Eight National Communication and Fifth Biennial Report of Hungary

1. EXECUTIVE SUMMARY

Basic characteristics of the country

Hungary is in Central Europe; the neighbouring countries are Austria, Croatia, Romania, Serbia, Slovakia, Slovenia and Ukraine. Geographically Hungary is mostly flat terrain, with hills and low mountains. Danube and Tisza are the two main rivers of the country; the largest lake is Lake Balaton. The capital city of Hungary is Budapest, with approximately 1.7 million inhabitants. Other major cities are Debrecen, Miskolc, Pécs, Szeged andGyőr with around 100-200 thousand inhabitants. Hungarian is the official language. The area of the country is 93,033 km2, of which 57, 4% is an agricultural area (46, 5% arable land, 2,5% garden, orchard, and vineyard, 8,4% grassland), 20.9% forest, 0.9% reed and fishpond, and 20,7% is uncultivated land area. According to the latest census, concluded in 2022[1], the population decreased further to 9.6 million with a life expectancy of 72.6 years for males, and 79.1 years for females. According to the latest census, the density of the population was 103.2 inhabitants/km^2. The climate is characterised as temperate, with cold, humid winters and warm summers. The average annual temperature is between 10 and 11 °C (50-52 °F).

Hungary is administratively subdivided into 20 regions, which are the 19 counties and the capital city of Budapest (independent of any county government). There are 3,155 municipalities in Hungary which are responsible for the provision of most local services, including the operation of schools, kindergartens, welfare and healthcare facilities, some office buildings and museums. Of the 3,155 municipalities, 25 are major metropolitan areas and over 2,800 are villages. Outside Budapest, the largest municipality in Hungary is Debrecen, with a population of 200,000 inhabitants.

Hungary is a long-standing parliamentary democracy, one of the leaders of political and economic transition in the region. Hungary became a member state of the European Union in 2004 and is pursuing economic stability and prosperity.

Hungary is a market economy; it has a highly internationalised and export-oriented business sector and a stable macroeconomic situation. The global economic crisis hit hard the Hungarian economy in 2009 but the recovery started soon, and the economy is now on a path of sustainable growth. Hungary’s macroeconomic situation is stable, and the economy has been on a sound path: the government debt has declined, the inflation ismoderate, and the country has shown a positive balance of trade since 2009.

Hungary’s GDP per capita in Purchasing Power Standards (PPS) was more than 74.6% of the EU-27 average in 2021. The private sector accounts for more than 80% of the GDP. Foreign ownership and investment in Hungarian firms are widespread, with foreign direct investment stock totalling more than €92 billion in 2021.

The employment rate is constantly rising; it was 80.2 % in 2022 Q2 regarding the population aged 20-64, well above the EU average of around 75%. The trend is in line with the headline

[1] The detailed result of the 2022 census are available here: https://nepszamlalas2022.ksh.hu/en/

objective of 78 % of the European Union, according to which the employment rate in the EU member states should reach 78 percent by 2030.

Hungary intends to further improve the country's labour market performance which requires to increasing the level of employment andimproving the productivity of the workforce and the conditions of employment. According to the European Pillar of Social Rights Action Plan, adopted in 2021 by the Council of the European Union, at least 78 % of the population aged 20 to 64 should be in employment by 2030. Exceeding the ambition of the EU-level headline target of 78%, Hungary set the target of 85% employment rate in the age group 20-64 to be achieved by 2030.

Industry is the most significant sector of the Hungarian national economy, its share in GDP was 22.4% in 2021. Although the volume of investments in the whole national economy decreased by 20% in 2016, the volume of investments in the field of industry performed much better by reaching 4.1% increase. The Government has approved the Irinyi Plan in February 2016. The strategy is a frame for further manufacturing industrial strategies.

In the 27 years since the fall of Communism, the Hungarian economy has undergone a fundamental structural change, resulting in a marked decline in the GHG intensity (-58%) accompanied by increasing energy efficiency and GDP between 1990 and 2015. As a result, economic growth and energy consumption are successfully decoupled in Hungary. The cumulated drop in the gross inland consumption of energy was 12.5%, while the cumulated GDP growth was 40.1% in these 25 years-time frames.

At the same time, Hungary is still heavily dependent on energy imports. The oil and gas dependency are around 80%. It is not only the import dependency which causes vulnerability for Hungary but also the unilateral character of it. A major part of the gas import originates from Russia, even if a part of it is transported to Hungary through the European network. Then it is not surprising that the key message of the Hungarian energy policy is seeking ways out of our energy dependency. The four means to achieve the above goal include energy savings, increasing the share of renewable energy sources to the greatest possible level, safe nuclear energy and the electrification of transport based on the former, and diversification of source countries and transit routes safeguarding Hungary’s natural gas and oil import.

Energy savings - The two most important elements of the energy efficiency improvement plans are the following: thermo retrofitting of buildings and the modernisation of heating and cooling systems; installation of high-efficiency new-, and modernisation of existing electric power stations.

Renewables - Thanks to the targeted supporting schemes (METÁR, Environmental and Energy Efficiency OP, etc.) and measures, the recent share (2021) of RES in the gross inland energy consumption is 14.1%. Hungary fulfilled the 13.00% national overall target for the share of energy from renewable energy sources in gross final consumption of energy in 2020.

Nuclear energy - Maintenance of about 50% nuclear share in the electricity mix is one of the key factors in securing the Hungarian energy independence. Besides energy security issues, replacing Paks Nuclear Power Plant - that has been nearly for 40 years in service- with the modern Paks-2 Power Plant is a key issue. A multiplicative impact of the surplus of ’valley’ electricity is that it can support e-mobility. It makes the implementation of Ányos Jedlik Plan 2.0 possible targeting a modal shift towards an ambitious electrification of the transport sector.

Energy Union – As an EU Member State, Hungary is part of the implementation of the EU's Energy Union Strategy aiming a transformation of European energy supply through the establishment of a fully integrated energy market. This will certainly give the opportunity for Hungary to diversify its energy import sources and transport routes providing secure, sustainable and affordable energy supply.

Water and Climate Coalition – The Coalition has been formed on the intitiative of 10 UN agencies in 2020, led by the World Meteorological Organization. The former President of Hungary, Mr. János Áder is actively involved in the Leaders Group which aims to provide strategic guidance on how integrating climate and water agenda in the world.

Domestic energy reserves – In longer term, depending on the speed of the innovation, domestic fossil energy reserves (coal, lignite, unconventional natural gas) also mean strategic backup for a future eco-friendly utilization involving BATs and R&D (zero carbon power plants, carbon capture and reuse) for power generation.

Hungary's central location in Europe and the accordingly dense motorway network are one of its most important competitive advantages. Four vital European transport corridors pass through Hungary, providing unparalleled access to all parts of Europe. As a result of intensive construction works along main transport corridors, major motorways and trunk roads reach national borders, ensuring faster and safer transportation.

Railway network covers the whole country, and it is an integral part of the international network, thus providing easy access by international express trains from the neighbouring and numerous other European countries. Around 18% of freight is transported by rail in Hungary, well above the EU average. Hungary is a landlocked country, but it has access to the Black Sea and the North Sea via the river Danube.

Within less than a year after the demise of the Hungarian national airlines, the market reinvigorated again. Both passenger numbers and cargo volumes soon reached and even exceeded the prior peaks.

The stock of cars has been increasing constantly in the last years. In 2021, the number of other fuel driven vehicles (hybrid, electric and mixed combustion) is twenty times higher than in 2010. Their share of total personal car stock is 4.1% in the total vehicle fleet is 1.5% (60,132 units, 31.10.2022).

The natural and climatic conditions of Hungary are very favourable for agricultural production. Thanks to its favourable natural endowments, Hungary has had a significant and internationally appreciated agricultural sector for centuries. Since Hungary's accession to the EU, its agriculture has developed considerably and its efficiency, competitiveness and profitability have begun to catch up with the EU27. 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 agriculture can be further increased in the future, with a better utilization of its capabilities.

Vegetable and fruit production has a long tradition in Hungary, thanks to the favourable natural conditions. Hungary's agricultural production decreased dramatically between 1990 and 2000 and the drop of livestock reached 50% which has been continued after the EU accession, too. In recent years, due to the Government's aims to reverse these trends, several measures were introduced which has resulted in positive changes in the animal husbandry sector. In the next years further increase of the livestock is expected.

In general, forests in Hungary have been managed sustainably for about a century, and overall, have continued to be carbon sinks. The new forests have added much to the services of the forests, including the sink capacity. The sink of the biomass of the forests established since 1990 have been 1.1-1.2 million tCO2 a year in this decade. The share of private forests amounts to 42.5%, whereas forests owned by local governments amount to 1%. Most forests (56.5%) are thus still state owned.

Greenhouse gas inventory information

In 2021, total emissions of greenhouse gases in Hungary were ***64.2 million tonnes*** carbon dioxide equivalents (CO_2-eq) excluding the LULUCF sector. (For the first time, GHGs were aggregated applying the global warming potentials from the IPCC Fifth Assessment Report.) Taking into account also the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 57.0 million tonnes CO_2-eq in 2021. Being about 6 tonnes, the Hungarian per capita emissions are below the European average. Compared to the base year (average of 1985-87), 1990, and 2005, our current emissions are lower by 42%, 32%, and 17%, respectively. This significant reduction was partly a consequence of the regime change in Hungary (1989-90) which brought in its train radical decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG relevant sectors like energy, industry and agriculture. Then, between 2005 and 2013, after a period of about 14 years of relatively stagnant emission level (1992-2005), GHG emissions fell again quite significantly by 24 per cent. The global financial and economic crisis exerted a major impact on the output of the Hungarian economy, consequently on the level of GHG emissions as well resulting in a quite significant drop of 9% between 2008 and 2009. Then, after a smaller increase in 2010, emissions decreased further in the following four years. In contrast, the decline in economic output stopped in the first quarter of 2010, and Hungary not only reached the pre-crisis level of GDP again in 2014 but exceeded it even in 2015. After 2013, emissions started growing again. Up to 2017, the overall increase reached 12%. After four years of increase, emissions have remained more or less at the same level between 2017 and 2019. In 2020, however, emissions fell by almost 3% to around 2016 levels, mainly due to a significant reduction in transport emissions as a consequence of COVID-19.

The most important greenhouse gas is carbon dioxide accounting for 76% of total GHG emissions. The main source of CO_2 emissions is burning of fossil fuels for energy purposes, including transport. CO_2 emissions have decreased by 43% since the middle of the 80's. Methane represents 14% in the GHG inventory. Methane is generated mainly at waste disposal sites and in animal farms, but the fugitive emissions of natural gas systems (i.e., transmission, storage, and distribution) are also important sources. CH_4 emissions are by 37% lower than in the base year. Nitrous oxide contributes 7% to the total GHG emissions. Its main sources are agricultural soils, and manure management. N_2O emissions are 55% lower compared to base year. The total emissions of fluorinated gases amount to 3%.

Policies and measures on climate change

Hungary's mitigation actions, as a Member State of the European Union, are determined to a great extent by the policies and regulations of the EU. The European Union's climate policy is guided by two major objectives: to reduce net greenhouse gas emissions by at least 55% by 2030, and to achieve climate neutrality in the EU by 2050.

At its October 2014 meeting, the European Council committed to reducing the EU's total greenhouse gas emissions by at least 40% gross by 2030 compared to 1990 levels. In December 2019, the European Commission adopted the Communication on the European Green Deal, which proposes the EU-wide goal of becoming climate neutral by 2050 and sets out a roadmap for the transition to a clean, circular economy. Meanwhile, at the European Council in December 2019, heads of state and government also set the EU-level target to achieve climate neutrality by 2050. In December 2020, the European Council agreed to increase the EU's 2030 climate target to at least -55% net emission reductions, compared to 1990 levels, a substantial improvement from the previous -40% target.

The 2050 climate neutrality goal and the new 2030 target have since been enshrined in EU legislation, in the so-called European Climate Law [Regulation (EU) 2021/1119 of the European Parliament and of the Council].

In July 2021, the European Commission adopted a series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050, including the new EU-wide intermediate target of an at least 55% net reduction in greenhouse gas emissions. The "Fit for 55" package aims to revise all relevant policy instruments. The Commission proposals are still under discussion by the member states.

Beyond the EU legislation the National Climate Change Strategy gives a framework to the country's climate policy. The strategy was reviewed in 2013. The updated NCCS II for 2017-2030 (NCCS II) was published and opened to public consultation in the spring of 2017. It was approved by the Parliament in October 2018. It includes a decarbonisation roadmap and gives a framework for national adaptation. Moreover it provides a target system of awareness-raising activities and an analysis of expected effects of climate change in Hungary.

The implementation of the NCCS II is ensured by Climate Change Action Plans. The first Climate Change Action Plan (2018-2020) was approved by the Government in January of 2020. These action plans define concrete measures with concrete responsible actors and funds in the field of mitigation, adaptation, climate-awareness raising and implemention.

Hungary has adopted several measures that serve the mitigation of GHG emissions and help achieving its climate policy targets. As these measures affect many territories of the economy several institutions are taking part of their implementation. The Ministry of Energy, the Ministry of Agriculture, the Ministry for National Economy, the Ministry of Interior and the Prime Minister's Office are the major policy makers.

Projections

For the report two scenarios were used. The "with existing measures scenario" (WEM) encompasses implemented and adopted policies and measures, while the "with additional measures scenario" (WAM) takes into account planned measures. As no new scenarios have been prepared specifically for the NC8-BR5 document, the outputs of the WEM and WAM scenarios have been integrated from the National Clean Development Strategy's (NCDS) business-as-usual (BAU) and the Early Achievement scenarios (EA). The NCDS's BAU corresponds to the NC8-BR5's WEM scenario and the NCDS's EA corresponds to the NC8/BR5's WAM scenario.

Total GHG emissions without LULUCF have been decreasing from 2007 until 2013 almost continuously, but it increased again in the last two years. According to our WEM scenario this will turn again into a downward trend with total emissions without LULUCF reaching 3.8 % lower level in 2020 and then mainly because many of the existing measures don't span out until 2030, it will rise slowly reaching a level 1.2 % below the 2015 level. In this scenario emissions will be 35.6% and 33.8 % lower than they were in 1990. According to the WAM scenario emissions will decrease by 4% until 2020 and by 2% until 2030. This compared to the 1990 level equals 35.7% and 34.4% respectively.

The residential sector will be a major contributor to GHG emissions reduction. The sector is expected to emit 18% and 41% less in 2020 and 2030 respectively mainly due to the new regulations on energy performance of buildings.

The largest increase is expected in the transport sector. The demand for transport and most of all for road transportation will most certainly continue to rise in the coming decades. The penetration of alternative fuels in road transportation will not be able to counterbalance this effect. Altogether, in the WEM scenario we project emissions from transport to be 22% higher in 2030 than they were in 2015, while in the WAM scenario we expect emissions to be 20% higher in 2030 than in 2015.

Climate change vulnerability and adaptation

Knowledge of the direction and quantified degree of the changes are indispensable for the preparation in terms of the effects of climate change, during the mapping of which it can rely basically on two sources: on the one hand, one can draw consequences regarding the climatic situation of the recent past and the present using collected and available measurements; on the other hand, one can quantify the expected, future changes of the 21st century applying model simulations. The trend analyses based on the controlled and homogenised measurement data recorded in the climatology database of the Hungarian Meteorological Service (OMSZ).

Similarly to the globaltrends, the average temperature will undoubtedly increase in Hungary, too. Based on the model calculation results shown for the 21st century, we have to expect a further increase in temperature with an extent that reaches 1°C in almost the entire country and every season by 2021–2050, and will exceed even 4°C in the summer months, compared to the reference period of 1961–1990. It is obvious that temperature extremities are shifting significantly towards warming up: the number of frosty days will decrease and the number of summer days and heatwave days will increase and will add up to a whole month by the end of the century.

The evolution of extremities has a characteristic spatial distribution and has a negative effect primarily on the central, southern and eastern parts of Hungary, signifying the importance of territorial vulnerability assessments.

The territorial differences in Hungary are attributable to various reasons (West–East, and recently Northwest–South economic division, inequalities between urban and rural areas), and may become aggravated by the impacts of climate change, as the vulnerability to the prognosticated mid- and long-term climatic changes is different for each area. A regional vulnerability comparison would therefore be quite urgent. Appropriate regional level climate vulnerability assessments are to integrate the challenges and tasks related to climate change into regional strategic planning and decision-making and reinforce the practical means. The aim of vulnerability assessment is to explore and detect the extent each region and settlement is vulnerable to the expected impacts of climate change. The aim of vulnerability assessment is not to determine absolute vulnerability but to compare regions and to determine relative differences.

The potential instrument for adaptation and the systemisation opportunities for action lines do have quite a wide range. A specific set of adaptation instruments forms a heterogeneous group. Its basic pillars are the development of human resources and consciousness, application of experiences from traditional farming methods, the proper selection of technological, technical innovations, and management tools and compliance with the external regulatory environment. All these presume the direct and indirect flow of necessary information, horizontal and vertical integration at a regional and country level, and the joining of individual adaptation activities into a larger, community system.

It should be emphasised that in certain cases the goals of adaptation, emission-regulation, and the specific measures to achieve them and the indirect effects of these measures are interconnected. This is particularly true for agriculture and forestry, and – to a limited extent – to energy management.

The Hungarian climate protection developments have two sources. On the one hand, incomes from international quota sales ensure encouragement old energy efficiency and building energy investments, on the other hand, Hungarian operational programmes ensure funds for supporting public (state, municipal, church, and civil) and private energy efficiency, renewable energy developments from the EU budget. The Hungarian framework and utilisation rules regarding EU funds are laid down by the Partnership Agreement, the fields of each development funded by each Fund are laid down in the operational programmes. The utilisation of incomes from quota sales is governed by Act LX of 2007 on the implementation framework for the United Nations Framework Convention on climate change and its Kyoto Protocol and by Act CCXVII of 2012 on the participation in the Community greenhouse gas trading scheme and in the implementation of the Effort Sharing Decision.

In the New Széchenyi Plan, the different policies execute their support policy through the operational programmes, and this is supplemented by the environmental protection and climate protection aids of agricultural and rural development programmes.

Assistance to developing countries

Hungary is dedicated to contributing to the commitment of developed countries to jointly mobilize USD 100 billion per year by 2020 from a wide variety of sources. Public finance has been provided through bilateral and multilateral channels. Assistance to developing country Parties that are particularly vulnerable to climate change is ensured by continuously providing financial support through bilateral channels in forms of grant and tied aid.

Striving to the mobilization effect of public financial resources Hungary works closely with actors of the national private sector. The main facilitators of Hungarian Balkan-oriented development and adaptation activities is the Western Balkans Green Center (WBGC), an international climate finance and development agency based on the decision of the Government of Hungary in 2018. The WBGC acts on initiatives that are key priorities for both climate policy and regional cooperation.

Hungary is active in the transfer of adaptive water management technologies. It has hosted several water-related international events to facilitate regional and international public and private sector cooperation and to promote innovative solutions in the field. Building on the success of the **Budapest Water Summits (BWS)** of 2013, 2016 and 2019, Hungary in December 2021 organised the **Planet Budapest 2021 Sustainability Expo and Summit,** focusing on the wider subject of **sustainable development. In addition, the Ministry of Foreign Affairs and Trade also established a dedicated department for water diplomacy in 2017.** Hungary is also supporting technology development and transfer through the UNFCCC Technology Mechanism, and the activities of the Climate Technology Center and Network.

Research and development

Regarding climate and environment related research, the main priorities are set by the National Climate Change Strategies, the National Environmental Programmes and the National Clean Development Strategy[2]. As of 2022, the most up to date documents are the National Clean Development Strategy approved by the Government in May 2021.

Although a significant part of all research in Hungary is carried out or coordinated by the Hungarian Academy of Sciences, several institutions, namely the Hungarian Meteorological Service and the Hungarian Forest Research Institute, along with Hungarian higher education institutions (Hungarian University of Agriculture and Life Sciences, Eötvös Loránd University, University of Sopron, Budapest University of Technology and Economics, Central European University, University of Miskolc) must be noted.

[2] Please find the National Clean Development Strategy here: https://unfccc.int/sites/default/files/resource/LTS_1_Hungary_2021_EN.pdf

The most important governmental institute dealing with climate change and the implementation of the NCCSs is the Ministry of Energy, which was one of the founders of the National IPCC Committee. The Hungarian Government continuously encourages scientists to participate in as many IPCC activities as possible, including the preparation of various IPCC reports.

As for the funding of research, it mainly stems from European Union sources and the National Research, Development and Innovation Fund. The total funding available for research, development, and innovation until 2020 is 1 200 billion HUF, provided from both EU and domestic sources in the framework of calls announced in cooperation with the National Research Development and Innovation Office.

One of the most relevant projects is the creation of the National Adaptation Geo-information System (NAGiS). The aim is to continuously operate a geoinformational data system based on Hungarian research and the results of Earth observation, which is capable of multipurpose use, such as supporting decision preparation and decision making.

The majority of observation activities are still carried out by the Hungarian Meteorological Service (OMSZ) and the Department of Meteorology at Eötvös Loránd University (ELTE). OMSZ operates the surface meteorological observation network all over the territory of Hungary, including 162 automatic weather stations and 142 hydrometeorological stations. The regular calibration and maintenance activities of the measurement equipment are also carried out by OMSZ annually. Since 1st January 2021, OMSZ provides its data on a free and open basis, thorugh the web portal odp.met.hu. It means that all observations, as well as climate projections are freely available to everyone. Besides short-range, medium-range, and monthly weather forecasts, OMSZ provides climate projections into future with the help of two regional climate models. Other two regional climate models were adopted by ELTE. The results of the projections have been applied in many national and international projects, such as the NAGiS project in which climate model results of OMSZ and ELTE were utilised for impact studies of hydrology, agriculture, tourism and critical infrastructure.

The University of Miskolc, whose technical faculties (Faculty of Earth Science and Engineering, Faculty of Material Science and Engineering, Faculty of Mechanical Engineering and Informatics) has recently performed outstandingly in the field of research and development. By the help of H2020, Life, INTERREG and other National funds lot of technical based projects were carried out with promising results. Several mitigation and adaptation solutions related to climate change and sustainability (energy utilisation, low-cost sensor network, natural resource research and utilisation, precision agriculture, raw material production, ITC development, waste management) have been implemented, which can help to reach of both domestic and international climate goals.

In September 2020, the University of Public Service launched the two-year postgraduate MA programme in International Water Governance and Water Diplomacy, which offers up-to-date, practice-oriented education for practicing and future water managers, diplomats, national and international civil servants on cross-border or global environmental issues, including climate change.

Education, public awareness, trainings

Besides remarkable mitigation and adaptation actions, the second National Climate Change Strategy (NCCS II) for 2017-2030 includes a "*Partnership for Climate*" Awareness-Raising Plan, with the aim of integrating climate awareness and sustainability into decision-making and actions on all levels of society. Climate Change education in *primary and secondary schools* is still embedded into the National Core Curriculum. The National Core Curriculum, renewed in 2020, includes 'building a commitment to a sustainable future' in the priority goals of learning. The curriculum expectations regarding sustainability in the core curriculum are included in the framework curricula, assigned to the knowledge requirements in each subject, thus ensuring that the horizontal educational objectives set out in the core curriculum are sufficiently embedded in the school practice with a variety of teaching and learning activities, using approaches from different subjects and disciplines together.

The topics of sustainability are also included in the renewed graduation requirements: among others, in the detailed requirements of Civic Studies, Economics, Geography, Biology, Physics, Chemistry and Science. Sustainability as a new examination was also introduced, and new subject curricula and textbooks were also made available.

Sustainability Thematic Week is a program coordinated by the Ministry of Interior, operating since 2016, with an increasing number of schools joining each year. In the past five years, the program has reached about half of the schools overall. In 2021, despite the threat posed by the coronavirus epidemic, nearly 400,000 students participated in the Sustainability Week. The program uses active learning, community action, and helps school work through lesson plans, campaigns, and teacher training programs.

With the support of the Ministry of Interior, a one-week event called The World's Largest Lesson is also organized, which in 2021 was joined by nearly 5,000 classes nationwide. The main goal of the program is to draw students'attention to the Sustainable Development Goals.

The values, the ways of action and operation and the topics of sustainability are integrated into the daily life of the approximately 1,300 public education institutions participating in the now 22-year-old Hungarian Eco-School Network. For example, most eco-schools have a so-called "energy commando": in these institutions, the energy-saving operation of the school building is realized with the active participation of the students. The Green Kindergarten Network, coordinated by the Ministry of Agriculture, has about 1,100 kindergartens nationwide. Thus, every third child or student in Hungary is educated for sustainability according to one of the pillars of the UNESCO ESD for 2030 Roadmap, the model of whole-institutional practice.

Aspects of climate change and other topics of sustainability are more and more widely taught at Hungarian *universities and colleges*, too, either as part of degree programmes on broader subjects such as environmental science, environmental engineering, earth sciences etc., or as elective courses freely available to students of any subject. One university offers Climate Research as a possible area of specialization in its MSc Meteorology programme. Several universities offer postgraduate specialist training course like Climate change adaptation engineering specialisation programme or Climate Policy Officer programme.

Complex campaigns for climate-consciousness are needed to encourage active participation of citizens. Complex awareness-raising should be done in the priority areas of adaptation and mitigation (reduction of energy consumption and the use of renewable energy, environmentally conscious consumption, preparation of households and workplaces to the negative effects of climate change, agriculture, use of land, nature conservation). The long-term goal is to represent climate change as a boundary condition, in every governmental campaign activity.

Several organisations in Hungary offer trainings related to climate change and a large number of conferences and expert workshops are taking place to address such topics. These are geared towards the general public, professionals and members of local authorities.

2. NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

2.1. Geographical conditions

Hungary is located in Central Europe; the neighbouring countries are Austria, Croatia, Romania, Serbia, Slovakia, Slovenia and Ukraine. Geographically Hungary is mostly flat terrain, with hills and low mountains. The Danube and the Tisza are the two main rivers of the country; the largest lake is Lake Balaton. The capital city of Hungary is Budapest, with approximately 1.7 million inhabitants. Other major cities are Debrecen, Miskolc, Pécs, Szeged andGyőr with around 100-200 thousand inhabitants. Hungarian is the official language.

The area of the country is 93,033 km2, of which 57, 4% is agricultural area (46, 5% arable land, 2,5% garden, orchard and vineyard, 8,4% grassland), 20.9% forest, 0.9% reed and fish-pond, 20,7% uncultivated land area.

Hungary is a long-standing parliamentary democracy, one of the leaders of political and economic transition in the region. Hungary became the member state of the European Union in 2004.

The administration is based on a regional system of 19 counties (each subdivided into districts) and the capital city; there are 20 NUTS 3 units of Hungary, and 8 regions qualifying as NUTS 2 units of Hungary.There are also 25 towns with county rights, the local authorities of these towns have extended powers, but these towns belong to the territory of the respective county instead of being independent territorial units. Figure 2.1. provides an administrative map of Hungary.

Figure 2.1. Map of Hungary

Source: ezilon.com

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

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.

The highest mountains of the country are located in the Carpathians: these lie in the northern parts; in a wide band along the Slovakian border (highest point is the Kékes at 1,014 metres).

Hungary's main river, the Danube ("Duna") divides the country into two parts. Other large rivers are the Tisza and Dráva, while Lake Balaton is located in Transdanubia which is a major lake water body of the country. Lake Hévíz, one of the largest thermal lakes globally, is also located in the Transdanubian part of Hungary. The second largest lake in the Carpathian Basin is the artificial Lake Tisza ("Tisza-tó").

2.2. Climatic conditions

Climate of Hungary

Hungary 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 belt 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.

If Hungary were to be classified according to a climate classification for global classification, a large part of the country would be classified by Köppen as Cfa - warm-moderate climate belt, 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 2.2., 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 2.2. 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.

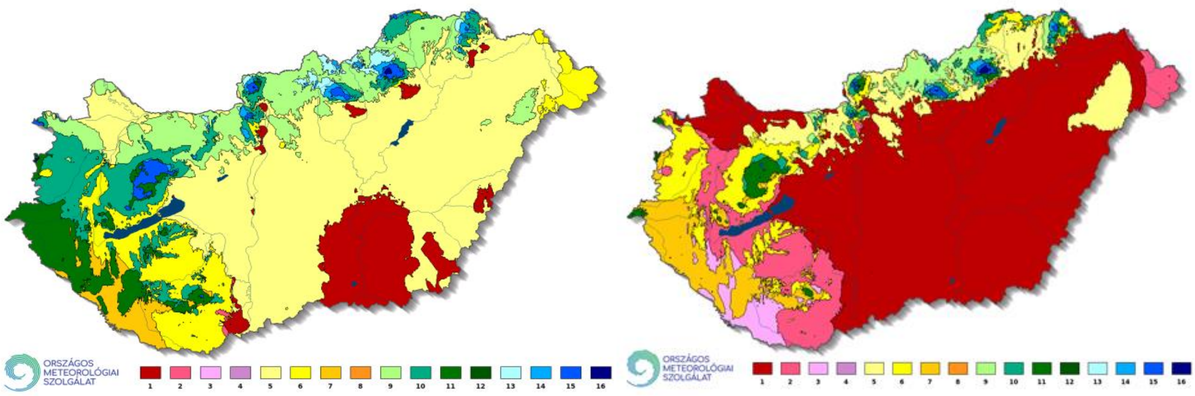


Figure 2.2. Climate zones of Hungary in 1961-1990 and 1991-2020 according to Péczely's classification. (1-warm and dry; 2-warm and moderate dry; 3-warm and moderate wet; 4-warm and wet; 5-moderate warm and dry; 6-moderate warm and moderate dry; 7- moderate warm and moderate wet; 8-moderate warm and wet; 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)

Observed temperature and precipitation change in Hungary

The countrywide changes are in well accordance with global trends. The 1.21°C increase of the national average temperature since the beginning of the last century (Figure 2.3) is higher than the global change estimated at 1°C. Over the period 1901-2020, summers warmed the greatest (1.33°C), the spring and winter changes are 1.18°C and 1.16°C respectively, while in the case of autumns we have seen the smallest temperature increase (0.99°C).

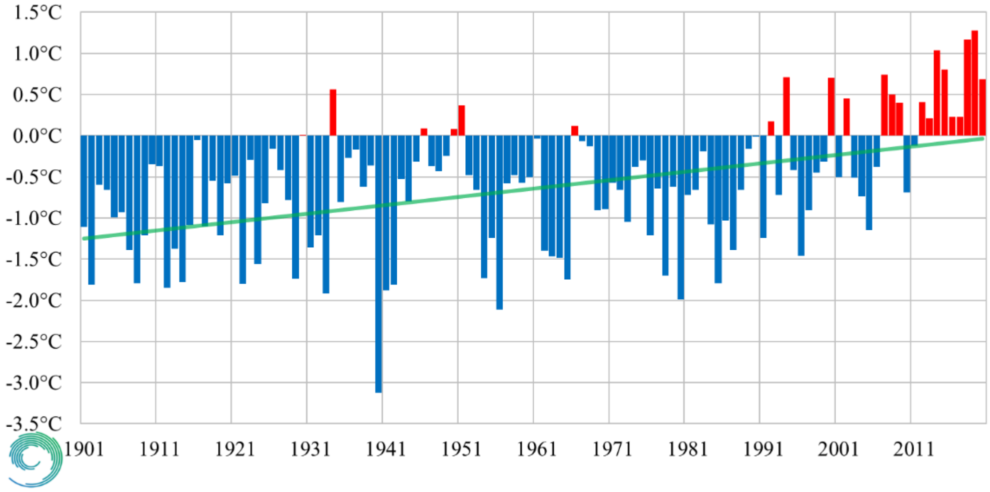


Figure 2.3. Annual mean temperature anomalies (°C) in Hungary between 1901 and 2020 relative to the average of the 1991-2020 normal period. (Countrywide averages are based on homogenised and interpolated national averages)

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 more than two weeks in these 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.

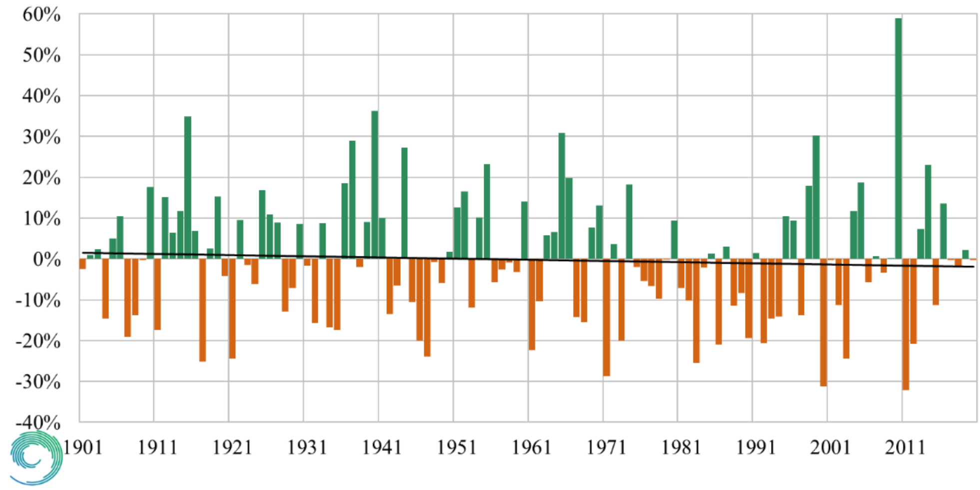


Figure 2.4. Annual mean total precipitation anomalies (%) in Hungary between 1901 and 2020 relative to the average of the 1991-2020 normal period. (Countrywide averages are based on homogenised and interpolated national averages)

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 1.4 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.

2.3. Population

At the beginning of 2021, the population of the country was 9.731 million, and a major part, 6.827 million people lived in urban areas. The life expectancy of the population was estimated 72.21 years for men and 78.74 years for women in 2020 (source: HCSO).

The population density of Hungary was 104.6 inhabitants/km^2 in 2021. Between 1970 and 2021 the population decreased by 591 thousand people. The population peak was in 1980 with 10.7 million inhabitants, since then a continuous decreasing tendency is showing. The age structure of the population is shown in Figure 2.5. The Government is committed to reverse the aging process. Therefore, in recent years, several policies have been introduced to provide incentives for families to having more children.

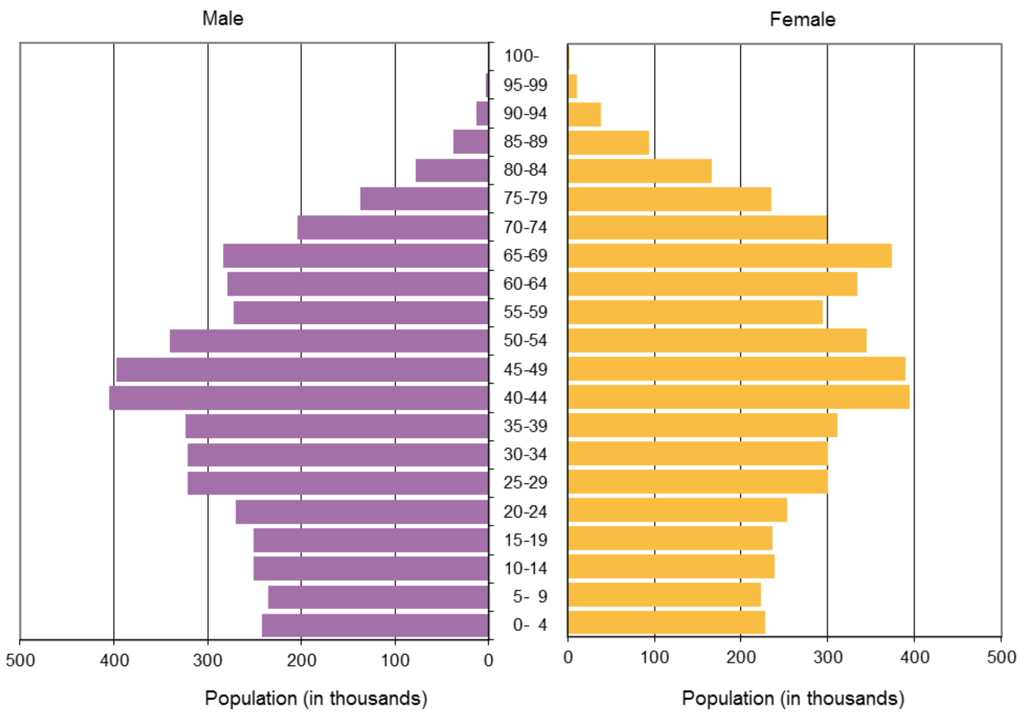


Figure 2.5. Population pyramid of Hungary, 2021
Source: Hungarian Central Statistical Office (KSH)

Figure 2.6. shows the changes of population between 1870 and 2021. The population number in the present territory of Hungary has doubled since 1870. The population declined during World War II, but due to the significantly increasing number of births in the 1950s, more than 10 million people were enumerated at the 1970 population census.

The population number peaked in 1980 and has been decreasing since then. In 2021, population amounted to 9.7 million.

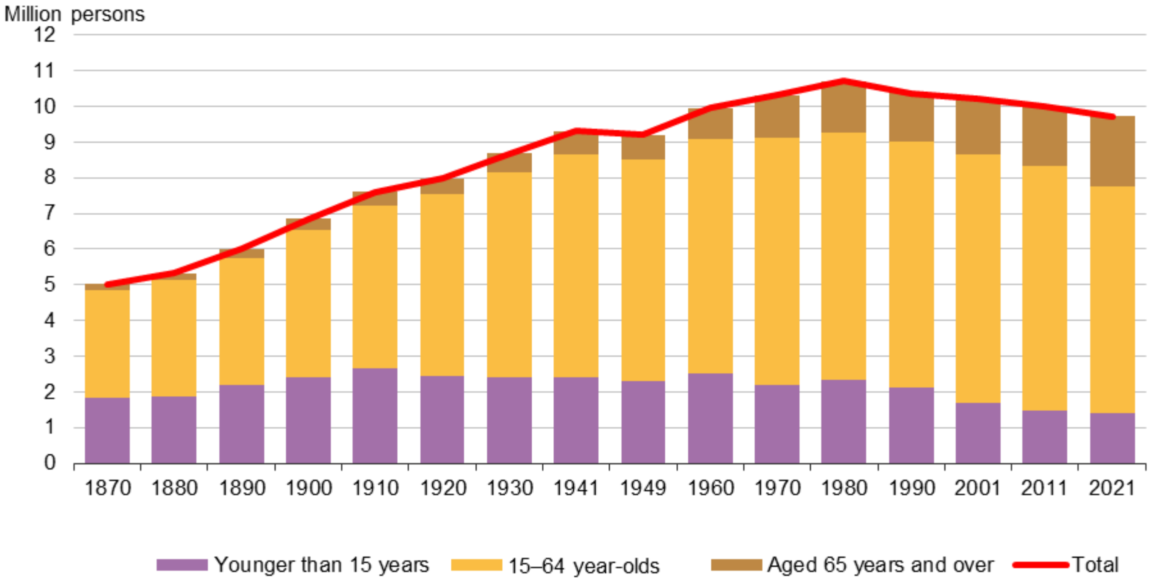


Figure 2.6. Age structure in Hungary, 1870-2021
Source: Hungarian Central Statistical Office (KSH)

The number of child population was just over 1.4 million in 2021, which is the lowest level since the first census of 1870 in Hungary. The number of children younger than 15 years was more than 2.6 million in 1910 and nearly 2.3 million after World War II. Then following the population policy measures of the 1950s, it has jumped more than 2.5 million by 1960. The number of births fell significantly from the 1970s until 2011, then a slow growing tendency has started. The impact of the government's family policy can be observed on the slow rise of child bearing since 2011. Due to these measures 93 thousand babies were born in 2021.

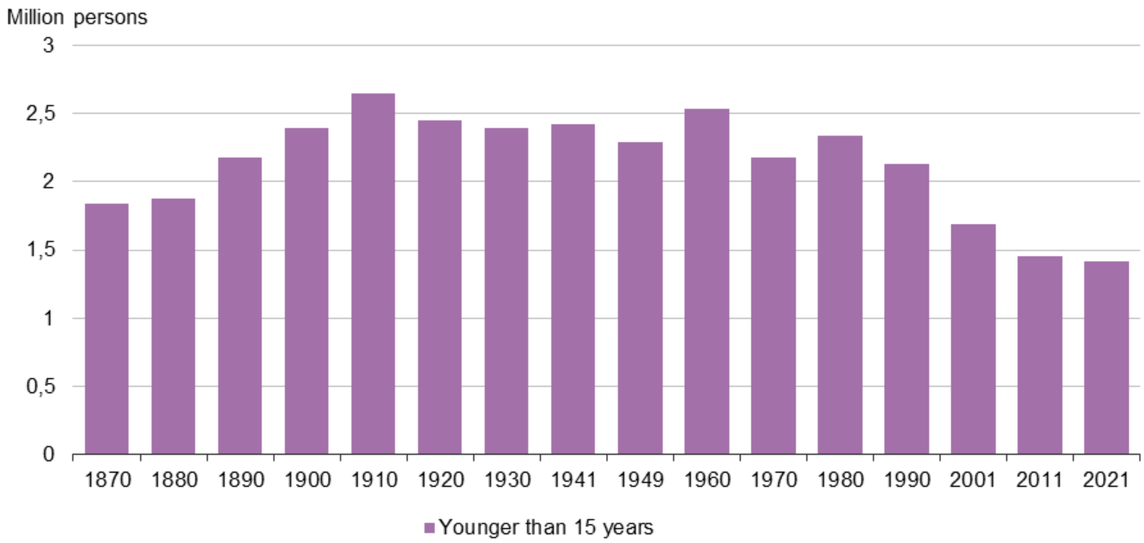


Figure 2.7. Population aged less than 15 years in Hungary, 1870-2021
Source: Hungarian Central Statistical Office (KSH)

The ageing index refers to the number of elderly population (aged 65 years and over) per 100 individuals younger than 14 years. The steep upward curve of this indicator shows the extent of population ageing. The size of elderly population, both in absolute and relative terms, exceeded that of those aged 0-14 years in 2005 for the first time. The predominance of the elderly has been steadily increasing since then. While the number of elderly people per one hundred children was 8 in 1870, it reached 139 in 2021.

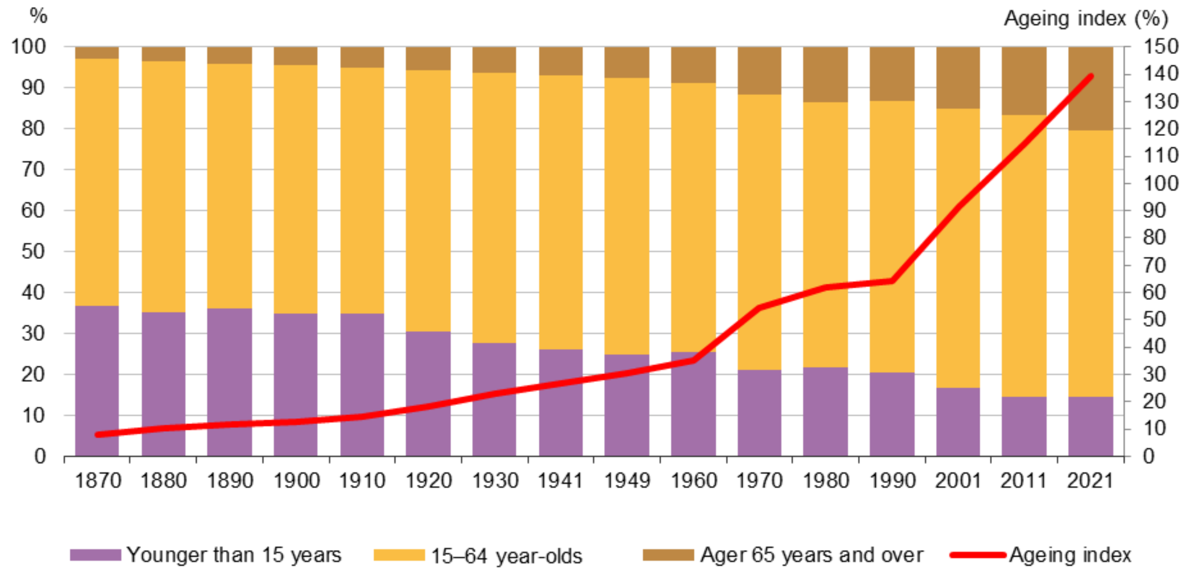


Figure 2.8. Age structure and ageing index in Hungary, 1870-2021
Source: Hungarian Central Statistical Office (KSH)

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 minorities live also Austria (in Burgenland), Croatia (mainly Slavonia). Slovenia is also host to a number of ethnic Hungarians. More than two million ethnic Hungarians live in the neighbouring countries.

2.4. Governmental structure

The President of the Republic, elected by the members of the Parliament has mostly a formal role, but he/she is nominally the Commander-in-Chief of the Armed Forces and his/her powers include the nomination of the Prime Minister who is to be elected by the majority of the votes of the Members of Parliament, based on the recommendation made by the President of the Republic.

Due to the Hungarian Constitution, the Prime Minister has the executive power as he/she appoints Cabinet ministers and has the exclusive right to dismiss them (similarly to the competences of the German federal chancellor).

The unicameral 199-member National Assembly ("Országgyűlés") is the highest organ of state authority, it initiates and approves legislation sponsored by the Prime Minister. Its members are elected for a four year term. The election threshold is 5 %, but it only applies to the multi-seat constituencies and the compensation seats, not the single-seat constituencies.

A 15-member Constitutional Court has the power to challenge legislation on grounds of unconstitutionality.

Hungary has undertaken significant government restructuring including the creation of a separate Ministry of Energy as of December 2022.

Climate change policy is underpinned by National Clean Development Strategy, the National Energy and Climate Plan and the Second National Climate Change Strategy (NCSS II). The energy sector is governed by the long-term National Energy Strategy of Hungary for 2030, the National Action Plan for Renewable Energy for 2020 and the National Energy Efficiency Action Plan for 2020 and the National Strategy for the Energy Performance of Buildings (2015).

2.5. Settlement structure and building stock

Hungary is administratively subdivided into 19 counties and the capital city of Budapest (independent of any county government). Besides the Capital, 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 considered to be major metropolitan areas and over 2,800 are villages. Outside Budapest (1,7 million inhabitants), the largest municipality in Hungary is Debrecen, with a population of 200.000inhabitants. The type and number of buildings owned by local municipalities is shown in Table 2.1.

	Total 2020	**Pre 1900 (%)**	**1901-1959 (%)**	**1960-1989 (%)**	**After 1989 (%)**
Edicational	**12 917**	**11,9**	**30,7**	**46,2**	**11,2**
Cultural	**5 625**	**16,4**	**36,8**	**36,1**	**10,7**
Sport	**2 616**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Health Service	**4 053**	**7,2**	**27,1**	**49,8**	**15,9**
Social	**2 419**	**10,7**	**34,9**	**36,9**	**17,5**
Health + Social Service	**6 472**	**8,5**	**30**	**45**	**16,5**
Trade, Service and Administration	**9 508**	**11,7**	**32,4**	**42,8**	**13,1**

Table 2.1. Type and age of buildings owned by local municipalities

Source: Hungarian Central Statistical Office (KSH), 2020

Residential flats

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

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 dwellings (1000)	3980	4134	4209	4402	4428	4581
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

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.

2.6. Economy

Hungary is a market economy; it has a highly internationalised and export-oriented business sector and a stable macroeconomic situation. A structural economic crisis began in the second half of the 1980s, which was followed by the transformation of the whole economic and political system in 1990. This process towards market economy resulted in transformational recession and the economic depression that lasted till 1995. Since then the economy began to develop and the growth rate of the Hungarian economy exceeded the EU average. In 2004 Hungary became the member of the EU. The crisis hit hard the Hungarian economy in 2009 but the recovery started soon and the economy is now on a path of sustainable growth.

	2013	2014	2015	2016	2017	2018	2019	2020	2021
GDP volume index (previous year = 100%)	101.8	104.2	103.7	102.2	104.3	105.4	104.9	95.5	107.1
Unemployment rate (%)	9,8	7,5	6,6	5,0	4,0	3,6	3,3	4,1	4,1
Inflation rate (%)	1.7	-0.2	-0.1	0.4	2.4	2.8	3.4	3.3	5.1

Balance of general government /GDP (%)	-2.6	-2.8	-2.0	-1.8	-2.5	-2.1	-2.0	-7.6	-7.2

Hungary's GDP per capita in Purchasing Power Standards (PPS) was more than 74.6% of the EU-27 average in 2021. The private sector accounts for more than 80% of GDP. Foreign ownership and investment in Hungarian firms are widespread, with foreign direct investment stock totalling more than €92 billion in 2021.

Table 2.3. Main economic indicators of Hungary in 2013-2021

Source: Hungarian Central Statistical Office (KSH), 2022

Macroeconomic environment

Considering macroeconomic trends it can be stated that the recession experienced in 2009 hit hard the Hungarian economy: economic activity and production plummeted in 2009 reaching its low in the middle of the same year. The recession turned to a slow growth in 2010 and 2011 however the crisis of the Eurozone inferred a highly unfavourable international economic environment significantly decreasing the growth rate of the Hungarian economy and turning it into a minor recession by 2012. From 2013 the economy has been on a healthy track, the external and internal conditions are improving.

Hungary shows a positive balance of trade since 2009. The GDP volume was overall 7.1% higher during 2021 than in 2020, and it even surpassed the prepandemic, 2019 level by 2.3%. Hungary was among the EU member states with the most significant performance growth.

The main economic indicators of the last years are shown in Table 2.3.

Employment

Since the peak of unemployment in 2010 Hungary's labour market has been characterised by positive trends. In 2021 the unemployment rate (in the age group of 15-74 years) was down to 4.1 % and it is much lower than the EU average (which is 7.0%).

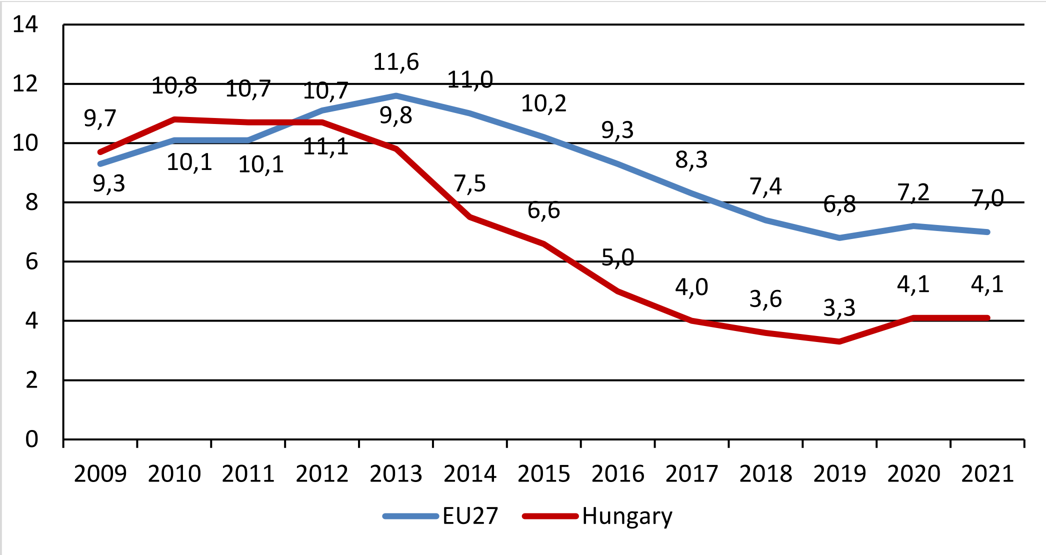


Figure 2.9 Unemployment rate in Hungary and in EU27

Source: Eurostat, 2022

The employment rate is constantly rising; it was 78.8% in 2021 regarding the population aged 20-64. The trend is in line with the headline objective of the Europe 2030 strategy, according to which the employment rate in the EU member states should reach 78 percent.

Hungary intends to further improve the country's labor market performance, which requires increasing the level of employment, improving the productivity of the workforce and the conditions of employment. According to the European Pillar of Social Rights Action Plan, adopted in 2021 by the Council of the European Union, at least 78 % of the population aged 20 to 64 should be in employment by 2030. Exceeding the ambition of the EU-level employment headline target of 78% Hungary set the target of 85% employment rate in the age group 20-64 to be achieved by 2030.

Financial assets and wealth of households

The gross wealth of households has increased steadily since 2008. Household savings are potential financial resources for other economic actors and thus they also underpin the macro-economic stability.

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 2.4: Net financial assets of households
Source: Central Bank of Hungary (MNB), 2024

The rising value of financial assets is attributable to several factors: besides the upward wage trend (caused by increases in minimum wage and guaranteed minimum wage hikes, as well as wage increases in the public and private sector) the higher saving rate during the lockdowns of COVID and revaluation of the financial stock also contributed.

Inflation

In the 2020s, several consecutive waves of inflation hit the global economy that has not been seen in 50 years. The supply-demand frictions following the COVID-19 epidemic, the energy crisis and the Russian-Ukrainian war had an impact in most countries of the world. The European Union and especially its Eastern member Member States, including Hungary, were heavily affected.

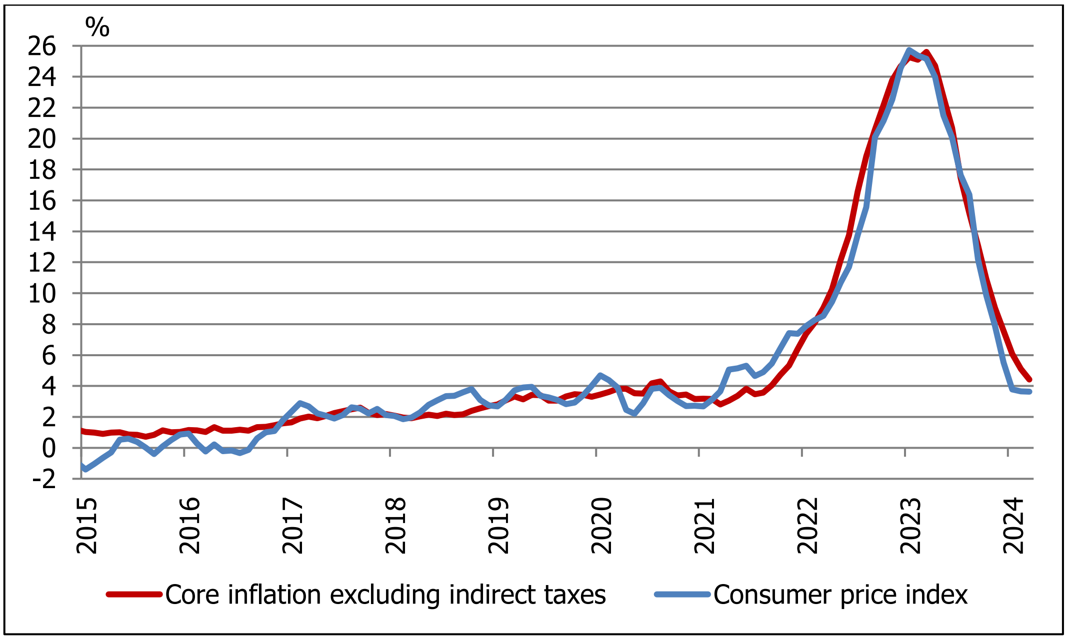


Figure 2.10 Inflation trends in Hungary
(monthly core inflation and consumer price index, year-on-year)
Source: Central Bank of Hungary (MNB), 2024

Price developments in Hungary followed the European trends but with higher volatility. Close to half of the Hungarian cumulative price increase between June 2021 and January 2024 is attributable to global and an additional one-third to regional factors. In the recent global inflation wave, higher price increase was seen in Central and Eastern Europe, significant part of which is explained by the greater sensitivity of the region to the development of global energy prices due to their higher energy-intensity and dependence on Russian energy import. In 2022, the European quotation of gas prices increased eight times and electricity prices increased five times compared to the average level of 2019.

The remaining less than a quarter of the cumulative price increase in Hungary during the inflationary wave was attributable to country specific reasons, such as competitiveness issues and the highest profit-driven inflation across Europe.

Inflation peaked in January 2023 and then a successful disinflation has been underway. The decline in inflation has been supported by disciplined monetary policy, government measures strengthening competition, subdued domestic demand and a significantly lower external cost environment. Between January 2023 and March 2024, inflation decreased from 25.7 percent to 3.6 percent. The pace of disinflation resembles to the historically successful disinflation episodes of the last 50 years. Historical evidence of global high-inflation periods in the past 50 years shows, that only in one quarter of the cases fell inflation below 10 percent from above 20 percent in the first year after the surge.

Entrepreneurial sector

In 2022 the number of active enterprises was 1050 thousand of which 584 thousand were private entrepreneurs and 466 thousand companies with legal entity. The proportion of SMEs in Hungary is 99.9 % of total enterprises and the remaining 0.1% (6963 units) consists of enterprises with more than 250 employees. Despite this, 32.6 % of employment and 56.1 % of total added value come from large enterprises.

Current account balance and financing

After the years of surplus in current account, the external balance of the Hungarian economy deteriorated significantly in 2022 mainly due to jump in energy prices. However, the current account balance turned positive again in 2023, as energy prices normalised and domestic demand was restrained due to high inflation.

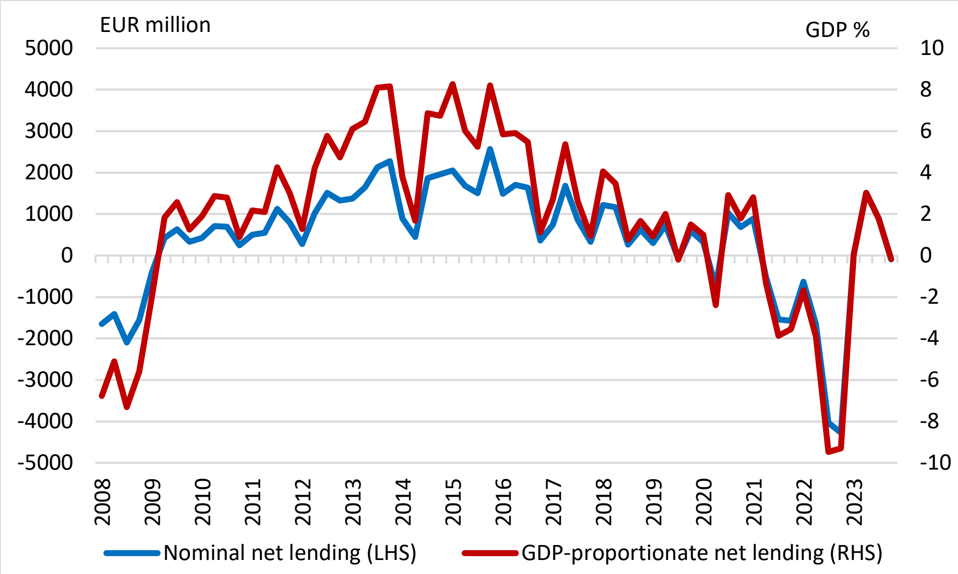


Figure 2.11 Net lending

Source: Central Bank of Hungary (MNB)

With the current account turning into surplus, external vulnerability of the Hungarian economy improved substantially in terms of almost all of the indicators. The gross and net external borrowing fell sharply, external debt ratios and FX debt ratio are low. Due to the contraction in net borrowing, net external debt remained below 15 per cent of GDP, i.e. close to its historic minimum trough in 2023. International reserves rose over 46 EUR billion to a historic high in March 2024, with these reserves substantially exceeding level expected by investors (short-term external debt stood below 34 EUR billion at the end of 2023. Regarding the sectoral saving development, the main factors behind improving external balance is the higher net financial saving of the private sector: households' net financial saving increased significantly, while the lower capital expenditure reduced the net borrowing requirement of the corporate sector. Gross public debt increased During the COVID period due to high fiscal deficit, but since 2020 it continuously fell again: by the end of 2023 it was close to 73 percent of GDP.

External trade

Due to its export orientation Hungary's economy is characterised by an increasing openness to the global economic system. The improvement of trade balance that started in 2009 resulted in record high surpluses eventually reach its end in 2020-21, when the pandemic crisis reach its peak period. The positive surpluses in the goods market returned as the energy crisis started to modere. At the top of this period the total external trade balance accounted for 9.8% of the Hungarian GDP. The key driving forces of external trade are basically the transport equipment and related industries and the strong services sectors export performance, which drove the trade balance to positive territory for many years. In the last years 77% of Hungary's export was conducted with EU member states and 70% of the import came from the single market. The German economy has an outstanding role in this circle: in last year 26,3% of our exports and imports were transacted with Germany. Our other important export partners are Italy, Romania, Slovakia, Poland, the Check Republic and

France, while on the import side Germany is followed by China, Austria, Poland, Korean Republic and Slovakia.

The figures for 2023 show a moderate increase with year-on-year growth rate of 0.9% for the exports and 4.3 % decrease for imports. The trade balance showed a remarkable trade surplus in 2023 thanks to the normalisation of energy prices and dependencies in the energy sector. Services show a stable growth: between 2010 and 2023 value of traded services grew by 117 %, the services sector more than doubled its trade value in the last decade.

Industry

Industry is in the focus of the Hungarian economic policy. The Irinyi Plan (launched in 2016) aims to raise the Hungarian industrial sector's contribution to the annual GDP from 26.5% (in 2016) to 30% by 2020. According to this Plan Hungary wants to be among the EU countries with the most highly developed industrial sectors by 2020. Manufacturing sector constituted 23.1% of GDP in 2016. It has seen massive output growth in recent years (by 42% compared to 2008) – the rate of growth exceeded the EU average (13.5%).
The bulk (95%) of Hungary's industrial sector output is generated by the manufacturing sub-sectors. The energy sector and mining account for 5% and 0.2% regarding the total economy. In terms of output value, the output of the transport equipment sector is 29 % of total industrial output. Companies with the largest incomes are operating in the following manufacturing sectors: transport equipment, computer, electronic and optical products and food, beverages and tobacco products.

