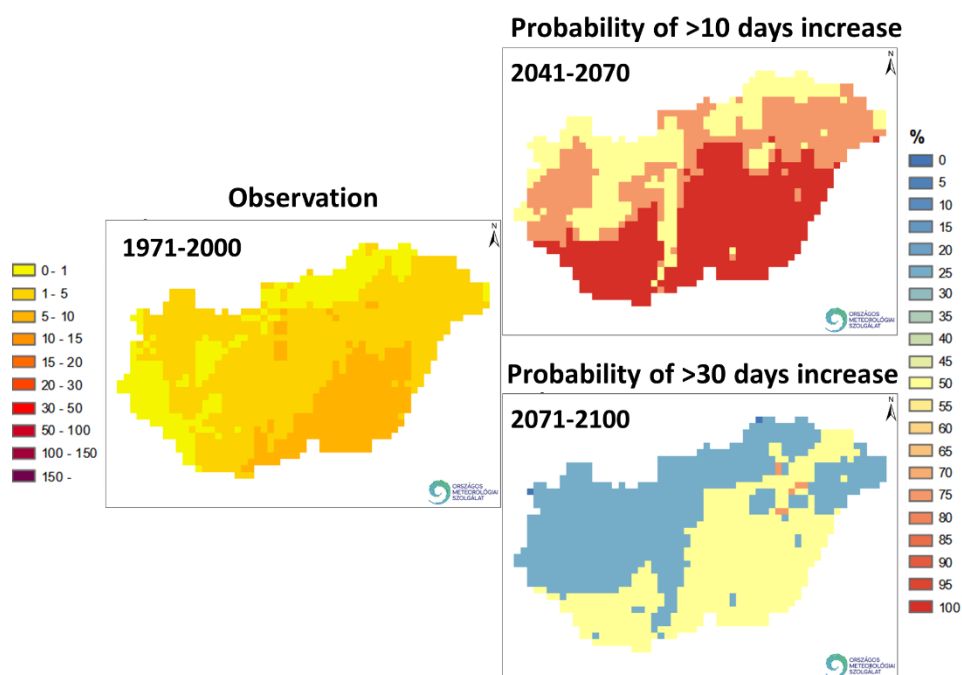


Figure 45. Annual mean number of second degree heatwave days (when the daily mean temperature reaches 25 °C for at least three days) according to observations in 1971–2000 (left panel). Probability of more than 10 days of increase in 2041–2070 (top right panel) and of more than 30 days of increase in 2071–2100 (bottom right panel) based on the ALADIN and REMO regional climate model simulations and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Reference period: 1971–2000.

Source: KLIMADAT, data source: HungaroMet

Future evolution of daily precipitation characteristics

In the past, the longest dry periods (when the daily sum of precipitation remains below 1 mm) lasted 17 and 15 days in spring and summer, while 20 and 22 days in winter and autumn in average. Based on the simulations, we might expect longer dry periods in summer and shorter ones in spring and autumn in 2041–2070, this tendency is projected to continue by the end of the century, apart from more probability for increasing duration in spring. The dry periods are tending to be longer on the middle and eastern-southeastern parts than the other parts of Hungary.

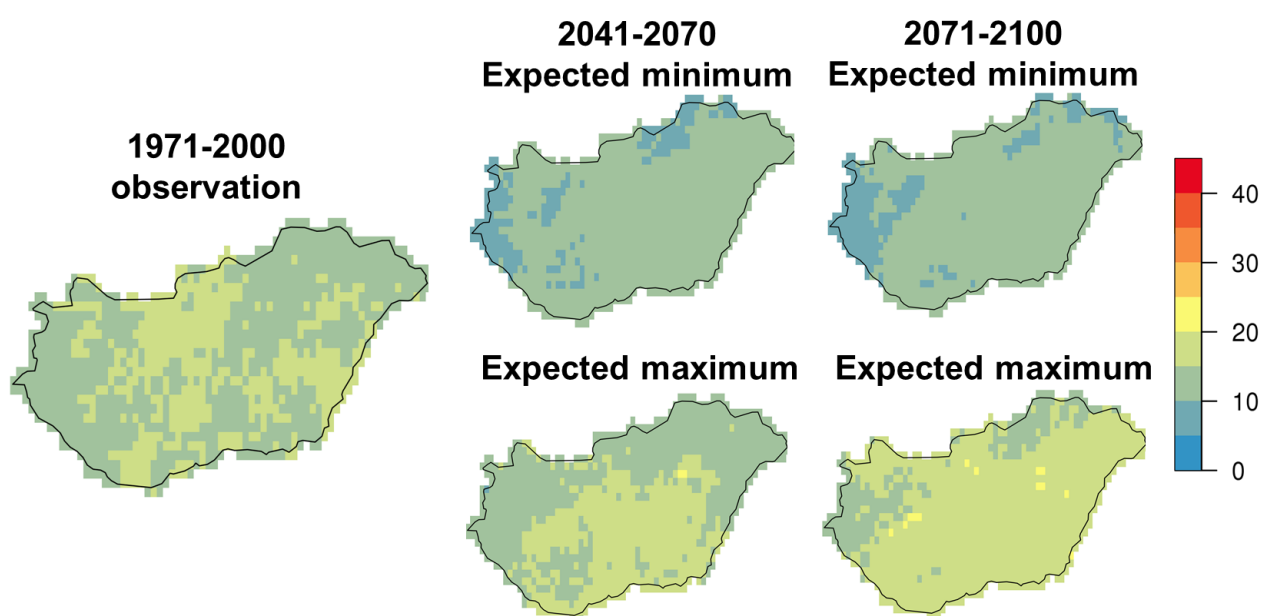


Figure 46. Maximum number of consecutive dry days (when the daily precipitation is less than 1 mm) in summer according to observations in 1971–2000 (left panel). The lowest (top middle and right panels) and highest (bottom middle and right panels) expected values of the indicator in 2041–2070 (middle panels) and 2071–2100 (right panels) based on the ALADIN and REMO regional climate model simulations and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios.

Source: HungaroMet

The annual number of days with high (more than 10 mm) precipitation amount varied mainly between 12 and 15 in East Hungary, while between 15 and 25 days in West Hungary in the period of 1971–2000. This indicator is expected to increase in the future, however, there is some chance for reduction in summer and spring. The highest values of the indicator are still foreseen in the western areas.

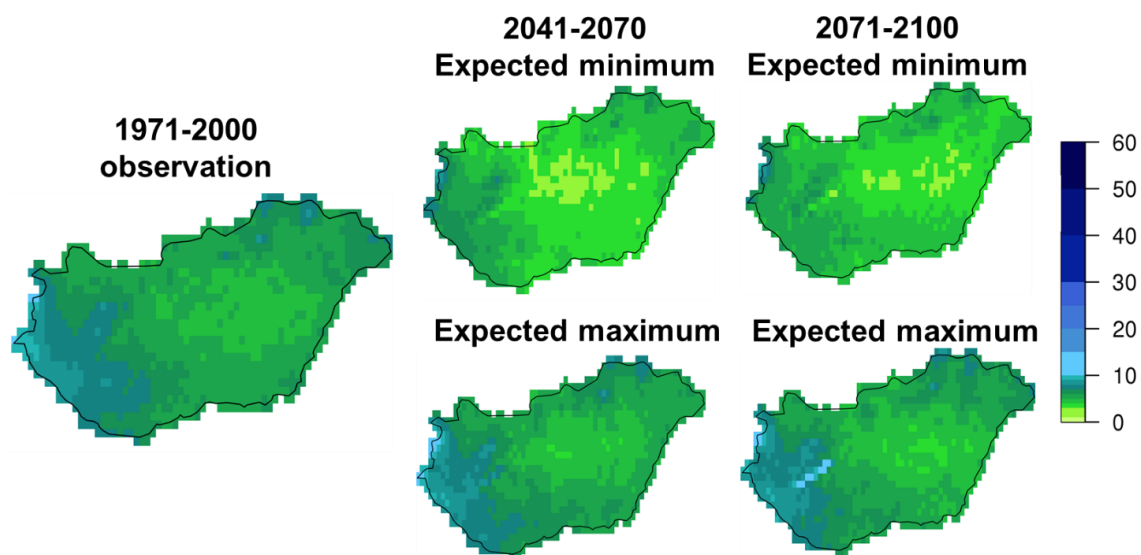


Figure 47. Mean number of days with precipitation amount higher than 10 mm in summer according to observations in 1971–2000 (left panel). The lowest (top middle and right panels) and highest (bottom middle and right panels) expected values of the indicator in 2041–2070 (middle panels) and 2071–2100 (right panels) based on the ALADIN and REMO regional climate model simulations and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios.

Source: HungaroMet

III.B.1.3. Observed and potential impacts of climate change, including sectoral, economic, social and/or environmental vulnerabilities

The observed and projected changes in climate variables cause a plethora of impacts across the environment, which affect virtually the entirety of nature as well as society. Since many of these changes are already a present reality, and many of them inevitable even according to the most optimistic mitigation scenarios, recognition of the **inevitable changes and adequate adaptation** is indispensable for a safe and sustainable future. The implementation of effective climate change adaptation measures necessitate detailed and quantified assessments of climate change trends and impacts, as well as the **vulnerabilities of natural environments and society**. This means not only information about climate change, but detailed knowledge on the sensitivity of the impacted systems as well. Below, important impacts of the observed and projected changes of climate variables for Hungary are highlighted from economic, natural and social aspects, and the major vulnerabilities are detailed by exposed sectors and areas.

Most important climate impacts affecting Hungary are related to **water management (drought, inland water/waterlogging, flash floods, and stressed water supplies)**, but the **vulnerability of forests and natural ecosystems**, climate impacts on **human health**, extreme weather events such as **wind and storm damages, and shallow geohazards** are also relevant.

Water-related climate change impacts, risks and vulnerabilities

Hungarian water bodies show different levels of vulnerability, but all of them are affected by different aspects of climate change; especially changes in the **spatio and temporal distribution**

of temperature and precipitation. The Projected changes in the **total amount of precipitation** in Hungary over a period of time are subject to particularly **significant uncertainty**, although it is more likely than not that average yearly precipitation will moderately increase. Model simulations show a shift in the **seasonality of precipitation**, largely agreeing that in the winter and spring period precipitation sums will increase during the century. For the autumn period, the projections are not quite as conclusive, and for the summer even less so. We can expect that by the end of the century summer would continue to be the wettest season of the year, and winter the driest, while the difference between the two periods would decrease. The secondary precipitation maximum of late autumn however is likely to decrease or disappear. Data shows that even a relatively minor change in precipitation and temperature has a major impact on the water cycle: a 15–20% annual fluctuation of average precipitation together with a 1–2 °C fluctuation of yearly average temperature can lead to **60% difference regarding mean annual flow**. Precipitation tends towards more **uneven temporal distribution**, as increasing number of days of **high precipitation** is observed and also expected in the future. Average length of **dry periods** will increase in the summer, while it is expected to decrease during autumn, and the trend for spring is less conclusive. The frequency and severity of droughts are likely to increase as well. Precipitation occurring over fewer days with higher intensity causes increase in **surface runoff** and decrease in **infiltration** to the ground, and this, combined with increased temperatures and more severe heat waves leads to higher chance of drought.

Based on vulnerability assessments, certain parts of the country are especially exposed to **drought**: at the end of the century, drought will mainly affect the areas of the Great and Little Hungarian Plain, especially along the banks of the Lower Tisza and the Kőrös rivers. **Droughts** impact water flow of water streams and may cause natural springs and small streams to dry up, threatening their ecosystems and human uses. **Groundwater levels will be further decreased by prolonged dry periods** as well, especially in the Danube-Tisza Interfluvial Sand Ridge and Nyírség of the Hungarian Great Plain – for this reason, water replenishment programmes are currently implemented in these two areas. Kiskunság and Southern Tisza encounter the same problem: due to the drastic drop in the groundwater level saline lakes may dry up earlier in the summer threatening their unique **halophytic habitats**. **Wetland habitats** of high biodiversity conservation value in the Nyírség and Szatmár regions of the Great Plain, and in the Hanság and Szigetköz in Western Hungary are also especially exposed. **Desertification** of current dry sand areas is expected. In remaining waters, summer water blooms (algae) become more frequent. Irrigation water demand will further increase due to drought, while the **quality and quantity of topsoil decrease** result in yield loss.

Long periods of drought and large amounts of rainfall are likely to occur over a short period causing floods, flash floods and waterlogging. Increased frequency of extreme precipitation events, storms and torrential rainfalls contributes to more frequent and destructive **flash floods** and **inland water inundation** in settlements. Flash floods mainly occur in small mountain and hilly watercourses, exacerbated by inadequate land use practices (e.g. extensive deforestation, farming on steep slopes) and dense water networks. In Hungary, flash floods are mainly concentrated in the North Hungarian and Transdanubian Mountains, the Transdanubian Hills, Mecsek and in the foothills of the Alps in Western Hungary.

Floods still poses a risk to tackle. Current trends suggest that as a lower riparian country, **frequency of large floods on our larger and medium-sized rivers is likely to increase** in the

future, and that they may occur earlier. This is indicated by the rise in flood levels, which is not only a climate issue, but often occurs due to the inadequate management and condition of floodplains. Regarding flood protection, the following climate impacts need to be taken into account: (1) floods related to winter rainfalls become more frequent, (2) floods related to melting snow and ice become unpredictable, (3) frequency and intensity of flash floods grow, (4) flood-related damages become more frequent. Water regime **will be more extreme, changing the fauna dynamics of the floodplains**, causing increased weeding and making room for invasive species.

Managing **water abundance and water shortage at the same time** poses a huge challenge for the water sector. **Storing excess amount of water** for periods of water scarcity is of high priority, as frequency and length of these alternating events has been increasing. Applying a water retention approach instead of draining excess water is gradually becoming more common. A potential solution to compensate for the damage caused by droughts is to retain water from large river tides and rainfall events and use it for irrigation during dry periods.

Most of our rivers show **diminishing tendencies of mean annual flow**, while the tendency is that the flow increases in the winter, and decreases during the summer months. Climate models used in NAGiS (National Adaptation Geo-information System) show that in the case of major lakes, **prolonged low water levels are likely in the future**, as water balance becomes instable. Lake Balaton is extremely exposed to this risk based on the tendencies of the past couple of decades. Increasing evaporation due to rise in average temperature is one of the greatest challenges, as **rising water temperature can cause water quantity and quality issues**. Annual rainfall has not decreased significantly, however, it tends to occur in shorter periods, with greater intensity, especially in summer. This causes increased surface runoff and reduced infiltration, affecting the supply of **groundwater bodies and soil moisture content, contributing to intensified summer droughts**.

Climate change impacts, risks and vulnerabilities – forestry and biodiversity

Climate change causes quite extensive and radical changes in the ecosystem, affecting its complex interactions (e.g. food chains). Climate affects biological processes of individuals, population dynamics, the spreading of species, and the structure and functioning of ecosystems. Examining different types of habitats separately, researchers found that expected climate impacts are usually **less favourable for forests, and more favourable for grassland habitats and forest steppe**; whereas the **natural vegetation inhabiting higher elevation proved to be more vulnerable than that of the plains**.