Meanwhile the value of gross value added in agriculture, forestry and fishing sector was 4.1 %, the proportion of market services was 47.7 % and the non-market services was 19.6 % in 2021.

Sectors	Share in total (%)
C Manufacturing	39,5
G Wholesale and retail trade, repair of motor vehicles and motorcycles	9,7
L Real estate activities	9,7
H Transportation and storage	9,3
A Agriculture, forestry and fishing	5,5
F Construction	5,0
D Electricity, gas, steam and air conditioning supply	4,5
M Professional, scientific and technical activities	4,1
N Administrative and support service activities	3,7
J Information and communication	2,9
I Accommodation and food service activities	2,0
E Water supply; sewerage, waste management and remediation activities	1,2
K Financial and insurance activities	0,8
B Mining and quarrying	*0,7*
R Arts, entertainment and recreation	0,5

Q	Human health and social work activities	0,5
S	Other service activities	0,2
P	Education	0,1

Table 2.5: Investments of national economy by sector in 2022 (industrial sectors with italic)

Source: Hungarian Central Statistical Office (KSH), 2022

The share of industrial sectors in total investments accounted for 49% in 2022. 39.5% of the investment was materialised in manufacturing; electricity, gas, steam and air-conditioning supply accounted for 4.5%; the share of construction was 5.0% while the role of mining and quarrying was minor. The high share of industrial sectors in total investments (which is much more than its value in the GDP) predicts an advanced growth of industrial sectors which is in line with the objectives of the Government.

Future prospects

The following table summarises a forecast for the fundamental indicators of the Hungarian economy based on the Macroeconomic and Budgetary Forecast 2022–2026 published in December 2022.

The Hungarian economy was one of the first to recover from the COVID crisis in which the comprehensive measures of the Government played a significant role. Also, after the record-high growth rate in 2021, a real GDP increase of 4.8% is expected in 2022, despite the extremely unfavorable conditions created by increasing price pressure and the escalation of the Russian-Ukrainian war.

In 2023, however, a more moderate growth of 1.5% can be expected. The main reason for the slowdown is the energy prices that are several times higher than before, as well as high inflation, which ultimately takes significant resources away from the economic agents. Despite the government subsidies, both the households and the corporate sector face significant additional expenses. Although the number of employed people may stagnate at a high level in 2023, at the same time, in line with the economic slowdown, the growth rate of wages is expected to moderate.

From 2024 onwards, the outlook is highly promising the growth is predicted to rebound and exceed 4% fuelled by accelerating productivity, investments and private consumption, while government consumption and net lending is expected to remain modest – thanks to which the government debt is on a decreasing path. Also, regarding the external trade, more dynamic annual growth rates of exports and imports can be expected stimulated by large volume export-oriented investments.

	2022	2023	2024	2025	2026
	% change				
Real GDP (constant prices)	4.8	1.5	4.1	4.3	4.5
Gross fixed capital formation	6.4	-1.0	4.9	4.8	4.1
Private consumption expenditure	6.7	0.9	3.0	3.8	3.8
Government consumption expenditure	0.8	0.5	1.3	1.4	1.4

Exports of goods and services	8.0	2.8	6.4	7.7	8.4
Imports of goods and services	8.3	1.4	5.2	6.9	7.0
Employment (15-74)	1.4	0.0	0.4	0.1	0.1
Labour productivity	3.4	1.5	3.7	4.1	4.4
Compensation per employee (HUF million)	6.5	7.5	8.2	8.9	9.7
	% of GDP				
General government ESA balance	-6.1	-3.9	-2.5	-1.5	-1.0
General government primary balance	-4.0	-1.9	0.6	1.9	2.0
Current account balance	-8.3	-5.9	-3.6	-2.0	-0.1
	%				
Harmonised Index of Consumer Prices	14.6	15.0	4.3	3.0	3.0

Table 2.6: Macroeconomic prospects 2022-2026

Source: Macroeconomic and Budgetary Forecast 2022–2026, December 2022

2.7. Energy

Country-specific trends

Security of supply - Hungary is immensely dependent on energy imports. The gas dependency is close to 80% and is increasing, because domestic production decreases more rapidly than demand. Similarly, the oil dependency is also high, 82-84% and the domestic production is falling. It is not only the import dependency, which causes vulnerability for Hungary, but also the unilateral character of it. The major part of the import and practically all the gas originates from Russia, even if a part of it is transported to Hungary through the European network. Then it is not surprising that the key message of the Hungarian energy policy is seeking ways out of our energy dependency, in particular natural gas and petroleum dependency. The five means to achieve the above goal include energy savings, increasing the share of renewable energy sources to the greatest possible level, safe nuclear energy and the electrification of transport based on the former, diversification of source and transit routes safeguarding Hungary's natural gas and oil import, and last but not at least, utilising domestic fossil energy reserves (coal, lignite, unconventional natural gas) in an eco-friendly manner involving BATs and R&D (zerocarbon 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 2.12.

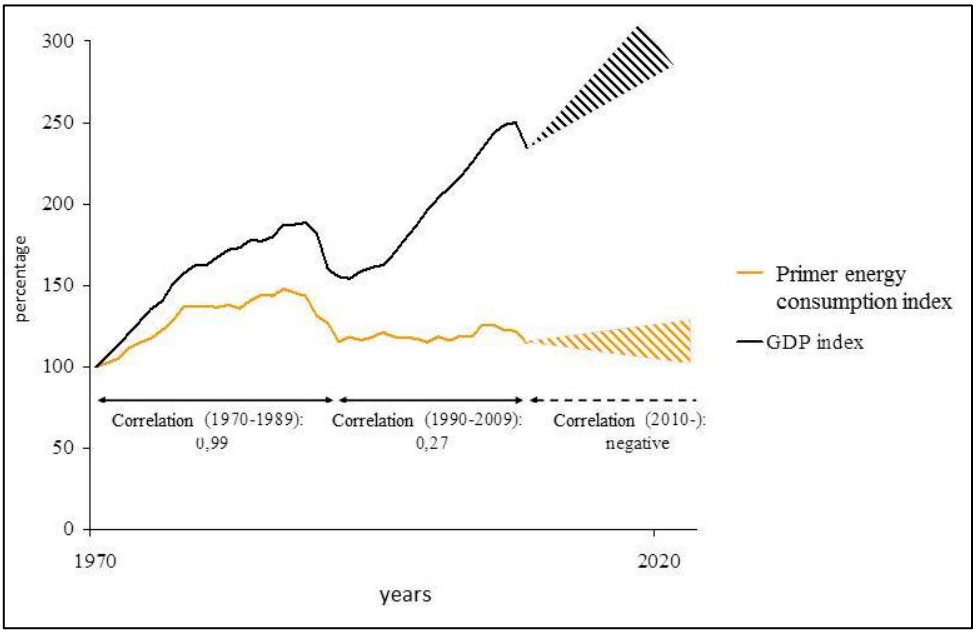


Figure 2.12: Economic growth and energy consumption is successfully decoupled in Hungary
Source: National Energy Strategy 2030

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. The three most important elements of the energy efficiency improvement plans are the following:

1. Thermo retrofitting of buildings and the modernisation of heating and cooling systems;
2. Installing high-efficiency new-, and modernisation of existing electric power stations;

3. Implementation of Ányos Jedlik Plan 2.0 targeting a modal shift toward ambitious electrification of the transport sector.

Renewables – As an EU Member State, Hungary is subject to a binding target of 13% of energy from RES by 2020. Thanks to the targeted supporting schemes (METÁR, Environmental and Energy Efficiency OP, etc.) and measures, the recent share (2021) of RES in the gross inland energy consumption is 14.1%, over the target set by the Renewable Energy Directive. Nevertheless, further efforts are needed to reach Hungary's 2030 targets in spreading RES applications. According to the National Energy Strategy 2030, with an outlook to 2040 the share of RES in the primary energy consumption has to reach 21%.

The expected increase in the share of renewables in the electricity sector is based fundamentally on a dynamic growth in photovoltaic production. According to the envisioned scenario, the share of domestic renewable energy sources in domestic electric power consumption will be increased to at least 20% by 2030. Based on data from the Hungarian Energy and Utilities Regulatory Authority, the proportion of renewables in the electrical sector reached 13.7% in 2021. In recent years, thanks to state subsidies, the utilization of solar energy has increased more and more, so the country will reach the 6 GW target planned for 2030 earlier. In 2022, the installed capacity of solar panels reached 4 GW. 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.

Key data

Energy use per capita: 2.5 toe (OECD average: 4.5), -1.7% since 2000

Energy intensity: 0.16 toe per 1000 USD (OECD average: 0.16), -20.8% since 2000

Total Final Consumption: residential sector 31%, industry 26%, transport 25%, commercial and agriculture 18% (OECD average: transport 32%, industry 32%, residential 19%, other 16%)

THE NET ELECTRICITY CONSUMPTION BY ECONOMIC SECTOR IS SHOWN IN THE TABLE BELOW

Source: http://www.mekh.hu/data-of-the-hungarian-electricity-system-2021

7.3 NETTÓ VILLAMOSENERGIA-FOGYASZTÁS GAZDASÁGI ÁGANKÉNT
NET ELECTRICITY CONSUMPTION IN DIFFERENT INDUSTRIAL SECTORS

NEMZETGAZDASÁGI ÁG / INDUSTRY OF THE NATIONAL ECONOMY		2014[2]	2015[2]	2016[2]	2017[2]	2018[2]	2019[2]	2020[2]	2021[1]
KÓD / CODE	MEGNEVEZÉSE / ITEM								
A	**Mezőgazdaság, vad-, erdő- és halgazdálkodás** Agriculture, wildlife management, forestry, and fishery	743	788	841	794	818	832	840	845
B	**Bányászat** Mining	84	94	104	108	117	122	117	131
C	**Feldolgozóipar** Manufacturing industry	13 540	14 329	14 292	14 851	14 154	14 107	13 980	13 925
D	**Villamosenergia-, gáz-, hőellátás** Electricity, gas, heating supply	1 391	1 234	1 220	1 139	1 188	1 169	1 130	1 168
F	**Építőipar** Construction industry	345	379	336	341	404	445	420	472
G	**Kereskedelem, javítás** Commerce, reparation	2 221	2 457	2 071	2 088	2 110	2 095	2 036	2 080
H	**Szállítás, raktározás, posta, távközlés** Transportation, storage, post, and telecommunications	1 359	1 507	1 863	1 935	1 898	1 946	1 851	1 928
I	**Szálláshely-szolgáltatás és vendéglátás** Accommodation and catering	541	536	607	631	691	723	590	600
P+Q+R+S	**Egyéb közösségi, személyi szolgáltatás** Other social or private services	1 332	1 245	1 197	1 397	1 274	1 292	1 181	1 296
	Háztartások Households	10 427	10 672	10 720	10 972	11 025	11 162	11 734	12 198
E+J+... +O+U	**Egyéb fogyasztás** Other consumption	5 017	4 885	5 666	5 977	7 267	7 659	7 612	9 204
	Nettó fogyasztás összesen Total net consumption	**37 000**	**38 124**	**38 917**	**40 232**	**40 945**	**41 552**	**41 491**	**43 848**
	ebből: egyetemes szolgáltatók értékesítése of which the sales of electricity universal service providers	10 919	11 068	11 070	11 318	11 597	11 761	12 197	13 199

Az adattartalom hosszú idősorban megtalálható a 10.9-es táblázatban. | Retrospect data can be found in table 10.9.
[1] **Előzetes adatok.** | Preliminary data.
[2] **Felülvizsgálva az előző évi kiadványhoz képest.** | Reviewed compared to previous publication.

The Built-in Capacity:

Source: http://www.mekh.hu/data-of-the-hungarian-electricity-system-2021.

(The data in the table above is provided in GWh.)

4.2B MEGOSZLÁS A KIS- ÉS NAGYERŐMŰVEK KÖZÖTT, 2021. DECEMBER 31-ÉN
SHARE BETWEEN SMALL AND LARGE POWER PLANTS ON 31 DECEMBER 2021

	BT IC		RTá ACc		RTv ACv		RTá/BT ARÁNY ACc/IC RATIO	RTá/BT HIÁNY (100%-RTá/BT ARÁNY) ACc/IC LOSS (100%-ACc/IC RATIO)
	MW	%	MW	%	MW	%	%	%
Nagyerőművek Large power plants	6 884,0	66,7%	5 642,3	62,5%	5 742,3	86,7%	82,0%	18,0%
Kiserőművek Small power plants	3 429,8	33,3%	3 379,4	37,5%	883,6	13,3%	98,5%	1,5%
Összesen Total	**10 313,8**	**100,0%**	**9 021,7**	**100,0%**	**6 625,9**	**100,0%**	**87,5%**	**12,5%**

ABBREVIATED NAME	FULL NAME	ABBREVIATED NAME	FULL NAME
AC	Available capacity (AC=ACv-PPM)	**PPM**	"Capacity decrease due to planned preventive maintenance"
ACc	Available capacity /constant/ (ACc=NTO+IC-CL)	**RC**	Reliable capacity (RC=AC-FO-Loss)
ACv	Available capacity /variable/(ACv=ACc+ATO-VarSt-Loss-WLoss)	**RDC**	Remaining domestic capacity
ATO	Actual trial operation	**RMC**	Remaining capacity
CL	Resultant of constant capacity losses and surpluses	**RRC**	Required remaining capacity
EXIM	Import-export balance	**TSOres**	TSO reserve
FO	Forced outage	**UPM**	Unplanned maintenance
HES	Hungarian electricity system	**VarLoss**	Variable losses (WLoss+VarStLoss-ATO)
IC	Gross installed electric capacity	**VarStLoss**	Variable losses due to steam supply
Loss	Other losses	**VET**	Electricity Act
NTO	Nominal trial operation	**Wloss**	Capacity losses due to weather

Supply and demand

Domestic energy production constitutes 42% of the **total primary energy supply (TPES)**, while the nation's reliance on imports is increasing (refer to Figure 2.13). Predominantly sourced from natural gas and oil, with nuclear power contributing significantly to electricity generation, these resources form the cornerstone of the energy landscape. Notably, oil primarily fuels the transportation sector, while natural gas commands the highest proportion of energy consumption within both residential and commercial domains.

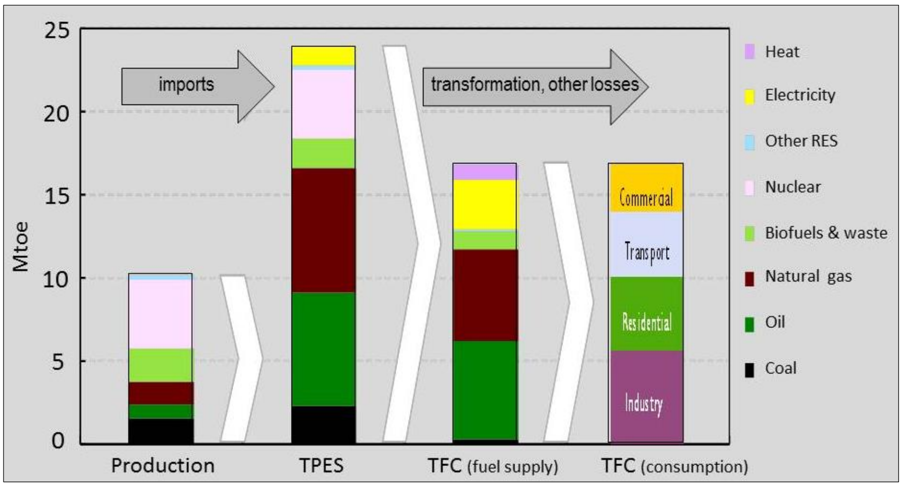


Figure 2.13. - Overview of energy production, TPES and TFC in 2014
Source: IEA (2016a), *Energy Balances of OECD Countries 2016*, www.iea.org/statistics/.

* Other renewables constitutes of small shares of wind, hydro, solar and geothermal

Supply

Total energy supply (TES) has been slowly declining in Hungary since a 1987 peak of 31 Mtoe (Figure 2.14.), to 24 Mtoe in 2015. Between 2005 and 2015, TPES has fallen by 13%, despite a 6.5% rebound in the last two years. Natural gas and oil account for almost one-third of TPES each, with the remaining energy supply coming mainly from nuclear, coal and biomass.

Note: Data are estimated for 2015.
** Negligible*

Figure 2.14.: Total energy supply by source, 1990-2022

Source: International Energy Agency

Energy production peaked at 16.8 Mtoe in 1987 and has declined by 37% since. (Figure 2.15.) 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 (Figure 2.13.) 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.

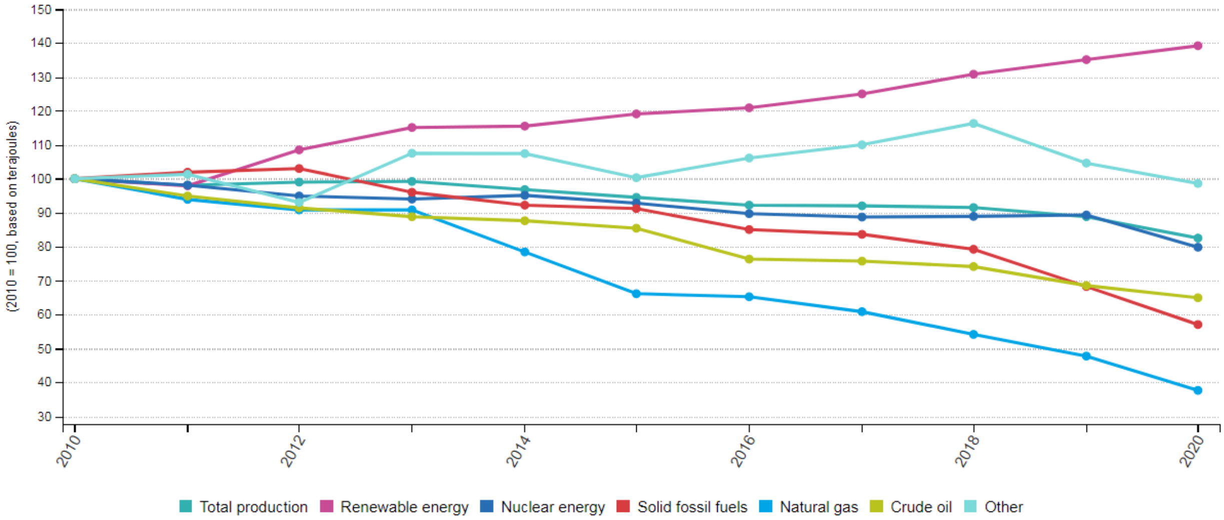


Figure 2.15. Primary energy production by fuel type, 2010-2020

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

Note: Data are estimated for 2015.
** Negligible*

Fossil fuel production has declined significantly over 42 years, from 15 Mtoe in 1978 to below 4 Mtoe in recent years. Coal production was 0.8 Mtoe in 2021, representing a decline of 47% since 2005. Natural gas dropped by 54% over the same period to record lows of 1.2 Mtoe. In 2015, biofuel and waste production were 2.0 Mtoe, an increase of 75% compared to 2005. 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 86% of its needs. Oil import dependency was higher in the past but has increased in the last decade from 80% in 2005 to 88% in 2015. Domestic coal production still meets about two-thirds of demand.

Demand

Total final consumption (TFC) of energy experienced a slight increase from the early 1990s until 2005 and continued its slightly upward trend ever since. Between 2004 and 2021, TFC slightly increased reaching its maximum of 18 Mtoe in 2021. Industry accounts for one-fourth of TFC (Figure 2.16.) since 2004 and generated about the same consumption in 2019 (Figure 2.16.). The transport sector accounts for almost one-third of TFC and consumption in this sector has been increasing heavily in the last decade.

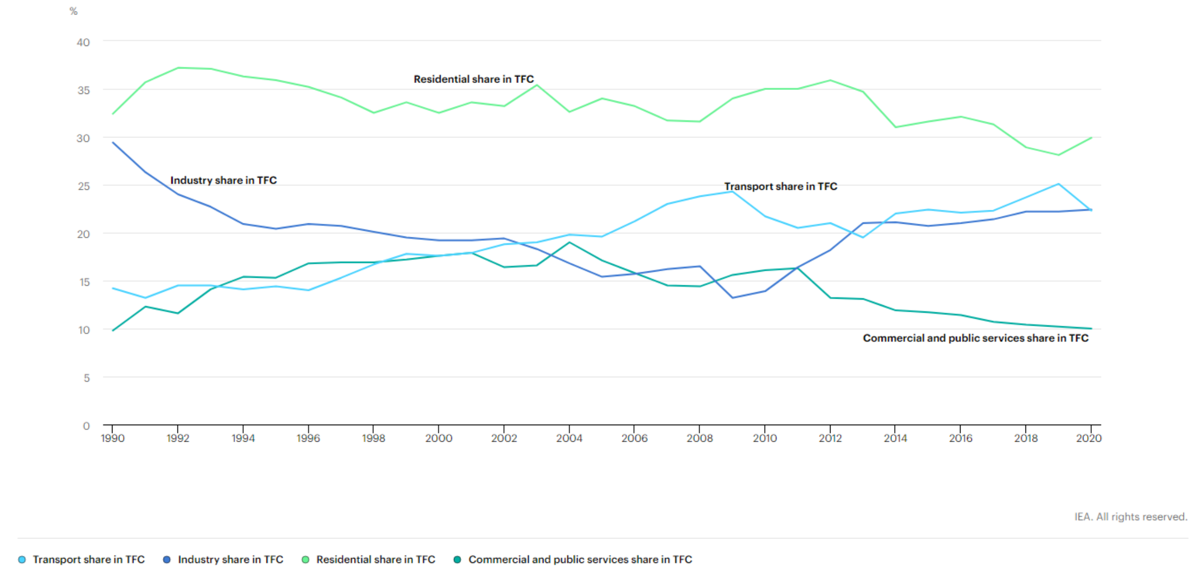


Figure 2.16. TFC by sector, 1990-2020
Source: IEA (2020) www.iea.org/statistics/.

* *Industry* includes non-energy use.
** *Commercial* includes commercial and public services, 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. **The transport sector** is the largest oil consumer accounting for 61% of oil in terms of TFC in 2014, followed by the industry sector, which uses oil as a fuel and as a feedstock (Figure 2.18.). **Natural gas and electricity** are the main energy sources consumed in the residential, commercial and industry sectors.

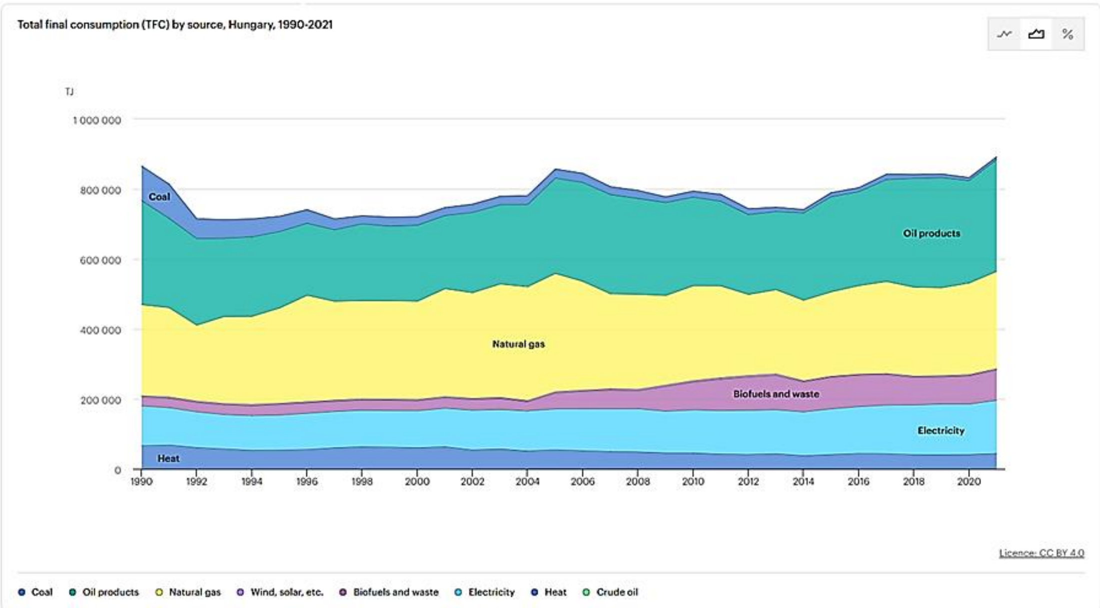


Figure 2.17: Total final consumption, by source, 1990-2021
Source: IEA (2024) https://www.iea.org/data-and-statistics/

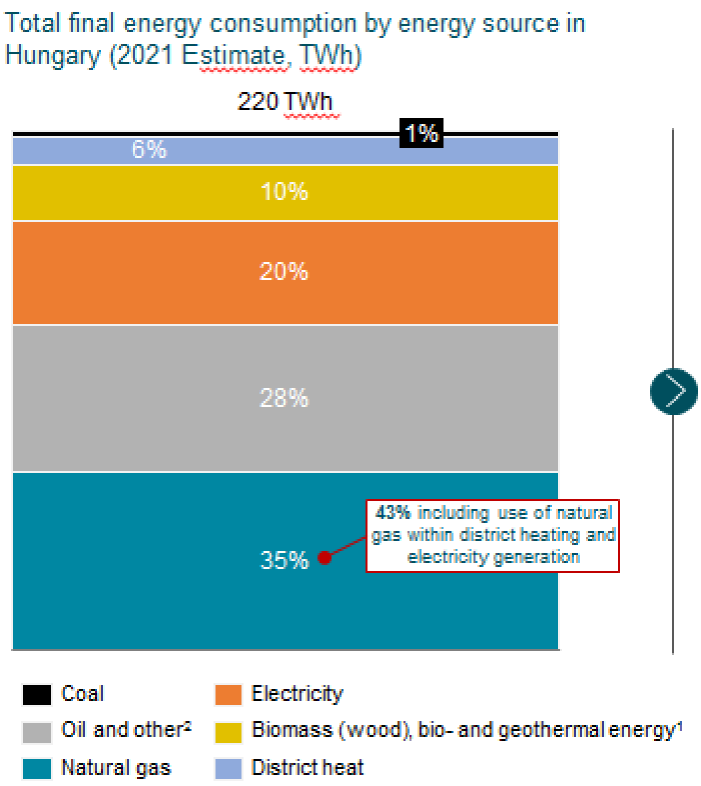


Figure 2.18. Fuel share of TFC by sector, 2021
Source: Eurostat, BCG analysis (2022)

* *Industry* includes non-energy use.
** *Commercial* includes commercial and public services, agriculture, fishing, and forestry.
*** Other renewables constitute of small shares of wind, hydro, solar and geothermal.

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 capacity expansion at Paks Nuclear Power Plant). The Ministry of Energy is also responsible for renewable energy, climate policy and energy efficiency.

The Ministry for Foreign Trade and Foreign Affairs is the project owner of the capacity expansion at the Paks nuclear power plant also known as the Paks 2 project.

MVM Group is a fully stateowned company that operates under the supervision of the Prime Minister's Office. Its portfolio covers the total domestic energy system.

The Ministry of Foreign Affairs and Trade is responsible for energy security and diplomacy.

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 Agency (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, as well as the related public relations activities. Supervisory Authority for Regulated Activities (SZTFH) is an independent regulatory body in Hungary that performs tasks defined by law, often unrelated and is subordinated only to legislation. 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.

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 land-locked 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 (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 2020. Domestic oil production, which was 0.86 Mt in 2015, is expected to continue to decline thereby increasing dependence on imports. Oil consumption increased from 6.6 Mt in

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

2014 to 7.1 Mt in 2015. The transportation sector dominated oil consumption accounting for 60% of demand in 2015.

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. Hungary receives about 10 bcm of natural gas yearly. Due to the changed circumstances, Hungary plans to reduce its Russian natural gas imports and consumption. For instance, to increase its energy independence, the country will reduce its use of natural gas in the final energy consumption from 34% to 9%, will increase the use of electricity in all sectors (industry, transport, and residential sectors) from 19% to 49% of final energy use. The country currently gains 15% of the electricity produced from renewable energy sources, which proportion will be increased to 60% by 2050. Partly with the rise of renewables and partly with nuclear energy, Hungary will reduce electricity imports from the current 36% to 6% by 2050; 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 was equivalent to 79 days of net imports on January 13, 2023. 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 with total stock levels standing at 92 days. 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 2023 are the Special Natural Gas Stock, which is 744 mcm and the Security Gas Stock (which was previously reduced to 915 mcm in 2015) is 1198 mcm in 2023, totalling 1942 mcm. The level of stocks is determined by a ministerial decree.

Electricity production and consumption

Source: http://www.mekh.hu/data-of-the-hungarian-electricity-system-2021

10.4 ORSZÁGOS BRUTTÓ ÉS NETTÓ VILLAMOSENERGIATERMELÉS, IMPORT-EXPORT SZALDÓ ÉS AZ ÖSSZES FELHASZNÁLÁS (GWh)

NATIONAL GROSS AND NET ELECTRICITY GENERATION, IMPORT-EXPORT BALANCE, AND TOTAL CONSUMPTION (GWh)

ÉV YEAR	1 BRUTTÓ TERMELÉS[1] GROSS GENERATION[1]	2 ERŐMŰVI ÖN-FOGYASZTÁS ONSITE CONSUMPTION OF POWER PLANTS	3 NETTÓ TERMELÉS (1-2) NET GENERATION (1-2)	4 IMPORT IMPORT	5 EXPORT EXPORT	6 IMPORT-EXPORT SZALDÓ (4-5) IMPORT-EXPORT BALANCE (4-5)	7 ÖSSZES FELHASZNÁLÁS (1+6) TOTAL CONSUMPTION (1+6)	8 BRUTTÓ FOGYASZTÁS (7-2) GROSS CONSUMPTION (7-2)	9 HÁLÓZATI VESZTESÉG NETWORK LOSSES	10 NETTÓ FOGYASZTÁS (8-9) NET CONSUMPTION (8-9)
2010	37 371	2 758	34 613	9 897	4 702	5 195	42 566	39 808	3 801	36 007
2011	35 984	2 484	33 500	14 664	8 022	6 642	42 626	40 142	3 784	36 358
2012	34 328	2 426	31 902	16 969	9 003	7 966	42 294	39 868	3 684	36 184
2013	30 306	2 264	28 042	16 638	4 760	11 878	42 184	39 920	3 663	36 257
2014	29 357	2 114	27 243	19 078	5 690	13 388	42 745	40 631	3 631	37 000
2015	30 250	2 117	28 133	19 936	6 249	13 687	43 937	41 820	3 695	38 124
2016	31 888	2 130	29 758	17 965	5 240	12 725	44 613	42 483	3 566	38 917
2017	32 879	2 067	30 812	19 803	6 926	12 876	45 755	43 689	3 456	40 232
2018	32 038	2 086	29 953	18 613	4 265	14 348	46 386	44 301	3 355	40 945
2019[3]	34 278	2 019	32 259	19 854	7 269	12 585	46 863	44 844	3 292	41 552
2020[3]	34 912	1 959	32 953	19 176	7 498	11 678	46 590	44 630	3 139	41 491
2021[2]	36 040	1 895	34 145	19 967	7 212	12 755	48 795	46 899	3 052	43 848

[1] **Háztartási méretű kiserőművek és egyes saját felhasználásra termelő kiserőművek adatait nem tartalmazza a táblázat 2019. év előtt.** | The table does not include the data of small-scale power plants and certain small power plants producing for private use before 2019.
[2] **Előzetes adatok.** | Preliminary data.
[3] **Felülvizsgálva az előző évi kiadványhoz képest.** | Reviewed compared to previous publication.

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 44%., with most of the remaining generation depending on coal, natural gas and about 10% of renewables. 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 the country's neighbours except for Slovenia, where the interconnector is planned to be built in the forthcoming years under a Project of Common Interest (PCI). In 2016 the electricity interconnection level of Hungary was 37%, having increased from 29% in 2014 and being well above the 2020 EU target of 10%.

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. Every power plant over 50 MW is required to keep an equivalent of 16 days of stocks of alternative fuel. In case of under-frequency in the grid, the TSO can make use of automatic or manual load shedding. Regulated electricity prices mean that voluntary load shedding (interruptible contracts) or smart metering are not measures available to the TSO in a disruption. The response system was well-tested during two major weather-related disturbances in recent years.

Nuclear energy was the source of 44% of domestically generated electricity in 2021 and will continue to play a major role in the power sector into the foreseeable future. NES 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, see Paks II. project which received the establishment permit this summer on August 29 besides the construction permit for the reactor building of unit 5, thus making it possible to start the construction work.

This objective can be ensured in several ways: a lifetime extension of Paks 1; 2. The construction of Paks 2 would be the largest investment in the Hungarian energy sector for several decades and therefore considered a flagship project by the government and the ownership rights are exercised directly by the Ministry for Foreign Affiars and Trade. Once Paks 2 commences operation it will need to be integrated into the electricity market and contribute in a competitive way to the "coal-nuclear-green" scenario, which is envisaged in NES 2030 with an outlook until 2040.

The four Paks 1 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 will 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 1 (the shut down is transferred to a later date by the extension of the operating time), the Paks II. Project received the establishment permit in the summer of 2022, and it will be operational by 2032 according to the plan.

In January 2014, Hungary signed an Inter-Governmental Agreement with the Russian Federation for the construction and technical support of two units of 1 200 MWe at Paks 2. 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 be financing the remaining 20%.

2.8. Industry

Industry is the most significant sector of the Hungarian national economy, its share in GDP was 22.4% in 2021. According to preliminary data, the volume of investments in the whole national economy increased by 4.3% in 2021 compared to the previous year.

Industrial production volume increased by 9.6% in 2021 compared to the low base a year earlier, and exceeded the pre-pandemic level. Most industrial sectors contributed to the growth, but output in the transport equipment manufacturing, having the largest share among sectors, continued to decline, with production stalling mainly due to the global chip shortage. Within manufacturing, the largest expansion was in electrical equipment manufacturing again, with the arrival of new firms producing vehicle batteries and electric motors.

In the 3rd quarter of 2022 the volume of developments increased by 7.7% compared to the same period of the previous year, and by 1.9% compared to the previous quarter (seasonally adjusted). The quickening was caused by the dynamic activity of households and businesses, while budgetary developments decreased. Manufacturing developments, having a dominant weight, as well as energy industry and housing investments increased the investments of the national economy, while transportation and storage, furthermore agriculture-related investments held them back.

The Government approved the Irinyi Plan in February 2016. The strategy is a frame for further manufacturing industrial strategies. It has identified five pillars and seven focus areas based on global industry trends, our opportunities, current experience, recent and potential export destinations, state of the domestic business environment, FDI attracting ability, and the ability to dissolve regional disparities.

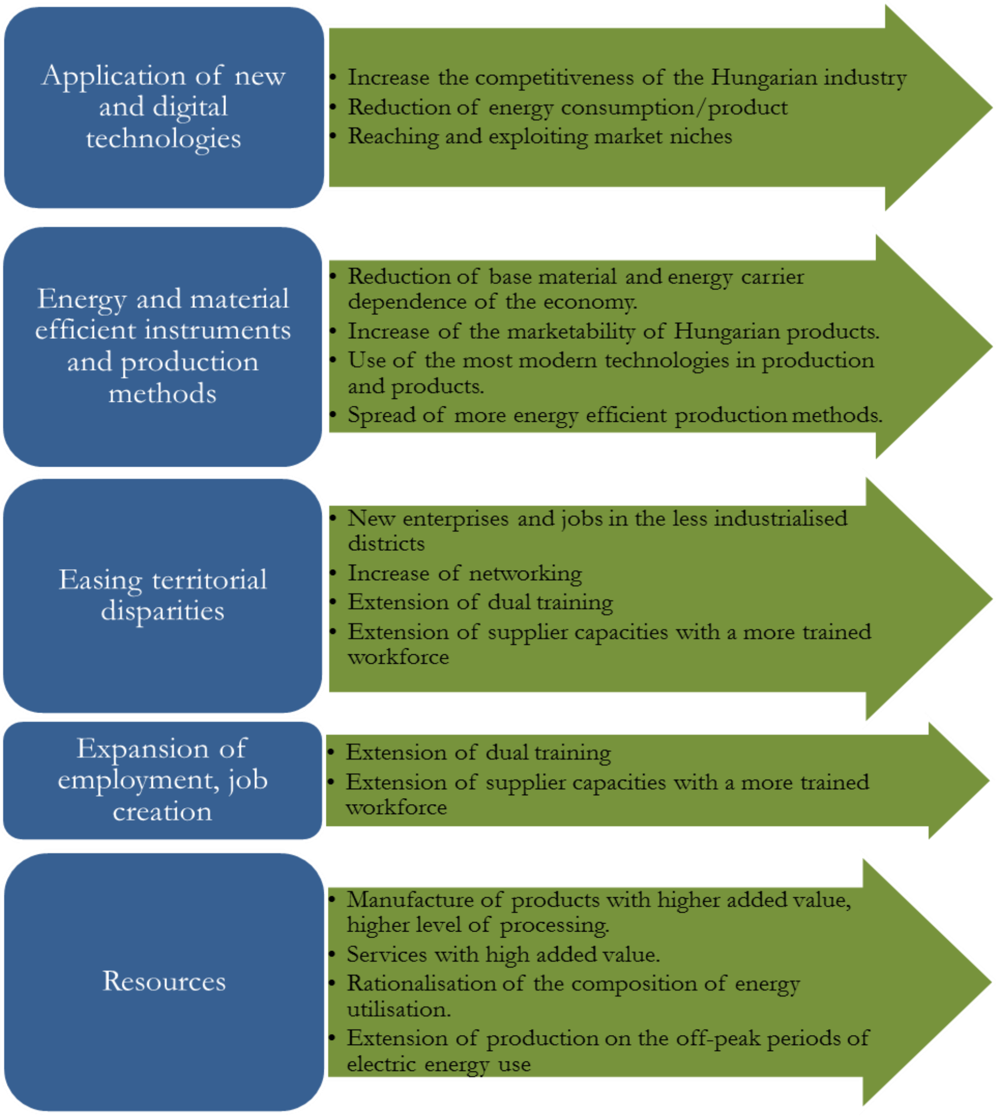


Figure 2.19 Five pillars of the Manufacturing Industrial Strategy2016

Source: Irinyi Plan, Ministry for National Economy, 2017

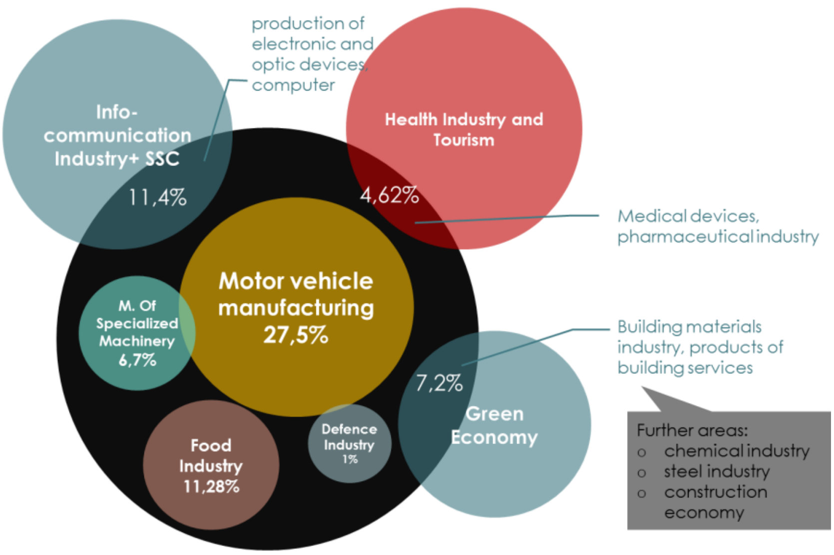


Figure 2.20 Connection between the priority sectors of the Irinyi Plan and the manufacturing industry

Source: Ministry for National Economy, 2017

The Irinyi Plan aims to strengthen the share of industry in GDP from 23% to 30%, as well as to ease the national economic dependence on the automotive industry. In the past period the pandemic, disruptions in supply chains and the market price increase of raw materials and energy carriers caused by negative world political and economic processes have not made it possible to achieve the goal. Despite all this, the industry strengthened by the measures taken along the set goals performed well in crises, the volume of GDP in 2021 overall was all 7.1% higher during the year than in 2020, it even exceeded the pre-pandemic 2019 level by 2.3%.

The **manufacturing industry**, is the most significant industrial segment in Hungary with its 1/3 share in the total industrial investment. According to recent data, small and medium-sized enterprises of the manufacturing industry were also more likely to invest besides the specific investments. FFurther, greenfield projects were concluded which had a positive effect on the expansion and development of the supplier network too.

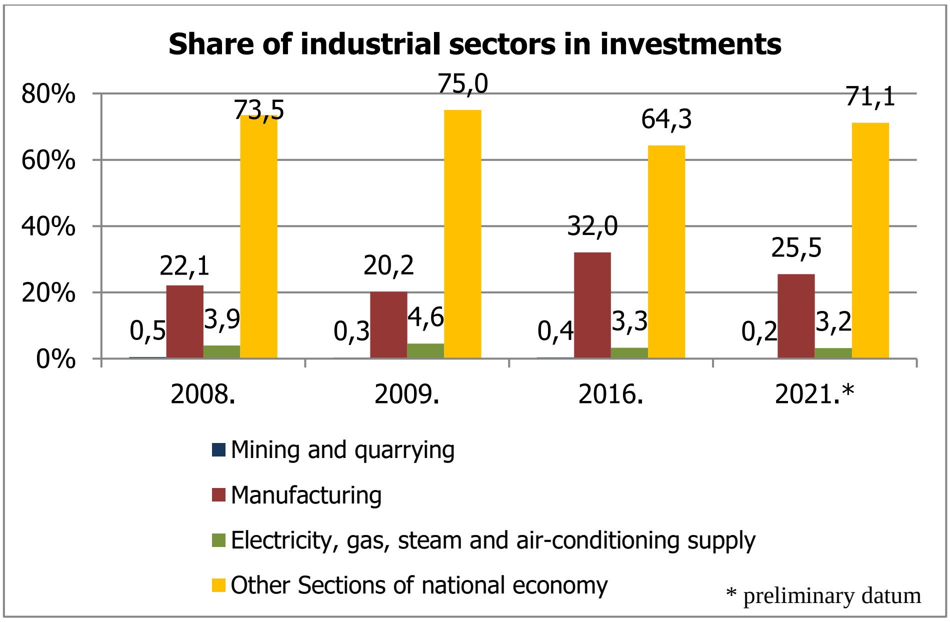


Figure 2.21 Share of industrial sectors in investments, 2021

Source: Hungarian Central Statistical Office (KSH), 2022

In the 3rd quarter of 2022 the seasonally adjusted volume of the national economy's investments increased by 1.9% compared to the previous quarter. Within it the seasonally adjusted volume of construction investments increased by 4.5%, while investments in machinery and equipment decreased by 2.0%

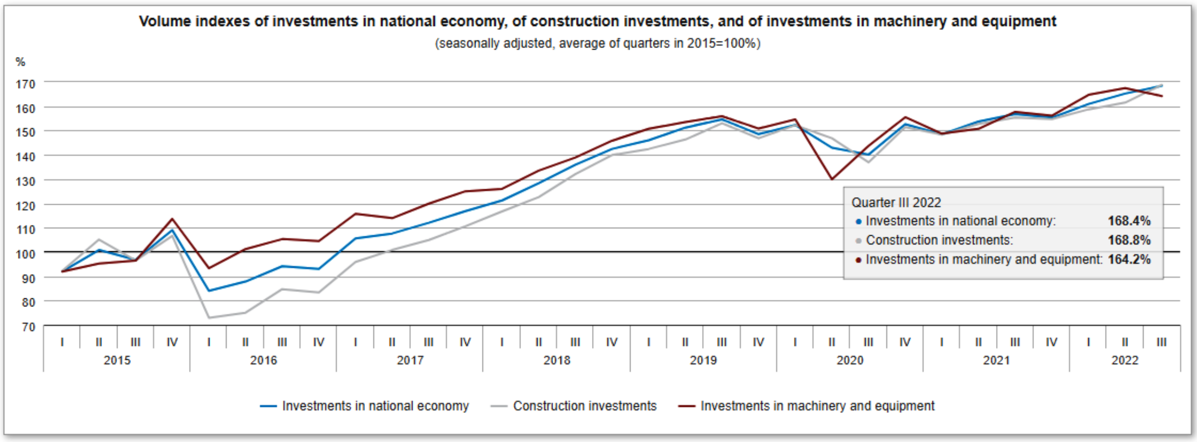


Figure 2.22

Source: Hungarian Central Statistical Office (KSH), 2022

In the 3rd quarter of 2022 compared to the same period of the previous year the volume of investment activity increased by 7.7%. Within it, **construction investments** representing almost two-thirds of the performance value of investments increased by 10%, **investments in machinery and equipment**, accounting for more than one-third of investments grew by 3.3%. Within machinery investments, the volume of imported machinery grew, while that of domestically produced ones decreased.

Among **enterprises** with at least 50 employees, accounting for 56% of the investment output, the volume of developments grew significantly by 10 % where developments of foreign-owned enterprises played a prominent role. At the same time at **budgetary units**, which accounted for 11% of investments, the performance dropped by about one-tenth. While central government bodies saw their developments decreasing significantly, purchases of fixed assets by local governments slightly increased. Investment volume at other categories (enterprises with fewer than 50 employees, private entrepreneurs, non-profit enterprises as well as households) grew by 9.5%.

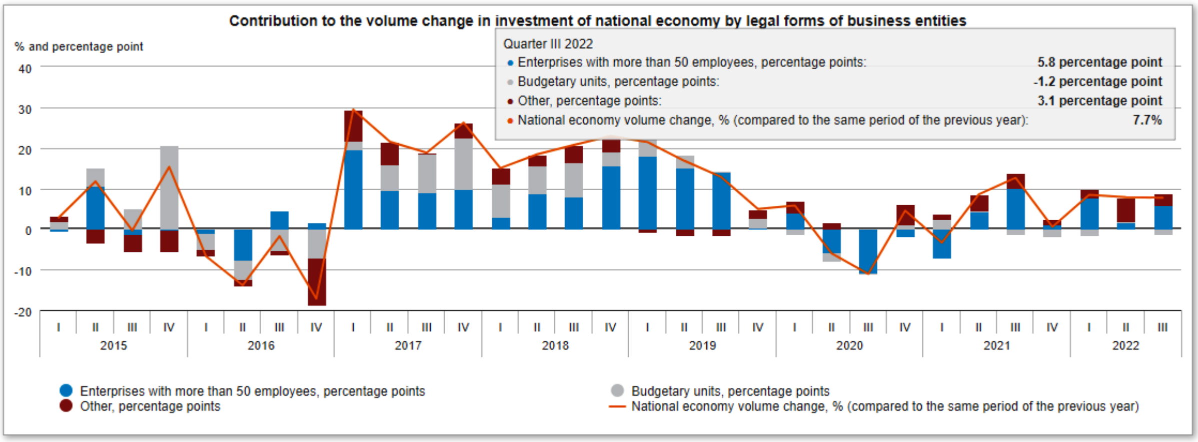


Figure 2.23

Source: Hungarian Central Statistical Office (KSH), 2022

Volume changes in investments over the reference period are different between sectors. Developments in **manufacturing**, **representing the largest proportion (30%)** of

developments in the national economy, **increased greatly (by 31%) in the third quarter**, thus this area significantly supported the increase in the volume of investments. This was primarily due to the high-volume projects started in the previous periods in the field of electrical equipment manufacturing, but the revival of investments in vehicle production also played a role in the growth. Developments in the third major subsection, the manufacture of food products, also significantly exceeded the previous year's value, in contrast, we measured a decrease in the production of basic metals and fabricated metal products.
Investment performance of **real estate activities**, the second largest investor, accounting for one-fifth of developments in the national economy, grew significantly, by 17%, primarily due to the large increase in dwelling constructions as well as property renovations, which represent, jointly, a decisive weight.
The decrease (-7.2%) typical of the previous quarter in the investment volume in **transportation and storage** continued, with the negative performance still mainly driven by a slowdown in public infrastructure developments.

In the field of **wholesale and retail trade** investments increased by 3.7%, due to the fact – among others – that enterprises operating in wholesale tradeincreased their investments.
After the significant expansion of the past quarters, the investment performance in **agriculture, forestry and fishing** decreased by 5.7% compared to the otherwise high base, wherethe the fact that larger companies dealing with stock-raising or crop production reduced their investment expenditure also played a role.

In the 6th largest weight representing energy industry section investments increased greatly, by about 45%, primarily due to the higher expenditure of public investments in the reference period.

Manufacturing contributed the most (by 7.6 percentage points) to the 7.7% volume increase of the national economy's investments in the 3nd quarter of 2022. Investment activity also grew due to the investment performance in real estate activities, energy industry, and trade (by 3.2, 1.2 as well as 0.2 percentage points). At the same time performance decreases in transportation and storage, and agriculture held back the volume increase (by 1.1 as well as 0.3 percentage points).

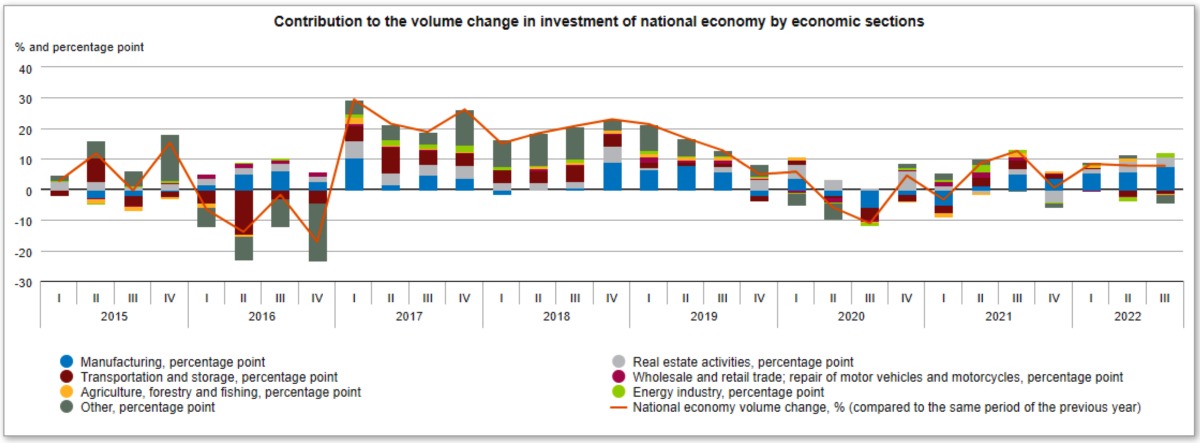


Figure 2.24

Source: Hungarian Central Statistical Office (KSH), 2022

Quarter III 2022

• Manufacturing, percentage point:	7.6 percentage point
• Real estate activities, percentage point:	3.2 percentage point
• Transportation and storage, percentage point:	-1.1 percentage point
• Wholesale and retail trade; repair of motor vehicles and motorcycles, percentage point:	0.2 percentage point
• Agriculture, forestry and fishing, percentage point:	-0.3 percentage point
• Energy industry, percentage point:	1.2 percentage point
• Other, percentage point:	-3.0 percentage point
• National economy volume change, % (compared to the same period of the previous year):	7.7%

Source: Hungarian Central Statistical Office (KSH), 2022

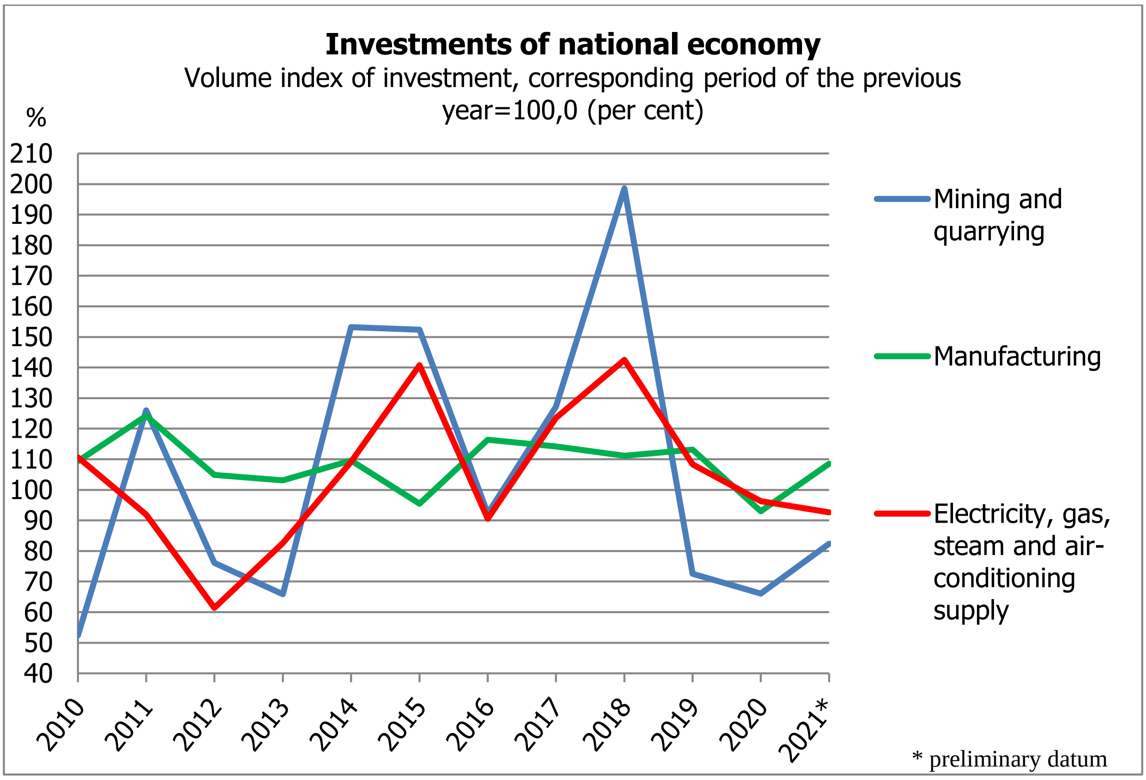


Figure 2.25 Investments of national economy, 2021

Source: Hungarian Central Statistical Office (KSH), 2022

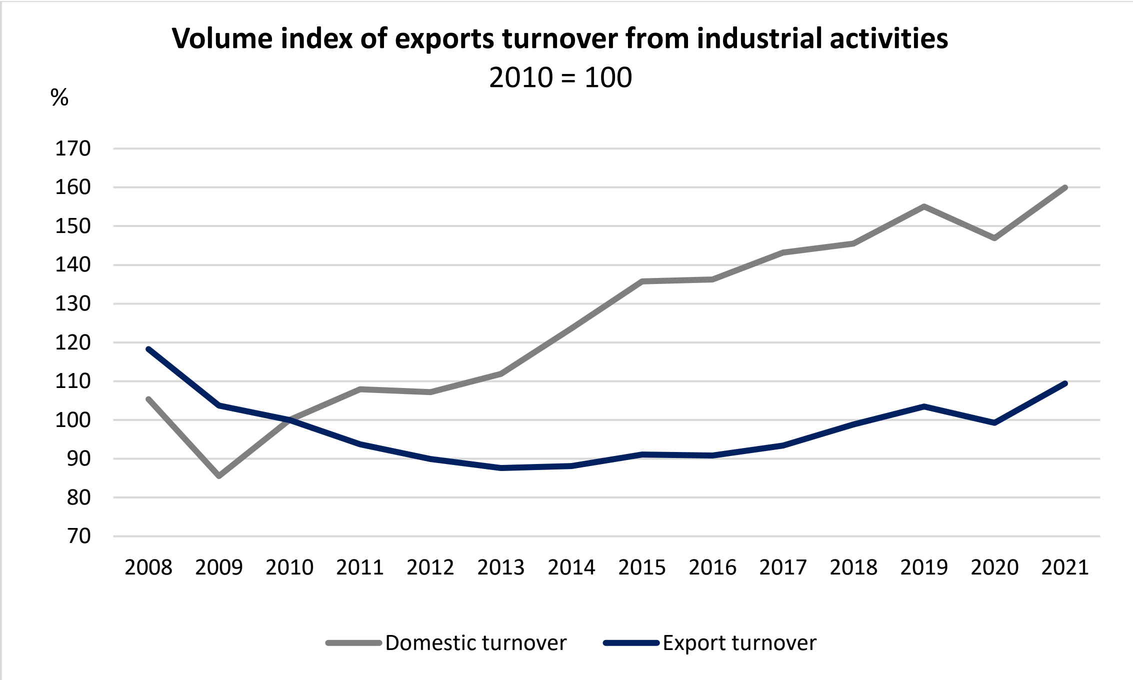


Figure 2.26 Volume index of export turnover from industrial activities, 2021

Source: Hungarian Central Statistical Office (KSH), 2022

In 2021, **industrial production** expanded by 9.6% compared to 2020, burdened by the coronavirus epidemic and also exceeded the level of 2019 before the pandemic. However, due to the lack of chips, production decreased in vehicle manufacturing, which is the most important and represents 24% of manufacturing production.

Foreign market sales rose by 8.9% in 2021. Similar to production, exports decreased only in 2012 and 2020 over ten years. Domestic sales of the industry exceeded the previous year by 11.4%.

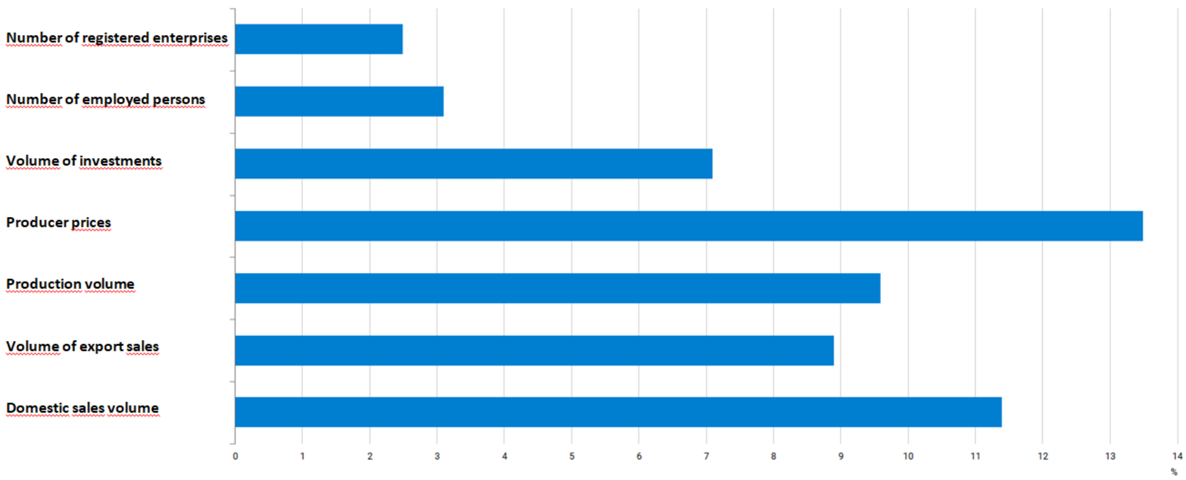


Figure 2.27.: Change in the main indicators of the industry compared to the previous year, 2021

Source: Hungarian Central Statistical Office (KSH), 2022

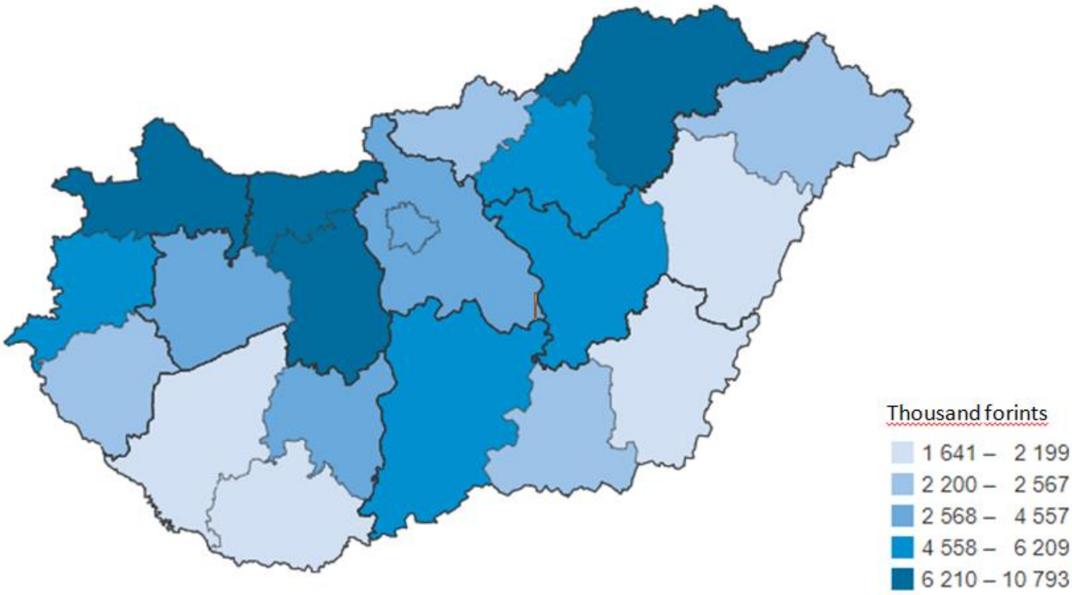


Figure 2.28: Industrial production per inhabitant, 2022. I–III. quarter

Source: Hungarian Central Statistical Office (KSH), 2022

The production value per inhabitant was the highest in Komárom-Esztergom and Győr-Moson-Sopron counties, more than double the national average (4.1 million forints). Based on the data by location of the companies employing at least 50 people, the volume of production increased by 6.7%. Most branches of the manufacturing industry contributed to this, this time too the production of electrical equipment, which also includes the production of batteries and electric motors, expanded to the greatest extent, by 28%. The performance of vehicle production, which accounts for almost a quarter of manufacturing output and thus has the largest weight, exceeded the previous year by 9.6%, thanks to the fact that, with the easing of spare parts supply problems, the industry expanded significantly in the third quarter. Among the largest centres of domestic production, the volume of production increased slightly in Győr-Moson-Sopron counties, and significantly in Bács-Kiskun, Komárom-Esztergom and Veszprém counties.