Life expectancy and growth potential of trees – just like any other plant – is mostly influenced by their habitat, in addition to their genetic characteristics. Growing conditions are significantly influenced by changes in annual precipitation distribution, increasing average annual temperature, more frequent periods of drought, low relative humidity and increase in the frequency of extreme weather events (e.g. wind storms). Besides **biodiversity degradation, extreme precipitation events damage natural ecosystems**, therefore their **rehabilitation and monitoring** is very important from a climate adaptation aspect. Due to Hungary's vegetation geography – lying in the transition zone between closed forests and forest steppe – almost half of our forest areas is especially vulnerable to climate impacts. **Forest desiccation** is a big issue,

especially European spruce (*Picea abies*) and larch (*Larix decidua*) populations were lost due to droughts of even this decade. The **state of forests, as well as the possibilities of economic and sustainable forest management are determined by changes in forest climate types or climate zones**. Climate change shifts climate zones, changing the habitats indigenous tree species. The forecasted pace of the shift is far faster than the spreading pace of tree species, therefore, trees stuck in unfavourable climate zones can exist only for limited time. According to climate models, the percentage of forest steppe climate would increase by almost one and a half times in the Carpathian basin, causing native beech (*Fagus sylvatica*) forests to disappear from the country, and other species to weaken, such as pedunculate oak (*Quercus robur*). Another emerging challenge is **invasive species** that better tolerate or prefer warmer climates and drier growing conditions such as boxelder maple (*Acer negundo*), green ash (*Fraxinus pennsylvanica*) displacing native plants. Among the new invasive species, the spread of **pests** such as herbivore insects, like the box tree moth (*Cydalima perspectalis*), native to East-Asia, or harmful invasive fungi further endanger forests, as well as sudden increases in the population of insects like (native) European spruce bark beetle (*Ips typographus*).

Climate change impacts, risks and vulnerabilities – agri-food systems

In the future, changes in precipitation and temperature will affect **not only the quantity and quality of our surface and groundwater, but also the condition of the soil**. Intense rainfall increases the rate of **soil erosion in hilly and mountainous areas**, leading to a **significant and rapid decline in soil fertility on eroded slopes** and in deeper sedimentation areas. **Salinization** of soils is also a risk, which causes damages to the agricultural sector. Milder winters can cause plants to germinate, grow and flower earlier, raising the risk of **late frost damages**. In the case of **vegetables and fruits**, climate change can have a **positive effect on yields** due to the increasing amount of heat, but it is **extremely important to provide irrigation**. **Vine-lands are more tolerant to drought** compared to other crops; however, drought damage can still occur.

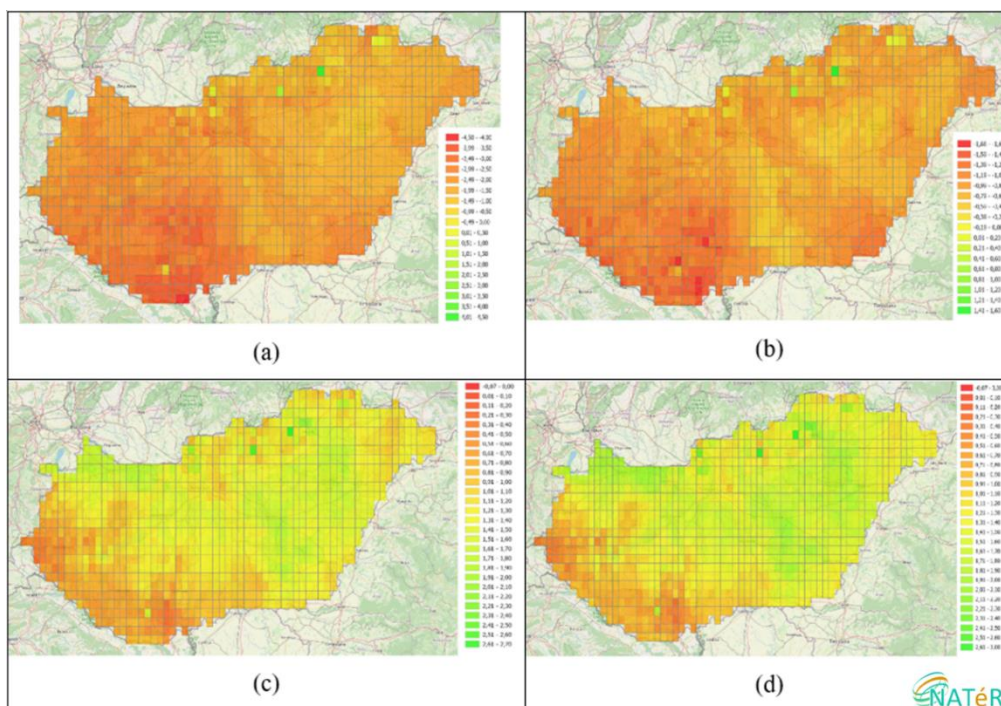


Figure 48. Changes in the average annual crop yield [metric tons per hectare] in Hungary for the period of 2071-2100 (a) maize (*Zea mays*), (b) sunflower (*Helianthus annuus*), (c) winter wheat (*Triticum aestivum*) and (d) winter barley (*Hordeum vulgare*).

Source: NAGiS

Arable crop production is highly affected by climate change: **spring crops** expected to show a **declining average yield**, while those sown in the fall are likely to show increasing yields. Field crop production is especially affected: **spring-sown crops (spring wheat, spring barley, rye, triticale, sunflower) will be the biggest losers, while autumn-sown crops (winter wheat, winter barley) show an increasing yield increase. Most significant negative effects will be on maize.** Water-intensive crops (sugar beets, potatoes, alfalfa) are expected to be grown exclusively with irrigation, but this may increase costs and reduce efficiency to such an extent that their cultivation may even cease (mainly sugar beets). The expected **impact of climate change on spring and autumn crops is different.** In the case of spring-sown crops, the yield loss can be as big as 30% or more. Herbal and spice sector could be one of the winners of climate change: the diversity of species makes the sector more adaptive compared to others. Climate change will **positively affect plant pests, as climatic conditions** (especially those affecting reproduction and overwintering) will be more favourable for them.

Animal husbandry is also exposed to the effects of climate change. Intensive livestock farming (cattle, swine, poultry) is affected by increased temperatures in the stables and coops. Price increases in water and feed due to climate effects and exposure to new, vector transmitted infectious diseases pose further vulnerabilities. Low water levels in surface water bodies and water scarcity will effect the fishing sector as well.

Climate change impacts, risks and vulnerabilities – human health

Climate change negatively affects human health in several ways. These impacts are already detectable in Hungary, and expected to increase in the future.

The biggest challenge is the increasing intensity and frequency of heat waves, causing for instance cardio-vascular problems. Elderly people, young children and people living with chronic illnesses are especially sensitive to this effect. Studies have shown that in the last thirty years the most severe heat waves caused a daily 12-52% excess mortality. **Between 2021 and 2050, the average number of hot days (days when the maximum daily temperature is at least 30 °C) is expected to increase by 77%**, while the average value of daily excess temperature over the 30 °C threshold temperature is expected to increase by 46%. This can lead to an estimated 51 mean daily excess death, adding up to a 783 per year. The annual average number of **heat wave days** (daily mean temperature reaches 25 °C) is expected to increase by the end of the century by up to over 30 days, depending on location (most exposed are the southern and south-eastern areas of Hungary), while the increased length of heat waves contributes to the more severe levels of heat stress. Vulnerability to heatwaves increases from the north-west to the southeast of the country. This is due to heat waves being more frequent and intense in the lowland areas, where adaptive capacity is lower (compared to other parts of the country) because of worse socio-economic situation. The effect is exacerbated also by the **urban heat island (UHI)** effect in urban. The UHI effect is caused by the properties of densely built up areas, such as heat absorbing and radiating building materials, lack of shades, lack of vegetation, low surface evapotranspiration and low infiltration and quick drainage of precipitation water, as well as the excess heat from machines, heating, transportation, and what is especially and increasingly prevalent during hot periods, air conditioning. It is imperative then for municipalities to combat UHI and ready their environments for extreme temperatures, ideally buy **climate adaptive infrastructural instalments** instead of air conditioning units, which only increase the UHI effect. **Healthcare institutions** also need to prepare for an increased number of patients during heat waves, as well as to provide adequate cooling and insulation.

Because of the altered climatic conditions, **new infectious diseases and animal vectors are emerging and spreading**, such as the yellow fever mosquito (*Aedes aegypti*) spreading illnesses such as dengue fever, West Nile fever, Zika fever and yellow fever. The increasing exposure to high **UV-radiation** raises the risk of **tumorous diseases**. **Pollinating season of certain allergen plant species is elongated** impacting allergic people, leaving not much more than one month in the year without any pollinating allergen plant. More frequent atmospheric inversions pose a threat to human health as well, causing **smog** both in the winter (sulphurous or London smog, with accumulation of aerosol particles near ground level) and in the summer (photochemical or Los Angeles smog, with high ground level ozone concentration).

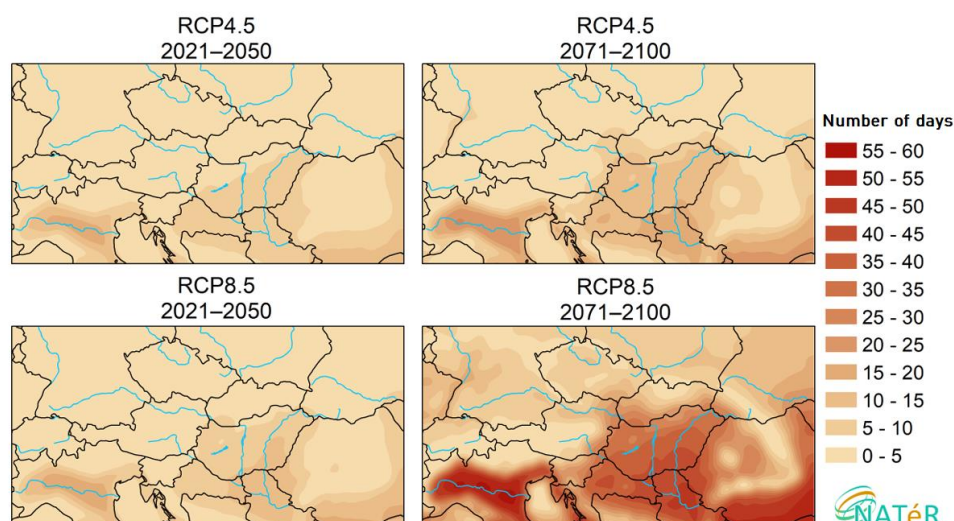


Figure 49. Annual number of heat wave days (days with daily mean temperature of at least 25 °C) by the middle and end of the century, based on two emission scenarios (RCP4.5, RCP8.5) calculated with RCA4/EC-EARTH climate model.

Source: NAGiS

Climate change impacts, risks and vulnerabilities – security, civil protection and disaster management

Increased frequency and intensity of **extreme weather events** (e.g. **droughts, heatwaves, storms**) requires effective adaptation in the following areas (among others): **food security, flood risk areas, drinking water supplies, critical infrastructure and industrial production. Increase in the frequency of flash flood, floods and storms damages transport infrastructure on the surface, as well as underground in lower-lying districts, flood plains, along watercourses.** The expected increase in the maximum **wind speed** and the frequency of windstorms by the end of the century poses a risk to the external boundary elements of buildings (facade and roof coverings, doors and windows, blinds, roofing, chimneys, antennas), traffic infrastructure and vegetation. Sudden heavy rainfall can also lead to landslides and mudslides. **Monumental buildings and historic areas** are also at risk by floods, extreme rainfall and wind, in addition to the unfavourable effects of extreme daily and annual temperature fluctuations and frequent changes in freezing/thawing.

Food security is expected to be affected by the increasing pressures on the agri-food system detailed above, as well as climate-related disruptions of global food and **agricultural supply chains**. Food safety is also affected by higher temperatures, increasing the likelihood of infections like **Salmonella bacterium**. Among **drinking water sources** the shallow underground reserves with coastal filtration (Noth Hungarian Mountains and near the Danube river), karstic (Transdanubian Mountains region, Mecsek mountains) and surface (the region of Lake Balaton) are the most vulnerable.

Climate change impacts, risks and vulnerabilities - tourism

Among economic sectors, **tourism is one of the most exposed to changes in climatic elements, as it is closely linked to the physical factors of geographical locations** (climate, vegetation, hydrographic and topographic features etc.). Changes in these factors affect the attractiveness of a given destination: they can limit or gradually make certain elements of the offer impossible, and/or encourage the development of new alternative products. Climatic conditions and weather extremes play a key role especially in the case of outdoor products. Such products are also dominant in Hungary: lakeside beach tourism, cultural heritage tourism (e.g. city visits, pilgrimage tourism, event tourism) and nature-based active tourism are all key elements of the domestic tourism supply. **Climate vulnerability assessment of tourism carried out in recent years examined exposure, sensitivity, adaptive capacity and vulnerability characteristics of destination areas** for 3 priority domestic tourism products (lakeside beach tourism; cultural heritage tourism; and nature-based active tourism) in Hungarian districts. Based on the results, **the most vulnerable areas are typically located in some lowland regions and in the outer and inner peripheral regions of the country**. The lowest vulnerability characterizes well-introduced destinations of the given product, due to the more favourable climatic exposure and/or lower sensitivity data (the latter is due to the traditional significance of tourism).

Within the category of active tourism, **winter sport tourism** is especially affected via decreased winter snow cover and higher average temperatures. Heat waves and UHI pose a challenge to city tourism. On the other hand, destinations of waterside tourism might face an increasing demand, but also have to cope with the temperature and precipitation extremes. Therefore, adaptation investments and diversification will be vital for the tourism sector.

Climate change impacts, risks and vulnerabilities – energy and infrastructure

The primary challenges for the energy sector is **changing energy needs and infrastructure damages**. In winter, there is usually a **decrease in heating energy demand (decreased number of heating degree days, increased average temperature during the heating period), while in summer a significant increase in cooling electricity demand (increased cooling number days)**. Increasing electricity demand can overwhelm the transmission system, and cause unexpected and large-scale power outages.

The biggest risks affecting power lines are fires caused by lightning, flash floods in mountain and hilly areas, floods in floodplains, as well as sudden heavy rainfall and landslides. **Landslides and mudslides can damage waste stores, electric and transportation infrastructure. Wet snow, rime and hoar in the winter** also pose a risk to **energy infrastructure**, especially electric transmission lines. The energy infrastructure is affected by increased temperatures and heat waves also, because of the heat expansion of metal instalments, especially electricity transmission cables and poles. **High temperature also causes the durability of transmission cables and their effectivity of energy transportation to decrease**. Furthermore, if high voltage cables hang too close to the ground due to their **sag increased by thermal expansion**, they are no longer up to the safety standards. Low water levels in surface water bodies, and also the increased temperature of water in the summer affect thermo-electric power plants and other industrial facilities using **cooling water**, especially the Paks Nuclear

Power Plant, which produced over 30% of electricity consumed in Hungary in 2024. Prolonged dry periods negatively affect **hydropower production** as well.

Considering the climatic exposure of solar energy, there is a maximum 15% difference in the total value of annual global radiation within the country, with the highest values on the southern border of the country. In the future this could change significantly depending on the scenario, especially for the period 2071-2100, as global radiation will be the highest in the **southeast part of the country**. Thus, this region will have **the highest potential for solar energy production**.

Built infrastructure and the **building stock** is vulnerable to a number of climate effects. Apart from disaster-like hazards such as storms, wind extremes, wildfires, flash floods, inundations, as mentioned above, buildings are damaged by larger **temperature fluctuations** due to heat expansion, and freezing and thawing of infiltrated water on days of temperature around freezing point. High temperatures can lead to the **deformations of roads and railroads**, and the desiccation of the soil during dry periods, as well as the decrease of ground water levels **lower the stability of the soil** posing additional a threat for large structures. Unfavourable weather conditions, such as slippery roads during wintertime precipitation events, lowered visibility and fog are expected to increase as well.

III.B.1.4. Approaches, methodologies and tools, and associated uncertainties and challenges

The future behavior of the climate system can be described by modelling tools. **Global climate models** can be used to investigate the interactions of the Earth system and the large-scale features of climate change, while regional climate models are used to explore the details, describing the dominant processes in a selected geographical area based on global model results. **Climate simulations involve uncertainty due to the natural variability of the climate**, the approximate nature of the physical processes and future anthropogenic activity. **Results can only be interpreted by quantifying uncertainties using the ensemble technique, where the results of several model experiments** (including using multiple representation of anthropogenic emission scenarios and different climate models) **are evaluated together, each of which provides an equally possible description of the future evolution of the climate system. One tool of this ensemble technique is to use the quantiles** (minimum, median, maximum) **of a model ensemble**.