Value of industrial production by sub-sections (at current prices in million HUF)

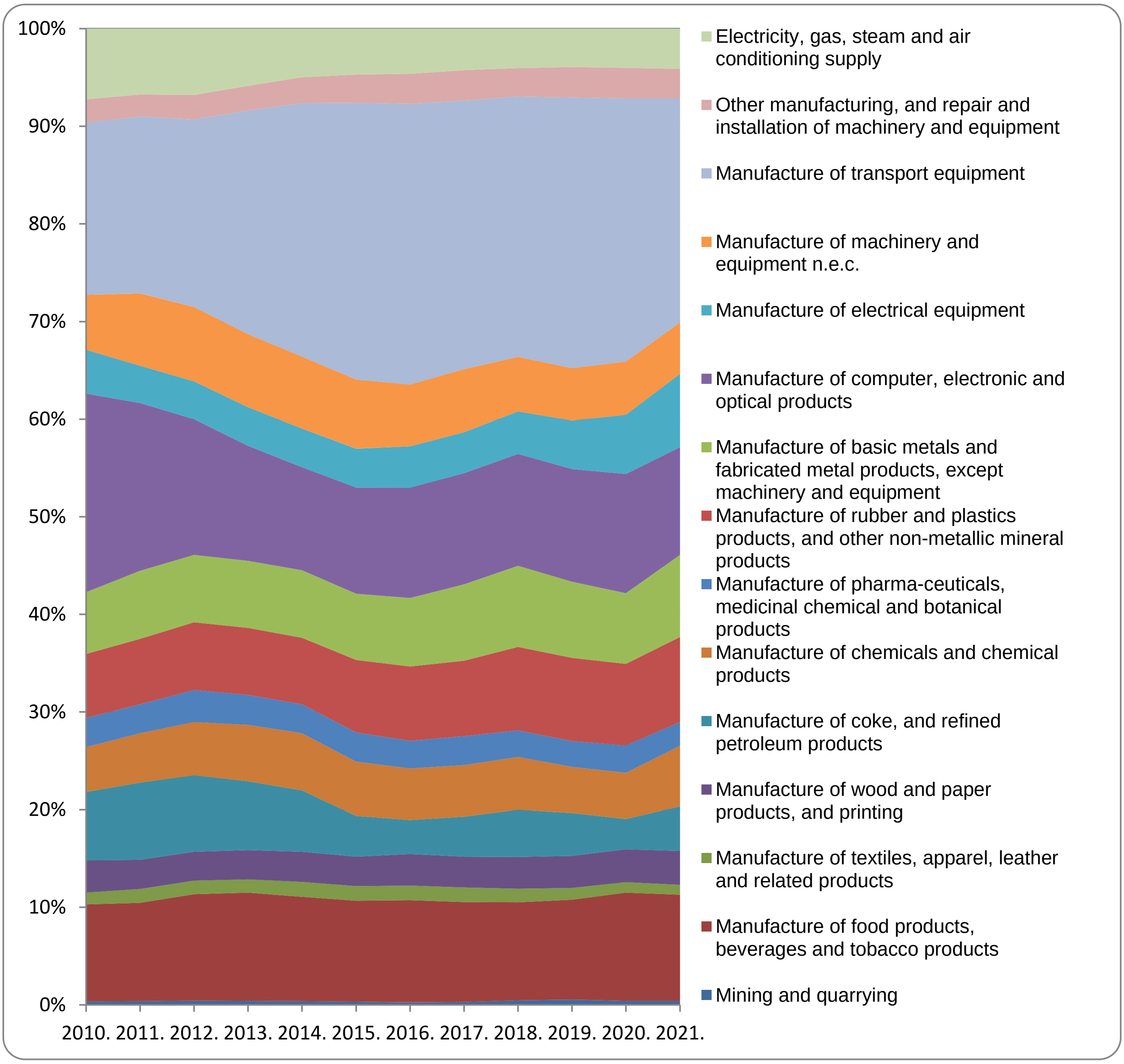


Figure 2.29 Industrial output by the most relevant sectors

Source: Hungarian Central Statistical Office (KSH), 2022

In 2021 among the branches of the national economy, in the manufacturing industry which accounts for 95% of production, output increased by 9.1% and sales increased in both sales directions. As in recent years, foreign market sales played a decisive role in the vast majority of manufacturing sub-sectors. The output of the mining industry, which accounts for 0.4% of industrial production, increased by 16.6%, and the output of the energy industry, which accounted for 4.2%, increased by 11.5% compared to 2020. In 2021, the number of people employed in industry - in enterprises employing at least 5 people - was nearly 732 thousand people, 3.1% more than in 2020.

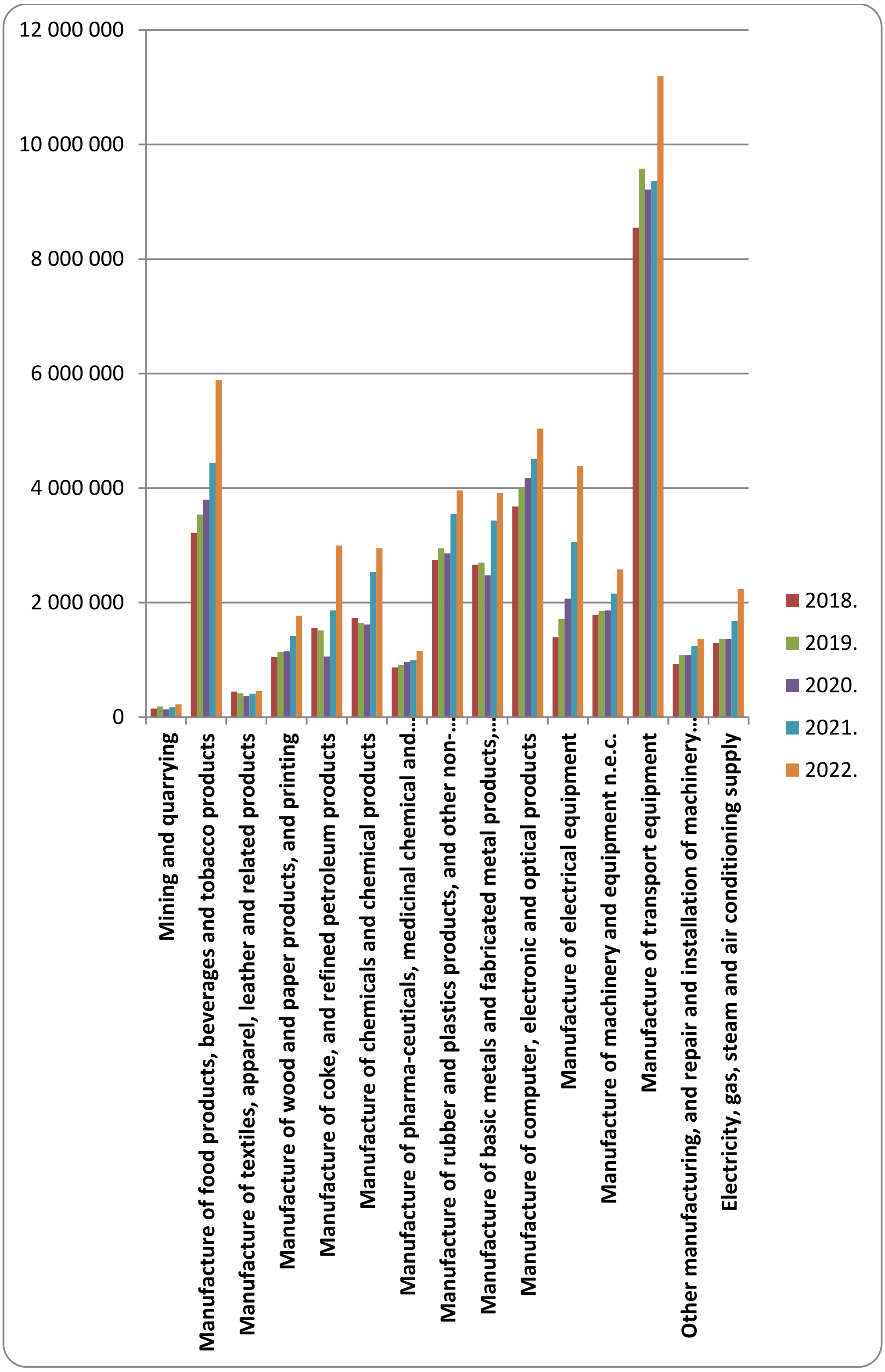


Figure 2.30.: Value of industrial production (at current prices in million HUF)

Source: Hungarian Central Statistical Office (KSH), 2022

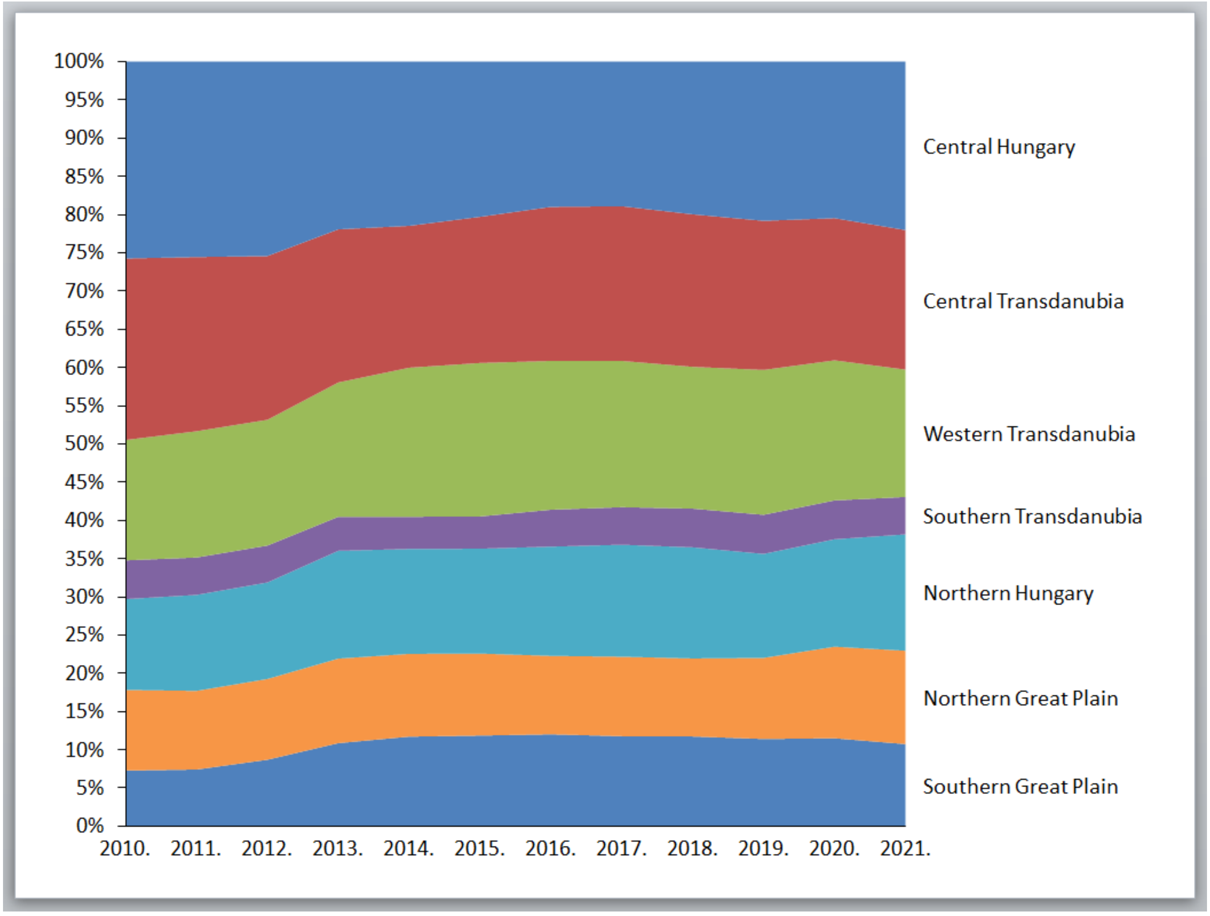


Figure 2.31: Value and volume indices of industrial production by local units

Source: Hungarian Central Statistical Office (KSH), 2022

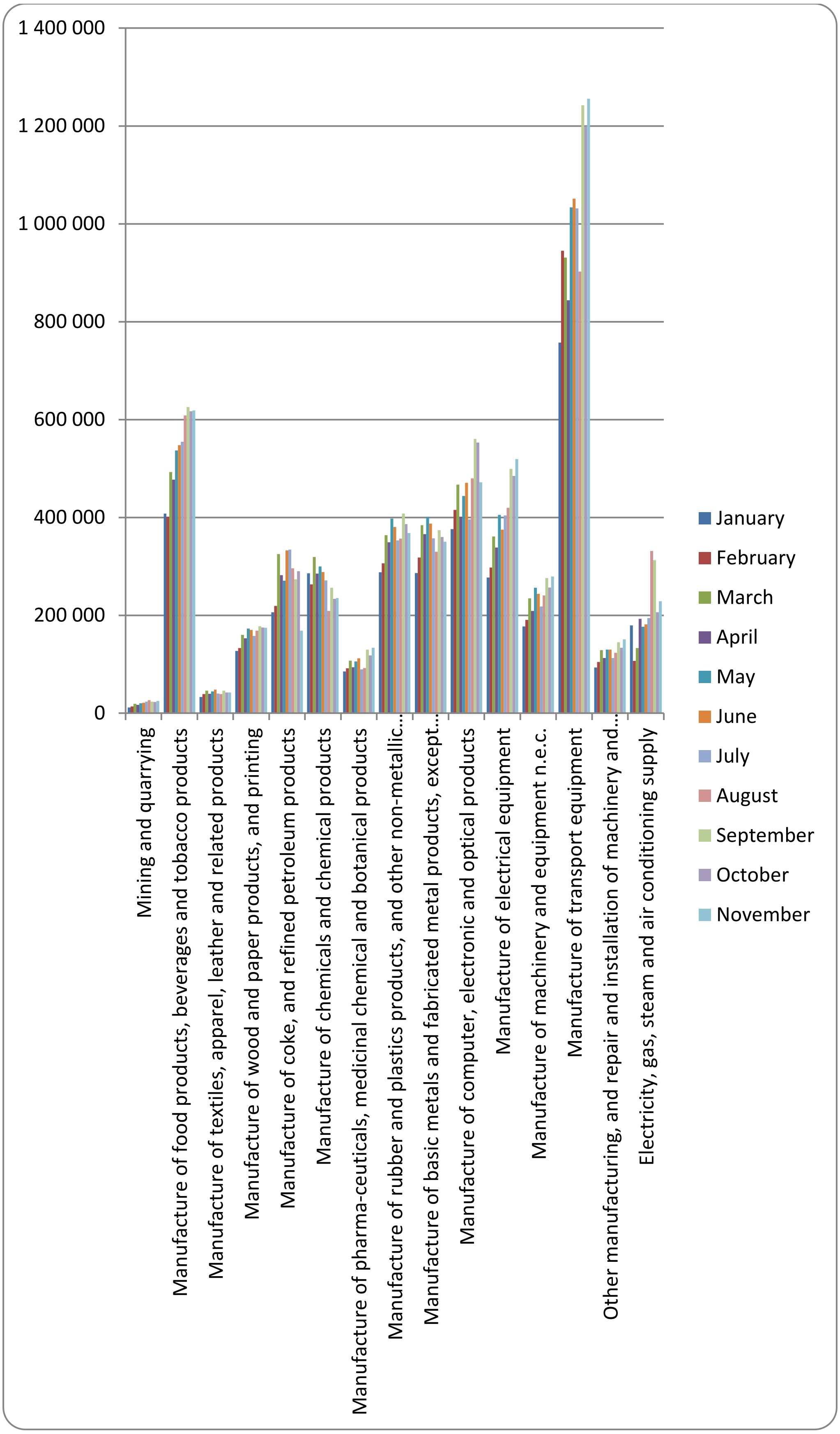


Figure 2.32: Value of industrial production by sub-sections monthly in 2022 (at current prices in million HUF)

In November 2022 the volume of industrial production grew by 0.5% year-on-year. Based on working-day adjusted data production rose by 0.8%. The volume of production lessened in the majority of the manufacturing subsections, out of the increasing ones the manufacture of electrical equipment grew the most. According to seasonally and working-day adjusted data industrial output was 0.7% lower than in October 2022.

The **volume of industrial production rose by 0.5%** compared to the same period of the previous year. (Compared to the November data published in the first estimate, the data in the second estimate did not change.)

Industrial output in November – according to seasonally and working-day adjusted indices – was 0.7% below the level of the previous month.

The volume of **industrial exports** was **5.1% higher** than a year earlier. Transport equipment export, representing a 32% weight within export sales in manufacturing grew by 25%, and the export in the manufacture of computer, electronic and optical products accounting for a 13% weight, decreased by 4.9%.

Industrial **domestic sales** were 3.2% higher, and domestic sales in manufacturing were 7.7% lower compared to the same month of the previous year. Within the industry, **production** increased by 1.3% in the decisive weight (95%) representing **manufacturing**, at the same time the output declined by 1.2% in the small weight representing **mining and quarrying**, and it dropped by 19.6% in the **energy industry** (electricity, gas, steam and air-conditioning supply).

The largest weight-carrying **mmanufacturerof transport equipment** representing 26% of manufacturing, surpassed by 23% the previous year’s data. Motor vehicle manufacturing went up by 19.9%, and the manufacture of parts and accessories for motor vehicles rose by 26%. The **manufacture of computer, electronic and optical products** accounting for 10% of manufacturing declined by 3.7% compared to the same month of the previous year. Out of the two largest groups, the manufacture of electronic components and boards increased by 22%, and the manufacture of consumer electronics fell by 30%. The **manufacture of food products, beverages and tobacco products** having a 13% share in manufacturing declined by 2.0%, first of all, due to a decrease in domestic sales, while export sales rose. The processing and preserving of meat and the production of meat products representing the largest weight (24%) dropped by 5.9% year-on-year. Besides, output decreased in 6 more groups: the manufacture of grain mill products, starches and starch products fell the most, by 27%. Production increased between 3.6 and 26% in the other groups, and the manufacture of other food products also containing the manufacture sugar, went up to the greatest extent.

Out of the subsections, the **manufacture of electrical equipment** representing an 11% weight grew at the highest rate, by 55%. Out of the two most significant weight-carrying groups the manufacture of batteries and accumulators went up by 97%, and the manufacture of electric motors, generators, transformers and electricity distribution and control apparatus rose by 62%.

Out of the two medium-weight representing subsections the **manufacture of rubber and plastics products, and other non-metallic mineral products** declined by 12.4%, the **manufacture of basic metals and fabricated metal products** dropped by 16.4% compared to the same month of the previous year.

The increase goes on for five months in the small-weight carrying **mmanufacturing of basic pharmaceutical products and pharmaceutical preparations**: the volume of production was 13.9% higher than in November of 2021, mainly as a result of an expansion in export sales.

Decreases continued in the **manufacture of chemicals and chemical products** (by 33%), primarily owing to the considerable fall in the manufacture of plastics in primary forms as well as the manufacture of fertilisers and nitrogen compounds.

The **manufacture of coke and refined petroleum products** dropped at the highest rate, by 50%, year-on-year, and sales fell in both directions.

Industrial output grew in three **regions**, it stagnated in one and declined in the other four, year-on-year. The highest volume growth was observed in Central Transdanubia (12.4%), and the most significant decline (15.6%) was registered in the Northern Great Plain.

The volume of total **new orders** in the observed divisions of manufacturing was 5.8% higher compared to November 2021. New domestic orders dropped by 1.9%, and new export orders grew by 7.2%. The **total stock of orders** at the end of 2022. November was above the previous year's level by 19.9%.

Industrial production increased by 6.0%. The volume of **export sales** representing 59% of all sales rose by 8.2%, and **domestic sales** accounting for 41% of all sales grew by 6.0%. Industrial production declined only in the Southern Transdanubia (by 0.5%). In the other **regions** volume increases between 0.7% and 12.9% were recorded, the highest one in the Pest region.

2.9. Transport

Infrastructure

Hungary's central location in Europe and the accordingly dense motorway network are one of its most important competitive advantages. Four vital European transport corridors pass through Hungary, providing unparalleled access to all parts of Europe, including major European ports and the fast-growing CIS 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 32 521 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. 2.33.).

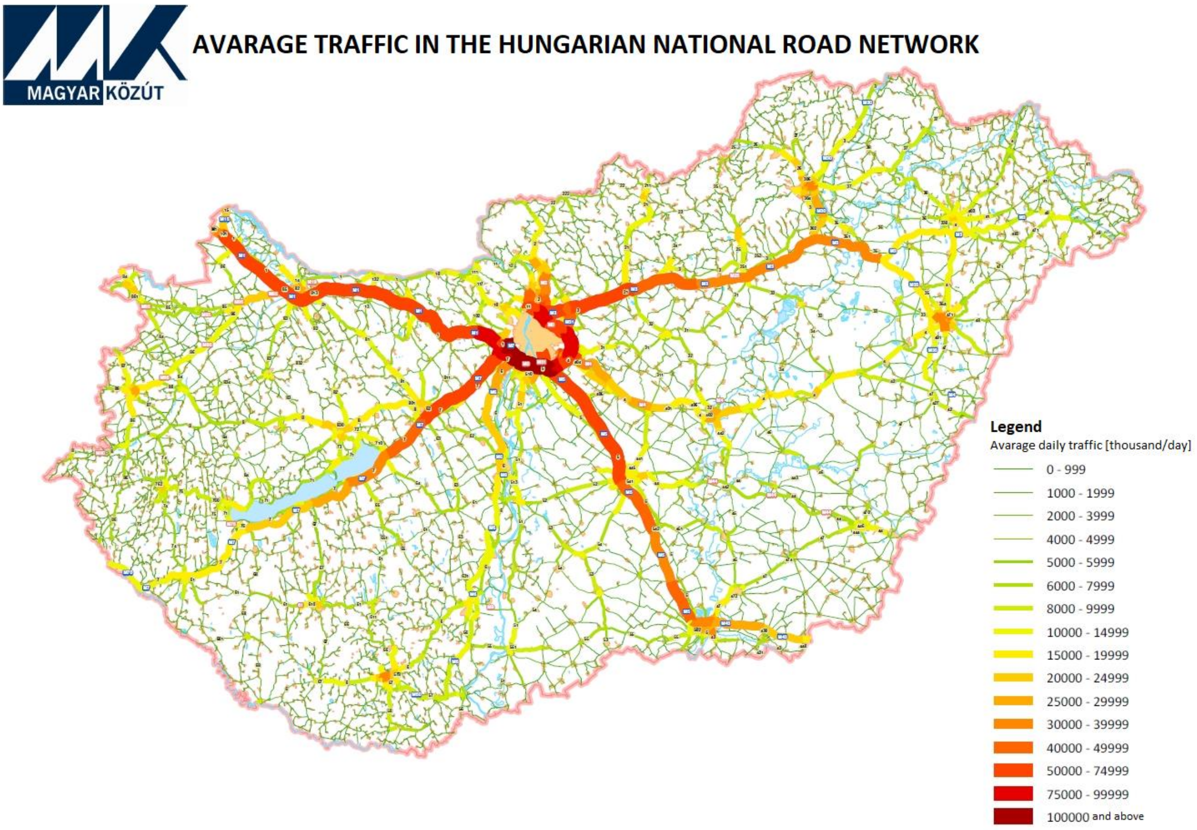


Figure 2.33. Traffic volumes (average daily traffic) on the Hungarian State Road network
Source: Hungarian Public Road Non-profit Plc. (based on data from2021)

8873 km of national roads are the main network, of which 2 481 km are part of the European road network. The length of the expressway network (motorways, motor roads) is 1 855 km, and the length of motorways with node branches is 2 390 km. 27% of the length of the national roads pass through settlements, so they play a significant role in the local traffic. There are 8 161 bridges on the national roads, 1 860 road-rail crossings (of which 1 399 are level crossings, of which 77 are insured), 9,108 road junctions and 6 577 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 mmotorways 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. Figure 2.34 shows the present and planned roads in Hungary (double lines are expressways).

Figure 2.34. Road network in Hungary: existing and planned roads
Source: National Infrastructure Development Corporation (NIF)

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 ccountry, the problem is caused by the saturation of the public roads and by delayed accessibility, respectively
- while the traffic problems in the large towns – congestions, parking difficulties, air pollution – remind us of teveloped countries, the access to peripheral areas has hardly improved in 50 years.

Railway Network

The railway network covers the whole country and it is an integral part of the international network, thus providing easy access by international express trains from the neighbouring and numerous other European countries.

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 (Sl) and Trieste (I) on the Adriatic and soon with Constantza (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 18% 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 3-3,5% 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 volumes at the largest Hungarian airport - Budapest Liszt Ferenc International Airport – also started to grow heavily but are still expected to be 25-30% less compared to the traffic level of 17 million passengers in 2019. Cargo traffic figures were not suffering due to the pandemic – a 15-20% yearly increase was experienced 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 closuresin Ukraine and Belarus. The Hungarian ATM provider Hungarocontrol has successfully managed to serve this extra traffic.

The other two international airports of Hungary - Debrecen and Hévíz-Balaton Airport at 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 ihasslowed down since 2012, but the average age is still increasing every year. The recent value is more than 15

years in 2021, and there is more than 2 2-year difference between diesel (14.0 years) and gasoline (16.1 years) passenger cars.
The 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. In 2020 there were 18% fewer (259,000) newly registered cars than in the previous year and in 2021 1.7% fewer cars (254,000) were registered for the first time in Hungary.

The stock of cars has been increasing constantly in the last few years.

Concerning the composition of the car stock, 64% were equipped with petrol engines in 2021 (2000 – 90%, 2010 – 79%, 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).

In 2021 the stock of Diesel-engine vehicles is 31% (1,272,218 pieces) (2000 – 10% (230 855), 2010 – 21% 619 807, 2016 – 29% 970,997 pieces). This is due to better consumption and increasing performance and happens despite the increasing cost from deNOx-measures already manifesting in (higher) consumer prices.

In 2021, the number of other fuel-driven vehicles (hybrid, electric and mixed combustion) is twenty times higher than in 2010. Their share of total personal car stock is 4.1%.

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

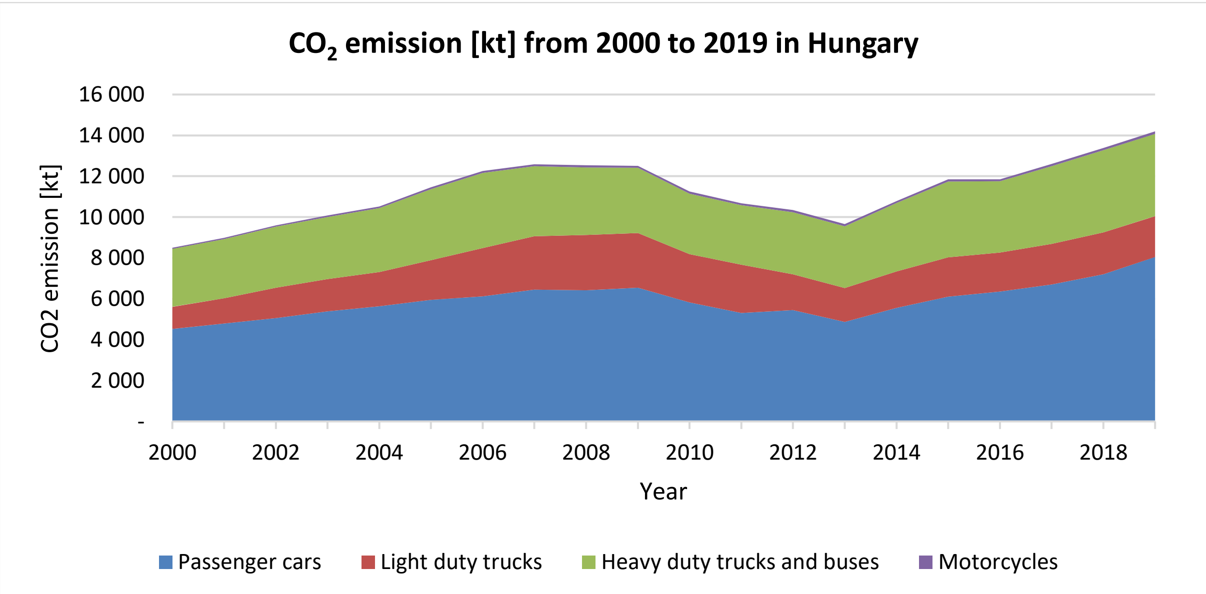


Figure 2.35 CO_2 emission (kt) trends of vehicle sectors from 2000 to 2019

Source: European Environment Agency, 2022, modified

Figure 2.35 shows the trends of CO_2 emission between 2000 and 2019. CO_2 emission is increasing again in these vehicle sectors (passenger cars, heavy-duty trucks, light commercial vehicles and buses) since 2013.

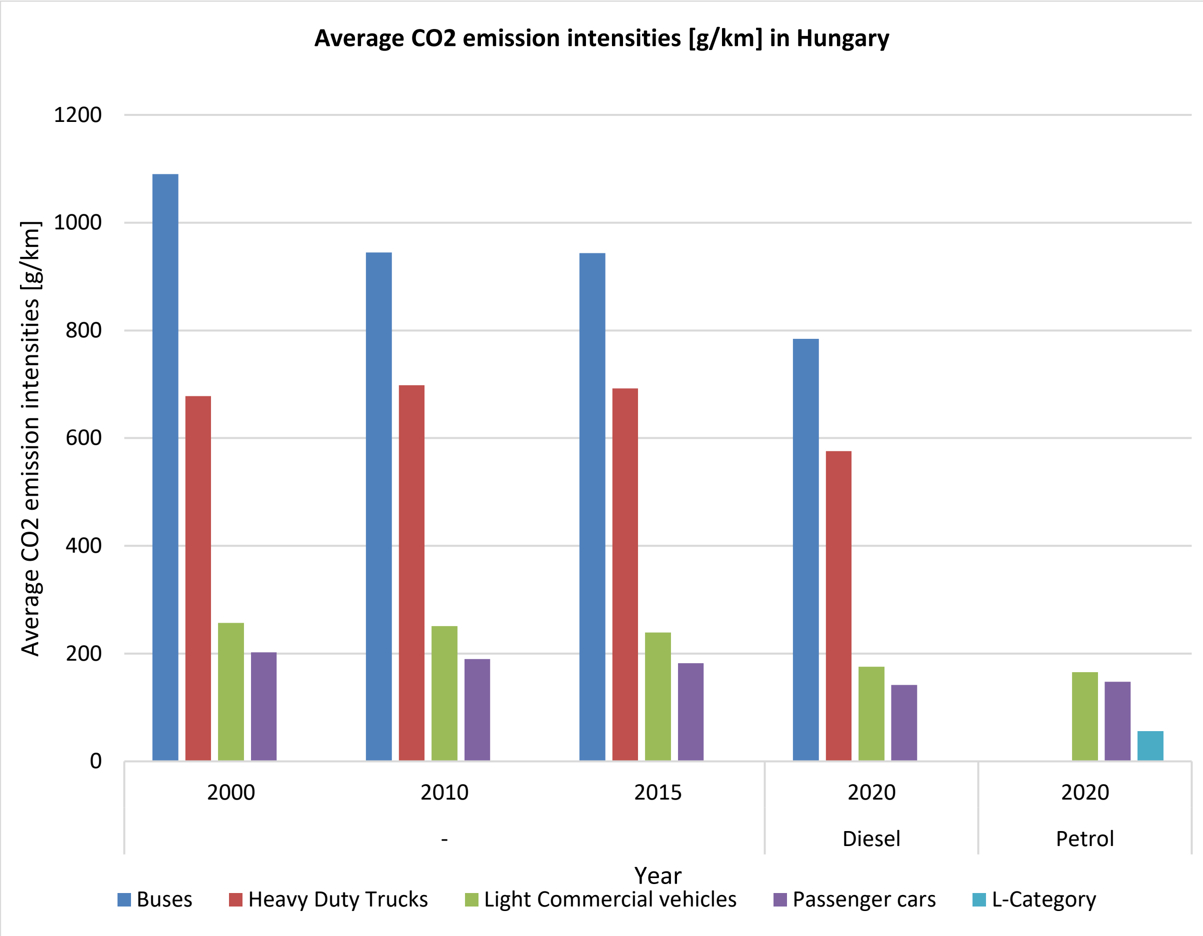


Figure 2.36 Average CO_2 emission intensities (g/km) in 2000, 2010, 2015 and 2020
Source: Institute for Transport Sciences (KTI), 2022

For CO_2 emission intensities (g/km) the average values of CO_2 emissions of vehicle categories were calculated in 2005, 2010, 2015 and 2020. Figure 2.36 shows the difference between vehicle categories. In every case (passenger cars, light commercial vehicles, heavy-duty trucks and buses) average CO_2 emission intensities (g/km) decreased between 2010 and 2020. In 2020 the most common fuel types (diesel, petrol) of vehicle categories are represented.

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 CO_2 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.

2.10. 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 acceded to the EU, its agriculture has developed considerably and its efficiency, competitiveness and profitability have begun to catch up with the EU14. 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 agriculture can be further increased in the future, with a better utilization of its capabilities.

Significance

Between 2016 and 2021, the share of agriculture in total gross value added was about 3.9-4.6%, the share of total investment was 4.0-5.2% and the share of total employment was 4.6-4.9%.

The output of agriculture increased further at current prices in 2021, continuing the trend which started in 2011, and reached a new record. According to the Economic Accounts of Agriculture, the output was HUF 3378 billion at current basic prices in 2021, 14.5% more than in 2020. Output volume decreased by 2.1%, while producer prices grew by 17.0 %. The outstanding performance in 2021 was driven by crop production, however, the volume of animal output increased further despite the low producer prices.

Between 2016 and 2021, the output of agriculture at current basic prices increased by 30.7 percent, and both crop production (+32.7%) and animal output (+29.9%) contributed to this achievement. Calculated at constant prices, the output of agriculture has decreased by 6.1% in the last five years: crop output decreased by 16.9%, while the animal sector experienced 6.8 % 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 10644.4 million, EUR 1030.1 million more than in the previous year and EUR 2622.2 million more than in 2016. Imports of agro-food products were EUR 7079.9 million (up 10.9% or EUR 697.7 million compared to 2020), and the trade balance was EUR 3564.5 million (+10.3% or EUR +332.4 million). In 2021 the share of agro-food products in total exports was about 8.7%, from imports was about 6.1%, and from the trade surplus was 53.6%.

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 (14.9% 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 2016-2021, the agricultural area decreased by 300.0 thousand hectares, of which arable land by 187.1 thousand hectares and grassland decreased by 28.7 thousand hectares, whereas the size of kitchen gardens decreased by 61.6 thousand hectares, vineyards and orchards decreased by 13.6-8.8 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, oilseeds and industrial crops dominate.

Wheat was produced on 891 million hectares in 2021, with a 6.0 tons/hectare average yield. The 5.3 million tons harvested production was 3.8% more than in the previous year. The production area of maize was 1.043 million hectares. The average yield in 2021 was 6.0 tons/hectare, a 29.8 percent drop compared to the previous year. The production dropped to 6.3 million tons (-25.1%). The main oilseeds (sunflower seed, rapeseed) were grown on 909 thousand hectares which was slightly less in 2021 than in the previous year (-14.0%). The harvested area of sunflower seed was 653 thousand hectares, 6.5% more than in 2020. The harvested area of rapeseed amounted to 256 thousand hectares, 17.3% less than in the previous year. The production of sunflower seed reached 1761 thousand tons (+3.7%), while 722 thousand tons of rapeseed were harvested (-17.7%). Sugar beet was grown on 12 thousand hectares in 2021, 7.7% less than in the previous year. The production of 645.4 thousand tons was 17.3% down on 2020 (2016- 2020: -33.5%).

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 83.2 thousand hectares in 2020, a 6.8% decrease over the previous year, the quantity produced decreased by 7.2% due to wet weather.

The area of orchards is 79.6 thousand hectares. In 2021 apple production was 399 thousand tons, 20% less than in 2019, while pear production amounted 20.3 thousand tons, 9.4 less than in the previous year.

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 63,300 hectares. In 2020 435 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 increased by 1.4% between 2016 and 2020. However, the number of cattle decreased in 2021 by 3.3%. The stock of cows has increased by 6.4 thousand to 420.2 thousand since 2020, which is 9.8% higher than in December 2016. The number of dairy cows decreased by 4.1% in in 2021, and it experienced a 5.5% decrease between 2016 and 2020. The number of beef cattle has decreased since 2020 (-26.0%) (influenced by statistical methodology), which has been 0.6% growth since 2016. Live cattle was mainly exported. Hungary was a net exporter of live cattle and beef in 2021.

The pig stock in December 2021 amounted to 2.726 million, which was about 4.4% lower than in the previous year. The number of sows fell by 4.1%. The number of pigs decreased both in agricultural enterprises and in private holdings.

In Hungary, 39.5 million poultry were slaughtered in 2021, 11.7% more than in 2020. During the last four years, the chicken production developed significantly, while the duck and geese sectors have been negatively affected by the appearance of avian influenza.

The sheep stock decreased by 6.0% to 887 thousand in 2021 compared to the previous year. The number of ewes also decreased, by 4.5%.

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.[4] 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.

Manure and fertiliser use

Areas fertilized with farmyard manures amounted to 191 thousand hectares on in 2019, the tendency shows decline (2018: 201 thousand hectares). Areas fertilized with chemical fertilizer amounted to 3056 thousand hectares in 2019 (2016: 2840 thousand hectares). Amount of fertilizer used was 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

[4] Please find the National Inventory Report 1985-2021 here: https://unfccc.int/documents/627849 and the CRF Tables here: https://unfccc.int/documents/627846

1985-2021 (Table 5.5.7). The difference between the two figures is due to the fact that the Hungarian Central Statistical Office and HungaroMet Hungarian Meteorological Service Nonprofit Zrt. 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.

2.11. Waste management

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 an increase in time series analysis, within which the amount of municipal waste also increased. The amount of the landfilled municipal waste shows a slight decrease. The most significant displacement was the rate of the material recovery, which increased significantly.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total waste (kt/year)	15167	14766	15731	15526	15453	17890	18233	19057	20154
Change in waste from previous year	96,8	97,4	106,5	98,7	99,5	115,8	101,9	104,5	105,7
Generated of municipal waste kg/person/year	408	382	38	380	382	384	383	388	402
Disposed of by landfill of municipal waste kg/person/year	263	244	221	202	192	186	189	196	217

Table 2.7. Tendency of waste generation and relevant indicators, 2012-2020*

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
Agricultural and food industry waste	797	933	890	681	645	613	623	790	749
Industrial and other business waste	5 797	5 759	6 189	5 900	5818	5951	5965	5644	5307
Construction and demolition waste	3 809	3 772	4 205	4 738	4718	6942	7240	8158	9543
Hazardous waste	776	565	653	498	551	616	658	674	623
Municipal waste	3987	3 738	3795	3712	3721	3768	3746	3791	3931

Table 2.8 Waste generated by source (ktons), 2012-2020

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 third of the total waste generated. The generated amount of this waste stream has typically stagnated and slightly decreased in the recent years. The reason for the smaller quantitative changes is e.g. a slight increase in non-hazardous waste generated during the state remediation program in 2014 and 2015.

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 101% change in volume from 2015 to 2020 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	
	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%	ktons	%
Amount of waste (kt)	15167166167 16616616616 61661661515 15 16616716616 61661661661 66		14 766		15 731		15 526		15453		17890		18233		19057		20154	
Material recovery	6 721	44	6 561	44	8 042	51	7 776	50	7906	51,2	10365	57,9	11112	60,9	12443	65,3	13537	67,17
Energy recovery (Incineration with energy recovery)	980	6	1 191	8	1 215	8	1 211	8	1409	9,1	1617	9	1363	7,5	1044	5,5	1079	5,4
Incineration	92	1	87	1	95	1	89	1	93	0,6	70	0,4	76	0,4	91	0,5	141	0,7
Disposal (Landfill)	6 978	46	6 426	44	5 932	38	6 257	40	5838	37,8	5445	30,4	5049	27,7	5310	27,9	4954	24,6
Other	395	3	501	3	365	2	192	1	220	1,4	291	1,6	633	3,5	168	0,9	442	2,2

Table 2.9 Generation and treatment of wastes (without sludge) 2012-2020

Source: Ministry of Energy-HIR

Table 2.8 shows that a significant shift can be observed in the treatment of total waste in the recent years. The amount of the landfilled waste has been decreased, whereas the amount of material recovery has been increased.

The introduction of the mandatory door-to-door separate collection of household paper, metal and plastic waste in 2015 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 2020 this rate reached 67%.The amount of disposal decreased from 46% in 2012 to 25% by 2019. The decrease for disposal has been significantly affected by the introduction of the landfill charge by 1 January 2013. The amount of landfill charge is HUF 6 000/ton.

2.12. Forestry and land-use change

There is a detailed system in Hungary to continuously collect data on forests and forestry, run by the Forestry Department of the National Land Center (NLCFD). A detailed description of forestry-related databases of the NLCFD in English can be found at http://portal.nebih.gov.hu/-/supplementary-information; http://www.nfk.gov.hu/download.php?id_file=40461.

A general description of the National Forest Inventory that collects data for the database in a cadastre-type system, as well as the Hungarian forests and forestry can be found in English at

http://portal.nebih.gov.hu/en/web/erdoleltar/?r=0
https://nfk.gov.hu/download.php?id_file=40336;
http://portal.nebih.gov.hu/documents/10182/862096/Forestry_related_databases.pdf/3ff92716-2301-4894-a724-72fafca9d4fc.

All statistical data on forests that are reported in this document were taken from the official statistics of the NLCFD as well as the most recent National Inventory Report, if not reported otherwise.

In general, forests in Hungary have been managed sustainably for about a century (Ministerial reports 2006-2017; Forest Europe 2020[5]) and, overall, have continued to be carbon sinks. 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), 206157 thousand ha were under forest management, which include forest sub-compartments and other sub-compartments. Both area and standing volume have been increasing for decades in the main forest-related land-use and land-use change categories (Figure 2.27.). The area of ther 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 established in the last eight decades or so, and more than 187 thousand ha since 1990.

[5] FOREST EUROPE, 2020: State of Europe's Forests 2020. URL: https://foresteurope.org/state-of-europes-forests/

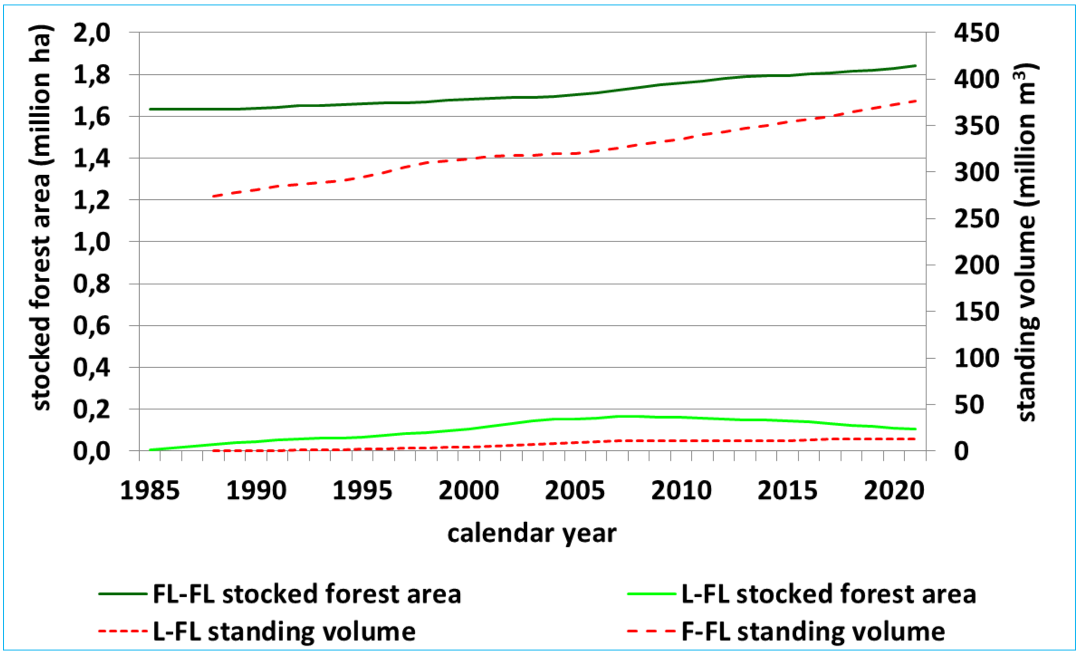


Figure 2.37 The development of the area and volume of stocked forests since 1985

Source: National Inventory Report Hungary, 2023

The new forests have added much to the services of the forests, including their sink capacity. The sink of the biomass of the forests established since 1990 have been 1.1-1.2 million tCO_2 a year in this decade. Considering that the sink of the forests that existed already before 1990, and that have ten times as large area than that of recent afforestations,have had only three-four times as much sink recently, these figures show how effective afforestation can be in terms of removing carbon from the air.

Also, there is not much pressure on our forests in terms of deforestations. We have deforestations each year (Table 2.10), 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	27	1
1990	613	613	2 243	2 243	27	4
1995	358	358	3 514	6 412	27	11
2000	719	1 187	5 898	10 586	27	16
2005	411	859	8 678	16 911	27	25
2010	208	2 351	8 467	22 667	28	31
2015	1 383	1 699	12 061	27 551	117	32
2020	1 191	1 503	19 220	37 593	134	37
2021	1 531	1 659	20 230	37 955	260	38

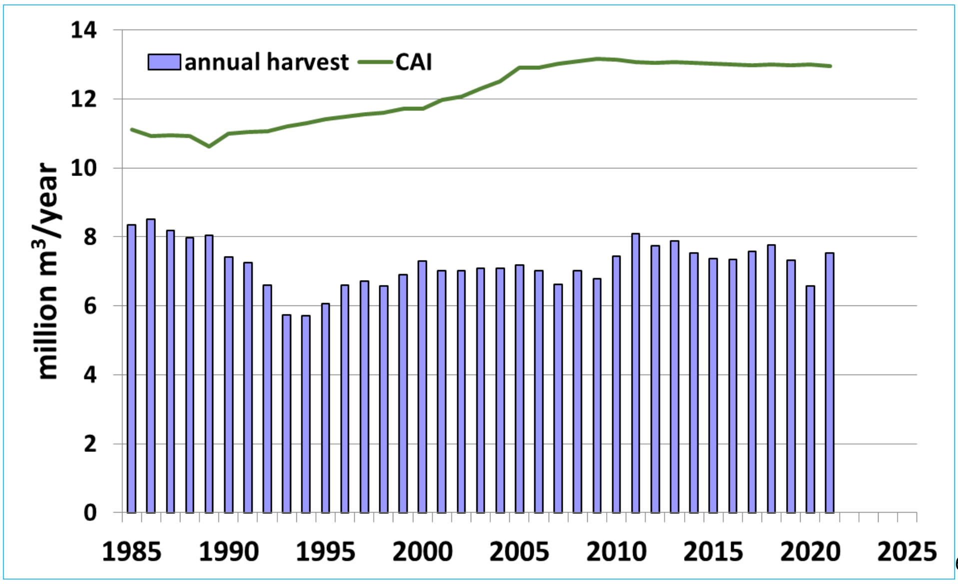
Table 2.10 The area of deforestations and resulting emissions from biomass cleared in Hungary in selected years

Source: National Inventory Report Hungary, 2023

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 governmentsamount to 1%. Most forests (56%) are thus still owned and managed by the state.

Most forests (approx. 63%) are classified as production forests. The share of protection forests is 36%, whereas forests serving predominantly social, touristic, educational and scientific purposes amount to 1%.

The sustainability of forest management in Hungary, as demonstrated above (Figure 2.37), has resulted in the fact that the stock volume of the Hungarian forests has continuously increased in the last several decades (from 257 million m^3 in 1981 to just over 403 million m^3 in 2015). This increase is partly due to the fact that forests have been predominantly young, but partly due to the continuing afforestation programmes, which have substantially increased forest resources since 1930 when they started. A third reason is that for the last several decades, the wood increment of the forests has always topped the sum of all harvests and mortality (Figure 2.38.), i.e., the amount of harvests has only been some 70% of the current annual increment. (CAI) Although the health monitoring of the forests indicates a slight increase in forest damages for the last three decades, the amount of salvage loggings (1995: 552 thousand m^3; 2000: 427 thousand m^3; 2005: 530 thousand m^3; 2011: 393 thousand m^3; 2015: 513 thousand m^3) has not shown any increasing (or decreasing) trend.



[6]

Figure 2.38 The total amount of annual harvest and the estimated current annual increment (CAI) over time in Hungary.

Source: National Inventory Report Hungary, 2023

[6] References: Forest Europe, 2015: State of Europe's Forests 2015.
NIR Hungary 2017. National Greenhouse Gas Inventory Report.
URL: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

3. GREENHOUSE GAS INVENTORY INFORMATION

3.1 Summary tables

GHG	BY	1990	1995	2000	2005	2010	2015	2020	2021
CO2	85,539	73,377	61,601	58,506	60,401	52,087	46,717	47,335	48,564
CH4	14,574	13,801	11,538	11,521	10,470	9,781	9,451	9,207	9,207
N2O	9,920	7,456	4,224	4,811	4,992	3,309	4,022	4,462	4,486
HFCs	NO	0	33	203	748	1,258	1,885	1,849	1,862
PFCs	333	338	200	254	252	4	4	2	2
SF6	8	13	53	84	92	94	122	111	97
NF3	NO	NO	NO	NO	NO	NO	NO	NO	NO
TOTAL	**110,373**	**94,985**	**77,648**	**75,378**	**76,955**	**66,534**	**62,201**	**62,965**	**64,218**

Base year (BY)=average of 1985-87

Table 3.1 Trend of emissions by GHGs, excluding LULUCF (Gg CO_2-eq)

Source: National Inventory Report, Hungary 2023

Sector	BY	1990	1995	2000	2005	2010	2015	2020	2021
Energy	80,210	69,449	59,197	56,658	57,368	49,979	44,609	44,680	46,133
Industry	14,542	11,359	8,050	7,959	8,848	6,402	6,993	7,353	7,150
Agriculture	12,058	10,091	6,042	6,149	6,082	5,604	6,654	7,170	7,202
LULUCF	-2,398	-3,362	-6,361	-1,099	-5,998	-4,832	-5,688	-7,110	-7,197
Waste	3,564	4,086	4,359	4,612	4,657	4,548	3,944	3,762	3,733
TOTAL	**107,975**	**91,623**	**71,287**	**74,279**	**70,957**	**61,702**	**56,513**	**55,856**	**57,020**

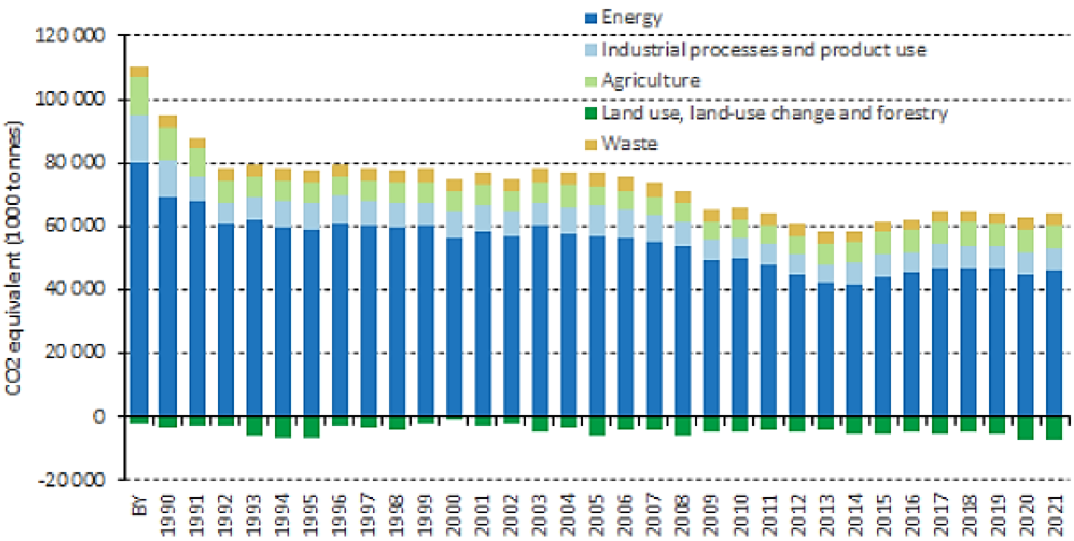
Base year (BY)=average of 1985-87

Table 3.2 Trend of emissions and removals by sector (including LULUCF, Gg CO_2-eq

Source: National Inventory Report, Hungary 2023

3.2 Descriptive summary

Compared to the base year, emissions were significantly reduced in the energy (-42%), industrial processes and product use (-51%), and agriculture (-40%) sectors. In contrast, emissions in the waste sector have increased since 1985 (+5%). The land use, land-use change and forestry (LULUCF) sector shows fluctuating behavior.



BY=average of 1985-87

Figure 3.1 Change in greenhouse gas emissions from the base year (BY, 1990-2021)

Source: National Inventory Report, Hungary 2023

Looking at the most recent trends since 2005, emissions have significantly decreased in the energy and industrial processes sectors by 20% and 19%, respectively. The agriculture sector seems to have recovered and could show an increase of 18% since 2005. The previous growing trend turned back in the waste sector (-20%).

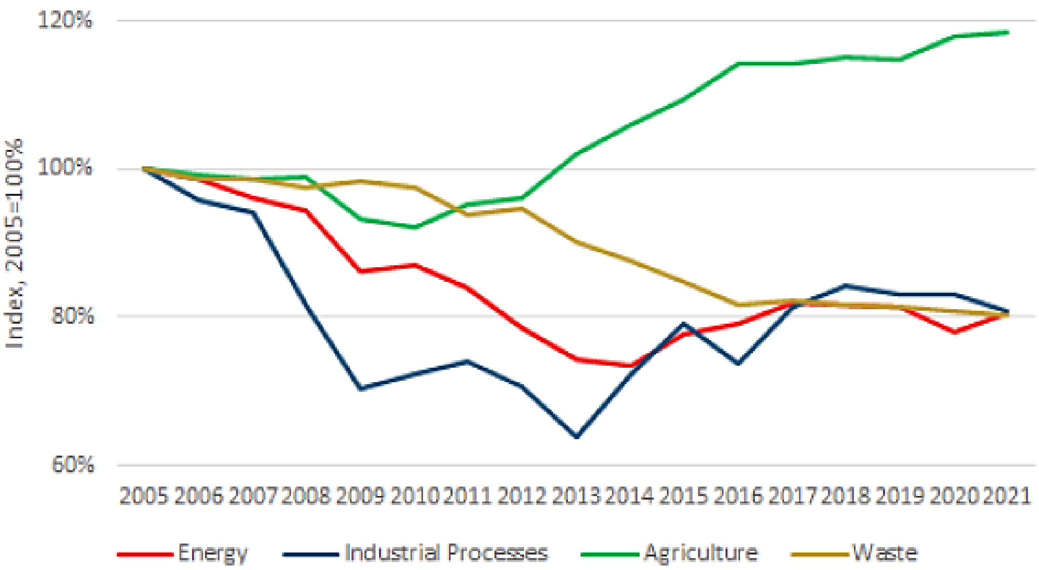


Figure 3.2 Recent trend of sectoral emissions (2005-2021)

Source of data: National Inventory Report, Hungary 2023

For a better understanding of the Hungarian emission trends, the time interval of the inventory should be split into three periods with different emission relevant economic processes in the background. The first period (1985-1995) would be the years of the regime change in Hungary, whereas in the second period (1995-2005) the rules of the market economy became decisive. The second period can also be characterized by the decoupling of GDP growth from the GHG emission trend which is undoubtedly an important development. By 1999, the GDP reached the pre-1990 level; however, emission levels remained significantly below the levels of the preceding years. Thus, the emissions per GDP were decreasing.

In the third period, after 2005, Hungary experienced an emission reduction of 24% up to 2013, out of which 6% occurred in the first three years up to 2008: basically, due to mild winters, higher energy prices, and modernization in the chemical industry. Then in 2009, the global financial-economic crisis made its radical influence felt which can also be seen in the dropping GDP values in *Fig. 2.2*.

From 2010 on a slight recovery of the economy could be observed, the emissions, in contrast, not just remained at a relatively low level but decreased again quite significantly. However, the decreasing trend stopped in 2013 and an increase of 11% could be observed altogether up to 2017. After four years of increase, emissions have remained more or less at the same level between 2017 and 2019. In 2020, however, emissions fell by almost 3% to around 2016 levels, mainly due to a significant reduction in transport emissions as a consequence of COVID-19. This decrease, however, proved to be temporary, in 2021 emissions increased again by 2 per cent.

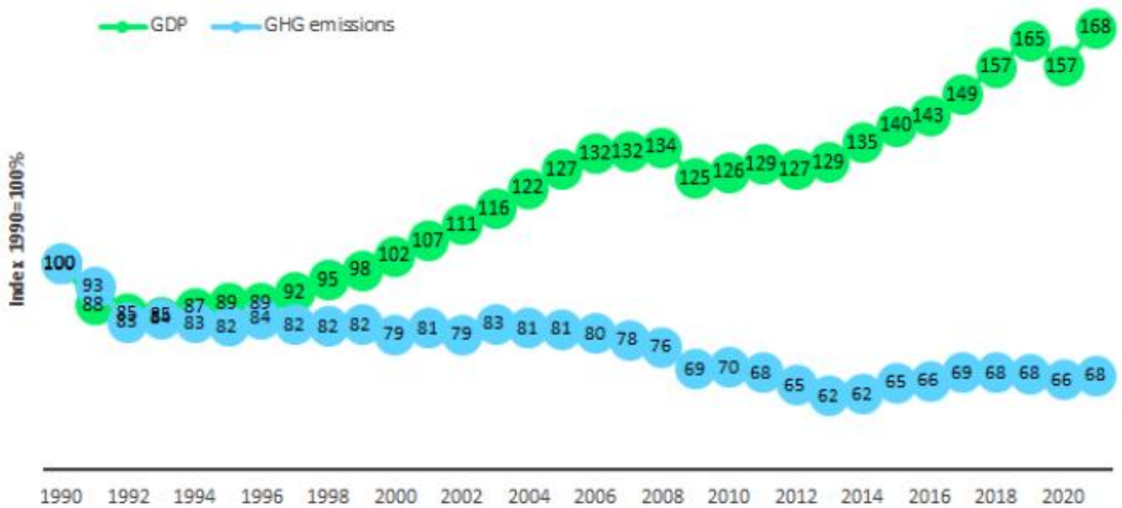


Figure 3.3 Comparison of trends in GDP and GHG emissions

Source: National Inventory Report, Hungary 2023

Starting with the *first* period (i.e., 1985-1995), the process of transition into a market economy brought in its train radical and painful decline in the output of the national economy. The production decreased in almost every economic sector including also the GHG-relevant sectors (energy, industry, and agriculture). Consequently, GHG emissions decreased substantially in these years by around 33 million tonnes of CO_2 equivalent. Between the mid 80's and the mid 90's emissions fell back in the energy sector by around 26%, and even more, by around 45-50% in the industrial processes and agriculture sectors.

The most significant drop in energy use occurred in the industry, especially in the energy-intensive industrial sectors (manufacture of basic metals and machinery, mining etc.). The industrial output of 1992 was two third of that of 1989. Several factories were closed, capacity utilization was reduced, and consequently, the production decreased more or less drastically in each industrial sector.

Some examples:

- Iron and steel production: two out of three plants were provisionally closed down.
- Aluminium: two out of three plants were closed down in 1991 (aluminium production stopped in 2006 eventually);
- Ferroalloys: ceased to exist (1991);
- Ammonia: four out of five plants were closed down (1987, 1991, 1992 and 2002);
- Nitric acid: three out of four plants were closed (1988, 1991 and 1995).

The agricultural sector suffered a similar decline. As a result of the political and economic processes, the number of agricultural farms was reduced by more than 30%, the number of employees by more than 50%, the volume index of the gross agricultural production by more than 30%, the livestock by about 50%, and the use of fertilizers by more than 60%. Consequently, the share of the agricultural sector in total GHG emissions decreased from 11% to 8%.