Regional climate models provide quantitative information on the future climate conditions of a country or region. Today, these models typically have a grid resolution of 10-25 km, i.e. they cover a city of several hundred km² (e.g. Budapest) with only a few (3-5) grid points. With insufficient resolution for the task, the description of the physical processes of the urban surface and the urban atmosphere are currently not considered at all or only with large approximation (e.g. the city is represented by a rock mass). **Regional climate models alone are therefore not yet suitable to provide detailed information on the urban impacts of climate change** and requires careful consideration using for impact studies over cities. **To refine regional climate model results, surface models are used**, which describe only the processes between the surface and the directly connected atmospheric layer (a few 10 m), rather than the whole-

atmosphere processes, and take the background climate described by the regional climate models as a forcing.

Under the aegis of the **KLIMADAT project** (KEHOP – 1.1.0-15-2015-00001: Assessment of climate change impacts in Hungary with regional climate model simulations and development of a representative climate database. Period: 2016-2022), **new regional climate projections have been achieved until the end of the XXI. century** with the **ALADIN and REMO regional climate models** for **Central and Eastern Europe on 10 km horizontal resolution**. The future anthropogenic activity was prescribed according to **two scenarios supposing medium (RCP4.5) and high (RCP8.5) emission**. **Based on the ALADIN's projections**, the climate change impacts on **urban environment were investigated using the SURFEX land surface model over Budapest**.

In addition to climate models, we should mention the importance of **climate vulnerability assessments**, which aim at estimating the climate risks associated with specific sites and objects as realistically as possible. **In Hungary the overwhelming majority of climate vulnerability assessments have been conducted by 2020 in the framework of the NAGiS**, however, especially since then, several other research workshops, universities and individual researches has dealt with this topic. The NAGiS-based analyses are based on the so-called **CIVAS-model** (Climate Impact and Vulnerability Assessment Scheme), which is **originated from the approach published in the 4th Assessment Report of IPCC**. This model was developed in the framework of the CLAVIER international climate research project to examine the impacts of climate change on ecology and on the built environment and to provide a standardized methodological background to quantitative climate impact assessments. Numerous experiences of application can be found in scientific literature, as it is logical, easy to understand and use in practice –and though the IPCC have developed new methodological background for CVAs since then in its consecutive assessment reports, significant part of the literature still uses the former, CIVAS-related impact-chain based frameworks. All **climate vulnerability assessments** completed in the framework of the **National Adaptation Geo-information System (NAGiS)**, and the results introduced by the **NCCS-2** also makes reference to this model.

The CIVAS-model is an impact chain-based model, for which the exposure, the sensitivity, and the adaptive capacity are determined, meanwhile expected impacts are calculated from the first two factors; vulnerability from the combination of expected impacts and adaptive capacity as a complex indicators. Exposure is usually a climatic indicator, which presents the changing climate at a given region based on historical meteorological data and climate models. It depends on the geographical endowments. **Sensitivity** shows the weather-dependent behaviour of affected systems. The sensitivity is mainly composed of physical or social parameters. It is influenced by the internal characteristics of the affected party. **Expected impact is a complex indicator** – the combination of exposure and sensitivity – which is specific both to the geographical location and to the system under examination. **Adaptive capacity** shows the character and strengths of the local social/economic responses to climate impacts. **Vulnerability is always a complex indicator which combines exposure, sensitivity and adaptive capacity**. It shows that the same expected impact can have more severe consequences in a region with lower adaptive capacity and vice versa.

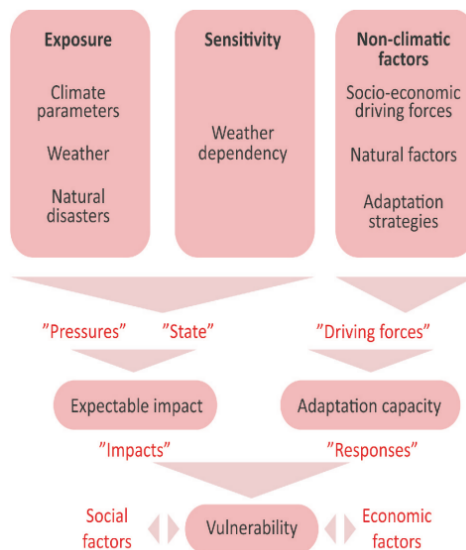


Figure 50. The structure of the CIVAS-model
 Source: *Second National Climate Change Strategy (NCCS-2)*

III.C. Adaptation priorities and barriers

III.C.1. Domestic priorities and progress towards those priorities

As already mentioned in chapter III.A. (“*National circumstances, institutional arrangements and legal frameworks*”), the main pillars of our Hungarian climate policy planning background are currently the **Second National Climate Change Strategy (NCCS-2)**, the Report on the Scientific Evaluation of the Current and Expected Climate Change Impacts on the Carpathian Basin (Carpathian Report) and the NCCS-2s **National Climate Change Action Plans (NCCP)**.

The NCCS-2 consists currently of 3 sub-strategies: the **National Decarbonization Roadmap**; the **National Adaptation Programme**; and the **Climate Change Awareness-Raising Programme**. According to the **Parliamentary Decree on the adoption 23/2018. (X. 31.)** of the NCCS-2, the **implementation** of the objectives and directions set out in the sub-strategies **is supported by the concrete actions of the National Climate Change Action Plans**.

Considering the fact that **the NCCS-2 is the highest level document in the Hungarian climate policy hierarchy**, the **different levels of adaptation-related objectives** (overall objective, specific objective, sub-objective) **of the NCCS-2 objective system can be considered as the national adaptation priorities**, which are the following:

Related overall goal:

- Exploring our capabilities, opportunities and limitations

Related specific (indicated by bold) and sub-objectives (indicated by italic):

- **Adaptation and preparation** (directly deals with adaptation)
 - *Preserve and enhance the sustainability of natural resources*
 - *Reduction of vulnerability of given regions and identification of adaptation options for vulnerable areas*
 - *Implementing resilient and innovative adaptation in vulnerable sectors and developing and integrating sector-specific adaptation strategies*
 - *Increasing risks in horizontal areas of key national strategic importance (including disaster management, critical infrastructure in water management and rural development)*
 - *Mitigate the expected societal impacts of climate change and improve society's adaptive capacity and awareness of adaptation options*
 - *Supporting adaptation research, innovation and publishing scientific research results*
- **Geo-information basing of climate vulnerability assessments** (directly deals with adaptation)
 - *Developing and maintaining the NAGiS system*
 - *Basic and applied research on climate change*
 - *Developing a methodology for climate vulnerability assessments and collecting related indicators*
- **Securing climate partnership** (implicit adaptation content connection)
 - *The adaptation of public administration*
 - *Awareness-raising of the media*
 - *Improving the climate awareness of the education system*
 - *The organization of social sustainability campaigns*
 - *Networking between civil society, the research sector, the private sector and the public sector*

Furthermore, the Carpathian report outlined in 2020 strategic directions highlighting the most important policy responses, intervention directions, and considerations of adaptation for the coming years, emphasizing:

- the importance of **ensuring financial support for the intervention directions** outlined in policy documents and sectoral development programs;
- the **importance of potential projects to fill research gaps, and facilitate more effective adaptation**. These include studies on the complex vulnerability of municipalities, changing regimes of large rivers, complex vulnerability of the domestic tourism sector, and human health impacts of climate change, especially heatwaves;

- the **potentials of the macro-regional extension of the NAGiS framework** practically into the direction of the Carpathian Basin to better mapping regional climate and vulnerability processes, as well as strengthening digitalization in climate protection;
- the need for focusing on the challenges of adaptation, particularly the **need for more effective involvement of private capital** (from both the public and private sectors)
- and the **lack of an integrated climate policy monitoring and evaluation system to track implementation and changing vulnerabilities**;
- key aspects of policy development planning, emphasizing the **increased integration of adaptation considerations into various sectoral activities**. These include natural resource management (such as water management), nature conservation, agriculture and forestry; urban development and energy in relation to physical infrastructure; and, lastly, the weather-sensitive sectors such as tourism and human health.

Progress on these adaptation priorities is summarized in the NCCS-2 evaluation report, the findings of which are reported in more detail in chapter F.) (*"Monitoring and evaluation of adaptation actions and processes"*).

III.C.2. Adaptation challenges and gaps, and barriers to adaptation

The revision of the NCCS-2 document conducted during 2022-2023 reveals and summarizes the most relevant adaptation-related challenges, shortcomings and obstacles that hinder the progress of climate adaptation efforts in Hungary. These are summarized in the following, grouped according to 3 main aspects:

Content and assessment of the second National Climate Change Strategy (NCCS-2) document and its Climate Change Action Plans

- Although vast majority of the affected sectors and their representatives are satisfied with the content and quality of the climate policy planning documents, during the development of the NCCS-2 Review Report, the interviewed sector experts criticized the structure and the clarity of the NCCS-2, suggesting that a shorter and more transparent format should be developed, which is more accessible to the general public and easier to use by the different sector experts.
- The Hungarian climate and energy policy planning document background is difficult to understand. The reason is that it is hard to separate the content and function of the parallel documents. Therefore, a portfolio clean-up of climate and energy policy planning documents is needed in the future.

Planning, legislative environment and results of climate policy

- There is a definite need from the direction of affected sectors for the continuation of operational level planning.

- A common problem, both domestically and internationally, is that the **greenhouse gas emission mitigation and adaptation benefits and spill-over effects of different development projects and programmes are not known or not precisely known**, as well as how EU fund-related Operative Programmes / CCAP measures and other development policy interventions, domestic policy documents' decarbonization and adaptation objectives are achieved. **Due to the planned monitoring and evaluation system**, it can also be possible to estimate the expected climate policy benefits of a project or investment proposal.
- The various spatial **climate vulnerability assessments and climate risk analyses would require up-to-date data**. This also justifies the need to **build a permanently developed climate policy monitoring and evaluation system**, which would be continuously updated with national **sectoral and thematic exposure, adaptation capacity and vulnerability data**, and could also be used to **monitor and evaluate the implementation of national mitigation and adaptation objectives and interventions**.
Several interviewed sectors indicated they there is a need for a denser, **continuous information flow** to improve the harmonization of different climate policy-related activities.

Relevant economical sector's climate-related performance

- As the NCCS-2 review report reveals, there is **increasing attention to climate issues and adaptation in laws and legislation across sectors – although more in generalities and principles and less in specifics**.
- As the NCCS-2 review report shows, **most of the relevant sectoral planning documents do not mention in their preliminary coherence analyses that they have taken NCCS-2 orientations into consideration**, and in general NCCS-2 is only mentioned in a small number of sectoral planning documents.
- The NCCS-2 review report has also shown that the spatial thinking on climate change is currently not really present neither in sectoral planning documents nor in climate policy documents (with the exclusion of the NCCS-2 NAS spatial vulnerability-oriented situation analysis), despite the fact that **climate change impacts are differentiated by regions**, which would be worth examining both at sectoral level and in climate adaptation objective- and action planning, too.

III.D. Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies

The Second National Climate Change Strategy of Hungary (NCCS-2) incorporates the National Adaptation Strategy. Furthermore, it identifies short-, medium and long-term action lines for different sectors that are affected by climate change. These are the following: *human health, water management, agriculture, forestry, energy infrastructure, tourism, and public safety.*

III.D.1. National Adaptation Strategy and the Carpathian Basin Report

The **National Adaptation Strategy (NAS)**, developed under the framework of NCCS-2 as its sub-strategy, defines Hungary's framework and opportunities for climate change adaptation and preparedness. It is based on the premise that climate change must be addressed in alignment with sustainable development, as its complex and wide-ranging nature is closely linked to social, economic, and environmental policies. The strategy also sets out a national adaptation vision:

"To ensure a livable Hungary that responds flexibly to climate change, prevents risks, and minimizes damages by providing a strategic framework that supports sustainable development through innovation."

The situation analysis part of the NAS incorporates vulnerability assessments based on then-recent NAGiS results, analyses the effects of climate change on water, soil, biodiversity, and forests; and its potential consequences on the affected sectors (water, agriculture, nature protection, forestry, disaster management, energy, tourism, settlement development and human health). It also identifies recommended adaptation action lines for these affected sectors.

The NAS outlines 6 key objectives (referred to in the document as "intervention areas"). These include

- preserving the availability and quality of natural resources and conserving natural and semi-natural ecosystems, furthermore restoring degraded ecosystems;
- development of region-specific adaptation strategies for vulnerable areas;
- development of adaptation responses for vulnerable sectors such as agriculture, forestry, tourism, energy, transport, and construction, urging the elaboration of sector-specific adaptation strategies and their integration into sectoral planning;
- the strategy underlines the importance of adaptation in nationally significant horizontal areas, such as disaster management, the development of critical infrastructure networks, rural development, and water management;
- enhancement of public awareness and adaptive capacity;
- strengthening research, development, and innovation in adaptation.

The recommended NAS short-, medium-, and long-term adaptation action lines extend across multiple sectors, including public health, water management, disaster response, security policy, nature conservation, agriculture & rural development, forestry, built environment, energy infrastructure, and tourism. In some areas, such as agriculture, forestry, and energy management, the strategy also integrates mitigation measures alongside adaptation efforts.

The NCCS-2 does not contain actual actions to be implemented. Identifying concrete actions is the task of the operational climate change action programmes. Both the 1st CCAP the 2nd CCAP draft comprised 3 sub-programmes, one for decarbonisation, one for adaptation and one for mitigation. One additional group of measures consisted of implementation, monitoring and financial actions.

The government's climate and energy policy package adopted in January 2020 included the document titled "**Report on the Scientific Evaluation of the Current and Expected Climate Change Impacts on the Carpathian Basin.**" This document has been one of the key components of domestic adaptation alongside the NCCS-2. It can be regarded as the most up-to-date climate change risk assessment and situation analysis of the Hungarian climate change adaptation and serves as the most recent background document for Hungary's climate policy, offering current strategic directions. It outlines the current and future climate change impacts affecting the Carpathian Basin its regions, the consequences, and vulnerability topics broken down by sector. The strategic directions outlined in the report highlight the most important policy responses, intervention directions, and considerations, including:

- The importance of ensuring financial support for the intervention directions outlined in policy documents and sectoral development programs.
- enlisting of potential projects to fill research gaps, and facilitate more effective adaptation. These include studies on the complex vulnerability of municipalities, changing regimes of large rivers, complex vulnerability of the domestic tourism sector, and human health impacts of climate change, especially heatwaves.
- The report also advocates for the macroregional extension of the NAGiS framework practically into the direction of the Carpathian Basin to better mapping regional climate and vulnerability processes, as well as strengthening digitalization in climate protection.
- The Carpathian Basin report highlights some of the challenges of adaptation, particularly the need for more effective involvement of private capital (from both the public and private sectors) and the lack of an integrated climate policy monitoring and evaluation system to track implementation and changing vulnerabilities.

III.D.2. National Adaptation Geo-information System (NAGiS)

Climate adaptation seeks spatially tailored responses to the geographically different climate change impacts of different territories. Since different regions of Hungary are vulnerable to climate impacts in adverse ways, a key task is the regional comparison of vulnerability levels. Regional-level climate vulnerability assessments reveal the relative spatial/territorial differences in climate change risks across various areas and municipalities. In 2012, the government recognized the importance of this activity when it decided to establish a national-

level, GIS-based adaptation system: the amendment of the 2007/LX Act ordered the establishment of the National Adaptation Geo-Information System (NAGiS). The NAGiS serves the goals outlined above, functioning as a decision-support and strategic planning tool and a key instrument for planning adaptation measures. The rules for its operation were defined in Government Decree 94/2014.