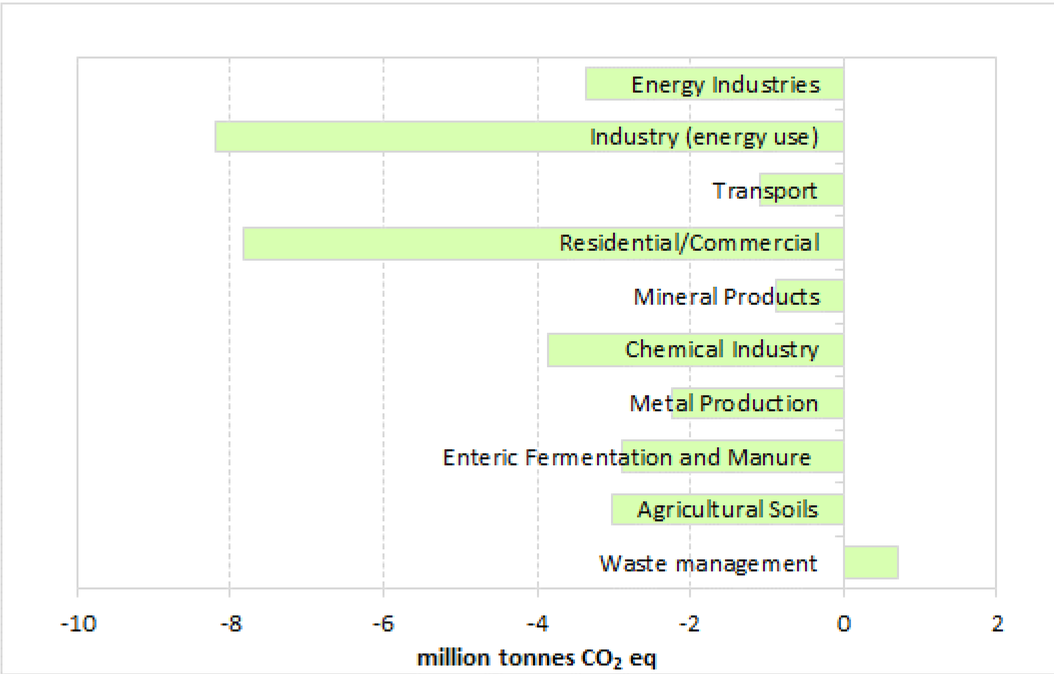


Figure 3.4 Changes in emissions due to regime change, between base year and 1995, million tonnes CO_2-eq

Source: National Inventory Report, Hungary 2023

The small increase of emissions in the Waste sector is exceptional among all the sectors, and it is attributable to the slightly increasing quantities of waste generated and collected but more importantly to the applied calculation method which assumes that the degradable organic component in waste decays slowly throughout a few decades.

After the mid 9'90s (i.e., in the *second* period between 1995 and 2005) emissions seemed to have stabilized at around 77 million tonnes of CO_2 equivalent. However, behind the quite stable emission level opposite processes could be observed which can be illustrated by the relatively bigger changes in the energy sector. The fuel use of industry decreased further which led to about 6% share only in GHG emissions around 2005. In contrast, emissions from transport increased significantly by almost 5 million tonnes of CO_2 equivalent which represented a growth of 60%.

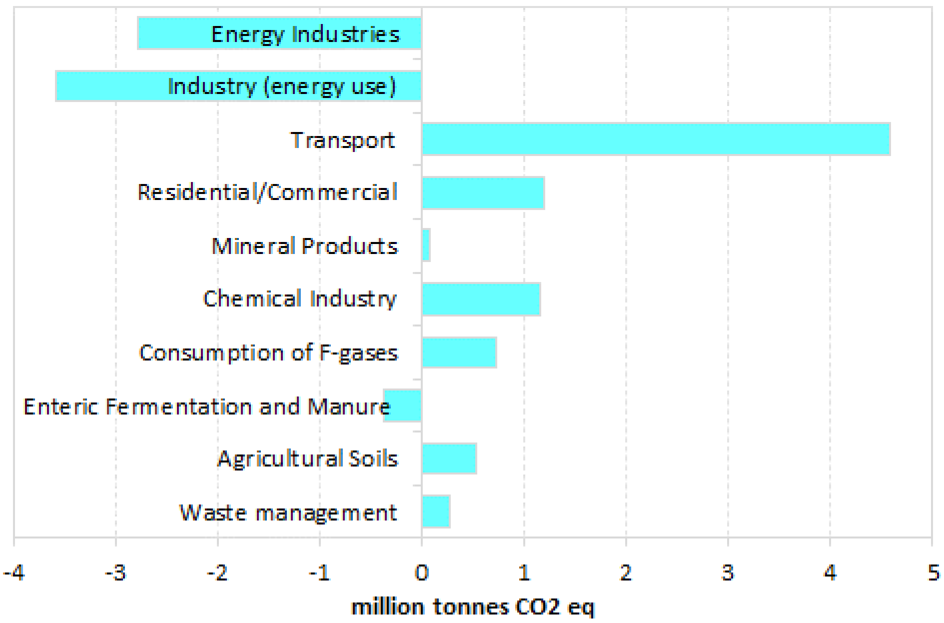


Figure 3.5 Changes in emissions between 1995 and 2005, million tonnes CO_2-eq

Source: National Inventory Report, Hungary 2023

In the third period, between 2005 and 2021, emissions fell by 12.7 million tonnes or 17%. (The decrease was even higher, 24%, if we look at the period between 2005 and 2013.) About a quarter of this decrease occurred between 2005 and 2008. The decreasing energy use by other sectors and manufacturing industries, and the diminishing process related emissions in the chemical industry were the main drivers of these changes. Most importantly, total fuel consumption in the residential sector decreased by about 16% (including a 33% drop in solid fuel and a 16% decrease in natural gas use) – mainly due to extreme mild winter in 2007 but probably the growing energy prices and the support for modernization of buildings might have played a role as well. Decreased production volumes and modernization in the chemical industry led to an emission reduction of about 45%. In contrast, emissions from energy industries and transport grew further. Then in 2009, the Hungarian economy was hit hard by the global economic crisis that exerted a significant effect on the emission level. Emissions (excluding LULUCF) decreased by 8% (-6.0 million tonnes) between 2008 and 2009. In comparison with 2008, emissions in 2009 were lower in all major sectors. The highest relative reduction (-14%) occurred in the industrial processes and product use sector mainly due to lower production volumes especially in mineral product manufacturing (-28%). Parallel to that, also energy use decreased in manufacturing industries and construction, consequently GHG emission also fell by 27% here. Regarding absolute changes in emissions, out of the 6 million tonnes reduction, fuel combustion was responsible for about 4.6 million tonnes. Although the energy demand increased in the heating season due to less favorable weather conditions, the fall in the production of energy intensive sectors led to an overall decline in energy use.

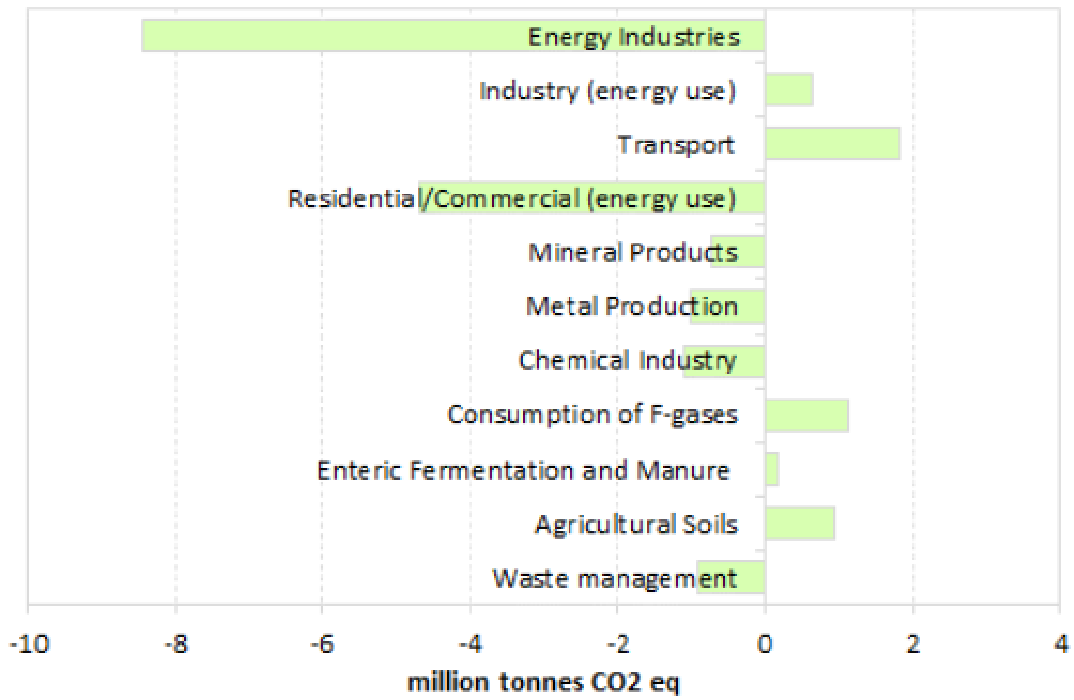


Figure 3.6 Changes in emissions between 2005 and 2021, million tonnes CO_2-eq

Source: National Inventory Report, Hungary 2023

The decline in economic output stopped in the first quarter of 2010. Mainly driven by the growth in export-oriented industrial production, the GDP grew by 1% in 2010. The change in GHG emissions was about the same. In the next three years, however, emissions decreased again altogether by 12%. Electricity production decreased by 21% between 2010 and 2014 reaching its lowest level since 1991. Classic fossil fuel (coal, oil, and natural gas) based production decreased by 43%, gas-based production alone by 63%. Natural gas consumption decreased also in the residential sector by 30% in the same four years to the lowest value after 1992. Also, the heating demand (HDD) was the lowest in 2014 in the entire inventory period.

After the lowest point in 2013, emissions started growing again. Up to 2017, the overall increase reached 12%. The increment percentage was highest in the industrial processes sector (31%) due to the increase in the production of minerals and metals (particularly iron and steel). Effect of the growth in the construction industry was the main driver of this invigorate increase of production and together emission in cement, lime and bricks industries. Steel industry could also profit from this growth with higher production. Significant increase of emissions might be observed in the subsector of product uses as ODS substitutes, and in the ammonia producing industry (production of fertilizers increased by 40% in the period).

Between 2017 and 2019, total emissions seemed to have stabilized. However, this stabilization of total emissions was a net result of several balancing processes: (1) increased emissions especially in transport, and (2) decreases in domestic energy use, and in the power sector.

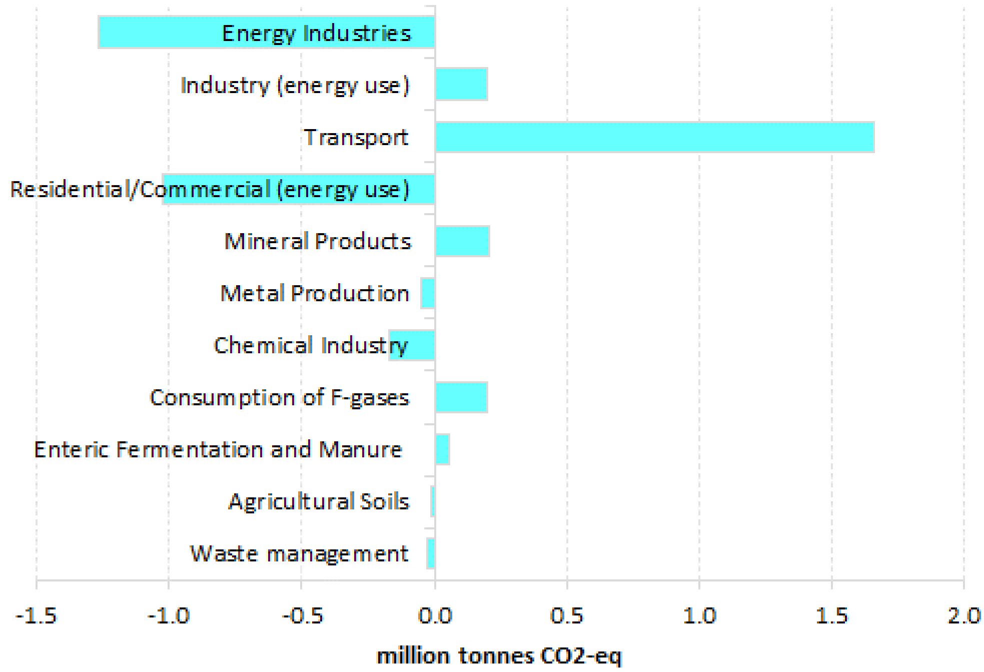


Figure 3.7 Changes in emissions between 2017 and 2019

Source: National Inventory Report, Hungary 2023

Then in 2020, emissions decreased by close to 3%. The transport sector due to reduced commuting, tourism and business travel contributed particularly to the decline of emissions as demonstrated by *Fig. 3.8* below. Current emissions are 18% below the 2005 level.

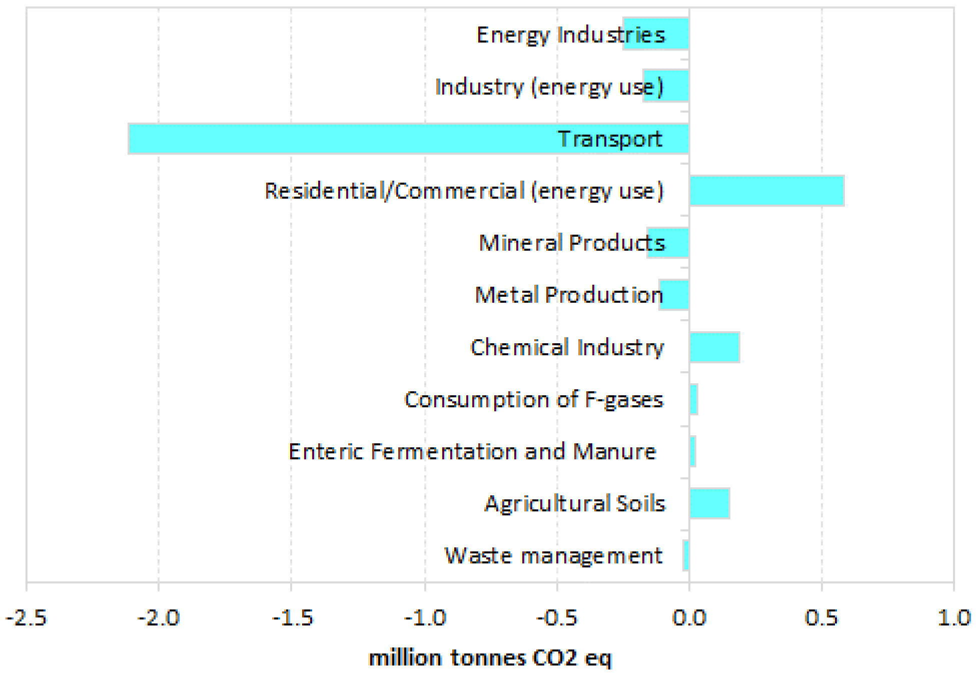


Figure 3.8 Changes in emissions between 2019 and 2020

Source: National Inventory Report, Hungary 2023

In 2021, emissions grew again: especially in the transport sector but buildings used also more energy due to higher heating demand. In contrast, emissions from energy industry decreased as coal-based power production fell significantly. All in all, total emissions increased by 2 per cent in 2021.

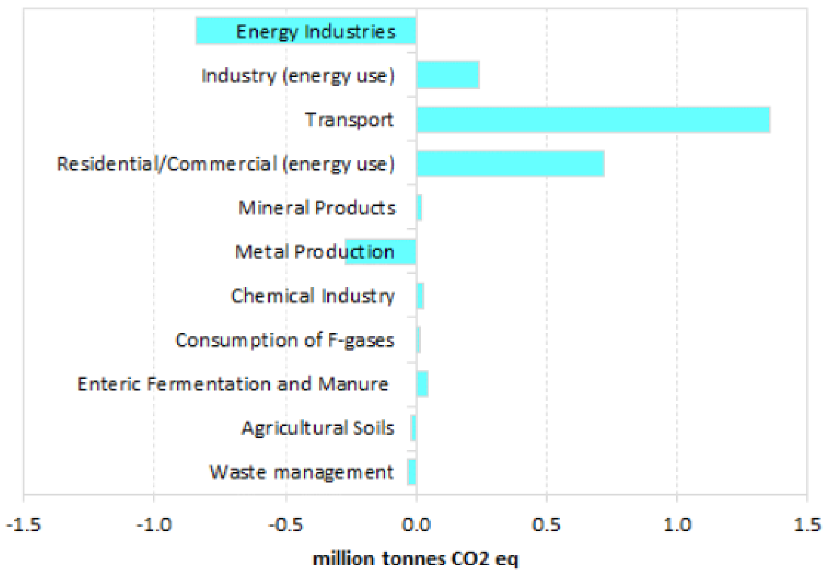


Figure 3.9. Changes in emissions between 2020 and 2021

Source: National Inventory Report, Hungary 2023

Description and interpretation of emission trends by gas

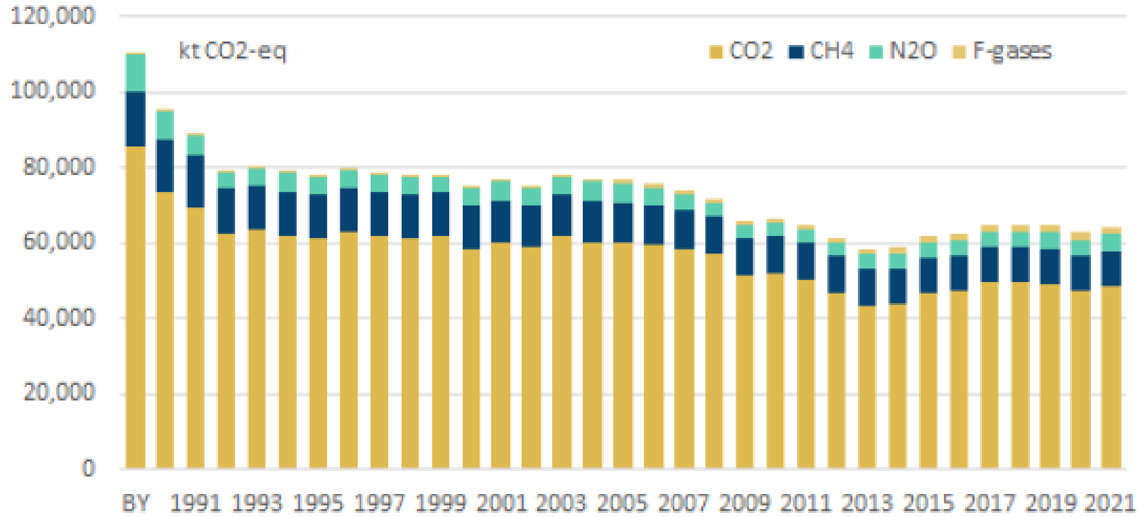


Figure 3.10 Greenhouse gas emissions by gas between base year and 2021

Source of data: National Inventory Report, Hungary 2023

The drop of **CO_2** emissions during the early 1990's was attributable to the reduction of fuel uses in conjunction with the decline of the national output. From the second half of the 1990's, emissions showed stagnating or slightly decreasing tendencies reflecting the effects of restructuring following the economic growth. The changes in the fuel-mix resulted in reduction of the specific emission levels. Between 2005 and 2013, CO_2 emissions decreased by 28 per cent, at about the same rate as during the regime change around 1990. The drop of emission accelerated after 2008 mainly driven by the global economic crisis, and the reduced fossil fuel based electricity production. Between 2013 and 2019, however, emissions increased again by 13%. Electricity production increased, transport sector showed a steadily increasing trend, and fuel consumption increased in manufacturing industry. In 2020, an exceptional year, CO_2 emissions dropped by 4%. Currently, CO_2 emissions are lower by 22% compared to 2005.

Figure 3.11 Trend of CO_2 emissions from some selected important sources

Source of data: National Inventory Report, Hungary 2023

As regards **CH_4** emissions, agriculture, fugitive emissions, and waste management are the trend setting sectors. Most importantly, reductions in the livestock resulted in lower emissions especially in the early part of the time series. Also, fugitive emissions from fuels declined significantly due to gradual closure of underground mines and modernization in the gas transmissions and distribution systems. Besides, emissions from waste disposal grew until 2008, but started to decrease recently. This is the reason why the resultant trend was relatively stagnating until the first half of the last decade, and why it has been slowly decreasing since then.

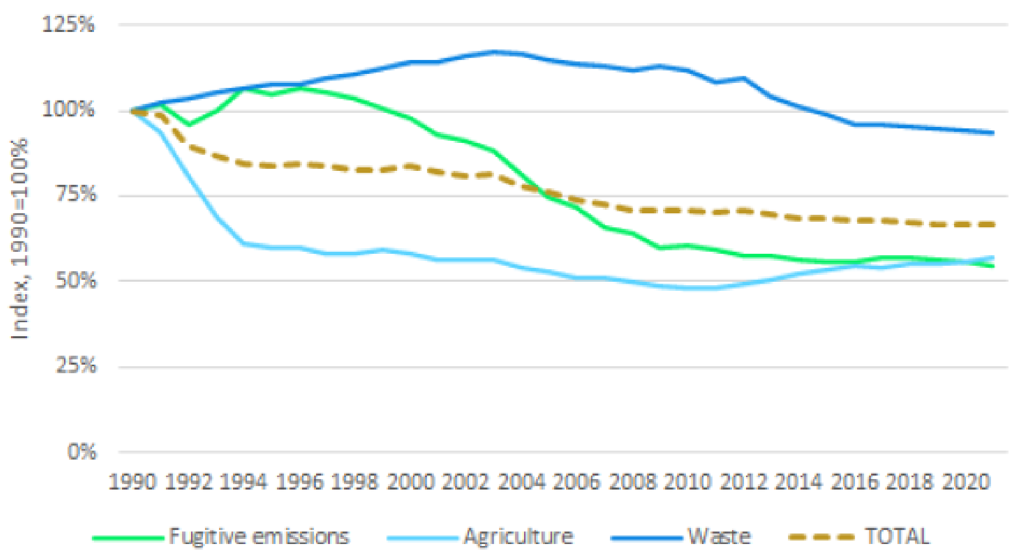


Figure 3.12 Trend of CH_4 emissions from some selected important sources

Source of data: National Inventory Report, Hungary 2023

Due to the above factors (i.e., fall in agricultural and industrial production), also **N_2O** emissions decreased significantly in the beginning of the period. Later it showed a slightly rising trend, followed by another drop primarily reflecting the fluctuations in agricultural output and the modernization of nitric-acid production. Then, after 2010, agricultural emissions started growing again, and especially emissions from agricultural soils grew by 40 % between 2010 and 2021.

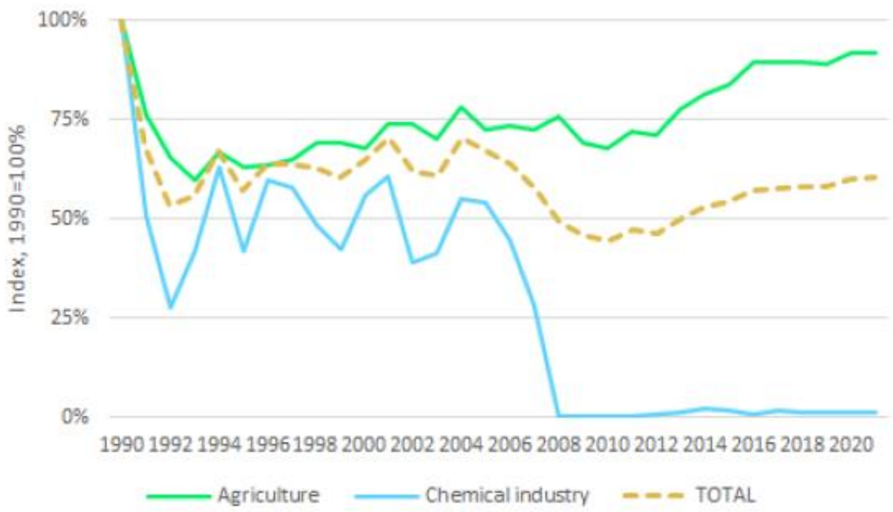


Figure 3.13 Trend of N_2O emissions from some selected important sources

Source of data: National Inventory Report, Hungary 2023

The use of **HFC** gases became more intensive in the second half of the 1990's in conjunction with the restriction of the use of chlorofluorocarbons as refrigerants. The rise of emissions is obvious.

PFCs emissions are principally related to aluminium production processes. Therefore, the tendencies of PFC emissions reflect the changes in aluminium production. Following a drastic reduction in the beginning of the period, the levels showed a slow but steady increase. Then the aluminium production ceased suddenly in 2006.

SF_6 emissions primarily depend on the uses in electricity transmission, as it is mainly used in electrical equipment, first of all in switchgears for insulation and arc quenching. So, the growth of the electricity consumption results in an increasing application of SF_6, however the tendencies vary according to the manufacturing/application needs and the steep increase seems to be stopped in the recent years in SF_6 emissions too.

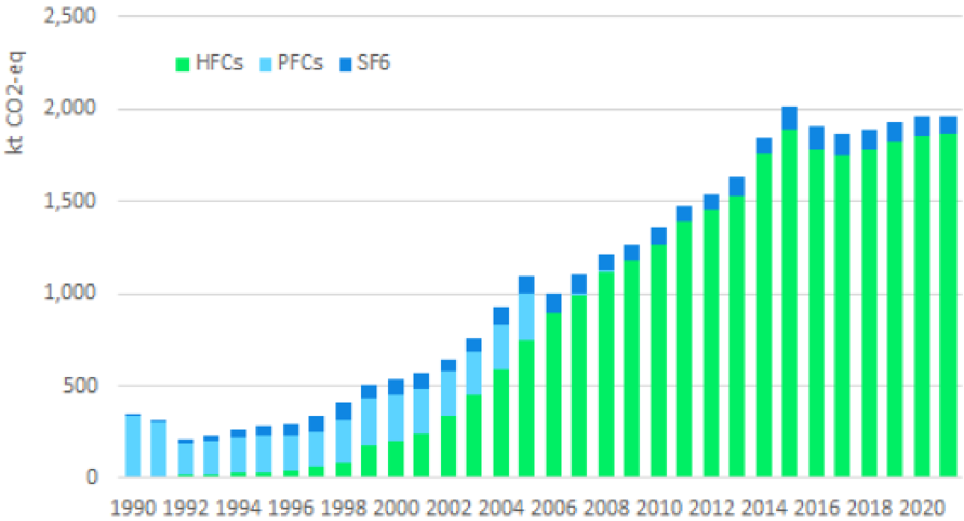


Figure 3.14 Trend of F-gas emissions (1990-2021)

Source of data: National Inventory Report, Hungary 2023

Description and interpretation of emission trends by sector

Production and use of energy generate most greenhouse gases, largely CO_2. The ***energy sector*** was responsible for 72% of total GHG emissions in 2021. Emissions in the energy sector decreased in the first part of the period as a result of reduced energy consumption and a more favorable fuel mix. The significant reduction in emissions between the base year and 1995 was mainly due to the economic transformation which caused sudden decrease in energy demand. (In this respect, it is perhaps worth mentioning that the decrease in fuel consumption between 2005 and 2014 was even higher!) In addition, ongoing changes in fuel-structure, i.e., gradual replacement of solid fuel by natural gas, led to further decrease of total emissions. Between 2005 and 2008 growing emissions from energy industries and transport could be observed, which were more than the offset by the drastic reductions in the residential sector and manufacturing industries. Due to the economic crisis, total combustible fuel consumption decreased by 6% in 2009. Fuel consumption decreased further until 2014 by 14%, but then it increased again by 11% until 2019. In 2020, total fuel consumption decreased by 2% and it is lower by 16% than in 2005.

Currently, 15% of domestic primary energy supply is nuclear, 13% is renewable which means that the remaining - overwhelming - part of primary energy demand has to be met by fossil fuels. Natural gas accounts for the largest share (47%) of incinerated, largely fossil fuels, followed by petroleum products (31%). Emissions have been positively influenced by the fact that the proportion of coal with higher specific emissions has fallen from 30% to 6% in the last 35 years, which is well below the current share of biomass in fuel consumption (14%).

The three most important sources of emissions in the energy sector are transport, energy industries, and "other sector" (mostly including residential and other buildings), representing respectively 22%, 18% and 21% of total national emissions in 2021. Energy use and emissions from manufacturing industries and construction contributed 8% to domestic total emissions. Fugitive (mostly methane) emissions from the domestic natural gas system represent 3% of total emissions

In recent years, the transport sector became the largest emitter, not only within the energy sector but also across all sectors, as transport accounted for 23% of total national emissions in 2019. However, as a result of preventative measures for COVID-19, emissions from the road transport-dominated sector fell sharply by 14% in 2020. Then, transport related emissions grew again in 2021 reaching almost the level of 2019. Compared to the previous low point, 2013, transport emissions were 39% higher. In addition, based on preliminary fuel sales data, it appears that further rising emissions are expected for 2022 in this sector. Considering energy industries, domestic electricity production increased further by 3%. However, coal-based power production dropped again significantly by 19% (after a decrease of 9% last year) whereas natural gas fired power plants with more favorable specific emission levels increased their production by 6%. Another welcome development is the sharp increase (54% in 2021!) in the use of solar energy: 11% of gross electricity production now comes from solar energy - more than from coal. The share of nuclear power generation was 44% in 2021. Electricity import had still a relatively large share with 26% in consumption. As a result of all the above, emissions from energy industries decreased by 7% in 2021. As 2021 was rather average and not as warm as the previous years, the heating energy consumption of households increased by 10%. Natural gas use and biomass consumption increased by 10% and 4%, respectively, whereas coal consumption decreased by 20%.

The significant increase in transport and heating emissions more than compensated for the decrease in the energy industry, so overall, the energy sector's emissions increased by 3% in 2021. The ***industrial processes and product use sector*** contributed 11% to total GHG emissions in 2021. The most important greenhouse gas was CO2, contributing 68% to total sectoral GHG emissions, followed by F-gases with 27%. In 2021, 38% of the emissions came from chemical industry, followed by 26% from product uses as ODS substitutes. Mineral industry has 19%, metal (namely iron and steel) industry has 12% contribution to sectoral GHG emissions, respectively. Other product uses (containing SF6 and N2O) and non-energy products from fuels and solvent use have the smallest influence on the 2021 IPPU inventory with 4% and 1%, respectively. Process related industrial emissions decreased by 51% between the base year and 2021, and by 19% between 2005 and 2021.
In 2021, the production of pig iron fell sharply due to problems in the operation of Hungary's only pig iron manufacturer, therefore the output of iron and steel production decreased by 24%. The growth of chemical industry emissions stopped in 2021 due to the stagnation of production observed in all sectors. The decrease in the emissions of mineral industry (mainly in cement production) in 2020 proved to be temporary, and in 2021 it increased again by 2% compared to the previous year. Emissions from the non-energy use of fuels and solvent use increased by just 1% after the stronger growth in 2020.

More than a quarter of industrial emissions come from the operation of equipment containing F-gases and from use of F-gas containing products. Category 2.F.1. (Refrigeration and air-conditioning) accounts for 88% of total F-gas emissions, emissions growth has stopped in recent years. Use of fluorinated and perfluorinated compounds (HFCs, PFCs) has been significant in Hungary since the early 1990s, but these gases became a commonly used refrigerant in the second half of the decade. Most of the equipment with F-gas installed after this period is now coming to the end of its lifetime. Disposal and regeneration of increasing quantities of gases from equipment end-of-life helps to stop emissions growth. In 2021, the **agriculture sector** accounted for 11% of total emissions. The contribution of agriculture to total emissions was similar also in the base year (BY). Emissions from agriculture include CH4 and N2O gases. 85 per cent of total N2O emissions were generated in agriculture in 2021. Emissions from agriculture have decreased by 40% over the period of 1985-2021. The bulk of this reduction occurred in the years between 1985 and 1995, when agricultural production fell by more than 30 per cent, and livestock numbers underwent a drastic decline.

Between 1996 and 2008, agricultural emissions had stagnated around 6.2 Mt with fluctuations up to 4.6%. Behind this trend there were compensatory processes. While the number of livestock decreased further leading to lower emission, the use of fertilizers increased by 68% in the period 1995-2007 which caused growing nitrous oxide emissions from agricultural soils. In 2008 the significantly rising fertilizer prices led to lower fertilizer use, which resulted in some reduction in the emission levels.

Agricultural emissions decreased both in 2009 and 2010. A major reduction in emissions occurred in 2009, when 11 per cent decline in swine population also contributed to the downward trend.

Agricultural emissions, after hitting the lowest point in 2010, had increased until 2018, mainly because of the increase in the inorganic fertilizer use, cattle livestock, and milk production per cow.
The GHG-emissions reflect the restructuring in the agricultural production has taken place since 2004, namely the increased ratio of crop to livestock production. Share of CH_4 emissions, which derive mainly from the animal husbandry, has decreased, while the N_2O emissions, originating primarily from the crop production has grown, since 2004.
Certain types of inorganic fertilizers as urea containing fertilizers and calcium ammonium nitrate (CAN) fertilizers contribute to the agricultural GHG-emissions not only with their nitrogen, but also their carbon content. In Hungary CAN fertilizers have become increasingly popular in the recent years, as a result N_2O and CO_2 emissions has tripled from this source since 2005.
In 2019, emissions growth temporarily slowed down, mainly due to the decreasing swine livestock and synthetic fertilizer use, but emissions increased again in 2020. In 2021, agricultural emissions were close to 2020 levels. With an average annual net sink of just above 4 million tCO_2 equivalent, the ***Land Use Land-Use Change and Forestry sector*** has been a net carbon sink over the entire inventory time series. In 2021, the net sink (including that from the harvested wood product carbon pool) reached 7.2 million tCO_2 equivalent. Forests removed 6.7 million tCO_2 from the air in 2021. Of the factors acting in the long-term, this was a result of rather intensive afforestations for decades as well as the sustainable management of the forests. The considerable increase in the forest sink in the last two years was due to the effects of the COVID pandemics that temporarily caused the reduction of harvesting. The carbon balance of the harvested wood product pool varies but considerably increased in the last five years, with a net sink of over 900 $ktCO_2$ in 2021. The non-forestry land-use sectors used to be small net sinks before 2016 but they have turned small sources since then. The net emission of these sectors has been estimated as 400 kt CO_2-eq in 2021. Due to its complex dynamics, the variation of the annual greenhouse gas balance of the LULUCF sector is relatively high, with no trend since 2005, i.e., for years with reliable data. The ***waste sector*** was responsible for 6% of total national GHG emissions in 2021. The largest category was solid waste disposal on land, representing 86% in 2021, followed by wastewater treatment and discharge (9%), biological treatment of solid waste (4%), and incineration of waste without energy recovery (1%). In contrast with other sectors, emissions from the waste sector are by 5% higher now than in the base year. However, the growth in emissions stopped in the last decade, and a reduction of 20% could be observed between 2005 and 2021. The degradation process in solid waste disposal sites is quite slow which means that waste that were disposed many years earlier have still an influence on current emission levels. However, the amount of disposed waste had dropped significantly since 2005 (e.g., landfilled municipal waste decreased by more than 50%) consequently methane emissions started to decrease as well. GHG emissions from wastewater handling have a pronounced decreasing trend due to a growing number of dwellings connected to the public sewerage network.

3.3 Institutional arrangements for the preparation of GHG inventories

The minister responsible for the environment has overall responsibility for the Hungarian Greenhouse Gas Inventory and the Hungarian National System for Climate Reporting. He is responsible for the institutional, legal and procedural arrangements for the national system and the strategic development of the national inventory. The tasks of the Ministry of Environment and Water have been taken over by the Ministry of Rural Development in 2010. The structure and duties of the ministries changed again somewhat after the elections in 2014, and the Ministry of Rural Development turned to Ministry of Agriculture which nevertheless has the same responsibilities regards environmental matters. Following the 2022 elections, the Ministry for Technology and Industry took over the environmental issues until December 1, when the new Ministry of Energy was established with responsibilities for climate policy and environment, among others. Therefore, the designated *single national entity* is now the **Ministry of Energy**.

Contact details of the single national entity are as follows:

Ministry of Energy

Head office: 1117 Budapest,
Október huszonharmadika u.
18.
Postal address: 1440 Budapest,
Pf. 1.

Phone: +36 1 795 6766, +36
1 795 3832, +36 1 896 3105

Fax: +36 1 550 39 44
E-mail:
ugyfelszolgalat@em.gov.hu

The national system has to be operated by the minister responsible for the environment, energy policy, forest management, agricultural policy and national budget. Within the Ministry of Energy, a Climate Policy Department has been established that plays a coordinating and supervisory role in the national system. The deputy of the head of this department is Hungary's current UNFCCC Focal Point.

Currently, the Governmental Decree 278/2014. (XI. 14.) regulates the preparation of the national GHG reports and the procedure of the obligatory data provision necessary for the inventories. This decree designates the Hungarian Meteorological Service 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.

The Hungarian Meteorological Service (OMSZ of which successor instituton is HungaroMet from the 1st January 2024) is a central office under the control of the minister responsible for the environment, i.e., currently the minister of energy. The duties of the Service are specified in a Governmental Decree from 2021 (353/2021. (VI. 24.)). These duties also include the preparation of emission inventories of greenhouse gases and air pollutants 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 national inventory reports (NIR) of Hungary.[7]

Information on the assessment of the economic and social consequences of response measures is provided in section 3.3. of the Fifth Biennial Report of Hungary (see Annex II).

3.4. National registry

No fundamental changes have taken place concerning the National registry since the submission of the previous National Communication (NC7 2018). Below is an overview of the consolidated registry system employed by EU Member States.

Directive 2009/29/EC adopted in 2009, provides for the centralization of the EU ETS operations into a single European Union registry operated by the European Commission as well as for the inclusion of the aviation sector. At the same time, and intending to increase efficiency in the operations of their respective national registries, the EU Member States who are also Parties to the Kyoto Protocol plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner by all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and Decision 24/CP.8.

The consolidated platform which implements the national registries in a consolidated manner (including the registry of the EU) is called the Union registry and was developed together with the new EU registry on the basis of the following modalities:

- Each Party retains its organization designated as its registry administrator to maintain the National egistry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries;
- Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number;
- Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a

[7] Please find NIR 2022 here: https://unfccc.int/documents/461959 and NIR 2023 here: https://unfccc.int/documents/627849

unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained;

- Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions;
- The transaction log and registries continue to reconcile their data with each other to ensure data consistency and facilitate the automated checks of the ITL;
- The requirements of paragraphs 44 to 48 of the Annex to Decision 13/CMP.1 concerning making non-confidential information accessible to the public is fulfilled by each Party through a publicly available web page hosted by the Union registry;
- All registries reside on a consolidated IT platform sharing the same infrastructure technologies. The chosen architecture implements modalities to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other, notably:
  - (a) With regards to the data exchange, each national registry connects to the ITL directly and establishes a secure communication link through a consolidated communication channel (VPN tunnel);
  - (b) The ITL remains responsible for authenticating the national registries and takes the full and final record of all transactions involving Kyoto units and other administrative processes such that those actions cannot be disputed or repudiated;
  - (c) With regard to data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation;
  - (d) The data storage architecture also ensures that the data about a national registry are distinguishable and uniquely identifiable from the data about other consolidated national registries;
  - (e) In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorisation and configuration rules.

Following the successful implementation of the EU registry, all national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. Croatia was migrated and consolidated as of 1 March 2013. During the go-live process, all relevant transaction and holdings data were migrated to the Union registry platform and the individual connections to and from the ITL were re-established for each Party.

The following changes to the National registry have occurred since the last National Communication report.

Table 3-1 *Changes to the EU national registry*

Reporting Item	Description
15/CMP.1 Annex II.E paragraph 32.(a) Change of name or contact	The primary contact is: Name: Ágnes Gulyás-Béky Position: head of department Organization: National Climate Protection Authority (NCPA) Address: 1117 Budapest, Október huszonharmadika u. 18.., Hungary Tel: +36-1-795-8019 E-mail: agnes.gulyas-beky@em.gov.hu Further contacts are: Name: Cseresznyák-Bognár Szilvia Position: head of unit Organization: National Climate Protection Authority (NCPA) Address: 1117 Budapest, Október huszonharmadika u. 18. ., Hungary Tel: +36-1-795-1282 E-mail: szilvia.cseresznyak-bognar@em.gov.hu Name: Eszter Noémi Györek Position: registry administrator Organization: National Climate Protection Authority (NCPA) Address: 1117 Budapest, Október huszonharmadika u. 18. , Hungary Tel: +36-1-896-7418 E-mail: noemi.eszter.gyorek@em.gov.hu Name: Bendegúz Laczkó Position: registry administrator Organization: National Climate Protection Authority (NCPA) Address: 1117 Budapest, Október huszonharmadika u. 18. ., Hungary Tel: +36-1-795-5450 E-mail: bendeguz.laczko@em.gov.hu
15/CMP.1 Annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.

Reporting Item	Description
15/CMP.1 Annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	In 2016 new tables were added to the database for the implementation of the CP2 functionality. Versions (latest: 13.6.8.3) of the Union registry released after 8.0.8 (the production version at the time of the last NC submission) introduced some changes in the structure of the database. Current database model is provided in Annex A. No change was required to the database and application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to each release of a new version in Production. Annex H testing is carried out whenever required by the applicable rules. Changes introduced in the last year of the reporting period are presented in Annex B. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 Annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 Annex II.E paragraph 32.(f) Change regarding security	The use of soft tokens for authentication and signature was introduced for the registry end users.
15/CMP.1 Annex II.E paragraph 32.(g) Change to list of publicly available information	Publicly available information is provided via the Union registry homepage for each registry. For Hungary, it is: https://unionregistry.ec.europa.eu/euregistry/HU/public/reports/publicReports.xhtml
15/CMP.1 Annex II.E paragraph 32.(h) Change of Internet address	The registry internet address changed during the reported period. The new URL is https://unionregistry.ec.europa.eu/euregistry/HU/index.xhtml

Reporting Item	Description
15/CMP.1 Annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 Annex II.E paragraph 32.(j) Change regarding test results	Both regression testing and tests on the new functionality are carried out prior to release of the new versions in Production. The site acceptance tests are carried out by quality assurance consultants on behalf of and assisted by the European Commission. Annex H testing is carried out whenever required by the applicable rules.

4. POLICIES AND MEASURES

4.1. Policy-making process

4.1.1. European Union framework

Hungary's mitigation actions, as a member state of the European Union, are determined primarily by the policies and regulations of the EU.

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 32.5% improvement in energy efficiency.

The EU's 2030 climate ambition was recently 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 an 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 belong 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'.

Below is a list of the most important cross-sectoral and sectoral policies and measures of the EU. For further details on EU climate legislation please see the 88th National Communication and 4th4th Biennial Report of the European Union.

Cross-Cutting Polices and Measures

- European Climate Law ((EU) 2021/1119 Regulation)
- Governance Regulation ((EU) 2018/1999)
- The EU Emissions Trading System (EU ETS) (Directive 2003/87/EC and a wide series of implementing and delegated legal acts based thereon; Decision (EU) 2015/1814)
- The Effort Sharing Regulation (ESR) RegulationR (Regulation (EU) 2018/842)
- Carbon Capture and Storage Directive (2009/31/EC)
- Energy Taxation Directive (2003/96/EC)
- Horizon 2020
- European Structural and Investment Funds (ESIF)
- National Emissions Ceilings Directive (2016/2284/EU)
- Covenant of Mayors for climate and energy *(not legally binding)*

Sectoral policies and measures: Energy

- Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council
- Directive 2009/28/EC on the promotion of the use of energy from renewable sources
- Directive 2010/31/EU on the energy performance of buildings
- Directive 2012/27/EU on energy efficiency

- Directive 2009/125/EC establishing a framework for the setting of eco-design requirements for energy-related products
- Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products
- Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU (Text with EEA relevance.)
- Proposal for a Regulation setting a framework for energy efficiency labelling and repealing Directive 2010/30/EU
- Commission Regulation (EU) 2021/341 of 23 February 2021 amending Regulations (EU) 2019/424, (EU) 2019/1781, (EU) 2019/2019, (EU) 2019/2020, (EU) 2019/2021, (EU) 2019/2022, (EU) 2019/2023 and (EU) 2019/2024 with regard to ecodesign requirements for servers and data storage products, electric motors and variable speed drives, refrigerating appliances, light sources and separate control gears, electronic displays, household dishwashers, household washing machines and household washer-dryers and refrigerating appliances with a direct sales function
- Commission Delegated Regulation (EU) 2021/340 of 17 December 2020 amending Delegated Regulations (EU) 2019/2013, (EU) 2019/2014, (EU) 2019/2015, (EU) 2019/2016, (EU) 2019/2017 and (EU) 2019/2018 with regard to energy labelling requirements for electronic displays, household washing machines and household washer-dryers, light sources, refrigerating appliances, household dishwashers, and refrigerating appliances with a direct sales function
- Commission Delegated Regulation (EU) 2015/2402 of 12 October 2015 reviewing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2012/27/EU of the European Parliament and of the Council and repealing Commission Implementing Decision 2011/877/EU
- 2008/952/EC: Commission Decision of 19 November 2008 establishing detailed guidelines for the implementation and application of Annex II to Directive 2004/8/EC of the European Parliament and of the Council (notified under document number C(2008) 7294) (Text with EEA relevance)
- The Commission Interpretative Communication on the "Community law applicable to public procurement and the possibilities for integrating environmental considerations into public procurement" (COM(2001) 274)
- Technical Support Instrument
- Energy Star Programme
- EU Project Development Assistance (PDA) Facilities
- European Energy Efficiency Fund (EEEF)
- European Regional Development Fund (ERDF)
- Recovery and Resilience Facility

- Modernisation Fund
- InvestEU Programme
- LIFE-Clean Energy Transition sub-programme
- People-centric sustainable built environment (Built4People)
- European Partnership for Clean Energy Transition
- EU Mission: Climate-Neutral and Smart Cities
- European local energy assistance
- InvestEU Advisory Hub
- Sustainable Energy Investment Forums
- De-risking Energy Efficiency Platform (DEEP)
- Motor Challenge Programme
- Strategic Energy Technology Plan (COM(2007) 723)
- Energy Union Strategy (COM(2015) 80 final)
- Biomass Action Plan
- Communication on Accelerating Clean Energy Innovation (COM(2016) 763 final)
- Communication from the Commission Ecodesign and energy labelling working plan 2020-2024
- Commission Notice The 2022 annual Union work programme for European standardisation 2022/C 66/01
- COMMISSION RECOMMENDATION of 28.9.2021 on Energy Efficiency First: from principles to practice. Guidelines and examples for its implementation in decision-making in the energy sector and beyond. C(2021) 7014 final
- Proposal for a Directive of the European Parliament and of the Council on energy efficiency (COM(2021) 258 final)
- Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a Social Climate Fund (COM(2021) 568 final)
- Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast) (COM(2021) 802 final)
- Proposal for revised Renewable Energy Directive (COM(2016) 767 final/2)
- Commission Implementing Decision on energy labelling, in support of and as regards: Commission Delegated Regulation (EU) 2015/1186, Commission Regulation (EU) 2015/1188, Commission Regulation (EU) 2015/1185
- EU heating and cooling strategy (COM(2016) 51 final)
- Commission Delegated Regulation (EU) 2019/826 of 4 March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and

of the Council on the contents of comprehensive assessments of the potential for efficient heating and cooling

Sectoral policies and measures: Transport

- CO_2 and Cars Regulation (EC 443/2009)
- CO_2 and Vans Regulation (EC 510/2011)
- Strategy for reducing Heavy-Duty Vehicles' fuel consumption and CO2 emissions
- Car and tyre labelling Directives (1999/94/EC and EC 1222/2009 respectively)
- Regulation of Safe motor vehicles and trailers (EC 661/2009)
- Renewable Energy Directive (2009/28/EC)
- Fuel Quality Directive (2009/30/EC)
- Infrastructure charging for heavy goods vehicles (1999/62//EC, amended by 2006/38/EC and 2011/76/EU)
- Directive 2014/94/EU on Deployment of Alternative Fuels Infrastructure
- Clean Vehicles Directive (2009/33/EC)
- Integrating maritime transport emissions in the EU's greenhouse gas reduction policies (COM(2013) 479 final and Regulation (EU) 2015/757)
- White Paper: Roadmap to a Single European Transport Area COM(2011) 144 final
- A European Strategy for Low-Emission Mobility (COM(2016) 501 final)
- Electromobility initiative, Green eMotion
- Fuel Cells and Hydrogen Joint Undertaking (JU)

Sectoral policies and measures: Industry / industrial processes

- Mobile Air Conditioning Systems (MAC) Directive (Directive 2006/40/EC)
- Fluorinated greenhouse gases regulation (Regulation (EU) No 517/2014)
- Industrial Emissions Directive 2010/75/EU (IED)

Sectoral policies and measures: Agriculture

- Agricultural Market and Income support (1st pillar of Common Agricultural Policy / CAP)
- Rural Development Policy (2nd pillar of CAP)
- Soil Thematic Strategy (COM(2006) 231)
- Nitrates Directive (91/676/EEC)

Sectoral policies and measures: Forestry / LULUCF

- LULUCF Regulation (Regulation (EU) 2018/841)

Sectoral policies and measures: Waste

- Directive on Waste (2008/98/EC)
- Directive on the landfill of waste (1999/31/EC)
- Directive on packaging and packaging waste (94/62/EC)
- Directive on the reduction of the impact of certain plastic products on the environment (EU) (2019/904)
- Directive on end-of-life vehicles (2000/53/EC)
- Directive on batteries and accumulators and waste batteries and accumulators (2006/66/EC)
- Directive on waste electrical and electronic equipment (2012/19/EU)
- Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Directive 2011/65/EU)
- A new Circular Economy Action Plan For a cleaner and more competitive Europe (COM(2020) 98 final)
- Closing the loop - An EU action plan for the Circular Economy (COM(2015) 614 final)
- A European Strategy for Plastics in a Circular Economy COM(2018) 28 final
- The European Green Deal (COM(2019) 640 final)
- Establishment of the EU Platform on Food Losses and Food Waste (August 2016)

4.1.2. National framework

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).

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 former Ministry for the Environment and Water developed Hungary's First National Climate Change Strategy for 2008-2025 (NCCS I), which entered into force via the Parliamentary Resolution 29/2008. This strategy covered three major areas of action: mitigation, adaptation and awareness raising.

According to the statutory requirements the NCCS I was reviewed in 2013 and the second National Climate Change Strategy (NCCS II) for 2014-2025 has been made, but after the Paris Agreement the NCCS II has been updated again. The updated NCCS II for 2017-2030 (NCCS II) was published and opened to public consultation in the spring of 2017. It was accepted by the Government and submitted to the Parliament in May 2017.

The NCCS II 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.

National Sustainable Development Framework Strategy 2012-2024

The National Framework Strategy on Sustainable Development has been adopted by the Hungarian Parliament in 2013. No changes were made to the strategy since the last national Communication. The monitoring of the implementation of the Strategy is ensured by the National Council for Sustainable Development established by the Parliament. Every two years, the Council prepares a report on the implementation of the Framework Strategy, including government measures related to four groups of resources: human, social, natural and economic. The latest report was adopted by the Council in 20212021.

National Environmental Programme up to 2026 (NEP-V)

The National Environmental Programme (NEP) is the comprehensive ystrategy 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 Programme has a horizontal approach covering society and economy in their entirety.

The recent National Environmental Programme (NEP-V) was adopted by the Parliament in 2022 (Resolution of the Parliament 62/2022 (XII. 9) OGY). The overarching objectives of NEP-V are the following:

- Improving the environmental condition in order to protect the health and quality of life of families and communities in Hungary.
- Contributing to the assurance of environmental conditions of sustainable development.

The NEP-V ensures the continuation of the tasks started earlier and also takes into account the new international and EU objectives.

The NEP-V has four strategic objectives and two horizontal objectives:

- Improving the quality of life and the environmental conditions of human health, reducing the effects of environmental pressure.

- Protection and recovery of natural values and resources and their sustainable use.
- Improving resource efficiency and making steps toward a green and circular economy.
- Improving environmental safety.
- Improving society's environmental awareness.
- Strengthening the ability to adapt to climate change.

In connection with climate change, the NEP-V includes the following objectives:

- By way of transitioning to a low carbon economy, the decrease of greenhouse gases and the strengthening of natural absorption-capacities-
- Successful implementation of adaptation to climate change in order to preserve the reserves and the quality of national resources (natural, human, social and economic).
- Increasing knowledge about climate change, promoting awareness about prevention and adaptation measures.

4.1.3. Responsibilities

The *Ministry of* Energy is primarily responsible for transport, energy, key public services and climate and environmental policy. Some of the priority goals of the Ministry are supporting domestic climate and environmental projects and keeping the private sector representatives informed of the latest EU and domestic funding opportunities. This Ministry includes – inter alia - the Climate Policy Department, which is responsible for international and EU level climate negotiations and national climate lawmaking. The Ministry also includes the National Climate Protection Authority, which carries out authority tasks relating the administration on F-gases and the EU ETS; the task related to the National Administrator of the Registry and EU ETS free allocation tasks. The Ministry of Energy is responsible for environment protection too. In addition it prepares the general rules of environmental protection, integrated pollution prevention, transboundary environmental impacts, environmental remediation, air protection and the protection from the harmful effects of noise and vibration. The Ministry regularly analyzes and evaluates the economic instruments of environmental protection, proposes to further develop them. It monitors and encourages the development of environmental protection equipment, tools, methods and procedures, such as the introduction of environmentally-friendly materials, energy and water-saving waste-efficient technologies. It is also responsible to develop environmental awareness-raising and educational programmes.

In the framework of its responsibilities for water protection, the *Ministry of Interior* prepares legislation on the protection of surface waters and groundwater, such as the protection of groundwater from nitrates from agricultural sources and economic control instruments for the identification of surface waters and their catchment areas sensitive to urban wastewater treatment. The Ministry contributes to the preparation and implementation of environmental legislation affecting water as an environmental element and it manages the implementation of tasks deriving from bi- and multilateral international agreements on water protection. The Ministry of Interior is also responsible for public education in Hungary, including curriculum design and implementation, national outomce assessment, evaluation and monitoring processes, the coordination and monitoring of whole-institutional excellence networks of education for sustainable development (the Hungarian Ecoschool and Green Kindergarten Netowkrs) as well as the coordination of the SustainabilityThematic Week and the World's Largest Lesson, moreover supporting teacher monitoring and evalution and in-service teacher trainings.

The *Ministry of Agriculture* is responsible for agricultural and forestry policy development and nature conservation. The Ministry of Agriculture is also responsible for agriculture and rural development. It 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.

4.2. Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures

Hungary has deposited its ratification documents concerning the Kyoto Protocol (including its Doha Amendment), the Paris Agreement under the Convention and also 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 laid down in the act on the implementation framework of the UNFCCC and the Kyoto Protocol (LX of 2007).

Hungary, as an EU Member State, fulfills its commitments for 2030 and 2050 jointly with the whole EU. The Emission Trading System (EU ETS) and Effort Sharing Decision (ESD)[8] 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).

These two laws and the Governmental Decrees on their implementation (Governmental Decrees 323/2007; 278/2014 and 14/2015; 410/2012 and 341/2013) provide the detailed rules of the enforcement and administrative procedures of the climate-related obligations in Hungary, in a publicly accessible form.

Act XLIV of 2020 on Climate Protection enshrines national emission reduction targets in law, with Hungary being one of the first Member States of the EU to do so. Hungary has laid down the emission reduction target of at least 40% by 2030 compared to 1990, while it has committed itself to becoming climate-neutral by 2050. The Climate Protection Act also determines our medium-term energy goals. After 2030, in the event of an increase in final energy consumption above the 2005 level, the increase will be provided exclusively from a

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

carbon-neutral energy source, and renewable energy sources will account for at least a 21% share of gross final energy consumption by 2030.

In July 2021, the European Commission adopted a series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050, including the new EU-wide intermediate target of an at least 55% net reduction in greenhouse gas emissions. The "Fit for 55" package proposes to revise several pieces of EU climate legislation, including the EU ETS Directive, the Effort Sharing Regulation and the LULUCF regulation. The legal acts that will be adopted as part of the package may also require certain revisions in Hungarian legislation.

4.3 Policies and measures and their effects

In this section, planned, adopted and implemented policies and measures are presented which contribute to the reduction of GHG emissions on a sectoral basis.

CTF table 3 includes the list of policies and measures. Furthermore, policies and measures are listed in Annex I of the draft updated National Energy and Climate Plan of Hungary, too.[9]

Regarding the projections of the estimated and expected total effect of implemented and adopted policies and measures in terms of GHG emissions avoided or sequestered, the projections are included in Hungary's National Energy and Climate Plan, Chapter 4. In the first Subchapter (4.1), subpoint ii. (Page 123-137) an assessment has been made of the sectoral changes expected to impact the energy system and GHG emissions. In Subchapter (4.2.1), subpoint i. (page 142- 149) we display data on the current trends in greenhouse gas emissions and removals, GHG emissions displayed by sector between the years of 1990-2020. In the next subpoint ii. (Page 149-155) of the same Subchapter the projections of sectoral developments with existing national and Union policies and measures are assessed until at least 2040.

Table 4.2 provides information on sectors affected by cross-sectoral policies. Information on whether a policy or measure is included in the "with existing measures" or "with additional measures" is presented in Annex section 5 of the 5th Biennial Report.

4.3.1 Cross-sectoral policies

Name	Objective	GHG affected	Type of instru-ment	Status	Implement-ing entity	Estimate of mitigation impact		
						2015	2020	2030
National Energy Strategy 2030	Multi-sectoral policy; Increase in renewable energy; energy efficiency improvement	CO_2	Planning	Implemented 2011-2030	Governmental offices	-	-	-
National Renewable Energy Action Plan	Increase in renewable energy	CO_2	Planning	Implemented 2010-2020	Governmental offices	-	-	-

[9] Please find the draft updated National Energy and Climate Plan of Hungary and its annexes here: https://commission.europa.eu/publications/hungary-draft-updated-necp-2021-2030_en

Energy and Climate Awareness Raising Action Plan	Demand management/reduction	CO_2	Planning	Implemented 2015-2020	Governmental offices	-	-	-
National Energy Efficiency Action Plan (NEEAP)	Efficiency improvements of buildings; Demand management/reduction	CO_2	Planning	Implemented 2015-2030	Governmental offices	-	-	-
Environment and Energy Efficiency Operational Program (EEEOP)	Increase in renewable energy; Efficiency improvements of buildings; Efficiency improvement of appliances; Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors; Efficiency improvement in the energy and transformation sector; Improved wastewater management systems; Enhanced recycling; Reduced landfilling	CO2	Economic	Implemented 2014-2023	Governmental offices	-	-	-
Territorial and Settlement Development Operative Programme (TSDOP)	Increase in renewable energy; Efficiency improvements of buildings; Modal shift to public transport or non-motorized transport; Improved transport infrastructure	CO_2	Economic	Implemented 2014-2023	Governmental offices	-	-	-
Competitive Central-Hungary Operational Programme (CCHOP)	Increase in renewable energy; Efficiency improvements of buildings; Efficiency improvement in the energy and transformation sector; Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors	CO_2	Economic	Implemented 2014-2023	Governmental offices	-	-	-
Rural Development Programme	Afforestation and reforestation; improving energy efficiency	CO2	Economic	Implemented 2014-2020	Governmental offices	-	-	-

Table 4.1 Cross-sectoral policies and measures

	Energy	Transport	Industry	Agricutlture	Forestry	Waste
National Energy Strategy 2030	x	x				
National Renewable Energy Action Plan	x	x				

Energy and Climate Awareness Raising Action Plan	x	x	x			x
National Energy Efficiency Action Plan (NEEAP)	x	x				
Environment and Energy Efficiency Operational Program (EEEOP)	x					x
Territorial and Settlement Development Operative Programme (TSDOP)	x	x				
Competitive Central-Hungary Operational Programme (CCHOP)	x	x				
Rural Development Programme	x				x	
National Air Pollution Control Programme (NAPC)	x	x	x	x	x	

Table 4.2. Sectors affected by cross-sectoral policies

Law on Climate Protection
The law on Climate protection (2020. XLIV.) acknowledges that climate change is one of the greatest challanges of our time and states the need to mitigate its effects and adapt to them. Among other goals it sets the goal for the country to become climate neutral by 2050.

National Energy Strategy 2030
The new National Energy Strategy published in 2020 is the comprehensive policy document of the energy sector. Providing clean, smart and affordable energy is the main goal of the strategy. It decribes the planned mesures in 6 flagship projects: 1. Climate friendly, flexible electricity production, 2. Improving the energy efficiency of the economy, 3.Transport greening, 4. Energy concious and modern Hungarian homes, 5. Energy innovation projects, 6. Program to establish the energy and climate concious society

National Energy and Climate Plan
The National Energy and Climate Plan describes Hungary's goals and planned measures for the 5 dimesions of the energy union.

National Energy Efficiency Action Plan (NEEAP)
The 3rd National Energy Efficiency Action Plan (NEEAP) - published in 2015 - describes the planned energy efficiency measures for each economic sector, the state of implementation of practical applications and measures related to Directive 2012/27/EU on Energy Efficiency and other programmes supporting better energy efficiency. Measures related to better energy efficiency of buildings - including new buildings with low energy consumption levels, and reconstruction of existing buildings - have the most significant effects on fulfilling the energy

efficiency targets. The main objective of the 3rd NEEAP is to achieve a significant reduction in primary energy consumption in all sectors of the economy, which means a remarkable reduction in building, residential and transport sector, as well. The Action Plan also includes the National Building Energy Performance Strategy, the Energy and Climate Awareness-Raising Action Plan, and the planned Transportation Energy Efficiency and District Heating Development Action Plans.