As a result of the first development phase (2013-2016), a multi-sectoral, versatile GIS system and database was created, which facilitates the identification of climate change impacts, the determination of vulnerability in different areas, and encourages adaptation to these impacts. Its 4 main pillars include:

- Mapping system: A 10x10 km resolution system containing hundreds of layers, which visually shows how different climate impacts may affect various regions of the country. The mapping system is freely available.
- GeoDat database: Contains observed and modelled climate exposure data, furthermore environmental, economic, and social sensitivity/expected impact/adaptability/vulnerability data across 16 vulnerability topics. Registered users can use the database for analyses and data extraction.
- Metadata base: Helps users navigate the information, acting as a "data map" for what and where data can be found, with multiple search options across data layers. While the metadata base displays all data layers uploaded to GeoDat, only a narrow subset is represented on the map.
- Document repository: Includes research reports, manuals, publications, handbooks, and awareness-raising materials created during the different development phases.

Between 2017 and 2020, the second development phase of the system took place. During this period:

- existing vulnerability topics were further developed and new ones (e.g., urban building stock vulnerability to storms, climate exposure of shallow geological hazards) were established.
- the system's user-friendliness and decision-support capabilities were improved, allowing the system to provide easily accessible, exportable thematic queries and reports and overviews of adaptation topics at municipal and regional levels, enabling stakeholders to access relevant data for their specific operational contexts (creating tools for policy and local government decision support,
- the Settlement Adaptation Barometer (an online situation analysis-supporting survey facilitating local strategic planning by identifying key local climate impacts and potential responses, guiding and encouraging broader stakeholder engagement) and Municipal Decision Support Module (a tool supporting evidence-based preparatory studies for local strategy planning by making climate change impacts and responses more accessible and customizable for local governments) and the Municipal Housing Stock Vulnerability Estimator modules were activated with enhanced online access. These newly created modules support urban development, climate adaptation planning

and implementation, project preparation, development, and implementation, as well as continuous information sharing with decision-makers and the local public.

After 2020 the further development of the system with the exclusion of a comprehensive project about vulnerability assessment of energy infrastructure (gas, district heating, electricity) networks and solar energy production, came to a halt. The directions of this further improvement and the intention of turning the NAGiS into an integrated MRE system is introduced in Chapter “*Monitoring and evaluation of adaptation actions and processes*” in a more detailed way.

The NAGiS currently holds data and conducted CVAs in the following thematic areas: demographics, climate, building vulnerability, forestry, groundwater level, land cover, geological hazards, economy, heatwaves, drinking water resources, climate change attitudes, ecology, ecosystem service indicators, field crop farming, tourism climatology, complex tourism sector vulnerability, and flash floods.

III.E. Progress on implementation of adaptation

As already explained in section D.) (“*Adaptation strategies, policies, plans, goals and actions to integrate adaptation into national policies and strategies*”) above, the **main document of the Hungarian climate policy is the NCCS-2**, which is divided into 3 sub-strategies. **The concrete practical implementation of the overall and specific objectives and lower-level objectives (sub-objectives or intervention areas) identified in the NCCS-2 occurred by the measures of the Climate Change Action Plans (CCAP).** As mentioned above, the actions of the CCAPs are divided into four pillars: decarbonization, adaptation, awareness-raising and implementation frameworks. **Each measure is presented in tabular form in the CCAP with the key information** (e.g. reason for action, timing, responsible partners for implementation, possible source of funding, output indicators).

In section III. C.) (‘Adaptation priorities and barriers’), **we have already introduced** the development of the NCCS-2 review report during 2022-2023 and **how the review document has revealed progress achieved so far in implementing the overall, specific and lower-level objectives of NCCS-2.** For this reason, **this chapter focuses on the progress in implementing the measures in the CCAP documents** covering the NCCS-2 intervention areas.

Based on the findings of the NCCS-2 review, **52 of the 65 measures of the 1st CCAP have been completed (80%), 11 are ongoing (17%) and 2 are not completed (3%).** Of all the measures, the completion rate for adaptation measures was the highest (but not much higher than for mitigation measures) and awareness-raising measures the lowest.

Focusing on adaptation, among the 1st CCAP adaptation measures, almost all of the **actions in agriculture, forestry, nature protection, disaster management, energy infrastructure have been implemented** according to the available information, and **majority of the measures in “water management” and “human health” group of measures have also been completed.** Overall, the implementation rate for each group of measures is not particularly low.

The **2nd CCAP** has remained only in a draft version, however, approximately half of its actions has been implemented or started to be implemented by the responsible sectors.

As an important milestone of the Hungarian climate policy, **on the basis of the NCCS-2 evaluation report** carried out in 2022-2023, the NCCS-2 will be updated in 2025/2026 . **Representatives of the relevant sectors will be involved in the updating process** in order to produce a revised strategy that integrates the views of the different ministries and responds to the actual challenges.

As already mentioned above in section III.A. (*“National circumstances, institutional arrangements and legal frameworks”*) the most important climate policy legislative change in recent years is that **Government Decree 94/2014 (21.III.)** on the detailed rules of the **National Adaptation Geo-information System (NAGiS)**, which defines the purpose and tasks of the NAGiS system *was modified in 2023 by Government Decree 591/2023 (XII.)*, **which assigns the operation of the NAGiS system to HungaroMet Hungarian Meteorological Service Nonprofit Ltd.**

III.F. Monitoring and evaluation of adaptation actions and processes

The chapter introduces climate adaptation policy-related monitoring and evaluation activities in Hungary and shares information about the establishment or use of domestic systems (including those in place or under development) to monitor and report on the implementation of adaptation actions.

III.F.1. Institutional background, responsibilities

As already mentioned in Chapter A.) (*“National circumstances, institutional arrangements and legal frameworks”*) of the document **in Hungary climate policy-related monitoring, reporting and evaluation (MRE) are the task of the ministry responsible for climate policy issues** (currently the Ministry of Energy and its Deputy State Secretariat for Climate Policy) **and its climate adaptation-related background institute, the National Adaptation Centre – currently a unit of the HungaroMet Hungarian Meteorological Service’s Climatology, Research and Development Directorate.** The Ministry of Energy’s Climate Policy Department regularly monitors the status of the measures of the second National Climate Change Strategy’s (NCCS-2) Climate Change Action Plans (CCAPs) from time to time. The related broader goal of the Ministry of Energy is to set up a comprehensive monitoring and evaluation framework related to energy- and climate policy, as the existing monitoring practices can vary from sector to sector and their managed data are diverse. Frequency of data collection and date of data publishing are very diverse, too.

In Hungary, systematic development policy-related MRE activities exist only in the sphere of ESIF Funds-related activities. There is no direct climate policy- oriented, let alone adaptation-focused MRE in Hungary. The NCCS-2 and its first CCAP declared a definite demand for the establishment of a complex climate policy oriented MRE system in Hungary.

III.F.2. Adaptation MRE tools, systems

This aforementioned system development has several antecedents in the recent years. Between 2019 and 2021 a project financed by the **EU Structural Reform Support Programme** was implemented by the **Swedish EPA focusing on European and Hungarian mitigation and monitoring practices**. Parallel with this, the **National Adaptation Centre conducted a complementary and wider survey about both European and Hungarian adaptation MRE activities; concentrating both on evaluation and monitoring practices** and the related system building processes. According to the results, **one of the biggest challenges of the Hungarian climate policy- especially adaptation policy- activities is that the given sectoral/thematic databases, inventories are neither interconnected with each other nor integrated into a single national database**. Specifically climate policy -related evaluations (that directly or indirectly affecting climate policy) did not occur until recently, namely until the elaboration of the 5-year evaluation of the NCCS-2.

The next step, based on the SRSP project and the National Adaptation Centre's own research results, **is planned to be the concrete establishment of an integrated climate policy MRE system, because the systematic, complex monitoring and evaluation of adaptation-related development objectives, measures and climate impacts is still lacking in Hungary**. With the set-up of the system our goal is to monitor and assess the implementation of the projects, programmes and strategies aiming at mitigation, adaptation, awareness raising and green economy development or awareness raising objectives in Hungary from different development funds as well as the changes in adaptive capacity and vulnerability of given sectors/regions.

Based on the above described studies and experiences, international and domestic examples, in 2024 a restructured and expanded development idea was submitted by the National Adaptation Centre to the Deputy State Secretariat for Climate Policy about the directions of the planned MRE system. According to the plans the system will comprise 3 main parts:

- 1. an integrated database**, comprising
 - spatial climate vulnerability data based on the current NAGiS GeoDat database;
 - spatial GHG emission data based on existing databases of the HungaroMet;
 - data on the implementation of climate policy objectives and interventions.
- 2. a map displaying tool based on the current NAGiS mapping system;**
- 3. and a group of interactive decision support tools**, such as
 - the municipal adaptation inventory;
 - the municipal housing stock vulnerability estimator module;
 - climate policy monitoring tool.

The system's set-up is planned to start in practice in the coming years, depending from political decision.

In the field of **climate impact-monitoring the National Adaptation Geo-Information System** (developed in its first phase from Norway and EEA grants between 2013 and 2016 and

improved further from Energy Efficiency and Environment OP fund between 2017 and 2020) **is still the basic tool and is intended to remain that**. The system is developed and operated by the HungaroMet National Adaptation Centre Department. **Its main function is to support national climate policy and local government decision making, providing its target groups with regularly updated data from climate observation and modelling, data about climate change impacts, consequences and potential adaptation capacities by sectors or vulnerability topics**. Among the latter ones the vulnerability to floods, flash floods and inland water inundations; the sensitivity of drinking water reservoirs; the exposure to droughts; the extreme weather-related vulnerability of housing stock; vulnerability of energy infrastructure networks, vulnerability of agriculture and forestry, and the human health-related vulnerability to heat waves can be mentioned.

III.F.3. Achievements, impacts, effectiveness and results

Achievements, impacts, effectiveness and results of the Hungarian climate adaptation policy was analysed first time ever by the **5-year evaluation process of the NCCS-2**. The process also **covered the implementation of the NCCP documents of the NCCS-2 as well as the evaluation of the performance of the domestic climate adaptation policy in general**.

Both the plans and the practice in the Hungarian climate policy –related MRE activities concentrate on three main pillars.

- Changes in climatic factors and (spatial) sensitivity, adaptive capacity and vulnerability indicators are monitored by HungaroMet.
- The same organisation monitors GHG emission trends.
- Meanwhile, the following-up of achievement of national climate policy goals, objectives, priorities and measures is the joint responsibility of the ministry responsible for climate policy (currently the Ministry of Energy) and its climate adaptation-related background institute, the HungaroMet National Adaptation Centre.

Actual adaptation priorities are identified in the second National Climate Change Strategy (NCCS-2) and its adaptation sub-strategy, the National Adaptation Strategy (NAS). Based on these and the short and medium term sectoral action lines of NCCS-2, concrete **adaptation measures were elaborated in the National Climate Change Action Plans (CCAPs) of the NCCS-2**.

Going through the six main adaptation priorities of NCCS-2 the following progress can be detected in the last 5 years according to the NCCS-2 evaluation report:

The NCCS-evaluation's indicator analysis showed that data were available for only a very limited number of the result indicators selected to measure the achievement of the **NCCS-2 adaptation sub-objectives**, so their achievement cannot be clearly established.

- We were able to examine four of the eight result indicators selected to monitor the sub-objective **"Preserve and enhance the sustainability of natural resources"**. A positive change since 2018 has been the increasing size of forest area and agricultural land under organic management. However, the extent of municipal green areas has decreased and

per capita household water consumption has increased, although the target should be to reduce the latter.

Out of the concrete results, forest conservation activities of Ministry of Agriculture' Forestry department and the Scientific Institute of Forestry; the functioning of nature conservation in its entirety; water conservation efforts of the National Water Management Directorate; the Ministry of Agriculture's activities in soil management and water use could be mentioned. The related research projects of Soil Research Institute directly; studies of the tourism sector and HungaroMet indirectly support this area.

- Regarding the „*Reduction of vulnerability of given regions and identification of adaptation options for vulnerable areas*” sub-objective the development of area-specific adaptation strategies and their integration into regional development plans is a step forward in the significant increase of the total population of municipalities having a climate strategy. However, no data were available for the other result indicators, so the achievement of this sub-objective cannot be fully assessed quantitatively.

Background data provided by the HungaroMet; destination management activities of the tourism sector; area-specific interventions of the Ministry of Agriculture, National Adaptation Centre and Soil Research Institute; research and regulatory results of the National Public Health and Pharmacology Centre for heat wave affected cities indirectly; and sector-focused interventions of the National Water Management Directorate directly contributed to the achievement of the sub-objective over the last half decade.

- Data were available for only one of the 8 result indicators selected to measure the sub-objective of „*Implementing resilient and innovative adaptation in vulnerable sectors and developing and integrating sector-specific adaptation strategies*”, namely the volume of water sold per capita for irrigation, which has increased since 2018 in line with the targets.

Adaptation interventions in water management by the National Water Management Directorate, adaptation interventions in agriculture and forestry by Ministry of Agriculture directly, sector specific interventions by National Disaster Risk Management Directorate and the transport sector indirectly serve the achievement of this sub-objective.

In relation to the first three NCCS-2 adaptation sub-objectives, an outstanding achievement in forest management is that in 2019 the **total area of forest and other woody vegetation** amounted to 2,316,400 ha. Several forestry measures of the first and second CCAPs and the **Károly Kaán Programme** aim at a continuous expansion of forest areas. In 2020-2021, the area of newly planted forests was almost as great as the total for the previous seven years, but forestry interviewees estimated that the current rate of forest area expansion is below the rate of 10-15,000 ha of new forest/woodland per year envisaged in the NCCS-2. Through the **Urban Forestation Programme**, afforestation of municipal areas is also increasing in the country. Progress has been made in the field of **sustainable forest management** in line with the NCCS-2 guidelines: continuous forest cover is being ensured as far as possible, semi-natural forest management is being promoted, cutting back on felling, leaving a larger proportion of old trees and deadwood, and greater attention is being paid to soil protection. Several LIFE and INTERREG projects aim to increase the area of small forest wetlands. Mixed regeneration and tree planting started to play a greater role than the patchier planting and regeneration that has

been practised so far; planting mixed stocks instead of single-aged stocks. Other tools for sustainable forest management include 10-year district forest plans, an early warning system development to reduce the risk of forest fires, applying forest management tools considering reduction of water stress, or the development of a site-specific model for tree species selection. The latter is increasingly coming to the fore in the context of forest adaptation. The **Forest Measurement and Monitoring System (EMMRE)** can be used to investigate which climate factors will change in the future in each production area in relation to current conditions and how they will change in the future. Accordingly, the Ministry of Agriculture is urging forward-looking, prudent planting and forest renewal in the longer term, based on EMMRE results. A significant amount of aid per hectare is earmarked for the use of climate-resistant propagating material. One of the most important tangible results has been the further development of EMMRE based on remote sensing, using satellite maps to assess the health of Hungary's forests. Monitoring the impact of the expectedly more frequent droughts is also a priority.

Water management is another prominent example of sectoral adaptation. The implementation of Hungary's **3rd River Basin Management Plan (RBMP3)** has progressed well. The term "risk prevention water damage management" has been integrated into the National Water Strategy, and projects in the field of flood protection are regularly targeted at this, with a special focus on the Upper Tisza Valley. With the completion of the Tisza-Túr reservoir, 31 flood-protection or partially flood-protection reservoirs with a total volume of 1 092 million m³, are now in operation in the Tisza valley. 5 reservoirs with a total volume of 386 million m³ are currently operating in the valleys of the Körös rivers. Under the VTT programme, 7 reservoirs with a total volume of 783 million m³ have been completed so far. A central effort has been launched to prepare integrated municipal water management plans. There are and have been (pilot) projects related to sustainable inland water management (LIFE-MICACC, LIFE-LOGOS). Since 2015, the **Operational Water Scarcity Assessment and Forecasting System** for monitoring water scarcity/drought has been continuously developed in Hungary, with 116 monitoring stations already installed.

- To help prepare for and adapt to „*Increasing risks in horizontal areas of key national strategic importance (including disaster management, critical infrastructure in water management and rural development)*”, the reduction in the number of inland water and local water damage events since 2018 is an important step towards achieving the sub-objective. The other result indicators could not be assessed due to lack of data, so the achievement of this sub-objective cannot be assessed in its entirety.

The sub-objective nominates 4 sectors in the NCCS-2 (**water management, risk management, agriculture/rural development, critical infrastructure**). The main results here are the new achievements of the National Water Management Directorate, the National Risk Management Directorate, the Ministry of Agriculture and the Ministry of Energy (the latter, for example, showed concrete results in the operation of the infrastructure networks and related research activities, e.g. energy infrastructure project within the NAGiS).

- A positive change regarding the sub-objective „*Mitigate the expected societal impacts of climate change and improve society's adaptive capacity and awareness of adaptation options*” is the reduction in the proportion of people who cannot keep their homes warm enough. The other three result indicators were not collected and the achievement of the sub-objective could not be assessed.

The **education and health** sectors are directly involved in helping society to adapt, while the National Disaster Risk Management Directorate, the National Tourism Agency, the Scientific Institute of Forestry and the National Water Management Directorate are indirectly involved through awareness-raising. Examples from the **tourism** sector include the Kajla programme as a way of promoting sustainability, which also boosts domestic tourism; labels such as the Responsible Gourmet, the Green Michelin starred restaurants or the Green Hotel Award, which also prioritise sustainability.

- An important element of the achievement of the sub-objective on „*Supporting adaptation research, innovation and publishing scientific research results*” is that since 2018 the number of vulnerability assessment topics available in the NAGiS system has increased, as well as the number of methodological guides and manuals, so the sub-objective shows significant progress.

In the field of **adaptation R&D&I**, the HungaroMet, the National Water Management Directorate, the Soil Research Institute, the National Public Health and Pharmacology Centre and the Lechner Knowledge Centre are involved as beneficiaries and suppliers of research results. Beyond the indirect transferability of the Ministry of Energy’s Environmental Development Department’s awareness-raising activities and the **adaptation of energy infrastructure networks** (e.g. district heating sector) or the research aimed at this (NAGiS energy infrastructure project), the EM’s **essentially mitigation** fields have, by definition, contributed less to adaptation issues with concrete results.

According to the NCCS-2 evaluation report the implementation of the NCCS-2 sectoral action lines for awareness-raising and the related actions identified in the CCAPs are now under way. The majority of the relevant NCCS-2 action lines are being implemented, while a slightly smaller number have been completed and closed. The rates for the CCAP actions are similar, but in general this pillar shows the weakest implementation results for CCAP I (and the best for the draft second CCAP II, but the total number of awareness raising actions in the second CCAP is very low, and only a small proportion of them has been launched). In terms of awareness raising performance, education, churches, the environmental units of the Ministry of Energy and the Blue Planet Foundation showed stronger results based on the interviews.

The achievement of the **NCCS-2’s awareness raising sub-objectives**:

- Regarding „*The organisation of social sustainability campaigns*”, subobjective, the nature conservation sector (Ministry of Agriculture and its background institutes) was particularly active, but the National Water Management Directorate, the Blue Planet Foundation, the National Disaster Risk Management Directorate, the National Public Health and Pharmacology Centre and the tourism sector were also actively involved in related campaigns.
- „*Networking between civil society, the research sector, the private sector and the public sector*” sub-objective has shown concrete results over the last half decade (the Blue Planet Foundation’s Planet Expo series, the activities of the education sector and the networking of the National Adaptation Centre can be mentioned).
- In the context of „*Improving the climate awareness of the education system*” sub-objective, the education sector performed extremely well, but the Ministry of Energy’s

Environment Development unit also contributed to the results of this sub-objective through school programmes, and the Blue Planet Foundation, the National Public Health and Pharmacology Centre and the HungaroMet National Adaptation Centre by developing educational materials and conducting training courses.

- *„The adaptation of public administration”* was almost absent from the results (only the Blue Planet Foundation indicated that it will launch a related programme next year).
- *„Involvement of churches into awareness raising activities”* also show several results during the recent years in Hungary according to the interviewed church partners.
- Though *„Awareness-raising of the media”* is more of an intentional activity (Blue Planet Foundation, tourism sector); based on the interviews, only the National Disaster Risk Management Directorate and the churches have regular and active contacts with public television.

The analysis of national sectoral strategic documents further enriches the picture: the climate awareness of society was targeted by strong attitude-building directions in most of the sectoral documents, which suggests that awareness raising is considered as an important tool in order to achieve the sectors’ mitigation and adaptation goals. Concrete examples were presented in the National Energy Strategy: development of the "Live energy and climate-consciously!" application for different age groups; conduction of the "How to consume climate- and energy-consciously" campaign; implementation of the "Climate and energy conscious workplace" program are especially mentioned.

The achievement of the specific objective of **climate vulnerability assessment** was assessed through the result indicator of the *number of users (persons) registered in the NAGiS*. From 2018 to October 2023, the number of registrations increased from 360 to 548. This number is at a reasonable pace compared to the number of registrations since the establishment of NAGiS, showing some slowdown; on the other hand, it is not considered to be particularly high.

The achievement of the **NCCS-2’s climate vulnerability assessment** sub-objectives:

- Based on the information obtained from the interviews, the implementation of the NCCS-2 sectoral action directions and the measures identified in the CCAPs related to climate vulnerability assessment is underway.
- Based on the results of the interviews, all sub-objectives (*„Development and maintenace of NAGiS”, „Climate change basic and applied researches”, and „Vulnerability methods and indicators”*) had concrete results.

The Hungarian Central Statistical Office’s (KSH) one-year process to improve climate change-related data collecting and processing in Hungary on the national level ended in the spring of 2024. The National Adaptation Centre reviewed the list of indicators, too. Detailed results have not been published so far.

To find out **how adaptation increased resilience and reduced impacts**; the aforementioned results of the half-time evaluation of the NCCS2 and its action plans from 2022-23 gives us some overall information in Hungary. However, the earlier statements of the last biennial report are still valid:

Without proper and operating MRE system it is hard to estimate that progress, however, we can state that numerous projects has been started or already been finished in the recent years (mainly from the relevant 2014-20 OPs, the Rural Development Programme and LIFE sources). These can contribute significantly to the cause of adaptation to and preparation for impacts of climate change. The „*Further Development of NAGiS*” (2017-20) project was a crucial step in strengthening adaptation decision support activities of national policy making and local governments in Hungary.

Cases when adaptation activities are not sufficient to avert impacts could be identified properly in the future when the long-time planned climate policy monitoring and evaluation system have been set up. Until then, only scattered, individual cases could be presented (e.g. using water drainage –oriented of grey infrastructure against flash floods, urban regeneration projects without proper natural shadowing, tree plantations without proper infiltration systems, etc.) which is not the function of this document.

Based on the NCCS-2 evaluation interviews, the implementation of **the NCCS-2 sectoral adaptation action lines and the adaptation/preparedness measures identified in the CCAPs are underway**. Most of the NCCS-2 action lines are being implemented, while a slightly smaller number have already been completed. **The rates are similar for the CCAP actions, with a higher rate of completed actions in the first CCAP. Above 90% of the 1st CCAP’s adaptation measures have been implemented so far** – however, these were mostly strategic planning or preparatory initiatives, serving as basis for future bigger research projects, developments and interventions. **Several of the adaptation measures of the draft second CCAP have been completed or partially completed between 2021-23**. Among the different sectors water management, forestry, nature conservation, disaster management and public health perform particularly well. Tourism, education, agriculture and settlement development have undertaken fewer measures so far in the CCAPs, but those few have been basically delivered.

Approaches and systems used in the Hungarian climate adaptation policy can be summarized in the followings. Changes in climatic factors and (spatial) sensitivity, adaptive capacity and vulnerability indicators are monitored by HungaroMet, as described above. The same organisation monitors GHG emission trends. Meanwhile, the following-up of achievement of national climate policy goals, objectives, priorities and measures is the joint responsibility of the ministry responsible for climate policy (Ministry of Energy) and its climate adaptation-related background institute, the HungaroMet.

Referring back to the above mentioned facts, the following-up of implementation of adaptation actions and achievement of adaptation objectives, according to the 1st CCAP and the NCCS-2, will be based on output and result indicators respectively. The sources of the formers are the reports of the project owners; of the latter are official statistical data or own reporting. NAGiS’s complex impact, adaptability and vulnerability indicators will be based mostly on statistical data.

Assessment of and indicators for adaptation is based on the monitoring and evaluation system chapter of the first CCAP its defined indicators. Among other things the achievement of these were analysed during the NCCS-2’ halftime evaluation process. The 5-year-evaluation of the NCCS-2 document, conducted in 2022-23, was based beyond sectoral interviews and document analyses even on the quantified monitoring of the achievement of the NCCS-2 targets

and action lines, as well as of the CCAP actions, however limited the chances of such an analysis was regarding the available indicators. A difficulty encountered during the review was that Hungary does not currently have its long-time planned climate policy monitoring system in place to track the exact implementation of the aforementioned documents and their objectives.

Output indicators showing the implementation of the measures of the first and second CCAPs are still relatively easy to obtain from those partners responsible for implementing the given measures. The Climate Policy Department of the Ministry of Energy has requested information on the implementation of the measures of the first CCAP from these responsible partners/authorities several times, last time in 2021.

According to the 2022-23 NCCS-2 evaluation report, 19 of the mitigation measures have been implemented and 4 are in progress, **25 of the adaptation measures have been implemented and 4 are in progress**, 4 of the awareness raising measures have been implemented, 2 are in progress, one has not been implemented, 4 of the implementation-related measures have been implemented, one is in progress and one has not been implemented. Based on this, the realization rate of the **adaptation measures was the highest (but the realization rate of the mitigation measures was not far behind)**, and that of **the awareness raising measures was the lowest**. Altogether, the period of the 1st CCAP can be evaluated as a positive outcome. Based on the NCCS-2 evaluation report, the results were naturally weaker in case of the 2nd CCAP draft's measures – the document's implementation has not started officially yet, however, some of its measures have accomplished. The implementation of the 2nd CCAP draft's measures were evaluated solely on the basis of the conducted interviews.

Result indicators measuring the achievement of the two overall and four specific objectives of NCCS-2 are already defined by the NCCS-2 strategy itself. However, for the lower level objectives (intervention areas), **result indicators were only defined by the Annex to the first CCAP**. In the course of **NCCS-2 evaluation**, an attempt was made to collect these result indicators in reality for the different objective levels, on the one hand to obtain information which indicators are publicly available and which ones require data to be requested from data owners or even to organise the collection of data for their calculation. On the other hand, it also allowed us to examine the progress towards the achievement of objectives for which public data are available. Overall, it emerged that for a significant **number of result indicators public data are not available**, so that monitoring of the achievement of the NCCS-2 objectives can be only partial.

Data is available for the result indicators of the two overall objectives of the NCCS-2, so it is expected that we will be able to continue to monitor these changes in the future. For the NCCS-2 specific objectives, up-to-date information is **not available for all result indicators**, some of these can also be collected/produced in the future. Public data are typically not available to measure the achievement of the NCCS-2 sub-objectives, and in many cases even new data collection would need to be organised and surveys conducted in the future. The availability and adequacy of data, along with considerations related to climate policy monitoring and evaluation, may indicate the relevance of further development and restructuring of NAGiS.

This approach can also be served by the two directions of the planned further development of the NAGiS system, as laid out in the Carpathian report and the annual research plans of the NAGiS. On the one hand, the implementation of the priority thematic development

directions (analysis of changes in the water regime of our large rivers, analysis of the complex vulnerability of the tourism sector, study of the health effects of climate change, development of a complex municipal vulnerability assessment module), and on the other hand, the geographical expansion of the system.

Effectiveness of the implementation of adaptation measures are analysed by the NCCS-2 evaluation report. On the one hand the above introduced outputs of the NCCS-2 evaluation report give us some answer to the question; on the other hand it can only be properly answered after the planned climate policy monitoring system has been set up and started its operation. Furthermore, adaptation results and impacts of EU funds-supported projects and programmes can be monitored and **evaluated through dimension code system of the EU-planning**. This was also the case in 2014-20, when even a comprehensive assessment was prepared about the climate adaptation-related OP-results of the programming period in Hungary, ordered by the central monitoring coordination unit of the Chancellery.

In the current programming period, adaptation actions, similarly to the 2014-20 period, will be supported also from EU (basically OP) sources. Due to the fact, that the implementation of the related new OPs (Energy Efficiency and Environment OP Plus; Territorial and Settlement Development OP Plus) have not started yet.

As for the follow-up of the adaptation policy, in particular **transparency of planning and implementation**; transparency of both planning and implementation of NCCS-2 and its action plans are intended to be secured through wide involvement of affected sectors' representatives through the Interministerial Working Group on Climate Change during the planning processes and even in the future when the evaluation process of the CCAPs will be conducted; and through comprehensive partnership processes right before the adoption phase of the documents.

How support programmes meet specific vulnerabilities and adaptation needs; and how adaptation actions influence other development goals - these questions can be answered when the long-time planned climate policy monitoring and evaluation system have been set up. The same is true for the analysis of ownership, stakeholder engagement, and alignment of adaptation actions with national and subnational policies, and replicability as well as results of adaptation actions and the sustainability of those results.

III.G. Cooperation, good practices, experience and lessons learned

III.G.1. Climate policy governance and background information

As already explained in section A.) ("*National circumstances, institutional arrangements and legal frameworks*") of the document, the responsibility for shaping Hungarian climate policy is basically the competence of two organisations. The **Deputy State Secretariat for Climate Policy within the Ministry of Energy** and its **Climate Policy Department** is responsible for securing the **legal framework and decision-making**, while the **HungaroMet National Adaptation Centre** (which is the climate adaptation-related background institution of the

Ministry of Energy) is responsible for decision **support activities strategic planning, monitoring and evaluation in the field of climate adaptation.**

The approach to combat climate change is based on the principles of sustainable development and the involvement of a wide range of stakeholders. The aim of climate change-related awareness raising is therefore integrating climate awareness and sustainability into the planning process, decision-making and actions on all levels of society. **The Climate Policy Department** of the Ministry of Energy **is also responsible for the coordination mechanism and stakeholder involvement in national adaptation policy.** The NCCS-2 has a dedicated sub-document for awareness raising (the **Climate Change Awareness Raising Action Plan**), which emphasizes the importance of partnership with media, education, churches, governmental, economic, civil and academic actors. As a national good practice example, during the elaboration of the NCCS-2, the CCAP a wide horizontal participation took place. The thematic consultations were carried out with numerous experts from affected national authorities in the framework of the Interministerial Working Group on Climate Change convened by the Deputy Secretariat of State for Climate Policy.

In the Awareness Raising Programme of the first training and attitude formation was implemented for municipal governments and economic organisations in different topics. Furthermore, educational and training programmes aimed at improving climate awareness and sustainability in higher education also continue, as well as in teacher and instructor training.

It is important to mention the National Council for Sustainable Development (NFFT) established in 2008, as an advisory and interest reconciliation body. NFFT as an independent national institution is responsible for:

- facilitating the definition of the principles, objectives and comprehensive tasks of sustainable development in Hungary
- the consideration of the related international cooperation
- promoting the regular revision and implementation of the sustainable development strategy
- supporting the coordination of the relevant planning and consultation activities
- raising awareness and social engagement and implementation of the international Sustainable Development Goals (SDG) adopted in 2015.

III.G.2. Information systems in Hungary

One of the specific objectives of NCCS-2 is permanently improving a geo-information-based national adaptation decision support system in Hungary as the basis for the spatial assessment of climate vulnerability (**National Adaptation Geo-information System, NAGiS**). The maps of **NAGiS** are publicly available, but access to basic data requires registration. The NAGiS System **has several** purposes, ranging from the **support of climate policy decision making, to facilitating national and subnational strategic planning and higher education.**

Another important information system in Hungary is called **KLIMADAT geo-information system** which, through its **new regional climate projections** have been achieved **until the end of the XXI. century** (with the ALADIN and REMO regional climate models for Central and Eastern Europe on 10 km horizontal resolution) and its **representative climate database** supports **climate impact assessments, adaptation planning** and **decision-making mechanisms**.