Environment and Energy Efficiency Operational Program (EEEOP)
EEEOP is one of the operational programmes during the 2014-2020 period accepted by the European Commission. The programme aims to support sustainable growth and contributes to achieving the Europe 2020 targets for smart, sustainable and inclusive growth. It should improve flood protection, provide better waste and wastewater management services and good quality drinking water to more residents, help protect natural habitats and species of community importance, and it should improve energy efficiency and the use of renewable energy sources. Priority axis 2 includes projects supporting waste water treatment capacity building and drinking water quality developments. Priority axis 3 includes supporting investment in separate waste collection and in municipal waste treatment facilities. Priority axis 5 supports investments in renewable energy supply, energy efficiency, enhancing district heating and heat energy supply systems. Priority axis 6 provide assistance for fostering crisis repair in the context of the COVID-19 by supporting green infrastructure, climate adaptation (Flood protection and water management developments) and energy developments.

Territorial and Settlement Development Operative Programme (TSDOP)
TSDOP is one of the operational programmes during the 2014-2020 period accepted by the European Commission. The programme aims to support regional, decentralised economic development and an increase in employment based on local resources. Priority axis 3 and 6 of TSDOP supports the following investments: 1. Investments related to sustainable public mobility 2. Energy efficiency improvements of buildings and use of renewable energy. The beneficiaries are local governments.

Competitive Central-Hungary Operational Programme (CCHOP)
CCHOP is one of the operational programmes during the 2014-2020 period accepted by the European Commission. The comprehensive objective of the programme is to ensure the development of the Central-Hungary Region and to further improve its competitiveness, whilst simultaneously decreasing the socio-economic disparities within the region. Priority axis 5 of CCHOP supports the following investments in the Central Hungarian Region: 1. Energy efficiency improvements and renewable energy use of companies 2. Modernisation of energy systems, district heating and other heat supply systems, increasing the share of renewables in the residential sector 3. Sustainable mobility.

Rural Development Programme
Rural Development Programme is one of the operational programmes during the 2014-2020 period accepted by the European Commission. The priority axis 5 of the Rural Development Program supports projects related to increasing the energy efficiency in the agricultural sector and promoting carbon sequestration by afforestation. Projects supported by the Programme: improvement of energy efficiency in the horticulture sector, construction of small sized energy-efficient silos and grain dryers, improvement of effectiveness of energy consumption in the

livestock sector, promotion of resource efficiency in processing sector, promotion of afforestation, investments in wood production, forestry technologies, forestry processing and market sale.

National Air Pollution Control Programme (NACP)

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 is covered all emissions sectors.

4.3.2 Energy

Name	Objective	GHG affected	Type of instrument	Status	Implementing entity	Estimate of mitigation impact		
1	2	3	4	5	6	2015	2020	2030
Operational grant for the production of renewable energies	Increase in renewable energy	CO_2	Economic	Implemented 2017-2026	Ministry of Energy; Hungarian Energy and Public Utility Regulatory Authority	-	-	-
Expansion of the Paks Nuclear Power Plant	Enhanced non-renewable low carbon generation (nuclear)	CO_2		Implemented 2014-2037	Minister withot portfolio responsible for the planning, construction and commissioning of the two new blocks at the Paks Nuclear Power Plant	-	-	-
National Building Energy Performance Strategy	Efficiency improvements of buildings	CO_2	Planning	Implemented 2015-2030	Ministry of National Development	-	-	-
New requirements on energy performance of buildings	Efficiency improvements of buildings	CO_2	Regulatory	Adopted 2018-	Prime Minister's Office	-	-	-
Energy saving programme for public buildings	Efficiency improvements of buildings; Efficiency improvement of appliances	CO_2	Regulatory	Adopted 2017-	Offices of National Energy Efficiency Advisory Network	-	-	-
Establishment of the National Energy Efficiency Advisory Network	Efficiency improvements of buildings	CO_2	Information	Adopted 2017	County Government Offices	-	-	-
Funding for the energy modernization of residential buildings - Warmth of Home Programme	Efficiency improvements of buildings; Increase in renewable energy	CO_2	Economic	Implemented 2008-	Ministry of Energy	-	-	-

Funding for the energy modernization of residential buildings – interest-free loan programme	Efficiency improvements of buildings; Increase in renewable energy	CO_2	Economic	Implemented 2017-	Ministry of Energy	-	-	-
Tax advantage for companies after energy efficiency investments	Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors; Demand management/reduction; Efficiency improvements of vehicles	CO_2	Regulatory	Implemented 2017-	National tax Office	-	-	-
Mandatory energy audit	Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors; Demand management/reduction; Efficiency improvements of vehicles	CO_2	Regulatory	Implemented : 2015-	Hungarian Energy and Public Utility Regulatory Authority			
Mandatory employment of an energy rapporteur	Efficiency improvement in services/ tertiary sector; Efficiency improvement in industrial end-use sectors; Demand management/reduction; Efficiency improvements of vehicles	CO_2	Regulatory	Implemented 2015-	National Tax Office	-	-	-
Economic Development and Innovation Operational Programme	Increase in renewable energy; Energy efficiency improvements of SME owned buildings;	CO_2	Economic	Implemented 2014-2023	Ministry of Energy	-	-	-

Table 4.3 Energy policies and measures

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 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.

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 tyre labelling requirements. Regulation (EU) 2020/740 seeks to harmonise information on the energy performance of tyres, wet braking and external rolling noise. It will apply to EU member countries from May 2020.

National policies

Targets and goals:

- Energy savings: NES 2030 targets 189 PJ or 23% of total primary energy savings by 2030.

- Increase the use of renewable and low-carbon energy: the share of renewable energy in TPES will rise from 7% in 2012 to approximately 20% by 2030; the share of nuclear will remain stable at approximately 25%.
- Power plant modernisation: In order to ensure the reliable supply of electric power, detailed proposals will be drawn up for the replacement of soon-to-be closed-down power plants. Electricity generation-related $CO2_2$-intensity will be reduced from 370g CO_2/kWh in 2012 to about 200g CO_2/ kWh by 2030.
- Modernisation of community district heating and private heat generation: The share of generation of heat from renewable energy sources will increase to 25% by 2030 from 10% in 2012.
- Increasing energy efficiency and reducing the CO_2 intensity of transport: increase the share of electric and hydrogen-based transport to 9% and the share of biofuels in transport to 15% by 2030 in order reduce both the sector's oil dependence and CO_2 emissions.
- Green industry and renewing agriculture: Agriculture is responsible for 13% to 15% of total GHG emissions. Promotion of agricultural technologies and organic farming will help reduce GHG emissions. Energy efficiency in agriculture may also be improved by supporting greenhouse cultivation based on the utilisation of sustainable geothermal energy.
- Waste-to-energy: Since municipal organic waste qualifies as biomass, its energy utilisation is added to the share of renewable energy sources. The utilisation of up to 60% of municipal waste in incineration plants, in strict adherence to environmental standards.
- Strengthening the role of the state: in 2012, government participation was moderate. While the government has a strong presence in the electricity sector, a similar presence should be established in the natural gas and oil sectors.

National Energy and Climate Plan (NECP)

The increase in renewable electricity generation for the grid in Hungary was primarily boosted by the feed-in system. This system was replaced by the METAR (Hungarian support scheme for renewable electricity) in 2017. Within the METAR framework incentive only available through technology-neutral renewable capacity tenders; production aid available within the conventional feed-in system only for experimental technologies and model projects.

Implementation of the Green District Heating Programme and increased consumption of energy recovered from waste water treatment, landfill gas and agricultural biogas play a key role in replacing natural gas and increasing use of renewable energy in the Hungarian heat market (greening of the district heating sector by increasing recovery of geothermal energy, biomass and waste for heating/cooling). Hungary encourages use of heat pumps and the burning of biomass in efficient individual heating equipment to satisfy the heating and cooling needs of modern buildings.

Hungary's 3rd National Energy Efficiency Action Plan (NEEAP)

Article 24 (2) of the Energy Efficiency Directive (2012/27/EU) of the European Parliament and Council requires EU Member States to prepare National Energy Efficiency Action Plans (hereinafter referred to as "NEAP") in every 3 years and submit them to the European Commission. The III. NEAP of Hungary was adopted by the Governmental Decision 1601/2015. (IX.8.). The energy efficiency targets of the III. NEAP had been created by calculating with the national energy data of 2012, the current energy trends and GDP forecasts, as well as taking into account the planned energy efficiency measures and by the Governmental Decree 1160/2015, dealing with national energy consumption forecasts.

The 2020 target for primary energy consumption is 1009 PJ (according to the "joint effort" plan). The target for final energy consumption (primary energy consumption minus losses caused by transformation, conversion, distribution of energy, as well as non-energy uses) is 693 PJ. The scenarios entitled „Ölbe tett kéz / Idly Hands" and „Közös erőfeszítés / Joint Effort" of the National Energy Strategy 2030 are calculating with primary energy use difference of 92 PJ, while the difference of final energy use is 73 PJ until 2020.
In order to fulfil the energy efficiency targets on the basis of the Climate- and Energy Consciousness Action Plan, the District Heating Development Action Plan, National Building Energy Strategy, as well as the planned Transportation Energy Efficiency Action Plan, NEAP describe the planned energy efficiency measures for each economic sector. NEAP also describes in detail the issues of implementation of practical applications and measures of the EU Directive on Energy Efficiency 2012/27/EU, as well as the supporting programs for better energy efficiency. Measures related to better energy efficiency of buildings, including new buildings with low energy consumption levels, as well as reconstruction of existing buildings, are having the most significant effects on fulfilling the energy efficiency targets. On this basis the National Building Energy Strategy (Governmental Decision 1073/2015. (II.25)) is part of NEAP.

Operational grant for the production of renewable energies
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 six tenders 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 sixth call, in March 2022, specifically supports the installation of renewable energy power plants with battery-powered energy storage.

Expansion of the Paks Nuclear Power Plant
In accordance with the National Energy Strategy, it is assumed that two new blocks - of approximately 1,200 MW each - will be put into operation by).2032 The currently operating 4 Paks blocks (2,000 MW) and the two new blocks (2,400 MW) will be operating in parallel from 2032, and .as long as possible, as long as the operating time extension of Paks 1 allows The shutdown of the four currently operating blocks is planned to happen by 2032, 2034, 2036 and 2037.

National Building Energy Performance Strategy
The National Building Energy Performance Strategy, which was published in 2015, is a part of the National Energy Efficiency Action Plan. The strategy sets out the main targets and directions for modernising the domestic building stock and achieving a significant decrease in

the energy demand of buildings until 2020, with projections until 2030. It also defines a conceptual framework for the building energy action plans and the specific programmes and actions to be implemented at a later stage. Detailed analysis of the domestic building stock can also be found within the Strategy. The list of government buildings that are covered by the renewal obligation in Article 5 of Directive 2012/27/EU and in the relevant national legislation (Act LVII of 1995 on Energy Efficiency, Section 8), and buildings with almost zero energy requirements (2010/31/EU Directive, Article 9) are both parts of the Strategy. As part of the 4th National Energy Efficiency Action Plan, the National Building Energy Strategy was also revised in 2017.

New requirements on energy performance of buildings
For new buildings of authorities: from 1 January 2018; for every other new buildings: from 1 January 2021 – from the mentioned deadlines new buildings have to meet nearly zero-energy building requirements: maximum 100 kWh/m2 specific annual energy demand for residential, maximum 90 kWh/m2 for commercial and office buildings and maximum 80 kWh/m2 for educational buildings. Furthermore, 25% of annual energy needs should be provided from renewable energy sources.

From 1 January 2018, buildings after renovation have to meet the following requirements: 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. 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.

Energy saving programme for public buildings
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.

Establishment of the National Energy Efficiency Advisory Network
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.

7 Funding for energy modernization of residential buildings - Warmth of Home Programme
The aim of the programme – since 2014 - is to achieve further reduction of households' energy costs from domestic budgetary resources by replacing outdated household machines, boilers, doors and windows. The majority of domestic resources available for improving the energy efficiency of residential buildings comes from the revenues of CO2 emission allowances. Between 2008 and 2013 revenues from Kyoto units were utilised within the Green Investment Scheme (GIS) budget heading for the above-mentioned purposes. From 2013 a part of the

revenues from the European Union's Emission Trading Scheme (EU ETS) waswas used for the promotion of non-refundable subsidies for residential energy efficiency.

The main target areas of the programme was: the increase of energy efficiency, the increase of energy savings, the reduction of GHG emissions and the reduction of energy dependency. In addition, emission reduction has direct environmental benefits: the mentioned improvements result in heat, energy and cost savings for buildings, heating systems and businesses; and the increase of renewable heat and power generation, which reduces dust and PM10 pollution.

The Warmth of Home Programme focused on creating a complex, short and long term package of measures that increases household energy efficiency and energy savings, thus contributing to lower energy costs. The 13 subprograms of the programme has enabled the energy modernization of more than 300,000 households with an allocation of more than 40 billion forints.[10]

The Government financed the improvement of energy efficiency and technical safety in residential buildings with the value of 50 billion HUF. Due to this support energy efficiency investment could be realized in the home of more than 235.000 family.

As a result of the above mentioned energy efficiency investments, Hungary's carbon dioxide emissions are reduced by more than 79,000 tons/year and the country's energy savings are increased by 0,2 PJ/year.

Funding for energy modernization of residential buildings – interest-free loan programme
The interest-free loan, which has been available since April 24 2017, represents a budget of 115 billion forints for energy modernization of family houses and condominiums and for the use of renewable energy sources. The financial sources of the credit line are the Economic Development and Innovation Operative Programme (GINOP) and the Competitive Central Hungary Operative Programme (VEKOP) of the EU. The credits are, inter alia, available for insulating residential properties, modernizing heating or hot water systems, and installing solar-panelled, solar-powered and heat pump systems. The amount of the loan, in case of natural persons, may vary from 500 thousand to 10 million forints, while in case of condominiums and housing associations from 500 thousand to 7 million forints for each apartment, with a maturity of 20 years. The expected contribution of the applicants is min. 10% of the eligible costs. The loan can also be used as an own contribution for other non-refundable constructions. According to the expectations, the loan programme will enable to renovate tens of thousands of apartments and family houses.

Tax advantage for companies after energy efficiency investments
In 2017 a new tax advantage was introduced, which can be requested by companies after their investments that increase energy efficiency.

Mandatory energy audit

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[10] According to the status on 8 September, 2017.

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
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 behaviours within the operation and decision-making of the organization.

Economic Development and Innovation Operational Programme (EDIOP)
EDIOP is one of the operational programmes during the 2014-2020 period accepted by the European Commission. Priority axis 4 of EDIOP supports energy efficiency improvement of buildings and economic activities and also investments related to renewable energy. The beneficiaries are SMEs. The EDIOP priority axis 8 supports investments in energy efficiency and renewable energy projects by companies.

Financial regulatory tools

European Cohesion Fund - European Structural and Investment Funds include the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund, the European Maritime and Fisheries Fund (EMFF), the European Agricultural Fund for Rural Development (EAFRD) provides Hungary with a total of 21.9 billion euro under the cohesion policy for the period 2014-2020. In addition, Hungary will also receive a grant of € 3.45 billion for rural development and a budget of 39 million euro will be available for the maritime sector and fishing.

The financial breakdown is as follows:

- 15 billion EUR for less developed regions (Central Transdanubia, Western Transdanubia, Southern Transdanubia, Northern Hungary, Northern Great Plain and Southern Great Plain)
- 436.7 million EUR for more developed regions
- 6 billion EUR through the Cohesion Fund
- 361.8 million EUR for European Territorial Cooperation
- 49.8 million EUR for Youth Employment initiative

The relevant priorities of the cohesion policy:

- Promoting employment through economic development, employment, education and social inclusion policies
- Tackling social and demographic challenges
- Improving the competitiveness and global performance of the business sector
- Implementation of local and territorial development aimed at promoting economic growth.

- Trans-European transport networks, notably priority projects of European interest as identified by the EU. The Cohesion Fund will support infrastructure projects under the Connecting Europe Facility;
- Increasing energy and resource efficiency
- Here, the Cohesion Fund can also support projects related to energy or transport, as long as they clearly benefit the environment in terms of energy efficiency, use of renewable energy, developing rail transport, supporting intermodality, strengthening public transport, etc.

Environmental and Energy Efficiency OP (Környezet- és Energetikai Hatékonysági Operatív Program - KEHOP)

Programme description:
The programme aims to support sustainable growth and contribute to achieving the Europe 2020 targets for smart, sustainable and inclusive growth. It should improve flood protection, provide better waste and wastewater management services and good quality drinking water to more residents, help protect natural habitats and species, and it should improve energy efficiency and the use of renewable energy sources.

Territorial and settlement development OP (Terület- és Településfejlesztési Operatív Program - TOP)

Programme description:
The programme aims to support regional, decentralised economic development and an increase in employment based on local resources. The programme allocates more than EUR 1 billion to integrated sustainable urban development actions in the framework of a dedicated priority.

Economic Development and Innovation Operational Programme (Gazdaságfejlesztési és Innovatív Operatív Program - GINOP)

Programme description:
The programme aims to stimulate the economies of the less developed regions in Hungary. Its most important priorities are the competitiveness of small-and medium sized enterprises, research and innovation, and employment. The programme also aims to develop the tourism industry, enterprises' energy efficiency, and information and communication technologies. Moreover it will stimulate the use of financial instruments to cover other objectives, like increasing renewable energy production and improving the energy efficiency of households and public buildings.

Transport Development Operational Programme (Integrált Közlekedésfejlesztési Operatív Program - IKOP)

Programme description:
The Operational Programme will support the development of transport infrastructure, which is seen as essential to increase economic competitiveness and stimulate job creation – the two key objectives of the EU's Lisbon Strategy for growth and jobs.

Good quality transport links make it easier for people to commute to and from work. The better the links the greater distances people can travel efficiently, which in itself can enable more people to enter the jobs market. What's more, improving transport links can also strengthen social and territorial cohesion.

<u>Rural Development Program</u> (Vidékfejlesztési Program – VP2)

Programme description:
The EU's rural development policy helps the rural areas of the EU to meet the wide range of economic, environmental and social challenges of the 21st century. The Rural Development Programme (RDP) for Hungary was formally adopted by the European Commission on 10 August 2015, outlining the Hungarian priorities for using the EUR 4.2 billion of public money that is available for the 7-year period 2014-2020 (EUR 3.4 billion from the EU budget and EUR 740 million of national co-funding).

EU CO_2 quota-based financial programs
In order to support the overall economic objectives (job creation, improving competitiveness, reducing energy import dependency) through boosting green economy including innovations in climate change mitigation/adaptation, different supporting schemes were launched from the time of the last IDR:
According to Article 25 paragraph (2) of Act XC of 2021 on Hungary's central government budget in 2022, the minister responsible for energy policy may increase the Energy and Climate Policy Modernisation Scheme by 100% of the revenues from the sale of aviation emission allowances, and by 50% of the revenues from the sale of emission allowances, in addition to those planned in the Budget Act. These incomes are used for the following greening aims set by Article 10 para 3 of the Directive 2003/87/EC[11]:

a) reduction of GHG emission;
b) contributions to the European Globalisation Adjustment Fund (EGF), launched at the Poznan Climate Change Conference (COP 4 and COP/MOP 4);
c) measures to avoid deforestation and help afforestation and reforestation in developing countries, which have ratified the international agreement on climate change;
d) transfer of technologies and to help adaptation to climate change in developing countries, which have ratified the international agreement on climate change;
e) safe capture and geological storage of CO2 originated from solid fossil fuel power plants or industrial activities in developing countries.
f) development of energy production from renewable energy sources;
g) measures aimed to help energy efficiency;

[11] **Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC**

h) measures or investments to reduce GHG emissions;

i) capture of CO2 through reforestation;

j) support for the participation in the initiatives of the European Strategic Energy Technology Plan and the European Technology Platforms;

k) safe capture and geological storage of CO2, originated from solid fossil based power plants or industrial activities;

l) measures helping the shift to low-GHG-emission transportation methods and to encourage the use low GHG emission public transportation methods and tools;

m) support for research and development related to energy efficiency and clean technologies, in case of industries, which need permissions for emitting GHG gases and mentioned in the GHG Emission Act. (Act LX of 2007 on the implementation framework for the United Nations Framework Convention on climate change and its Kyoto Protocol);

n) research and development aimed at the adaptation to climate change and GHG emission reduction, as well as implementation of demonstration projects;

o) support for the development of new technologies aimed to help the shift to low carbon economy;

p) financial support for social measures of lower and middle income households to help their energy efficiency.

Energy taxation

The European Union (EU) Energy Tax Directive (2003/96/EC) sets the EU framework for the taxation of energy products and electricity. The Directive sets minimum tax rates for all energy products including coal, natural gas and electricity. For each, it sets a minimum level of tax expressed in terms of the volume, weight, or energy content of the fuel. The Directive is also intended to reduce distortions of competition, both between member states as a result from divergent rates of tax on energy products, and between mineral oils and the other energy products (OECD, 2016c).

In 2015, excise and VAT together accounted for 57.2% of the final price of a litre of premium unleaded gasoline, 54% of the final price of a litre of automotive diesel and 61.9% of the final price of litre of light fuel oil for households.

Motor car purchases are also taxed and VAT is payable at 27% alongside a registration tax. The registration tax varies from HUF 45 000 to HUF 400 000 on new passenger cars according to engine type (diesel or petrol) and engine cylinder capacity, and from HUF 20 000 to HUF 230 000 on motorcycles according to engine cylinder capacity. For cars generating great levels of emissions, higher rates are levied (400%, 600%, 800% or 1 200%), but the rate is reduced according to a scale based on age (until 90%). A reduced rate is levied to hybrid cars and HUF 0 is levied on electric vehicles.

The transfer of motor vehicles is also liable to tax: the rate of duty is determined on the basis of vehicle’s engine capacity (in kW). The tax rate varies from HUF 300/kW to HUF 850/kW depending on the age of the vehicle (the older the vehicle, the lower the liability). Reduced rates apply to cars with hybrid engines or with gas-powered engines (HUF 76 000) and for cars with electric engines (HUF 0).

4.3.3. Transport

Name	Objective	GHG affected	Type of instrument	Status	Implementing entity	Estimate of mitigation impact		
						2015	2020	2030
National Transport Infrastructure Development Strategy	Efficiency improvements of vehicles; Low carbon fuels/electric cars; Modal shift to public transport or non-motorized transport; Improved transport infrastructure	CO_2	Planning	Implemented: 2014-2020	Ministry of National Development	**-**	**-**	**-**
National Framework Plan for the Development of Alternative Fuels Infrastructure	Efficiency improvements of vehicles; Low carbon fuels/electric cars; Improved transport infrastructure	CO_2	Planning	Implemented: 2016-2030	Ministry ofEnergy	**-**	**-**	**-**
Ányos Jedlik Plan 2.0 for the promotion of e-mobility	Efficiency improvements of vehicles, Low carbon fuels/electric cars, Improved transport infrastructure	CO_2	Planning	Implemented: 2019-	Ministry of Energy	**-**	**-**	**-**
Financial support for the purchase of electric vehicles	Low carbon fuels/electric cars	CO_2	Economic	Implemented: 2016-	Ministry of Energy	-	-	-
government**Tax allowances after environmentally friendly vehicles**	Low carbon fuels/electric cars; Efficiency improvements of vehicles	CO_2	Fiscal	Implemented 2016	Ministry of Financial	-	-	-
Application of usage-based road toll on heavy duty vehicles.	Efficiency improvements of vehicles; Demand management/reduction	CO_2	Fiscal	Implemented: 2013	Ministry of Construction and Transport	79.4	136.6	-
Green Bus Program	Efficiency improvements of vehicles; Low carbon fuels/electric cars	CO_2	Fiscal	Implemented: 2020-2029	Ministry of Energy	-	-	-
MOL NEXT-E project	Low carbon fuels/electric cars; Improved transport infrastructure	CO_2	Economic	Implemented: 2017-2021	MOL, Ministry for Innovation and Technology	-	-	-
Improvement of the bicycle transportation network	Modal shift to public transport or non-motorized transport; Improved behaviour; Improved transport infrastructure	CO_2	Economic	Implemented: 2010-2020	Ministry of National Development	213	1550	-
Improvement of the railway vehicle fleet	Modal shift to public transport or non-motorized transport; Efficiency improvements of vehicles	CO_2	Economic	Implemented: 2015-2020	Ministry of National Development	-	2,4	-

Replacement of vehicle of public transport service companies	Efficiency improvements of vehicles; Modal shift to public transport or non-motorized transport	CO_2	Economic	Planned: 2017-2020	Ministry of National Developmen t	-	13	35
Education and broad application of eco-driving	Improved behaviour	CO_2	Voluntary/ negotiated agreement s, Education, Regulatory	Planned: 2018-	Ministry of National Developmen t	-	68.2	-
Integrated Transport Development Operational Program (ITOP)	Improved transport infrastructure; Modal shift to public transport or non-motorized transport; Efficiency improvements of vehicles	CO2	Economic	Implemente d: 2014-2023	Ministry of National Developmen t	-	-	-

Table 4.4.Transport policies and measures

National Transport Infrastructure Development Strategy

The National Transport Infrastructure Development Strategy is the main policy document in the transport sector. The National Strategy for Transport Infrastructure Development 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),

- favouring public transport over private transport in passenger transport, encouraging non-motorised transport and improving the safety and comfort of walking and cycling,

- in freight transport, encouraging rail and waterborne transport and combined transport.

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.

National Framework Plan for the Development of Alternative Fuels Infrastructure

The National Framework Plan for the Development of Alternative Fuels Infrastructure (adopted by 1782/2016. Government Decision in 2016) identifies national targets on 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 numbers of alternative fuel infrastructure and number of vehicles was carried out in 2020.

Ányos Jedlik Plan 2.0 for the promotion of e-mobility
Ányos Jedlik Plan 2.0 is the main policy document for the promotion of e-mobility in Hungary. The Ányos Jedlik Plan, which was approved in 2015, defines targets for the number of electric cars and charging points. In accordance with the Ányos Jedlik Plan, the institution of green license plates was introduced in 2015, providing many benefits to owners of environmentally friendly vehicles.

In 2019 the Ányos Jedlik Plan 2.0 was announced which promotes a more rapid development of e-mobility. Electric cars will be one of the drivers of innovation and technological development, so the review focused on supporting developments and innovation activities related to the spread of electromobility. 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 enterprises and private persons to buy electric cars
This is a sub-programme of the Ányos Jedlik Plan 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 maximum 1.5 million forints/vehicle. The sub-programme was launched in 2016.

Financial support for the establishment of electric charging stations
This sub-programme of the Ányos Jedlik Plan supports the establishment of electric charging stations by local governments.

Tax allowances after environmentally friendly vehicles
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 the 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 entering to these vehicles.

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.

Application of usage-based road toll on heavy duty vehicles.
A road toll was introduced for heavy duty vehicles in 2013. The road toll depends on vehicle weight (characterised by number of axes) and on environmental performance of the vehicle (Euro norm). It gives an incentive for better organisation of freight delivery and for better use of payload capacity. The Decree of the Ministry of National Development No. 25/2013. (V. 31.) about the road toll system was amended in 2019 with stricter paying schemes. According to the amendment, motor vehicles with an engine of EURO V standard or better belong to the environmental category A; motor vehicles equipped with engines of EURO II, EURO III and EURO IV standard belong to environmental category B and motor vehicles with an engine of EURO I or below belong to environmental category C. Differentiation factors are assigned to the environmental categories which determine the scale of road tolls.

Green Bus Program
The Green Bus Porgram aims to support municipalities of cities and their transport organizers and local public passenger transport service providers. During the first phase the municipalities could apply to purchase EURO VI, CNG and electric buses. From 1 January 2022, only electric buses will be available and municipalities with a population of less than 25 000 can also apply for electric buses.

NEXT-E project

The goal of the NEXT-E project is to install 222 fast chargers charging and 30 ultra-fast charging in the participating countries. This meant the following for Hungary: as a participating country: the installation of 54 charging fast chargers and 5 ultra-fast charging chargers. The project was implemented between 2017 and 2022. The construction of the NEXT-E charging network in Hungary was completed in the summer of 2021.

Improvement of the bicycle transportation network
The government aims to increase the length of bicycle roads by an additional 1000 kms until 2020, to increase the share of daily bicycle users 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 kms. The construction and the preparation of about 850 kilometers of cycle paths are supported nationwide. By 2030, the bicycle roads are expected to reach 15 000 kms.

Improvement of the railway vehicle fleet
Modern electric suburban train acquisition, which is planned to enter service between 2018 and 2022. Within the framework of this improvement 40 suburban trains are going to be purchased by 2022. The purchases of trains are financed from the Integrated Transport Development Operative Programme (IKOP) of the EU.

Replacement of vehicle of public transport service companies
The replacement of public transport service companies' vehicles has decreased in recent years. The average age of Hungarian public bus fleet was 14.46 years at the end 2015. Between 2016 and 2020, 1813 buses are required to be replaced, and after 2020 additional 6000 bus replacement becomes necessary.

Education and broad application of eco-driving (environmentally conscious driving)
Learning environmentally conscious Eco-driving techniques is a framework that includes the development of educational materials, the certification of learning equipments and facilities, the organization and implementation of awareness-raising campaigns, the implementation of pilot projects with voluntary participants and periodic compulsory driving education for transport safety, in order to increase environmental performance of cars. Currently, the National Emissions Ceilings Directive (NECD) adopted in 2020 by the Government decision no.

1231/2020. (V.15.) includes a measurement package in which the awareness raising and teaching of eco-driving is defined.

The energy-saving driving techniques could be integrated into the basic and supplementary training of private and professional drivers consisting of a theoretical and a practical part. The theoretical part could include the description of technical factors influencing fuel consumption and driving elements. The practical part can be implemented using a computer, simulator, or a vehicle. It could be also voluntary (encouraged, supported) training. The eco-driving can be implemented to Decree of the Ministry of Economy and Transport no. 24/2005. (IV. 21.). With the eco-driving 4-11% reduction in consumption compared to your previous driving style can be achieved and similar reduction in CO_2. It will have an indirect positive effect on road safety. The impact on total national fuel consumption is difficult to quantify, depending on number of drivers, but approximately 100 000 new, environmentally conscious driving license holders could enter the market. The reduction of fuel consumption by an educated person is estimated according to different learning types: computer training approx. 4%; simulator training approx. 9%; real-time training in a vehicle is approx. 11%.

Integrated Transport Development Operational Program (ITOP)
ITOP is one of the operational programmes during the 2014-2020 period accepted by the European Commission. It serves the improvement of energy efficiency in the transport sector through the direct strengthening of public transport and other means of transport which are less harmful to the environment. Transport on road, railway and rivers are included, both freight and passenger transport. However, this strategy was not designed to serve climate purposes only but it plays an essential part in the development of the Hungarian TEN-T infrastructure (both road and railway), shortening travel times and decreasing the emission of air pollutants (PM10, NOx).

International aviation and maritime transport

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 are 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).

4.3.4. Agriculture

Name	Objective	GHG affected	Type of instrument	Status	Implementing entity	Estimate of mitigation impact		
						2015	2020	2030

Protection against soil erosion	Protection and sustainable use of natural resources	CO_2, N_2O	Regulatory	Implemented 2013-	Governmental offices and farmers	-	-	-
Good Agricultural Practice to protect waters against pollution caused by nitrates from agricultural sources	Protection and sustainable use of natural resources	CH_4, N_2O	Regulatory	Implemented 2008-	Governmental offices, farmers	-	-	-
Greening payment	Adopting and maintaining environmental and climate friendly farming practices	CO_2, N_2O	Economic	Implemented 2015-	Paying agency and farmers	-	-	-
Rural development measures to develop animal husbandry farms	Improving energy efficiency and competitiveness and reducing emission	N_2O, CH_4	Economic	Implemented 2014-	Paying agency and farmers			
Rural development measures to improve the condition of environment	Increase climate friendly farming practices and carbon sequestration	CO_2, N_2O	Economic	Implemented 2014-	Paying agency and farmers			
National Air Pollution Control Program	Decreasing ammonia emission	N_2O, CH_4	Regulatory/ Economic	Implemented 2020-	Governmental offices, farmers			
Irrigation Development	Increase irrigated area	CO_2, N_2O	Regulatory/ Economic	Implemented 2018-	Governmental offices, Paying agency and farmers			

Table 4.5 Agriculture policies and measures

As 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 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.

At present, the following measures and policies are implemented:

Protection against soil erosion

Soil plays an important role in carbon capture, so 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. Erodicability 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.

The Decree 50/2008 of the Ministry of Agriculture and Rural Development has been 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 preventing loss of soil organic matter, for example appropriate nutrient management, reduced tillage, protecting of layer with high organic matter content, utilising in 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 adopted in 2021 and will take into force from 2026. The SAP as agri-political document, deals with the issue of the soil protection and mineral resources management and coherent with EU's common policies such as Farm to Fork Strategy as part of the Green Deal. To decrease soil degradation, the SAP aims to raise farmers' awareness on the good practices which can contribute to the climate adaption. From 2026 farmer shall make soil protection plan at 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 base on a detailed soil database.

Good Agricultural Practice to protect waters against pollution caused by nitrates from agricultural sources

Hungary, as member state of the EU had to implement Directive 91/676/EC. Therefore, the rules of Good Agricultural Practice were set out in the Ministerial Decree 59/2008. The rules concern – among others – environmentally friendly manure and slurry management including storage and land application. 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 31st of October and the 15th of February. There are certain regulations concerning storing, treating of manure or slurry on the animal farm and on the field as well.

Greening payment

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.

Rural development measures to develop animal husbandry farms

Due to these measures, farms have a chance to build new and modern manure-silos or slurry tanks or purchasing new manure or slurry sprayer facilities using modern technology of measuring and spraying and controlling. The technology applied by the farms shall meet the requirements of the Best Available Technology (BAT). The capacity of the manure silos or slurry tanks shall be planned for storing at least for 6 months. The isolation of the ground and wall has to be absolute 100 %. These measures enable farmers to apply the rules of Good Agricultural Practice and to decrease the NH_3, NO_2, CH_4 emissions.

Rural development measures to improve the condition of environment

There are several measures within the framework of the Rural Development Program with the objective to protect the biodiversity, traditional landscapes, to improve the condition of soil and the nutrient management and to enhance agricultural practices aiming climate protection. These measures are supported mainly area-based such as:

- Agri-environment and climate measures
- Organic farming
- Transition to organic farming
- Maintaining organic farming
- Compensation payment for Natura 2000 grasslands

National Air Pollution Control Program

Based on the 2016/2284 EU directive (NEC), Hungary prepared the National Air Pollution Control Program (NAPCP) which was accepted by the Hungarian Government in 2020 and submitted to the European Commission. 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 emission (CH4, N2O) from fertilizer usage, too.

Irrigation Development

The Hungarian Government started an irrigation development program in 2018 to increase the irrigated area by 100 000 hectares until 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 farmer may apply for support to investment 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.

4.3.5. Forestry

Name	Objective	GHG affected	Type of instrument	Status	Implement-ing entity	Estimated mitigation impact		
						2015	2020	2030
National Forest Programme	Afforestation and reforestation	CO_2	Regulatory	Implemented 2016-2030	Ministry of Agriculture	-	-	-

Table 4.6. Forestry policies and measures

National Forest Strategy 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 annual afforestations of around 15 thousand ha. The Strategy refers to climate change mitigation by promoting forest biomass and protection of forests which directly affects CO_2 emission reduction targets.

4.3.6. Waste

Name	Objective	GHG affected	Type of instrument	Status	Implemen t-ing entity	Estimated mitigation impact		
						2015	2020	2030
Waste Legislation	Prevention of the production of waste, Preparing waste for re-use, Enhanced recycling; Other recovery of waste, such as, in particular, energy recovery; Improved treatment technologies; Uninterrupted and continuous provision of the waste management public service; Improved municipal waste collection; Reduced landfilling	CH4	Regulatory	Implemented: 2014-	Ministry of Energy	-	-	-
National Waste Management Plan	Prevention of the production of waste, Preparing waste for re-use, Enhanced recycling; Other recovery of waste, such as, in particular, energy recovery;	CH4	Planning	Implemented: 2021-2027	Ministry of Energy	-	-	-

	Improved treatment technologies; Improved municipal waste collection; Reduced landfilling							
The National Waste Management Public Services Plan	Uninterrupted and continuous provision of the waste management public service; Improved municipal waste collection; Enhanced recycling; Reduced landfilling; Improved treatment technologies	CH4	Planning	Implemented: 2016-	Ministry of Energy	-	-	-
Environmental Product Fee	Demand management / reduction; Enhanced recycling; Reduced landfilling	CH4	Fiscal	Implemented: 2011-	Ministry of Agriculture	-	-	-
Lowering the share of landfilling in municipal solid waste treatment	Reduced landfilling	CH4	Planning	Implemented: 2016-2030	Ministry of Energy	-	-	-
Jenő Kvassay Plan	Improved wastewater management systems; Improved treatment technologies	CH4, N2O	Planning	Implemented: 2017-2030	Ministry of Interior	-	-	-
National Implementation Programme on Waste Water Collection and Treatment	Improved wastewater management systems	CH4	Regulatory	Implemented: 2002-	Ministry of Interior	-	-	-
Sewage Sludge Treatment Strategy	Improved wastewater management systems	CH4, N2O	Planning	Implemented: 2014-2023	Ministry of Interior	-	-	-

Table 4.7. Waste policies and measures

Waste Legislation

The EU's 2008/98/EC directive on waste (Waste Framework Directive) defines the basic regulatory framework for the 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 reutilisationpreparing for re-use, reutilisation recycling and other material recovery rate should be at least 70%. Deversion of waste from landfill should be aided by the implementation of a separated waste collection system for glass, metal, plastic, and paper generated in households.

According to the 31/1999/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.

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 has become 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.

National Waste Management Plan

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 the 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 the 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 Government's aim is to make the Hungarian waste management sector a model of the circular economy in Europe. 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 will be introduced in the waste management sector from July 1, 2023. According to the new model, a concession holder will have 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 a 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 is to ensure the continuity of supply in the field of waste management by guaranteeing a smooth transition to a circular economy, and 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

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.

Environmental Product Fee

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, tyres, 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 regulates the environmental product fee.*Jenő Kvassay Plan*

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.

National Implementation Programme on Waste Water Collection and Treatment

The programme was introduced in 2002. Its aim is to improve the treatment of waste water collected in the public utility sewage systems, the sewerage of settlements and regions and to increase the recovery rate of waste water. The quantified objectives identified by the programme are obsolete and currently under review.

Sewage Sludge Treatment Strategy

The strategy includes a 10 year (2014-2023) development plan of 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 developments 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 utilisation, 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 trough improving the tools of farmers and by management tools. 4. Enforcing strategic level planning when using recultivation areas 5. Ensuring and gradual building of energy recovery capacities 6. Management tools.

4.3.7. Industrial processes and product use

Name	Objective	GHG affected	Type of instrument	Status	Implement-ing entity	Estimated mitigation impact		
						2015	2020	2030
HFC-Phase-Down according to EU F-gas Regulation	Objective on EU level: 70 % emission reduction for Fgases by 2030 compared to 2005	HFCs	Economic, Regulatory	Implemented: 2015	Ministry of Energy	-	-	-
SF_6 bans under the EU FGas Regulation	Objective on EU level: 70 % emission reduction for Fgases by 2030 compared to 2005	SF_6	Regulatory	Implemented: 2006	Ministry of Energy	-	-	-

Table 4.8. F-gas policies and measures

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 per cent by the late 2040s. The Kigali Amendment came into effect on 1st January 2019, and Hungary, as a developed country alongside with 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 aims 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 lays 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. The F-GAS Regulations contains exemptions from this prohibition, but just in a very limited scale.
- The F-gas Regulation 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.
- The F-gas Regulation obliges 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 the 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 prohibit the charging of the air conditioning systems with such gases. Automotive manufacturers must provide the competent authority all relevant technical information regarding activities involving servicing, 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 the Government Regulation No. 14/2015.

Recognising the need for enhanced climate action in light of the European Climate Law, better alignment with the Montreal Protocol and stronger enforcement, the European Commission thoroughly reviewed the 2014 F-gas Regulation. The new F-Gas Regulation (EU) No. 2024/573 entered into force on 11 March 2024. The domestic legal environment is currently being reviewed and the legislative framework amended to bring Hungary into line with the requirements of the new Regulation.

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.

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.

4.4. Policies and measures no longer in place

This section presents a list of policies and measures that were included in the 6th National Communication of Hungary, but are no longer in place. In the list there are strategies and action plans that has expired and were revised.

- Second National Energy Efficiency Action Plan (Expired and revised)
- Compulsory take-over of renewable based power at subsidized prices(KÁT)
- Liveable panel buildings" sub-programme
- "Our home" reconstruction sub-programme
- "Renewable Public Institutions Sub-Programme
- “Power saving households" programme

- National Forest Programme 2006–2015 (Replaced by the National Forest Strategy 2016-2030)
- National Environmental Programme 2009-20141520 (Expired and revised)
- New Hungary Rural Development Strategic Plan (2007–2013) (Expired and revised)
- New Széchenyi Plan with its operative programmes (have expired and were replaced by Széchenyi 2020)
- National Waste Management Plan 2014-2020

5. PROJECTIONS AND THE TOTAL EFFECT OF GREENHOUSE GAS EMISSIONS

5.1. Projections

For this report a 'with existing measures' (WEM) and a 'with additional measures' scenario (WAM) were constructed. Projections are made for every five years between 2040 and the base year. 2016 was chosen as the base year for the energy sector projections while in other sectors 2019 was chosen. In Table1a the latest available data from the inventory (2019) was presented under base year as only a single year can be added. Projections for the energy sector were made in a model called Times. The base data of this model partly due to its bottom-up nature is not entirely consistent with the National Inventory Report. Additional emissions allocated to 1.A.2. Manufacturing industries and construction were compansated for in 2. Industrial processess and product use. Yet change in emissions for consistency reasons are compared to the 2019 inventory data in this section which resuslt in some distortions in sectoral reduction rates.

Projections were made for all direct greenhouse gases occurring, namely: CO_2, CH_4, N_2O, PFCs, HFCs and SF.

The global warming potentials used in the calculations are presented in table 5.1 below.

GHG	**CO_2-equivalent**
CO_2	1
CH_4	25
N_2O	298
SF_6	**22800**

Table 5.1. Global warming potentials used

In order to compare the modelling results of transport emissions with domestic greenhouse gas emission trends, the determination of transport demand had to be based on data consistent with the national emissions inventory, therefore the starting point was the transport statistics defined by Eurostat and DG MOVE based on the territoriality principle.

In the WEM scenario, total GHG emission excluding LULUCF decreases by 37% by 2030 compared to 1990, thus falls short of achieving the 40% reduction target adopted in Hungary's National Energy and Climate Plan. Yet in the WAM scenario this goal is achieved as total emission excluding LULUCF decreases by 51%. With LULUCF total emission reduction equals to 36% in the WEM and 49.6% in the WAM scenario.

Projections in tabular format were prepared as part of the draft updated National Energy and Climate Plan of Hungary, too.

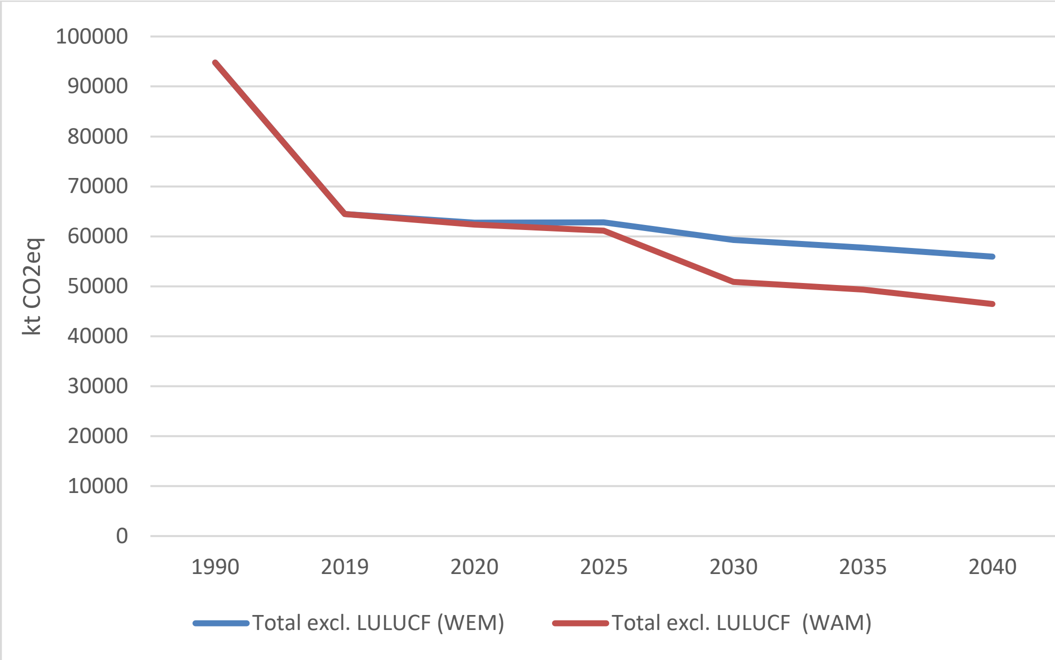


Figure 5.1: Total GHG emission excluding LULUCF by scenario

Hungary's target for 2030 under the effort sharing regulation is -7% compared to the 2005 level. In the WEM scenario emissions under the ESR are reduced by 8.3%, and 22.4% in the WAM scenario thus reduction surpasses the target in both.

In the WEM scenario by 2030 reduction is achieved compared to the latest available data (2019) in the energy, industrial processes and product use sectors while emissions increase in agriculture and the waste sector. Emissions reduced in the energy sector to the largest extent (-11.2%) while emissions increase the most in the waste sector (+11.7%)

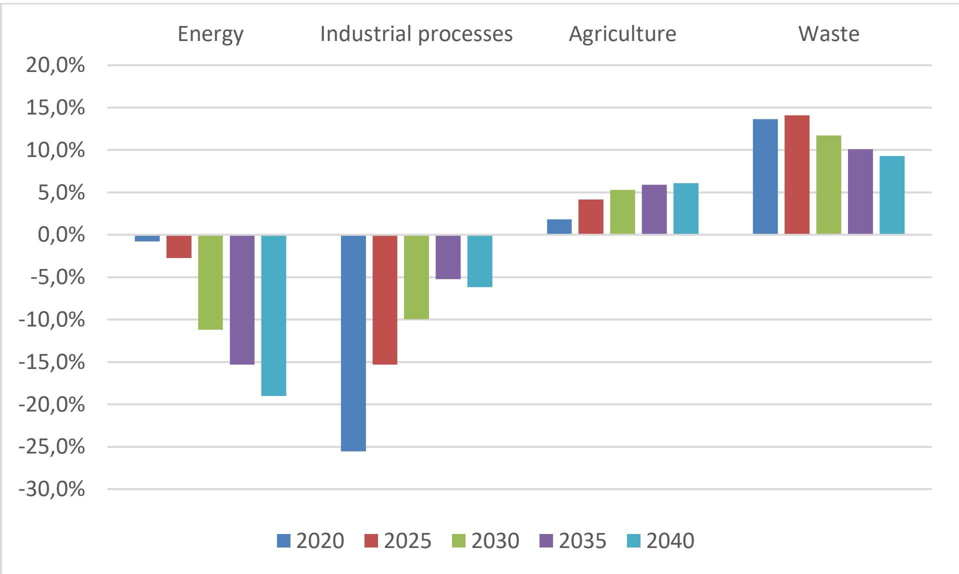


Figure 5.2: GHG reduction by sector (WEM)

In the WAM scenario reduction is achieved in all sectors. As in the WEM scenario the largest reduction is also achieved in the energy sector (-27%). It is followed by industrial processes and product use (-10.7%), waste (-4.5%) and agriculture (-1.6%).

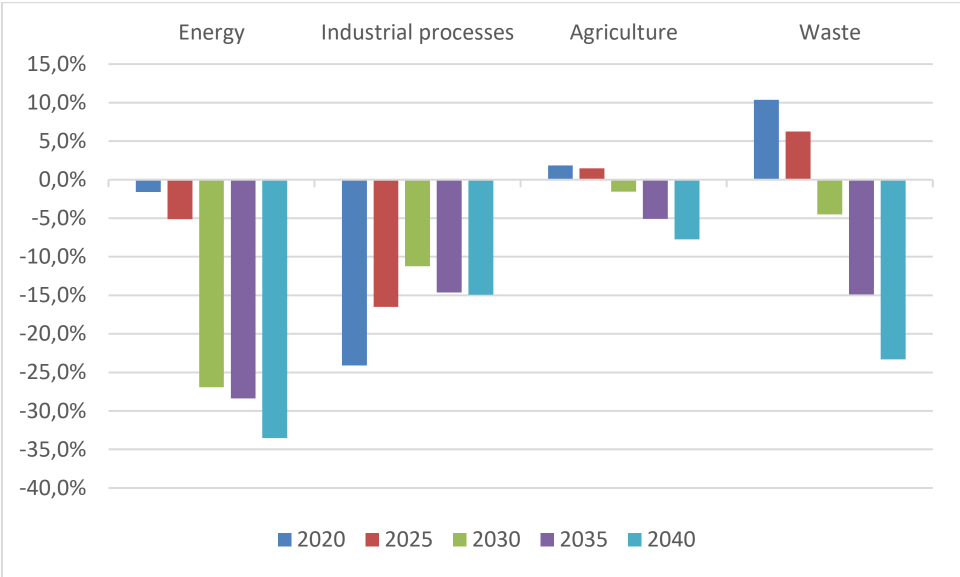


Figure 5.3: GHG reduction by sector (WAM)

In the WEM scenario only the decrease of CO2 emissions is expected, -13.9% by 2040 vs. 2019. The rest of GHG emission are projected to increase. Among the latter the emission of fluorinated gases is projected to rise to the largest extent, by 29.2% by 2030. CH4 emissions rise by 11% while 1.6% more N2O is emitted in 2030.

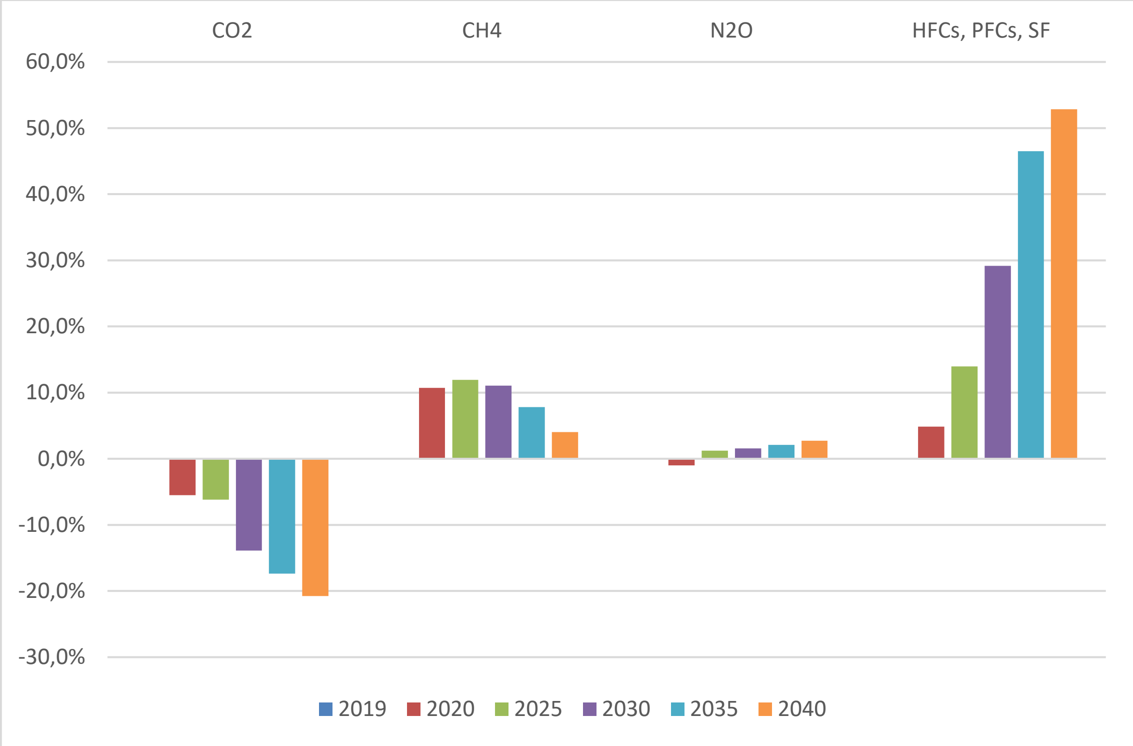


Figure 5.4: Projected change of GHG emissions by gas (WEM)

In the WAM scenario by 2030 the emission of all GHGs is expected to be reduced except for fluorinated gases (+19%). CO2 emissions in this scenario are 27.9% lower in 2030 than in 2019.CH4 emission decrease by 1.6% and N2O emissions by 6.4%.

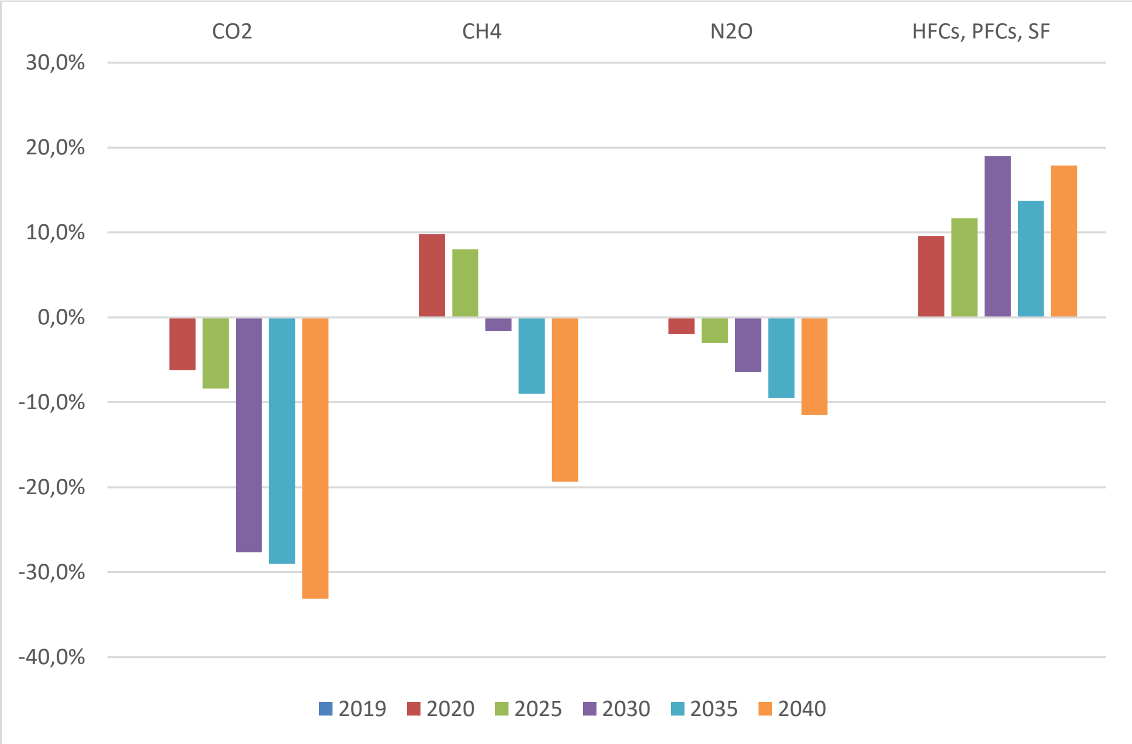


Figure 5.5: Projected change of GHG emissions by gas (WAM)

Energy

Energy sector projections were performed using TIMES model. TIMES is a technology rich, bottom-up model generator, which uses linear-programming to produce a least-cost energy system, optimized according to a number of user constraints.

As no new scenarios have been prepared for the NC8-BR5 document, the outputs of the WEM and WAM scenarios have been integrated from the NCDS file, the business-as-usual (BAU) scenario and the early achievement scenario (EA). The NCDS's BAU corresponds to the NC8-BR5's WEM scenarios and the NCDS's EA corresponds to the NC8/BR5's WAM scenarios.

The Business-As-Usual (BAU) scenario follows the current trends. It doesn't contain any constrains applied in the model for 2030, 2050 on the share of renewable energy, energy efficiency and GHG emissions. No additional measures were considered in this scenario.

The Early Achievement (EA) scenario's goal is to achieve climate neutrality by 2050. The scenario assumes 734 PJ final energy consumption at most and 27% share of renewable energy in gross final energy consumption at least for 2030. After 2030 a linear GHG reduction pathway is assumed.

	Business-As-Usual (BAU)	Early-Action Scenario (EA)

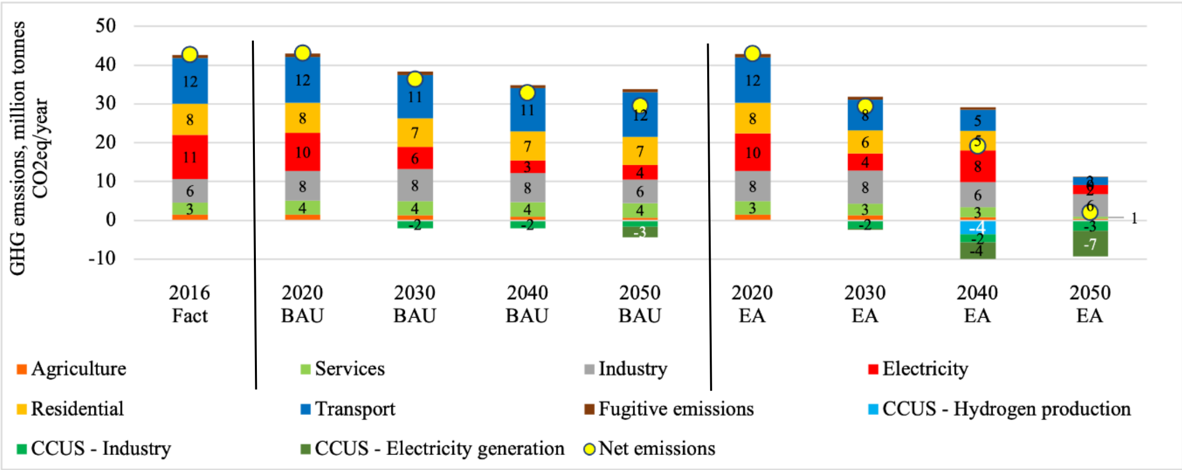
GHG emission by 2050, mt CO2eq		No limit	2 Mt CO2eq
GHG reduction path between 2030-2050		No limit	Linear reduction
Biomass consumption limit		The 2016 100 PJ linearly decreases to 75 PJ by 2050-	
Possibility for hydrogen blending		In 2025 max. 0,1%, in 2030 max 2%, in 2035 10%, in 2040 20%, in 2045 35%, in 2050 50%	
Geothermal energy production limit, MW		Max 300 MW	
Wind energy		Installed capacities cannot exceed current levels.	Wind capacities cannot be higher than in the LA scenario
Paks2		It enters until 2030	
2030 limits	Final energy consumption	No limit	Max 734 PJ
	Share of renewable energy	No limit	Min 27,5%
	GHG emission	No limit	36,3 mt CO2eq

Figure 5.6: Constrains applied in the scenarios

Achieving net zero greenhouse gas emissions at the national level is possible if emissions from the energy sector fall to at least 2 million tons CO2eq from the current value of 40 million tons, i.e., a 96% reduction is needed.

CCUS technology is essential to achieve the goals. With the current knowledge and technologies, it would not be possible to reduce GHG emissions in the energy sector to the required level without carbon sequestration. In many sub-sectors, such as industry, transport and others (such as carbon leakage and agricultural energy use), full decarbonization cannot be achieved without CCUS. The CCUS technologies typicallyenter the energy system in the 2030s, possibly the 2040s, as in most cases there are cheaper solutions to tackle GHG emissions.

Under the BAU scenario, GHG emissions will decrease slightly for the energy sector, but will still emit almost 30 million tons of CO2eq in 2050, a reduction ofabout 57% compared to the base year 1990. The largest decrease is in the energy sector and bioenergy with CCUS also appears in the BAU scenario, due to the high CO2 quota price.