III.G.3. Relevant climate research institutions

Research related to climate change is carried out at various institutions across Hungary. These include the **Hungarian Academy of Sciences (MTA)**, university and college departments, dedicated state institutions such as HungaroMet, as well as NGOs, private consultancies and think tanks.

HungaroMet Hungarian Meteorological Service is one of the central institutions in the field of climate change research and policy. As of 1st January 2024, HungaroMet is the legal successor of the Hungarian Meteorological Service (OMSZ); a non-profit, state-owned company, designated to cover public meteorological duties in Hungary. This new organization has an extended scope of tasks: **apart from meteorological observation and climatological modelling and predictions, it acts as a comprehensive climate policy and environmental background institution** (integrating noise- and air pollution fields). Regarding the meteorological/climatological pillar, HungaroMet is responsible for operating the national meteorological database and relevant IT and telecommunications systems; for producing accurate meteorological, climatological and climate adaptation information; as well as operating atmospheric meteorological, and air quality measurement networks. HungaroMet issues weather warnings for protection of life and property and provides aviation meteorological and environment protection services over Hungary. The policy-pillar includes climate adaptation-related decision supporting, monitoring, and strategic planning activities, provided by the National Adaptation Centre, unit of the Climatology, Research and Development Directorate.

The activity of HungaroMet is based on the extended **national and international infrastructures** including the surface observational network and remote sensing instruments over Hungary, running the telecommunication and informatics system for obtaining meteorological data from the Global Telecommunication System of the World Meteorological Organization, archiving and processing its own meteorological and climatological database, and for the operation of numerical weather and climate models. HungaroMet carries out intensive co-operations with various international organizations on research, development and operative activities. Most important ones are the Network of European National Meteorological Services (EUMETNET), the European Centre for Medium-Range Weather Forecasts (ECMWF) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).

In regard to the **support for developing countries** to establish and maintain observing systems and related data, HungaroMet has taken the following actions:

- Six Turkish experts visited HungaroMet in 2015 to study the methods of official air quality measurements.

- In the framework of the “ICT technologies and observational requirements for SEE-MHEWS-A project”, the Hungarian Meteorological Service shares the experiences on its observation network and visualization of its forecasting products with developing countries taking part in the project.
- In the framework of the bilateral agreement between the Hungarian Meteorological Service and the Ukrainian Hydrometeorological Center, HungaroMet shares experiences on the field of air pollution measurements, meteorology and forecasting services.
- With 4% of its yearly WMO membership fee, Hungary supports developing countries. With this part of the membership fees, WMO supports education, water resource management, flood and disaster recovery and agricultural implementation, mainly in African and Asian countries.

Because of the open data policy introduced in 2021, **long climate data sets are available to the public for climate change research** (odp.met.hu).

III.G.4. Additional related international activities

Since the 1990s, the Hungarian Meteorological Service has been providing daily data to the **WMO Global Atmosphere Watch (GAW) Programme**:

- **World Data Centre for Greenhouse Gases (WDCGG)**: continuous tall-tower observation of greenhouse gas concentrations (CO₂, methane) from different levels (at heights of 10 m, 48 m, 82 m, 115m).
- **World Data Centre for Reactive Gases (WDCRG)**: daily mean concentration of tropospheric ozone, nitrogen-dioxide, and sulphur-dioxide from its background monitoring station.

The ISCD01 HABP climat BUFR bulletin contains 5 stations operated by the Hungarian Meteorological Service. CLIMAT messages are transmitted to Vienna (LOWM RTH) to the WMO-WIGOS (GCOS Surface Network) database. Climate analyses are regularly provided to the World Climate Data and Monitoring Programme (WCDMP).

The Hungarian Meteorological Service also took part in COST Action ES1207, *A European BREWer NETWORK* (EUBREWNET) (2013-2017). This project involved appr. 20 European Brewer spectrophotometers. The experimental measurement network aimed at detailed, quasi real-time investigation of Brewer spectrophotometers according to uniform criteria to further increase the reliability and uniform interpretation of the measurements.

HungaroMet actively took part in the regional project ‘**South-East European Multi-Hazard Early Warning Advisory System**’ in 2019-2021, initiated by the WMO and supported by the World Bank.

HungaroMet also provides daily support of measured daily total ozone value to both GAW / GO3OS centres: Atmospheric Physics Laboratory of Aristotle University, Thessaloniki and to World Ozone and UV Data Center, Downsview, Canada. Furthermore,

monthly support is given of coded data file, including daily averages of measured total ozone and sulphur-dioxide, to World Ozone and UV Data Center, Downsview, Canada.

With the leadership of HungaroMet the daily gridded climatological database was prepared in the Carpathian region in the frame of the CarpatClim project sponsored by the Joint Research Centre of the European Commission. The outcome of the project is a 0.1° (about 10 × 10 km) spatial resolution homogenized and gridded dataset on a daily scale for basic meteorological variables and several climate indicators, 37 in total, on different time scales from 1961 to 2010.⁷¹

Drought monitoring system operated by the Hungarian Meteorological Service between March 1 and September 30. : HungaroMet performs calculations for two main groups of field crops: cereals and winter rapeseed, and summer crops. This distinction is necessary because their growing seasons and phenological phases differ significantly. The agricultural drought level is determined based on daily soil moisture calculations by HungaroMet, measured across a 5x5 km grid at three depths (0–20 cm, 20–50 cm, and 50–100 cm). The three soil moisture layers are weighted according to the root depth distribution of the two crop groups, and the drought level is then categorized accordingly.

III.G.5. Systematic observation

The bulk of observation activities are still carried out by the Hungarian Meteorological Service (HungaroMet) and partly by the Department of Meteorology at Eötvös Loránd University (ELTE). **Eötvös Loránd University (ELTE)**, with over 25,000 students, is one of the major universities in Hungary. MSc degree in meteorology can exclusively be obtained at this university in the country. Main research activities at the Department of Meteorology include the dynamical modelling of atmospheric processes, downscaling of global climate change projections, analysis of climatological extremes, estimation of regional climate change, monitoring and modelling of regional carbon balance, greenhouse gas concentration measurements, air pollution modelling, and soil-vegetation-atmosphere transfer modelling.

HungaroMet is a state-owned non-profit public limited company; being the national meteorological service of Hungary it is responsible for supplying meteorological, atmospheric environmental and climate information, and for the provision of warnings about severe weather situations in Hungary. HungaroMet operates the **surface meteorological observation network** all over the territory of Hungary, including 162 automatic weather stations and 142 hydrometeorological stations, and about 430 conventional rainfall stations. The automatic meteorological stations basically measure the weather parameters (air temperature and humidity, air pressure, wind, precipitation), but we also perform gamma-dose rate measurements at 28 sites for early detection of radioactive hazard, at three places aerosols with alpha, beta and gamma activity are monitored and at some dozen stations we measure soil temperature and soil moisture at several layers, which are important for agriculture. The regular calibration and maintenance activities of the measurement equipment are also carried out by HungaroMet annually. The network has been extended by several sites during the last years in

⁷¹ The dataset is publicly available on the project homepage: <http://www.carpatclim-eu.org>

the frame of a KEHOP project on Disaster Risk Assessment Network, and an Interreg project on mitigating the negative effects of hail in Satu Mare County.

To measure atmospheric state variables vertically, HungaroMet regularly launch **radiosondes** in Budapest and Szeged (since 2020 in automatic regime) at the same time as about other 750 radiosonde stations around the world. The sonde is lifted up by a hydrogen-filled meteorological balloon. The probe rises up to 25 to 30 km in about one and a half hours, while its electronic sensors are continuously measuring and its transmitter broadcasting the pressure (for certain type), temperature, relative humidity of the surrounding air and current GPS coordinates of the radiosonde to determine the direction and speed of the upper wind. The four daily ascents instead of the previous two resulted in significant progress, thanks to the recent testing and introduction of a new, more economical radiosonde, the developing and refining of which staff of HungaroMet were also involved in.

In recent years, HungaroMet have put great emphasis on the **development of the national weather radar network**, which monitors rainfall, measures intensity of precipitation and tracks the atmospheric events. HungaroMet operates a network of five radars, the latest of which was installed in South Transdanubia. In addition to the installation of the new device, upgrade of the Budapest, Pogányvár and Napkor radars was also completed. The organisation have not only developed our equipment, but also the products obtainable from the results of radar measurements. Instead of the former two-dimensional radar images, three-dimensional composite images are being made, enabling investigation of not only the horizontal properties of precipitation systems, but their vertical structure as well. The new products significantly contribute to severe weather forecasting and aviation meteorology.

It is very important to have meteorological data from not only the places where meteorological stations operate, but to know the more real-time values of meteorological parameters available for both the current weather conditions as well as forecasts and warnings. This is the purpose of **remote sensing techniques**. In addition to the **radars and the lightning detection system** nearly 20 disdrometers help to calibrate radar precipitation data at present, while two wind profilers constantly measure the changes in wind by altitude. Recently HungaroMet have installed 10 **ceilometers** for serving aviation needs.

HungaroMet also operates the **national Air Quality Reference Centre (AQRC)**, which carries out **field and laboratory calibrations of gas analyses of the Hungarian air quality network**, organising intercomparison exercises and responsible for the QA/QC programs in Hungary. Besides, it is also responsible for the **operation of the background air pollution monitoring stations**, data submission for international organizations (WMO, EMEP, EEA), **examination of the trace element concentration**, and expert reports for the national authorities.

Long-term meteorological observations are references for climate variability and change assessments. To emphasize their importance, the World Meteorologic Organization (WMO) has a mechanism to recognize centennial observing stations. In 2020 and 2021, 5 meteorological stations from Hungary (Budapest, Szeged, Pécs/Pogány, Szombathely, and Debrecen) with more than 100 years of measurement records have been recognized by WMO as Centennial Observing Stations.

Besides short-range, medium-range, and monthly weather forecasts, HungaroMet provides climate projections into future with the help of two regional climate models which were adopted

by the Hungarian Meteorological Service: the ALADIN-Climate model developed by Météo-France; and the REMO model developed by the Max Planck Institute for Meteorology in Hamburg. Other two regional climate models were adopted by ELTE: the RegCM model originally available from ICTP (International Centre for Theoretical Physics), and the PRECIS model developed by the UK MetOffice Hadley Centre.

The results of the projections have been applied in many national and international projects, such as the National Adaptation Geo-information System (NAGiS) project in which climate model results of HungaroMet and ELTE (Eötvös Loránd University) were utilised for impact studies of hydrology, agriculture, tourism and critical infrastructure. HungaroMet is also the owner of the national climate database, and thus has participated in relevant projects such as the DMCSEE (**Drought Management Centre for South-eastern Europe**) project, which aimed at preparing regional drought monitoring, analysis, and early warning products. ELTE developed and disseminated the so-called FORESEE database⁷² which is an observation based climatological dataset combined with bias corrected climate scenarios covering the period of 1951-2100. In FORESEE 10 different climate model results are available to estimate uncertainty in the future projections. FORESEE is being used in different climate change related impact studies in Central Europe and is freely available to the scientific community and for decision makers.

III.G.6. Atmospheric observation

One of the Hungary's most important observation sites for atmospheric constituents is the Hegyhátsál greenhouse gas monitoring station,⁷³ which is operated by the **Institute for Nuclear Physics** with scientific contributions from **ELTE** and the **Institute of Earth Physics and Space Science**. Established in 1993 by the Hungarian Meteorological Service, it was among the first European tall-tower stations to take up continuous observation of greenhouse gas concentrations from different levels of its tower (at heights of 10 m, 48 m, 82 m, 115 m) and has produced an invaluable time-series of measurement data since then. At Hegyhátsál monitoring of surface-atmosphere exchange of carbon dioxide was started in 1997 using the eddy covariance technique. Most recently the infrastructure was extended to enable monitoring of nitrous oxide emission of the surrounding agricultural region. The operation of the Hegyhátsál station was taken over from the Hungarian Meteorological Service by the **Institute for Nuclear Research** in 2020. The monitoring site provides data for the World Meteorological Organisation Global Atmosphere Watch Programme (WMO GAW), and it is the member of the pan-European Integrated Carbon Observation System (ICOS).⁷⁴ It also contributes to the Global Greenhouse Gas Reference Network maintained by the National Oceanic and Atmospheric Administration of the United States of America.

Apart from observation activities at Hegyhátsál, HungaroMet was granted funding from the National Office for Research and Technology to establish a dedicated network of measuring stations for very precise tracking of the effects of global climate change on Hungary. These

⁷² <http://nimbus.elte.hu/FORESEE>

⁷³ <http://nimbus.elte.hu/hhs/>

⁷⁴ <https://icos.atomki.hu/>

stations were being set up between 2006 and 2009 and are designed to be precise enough to make long-term coherent climate change observation possible.

In the field of satellite observation, it has been an important step for Hungary to become a full member of **EUMETSAT**, the **European Organisation for the Exploitation of Meteorological Satellites**, in October 2008. EUMETSAT has been monitoring the weather and climate from space since the late 70s and thus provides dedicated climate information to United Nations' Intergovernmental Panel on Climate Change and other global initiatives.

III.G.7. Terrestrial observation and carbon balance

Hungarian institutions have participated in several international research efforts on terrestrial carbon balance (and greenhouse gas balance in general) in last decades.

ELTE and HungaroMet jointly participated in the AEROCARB (2000-2002) and CHIOTTO (2002-2005) FP5 projects. The aim of the projects was to develop the existing infrastructure at the Hegyhátsál tall tower site, and to establish airborne measurements.

The **Department of Meteorology of ELTE** as well as **Szent István University of Gödöllő** were partners in the “CarboEurope-IP”⁷⁵ project which ran from 2004 until 2008. CarboEurope-IP was a huge European project with almost 100 partners that worked together on an Assessment of the European Terrestrial Carbon Balance. Goals of the project were to advance the understanding of the role of the European continent in the global carbon cycle and to significantly enhance the understanding of and the methodologies for the observation, quantification and prediction of the terrestrial carbon cycle of Europe. Key research products of CarboEurope-IP included improved quantitative estimates of the European carbon balance and new technologies to help reduce the associated uncertainties.

HungaroMet and ELTE were also involved in the European project called “Carbon-Pro” (Carbon balance drafting and new resources management tools according to Kyoto Protocol) in 2006/2007. Its overall objective was to assess the characteristics of the main agricultural and forest systems in the CADSES area (Central Adriatic, Danubian and South-eastern European Space) in relationship to the strategies set up by the Kyoto Protocol for agricultural and forest systems and to evaluate their sink capacity.

Later, HungaroMet and ELTE participated in IMECC EU FP6⁷⁶ (2007-2011) and InGOS EU FP7⁷⁷ (2011-2015) projects. Both projects focus on the monitoring of non-CO2 greenhouse gases less studied formerly (e.g. methane, nitrous oxide, sulphur hexafluoride, etc.). Between 2017.2020, HungaroMet participated in the EU HORIZON2020 project, called RINGO (Readiness of ICOS for necessities of integrated global observations RINGO). It aimed at investigation and preparation of the Hungarian stations for decision to join the ICOS network.

As subcontractor ELTE and HungaroMet participated in the GHG-Europe project (run from 2010 to 2013) which was the continuation of the CarboEurope-IP projects and focused on the overall greenhouse gas budget of Europe.

⁷⁵ <http://www.carboeurope.org/>

⁷⁶ <http://imecc.ipsl.jussieu.fr/index.html>

⁷⁷ <http://www.ingos-infrastructure.eu/>

Through HungaroMet and the **University of Pannonia**, Hungary participated in COST Action 725 on Establishing a European Phenological Data Platform for Climatological Applications. The main objective of the project was to establish a European reference data set of phenological observations to be used for climatological purposes, especially climate monitoring and detection of changes.

The **NEESPI Regional Focus Research Centre at the University of Sopron** (formerly: University of West Hungary) is likely to also contribute to terrestrial observation activities in Hungary in the future as the NEESPI initiative is focusing on the ability to measure, monitor and model processes that will provide accurate future projections of climatic and environmental changes in the Northern Eurasian region.