Source: Eurostat, own modeling result

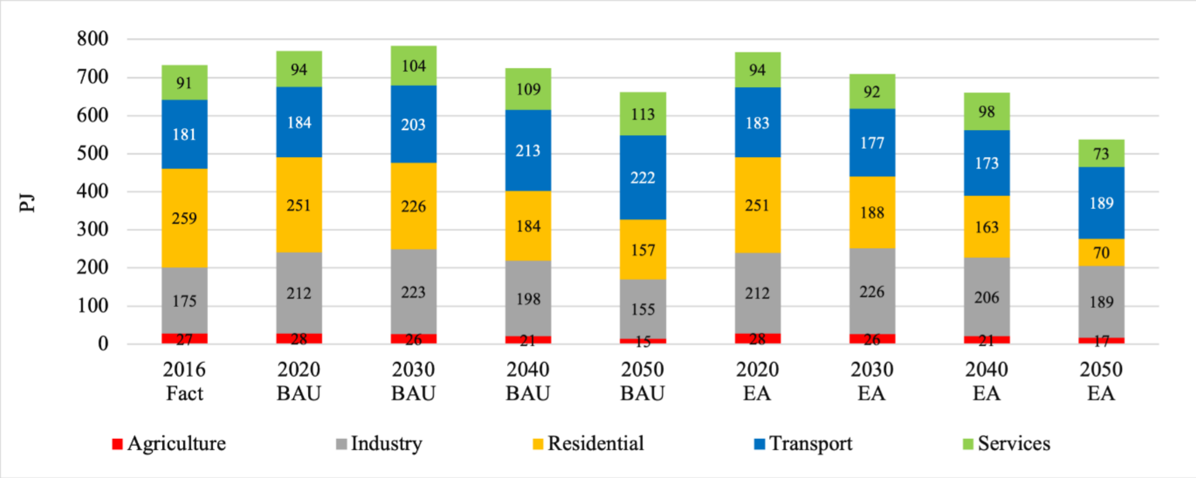
Figure 5.7: GHG emissions in each scenario, 2016-2050 (million tons of CO2eq/year)

Change in final energy consumption by sector

The household sub-sector clearly has the greatest potential for energy savings. Even in the case of the BAU scenario, the households' energy consumption decreases significantly, due to the substantially lower energy consumption of new appliances, newly built dwellings and renovations implemented primarily under the energy efficiency obligation scheme. These will result in a decrease of the energy consumption from 260 PJ to below 160 PJ by 2050 even under the BAU scenario. The decrease is even more significant in the EA scenario, where by 2050 the energy consumption of households will decrease to 70 PJ, which is26% of the consumption of the base year.

The energy consumption of the industrial sector develops very differently between the examined scenarios. In the BAU scenario, GDP growth is accompanied by an increase in energy consumption at the beginning, followed by energy efficiency investments, and a steadily declining trend from the 2030s onwards. In the EA scenario, the trend is completely similar until 2030, but thereafter, energy consumption will decrease less than in the BAU scenario. This is not because energy efficiency investments would not take place here, but because the EA scenario will lead to faster GDP growth, which in turn will be accompanied by an increase in industrial production and thus energy consumption. Faster economic growth is due to the significantly higher level of investment activity in the national economy in the climate-neutral scenario.

The service and transport sectors follow very similar trajectories in the two scenarios. If no climate targets are set, energy consumption in both sectors will increase slightly, while in the EA scenario it will decrease by 10-20% compared to current levels due to energy efficiency investments and more efficient fuel composition.



Source: Eurostat, own modeling result

Figure 5.8: Composition of final energy consumption by sector in each scenario, 2016-2050 (PJ)

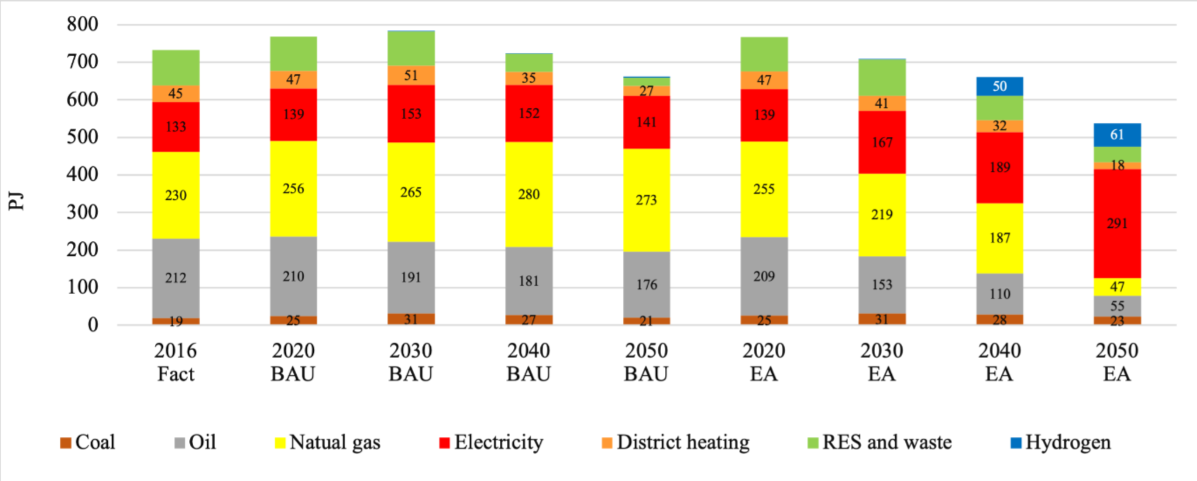
Fuel composition of final energy consumption – hydrogen partly replaces natural gas; high degree of electrification

The composition of final energy consumption needs to change significantly in order to reach the climate neutrality target by 2050.

There is no significant shift in the BAU scenario, and even the share of natural gas is increasing, displacing mainly renewable energy sources. **The biggest change in the EA scenario is due to large-scale electrification, which affects the entire spectrum of the energy sector**. By 2050, electricity consumption will account for more than half of total energy consumption. The high degree of electrification is accompanied by a drastic increase in electricity production. As a result of electrification in transport, oil consumption will fall dramatically by 2050 to a quarter of the current use.

The other significant change which will start in the 2040s, is the decline in natural gas consumption and the complete disappearance thereof in some sectors. Natural gas is partly replaced by hydrogen, mainly in the transport and industrial sectors. Hydrogen plays an important role, providing 10-15% of final energy consumption, partly through blending into the natural gas grid. The maximum blending rate in 2050 is 50%. This is a theoretical average value, which shows that half of the domestic "gas consumption" (theoretical mixture of hydrogen and natural gas) will consist half of natural gas and half of hydrogen. There will be dedicated hydrogen pipelines that will supply 100% pure hydrogen, as well as sectors and activities where pure hydrogen will be needed (e.g. transport, industrial raw materials). 50% of hydrogen will not be actually fed into the natural gas network.

At first glance, it may seem surprising that the use of renewable energy sources in both scenarios will fall to a third/quarter, of the current level by the middle of the century. This can be explained by the fact that the limited use of biomass is utilized in electricity generation, where the greatest GHG savings can be achieved with the help of biomass power plants equipped with CCUS technology.

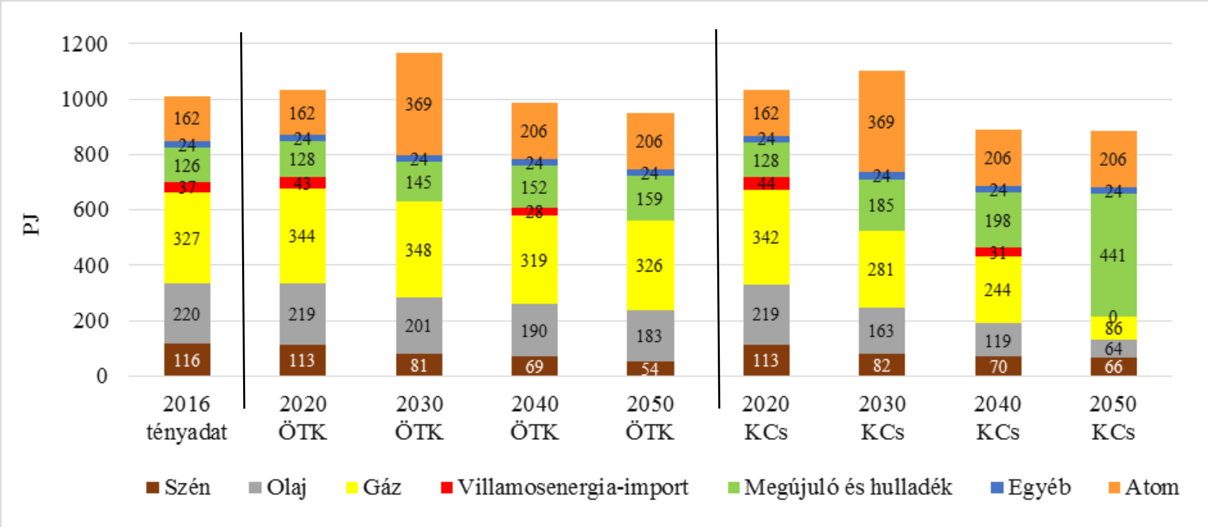


Source: Eurostat, own modeling result

Figure 5.9: Final energy consumption fuel composition in each scenario, 2016-2050 (PJ)

Fuel composition of primary energy use - strong renewable penetration by 2050

There will be an increase in primary energy use until 2030, in both the BAU and the EA scenarios, due to the fact that the new Paks nuclear power plant units will be commissioned and even the old units will run in parallel during this period. However, even then, the two scenarios begin to separate; differences can be found mainly in the use of natural gas and in the case of renewables. In the case of BAU, the rate of primary energy consumption will be at the current level by 2050, while under the EA scenario it will fall below 900 PJ. In the latter scenario, **a strong renewable dominance in the primary energy mix can already be observed in 2050**, resulting from the high use of solar and wind energy, as well as biomass and biofuels.



Source: Eurostat, own modeling result

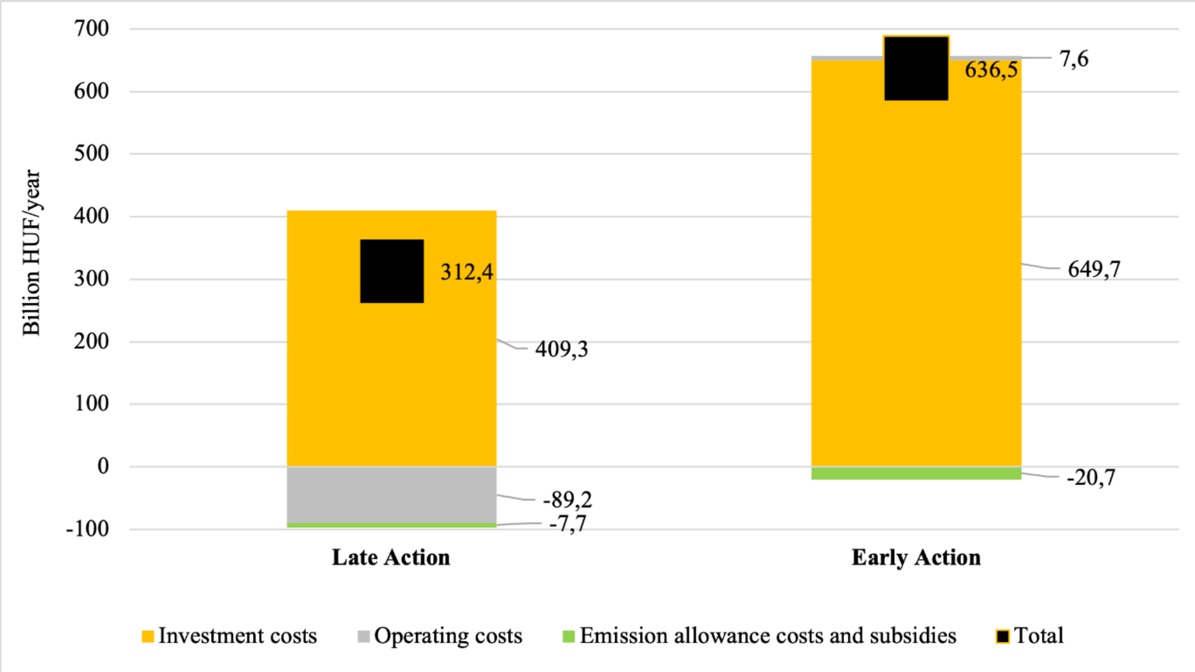
Figure 5.10: Fuel composition of primary energy use in each scenario, 2016-2050 (PJ)

Social costs

The HU-TIMES model provides an opportunity to quantify the additional costs of achieving the goals in the energy sector. These costs are not entirely borne by public finances, the way in which the burden is shared between the state and private actors depends on the regulation of the given subsector.

The analyzes distinguish three main cost categories: investment cost (CAPEX), operating cost (OPEX), and EU ETS quota costs and subsidies. The latter include the amount of support for renewables and the cost of CO2 quotas for companies covered by the EU ETS. It is important to emphasize that the HU-TIMES model only quantifies the costs in the energy sector, the benefits - e.g. avoiding the costs of air pollution or the impact on GDP - are simulated by the GEM model.

The largest change can be observed in investment costs. In the case of the EA scenario, there is an additional investment need of HUF 650 billion per year compared to the BAU scenario, which is offset by the lower operating costs and the lower amount of quota costs/subsidies**. The net value of benefits and costs represents an additional cost of HUF 637 billion annually in order to achieve the goals of the sector.**



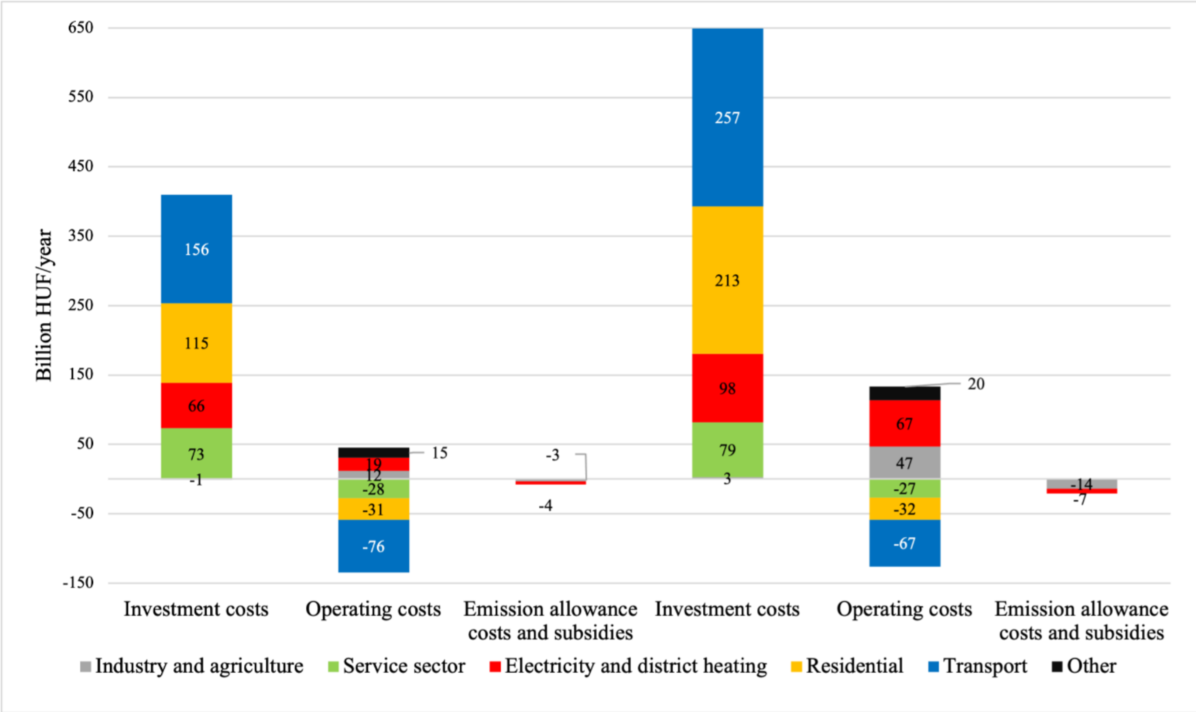
Source: HU-TIMES modeling result

Figure 5.11: Distribution of annualized additional costs by category compared to the BAU scenario, HUF billion/year

Additional investment costs are mostly concentrated in the transport sector and households, respectively. In the EA scenario, the additional investment cost required in the transport sector is HUF 256 billion per year (40% of the total additional investment), in the residential sector it is HUF 210 billion annually (33%). The electricity and district heating sectors account for 15% of investments, while the service sector accounts for 12%.

There is no significant additional investment cost for the industrial segment. This is due to the fact that investments that are made in the EA scenario are also taking place in the BAU scenario. At the same time, in the case of the industrial sector, a change of fuel is indicated by the projections of the climate-neutral scenario, which can also be seen in the change of operating cost. In order to meet 2050 targets in the energy sector, it is necessary to switch to more expensive but cleaner fuels (e.g. carbon-free hydrogen or electricity).

As a result of additional investments, however, operating costs will decrease in the household segment, transport and the service sector. This is due to e.g. the increasing number of vehicles with lower fuel consumption, or to energy efficiency investments (e.g. insulation, window replacement, more efficient heating).



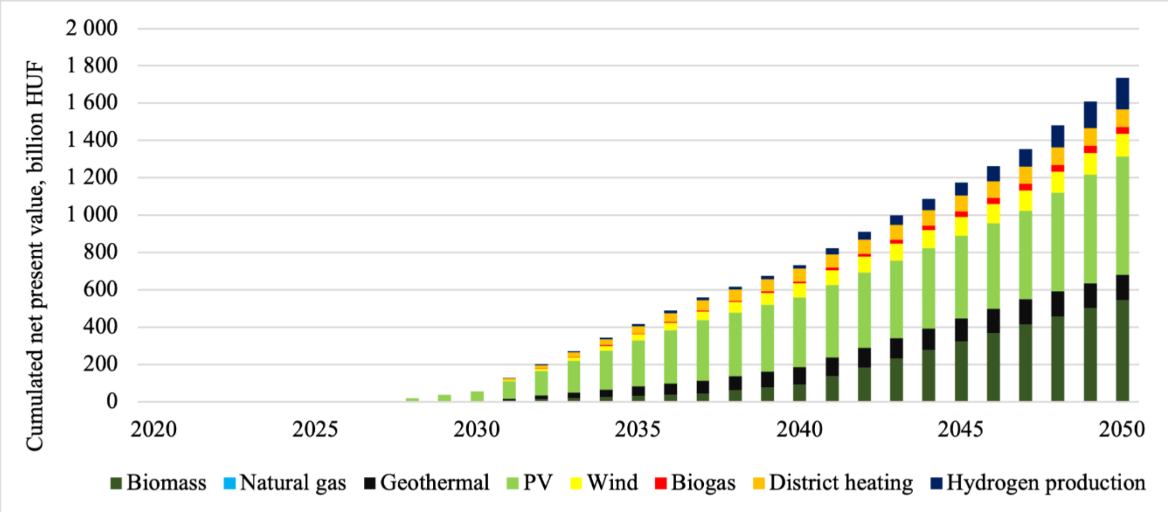
Source: HU-TIMES modeling result

Figure 5.12: Distribution of annualized additional costs of LA and EA scenarios compared to the BAU scenario, HUF billion/year

In the cost analysis, the impact of allowance prices for the EA scenario **was analyzed using a sensitivity analysis, assuming that the price of CO2 allowances would be doubled between 2030 and 2050. As a result, the cost of achieving the decarbonization target will increase by about 1.5%, by HUF 10 billion annually.** At the same time, higher quota prices have an incentive to achieve the targets by making pollution a more serious cost factor for companies.

The HU-TIMES model also provides an opportunity to show investment costs in more detail, especially in the transport, electricity and district heating sectors.

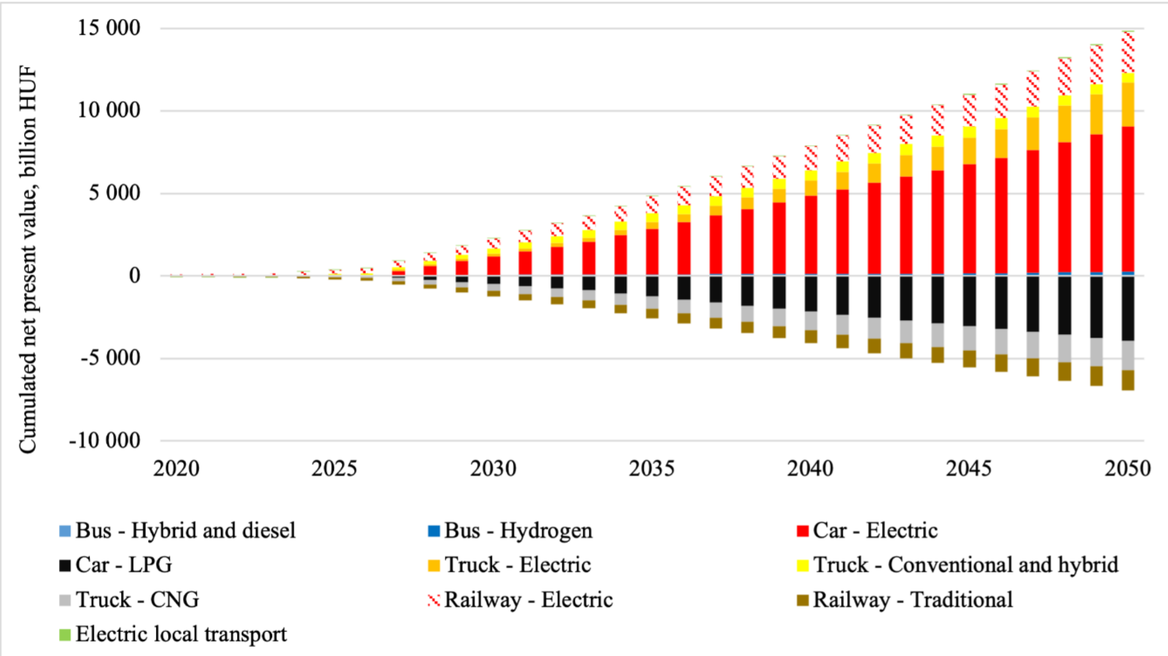
In the electricity and district heating sector, the differences in investment costs between the EA scenario and the BAU scenario are shown in the figure below. Costs show discounted, cumulative values for 2016. In total, by 2050, an additional investment of about HUF 3,600 billion is needed to achieve the net zero emission goals. The additional costs will be evenly distributed until 2045, after which additional investment costs will be higher.



Source: Eurostat, own modeling result, HU-TIMES modeling result

Figure 5.13: Difference in the net present value of the annual cumulated investment costs of the EA and BAU scenarios in the electricity and district heating sector, HUF billion/year

The transport sector shows a significantly more heterogeneous picture.



Source: Eurostat, own modeling result, HU-TIMES modeling result

Figure 5.14: Difference between the net present value of the annual cumulated investment costs of the EA and BAU scenarios in the transport sector, HUF billion/year

The total net additional cost amounts to HUF 10,000 billion, however, there are investments that are implemented only in the BAU scenario, while others appear only in the EA scenario. In the latter case, the largest item (compared to the BAU scenario) is electric cars (HUF 10,000 billion), but the additional investment costs of vehicles using railway electricity (HUF 2,800 billion) and trucks using electricity (HUF 3,300 billion) are also significant. However, in the case of the EA scenario, there are cost elements that are absent, as opposed to the BAU scenario. Approximately HUF 4,400 billion less could be spent on LPG-powered cars, HUF 2,000 billion less on CNG-powered trucks and HUF 1,300 billion less on diesel-powered railway cars in the EA scenario compared to the BAU. The incurrence of additional investment costs over the whole period is almost linear for the transport sector.

Decarbonization of households requires a reduction in natural gas and the spread of alternative solutions (especially heat pumps)

Household energy consumption is also declining in the BAU scenario. This is mainly due to the low energy consumption of newly built buildings, and in many cases the renovation of buildings is a profitable investment, i.e., the post-renovation utility savings can compensate the renovation costs. In terms of fuel composition, firewood use is constantly declining from an initial level of 74 PJ to a few PJ by 2050. This is due to the fact that households are switching to more efficient and, in the long run, more economical fuel, especially natural gas. In the case of natural gas consumption, a slight increase can thus be observed. Electricity consumption is declining due to the expected replacement of household appliances, as new appliances operate at significantly lower energy intensities.

The EA scenario already shows other trends in 2030. Due **to stronger energy efficiency investments, the energy consumption of this sector will be almost 50 PJ lower in 2030 than in the BAU scenario.** Energy efficiency investments will continue beyond the 2030s. At the same time, there is a constant shift in fuel: natural gas is decreasing and will be pushed back to a minimum level by 2050 according to the EA scenario. Meanwhile, coal is disappearing from the energy mix[12], contributing to making net zero GHG emissions available at the national level as well.[13] In this regard, a large-scale infrastructure development is imminent. For example, the solar panel program will be part of the transformation. And there are also pilot projects targeting municipalities where natural gas is currently not introduced.[14] The experience gained during these projects will also be an important and key element of the transition.

As biomass, i.e. firewood, isavailable to a limited extent, the use of this type of fuel is reduced to a minimum. In the EA scenario in 2040, hydrogen will appear as energy blended into the natural gas grid. This is more of a temporary solution, as electricity will remain the only widely available, zero-emission fuel in the long run.

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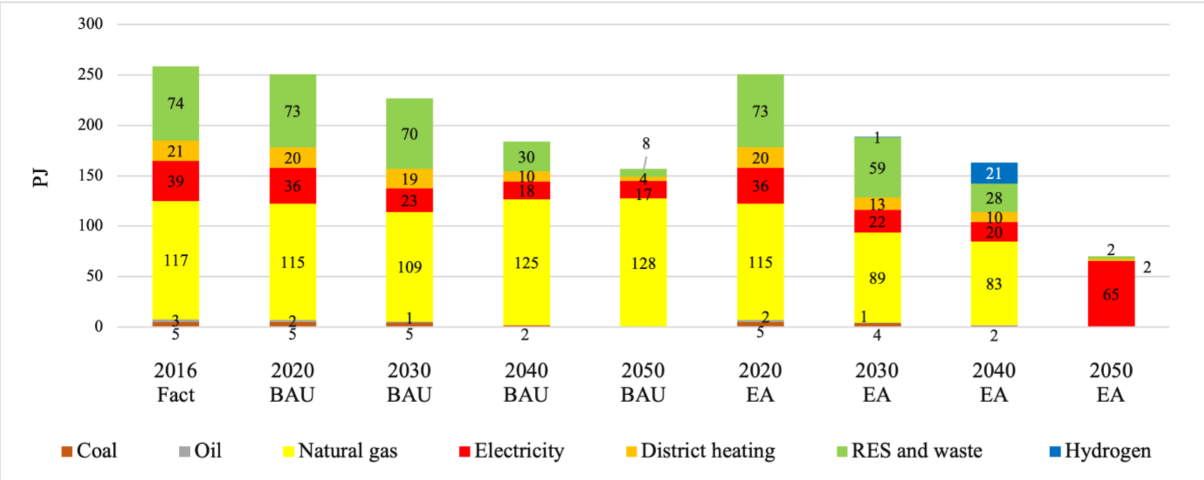
[12] The elimination of coal combustion is also important from the point of view of air pollution. Restrictions on the use of certain solid fuels by the population and making the social fuel support system more environmentally friendly are listed among the measures to be taken in the National Air Pollution Reduction Program.

[13] Further details on the measures planned in connection with the utilization of gas pipelines in Hungary can be found in Hungary's National Energy and Climate Plan adopted in January 2020.

[14] Within the framework of the energy innovation tender package announced in March 2020, the call "Ensuring the energy supply of settlements using alternative gas supply methods and using modern technologies and flexibility services" was announced, with a budget of HUF 3 billion.

Consultations with stakeholders have also confirmed that one of the most cost-effective ways to achieve long-term decarbonization target is to increase energy efficiency in the household and service sectors and to use renewable electricity, which requires the promotion of decentralized - prosumer - networks.

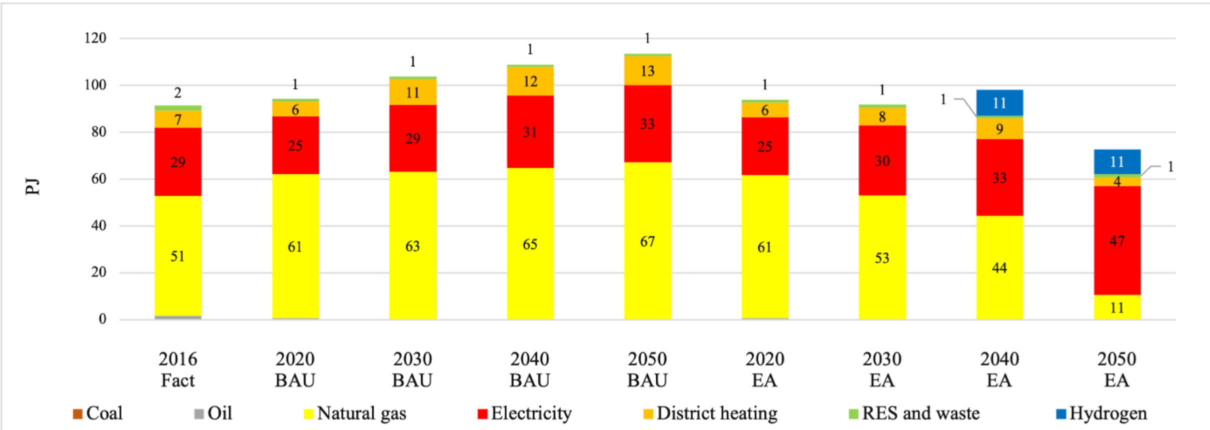


Source: Eurostat, own modeling result

Figure 5.15: Distribution of energy consumption of the household sector in the BAU and EA scenarios

Electrification and partial natural gas phase-out in the service sector

In the case of the BAU scenario, the **energy consumption of the service sector** will also increase from 91 PJ in 2016 to 113 PJ, which is generated by GDP growth and cannot be offset by energy efficiency investments. The fuel composition does not change significantly.



Source: Eurostat, own modeling

Figure 1 Distribution of energy consumption in the service sector in the BAU and EA scenario

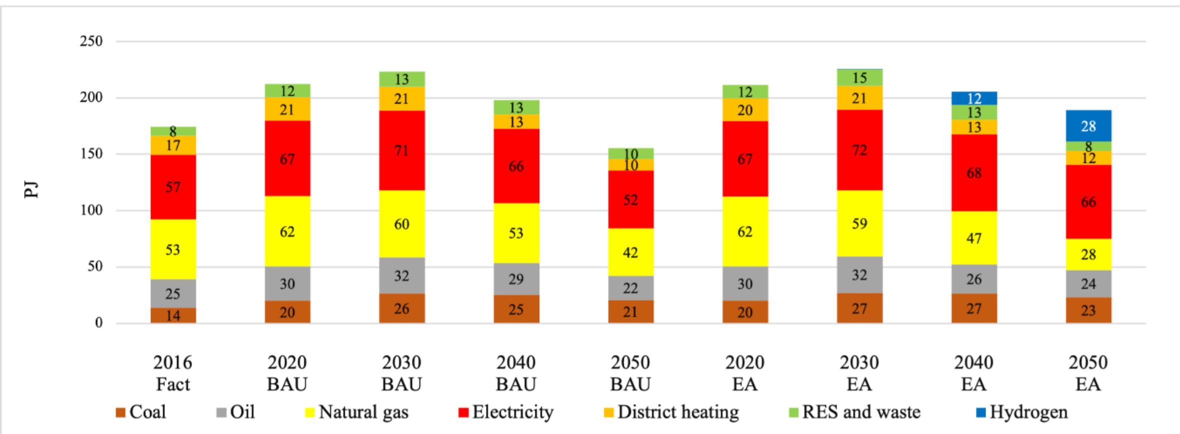
The implementation of the EA scenario presupposes important changes. On the one hand, energy consumption will stagnate and increase slightly until 2040, but after that a declining trend will emerge. Although the energy savings are significantly lower than for households, it certainly seems that intervention is needed to reduce energy consumption in the energy sector. Such a regulatory tool could be the energy efficiency obligation scheme to be introduced, investment or operating subsidies, but these could include direct, e.g. prohibitive instruments as well. There is also a significant change in fuel composition: the use of natural gas will decrease significantly, accompanied by an increasing proportion of hydrogen, as well as a high degree of electrification will be achieved by **2050,** when **electricity will account for two thirds of the energy consumption of the entire service sector.**

<u>In addition to CCUS, hydrogen and electrification play a key role in the partial decarbonization of industry</u>

The change in industrial *energy consumption* is characterized by an upward trend in the beginning in both the BAU and EA scenarios, but energy consumption will start to decline from the 2030s due to the energy efficiency investments. In both scenarios, these investments are driven by the market, i.e., there is no need for government incentives. In the EA scenario, the rate of energy reduction is lower than in the BAU scenario. This is due to the fact that higher investments in the national economy increases GDP, which increases industrial demand, including energy consumption.

While there is no significant change in the fuel structure in the BAU scenario, a substantial realignment can be predicted in the EA scenario. Hydrogen will appear from 2040 and will play an increasingly important role, accounting for 15% of total energy consumption by 2050. Hydrogen primarily replaces natural gas. During the consultation stream called "Climate Breakfasts" held in 2020, the role of hydrogen was also highlighted by the private sector actors as an important factor in industrial decarbonization.

The stakeholder consultation also confirmed the importance of digitization and electrification in the long-term process of industrial decarbonization. In addition, representatives from the private sector stressed the need to increase energy efficiency. They consider it particularly important to introduce incentives for research and development to ensure the competitiveness of domestic actors in the development, production and export of new, energy-efficient and renewable energy-based technologies.



Source: Eurostat, own modeling

Figure 5.17: Distribution of energy consumption in the industrial sector in the BAU and EA scenario

Electrification, biofuels and hydrogen are all needed for the partial decarbonization of the transport sector

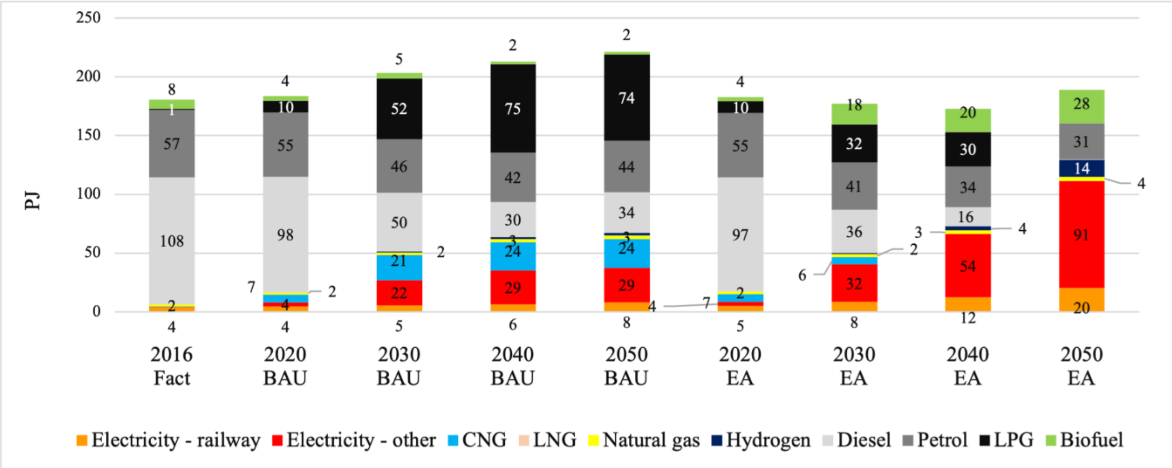
In the **transport sector**, energy use is increasing in both the BAU and EA scenarios, albeit to very different degrees. While energy consumption will increase by about 50 PJ in the BAU scenario between 2016 and 2050, this value will be only 8 PJ in the EA scenario.

Diesel consumption will decrease the most by 2050: to 34 PJ in the BAU scenario, while in the EA scenario, this fuel will completely disappear by the end of the period. This requires regulatory intervention that either supports the spread of cleaner solutions (e.g., subsidizing electric cars) or penalizes (e.g., higher tax), possibly limiting fossil fuel technologies.

Hungary is already taking significant steps to promote electromobility. **Electromobility and electric propulsion are expected to become increasingly important in the future**, so the market is expected to adapt more and more to new circumstances on its own and require fewer incentives. Already in the BAU scenario the electricity consumption in 2050 will be 37 PJ, which could thus account for 17% of the total transport sector without further action. In the EA scenario, this value is already close to 60% (111 PJ).

The use of hydrogen in transport is also essential to achieve the decarbonization goals. Hydrogen will appear to a greater extent in the 2040s, and by 2050 its share will be significant (8%). The biofuel share will be twice as much, with the rise of second-generation biofuels, and the relegation of first-generation biofuels to the background.

Consultations with industry representatives have also confirmed that decarbonization can be promoted in the automotive industry through fuel switching and the introduction of hydrogen, as well as a change of approach. In order to significantly reduce GHG emissions, it is justified, in consultation with industry, to support the purchase of "clean" electric vehicles (battery-powered vehicles and hydrogen fuel cell buses) for public transport, as well as the appropriate development of the charging station network and infrastructure.



Source: Eurostat, own modeling

Figure 5.18: Distribution of energy consumption in the transport sector in the BAU and EA scenarios

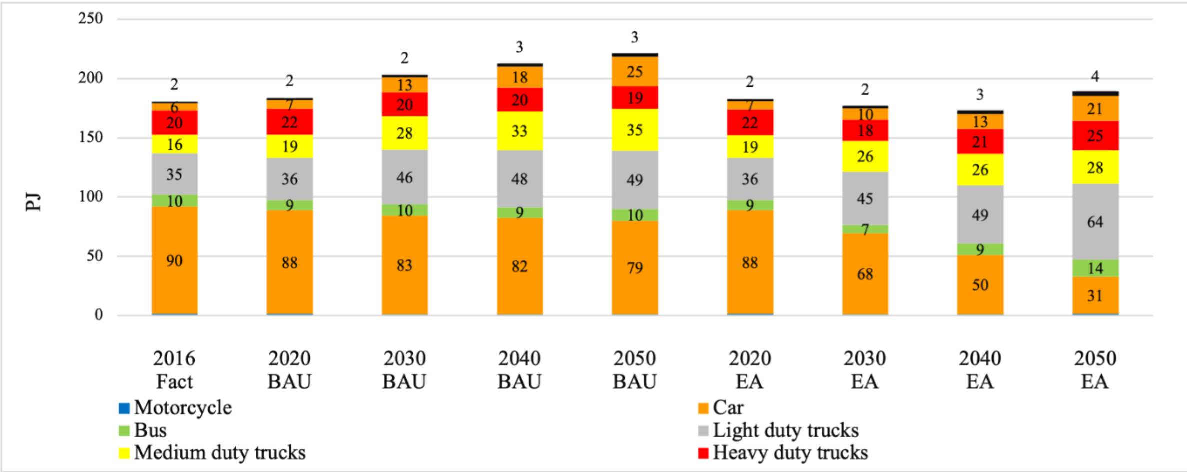
There are also significant changes in the transport modes. While in the BAU scenario, the energy consumption of passenger cars will decrease only slightly, in the EA scenario it will be reduced by about two-thirds by 2050. **Passenger transport is partly diverted to rail and bus**, which have a significantly more favorable GHG balance per passenger-kilometer. Cycling and car sharing should also be further promoted.

As far as *bus traffic* is concerned, a pilot project has been developed to replace the public transport bus fleet locally. The aim of the Green Bus Program[15] is to replace the local public bus fleet by encouraging domestic bus production, to reduce the average age of operated buses, the emission values and maintenance and operating costs of bus transport, and to improve the quality of travel services.

With regard to railways, the goal is that by 2040, all electric traction vehicles will be able to produce the most efficient traction known today, with significantly lower consumption during braking and fed back into the grid or own battery than most models running today. Non-electrified line sections can be accessed by battery-powered vehicles, the acquisition of which is planned to be phased in from 2021 onwards.

With the current level of *cycling*, a reduction of 15.25 million tons of CO2 emissions per year can be achieved in Europe. This reduction in emissions occurs precisely in the most problematic, densely populated urban areas, and therefore greatly improves the health, quality of life and livability of cities living there. In addition to traditional cycling and the necessary infrastructure, electric bicycles and scooters can play a greater role in urban transport and its decarbonization in the long term.

[15] Government resolution 1537/2019 (IX. 20.) on the tasks related to the new bus strategy concept of Hungary and the Green Bus Model Project.

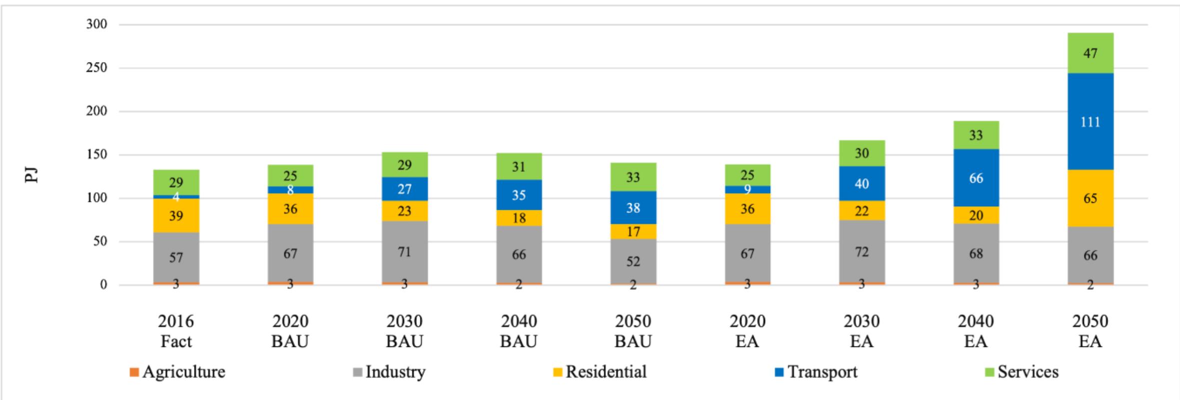


Source: Eurostat, own modeling

Figure 5.19: Distribution of energy consumption in the transport sector according to different modes of transport in the BAU and EA scenario

Renewable and nuclear-based electricity consumption and generation

The energy sector as a whole is impacted by electrification, which is also the most important trend leading to decarbonization. In the case of the BAU scenario, it can be seen that electricity consumption does not really change: an increasing trend can be observed between 2016 and 2030, which is then decreases, mainly due to industrial and residential energy efficiency investments. In contrast, a significant change can be seen in the EA scenario. From the 2020s onwards, we are witnessing a strong growth, driven decisively by the electrification of transport. However, the biggest increase will be in the 2040s, when consumption will increase from 190 PJ to 291 PJ, thanks to the electrification of transport and, with the spread of heat pumps, the household sector. For the whole period, the growth rate is 2.2%.



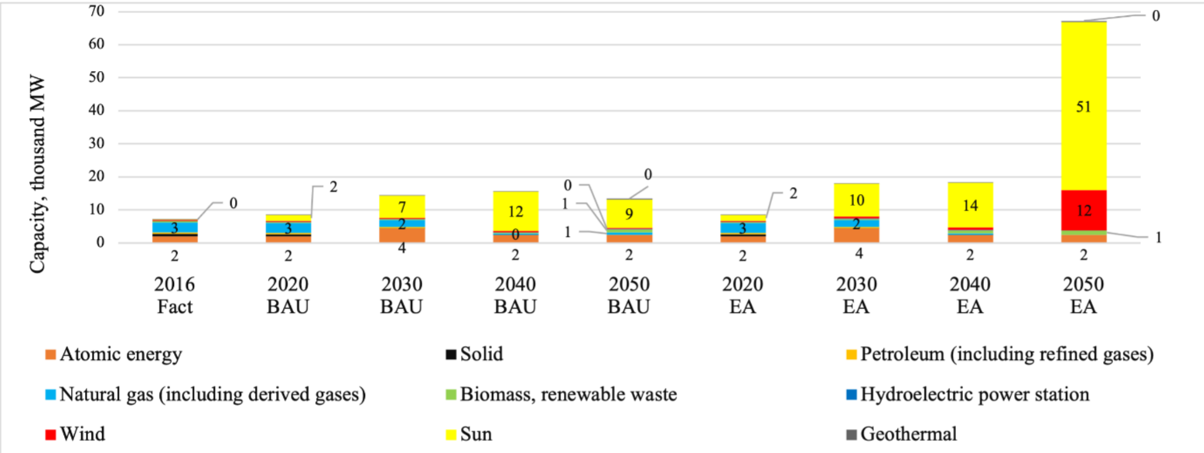
Source: Eurostat, own modeling

Figure 5.20: Composition of electricity consumption in the BAU and EA scenario

Such a significant increase in electricity consumption is accompanied by an increase in production demand. **Achieving the 2050 climate neutrality target and meeting consumption will require around 65 GW of clean generation capacity in addition to nuclear capacity**. Of this, 51 GW is PV and 12 GW is wind power capacity and 1.5 GW is biomass CCUS.

The high degree of electrification is really accelerating from the 2040s. By then, support for the current modernization of residential heating systems will run out.

It is also important to note that, in accordance with the principle of sustainable land use, brownfield sites should be given priority in connection with the installation of renewable energy production capacities (especially solar panels).

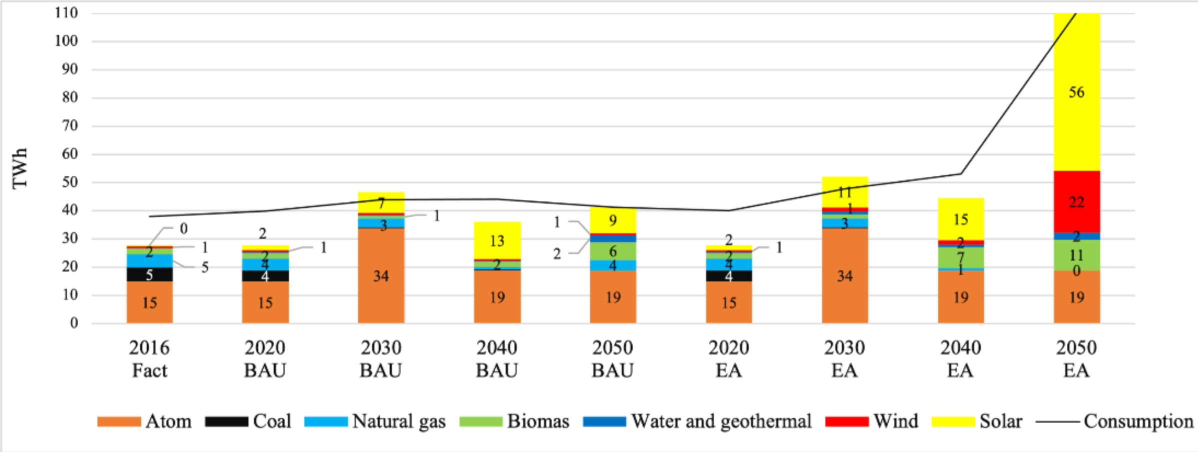


Source: Eurostat, own modeling

Figure 5.21: Composition of installed electricity capacities in the BAU and EA scenario

With the build-up of new renewable energy generation capacities, it will also be necessary to build storage capacity from the 2040s onwards for the system to have sufficient flexible capacity. Electricity storage capacities in 2050 in the EA scenario will amount to tens of gigawatts of capacity. The opinion of industry experts also confirms the important role of battery energy storage technologies, hydrogen and the interconnection of the electricity and gas sectors through hydrogen in the decarbonization process.

In parallel with electrification, security of energy supply will also be strengthened. In 2030, due to the parallel operation of the existing and new Paks units, Hungary will be a net exporter, and then with the shutdown of the old nuclear power plant units, the country will become a net importer again. However, the import share in the EA scenario is only about half (16%) of today's levels. In 2050, due to the significant renewable energy production capacity and the available storage capacity, domestic production will almost completely cover consumption.



Source: own modelling results

Figure 2 Composition of electricity generation in the BAU and EA scenario

Industrial processes and product use

Key driver in IPPU sector in Hungary is the compliance with air quality standards (BAT Ref. Documents), therefore GHG and air pollutant projections were harmonized, which means same activity data and same projection pathways. Activity data used for projection of IPPU emissions was based on projection results from the National Clean Development Strategy 2020-2050 (hereinafter the Strategy). The document states that Hungary is committed to achieve climate neutrality by 2050**.**

Energy use in the industrial sector develops differently in the WEM and WAM scenarios examined in the Strategy. In the WEM scenario, due to GDP growth at the beginning of the period under review, the increase in energy consumption is dominant, and then energy efficiency investments are able to offset this, and a continuously decreasing trend can be observed from the 2030s. The WAM, climate-neutral scenario shows a declining trend, although some growth is projected until 2030.

According to the Strategy, achieving the decarbonisation goal in industry cannot be based on curbing production: efficiency investments and technological developments are needed. In order to effectively reduce process emissions, dramatic changes need to be made in the future in those industrial subsectors that account for a significant share of GHG emissions, namely petrochemicals, iron and steel, ammonia and cement. Furthermore, accelerating the clean energy transition and implementing investments early can serve as an incentive for recovery during the economic crisis caused by the COVID-19 epidemic. Therefore, after a setback in 2020, an increasing trend is calculated in the industrial sectors in both scenarios.

Based on some available activity data for 2020 (cement, lime and steel production data from the EU-ETS database, and building construction data from HCSO), in 2020 the industrial production decreased by about 9% compared to the most recent historic year 2019. For 2025, 2030, 2035 and 2040, the growth rates projected in the Strategy were used.

In sector 2A, WEM and WAM trends in the energy consumption (without electricity) in the INM (non-metallic mineral industry) computed by the Strategy were used to calculate activity data. CO_2 emissions were calculated using plant specific emission factors.

In sector 2B1 and 2B2, WEM and WAM trends in the natural gas consumption (IZQGASNAT) computed by the Strategy were used to calculate activity data. CO_2 and N_2O emissions were calculated using plant specific emission factors.

As there are many different products in sector 2B8, WEM and WAM trends in the naphta consumption (IZQOILNAP) computed by the Strategy were used to calculate CO_2 and CH_4 emissions directly. Emission from ethylene production was subtracted from the emissions as it is counted for in sector 1A2 in the Strategy calculations.

In sector 2C, WEM and WAM trends in the energy consumption (without electricity and district heating) in the IIS (iron and steel industry) computed by the Strategy were used to calculate activity data. CO_2 and CH_4 emissions were calculated using plant specific emission factors. Emission from coke consumption in pig iron production was subtracted from the emissions as it is counted for in sector 1A2 in the Strategy calculations.

In category 2F and 2G, there is an increasing trend in the forecast as well as in the historical data.

In sector Refrigeration and air-conditioning (2.F.1) (EU) No 517/2014 (the 'F-gas Regulation) Regulation is the principal for current and future regulations. Although this Regulation contains a number of restrictions on the marketing ban from 2007, most of the restrictions are due to be implemented around 2020. For example, 2020 is a significant date on the market of equipment containing new gases above 2500 GWP in stationary commercial refrigeration equipment and the ban on gases above GWP 150 from 2022. In this sector, delayed emissions are the decisive factor in the value of emissions, which appear at different times for each subcategory (on average, we should expect lifetimes of 15-25 years).

Therefore, measures period after 2020 will not yet have a significant impact on the value of emissions as projection WEM, so therefore we used a linear trend fitting for almost each subcategory (except for 2F1b and 2F1e).

For WAM projection, we have also taken into account that the review of the current regulation is already in progress and the emissions trend is slowly stops as a result of the restrictions already in place and future regulations. Although refrigeration and air-conditioning equipment is becoming more widespread and will be needed more and more as a result of the continued expansion of the food supply, the regulations will mean that many of the gases currently on the market will no longer be used and will be replaced by alternatives with much lower GWP. The Commission is currently reviewing the "F-gas Regulation".

This review will evaluate how well the Regulation has functioned, following the standard framework for evaluation of EU policies by examining its relevance, effectiveness, efficiency, coherence and EU added value. Specific measures are not yet known and will not yet affect emissions until 2040.

Commercial refrigeration sector (2F1a) typically the largest emitting source in 2F. The sector includes small, medium and large warehousing and storage facilities in the commercial sector. The commercial refrigeration sector is growing faster than the population globally.

F-gas emissions from domestic refrigerators (2F1b) were the largest source of F-gas emissions in the early 1990s in 2F, but since then the use of HFC-134a in domestic equipment has been completely banned in 2015 and charging domestic refrigerators with HFC-134a has already been phasing out in 2008 in Hungary. As a result of banning, most household refrigerators in the EU are now running on low GWP gas (R600a). Emission in Hungary will be stopped by the early 2020s due to the average lifetime (15 years) of refrigerators.

2F1e sector is expected to grow for a few years, but then a decreasing trend is observed due to the regulation of uses in mobile-air conditioning equipment. The largest source of emissions (cars) is already covered by current legislation to switch to more environmentally friendly refrigerants. By 2040 the emissions of the sector will be around 45 kt CO2 eq.

Categories 2F2, 2F3 and 2F4 are calculated on the basis of the regulations in force ('F-gas Regulation').

Projected emissions from 2G1 are significantly higher than historical GHG emission. The main reason for this increasing trend is that end-of-life emissions are calculated after 2020. For 2G2, the emission trend is determined by the emissions from soundproof-windows until 2033. Emission of SF6 increasing until 2024 and after the trend is decreasing. As the additional uses are calculated with prompt emissions and the projected use remains mainly constant in the future, emissions will also remain at this projected level. Emissions from 2034 onwards are 9.65 Gg CO2eq, 5.4% lower than in 2018.

To calculate projected N2O emission from 2G3, we used the historical data with a linear trend.

Agriculture

In the WEM scenario emissions rise slightly by 5.3% by 2030 compared to 2019. In the WAM scenario emissions decrease by 2%.

Land use, land-use change and forestry

To estimate biomass carbon stock changes, the model applies net growth (=gross growth minus thinnings minus mortality) to age classes (1-150 years in annual steps). The net growth model was developed by 22 species/species groups and 6 yield classes for the reference period 2000-2009. Final harvest is modelled for specific age for each species and yield class so that the age was set during calibration at which modelled final harvests were equal to actual ones. Biomass carbon stock changes due to a specific harvest scenario is modelled at the species level by adding or deducting any differences between the harvest levels assumed in the FRL and in the scenario. Below-ground biomass and HWP stock changes are calculated as in the GHG inventory. Deadwood is modelled using reverse modelling based on species-specific stocks (measured by the NFI) 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 are the same as in the GHG inventory.

To estimate biomass carbon stock changes due to land use change, the model applies gross growth functions to age classes (1-120 years in annual steps). The growth model was taken from published yield functions for 18 species/species groups and 6 yield classes (for references see http://www.scientia.hu/casmofor/creditsE.php). Thinnings and final harvest 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. No harvest scenarios were modelled, only different afforestation scenarios. Below-ground biomass and HWP stock changes are calculated as in the GHG inventory. Deadwood is modelled using data from the NFI combined with expert judgment and first-order decay functions. Changes in the litter and soil pools were assumed using the same parameters that are applied in the GHG inventory. Non-CO2 emissions and emissions from organic soils were assumed not to take place in afforestations. Definitions are the same 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.

The sector maintains its net sink status in the WEM scenario but its sink capacities shrink to the half of the 2019 level. In the WAM scenario it increases its net sink capacities by 24% compared to 2019.

Waste

For making projections, basically the same methodologies were used as for the inventory. More specifically, the same Tier 2 methodology as implemented in the IPCC Waste Model was applied for methane emission calculation for solid waste disposal. As for activity data (i.e. amount of disposed waste), information received from the ministry responsible for waste management was taken into account. The main underlying assumption was that the amount of waste disposed would be significantly reduced and disposal of degradable organic waste (e.g. food and garden waste) would cease after 2023, and also textile waste would not be disposed in 2030. As a consequence, methane generation potential will decrease and so will the amount of recovered biogas. Projected amount of the main degradable waste types disposed together with the resulting methane emission is summarized in the figure below.

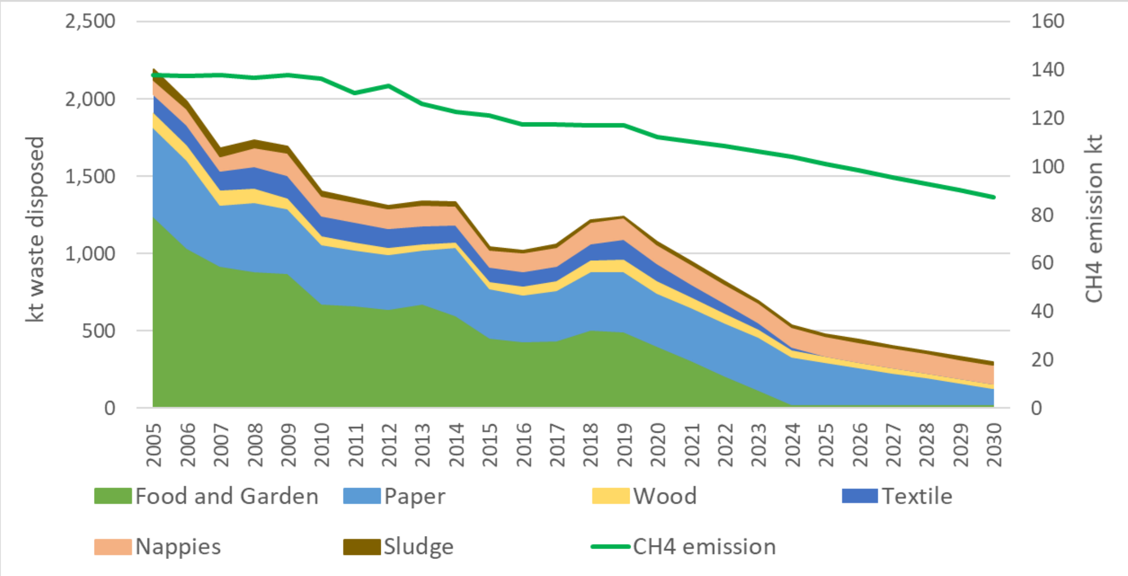


Figure 5.23: Composition of disposed waste and CH4 emissions

In the source category biological treatment of waste, composting of both municipal solid waste and sewage sludge were considered. As Tier 1 method with default emission factors was applied, the trend was determined by changes in activity data. Information received from the ministry responsible for waste management was taken into account. It was assumed that growth in composting will continue until 2030, we calculated with a 35-fold increase between 2005 and 2030 as regards composted MSW, and with the average of the amount of sludge composted in the last five years kept constant. Leakages from other biogas production were also considered here with the default methodology. Projection of biogas production seems to be quite uncertain for the moment therefore in this submission we did not introduce any trend and kept the same average values of years 2015-2019 constant.

Waste incineration without energy recovery represents currently 1% of the waste sector emissions. As we did not expect any significant changes in this field, we did not introduce any trend and kept the average value of waste incinerated in years 2017-2019 constant up to 2030.

Methane emissions in wastewater treatment and discharge are highly determined by the share of dwellings connected to the public sewerage network that is expected to increase to 91% by 2030 from the current share of 82.6%. Parallel to that, sewage sludge gas recovery would grow by 11.8%. As for N2O emissions, we do not expect significant change in per capita protein consumption. However, tertiary treatment would reach a share of 99% by 2030 (from the current 89%) which would increase the N-removal from the effluent, consequently decrease N2O emissions.

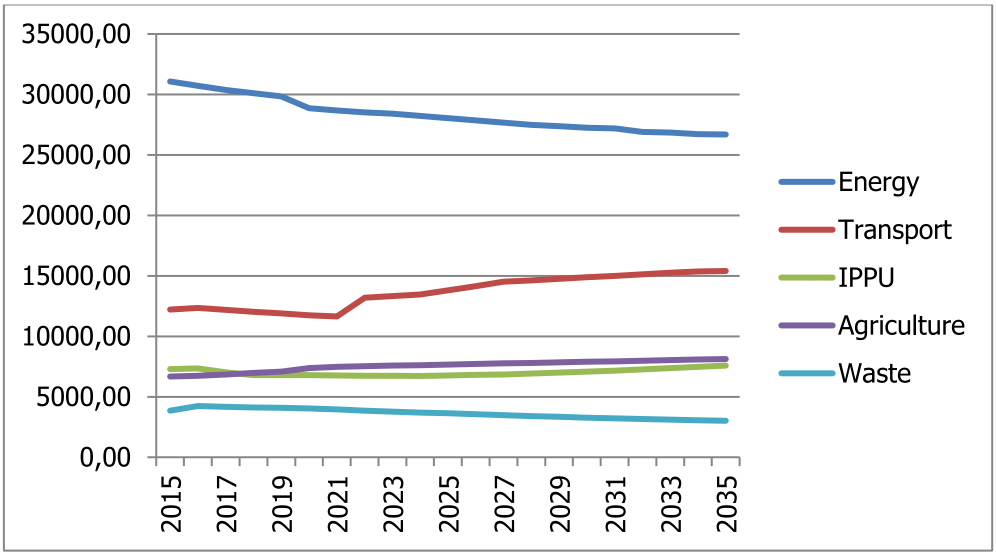


Figure 5.24

This sink can only be preserved in the WEM and WAM scenarios, in which case the sink can even be increased

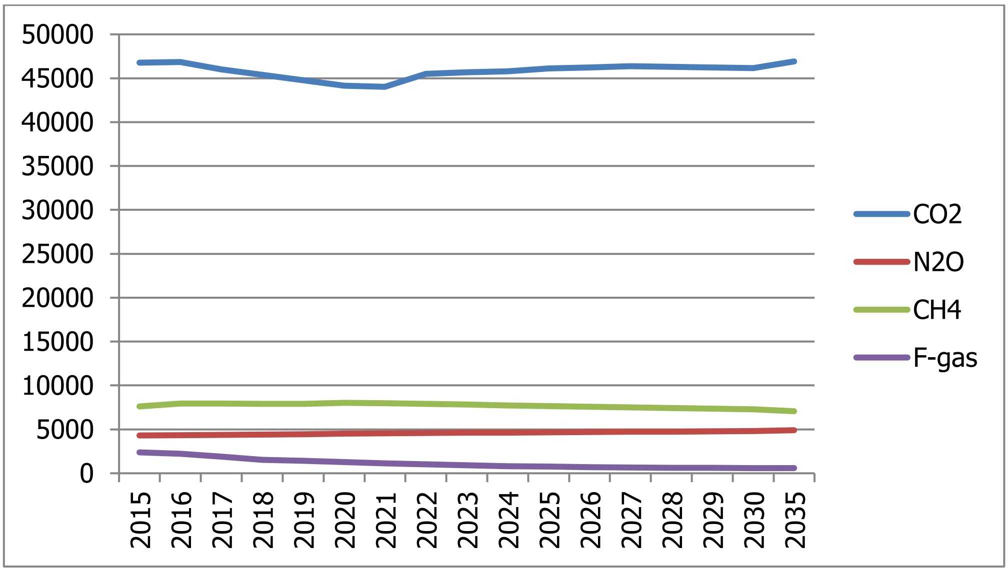


Figure 5.25

5.2. Sensitivity analysis

A sensitivity analysis was performed on EU ETS carbon price, only in the energy sector.