Climate change related research activities of University of Sopron are the following:

- Remote-sensing based forest health monitoring system (duration: 2019-),
- Importance of tree plantations in mitigating the harmful effects of climate change (duration: 2022-2025),
- Increasing the importance of forestry and wood sector in climate change mitigation (duration: 2022-2025),
- Design and construction of forest structure conversion for climate protection, demonstration and learning areas (2023-),
- Investigation of the interactions between climate change and biological invasions with forest conservation relevance (2023-),
- Assessment and development of urban green infrastructure from a climate change perspective (2023-),
- Integrated Forest Fire Action Plan for Climate Protection (2023-),
- Establishment of management to ensure the carbon sequestration capacity of lowland forests under drying environmental conditions (2023), Remote sensing assessment of carbon storage in forest stands and soils (SOIL-SENSE) (2023-) Phase III.

The **National Adaptation Centre** (NAC, operator of the National Adaptation Geo-information System, NAGiS) has been integrated into HungaroMet Hungarian Meteorological Service, functions as a **governmental background institution of the Hungarian Ministry of Energy**, in the field of climate change adaptation. Its main tasks include the **operation and further development of NAGiS, adaptation related strategic planning**, monitoring and evaluation, as well as conducting researches in the field of climate adaptation and vulnerability. NAC actively takes part in international and domestic research projects related adaptation; international cooperation aimed at climate adaptation experience- and knowledge sharing. It is a member of the **European Environment Information and Observation Network (EIONET)**, a partnership network of the European Environment Agency (EEA) and its 38 member and cooperating countries. NAC regularly participates in webinars and meetings, and takes part in consultations regarding EEA briefings and reports. As the representative of Hungary and its Ministry of Energy, the National Adaptation Centre of HungaroMet has taken part since 2015 in the **Interest Group on Climate Change Adaptation of the EPA Network** originally established for facilitating the implementation of the first EU Adaptation Strategy in the field of adaptation-related strategic planning and MRE activities. The group organises meetings in every sixth months, every time in another member state. Topics discussed include maladaptation, flood protection measures, MRE issues, current international and EU policy

developments etc. Within the EPA IG CCA, a sub-working group was established in 2024 on adaptation monitoring, evaluation, reporting and learning (EPA IG CCA MERL) which NAC is also participating in. These international platforms enable exchange of information on adaptation-oriented strategic planning, national best practices and nature-based adaptation solutions with partner countries. In 2025, HungaroMet will host the joint EPA-EIONET meeting in Budapest.

The **Hungarian Academy of Sciences (MTA)** besides its role in coordinating and initiating research activities, it also carries out research through its own institutes as well as through joint research groups attached to Hungarian universities and other scientific institutions. One of its institutions is the **Centre for Ecological Research**, primarily dedicated to ecological research, but many of their studies are related to the impact of agriculture and forestry on biodiversity, traditional ecological knowledge or interdisciplinary topics. The Centre is involved in EU and global policy development, conducting **high-quality research on biodiversity and ecosystems, including aquatic and terrestrial life**. Three Institutes are integrated into the Centre: the Institute of Aquatic Ecology, the Institute of Ecology and Botany and the Institute of Evolution.

- The **Institute of Aquatic Ecology** is the largest scientific centre in Hungary which considers its mission to be the outstanding **regional engagement in the field of aquatic ecology and its co-studies**, and to establish and represent international research trends in Hungary. The Institute's primary mission is to **conduct basic research, with a special focus on integrative, systems ecology approaches to climate change, invasions and anthropogenic impacts on water**, thus contributing to the maintenance and improvement of the ecological status of our domestic waters.
- The **Institute of Ecology and Botany** seeks to propose **scientific solutions to the environmental challenges of our time**, such as **land-use change, habitat degradation, climate change, urbanisation, the effects of intensive agriculture, invasions, and the emergence of new diseases**. The Institute's nearly 80 researchers, organised in research groups, work on a wide range of organism groups and habitats, using a variety of methodological approaches. In addition to its basic research activities, the institute carries out a number of **public monitoring and applied research activities**.
- The **Institute of Evolution is the largest theoretical evolutionary biology scientific centre in Hungary**, with research interests spanning all levels of biological organisation. It investigates the origin of life, transitions in evolution involving large increases in complexity (including the origin of human language and cooperation), evolutionary aspects of neural networks, the relationship between learning and evolution, and evolutionary-ecological processes, with a particular focus on the dynamics of emerging infectious diseases under the impact of climate change.

The **Hungarian Research Network (HUN-REN)** founded in 2019 is an **independent research network** acting as a central pillar of the country's scientific domain. Its governing body is responsible for the maintenance, management and operation of research institutes and research centres formerly part of MTA. HUN-REN comprises 11 research centres, 8 research institutes and 116 funded research teams carrying out basic and applied research in all fields of science, including mathematics and natural sciences, humanities and life sciences. Among

these, it is worth mentioning the **Institute for Regional Studies** of the Centre for Economic and Regional Studies (CERS), the base institute of Hungarian regional science, which carries out climate vulnerability assessments and research related to climate policy.

III.G.8. Funding and projects

Hungary is not only committed towards adaptation measures on the national, but also on the international level. **Several projects launched in recent years aim at facilitating more efficient adaptation on cross-border, as well as multiple governance levels.** These are mainly financed by the European Union in the framework of HORIZON, INTERREG and LIFE programmes.

The Environmental and Energy Efficiency Operational Programme Plus (hereinafter referred to as KEHOP Plusz) offers support for eliminating problems deriving from the impacts of climate change – for example floods and waterlogging, droughts, overusage of our resources.

The five priorities of KEHOP Plusz are the following:

1. Water management and disaster risk reduction
2. Circular economies and sustainability
3. Environment and nature conservation
4. Renewable energy economy
5. Just Transition Fund

The European Territorial Cooperation (ETC), as one of the objectives of the cohesion policy, provides the framework for the implementation of joint actions and the exchange of policy experiences among the Member States, at national, regional and local levels. Concerning the involvement of Hungary, seven cross-border, two transnational and four interregional programmes are being elaborated for the programming period.

Between 2021 and 2027, Hungary participates in the **Interreg Central Europe Programme** (involving 9 countries) and in the extended Danube Transnational Programme that includes 14 partner countries. Furthermore, Hungary takes part in all of the **four interregional cooperation programmes**: *URBACT* (supporting cooperation of cities); *ESPON* (examining territorial facts and processes and supporting regional policies' decision making); **Interreg Europe** (supporting interregional knowledge exchange and experience sharing) and *INTERACT* (helping the work of joint secretary of the Interreg programmes' managing authorities). Of the four macro-regional strategies of the EU, we are involved in the implementation of the EU Strategy for the Danube Region (EUSDR).

The LIFE Programme⁷⁸ has supported about 6000 successful projects since 1992 in order to implement environmental goals set out by the Member States in active cooperation of the public and private sectors. The LIFE is the only dedicated EU source for nature-, environment- and climate protection. From 2021, LIFE supports projects related to *clean energy transition*, too.

⁷⁸ L'Instrument Financier pour l'Environnement

The whole budget of the LIFE Programme for the 2021-2027 period is 5.4 billion €. Its climate policy subprogramme supports 3 main fields: mitigation; adaptation and climate governance and information actions.

RESTORIVER

The INTERREG project named **RESTORIVER** (funded by the Danube Region Programme, co-funded by the EU) is a 2-year project started in January 2024. It aims to restore river banks and riparian areas through natural water retention measures along the Danube and its tributaries that have been adversely affected by human activities,. The project **brings together water management, climate and nature conservation policy and knowledge institutions along the Danube** and its tributaries to explore the multiple climatic, social, economic and ecological benefits of natural water retention measures (NWRM). They identify and design high-impact interventions and **implement pilot actions** to test them. The project involves multiple Hungarian partners (e.g. WWF World Wide Fund for Nature Hungary, Érd Municipality, and the General Directorate of Water Management). One of the pilots is being implemented in the area of Érd.

LIFE-MICACC

From LIFE programme funds several projects were implemented/are being implemented currently in Hungary during the recent years. One of them, the LIFE MICACC project's overall goal was to **improve climate resilience of vulnerable municipalities in Hungary** by reducing their risks stemming from climate change. For this purpose, it tested, introduced and fostered the integration of sustainable ecosystem-based water management approaches into natural resources management strategies and land use planning practice of local governments. Additionally, it intended to strengthen the coordination role of local municipalities in climate change adaptation planning and recognition of risks. **The project concentrated on 5 model solutions in 5 pilot areas, implementing Natural Water Retention Measures (NWRM) in the intervention areas selected in the five partner municipalities.** The project had an important added value because NWRM solutions are little known and are less widespread in Hungary, despite the fact that their application has many benefits for municipalities.

Within the framework of the project **training and e-learning materials were also elaborated and training sessions were held** to introduce the negative effects of climate change (at the municipal and river basin level) and the basic principles and possible ways of adaptation, through presentations and different exercises for the different municipalities' participants. The project has also developed an **app that aims to provide community-based information on NWRMs** and provide an opportunity for stakeholders to learn and share good practices. The mobile app is mainly designed for municipal staff, but it can also be useful for water management professionals, environmental experts and farmers, as well as for laymen, as it brings together all relevant information on natural water retention in one place in an easy-to-understand way.

LIFE LOGOS 4 WATERS

The LIFE LOGOS 4 WATERS (*Integrated application of innovative water management methods at river basin by coordination of local governments*) **project is the successor of LIFE-MICACC**, which runs from 2021 to 2025. Its overall **goal is to strengthen the capacity of local authorities to adapt to climate change and to mobilize and use related funding**. LOGOS tries to encourage the dissemination of more domestic and foreign NWRM good practices in cooperation with local governments. This is achieved by mitigating the negative water-balance situation through the **demonstration of integrated ecosystem-based water management solutions applied at river catchment level**. An additional goal of the project is to encourage the dissemination of several domestic and foreign, local and water catchment level Natural Water Retention Measures (NWRMs) good practice by sharing the results, in the coordination of local municipalities. **Two pilot sites** – where **complex, catchment-level integrated solutions based on natural water retention are being implemented** –are included in the project: one in a **hilly catchment area** including settlements threatened by flash floods (Püspökszilágy and its surroundings: the catchment areas of the Gombás and Szilágyi streams) covering 9 affected settlements. The other pilot site is in a **lowland** area struggling with the dual problem of water surplus and water scarce periods along the river Danube (Bátya and surroundings) covering 5 affected settlements. The project contributes greatly to a more efficient subnational adaptation by creating an **Integrated Municipal Decision Support Platform on which the relevant water management and climate change adaptation (CCA) expertise and tools are available to local governments** in a structured form. In the framework of the project, **methodology guidelines and manuals were developed** as well, to facilitate the adaptation actions of local governments. Besides supporting materials, **the project provided financial support to 15 local governments in the form of a municipal small grant programme**. Professional support was also provided for local governments to increase the adaptation and absorption capacity of local governments. A **national awareness-raising activity** on local/municipal/catchment adaptation options, focused on NWRMs is also carried out.

LIFE IP North-HU-Trans

In connection with climate adaptation, the Hungarian Ministry responsible for climate policy (Ministry of Energy) is implementing the 9-year-long LIFE-IP North-HU-Trans project with 22 consortium partners. The project started in September 2020 and is expected to end in October 2029. The project targets the Northern Hungary region where Mátra Power Plant (MPP), the second largest power plant in the Hungarian electricity production system is located. The project, to catalyse the full implementation of the National Energy and Climate Plan of Hungary and the reduction of the GHG emissions of the Hungarian electricity production system by nearly 50% (equal to the 14% share of total CO₂ emission), will contribute to the decarbonisation of the MPP by 2030. **The project aims to mitigate the potential negative socio-economic, energy and environmental consequences of the lignite phase-out, specifically in northern Hungary**. An important result since the start of the project has been the **establishment of the Coal Commission**, whose mission is to provide platform for multi-stakeholder consultation in order to support the sustainable and just transition of the North Hungarian region and involve all stakeholders and ensure their participation in the transition

process. A **mentoring programme** has also been launched for the local employers in order to ensure the adequate employment even after coal transition together with **awareness raising actions** to emphasize the importance of coal transition. Other important elements are the preparatory actions, the results of which are various studies describing the current situation (e.g. state of the environment) and problems.

LIFE-CLIMCOOP

The LIFE-CLIMCOOP project started in 2020 and ended in November 2024. The overall goal of the project was to develop, test and demonstrate collective actions **between a municipal government and a multinational industrial company** to reduce local climate risks and enhance joint climate change adaptation for vulnerable urban and industrial areas in the selected region, in Hungary and in Eastern-Central Europe. The project provided several innovative and nature-based solutions to this end, by defining actions and tasks in close cooperation between cities and industrial actors. **The city of Kazincbarcika** and the CEE region's largest chemical company, **the Wanhua BorsodChem Inc.** joined the **University of Miskolc and other professional organizations** (such as the HungaroMet National Adaptation Centre; the KÖVET Association for Sustainable Economies; GeoGold Kárpátia Ltd.) to encourage climate adaptation in the region. One of the most important output of the project is a **joint city-company vulnerability study and a joint city-company Climate Adaptation Strategy** which, based on the most relevant climate effects (e.g. extreme storms, extreme precipitation; heatwaves) appearing in the region and identified by the above mentioned vulnerability study. The Strategy's objective and measure system support small-scale, nature-based climate adaptation interventions (e.g. log dams, green roofs, residential water collection, tree inventory, etc.). To better adapt to climate change impacts (especially water scarcity and increasing temperature), BorsodChem developed a water treatment prototype with a capacity of 1 m³/hour for treating grey water from different sources (industrial water, urban rainwater and in the longer term, urban treated wastewater). Treated water has the potential for wide-scale use e.g. as cooling water or for irrigation of urban green areas. A **climate platform** – functioning as a local coordination forum – was set up to ensure proper monitoring and implementation of the Strategy's measures. The municipality-company partnership experiences of the LIFE-CLIMCOOP cooperation are planned to be reproduced in other geographical locations. Some of the project results include the elaboration of a **Methodological Guide for local governments and private companies to help create joint municipality-company climate change adaptation strategies in other partnerships**. The Guide offers step-by-step introduction of planning-methodological tools and examples based on the experience of the joint Climate Adaptation Strategy developed for Kazincbarcika and BorsodChem Inc. As an annex to the methodological guide, an **e-collection of good climate adaptation practices** by different topics (e.g. periods of extreme rainfall and water scarcity; storm damage to buildings, climate awareness) was also prepared, which is publicly available. In the framework of the project, results were disseminated via **interactive workshops** focusing on climate adaptation of municipalities and companies. Besides, an **online course was prepared for municipalities** on the effects of climate change and adaptation options, aiming at facilitating subnational adaptation.

LIFE in Runoff

Led by the Hegyvidék Municipality (Budapest's District XII), in cooperation with Erzsébetváros (District VII), Pestszentlőrinc-Pestszentimre (District XVIII), the Municipality of Budapest and several other professional partners, the main objective of the LIFE in Runoff project (2021-2025) is to **support urban climate adaptation in the field of rainfall management by finding and strengthening synergies between green, blue and grey infrastructures**. By combining a nature-based approach with technological solutions, the harmful effects of sudden rainfall can be effectively reduced. Vulnerability assessments will be used to identify intervention points in the three Budapest partner districts, followed by **demonstration elements to showcase urban stormwater management options**. **The project also aims to present tools for municipalities** in line with the EU's climate adaptation strategy **that can be used by other, and to create a relevant knowledge useful for the profession – including collecting best practices of urban stormwater retention and management**. In the framework of the project, a **national awareness raising campaign** is ongoing, focusing on topics like green roofs and stormwater retention in urban environment.