	2016	2020	2025	2030	2035	2040	2050 (optional)
WEM/WAM scenarios	6,57	25,03	46,23	35,16	42,58	50	88

Sensitivity analysis	6,57	25,03	46,23	35,16	63,87	92,58	150

Table5.2 - EU ETS carbon price in the different scenarios

According to the analysis the higher EU ETS carbon prices would result in 53% lower EU ETS emissions and 14.8% higher ESR emissions, while total emissions excluding LULUCF would be 8.9% lower in 2030 compared to the WAM scenario.

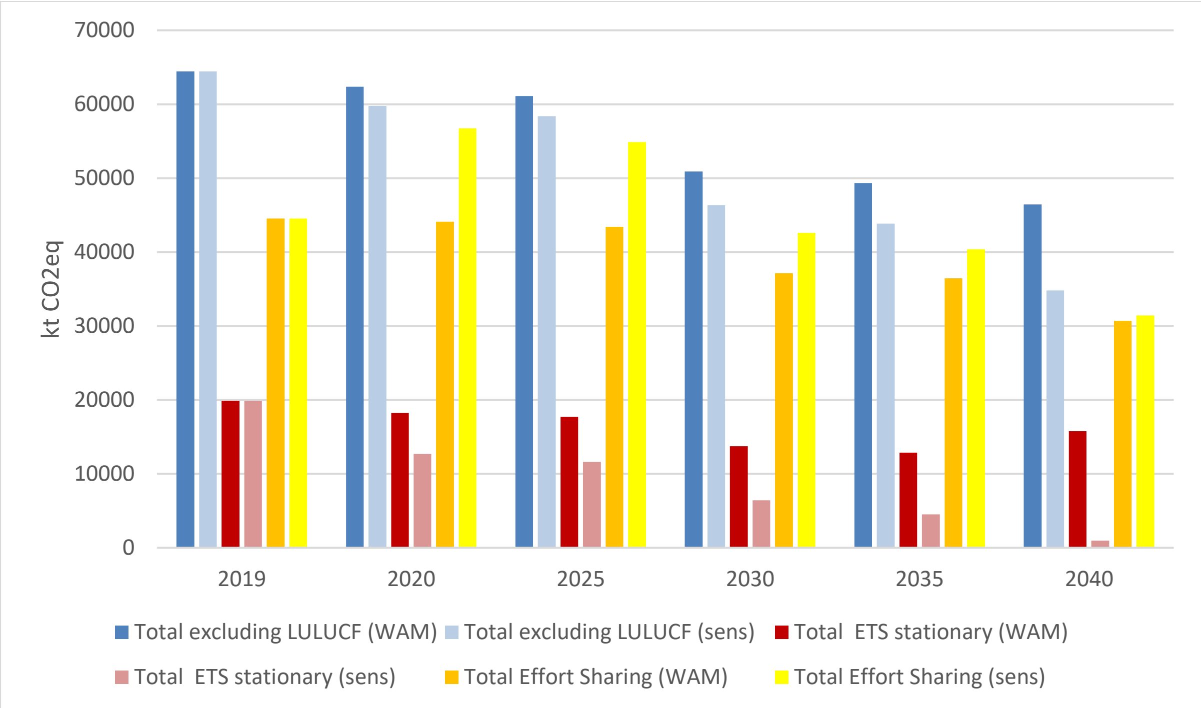


Figure 5.26 - Results of the sensitivity analysis

5.3. Supplementarity relating to mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol

The joint mitigation effort of the EU is mainly based on action on EU level. As the EU has a common emission reduction target, this is considered as domestic action. The emission allowances of the intra-EU policies can be traded:

- between stationary installations and aircraft operators in different Member States under the EU Emission Trading System (EU ETS) (EUA and EUAA allowances)
- between Member States under the Effort Sharing Decision (ESD) (AEA allowances).

However, in the period 2013-2020, it is still possible to use credits generated in projects under Article 6 and 12 of the Kyoto Protocol (CER and ERU) in a limited amount for compliance within the two above-mentioned EU policies. The principles of doing so is described in Articles 11a and 11b of the currently applicable text of the 2003/87/EU Directive concerning EU ETS and Article 5 of the 2009/406/EU Decision concerning ESD.

5.4. Methodology

The methodology of making GHG projection has been completely replaced since the lase biennial report. For creating projections in the energy sector the HU-TIMES model was used. The Green Economy Model (GEM) was used to make projections for the rest of the sectors and to estimate social costs and benefits of greenhouse gas reduction.

Description of the HU-TIMES model

The TIMES ("The Integrated MARKAL-EFOM System") model is an internationally used and accepted model developed by the International Energy Agency from the MARKAL model, which has a decades-long history. The robustness and flexibility of the model is illustrated by a number of research examples, whether the approach is global, international, national or regional. The TIMES model applies an integrated approach, in which it is possible to take into account two different but complementary approaches. It provides an opportunity to model the technically relevant characteristics of individual technologies, even at the production unit level, while examining comprehensive energy policy decisions from a more holistic, economic perspective. In terms of the operation of the TIMES model, it uses mathematical optimization in order to optimize the expression in the objective function while taking into account - technological - constraints. The expression in the objective function may include maximizing total social utility or minimizing total production cost. Due to its structure, the TIMES model is suitable for assessing long-term energy policy decisions, where the examined time horizon can be several years or decades. In addition, the assessed time periods, such as years, which together produce the time horizon under examination, can be disaggregated into time scale — days, parts of day, hours — depending on how demand- or supply-side rules justify it. The HU-TIMES model is a TIMES model further developed by REKK and Klímapolitika for the entire Hungarian energy sector. In this, the technological and cost-side characteristics of the domestic electricity and district heating facilities, as well as the technological and demand-side characteristics in the examined end-user sectors appear. With the help of the model, we examine the additional costs of achieving the individual energy policy goals at the lowest cost principle compared to the reference case. In order to develop the HU-TIMES model as accurately and up-to-date as possible, both primary research – i.e. stakeholder interviews – and secondary research – i.e. data found in domestic and international literature – have been conducted. . This facilitated application of the most accurate values possible to both supply-side and demand-side characteristics. The HU-TIMES model is suitable for analyzing the energy sector from the side of both the production (technological) and costs (economic). In addition, greenhouse gas (GHG) emissions from the energy sector can be extracted as a result and used as a constraint for the operation of the model. In the HU-TIMES model, the emissions of carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4) were studied. For each energy source, the emission values for each above-mentioned greenhouse gas have been determined as one of the characteristics of the energy source. This allows us to analyze GHG emissions and their changes, and thus the costs of abatement, at the sectoral or even technological level.

During the TIMES modeling, it is possible to divide the different sectors into several times slices within a year. This is important for the electricity and district heating sectors, as both the demand side and the supply side can differ significantly from hour to hour. In the HU-

TIMES model, a total of 96 slices were defined: we distinguished between weekends and weekdays (2 different groups), each month (12 different groups), and four periods within a day. It was necessary to differentiate between the months because of the heat consumption, as district heat consumption is considerably higher for the population e.g. in winter than in summer. The distinction between weekends and weekdays was mainly due to the demand side of the electricity sector, as electricity consumption was significantly higher on weekdays than on weekends. Differentiating between the parts of the day is justified on both the demand and supply sides. On the one hand, electricity consumption changes significantly during the day. On the other hand, the production of mainly weather-dependent, solar power plants shows a significant change.

Industrial sector

The TIMES model is characterized by an integrated modeling methodology, combining a bottom-up approach that describes technologies and industrial sub-sectors in more detail, and a more holistic top-down analysis of the energy sector (and its economics). The application of the TIMES integrated model allows the analysis of the longer-term operation, energy consumption and emissions of one or more sectors, as well as their costs, in the light of individual energy policy decisions, which is supported by technological detail. In the meantime, this "bottom-up" approach does not fully characterize the modeling methodology. Therefore, when evaluating more comprehensive analyzes, the modeler is not hindered by additional information resulting from over-detailing.

When creating the HU-TIMES model, the aim was to describe each end-user sector and subsector in as much detail as possible from a technological point of view. However, for some industrial sub-sectors and the agricultural sector, modeling could be less detailed due to the existence of three factors. Partly, because detailed cost and energy consumption data were not available for the current technologies, or the sub-sector is rather characterized by heterogeneous technologies and production processes. Furthermore, in some cases so many actors are active in a given sector that detailed data collection was not possible. Due to these constraints, in addition to the "bottom-up" approach, we used two additional methodologies:

- A "*bottom-up*" approach was used for sectors with a small number of homogeneous actors and available information. Therefore, energy-using technologies have been modeled in detail, both in terms of technological data and costs, such as iron and steel and cement production.

- In the case of the "*top-down*" approach, the change in the distribution of fuel consumption is described by the individual own-price elasticity of the energy carriers in each sector. This methodology was applied in the case of sub-sectors where there are several actors using less heterogeneous technology and production process, so detailed data collection could not be solved. The specific individual own-price elasticity of the energy carriers was estimated on the basis of literature values. "Top-down" approach has been applied for example in the machinery, non-ferrous metals and transport equipment sectors.

- In the case of unchanged fuel distribution methodology, the distribution of fuel consumption compared to the base year (2016) is considered unchanged. Thus, the model satisfies future demand growth for these sectors without changing the ratio of demand for a given energy carrier to demand. Therefore, the ratio of energy use depends on the change in demand and the distribution of fuel consumption in the base year. This approach has been used mainly for those "other" sectors for which there is no reporting obligation or for which the sector's own (supply) price elasticity estimate is not available.

In the HU-TIMES model, energy uses were differentiated according to the consumption of a given industrial sector by companies covered by the Emissions Trading Scheme (ETS) and those operated by smaller capacity operators. From a modeling point of view, therefore, we distinguish between 'ETS and non-ETS fuels' (such as ETS natural gas and non-ETS natural gas). Then, for a given industrial subsector, these have been calibrated for the base year.

Determining the expected future demand in the sectors included in the Times model required a metric forecast that does not determine the type of energy used in each sector, as the model determines the types of energy used and their energy mix based on technical and economic characteristics quantity. This is because the model determines the types of energy used and their amount based on the optimal mix of technologies calculated on the basis of the technical and economic characteristics of the technologies fed. The measures of sectoral demand were determined by the characteristics of the final products of each sector. In the case of sectors emitting products that can be considered relatively homogeneous, it was also possible to forecast demand in kind (e.g. in the case of the cement industry, tons of product). In the transport sector, passenger-kilometers or ton-kilometers have been forecasted, but in some sectors the diversity of products produced has made it necessary to estimate volume indices (e.g. food industry).

Transport sector

The transport module of the model is basically a bottom-up model, so it is built based on individual technologies (vehicles). Bottom-up modeled demand segments and transportation technologies cover the road and rail portion of passenger and freight traffic, while water, and pipeline transportation / transportation are simplified in the model:

- Bottom-up modelling: road and rail passenger transport, road and rail freight transport.
- Other sectors: water freight transport, pipeline freight transport.

The transport sector is modeled in most TIMES / MARKAL models by transport modes. In this approach, the goal of optimization is to meet the transport demands determined by each mode in the most efficient way (at the lowest cost) using technologies belonging to the given modes (e.g., the demand for car use with different types of cars).

However, some newer applications provide the ability to change modes. This essentially means defining larger demand groups (e.g. local passenger transport) that can be met by multi-modal technology. This is important because switching between modes of transport (e.g. from individual to public, from road to rail) is a crucial element in meeting both cost minimization and climate protection objectives. In order to be able to analyze these policies and natural adaptation processes, the model allows for mode switching.

In order to be able to model the mode change, the following four aggregate transport demand groups were defined (in brackets the transport modes capable of satisfying the given transport demand):

- Local passenger transport (motorcycle car, bus, trolleybus, tram, metro, Suburban train)
- Intercity passenger transport (motorcycle, car, bus, passenger train)
- Short distance (<50km) freight transport (light commercial vehicle and truck with a maximum gross weight of less than 7 t)
- Long distance (> 50km) freight transport (all lorries and freight trains)

During the modeling, the transport demands must be determined at the level of each transport mode or distance. Incorporating the possibility of mode switching means that the model does seek to satisfy the total above-mentioned four aggregated demands instead of the demand determined by each mode. That is, the resulting modal split may differ from the base case — under the specified constraint conditions.

Electricity and district heating sector

For power plants and heating plants, the following input data were determined for each facility separately. In the case of power plants, the data source was the European Electricity Market Model developed by REKK. The data of heating plants and connected power plants are mostly derived from the Hungarian District Heating Market Model, also developed by REKK

- Electricity and heat generation capacity
- Annual plant closure due to maintenance
- The availability of the specific technology in each time slice, which is especially important for weather-dependent renewable production
- Electricity and heat generation efficiency
- Fixed and variable operating costs
- Type of fuel used
- In the case of cogeneration, the ratio of heat production to electricity production
- For each installation, it is necessary to determine whether or not it is covered by the European Emissions Trading Scheme (ETS), as if so, their production costs will increase as a function of the allowance price.

For plants that also produce district heating, it was also necessary to set a maximum annual production limit. The incorporation of this limit was necessary because we did not define a separate region for each district heating district, so it is possible to avoid that, e.g. the Budapest heat production facilities cannot meet the district heating consumption in Debrecen. The maximum production was determined by the 2016 district heat consumption value of the given district heating area. This is a kind of simplification, as these values do not change over time. So in the case of decreasing district heating consumption, it is conceivable that a given district heating plant will meet a heat demand that does not occur in the given district heating zone. Although the TIMES model would allow us to define separate districts, this is not possible due to the limited availability of data. This would also mean that, e.g the building stock would have to be divided into many parts, so we would need to know how many and what type of building is connected to the district heating system in a given district heating area.

In the fossil and nuclear case, the HU-TIMES model differentiates power plant units at the block level, while it aggregates renewables at the technology level. The model includes data for the existing power plants from a total of 23 conventional and nuclear power plants, 11 renewable electricity generators, 82 cogeneration plants, and 97 heat generation facilities. That is, the data of a total of 213 facilities are included in the current version of HU-TIMES.

The model considers the possible use of 8 different kind of „new" – i.e. which will be available in the future – renewable power generation technologies, 7 new conventional, 5 co-generation and three only-heat generation technologies. The HU-TIMES model further considers an exogenous technological learning curve, thus the some technological or economic characteristics of a given technology may change over time, based on when it is integrated. For example in case of photovoltaic technology, the investment cost in 2050 is halved, compared to the 2020 investment cost level.

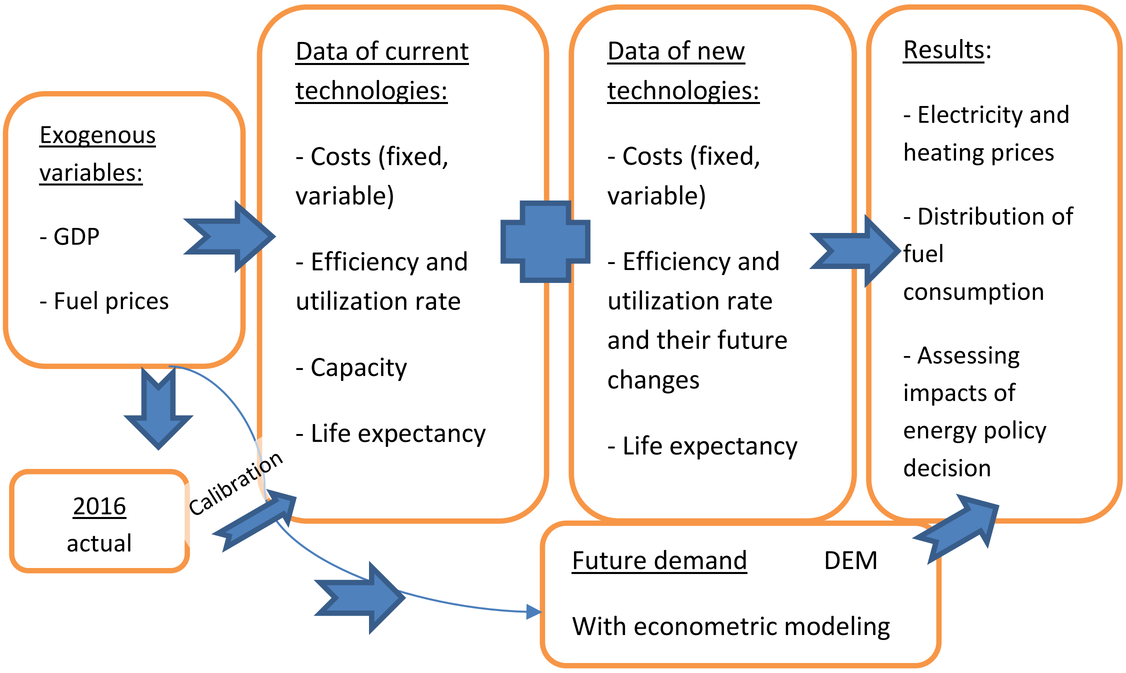
Households and services sector

In the building sector, we used a bottom-up methodology, as shown in the table below:

Residential buildings	Commercial and public buildings
Cooling, heating	
„Building stock" model 26 building type • Heating-cooling energy need Change in the building stock (new construction, renovation, expiry)	„Building stock" model 41 building type • Heating-cooling energy need, energy audits, based on studies Change in the building stock (new construction, renovation, expiry)
Other	
By end use purpose: • HMV (by building type) • Cooling • Refrigerator • Freezing • Washing • Cooking • Lighting • Other	By end use purpose, by type of building: • Cooling • Warm water • Ventilation Aggregated: • Lighting • Other

A so-called "building stock" model was used for modeling. In this approach, the first step is to identify building types that have certain common features in terms of energy use. The characteristics of these buildings (e.g. energy properties of walls and doors, heating systems) are then outlined. The model then invests to improve these energy properties if it meets a cost-optimal solution (either on a market basis or as a result of support schemes introduced into the model) or a constraint (e.g. an emission reduction target) if necessary.

Structure and limits of the HU-TIMES model



Structure of the HU-TIMES

The input data of HU-TIMES can be divided into 5 main groups, which together build the model and can be used to calculate the results:

1. *Exogenous variables:* these input data are macro factors that significantly influence the operation of the domestic energy sector, which are treated exogenously by the current HU-TIMES model. Therefore, the variables in the model have no effect on them (so we have to treat the HU-TIMES model as a partial equilibrium model). Such variables used are changes in GDP and population, changes in fuel and ETS prices, and the social discount rate.

2. The second main input data group is the development of actual demand in the *base year (2016)*. For the HU-TIMES model, actual (energy) demand was taken from the 2016 Hungarian energy balance published by EUROSTAT. If demand was measured in non-energy units, additional literature values - such as million passenger-kilometers for the transport sector or lumens for household lighting[16] - were used which were then calibrated for the aforementioned national energy balance.

3. To determine future demand, we performed econometric modelling so that estimates for the period 2017-2050 relative to actual demand in 2016 were available. This econometric modelling exercise was based on historical values, where the main independent variables are GDP, population and energy prices.

[16] The unit of luminous flux is the lumen. Luminous flux is data specific to the light source.

4. The data of the current technologies were determined for all eight examined sectors (supply - upstream / SUP /, electricity and district heating / PWR /, agriculture / AGR /, industry / IND /, household / RSD / and tertiary sector / COM /, transport / TRN / and "other" sectors / OTH /). Examples of such technological data are capacity, utilization, service life, and operating costs.

5. The data of "new" (available in the future) technologies were determined for the end-user sectors and for the electricity and district heating sectors. This technological data includes investment, operating and maintenance costs, as well as technological data, such as life expectancy, efficiency and overall utilization characteristics, and their expected future development.

HU-TIMES modeling results include the expected development of primary values from mathematical (linear) optimization, such as the use of primary and secondary energy sources or the capacity of future technologies. These rather present the future energy use of the analyzed regions from a technology and production management point of view

In contrast, the dual results of mathematical optimization analyze the energy system from an economic point of view. Depending on the primary assumptions, they can answer questions such as the development of the price of secondary energy sources (electricity and heat) and the change in the welfare of individual market participants.

With the help of the scenario analysis applied in the HU-TIMES model, we can analyze the effects of future energy policy decisions from both the technological (primary) and economic (dual) sides. For example, how the distribution of energy use and the capacity of the applied energy-intensive technologies in the industrial sectors change if we require the operation of a basic power plant operating with a given technology and energy carrier in the studied area. These more technological questions are answered by primary variables, and the precise description of current and future technologies plays an important role in answering them. At the same time, we can add other, more economically interesting suggestions to the previous questions, which can be answered with the dual variables. If the primary power plant, which is also included in the previous question, is integrated, these questions can be: i) how will the prices of secondary energy sources change, ii) what shifts in social welfare can be expected, or iii) is the construction and operation of the given power plant economically sustainable? To answer these questions, a reference case (the power plant is not integrated) and an alternative case (the power plant is integrated) should be considered, where the results obtained for the alternative scenario should be compared with the results of the reference case.

One of the limitations of the HU-TIMES model is that its results reflect a state of partial equilibrium. Since the model treats several significant variables (such as change in GDP, population) exogenously, we define these as external endowments. However, sensitivity testing can limit the uncertainty arising from possible future variations in these exogenous variables.

The use of the HU-TIMES model, like any other model, cannot be applied to predict the near or distant future energy system, but rather to present the context of the system. When evaluating the results, we do not "predict" the future, but rather draw attention to the possible effects of individual energy policy decisions.

The table below illustrates the data sources used for the main indicators by sector.

Table 5.3 - Energy consumption

Indicator	Type	Source
Data of current plants and heating plants	Stock data	REKK European Electricity Market Model
Characteristics of the building stock	Stock data	Multicontact (2020): Hungary: Modernization of Public and Residential Buildings - Identification and Elaboration of Support Programs
Sub-sector-level volume index in the industrial and transport sectors	Time series	Central Statistical Office

Table 5.4 - Transport

Indicator	Type	Source
Current HGV stock	Stock data	KSH (2017), KSH Stadat stock data[17], UNFCCC (2018), Eurostat
Current public transport vehicle stock	Stock data	Bus: Central Statistical Office[18] and Eurostat[19], Trolleybus: BKV Zrt., DKV Zrt., SZKT Zrt. Websites[20]
Current personal vehicle stock	Stock data	Central Statistical Office

Description of the Green Economy Model

[17] HGV stock http://statinfo.ksh.hu/Statinfo/themeSelector.jsp?lang=hu

[18] Statinfo informative database, bus stock, http://statinfo.ksh.hu/Statinfo/themeSelector.jsp

[19] Eurostat bus stock data https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_eqs_busmot&lang=en

[20] www.dkv.hu, www.szkt.hu

Methodology

Systems Thinking is used as underlying method for the quantitative analysis carried out with the Green Economy model (GEM), by combining knowledge and experience in System Dynamics and project finance assessments as well as sectoral assessments (e.g. energy, LULUCF and waste management).

A systems approach is required to identify and estimate relevant criteria for selecting among possible projects and interventions. These include (i) cost-effectiveness analysis; (ii) costing of interventions to improve or reduce risks to investments; and (iii) inequitable risks borne by vulnerable population groups and economic sector (e.g. carbon intensive and trade exposed). These costs can be economic, as well economic valuations of social and environmental outcomes. We propose the use of an integrated framework of analysis, based on Systems Thinking (i.e. the GEM model), which performs knowledge integration. The framework meets the increasing need to address shared, borderless challenges such as land use change, health and well-being.

Various approaches are proposed below to deliver (a) the identification of the main drivers of change at the local level (qualitative and stakeholder driven), (b) an evaluation of the strength of the relationships existing across variables, (c) a science-based sectoral and spatial analysis for the assessment of various investment outcomes. This approach can support project formulation and assessment by anticipating the possible emergence of unintended effects. This approach allows us to maximize value for money, assessing project outcomes (i) across sectors, (ii) economic actors, (iii) dimensions of development, (iv) over time.

Causal Loop Diagrams (CLDs): system maps are a powerful tool to identify causality using a systems approach, anticipate impacts (both desired and undesired) and test the ambition and possible transformational outcomes. A Causal Loop Diagram (CLD) is a map of the system analyzed, or, better, a way to explore and represent the interconnections between the key indicators in the analyzed sector or system (Probst & Bassi, 2014). As indicated by John Sterman, "*A causal diagram consists of variables connected by arrows denoting the causal influences among the variables. The important feedback loops are also identified in the diagram. Variables are related by causal links, shown by arrows. Link polarities describe the structure of the system. They do not describe the behavior of the variables. That is, they describe what would happen if there were a change. They do not describe what actually happens. Rather, it tells you what would happen if the variable were to change."* (Sterman, 2000). Practically, the creation of a CLD supports (a) the selection of relevant indicators, (b) the determination of causality among these variables, and (c) the identification of critical drivers of change (e.g. feedback loops, or circular relations) that are the primary responsible for the past, present and future behavior (or trends) of the system. The use of CLDs is proposed because (i) it elicits knowledge and creates a shared understanding of the key drivers of change of a system, and hence on the possible outcomes of policy implementation across sectors and actors; (ii) CLDs highlight the boundaries of the analysis, supporting the inclusion of social, economic and environmental indicators in a single framework of analysis to fully capture the benefits of a CE; (iii) by visualizing how variables in the system are interconnected, CLDs allow all stakeholders to reach a basic-to-advanced knowledge of the systemic properties of the issues analyzed.

Integrated Cost Benefit Analysis (CBA) for mapping the Socio-Economic Benefits of investments, for increased resilience (or the investment and local development): CBA assess the outcomes of projects on three main components: investments, avoided costs and added benefits. An integrated or extended CBA takes into account both social and environmental avoided costs and added benefits in addition to the more traditional economic ones. This allows to estimate contributions to society, in addition to direct returns of the investment for investors (which is one of the main bottlenecks faced now). The example of renewable energy is presented next:

- *Investments:* From a private sector perspective, investments refer to the monetary costs of implementing a decision. For renewable energy operators, increased investment in the sector entails, among others, in the cost of the RE modules, implementation and maintenance. From a public sector point of view, investments refer to the allocation and/or reallocation of financial resources with the aim of reaching a stated policy target such as creating the enabling conditions for the investment. For example it may include public expenditure for incentives for RE, or the cost of providing preferential loans, or collateral. In the case of public procurement, the investment would relate to the actual capacity of the RE system (MW, installation and operation and maintenance costs).
- *Avoided costs:* The estimation of potential avoided costs considers the results of the successful implementation of an investment or policy. In the case of switching to renewable energy, these avoided costs refer to direct savings derived from reduced fossil fuel energy purchases, or the overall cost reduction for power generation and transmission lines when using renewables that are either centralized or decentralized. Other avoided costs include health costs that would decline as a result of reduced emissions and air pollution. These can be measured in the form of premature deaths avoided and life value savings, or savings in public health budgets
- *Added benefits:* Among the added benefits are the monetary value of economic, social and environmental outcomes deriving from investment or policy implementation, beyond the performance of the baseline scenario, focusing on short-, medium- and long-term impacts across sectors and actors. This includes health benefits in terms of labor productivity (not seen as an avoided cost, but as an increase of productivity beyond baseline values), as well increased employment (with renewable energy being more labor intensive than other centralized thermal power generation). For some specific contexts, added benefits emerge also from the increased economic competitiveness resulting from lower electricity generation costs and prices, or from the higher reliability of electricity generated from renewable energy. These are all additional benefits that would not accrue in a business-as-usual scenario.

The Green Economy Model (GEM)

Finding that most currently available models are either too detailed or too narrowly focused on one or two sectors to effectively capture the many drivers of development at country level, the Green Economy Model (GEM) customized to Hungary was designed to assess policy outcomes across sectors, economic actors, dimensions of development, and over time.

GEM extends and advances the policy analysis carried out with sectoral tools by accounting for the dynamic interplay between economic sectors, as well as social, economic and environmental dimensions of development (Bassi, 2015). The inclusion of cross-sectoral relations supports a wider analysis of the implications of alternative development policies, and proposes a long-term perspective that allows for the identification and anticipation of potential side effects and sustainability of different strategies.

GEM is built using the System Dynamics (SD) methodology, serving primarily as a knowledge integrator. SD is a form of computer simulation modelling designed to facilitate a comprehensive approach to development planning in the medium to long term (Meadows, 1980; Randers, 1980; Richardson & Pugh, 1981; Forrester, 2002). SD operates by simulating differential equations with "what if" scenarios, explicitly represents stocks and flows, and can integrate optimization and econometrics. The purpose of SD is not to make precise predictions of the future, or to optimize performance; rather, these models are used to inform policy formulation, forecasting policy outcomes (both desirable and undesirable) and leading to the creation of a resilient and well-balanced strategy (Roberts, Andersen, Deal, Garet, & Shaffer, 1983; Probst & Bassi, 2014).

GEM includes four key capitals (physical, human, social and natural) as interconnected via the explicit representation of feedback loops (reinforcing or balancing). Policies can be implemented to strengthen growth (i.e. reinforcing loops) or curb change (e.g. by strengthening balancing loops). In this specific study GEM is used to (1) test the effectiveness of individual policies and investments (by assessing their impact within and across sectors, and for social, economic and environmental indicators); and (2) inform development planning (by assessing the outcomes of the simultaneous implementation of various intervention options).

GEM-Hungary conceptualization – Overview of the Causal Loop Diagram (CLD)

The CLD created is a simplified representation of reality, and includes a small subset of the variables that will be included in the GEM model. The CLD focuses on the identification of indicators, establishing causality, and determining what key drivers of change (feedback loops) have affected past trends and will determine future paths.

To explain the CLD, we first explore how the economy is being driven by Reinforcing Loops (R) that trigger growth. This is primarily driven by consumption, investment and innovation that triggers production (loops R1 and R2).

On the other hand, economic growth is giving rise to various balancing factors (or Balancing Loops). One of these is the growing trend of congestion (B1 and B3), which is further exacerbating the increase in air pollution (B2) resulting from energy use. Production is also influenced by energy consumption and competitiveness (B4) and generates impacts on waste generation and food quality (B5).

Low Carbon Development strategies, one example of which is the EU Green Deal, are designed to use various strategies (in yellow) to influence GHG emissions from energy demand and supply, industry and IPPU, agriculture and LULUCF. The expected outcomes (in pink) include cleaner air, water and soils (through interventions on energy efficiency, clean energy, waste reduction, improved agriculture practices), also resulting in better human health, better transport alternatives and access to distributed power generation options (and so better access to more modern and resilient services).

Practically, low carbon development plans aim at making balancing factors weaker, so that the economy can continue to grow, but in a more sustainable and resilient way. This results in lower costs for society, and improved well-being.

Covid19: threats and opportunities for low carbon development

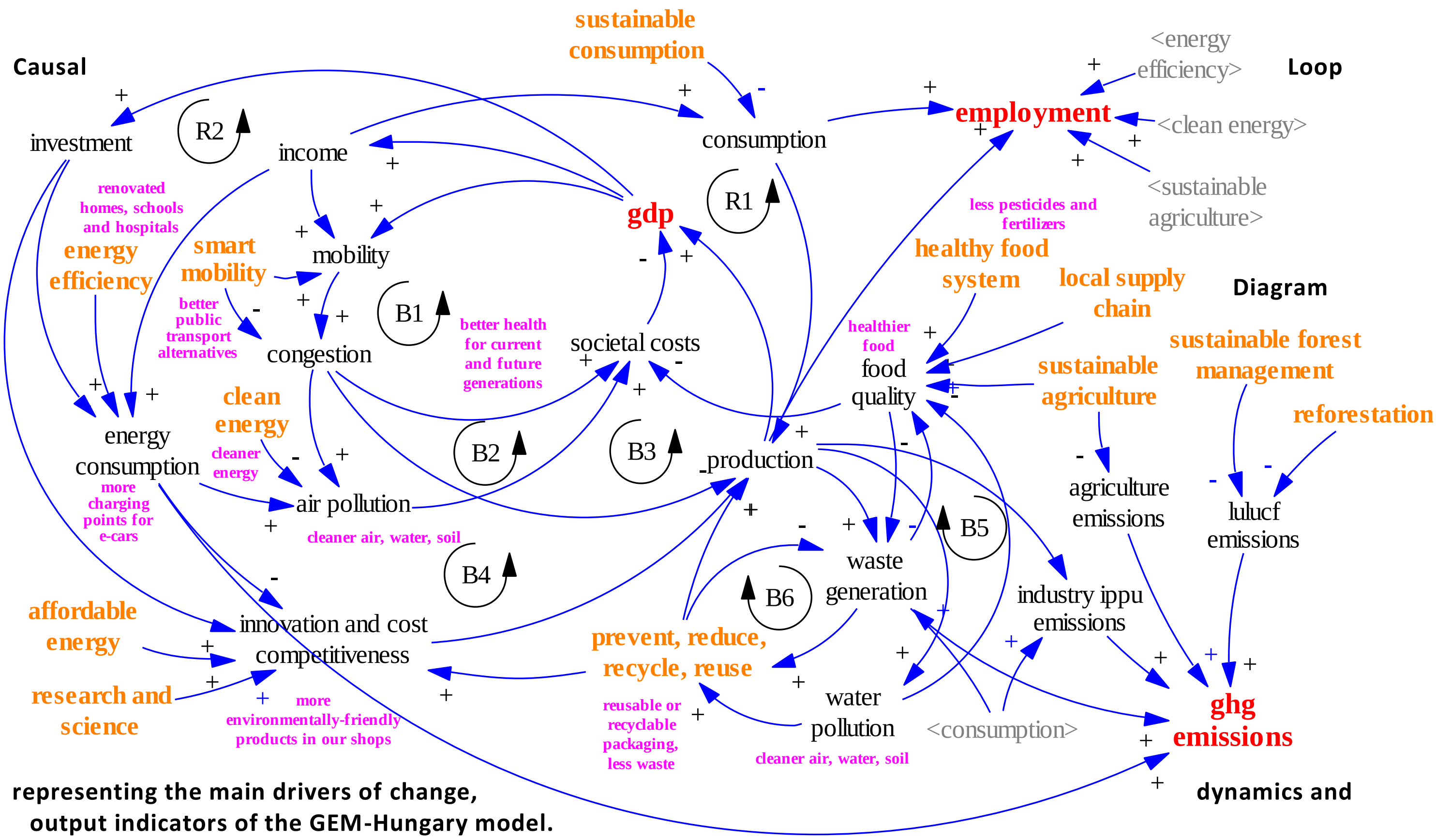
The inclusion of covid19 requires the addition of several variables, representing (i) impacts of the outbreak (e.g. consumption) and (ii) response measures (e.g. public stimulus). The addition of these variables introduces new dynamics, and feedback loops that will be fully represented in the GEM model, as follows:

- Reduction of GDP via the reduction of production (due to demand and limited labor force availability);
- Reduction of GDP via the reduction of consumption (due to social distancing, avoided travel);
- Reduced economic performance due to the higher cost of doing business and insurance premiums;
- Reduced country performance due to the increase of country risk and public costs (higher country risk leading to higher debt costs, higher public costs related to health and stimulus packages).

These four dynamics affect two existing reinforcing loops (R1 and R2), having a negative impact on GDP via consumption and production, possibly triggering a vicious cycle and hence a recession. The introduction of public stimulus instead adds reinforcing loops. The former represents the short-term solution implemented by governments, to stimulate investments. The latter represent the expectation that, once the economy starts growing again, it will generate additional growth that allows to reduce the debt accumulated in the short term. The dynamics triggered by the increase of debt are represented by a new balancing loop. Higher debt will reduce the potential for new investments in the future, due to the higher cost of debt servicing, and to budget constraints related to financial stability.

It results that covid19 has turned two drivers of growth (R1 and R2) from virtuous to vicious cycles, practically into causes of recession. This triggers balancing loop, which highlights the limited (finite) amount of financial resources available for the government. The expectation is that, if the stimulus is allocated well, after the lockdown ends, it will kick start production and consumption to levels that will allow to stimulate employment, increase government revenues, and limit the constraints posed by medium- and longer-term debt.

Concerning environmental performance, the reduction of economic performance reduces energy consumption and air pollution, and hence societal impacts, driven by R2, as well as by B1, B2, B3 and B4. With economic recovery the opposite dynamics will return, as described earlier. As a result, little change is expected to these dynamics, unless permanent impacts emerge (e.g. smart working remains common practice).



Causal Loop Diagram representing the main drivers of change, dynamics and output indicators of the GEM-Hungary model.

Legend:

- The key systemic indicators for the analysis carried out with GEM-Hungary are presented in red: GDP, employment and GHG emissions.

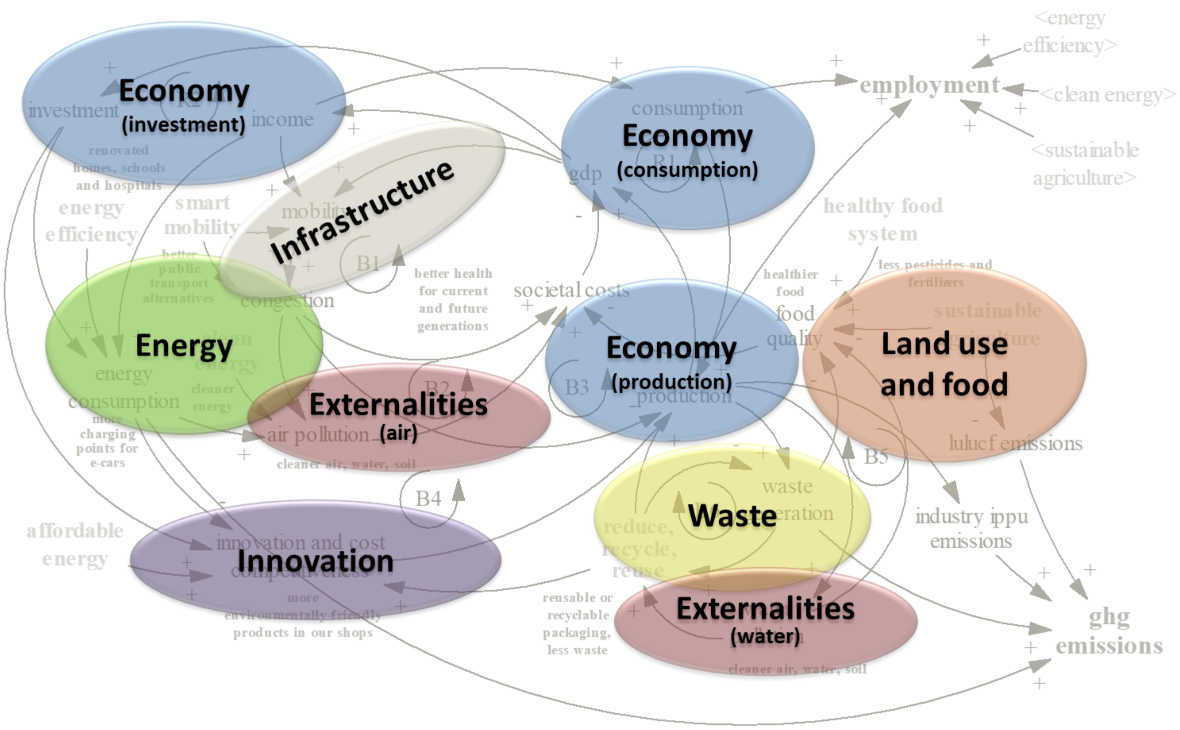
- All key areas of intervention and sources of GHG emissions are covered in the CLD: energy demand and supply, industry and IPPU, agriculture and LULUCF.

- Pink: EU Green Deal benefits for future generations (https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6717)
- Orange: all key intervention options (areas),aligned with the EU Green Deal (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN)

GEM integration with other models

The CLD presented above represents a simplified conceptualization of the system. The CLD is not the mathematical model (GEM), but it is used to guide its development. Practically, the CLD is a blueprint for the customization of GEM to the context of Hungary. It results that (i) the mathematical model will be based on the CLD, on the other hand (ii) the mathematical model will be more detailed (e.g. with several sectors, many indicators for each sector) but (ii) it may not include all the variables of the CLD (or not in the same way as these are presented in the CLD). One of the reasons for excluding indicators is lack of data, or the spatial dimension of a problem (e.g. congestion, air and water pollution are location-specific data that cannot be estimate at national level; on the other hand, the economic impact of congestion, air and water pollution can be summed up and estimated at national level). Further, it is anticipated that some indicators may be difficult to quantify with confidence. Priority for research will be given to indicators related to emissions and low carbon development.

The CLD is useful as it captures the main dynamics of change (or feedback loops) in the system. As a result, it indicates what the thematic areas are that should be included in the model, and assessed when analysing model results. The below figure presents the main thematic areas included in the CLD, namely the economy (with consumption, production and investment), infrastructure (e.g. including energy and water supply, waste management), land use and food production, innovation and waste generation, as well as externalities (e.g. related to air and water pollution, as well as health).



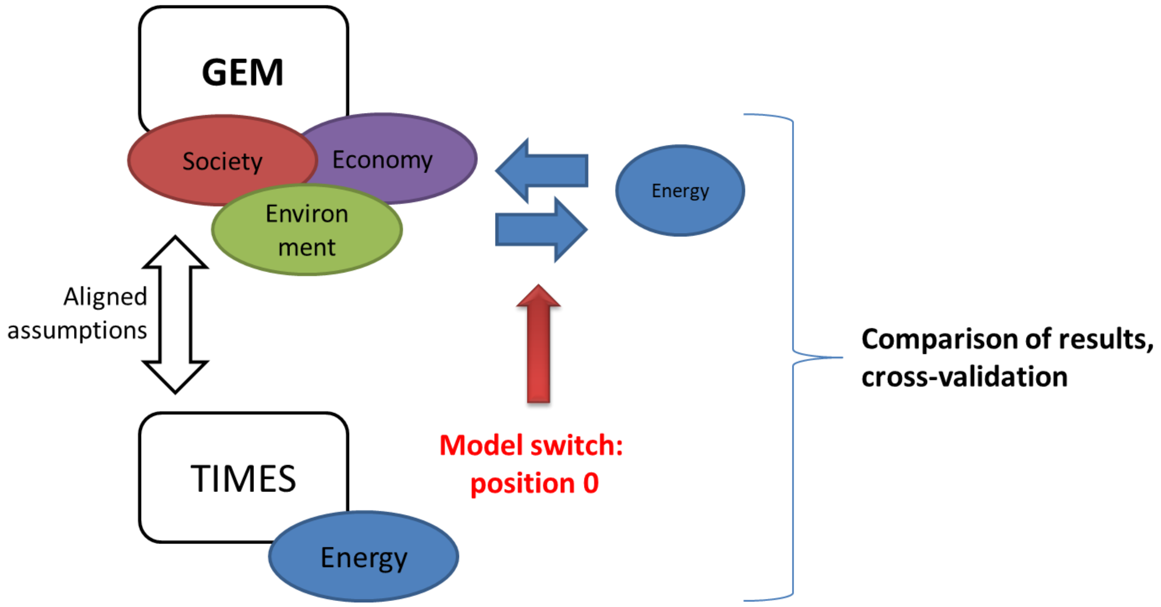
Thematic areas emerging from the CLD.

The cross-sectoral nature of the model calls for the integration of knowledge, including indicators and models. Of particular relevance is the integration of TIMES and GEM, due to the predominant role of the energy sector in the generation of emissions, and to the complementarity nature of the two models (TIMES being a bottom-up technology-rich model, and GEM being more aggregated and cross-sectoral).

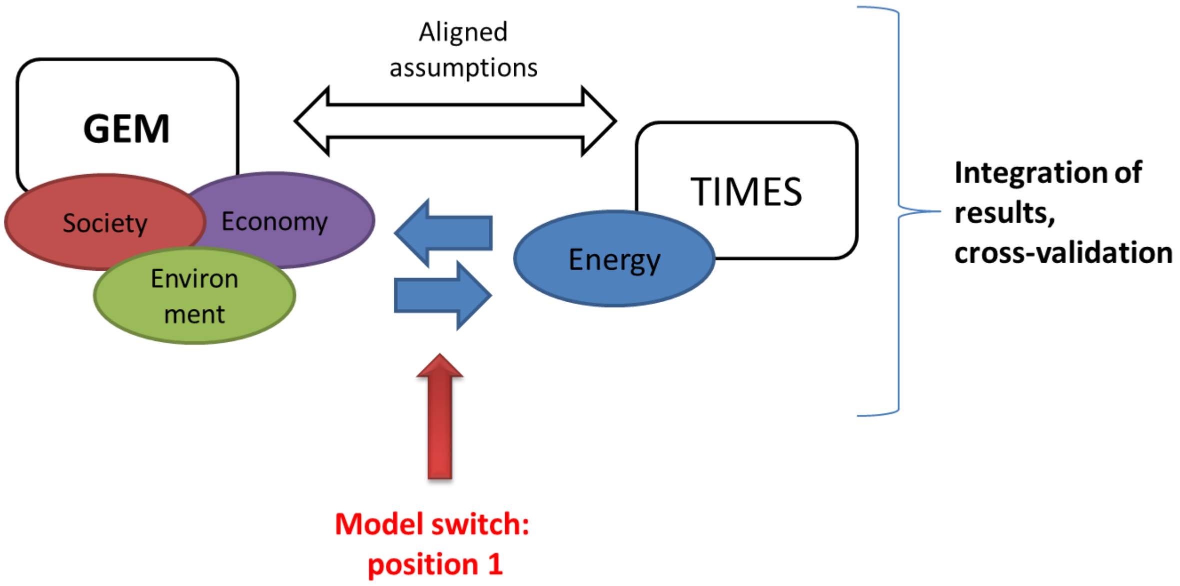
The two following figures show how GEM and TIMES interact: (i) GEM runs its energy modules, or (ii) GEM uses inputs from TIMES, and in this case the energy demand calculation of GEM is bypassed. The second approach allows to capture the strengths of both models: the dynamic and comprehensive nature of GEM and the higher level of detail for the energy sector of TIMES.

In the second scenario, the main dynamic element to consider is GDP. This is because GDP is estimated with GEM, but it is also used by TIMES to generate demand for energy services. There is, therefore a feedback loop between the two models. As a result, GDP from GEM is passed on to TIMES for a re-simulation of the model (if the change in GDP is large, more than one iteration will be needed). This allows the two models to work with the same GDP value for the same scenario (but both models will use a different GDP value in each scenario, because the policies and investments in each scenario will determine GDP growth).

While GEM generates GDP for TIMES, TIMES generates energy prices, power generation capacity (which affects employment in GEM) and emissions that impact various indicators, sectors and dynamics in GEM.



Interaction between GEM and TIMES, option 1 (alignment of assumptions, comparison of results and cross-validation).



Interaction between GEM and TIMES, option 2 (alignment of assumptions, soft coupling with integration of results, via GDP and energy outputs, and cross-validation).

Overview of the mathematic modell:

Sector	Description
Climate assumptions	The climate assumptions module estimates changes in precipitation and temperature over time. It provides information about monthly precipitation and seasonal variability in precipitation and temperature.
Population	The population module forecasts population growth, an important input for several other sectors in the model.
Land	The land use module provides information about aggregate land use and land use change over time. The two modules allow for assessing the impacts of policies on land use and related emissions from land.
Emissions from land	
GDP	The Gross Domestic Product module provides information about the development of Hungary's real GDP, the three sectoral values added (agriculture, industry and services), their respective shares in total real GDP and sectoral employment. This module allows for assessing policy impacts on total real GDP and real GDP growth as well structural changes in economy and employment.
Agriculture value added	
Industry value added	
Services value added	
Employment and technology	
Household	The household account module serves for the calculation of disposable income and private consumption, private savings and investment.
Government	The government accounts module provides an overview of government revenues, investments and debt. It allows for analyzing different public spending strategies and it is used as

	the entry point for the simulation of a government stimulus post covid-19.
Sustainable agriculture Crop production	The crop production module calculates crop production, crop yield, and potential climate change impacts on conventional and sustainable cropland.
Fertilizer application	Chemical fertilizer application from agriculture is calculated based on the total land used for crop production and a fertilizer per hectare multiplier.
Emissions from managed soils	This module provides information about GHG emissions from livestock and managed soils. Emissions from managed soils are consistent with the NIR structure (indirect N2O emissions from manure management, CO2 emissions from limestone and urea application, and N2O emissions from fertilizer application).
Energy demand Energy emissions – CO2 & CO2e Energy emissions – CH4 & Sox Energy expenditure	The model projects national energy consumption by sector and energy source, from 2000 to 2050. Energy consumption is then multiplied by GHG emission factors to obtain total national emissions from the use of energy. Energy demand and related emissions is aligned with TIMES model outputs.
Power generation capacity Employment from power generation	The power generation module captures the demand for electricity, transmission losses and required and current power generation capacity. The module uses the total normalized electricity demand as input to assess electricity generation by technology and forecast future capacity requirements. It further provides information about total electricity generation, both by technology and system-wide, the shares of generation by technology as well as the employment provided.
Total CO2e emissions	The CO2e emissions module calculates country-wide CO2 emissions from all sectors (IPPU, LULUCF, waste, agriculture and managed soil, energy). The module provides information about the development of CO2e emission over time and allows for the assessment of policy impacts on CO2e emissions per capita and the social cost of carbon.
Wastewater generation Wastewater treatment	The wastewater generation module calculates the amount of people covered by sewage treatment systems and nitrogen (N) loadings emitted into the environment. It provides information about the amount of N released into the environment and estimates the hidden cost associated with releasing N loadings. The module can be used to assess policy impacts on sewage system coverage on the release of N loadings and potential productivity gains.
Roads Employment from roads	The roads module provides information about the size of the total road network, as well as additional construction and ongoing maintenance activities. The road module provides information about the current road network and the costs of road construction.

<table>
<tr><td>Livestock</td><td rowspan="4">The livestock sector contains the following four stocks: i) dairy cattle, ii) non-dairy cattle, iii) pigs, and iv) remaining livestock. Cattle and hogs are accounted for separately, because they represent the major share of animals that contribute to CH_4 and N_2O emissions in Hungary.
CH_4 emissions are calculated based on the Tier 1 methodology of the national inventory report. Methane emissions are calculated using the digestive processes and the excretion of gases from livestock animals.
The amount of manure is driven by the number of animals and the annual excretion amount per animal. Nitrous oxide emissions from manure management depend on the amount and type of manure, as the excrements of livestock species differ in N content.</td></tr>
<tr><td>Livestock - CH_4 emissions</td></tr>
<tr><td>Livestock - Manure N and N_2O</td></tr>
<tr><td>Livestock - Organic fertilizer from manure</td></tr>
<tr><td>Waste management</td><td rowspan="5">The solid waste generation module captures the generation of waste from agriculture and food processing, industry waste and municipalities (municipal solid waste) and provides information about waste management practices. It serves to forecast waste volumes and costs by type of treatment and allows for analyzing the impact of policies targeting waste management on total waste volumes, treatment cost and emissions.</td></tr>
<tr><td>Waste management - Municipal solid waste</td></tr>
<tr><td>Waste management - Capital & O&M cost</td></tr>
<tr><td>Waste management - Cost shares</td></tr>
<tr><td>Waste management - Cumulative cost</td></tr>
<tr><td>Waste management - Agriculture and Industrial</td><td>The same structure is used to model agriculture and industrial waste flows and management options.</td></tr>
<tr><td>Waste management - Policy</td><td>This module summarizes all interventions analyzed in the waste management sector, with various treatment options.</td></tr>
<tr><td>Employment from waste management</td><td>This module calculate employment from waste management.</td></tr>
<tr><td>Vehicle stock</td><td rowspan="13">The transport module in GEM provides information about the number of vehicles (private vehicles and buses), their energy use, cost of purchase and maintenance, and emissions related to energy use in the transport sector. This module is aligned with TIMES assumptions on vehicle stocks and energy use and the transition towards more sustainable transport.
This module also estimates the social and environmental externalities created by the transport sector (e.g. respiratory diseases).</td></tr>
<tr><td>Public transport</td></tr>
<tr><td>Vehicle-km traveled</td></tr>
<tr><td>Transport energy demand and emissions</td></tr>
<tr><td>Congestion</td></tr>
<tr><td>Accidents</td></tr>
<tr><td>Air pollution transport</td></tr>
<tr><td>Respiratory diseases</td></tr>
<tr><td>Cost of vehicle ownership</td></tr>
<tr><td>Cost per vehicle</td></tr>
<tr><td>Cost of public transport</td></tr>
<tr><td>Cost per bus</td></tr>
<tr><td>Traffic-related externalities</td></tr>
</table>

LULUCF

For the forestry sector, projections were developed by using two models developed domestically1. for afforestations up to 2050, the model CASMOFOR was used,2. for all other forests (all of the considered to be managed foreststhe model CASMOFOR-NFD was used (Somogyi et al., 2019[21]).

(1) The CASMOFOR model[22] is an accounting-type, IPCC compatible model that applies the gain-loss method using standard yield tables, silvicultural models and other basic parameters of the forest carbon cycle. Although a different methodology (i.e., the stock change method) is used in the greenhouse gas (GHG) inventory, the two methodologies are compatible and the estimates are close to the ones in the GHG inventory (with CASMOFOR underestimating the GHG estimate by 9%). However, this underestimation was ignored in the current projectionsbecause they largely exclude the estimation of non-CO_2 emissions , which may results in an of the net sink in the projections, mainly because of the uncertainty of possible future damage to forests due to climate change (note that Somogyi, 2018[23] estimated that such emissions can be very large). Inthe BAU scenario, we have assumed that low level of afforestations will be accomplished (higher than in recent years but lower than that in 2021), although with an increasing trend. Inthe WAM scenario, we assumed a level double the BAU scenario and inthe WAM scenario, we assumed that afforestations will start from around the level in 2021 and remain between the BAU and the WAM scenarios (2) For all forests that existed before 2017 (i.e., the year when the projection for the existing forests was started), we obtained area and volud data by species and age from the National Forestry Database. From this data, model CASMOFOR-NFD projects changes of woody volume by applying standard yield tables and harvest levels (for both thinnings and final harvests) that correspond to the various harvest scenarios. It was assumed in the simulations that no species change takes place after final harvests (this assumption may not hold in the long run, but it is irrelevant for the simulation period). For other details of carbon stock change estimation, see the publication referenced above.

In the BAU scenario it was assumed that harvest levels will continue to gradually increase along the trend in the period 2000-2016. This slow increase would be a realistic one because of the current age-class distribution of our forests and the recent and future afforestations. In the WEM scenario it was assumed that harvest levels will be less stabilizing at around the level in 2021. Finally, a harvest level was taken for the WAM scenario that seems necessary to achive a sink high enough to ensure carbon neutrality in 2050. For the total forest area, and for all scenarios, the projected emissions are calculated by adding up the emissionsfrom the newly afforested areasand those for all other forests

[21] Somogyi, Z., Tobisch, T., Szepesi, A. 2019. National Forest Accounting Plan, Hungary, Budapest. Gödöllõ, Hungary: Nemzeti Agrárkutatási és Innovációs Központ (NAIK), (2019) pp. 118. URL: http://cdr.eionet.europa.eu/hu/eu/mmr/lulucf/envxgc1ma

[22] www.scientia.hu/casmofor

[23] Somogyi, Z., 2018. Long-Term Mortality and Carbon Balance: Grim Predictions. In: Mátyás, Cs., Berki, I., Bidló, A., Csóka, Gy., Czimber, K., Führer, E., Gálos, B., Gribovszki, Z., Illés, G., Hirka, A., Somogyi, Z. 2018. Sustainability of Forest Cover under Climate Change on the Temperate-Continental Xeric Limits. Forests 9 (8): 489. DOI: https://doi.org/10.3390/f9080489

The strengths and weaknesses of the models

The HU-TIMES model is a technology rich (bottom-up) model, which describes the energy flow and technology usage and GHG emission of several sub-sector within the Hungarian energy sector. Outputs highly depend on external – macro-economic – factors, such as GDP, population etc. (partial equilibrium model).
Applying HU-TIMES model with other general equilibrium model (e.g. the GEM model), can highlight the impact of changes in the investment within the energy sector on macro-economic parameters and vice-versa.
During the NCDS's background calculation HU-TIMES was soft-linked with GEM model: several iterations made for the different scenarios, thus the strenghts of these two approaches have been combined.

However, there is no information that iterations have been made between GEM and other sectors' models, which could support the analysis of overlaps or synergies that may exist between different PaMs among the different sectors.

6. VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

a. Expected impacts of climate change

Modelling background for impact assessment

In order to properly prepare for future climate conditions, numerical models can serve as 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 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 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 future socio-economic developments are constructed. Climate models provide the possible evolution of the climate as a response to a certain anthropogenic scenario.

Future climate projections include uncertainties deriving from the chaotic nature of the climate system, from imperfections of the numerical models and from the ambiguous evolution of 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.mbfsz.gov.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 Hungarian Meteorological Service (OMSZ) implemented an 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 OMSZ are organized in a database and the KLIMADAT visualization platform was developed and opened to the public (https://klimadat.met.hu). The platform aims to aid impact researchers, planners, and 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 shifts can be selected from the time range covering 1971–2100.

Simulated temperature change

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 2021–2050, which is significant (i.e. the change exceeds the natural variability) for the whole country. The chosen scenario starts to have considerable impact on temperature change mostly between 2040 and 2060 when the simulation results tend to diverge (Fig.). The warming during the 21st century seems to continue along the RCP8.5 scenario, however, this is not the case along the RCP4.5 one: the mean temperature in some seasons and decades can slightly decrease in the later decades. By the end of the century, the increase averaged over Hungary is expected between 1.6 and 4 °C, and the impact of different scenarios is clearly visible: the highest warming is obtained in the experiments with RCP8.5. The largest changes are projected in summer and winter, with a considerable spatial variation in winter: two model simulations show stronger warming over northern Hungary (4-5 °C by the end of the century), while two simulations project larger changes in the western and eastern parts of the country (Fig. 6.1). The coldest month will remain January in the future, however, its mean temperature will be above 0 °C already in 2021–2050 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.

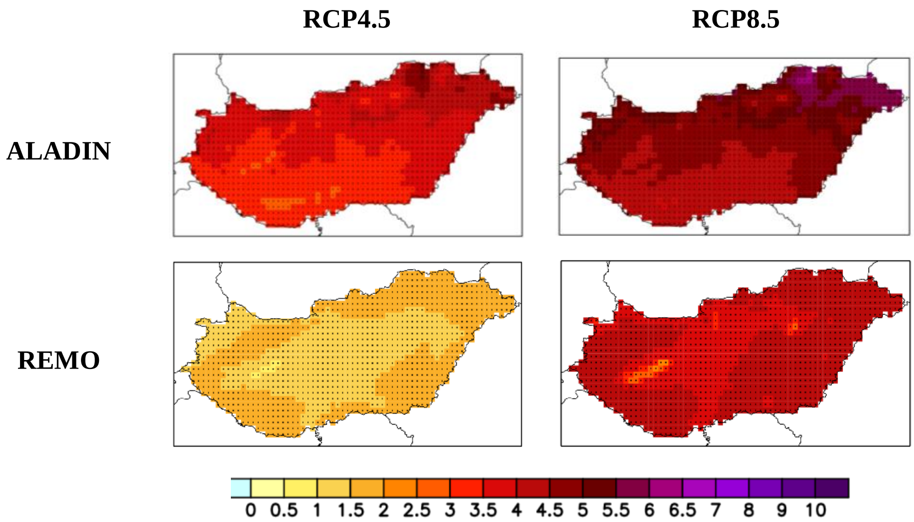


Figure 6.1a: Winter mean temperature change [°C] in 2071–2100 based on the results of the ALADIN and REMO regional climate models and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Reference period: 1971–2000 (Source: Hungarian Meteorological Service)

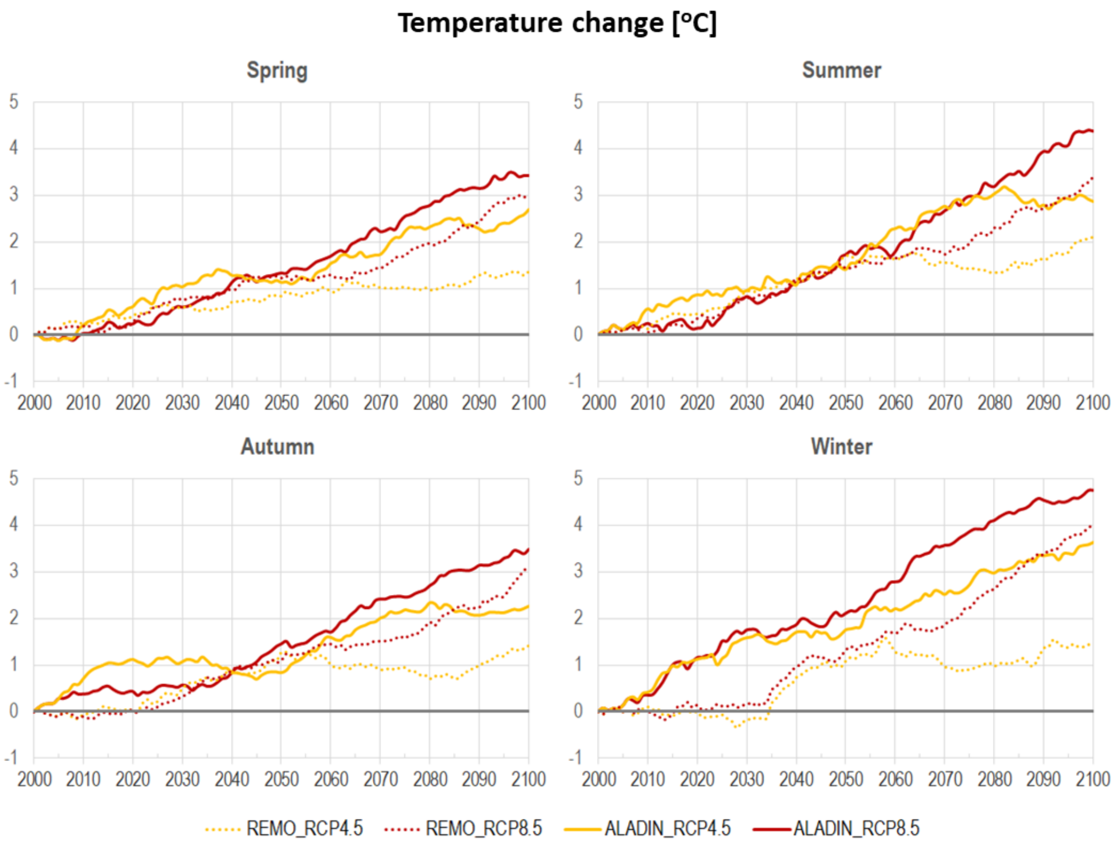


Figure 6.1.b: 30-year moving average of the seasonal temperature change [°C] in Hungary based on the results of the ALADIN and REMO regional climate models and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Reference period: 1971–2000. (Source: Hungarian Meteorological Service)

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 (Fig. 6.2). 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 following the high emission (RCP8.5) scenario than with the moderate one (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.