Climate change related, and geological vulnerability assessment of the Hungarian critical infrastructure networks project

The project took place between 2020 and 2023 and aimed at the climatological and geological vulnerability assessment of Hungarian energy infrastructure networks (electricity, gas, and district heating systems). It analysed the **climatic and geological vulnerability of the Hungarian energy supply** and integrated the results into the NAGiS system. Challenges of changing energy demands were identified, as well as their impact on electricity, gas, and district heating suppliers; climatic and geological vulnerability of infrastructure elements were assessed and the climate vulnerability of solar energy production was examined. Furthermore, **it provided sector-specific recommendations, to facilitate sectoral planning and decision making** along with construction and operation of a climate-friendly energy infrastructure, facilitating better preparation for future climate impacts. In the framework of the project, **studies evaluated and calculated the energy infrastructure network related climate impacts**, contributing to a better prepared sectoral planning. Main vulnerability results of the project are easily accessible by the 233 newly **integrated map layers in the NAGiS system**.

HORIZON AdaptationHubs

The HORIZON AdaptationHubs project launching in 2025 will greatly contribute to information and experience sharing in EU countries by establishing **National Multilevel Governance Adaptation Hubs (NAHs)**. These will not only support more efficient and better-integrated EU-level, national and subnational adaptation efforts, but also facilitate the overall implementation of the EU Adaptation Strategy, the European Green Deal, the Mission on Adaptation to Climate Change, the European Climate Law, and the future EU Climate Action Plan. From the Hungarian side, the HungaroMet National Adaptation Centre participates in the project and is responsible for setting up the Hungarian hub. Apart from these national adaptation networks in each EU member state, a robust **grouping and twinning scheme** will further

promote national, cross-border and EU-wide exchanges and cooperation in the field of adaptation. Apart from EU sources, an important source of R&D&I funds in Hungary is the **National Research, Development and Innovation Fund**, managed by the **National Research, Development and Innovation Office (NKFIH)**. To further strengthen innovation results, besides the NKFIH as a funding office, the National Innovation Agency (NIÜ) was established. The Agency aims to strengthen Hungary's innovation capacity by providing support for the changing needs of the innovation ecosystem, connecting its actors and spreading innovation culture and behaviour.

INTERREG Danube-ADAPT

With the leading partner of HungaroMet, this project (2025-2027) aims at building an evidence-based, territorially integrated **policy support system for climate change forecasting and vulnerability assessment in the Danube Region**. 15 partners and 7 associated partners from 8 countries of the Danube macro-region work together to tackle climate challenges in a harmonised way, building on international good practices and vulnerability assessment based approach following NAGiS's example. It will:

- identify main risk areas determining climate vulnerability, with emphasis on macro-regional and cross-border environmental, socioeconomic factors;
- develop climate impact chains and sample vulnerability assessment to put these into practice;
- facilitate integration of these practices into strategic planning.

Planned project results include for example a climate adaptation metadatabase, a map collection publication, a good practice collection, an e-guide for the strategic planning use of the vulnerability assessment and climatological database and e-learning materials for using the database and the indicator catalogue.

DIMOP_PLUSZ-2.3.1-23-2023-0000 project

This project named *Development of an Environmental Monitoring System Using Installed Data Collection Systems, Climate Protection Data Repository, and Related Service Environment* running from 2024 until 2026, aims to create a **public portal for easy access to meteorological and climatological data, supporting climate change adaptation**. It will expand HungaroMet's measurement network, develop databases, and implement IT systems for data quality and storage. The project also includes processing non-accredited data, developing filtering algorithms, and digitizing historical records. The online platform will enable BIG DATA-based climate and weather forecasting. Overall, it will help Hungary monitor, analyze, and mitigate the effects of climate change.

Copernicus Climate Change Service (C3S)

HungaroMet participated in this project between 2017-2020, based on Surface in-situ Observations, where different climate databases over Europe were compared and analysed. The

C3S service is operated by ECMWF and provides climate information and essential climate variables all over Europe, based on global and regional reanalyses (covering a comprehensive Earth system domain: atmosphere, ocean, land, carbon), products based on observations alone (gridded, homogenised station series, reprocessed climate data records). **Hungary is a Cooperating Member State of ECMWF since 1994, and HungaroMet represents the country in the organization.** HungaroMet also is a member of **EUMETNET Climate Programme**, which coordinates the climate data and services of the national meteorological services in Europe.

National Multidisciplinary Laboratory for Climate Change

National Laboratories Programme was created by the National Research, Development and Innovation Office. 25 National Laboratories have been set up across the country in four major focus areas (Healthy Living; Safety and Security; Digital Transformation of Economy and Society; and Green Transition), and more are in the pipeline. One of these laboratories is the **National Multidisciplinary Laboratory for Climate Change**, which was established to analyze the effects of climate change in Hungary. It is being implemented under the leadership of the University of Pannonia. Partners working together in the Laboratory besides HungaroMet are universities (Eötvös Loránd University, University of Miskolc, Semmelweis University) and research institutions (Balaton Limnological Research Institute, Institute of Aquatic Ecology of the Centre for Ecological Research). The project follows a multidisciplinary approach under unified professional coordination. In addition to studying the **characteristics of climate change and its impacts on human health, natural and economic systems, and society**, the National Laboratory also conducts **research and development in the fields of technological, economic, and social adaptation.**

Supporting nature-based solutions (Nbs) in Hungary

With regards to nature-based solutions, the project "Supporting Green and Blue Municipal Infrastructure" was implemented in 2021-2022 with the financial support of the European Union's Structural Reform Support Programme, later known as the Technical Support Instrument (SRSP/TSI). During the project, the OECD worked with the Ministry of Innovation and Technology (with its KEHOP+ Managing Authority) to identify the main barriers to the use of nature-based solutions (NbS) at local level and to propose reforms to overcome these barriers based on international best practices. The project also aimed to support national authorities in developing policies and strategies to increase their capacity for implementation.

Another related project is "***Applying nature-based solutions to improve the climate resilience of local governments***" (NBS4LIFE), coordinated by the Ministry of Public Administration and Territorial Development of Hungary (initially the Ministry of Interior) and incorporating project partners from five other EU Member States. It has been running since 2023 with the support of **Interreg Europe**. It aims to identify local specificities and objectives for the proper preparation of projects using nature-based solutions, to improve the policy level planning and funding requirements for effective support of NbS projects, and to improve the policy environment for the implementation of NbS projects.

Priority axis 2 of **EEOP Plus/KEHOP Plusz** include the target area of “**Investments in green and blue infrastructure in municipalities, nature-based solutions**”. **Spatial and Urban Development Operational Programme Plus (TOP Plusz)** is also relevant in terms of supporting nature based solutions and municipal green and blue infrastructure.

In addition, the Hungarian Network of Nature-based Solutions (TeamHUB) was established in 2022. Team HUB is a professional community of organisations and individuals committed to the widespread dissemination of nature-based solutions in Hungary.⁷⁹

Adaptation on the subnational level

In Hungary, there are no legal requirements at subnational level for having a climate change strategy, but all counties and an increasing number of municipalities have prepared their climate change strategy during the recent years from Energy Efficiency and Environment OP sources. As a result, **132 municipalities developed their own local strategies**. A disadvantage is that without legal requirements and proper financial sources, the settlements will not be encouraged to implement and regularly revise/renew their strategy. In connection with the county climate strategy planning activities, the so called „**county climate platforms**” have been set up. **These platforms have a broad membership (from the administration, through civil society, and NGOs to business organizations etc.) and their main aim is to facilitate the implementation of local climate actions. Climate change awareness at the subnational level is also increasing, mainly facilitated by awareness raising campaigns/initiatives of EU-funded projects.** Besides, via the Territorial and Settlement Development Operational Programme many municipalities had the opportunity to elaborate their own Sustainable Energy and Climate Action Plan and as part of the process become members of the **Covenant of Mayors for Climate and Energy**. **The Covenant has 357 signatories (not only municipalities) from Hungary** based on the website.

It is important to mention the Hungarian association of local authorities called **Alliance of Climate-Friendly Municipalities**, which has now more than 88 members. It aims at:

- increasing climate awareness by sharing professional experience;
- facilitating and helping local and municipal authorities adapt to climate change;
- supporting climate change initiatives (Covenant of Mayors on Climate and Energy);
- unfolding municipal climate strategies (as well as SECAPs);
- providing methodological and tendering advice;
- implementing public campaigns with an environmental and climate protection focus.

⁷⁹ <https://networknature.eu/team-hub-term%C3%A9szet-alap%C3%BA-megold%C3%A1sok-magyarorsz%C3%A1gi-h%C3%A1ll%C3%B3zata>

IV. Information on financial, technology development and transfer and capacity building support provided and mobilized under Articles 9–11 of the Paris Agreement

IV.A. National circumstances and institutional arrangements

Hungary is committed to contribute to the green transition of developing countries. Besides contributing to the Green Climate Fund, bilateral climate finance is also of very high importance. Knowledge transfer and technology export in the field of adaptive water management technologies and related sustainable agricultural practices is a priority in our support to developing countries. The Hungarian Government has bilaterally supported the implementation of several projects in developing countries in the form of non-reimbursable grants. In addition, the Hungarian Export-Import Bank has concluded tied aid loan agreements with a number of developing countries (e.g. Indonesia, Uganda, Kenya, Sri Lanka, Laos, Vietnam) in recent years. These loans are characterised by below-market interest rates and non-reimbursable elements. In total, Hungary provided EUR 17.5 million in climate finance to developing countries in 2021, EUR 8.2 million in 2022, and EUR 8.67 million in 2023.

In Hungary, financial support to developing countries are mainly provided by the Ministry of Foreign Affairs and Trade, for example, its Department for Hungary Helps Programmes and Department of Water Diplomacy. Tracking progress and reporting on climate finance are carried out by the Climate Policy Department of the Ministry of Energy. Furthermore, the Western Balkans Green Centre (and its successor institutions) that has been a background institution of the Ministry of Energy, contributed to the green transition of the Western Balkans region (six eligible countries: Serbia, Montenegro, Bosnia and Herzegovina, North Macedonia, Albania, Kosovo).

The Government Decision of 1770/2018 on Hungary's participation in international climate finance outlines the scope, channels, and major partner institutions for the country's international climate finance activities. The decision also opted for providing financial means for the years 2019-2023: HUF 3.6 billion for climate finance projects via the Western Balkans Green Center. Hungary has built and maintains a strategic partnership with the Global Green Growth Institute (GGGI) as well. Through the GGGI, Hungary funded and implemented international projects, including the Western Balkans Green Fund Project, aiming at establishing a regional climate finance tool to support the implementation of the Nationally Determined Contributions of the Western Balkan countries.

Hungary reports annually on financial and technological support provided to developing countries under the EU's Governance Regulation (REGULATION (EU) 2018/1999). Hungary communicates on the climate finance amounts provided and mobilized in previous years in its reports.

IV.B. Underlying assumptions, definitions and methodologies

- Projects disbursed in the calendar years 2021 and 2022 have been included.
- Conversion between Hungarian Forints (HUF) and United States dollars (USD): annual average exchange rate published by the Hungarian Central Bank were used (2021: 1 USD=303.29 HUF; 2022: 1 USD=373.12 HUF).
- Only ‘disbursed’ projects have been reported.
- Projects were classified as Official Development Assistance (ODA) and Other Official Flows (OOF), based on the OECD DAC methodology.
- Benefitting developing countries and multilateral organisations were identified as ODA-recipients based on the OECD DAC list of ODA eligible recipients.
- Description of the type of support (adaptation, mitigation, cross-cutting) was based on project description.
- The relevance of a given project for capacity building or technology transfer was assessed on the basis of data reported to the European Commission (under the Energy Union Governance Regulation)

IV.C. Information on financial support provided and mobilized under Article 9 of the Paris Agreement

Between 2020 and 2023, Hungary focused its climate finance efforts to the **Western Balkans** region (six eligible countries: Serbia, Montenegro, Bosnia and Herzegovina, North Macedonia, Albania, Kosovo). The Western Balkans Green Centre provided funding opportunities and non-reimbursable support for the preparation and implementation of climate change activities in the six target countries to Hungarian-based businesses, science and education centres and other economic operators. In 2020 and 2021, the Centre has launched a total of 4 calls for proposals, each with a budget of HUF 400 million, to which there has been exceptional interest. Beneficiaries prepared climate protection and green economy infrastructure investments and implemented capacity building programmes to improve local public services. In all cases, the projects were endorsed by a local or central authority or partner. The support schemes launched and operated between 2020 and 2023 have delivered 47 investment preparation and capacity building projects, preparing investments of around HUF 80-100 billion. Supported sectors included water management (e.g. flash flood management, water quality improvement), renewable energy (e.g. solar energy, geothermal waste heat recovery, sustainable district heating), energy efficiency, wastewater treatment, waste management, remediation, awareness raising, smart cities. Several projects have involved carrying out various assessments, strategy development, planning and modelling tasks, research activities and project documentation (feasibility studies, cost-benefit analyses, study designs).

Other regions, especially **Southeast Asia and Africa** have also played a significant role in Hungary’s support activities (examples for recipient countries: Lao People’s Democratic Republic, Sri Lanka, Vietnam, Indonesia, Cabo Verde).

Based on data published by the European Commission, Hungary provided **17.5 million EUR** as climate finance to developing countries **in 2021**. Out of this amount, 9.96 million EUR was provided for mitigation, 7.08 million EUR for adaptation, and 0.515 million EUR for cross-

cutting actions. **In 2022**, Hungary committed and provided more than **8.2 million EUR** (8 227 805 EUR) to developing countries. **Knowledge transfer and technology export in the field of adaptive water management technologies and related sustainable agricultural practices** is a priority in our support to developing countries (for example, by creating and maintaining local water purification, water management and irrigation development systems). EUR 1.7 million-1.7 million was provided for both climate mitigation and adaptation, and more than 4.8 million EUR for cross-cutting support. **In 2023**, also based on the data published by the European Commission, Hungary spent a total of **EUR 8.67 million on international climate finance**, of which the largest amounts went for adaptation (EUR 5.64 million) and cross-cutting measures (EUR 3.03 million).

Besides bilateral climate finance, Hungary supports developing countries also through the **Green Climate Fund**. In 2015, Hungary contributed by 1 billion HUF to the initial resource mobilization of the Fund. In the first replenishment period, Hungary contributed a further 200 million HUF for the 2020-2023 operation of the Fund. In 2023, Hungary announced the provision of a 100 million HUF contribution for the second replenishment of the Fund.

Furthermore, the Hungarian Government has continuously supported the work of the IPCC through **voluntary financial contributions to the IPCC Trust Fund** since 2017. In 2023, our contribution amounted to 20 million HUF, while in 2024 it was 25 million HUF (in 2021: 10 million HUF).

CTF Tables of Annex III include the detailed list of Hungary's support measures in 2021 and 2022.

IV.D. Information on support for technology development and transfer provided under Article 10 of the Paris Agreement

Knowledge transfer and technology export in the field of adaptive water management technologies and related sustainable agricultural practices is a priority in our support to developing countries. Hungary financially supported several developing countries, including Sri Lanka, Vietnam, Indonesia, Cabo Verde and Lao People's Democratic Republic by creating and maintaining local water purification, water management and irrigation development systems.

IV.E. Information on capacity-building support provided under Article 11 of the Paris Agreement

Projects addressing fully or partly capacity-building include for example: eco-conscious training, establishing an agricultural model farm, establishment of a Hungarian model agricultural knowledge transfer centre, installing water purification systems etc.

V. Annexes

V.A. Annex I: Common reporting tables for electronic reporting of information in national inventory reports of anthropogenic emissions by sources and removals of greenhouse gases by sinks (CRFs)

National inventory document (NID) of anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs) and the Common Reporting Format Tables (CRF tables) have been reported by Hungary to the UNFCCC Secretariat and are available at: <https://unfccc.int/ghg-inventories-annex-i-parties/2024> and <https://unfccc.int/first-biennial-transparency-reports>.

V.B. Annex II: Common tabular formats on information necessary to track progress (CTF Tables)

See the attached CTF tables.

V.C. Annex III: Common table formats for electronic reporting of information on financial, technology development, transfer and capacity-building support provided and mobilised, as well as support needed and received, under Articles 9-11 of the Paris Agreement (CTF Tables)

See the attached CTF tables.