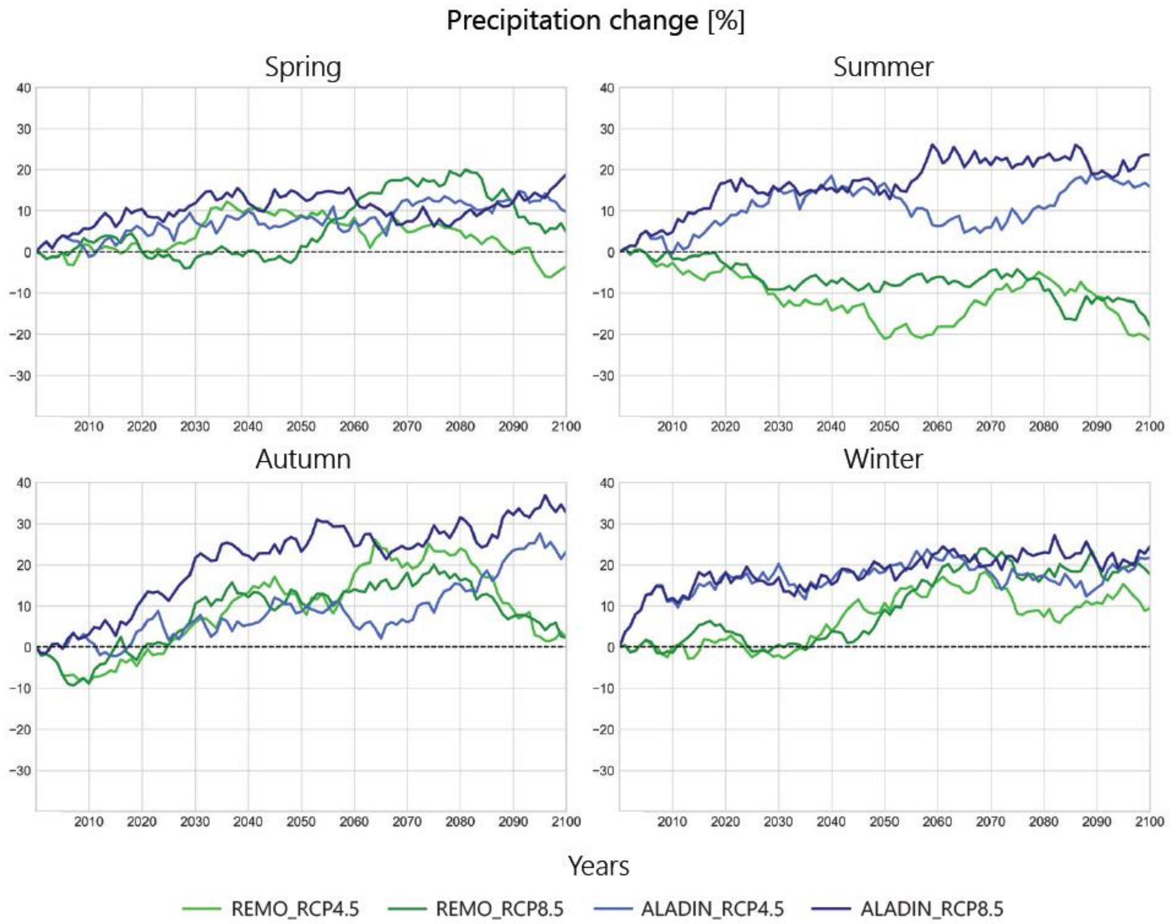


Figure 6.2.: 30-year moving average of the seasonal mean precipitation change [%] in Hungary based on the results of the ALADIN and REMO regional climate models and taking into account the moderate (RCP4.5) and high (RCP8.5) emission anthropogenic scenarios. Reference period: 1971–2000. (Source: Hungarian Meteorological Service)

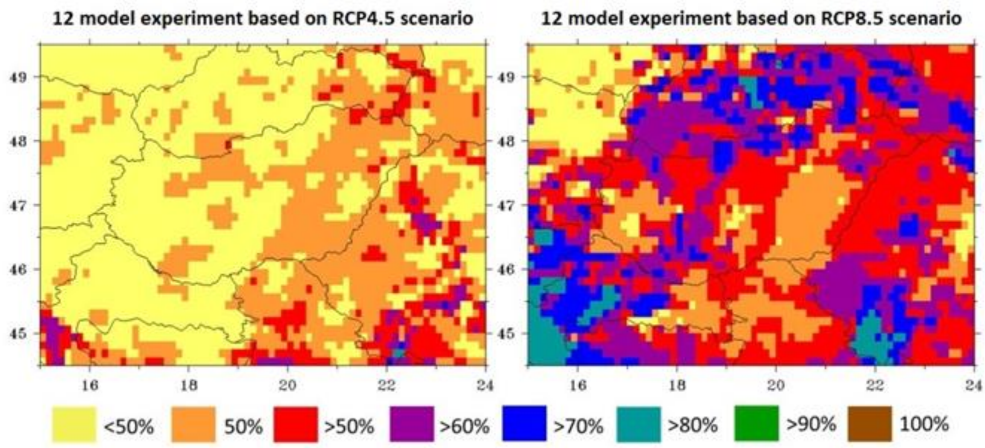


Figure 6.3: Probability of a decrease in summer precipitation [%] by 2071–2100 based on European model experiments using moderate (RCP4.5 - left) and high (RCP8.5 - right) emission anthropogenic scenarios. Reference period: 1971–2000. (Source: Hungarian Meteorological Service, source of basic data: EURO-CORDEX)

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 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 2021–2050, while by the end of the century two simulations project 30 days more second degree heatwave days in this area (Fig. 6.4). All these suggest that Hungary is especially exposed to heat related risks, which may be further exacerbated in cities.

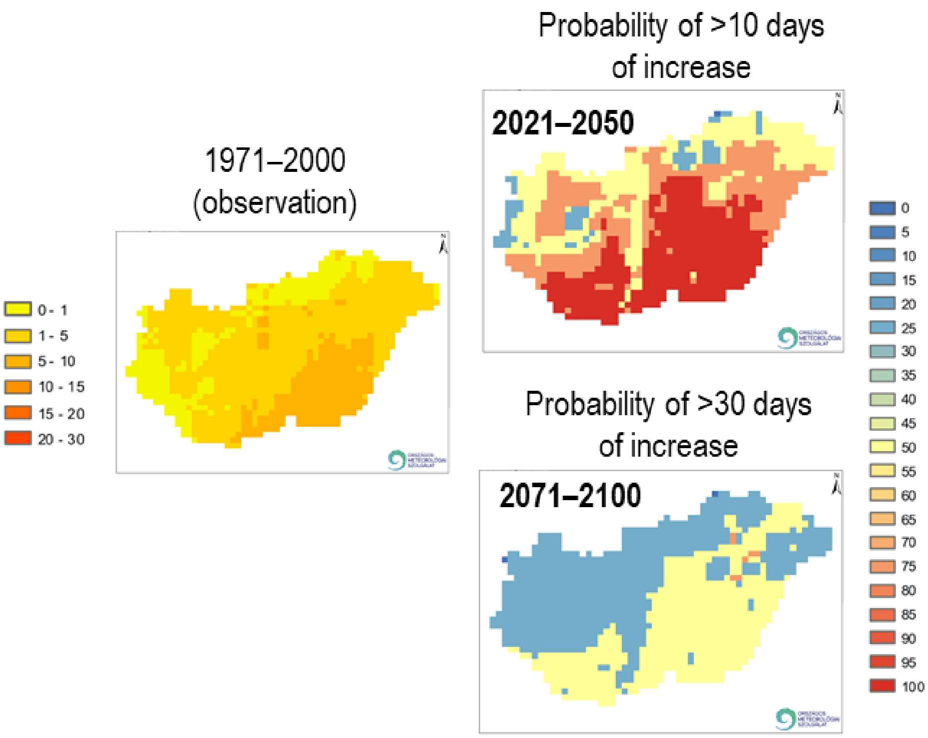


Figure 6.4: Annual mean number of second degree heatwave days (when the daily mean temperature reaches 25 °C for at least three days) according to observations in

1971–2000 (left panel). Probability of more than 10 days of increase in 2021–2050 (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: Hungarian Meteorological Service)

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 can expect longer dry periods in summer (Fig. 6.5) and shorter ones in spring and autumn in 2021–2050, 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 eastern-southeastern parts than the other parts of Hungary.

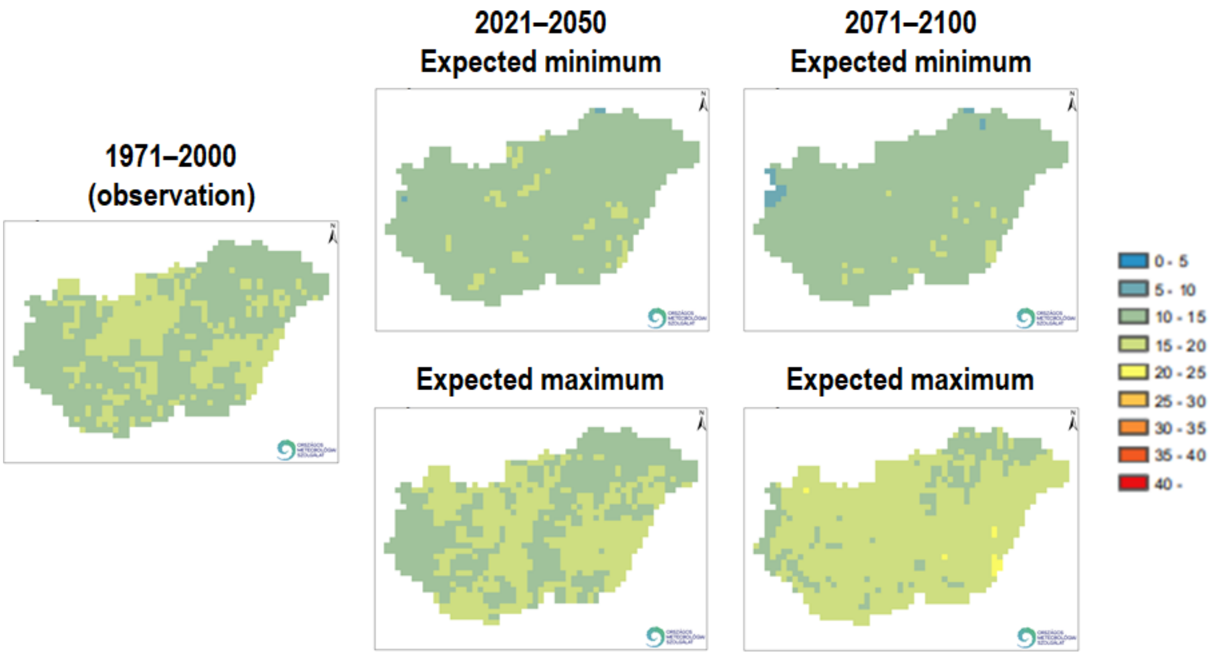


Figure 6.5: Maximum number of consecutive dry days (when the daily precipitation is less than 1 mm) in summer according to observations in 1971–2000 (left panel). The lowest (top middle and right panels) and highest (bottom middle and right panels) expected values of the indicator in 2021–2050 (middle 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: KLIMADAT, data source: Hungarian Meteorological Service)

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 (Fig. 6.6).

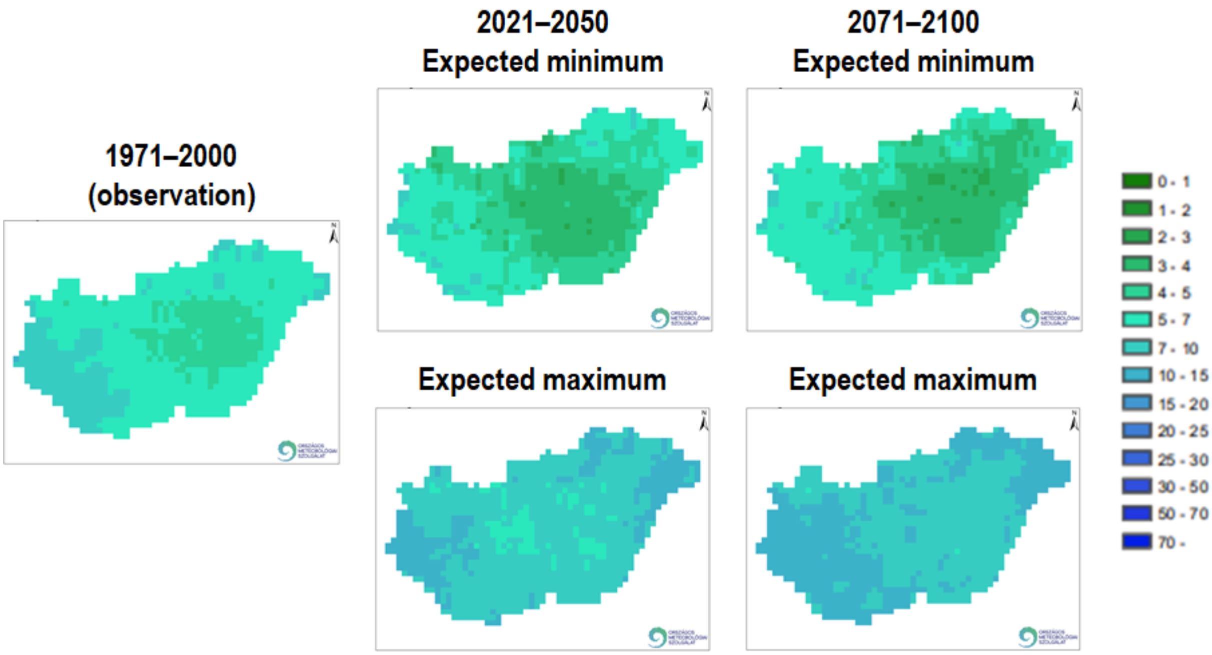


Figure 6.6: Mean number of days with precipitation amount higher than 10 mm in summer according to observations in 1971–2000 (left panel). The lowest (top middle and right panels) and highest (bottom middle and right panels) expected values of the indicator in 2021–2050 (middle panels) and 2071–2100 (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: KLIMADAT, data source: Hungarian Meteorological Service)

b. Vulnerability assessment

In Hungary, territorial vulnerability assessments are basically conducted within the National Adaptation Geo-Information System (NAGiS), the principal decision supporting GIS-based tool of the national adaptation policy. The system was developed and is currently operated by the Western Balkans Green Center Nonprofit Ltd. The Ltd., as legal successor of the Hungarian Mining and Geological Survey (HMGS) in the field of climate adaptation, serves as a background institute of the Ministry of Energy. The following subchapters were completed with the newest results of NAGiS's analyses and assessments.

i. Agriculture

In Hungary, agriculture is the most vulnerable sector to climate change. The effects of climate change are differentiated in time and space, and cause different damages, subject to amongst others, the specificities of nature, land use, agro-techniques. Amongst the elemental types of damages, drought causes the highest loss in the long run in Hungary, and it is followed by frost damage and water damage. Considering the fact that we have to expect an increasing average temperature and a decreasing precipitation in summer, it can be concluded that the largest challenge agriculture faces is the increasing chances of droughts. The vulnerability of various forms of land use, including arable crop production, to climate change were studied in detail in the „Extended National Adaptation Geoinformation System within the Agriculture Sector" (AGRAGIS) project closed in 2016.

In addition to the process of warming and drying, unexpected meteorological phenomena can also cause significant damage. The followings can be mentioned among weather and climate-related agricultural risks:

- flood, inland water;
- drought;
- torrential rains, mud avalanches, landslides, soil erosion;
- wind storms, wind erosion;
- hails, freezing rains, fog, hoarfrost;
- snowdrift, snow barriers;
- increase of the number of heat days, heatwaves, more intense UVB radiation;
- early and late frost, frost damage;
- wildfires;
- appearance of new pathogens, pests and weeds; increase of damage by indigenous species that have been of minor significance so far and that may develop to be pests or pathogens.

As a consequence of climate change, the Agricultural Risk Management System (ARMS) will play an increasing role. Connecting data collected in the ARMS with the data of the Hungarian test operations will allow for the elaboration, modelling of adaptation strategies that are effective solutions for farmers against climate change.

The basis for agricultural adaptation, and a fundamental precondition to agricultural production, arewater and fertile soil. The basis of adaptive intervention is adjusting land use to the changing ecological conditions.

In 2018, a study entitled *"Methodological renewal of land use modeling, performance of spatial sample evaluation"* was carried out within the framework of the „Further development of NAGiS" project. The overall aim of the study was to refine information on vulnerable sectors and stakeholders and to develop climate impact assessment planning and assessment methodologies. Within this general topic, the research undertook land use and its change, modeling and exploration of the connections related to climate change. More detailed information about the study and the main results of the research can be found on the official website of NAGiS.

The fundamental condition for agricultural production is water, so it is important to retain thenatural precipitation in the microregional water cycle, and facilitating its filtration into the soil. The fertile soil is the largest water reservoir in Hungary, its preservation and utilisation, and the supplying of missing water, have got key importance. Retention, utilisation of water and precipitation coming on streams and irrigation are not only increase the foundation of yield security but also effectively combat against droughts, inland waters, floods and weather anomalies. Our land useand the agricultural production structure must be revised and adjusted to the changing conditions, thus decreasing irrational, intensive, wasting and unsustainable activities. The solution for areas that are deep-lying, affected by inland waters and have a heavy soil could be a modern technique and technology and soil cultivation. In accordance with the findings of the Kvassay Jenő Plan, encouraging water use adjusting to water resources and elimination of the constraint of rapid water drainageare urging tasks both in the short and medium run. An organisational, stakeholder and pricing system that encourages water retention must be set up.

The exploitation of the agroecology opportunities for Hungary is particularly important. Following the principles of agroecology - also known as circular agriculture -, the ecological footprint of agriculture is decreasing and the soil's water retention and carbon capture capacity is increasing. At the same time, this can be combined with advanced instrumentation, such as using soil sensors.

In terms of agriculture, choosing a form of land use that corresponds to the current state of the growing location is an important element of adaptation to extreme water regimes. The race for water between various sectors and forms of land use will likely get more intense on those areas which are afflicted by drought. The effect of climate change on the soil is described in detail in chapter protection against soil erosion.

More than half of the arable lands of Hungary are affected by groundwater flooding, especially in the deep-Iying Great Plains, Little Plain and the Dunamellék (Danube Reqion)[24]. It should be noted that storing water in the soil, the fight against groundwater floods and droughts and a transformation of soil cultivation also contribute to the prevention of floods. Areas that are deep-Iying, regularly affected by groundwater floods and have defective soil should be withdrawn from field cultivation by changing the form of cultivation or the form of land use. Aid systems should be adjusted to the optimised forms of landscape, area and land use of multiple aspects.

Ice rains are a significant risk factor in agriculture. Areas most exposed to the risk of ice included Tolna, Baranya and Somogy counties, where the harmful effect of hails was significantly reduced by the soil generator hail suppression introduced in 1991. Extending this system to a country level is currently under planning, it can be implemented within short time. Hails continue to occur frequently in the Danube-Tisza Interfluve and in historical wine regions, where the application of ice webs has somewhat reduced the economic damage. As regards earlier blooming, especially in the case of fruit trees, frost damage is the largest troublemaker. There are various protection solutions which could reduce and eliminate extreme weather hazards like: ice web, hail suppressor with soil generator, paraffin cans, irrigation against frost, foil cover.

Water reserves can considerably enhance agricultural adaptability, the establishment of multipurpose reservoirs, their use for irrigation, extension of lake fisheries, increase of biodiversity, long term integration of nature conservation and agriculture, utilisation of areas exposed to floods and protected with summer dams with flood-resistant, moreovertheflood-requiring forms of cultivation. Irrigation should be encouraged in connection with the restoration of previous systems and the creation of new ones, first of ali on good production

[24] Kvassay Jenő Plan – National Water Strategy. General Directorate of Water Management. Budapest, 2015. 3. p

locations and valuable plantations, in case of production in foil tents and greenhouses, for certain arable crops and technological phases (irrigation for germination). Irrigation can be realistic for such forms of production that produce high added value, and can be considered as a local solution only. In most of our regions, the solution is the planning and harmonisation of the water demand, establishment of water regulation of water retention and the landscape management systems based thereon facilitation of infiltration and involvement of cultures requiring less water into cultivation. In case of irrigation, it is advisable to consider the increasing price of food products and irrigation water. It is worth applying already forgotten traditional methods to irrigate gardens around houses, spray trees, wash clothes and clean such as the capturing, storage of the precipitation using cisterns, tanks, tubs and barrels. The application of these methods are possible on the small scale, regarding the fact that rainwater can be captured and used to a limited extent.

Wherever it is possible, the cultivation procedures that can prevent the settlement of non-indigenous pests in agricultural life communities, their propagation and reduce the harm caused by them should be elaborated and applied.

Similarly to the Chapters on Forests, the spreading of non-indigenous and rapidly spreading pests, pathogens and weeds, as an effect of climate change, should be expected in agriculture as well. This process can entail a significant cutting out of indigenous species. The adaptation to this phenomenon must build on the better understanding of natural processes and the application of semi-natural protection methods such as using invasive plants for grazing; succession; facilitation of the closing of disturbed areas; increasing of biodiversity; human-driven supporting of the self-protection mechanisms of indigenous communities.

The living conditions and income of rural population might be significantly influenced by the changes of environmental conditions, especially in vulnerable areas that are more exposed to droughts. It can be expected that the capacity of these regions to maintain its population will deteriorate and further migration, local population shrinkage may be expected. According to the research conducted by HAS Research Centre of Economics and Regional Studies, most of the townships of Hungary should expect population decline until 2050, and this can reach even 50 in certain townships (in the Southwestern part of Transdanubia and in Northeastern Hunqary)[25]". From our point of view themost important thing that traditional farming measures can stop or at least slow the depopulation of the countryside.

Animal husbandry may respond differently to the expected effects of climate change, depending on the species and type of husbandry. Intensive animal husbandry is the most vulnerable. Cattle, pigs and poultry in intensive livestock farming are very sensitive and react with yield decline to certain shocks. Certain traditional animal breeds (such as the Hungarian grey cattle, mangalica, the Racka sheep, Hungarian chicken) are more adaptive thanks to their genetics and their extensive farming technology, but their productivity do not reach the level of intensive breeds. The increasing water and shading demand of animals should also be taken into consideration. In the development of animal breeds, in addition to performance and quality, the characteristics that better tolerate the expected effects of climate change and

[25] Tagai G. (2015): Township-level population estimation until 2051. In: Czirfusz M.; Hoyk E.; Suvák A. (editor): Klímaváltozás, társadalom, gazdaság (Climate change, society, economy) Hosszú távú területi folyamatok és trendek Magyarországon. (Long-term regional processes and trends in Hungary.) Publikon Kiadó, Pécs. 141-166.p.

changes in farming conditions, as well as the preparation of animal health for the expected effects has play an important role. The most important question and greatest challenge of the adaptation to climate change in livestock farming will be the predictable supplying of feed and water (management of droughts, floods and extreme weather phenomena in feed production and water management). It's important that the plants and animals kept in Hungary have a species composition which could adapt easier to the expected climate change. The agroecological conditions of Hungary would allow for a varied and balanced product structure, howeverthe structure of agriculrural production has been upset at the expense of the two main parts, crop production and livestock farming, at the detriment of the latter. Within the domain of livestock farming, cattle husbandry is in the most critical situation, due to the difficulties of the European, including the Hungarian milk market. A significant increase of the cattle stock would be possible if our GHG emission would increase as little as possible.

It has already become typical in Hungary, that in one year there may be serious floods, inland waters, droughts and frost damages, which means that the expected warming and drying raises the serious question of food security. Critical years show an increase inour dependence on food imports, while the demandfor food production in countries with scarce natural resources is increasing, which means that the price of imported food will increase sharply. Risks of food supply can be reduced by reinforcing the adaptability of Hungarian crop production and its consequences can be mitigated.

The global climate change could have a significant effect on food production and the security of food supply. In order to prevent harmful social and economic effects, the expected effects of climate change must be modelled in the field of agriculture and we must prepare for such effects.[26]

The preparation of agriculture to the climate change can be supported by farming systems that align to local conditions, and which are profitable and sustainable. These spare natural resources, do not impose loads on the environment, these are water and energy-efficient, build on local and traditional knowledge, reduce carbon-dioxide, methane which getting into the atmosphere from the soil, prevent erosion, thus their further development and spreading can be a cornerstone to adaptation.

Opportunities to mitigate agricultural damage caused by the climate change

- establishment of a water-retaining water regulation and landscape management, sustainable irrigation;
- increasing biodiversity, growing multiple plant species together, creation of meadow-protecting forest belts with indigenous species (trees and shrubs: hawthorn, sloe, maple, other species according to the habitat concerned);
- improvement and introduction into production of plant breeds that can adapt well and can be grown securely;
- introduction of cultures that are varied, capable of self-protection and seminatural (fruit plantations, extensive orchards, systems of agroforestry);

[26] Draft of the Food Economy Programme of Hungary 2016–2050. Ministry of Agriculture, 2016.

- involvement of indigenous local species into the production which are less sensitive to weather extremities;
- applying soil cultivation methods that imply less soil disturbance, applying mulching, composting and green manure;
- planting semi-natural biotopes, forest belts, turning pastures into groves;
- increase of green surfaces;
- insulation, cooling, ventilation of livestock buildings, shading around stails;
- preparation of plant protection and animal health;
- general introduction of sustainable farming systems, with special regard to the spreading of ecological farming;
- increase research activities to support the foregoing, supporting farmers with the necessary knowledge and advice.

The strategic framework of the applicable agriculture

In addition to the direct products, agriculture provides many particularly important services to the society, via, amongst others, employment, maintenance of landscape diversity and biodiversity. The conditionality of the applicable agriculture (.Figure 6.7) can be formulated, in consideration of the strategic directions set out by the National Rural Strategy and the Kvassay Jenő Plan - National Water Strategy and the National Framework Strategy on Sustainable Development, as follows:

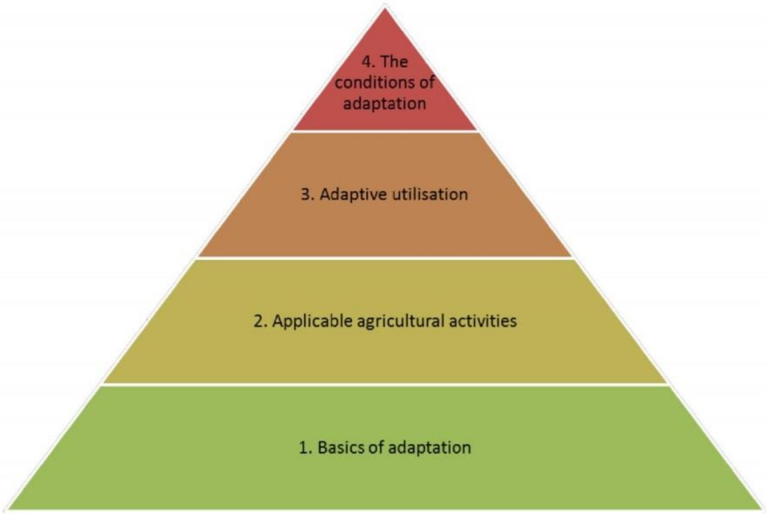


Figure 6.7: System of an agricultural strategy adapting to the climate and weather change
Source: Csete (2013)

Basics of adaptation

The foundation for the adaptation strategy of agriculture and the precondition and essence of every other development is water: the balance should be made between the resources that are becoming scarce and are distributed less and less evenly, and the increasing demand. An appropriate use of landscape, aligning to the changing climatic and ecological conditions, must be established, and maintenance of the water demand at a reasonable level must be ensured. Special attention must be paid to landscape-Ievel water resupplying, establishment of microregional water cycles, semi-natural water resupplying and water storage and the farming systems based on them. Landscape mosaicism must be increased, as it decreases landscape vulnerability. Water supply to crop production, livestock farming, processing and farmers, which align with the correctly chosen form of land use, must be ensured, first of all by facilitating, preserving the infiltration of natural precipitation into the soil, the reduction of evaporation, reasonable and efficient use, satisfying the water demand with various other solutions like irrigation, storage and consideration of surface, soil and stratum waters.

In 2018, a study entitled *"Climate Change Adaptation Research in Hungarian Agriculture"* was conducted within the framework of the „Further development of NAGiS" project. The general objective of the research was to explore which agro-climatic factors most influence the technical efficiency of Hungarian crop producers, to review the possibilities of domestic risk management, and to examine the issue of adaptation.

The research consisted of the following chapters: Climate change and agricultural production; Climate impact assessment of Hungarian agriculture; Presentation and evaluation of climate change risk management techniques in Hungarian agriculture; Factors determining producers' adaptation decisions. For more detailed information on the research, please visit the official NAGiS website.

Applicable agricultural activities

The most important element of the adaptation strategy of agricultural activities is the enforcement of sustainability, applying sustainable production systems and a sustainable way of farming. The second level has effects & responses related to sowings, plantations, livestock and the applied techniques and technologies (modern, water-efficient soil cultivation, transformation of production and sowing structure, application of indigenous, semi-indigenous and regional breeds that are less sensitive to extremities). It is important that the adaptation process does not only facilitate the attainment of sustainable development in environmental terms, but it should improve the capacity to retain the rural population as well.

The point of the adaptive utilisation strategy is to utilise the entire biomass produced, as it also includesthe qualitative and quantitative security of the products and the foodproduced, feeding and energy supply. As laid down in the National Rural Strategy, the goal is to implement a form of agricultural production that is based on environmentally sustainable small and medium sized farms and their cooperation and produces quality produce with hig h added value. The systems of local production, processing and local consumption play a prominent role in this.

The strategy for the conditions for adaptation underpins the implementation with the institutional background, expert advice to the supervisors, preparation of the residents, local preparation for the increasingly common agricultural fire hazards, disaster protection, insurance, procurement of protective equipment and equipment, and transformation of the tender and financial system.

ii. Housing and inhabitation

The most significant physical threat to the built environment and settlement infrastructure comes from the flood-like rainfalls accompanying storms and the increase in wind speed. The challenge facing people living and working in buildings comes from the increasing frequency and intensity of heatwaves. The characteristics of the building stock and settlement structure can significantly influence the effects of climate change. Setting up the right regulatory environment, conscious urban planning can reduce the negative effects of climate change.

Building stock

As an effect of the climate change, the frequency and intensity of heatwaves is expected to increase in the future, meaning that they will appear more frequently, last longer and entail higher average daily temperatures. This phenomenon does not pose a direct threat to the condition of the building stock, but might mean a great risk in terms of public health. In terms of protection against the heat, the appropriate use of the options of active (air conditioning, ventilation systems) and passive (shading, orientation, thermaI insulation) adaptation, and the consideration of thermaI protection during the development of building & construction policies and the designing and construction of buildings plays a great role in adaptation to the future heatwawes. This need is declared in the National Building Energy Strategy as well: *"The renovation of buildings should pay special attention to ensuring the weather-resistance of buildings, and, especially, the protection against summer warming, possibly with architectural and gardening means, avoiding the consumption of electricity."*[27] The air conditioners release the heat extracted from the buildings into the environment which further enhances the thermal insulation effect of densely built-up areas. Individual cooling devices mounted onto the facade increase the heat stress on the adjacent apartments as well; therefore they lead to, as some sort of a chain reaction, the mounting of further devices, the further increasing of the heat stress could be experienced and through the significant increase of energy consumption, an increasing GHG emission as well. It is therefore recommended to use air conditioners carefully, to the lowest possible extent and it is practical to place the device on top of the roof".

The increasing wind speed and the expected increase in the frequency of wind storms means a direct physical source of danger to the building stock, which primarily affects the external boundary structures of buildings, meaning the structures on the facade and the roof.[28]

In addition to the dimensioning of support structures, problems might be expected to occur with the mounted claddings, doors and windows and shades. With regard to the roof, it is necessary to prepare primarily for damage to the roofing elements and waterproofing sheets, as well as to the elements protruding from the roof plane (lightning protection devices, chimneys, antennas).Strong wind blows in the vicinity of buildings can damage street fixtures (warning lights, electric pylons, phone boxes) and the vegetation, thus causing serious damage to the buildings as well.[29]

Due to the increasing frequency of extreme weather phenomena, a more frequent occurrence of sudden rainfalls with high yield in precipitation must be expected. Their harmful effect is subject to the topology of the region, the vegetation coverage of the vicinity, the condition and throughput capacity of water drainage systems and the structure and location of

[27] Government Decision No. 1073/2015. (II. 25.) Korm. on the National Building Energy Strategy

[28] Urban Climate Guide. Magyar Urbanisztikai Tudásközpont Nonprofit Kft. (2012)

[29] Ministry of Home Affairs – VÁTI Nonprofit Kft. (2011): Climate-friendly cities – Manual on the tasks and opportunities of European cities, in relation to climate change, Ministry of Home Affairs – VÁTI, Budapest

settlements. We can expect the emergence of flash floods in hilly regions and inland waters in lowlands. Sudden rainfalls might cause surface movements in certain areas; it is probable that the number of building damages will increase due to the thickening clay soil. These phenomena can cause serious damage to the building stock, the most important tasks in the avoidance of which are appropriate rainwater management and the revising, tightening of and systematic compliance with building codes and prevention.

Historic buildings, historic sites - similarly to the whole of the building stock - are endangered by river floods, floods due to extreme rainfalls and the increasing frequency of extreme wind speeds, but one must mention extreme daily and yearly temperature fluctuations, and the negative effects of rapid changes in freezing and melting as well. The changing temperature can cause cracks and ruptures. Pests mean a treat to the wooden and other organic building materials of historic buildings, and their potential propagation besides that the appearance of new, invasive species that have not been present in our region so far are expected. Historic buildings are often more vulnerable to the effects of climate change, moreover, architectural solutions applied on other buildings can be applied on historic buildings to a limited extent.

It must be mentioned that the expected climatic effects might intensify certain geological sources of danger (e.g. collapse of embankment walls, landslides, mudflows) that pose a threat to the built environment as well.

Urban development, urban planning

The settlement structure has a great influence on the climatic conditions of settlements. Green surfaces can help reduce the extent of the effects of climate change and the adaptation to them: through absorbing a part of light, green surfaces restrain the (non- greenhouse) warming of the air layer near the soil surface, evaporation during evapotranspiration cools down the microclimate, and reduces the greenhouse effect through capturing carbon-dioxide. Building density, the ratio of paved surfaces, the location, proportion and quality of plant vegetation and the morphological characteristics and physical layout of the settlement, the proportion of shaded areas and the natural ventilation of streets ali play an important role in the microclimatic conditions of settlements, therefore they have a decisive role in the adaptation to the effects of climate change. The settlement structure itself is not a bearer of the effects of climate change, but the right transformation of the structures of settlements can reduce the extent of negative effects to the residents, the building stock and the infrastructure. The tools of urban development and planning can be used to make efficient adaptive measures to reduce the effects of climate change.

Reduction of heatwaves in the cities and the protection of air cleanness make it especially important to ensure such ventilation routes and wind channels in cities allow the fresh air to get into the downtown from the outer belt areas, thus cleaning and cooling the urban air. In terms of ventilation in large cities, special attention must be paid to the building density of the settlements in the agglomeration and the preservation of undeveloped areas around the cities (forests, agricultural areas).

In addition to ventilation, shading also plays a very important role in the protection against the heat, as the proper shading methods - such as defining the location and height of buildings, planting avenues and plant vegetation, other shading solutions - can significantly reduce the effects of heatwaves.

Increasing the proportion of green surfaces and reducing paved and cladded surfaces can also be a great contribution to the mitigation of climate change effects. In addition to mitigating the heat island effect, green areas play a significant role in the water balance of the settlements as well. The city and the system of its green surfaces, and other living communities of urban life, form a single ecological system. In addition to increasing the proportion of urban green areas, improving their quality has also got aspecial importance, not only for human use but for the ecology as well. In parallel, the cities must start to reduce paved areas and must consider the type, light reflection characteristics - such as colour - of new pavements in their selection process, so that this makes the least contribution to the urban heat island effect. The application of permeable pavements offers the opportunity of keeping precipitation "in place". The development of built environment must pay increased attention to the preservation, extension and revitalisation of semi-natural aquatic and nonaquatic habitats, as they play a significant role in urban temperature control. However the planting of non-indigenous, invasive species should be avoided during the creation of urban green areas.

Adaptation requires the development of a sustainable urban structure that is ideal in terms of climatic aspects should be striven for. Planning of area use and regulation can affect the arrangement of the elements of the built environment, therefore the distances of urban transport, the energy required for heating and cooling buildings and the vulnerability of the built environment.[30]

In 2018, a study entitled *"Municipal suitable methodology for the assessment of the climate change vulnerability of the Hungarian building stock"* was prepared by Lechner Knowledge Center within the framework of the „Further development of NAGiS" project. The primary objective of the study was to develop a methodology for estimating the relative climate change vulnerability of the building stock at the municipal level as a module of the NAGiS.

In addition, the aim is to apply the developed methodology, to implement a vulnerability study for cities with a population of more than 10,000 and for district cities. The results of the studies will be integrated into the NAGiS system. More detailed information about the study and the main results of the research can be found on the official website of NAGiS.

The large cities and homestead areas are the most vulnerable to heatwaves. As a result of the heat islands developing due to the typically high building density and weak ventilation in large cities, the average temperature is higher and the negative effects of this phenomenon occur more intensely. Although farmstead areas do not have the heat island effect, the weaker infrastructure of healthcare and social services and the lower income of the local population make the residents of such areas more vulnerable to the effects of heatwaves.

iii. Transportation

The expected climate change has a direct negative effect on the vehicles, passengers, traffic and the transport infrastructure. Heatwaves mean an outstanding load to the participants of public transportation, as the temperature inside public transport vehicles can be many degrees

[30] Cities and Climate Change; OECD Publishing, 2010. (http://www.oecd.org/gov/citiesandclimatechange.htm)

higher than outside. Due to the copious heat forming in tunnels and the balancing of surface and underground temperature, the heat causes problems for vehicles running under the ground. In order to eliminate this issue, ventilation and air conditioning must be intensified inside the vehicles. In the case of private transport, high temperature can cause issues of transport safety (such as attention disorder); therefore, special attention must be paid to the proper informing of transport participants.

An increasing frequency of asphalt damage can be expected in the summer months. An extended period of heat can entail a drastic acceleration of pavement rutting. This, on the one hand, adversely affects transport and makes the closing or transport limitation of certain sections necessary in extreme cases, and, on the other hand, the warm road pavement adds to the heating of the already warm air of cities. Hot days can bring about the deformation of rails as well. Planning roads and fixed track transport systems must consider the expected increase in temperature and the increasing frequency of heatwaves. In addition, it is practical to make the pavement of roads and footways more resistant to heat and to use a more resistant pavement (pavement blocks, concrete) that does not warm up that much instead of asphalt wherever possible.

In wintertime, the occurrence of slippery roads and poor visibility conditions (fog) can increase, which can entail the deterioration of traffic conditions. Temperature levels near the freezing point and precipitation of changing consistency also negatively affect the condition of road pavements: humidity infiltrating and freezing in the cracks of asphalt causes potholes, and this phenomenon will become more frequent. If the increasing quantities of winter precipitation fall in the form of snow, we have to prepare for the increasing frequency of snow barriers.

The increasing frequency of floods and storms also poses a threat to transport. Elements of transport infrastructure on the surface can become flooded with water in lower-Iying parts of cities, floodplains, and streams, but river floods also can cause difficulties in underground transportation. One part of the road and footway network can become covered with water, and water pouring from higher areas can wash away roads and other structures. The various flood phenomena occurring at embankments against flood cause further problems during floods (e.g., up-warping, geysers, liquidation of the subsoil), which can damage the infrastructure. Sudden precipitation can be out a road, and railway embankments, riverbanks and can sometimes cause landslides; durable drought can cause damage to the condition of the same structures (sinking). Climate change can negatively affect the biodiversity of plant vegetation and habitats along roads, and motorways. Storms accompanied by fiercer, more vigorous wind blows can damage transport safety equipment, traffic lamps, and signs. An increasing number of lightning events in summer can threaten railway safety equipment.

The so-called "Los Angeles smog" can develop during heatwaves, formed by solid sunshine (UV radiation), weak air movement and pollutants emitted by transport (NO_x, hydrocarbons, CO). Change in the flow systems due to the effects of climate change makes several meteorological situations (inversion situations causing weak vertical and horizontal mixing) likely in the wintertime, and this can be good for the accumulation of aerosol particles[31] (PM10 and PM2.5) in the layer near to the soil. A temperature near the freezing point will further

[31] An important element of air pollution is aerosol (fine particle material distributed in the air, with a particle size from 10 µm to 50nm), the various types of which are classified according to particle size. The most harmful is PM2.5, because after breathing in, it does not leave the lungs, or does not leave the lungs easily, it forms sediments and causes inflammation, increasing the risk of various respiratory diseases.

increase the emission of aerosol particles of heating, resulting in further air quality degradation. The prevention of the development of both types of negative air quality situations requires the reduction of air pollution, emissions due to transport, and residential heating (e.g., PM10, nitrogen oxides, etc.). A similar tool for this is bringing public transport into the foreground, reducing the demand for motorized private transport, spreading alternative drivers, and relegation fuels into the background in residential heating. In order to change the future trends of air quality positively in terms of public health and ecology, serious residential awareness-raising and technological changes will be necessary.

iv. Waste management

Waste management itself is less affected by the effects of climate change; the greatest adaptation challenge is the safe operation of the existing infrastructure, especially landfills. Changes in the precipitation patterns due to the climate change affect the operation of landfills and and wastewater treatment facilities as well. As regards waste management, health and epidemic risks can increase significantly. In addition, the various tailing management facilities, sludge reservoirs and slag heaps are mean special problem, because the large amount of and often hazardous waste could cause serious issues, even disasters if the storage facilities get damaged. As regards hazardous operations, it can be concluded that the climate change mostly affects the infrastructure of existing facilities.

Landfills were insulated according to the local environmental conditions. Howvere the climate change can intensify precipitation-caused erosion, changes in the groundwater-Ievel can cause changes in soil mechanics and movements, resulting in damage to landfill insulation and stability. Changes in wind speed and direction, as well as the expected increase in maximum wind speed, may increase the load caused by flying dust in the vicinity of landfills. In any case, the solution would be the assessment of risks, implementation of the necessary individual interventions, improvement of physical protection and the development of monitoring systems.

v. Energy infrastructure

The assessment of the climate vulnerability of the energy sector cannot ignore the fact that energy supply is a primary driver of the economy and the society; therefore, minor effects can have a spill-over effect and affect the functioning of the economy on the whole.

For the power plants, the primary challenge lies in the energy demand changes. In wintertime, one can expect a reduction in heating energy demand (primarily natural gas consumption). In the summertime, one can expect an increase in electricity consumption for air conditioning; even the demand for district air conditioning can appear in Hungary. The cooling water supply for heat and electricity generation in power plants will also change.

According to the expectations, residential natural gas consumption will reduce in the following years, according to the research in 2019 on vulnerability assessment of gas supply, electricity, and district heating[32]. The analyses performed uniformly predict a declining trend in the heating degree days (days where (HDD) over the next 30 years across the country due to the warming climate. The heating degree day (HDD) is the specified value of temperatures below

[32] Further development of NAGiS No. KEHOP-1.1.0-15-2016-00007: Priority project Climate assessment of electricity, natural gas, and district heating (critical infrastructures): Climate assessment of gas supply (more details on https://nater.mbfsz.gov.hu/hu/node/176)

the heating threshold (16 ° C) in proportion to the amount of cold during the heating period. The decreasing number of heating degree days (HDD) predicts that less natural gas will need to be stored from year to year, contributing to a more balanced security of supply. Furthermore, it may also lead to a reduction in GHG emissions from fossil fuel combustion in the residential sector.

The temperature of the available cooling water (or cooling air) has a significant technological effect in the case of power plants with gas turbines; the increase of external air temperature reduces the output. The increasing temperature and discharge of rivers - primarily the Danube for Hungary - can also cause problems regarding the availability of cooling water at the appropriate temperature and quantity. It must be mentioned that climatic factors can also affect the road and rail transportation of solid energy carriers (primarily lignite, fuelwood, hay), and they might mean a risk to supply security. Based on climatic models, another study on climate adaptation[33] expects an accelerating increase in electricity consumption, most significantly affected by climatic factors and economic trends. Socio-economic impacts will typically be twofold, as seen in regional differences. With the proliferation of electric devices, the electrification of means of transport will result in the most significant positive displacement. At the same time, the actual extent of this can only be predicted today by conservative estimates.

In 2019 in "Further development of NAGiS" project a vulnerability assessment study have been made based on climate modeling[34]. The research predicts that the heating period's average daily temperatures may increase by up to 2 ° C by 2050 compared to the base. However, according to climate data, an increase of up to 5 ° C can occur at the lowest temperature. As a result, the length of the heating period will be shorter.

Climate change will affect the availability of renewable energy sources as well. However the degree of the changes (sometimes even the direction of the change) is quite uncertain. The use of solar energy will likely be affected by the increasing global radiation and changes in cloud coverage. Meanwhile, the changing discharge of rivers will fundamentally determine hydro energy use. Furthermore, shifts in the wind regime will determine the output of wind power plants. The availability of energy carriers produced by agriculture is highly uncertain. The yield of the material for these renewable energy carriers (primarily corn, rapeseed, hay, fuelwood, and trimmings) and their acquisition price is likely to be affected by climate change, to an extent unknown today.

Increasing risks can be identified in energy transmission systems and public utility services. The increasing frequency of storms accompanied by strong wind blows can threaten transmission systems, transformers, and the softening of the soil will make support structures unstable. In the coldest months of the year, hoarfrost, watery snow load, and freezing rain pose an increased load to transmitter lines. Transmitter lines are exposed to new risks due to the increasing frequency of forest fires in woodlands and floods in floodplains. The increasing

[33] The assessment of the electricity supply in Hungary from the aspect of climate change (more details on https://nater.mbfsz.gov.hu/hu/node/176)

[34] KEHOP-1.1.0-15-2016-00007 No. project NAGiS development vulnerability assessment of electricity, natural gas, and district heating (critical infrastructures): Climatic assessment of district heating (more details on https://nater.mbfsz.gov.hu/hu/node/176)

frequency of hot days and days with heat alert, especially in larger cities, increase the peak load on electricity generation, and this can cause unexpected power cuts on larger areas. In addition to these realistic physical effects, the increasing temperature will also make the capacity of transmission networks drop. Both the energy providers and the consumers must prepare for the expected effects. On the one hand, consumers must expect increased risks of infrastructural malfunctions (Longer or more frequent outages) and, on the other hand, sometimes increased costs (e.g., insurance premiums, investments to increase individual safety).

vi. Tourism

The „Further development of the National Adaptation Geo-Information System" project started in 2017 in the coordination of the Hungarian Mining and Geological Survey's National Adaptation Centre Department. The „C3" module of the project dealt directly with climate vulnerability of the tourism sector in Hungary. The main objective of this work package was to introduce the methodological background developed by the research project for the analysis and assessment of the tourism sector's climate vulnerability and its components such as the sensitivity of the sector, the potential climate change impacts on tourism and the adaptation capacity of the local communities and economies. The main aim was to provide local and national level actors of the sector with useable methodology to assess their respective vulnerability to climate change on a relatively quantitative way. The module analysed these aspects through complex indices in an integrated way. Beyond the analysis of present situation the project tried to model conditions in future periods. Narrative and cartographic outputs of the analysis were results of the steps of the CIVAS methodology, producing thematic maps in microregional resolution at national and in settlement resolution at local levels (the latter were prepared for 3 pilot region: Balaton region, Mátra-Bükk Recreational District and Pécs urban region) for exposure, sensitivity, impact, adaptability and vulnerability data. Analyses concentrated on 3 time-windows: beyond present time situation analysis, both for the 2021-2050 and the 2071-2100 periods. Microregional and settlement level climate exposure/sensitivity/impact/adaptive capacity and climate vulnerability data were identified according to the combination of 2 meteorological models (EC-EARTH, CNRM-CM5) and 2 climate change scenarios chosen out of the 4 new generation Representative Concentration Pathways of the 5th Assessment Report (AR5) of IPCC: RCP4.5 and RCP8.5. The parallel use of more models and scenarios (and their combinations) guarantees the elimination of insecurity deriving from naturally contradicting model results and helps to elaborate more realistic projections through comparisons of parallel results. The analyses introduced by the article work package were just the beginning: their future expansion could further deepen the explanatory power and usefulness of the methodology. Realizing the existing and potential climate change impacts on the sector and the lack of undeveloped / unconscious nature of potential preparatory adaptive or preventive measures it is evident that there is an unambiguous necessity for the deepening and dissemination of related knowledge base in Hungary. To support these, the results this research can serve as initial steps[35]. Additional local analyses and field works were also conducted to identify local adaptation best practices in tourism adaptation. These were classified into 4 main groups: climate change resilient

[35] Sütő Attila, Fejes Lilian (2019): Territorial differencies in existing and potential climate vulnerability of the tourism sector in Hungary. Tér és Társadalom. https://doi.org/10.17649/TET.33.3.3178

product development; water-, energy- and resource efficiency improvement; conducting awareness raising activities; and architectural solutions. For more details please see the scientific article of Sütő A-Fejel L. (2019) and the NAGiS website.[36]

vii. Public security

General context of the climate change and security

The extreme weather conditions subject human civilization and societies to more direct, widespread, frequent stress. The extreme weather conditions, including droughts, heatwaves, storms, fires, floods, and landslides caused by these, can have such consequences that the municipalities countries affected by these cannot handle alone. The situation is made even more complex because that an extreme natural disaster can be followed by other ones or may be accompanied by any other natural emergency. They can, on the whole, intensify the adverse effects and consequences of each other, usually progressively and exponentially.. The consequences of climate change, especially the increased threats to the natural and human-made environment, have made climate change one of the central elements of defence policy.

An often-cited document in the European context of climate change is the Solana Report titled „*Climate Change and international safety"*[37] issued in 2008. It names seven security threats related to climate change, all of them jeopardizing the security of both the global community and the security of states. According to the Solana Report, the climatic factor multiplies the relationship between climate and defence, meaning that it can exponentiate the existing, known defence risks. It accelerates negative trends in security, escalates the current tension, conflicts in international relationships, and appears as a single factor of threat only. Therefore, climate change effects "only" indirectly onto global and regional defence policies, which usually aggravates existing problems. In fact that the threats of climate change do not afflict the regions, states equally. This is basically attributable to two reasons: the geographical location of countries makes them be differently exposed to the effects of these treats, and their level of political, socio-economic development, which would make them capable of treating the consequences of climate change, is different. Both aspects affect the European political and economic interests and, although indirectly, mean an actual and ever-increasing threat to Western democracies. The position of the World Bank[38] is that the source of the potential conflicts emerging as a result of climate change can be three factors: the shrinkage of natural and terrestrial resources, the increasing sea level, and natural disasters.

The effects of climate change on the security policy of Hungary

Regarding the climate change effects affecting our security policy, the following trends, forms of occurrence, phenomena, and their direct interference should be expected in Hungary.

- *Security of health and food NAGiS supply:* Heatwaves, prolonged dry periods can intensify the emergence of diseases, infections, epidemics, which can threaten to the

[36] Sütő A., Fejes L. (2019): A turizmus ágazat jelenlegi és potenciális éghajlati sérülékenységének területi különbségei Magyarországon. Tér és Társadalom 3/2019. and https://nater.mbfsz.gov.hu/sites/nater.mfgi.hu/files/files/Turizmus_Kutat%c3%a1si_jelentes.pdf

[37] Climate Change and International Security, Paper from the High Representative and the European Commission to the European Council, S113/08, 14 March 2008, 11. p..

[38] 1Halvard Buhaug, Nils Petter Gleditsch and Ole Magnus Theisen, Implications of Climate Change for Armed Conflict, Social Development, The World Bank, 1818 H Street, NW, Washington, DC 20433

security of the whole nation in extreme cases (e.g., stable and exceptionally high temperature). The increasing frequency and length of dry periods and heatwaves pose a risk to food supply and food security. The extreme distribution of precipitation poses a threat to irrigation systems. In lower-Iying areas, crop production, livestock farming, game management, fisheries may be exposed to an increasing threat of river and groundwater floods. Climate change may entail the occurrence of new pests and the increase of the risk of diseases spreading with foodstuffs. The strategic goals, action lines related to food chain security are included in the Food Chain Security Strategy.

- *National security:* Hungary can become a target or transit country of global climate migration from coastal areas flooded due to the melting of polar ice caps. Furthermore, from the Near East, North Africa, or even Mediterranean countries, caused by prolonged heatwaves, dry periods, and severe water and food scarcity. *Infrastructural and public utility security:* The more and more hectic changes in river stands (sometimes extraordinarily high, sometimes minimal) can accelerate changes in riverbeds, which can pose a threat to dams and protective facilities. Infrastructure built on rivers, inland navigation can get damaged, and channels can become stuck. The increasing risk of river floods, groundwater floods means a direct threat to settlements, transport, and critical infrastructure elements. The winter months can see the emergence of snowstorms and blizzards in the Carpathian Basin, paralyzing the transportation of entire regions or even the whole country. Low water levels on rivers and the lack of rain replenishment can cause the decline of the river and near-soil water resources, endangering the water supply. Extreme weather events, primarily storms, risk the electrical network and some aspects of the telecommunication infrastructure, directly affecting internet access and electronic data exchange.
- *Industrial security:* As a consequence of climate change, water scarcity, increased cooling demand, the increasing costs of CO_2 reduction, and the changing consumer demand can affect specific resource-intensive industrial sectors, such as the chemical *industry, food industry, building materials industry, negatively. The flash floods caused by the suddenly pouring, flood-like rains can threaten certain hazardous material storage facilities, waste management facilities, therefore, especially the facilities of hazardous waste disposal. The increasing frequency of extreme weather phenomena can increase the probability of breakdowns related to hazardous materials, increase the number and gravity of unexpected events related to hazardous material emission.*
- *Ecological security:* The shifting of ecological zones, the appearance of Mediterranean, subtropical environments will harm biodiversity. Especially the habitats and species of wetland areas, grasslands, and forests will be under threat.

c. Adaptation measures

The Chapter 6.3. is based on the content of the second National Climate Change Strategy of Hungary (NCCS-2). The strategy identifies short-, medium and long-term action lines for each sector that is affected by climate change. The NCCS-2 was adopted by the Hungarian Parliament in October 2018. According to the strategy, its implementation is based on 4 consecutive, 3-year-long action programmes, the Climate Change Action Plans (CCAPs) whose task is to operationalize the NCCS-2 action lines, transforming them into concrete measures. Among the CCAPs the first one was CCAP-1 for the period 2018-2020. It was adopted by the Government in January 2020, as part of the governmental climate and energy package of

2020. The second CCAP were elaborated during 2020-21 and now it is waiting for governmental adoption (that is expected to happen by 2023). The following sectoral subchapters enlist the relevant NCCS-2 action lines in conection with each sector; additionally the subchapters has been completed with the mention of the relevant measures of CCAP-1 and indicative directions of the CCAP-2 draft.

i. Human health

As a result of the effects of climate change, there are many new risks in our lives, especially health-related ones, that we need to be prepared for. There is a need for human health considerations to be included in numerous policies, including climate policy. The climate adaptation tasks related to human health are included in the National Environmental Protection Programme (NEPP). The Second National Climate Change Strategy sets out the following action lines in the topic of human health.

Short-term action lines

- Obliging the institutions supplying larger (social, educational) groups to compile an "action plan" for heatwave management and to elaborate the related a central system of criteria for that.
- Introducing requirements to efficiently regulate working conditions in indoor and outdoor workplaces in order that the increasing temperature does not pose a health threat.
- In case of ticks, sandflies and other animal carriers (so-called vectors) it is particularly important to control the prevalence, to monitor infections, and the rate of virus - transmission and set up a related surveillance system.
- Development of the system of environmental health protection and disease surveillance, (further) development of a climate health network based on the principle of "minimum structures", with the implementation of the minimum necessary and sufficient modifications on the existing system. It is advisable to extend the Climate Health Network – already operating in Budapest - nationwide. Emergency situations related to climate change and variability and rapid public health responding must be prepared for. Standardised early warning systems need to be developed; conditions of emergency care must be improved, with special regard to disaster events.
- Healthcare and social workers must receive specialised training; climate-related health information must be included in the curricula of educational institutions of different levels within the framework of awareness-raising. It is recommended to increase public consciousness about climate health through involvement of the media and preparing educational materials. Residents should be regularly informed about potential threats via comprehensive campaigns involving NGOs, churches and municipalities.
- "Best practices", research results, data, information, technology and tools related to climate change, health and environment need to be shared with healthcare operators. The healthcare sector must receive information, instruments and advice based on the educational material of the WHO and domestic experience.

Mid-term action lines

- Food security measures need to be extended to adress the indirect effects of climate change. Environmentally, socially and economically sustainable food production, trade and food security must be ensured. To this end, relevant legislation needs to be regularly reviewed, with strict monitoring of compliance, providing the appropriate institutional framework.
- Strengthen the health care system to prepare for threats of climate change, with special regard to extreme weather events. A review of the internal organization and and operation of public health care system is needed to integrate climate adaptation requirements into them. Transformation of healthcare institutions must be implemented for successful adaptation by modernizing the thermaI insulation andcooling of buildings.
- Gradual strengthening of the role of prevention (preventive preparation) in health care, then give it a predominance over the reactive intervention (rescue, patient care, rehabilitation).
- The possibility of introducing additional vaccines and vaccination practice, the option of developing the rapid adaptability of vaccine production with new molecular genetic methods, should be reviewed.
- Enumeration of all diseases that occur in Hungary today and might occur in the future as a result of climate change, exploration of their characteristics and access to the (probably growing) group of stakeholders to precautionary measures.
- Assessing the prevalence of animal species involved in the spread of pathogens; development of methods to slow the spread, to reduce the number of vectors and to fix epidemics.

Long-term action lines

- Comprehensive integration of climate change into policies concerning human and social resources, taking actual changes in the climate also into consideration.

Concrete, operational interventions

The CCAP-1 programme defined 4 specific measures to address the human health effects of climate change. These actions are as follows:

- Surveying the heat and UV protection plans of healthcare and social institutions in order to ensure the temperature regulation and UV radiation protection of critical rooms as well as optimizing other indoor environmental factors (air and water quality) related to climate change;
- Revision and development of extreme weather warning systems;
- Elaboration of further research directions for the monitoring system of infectious diseases;
- Preparation of the monitoring system of allergenic plants.

The draft version of CCAP-2 (under adoption) includes further additional measures for the next years, based on the measures of CCAP-1.

ii. Water management

Climate change poses significant challanges for all fields of water management. The magnitude of this challenge stems from the complexity and uncertainty of climate change and its effects. Water management does not only face the challenge meant by the effects of climate change, but also the non-climatic effects, and their interactions. Climate change is thus an increasing risk for water management. The extent of the risk is uncertain, depending on the probability and severity of the occurrence. Adaptation to the impacts that have very severe consequences may be reasonable, bearing in mind the principle of precaution, even if the probability of occurrence is low. Adaptation reduces risks, preventing or minimazing vulnerability. The start of adaptation efforts should not be delayed, because the effects are there even in the short run and might be significant if the negative climate scenarios are met. Adaptation also takes a lot of time, particularly if the measures must be discussed with a broad range of stakeholders.

It would be practical to lay down the detailed water management tasks of climate adaptation in the integrated water management and water protection concepts, national and regional programmes, plans (e.g. in the plans on river basin and flood risk management and in the implementation framework of the *Kvassay Jenő Plan* - National Water Strategy) taking the following action lines into consideration:

<u>*Short-term action lines*</u>

- The Programme on Further Developing the Vásárhelyi Plan must be continued. The water management and supporting conditions for the establishment of floodplain landscape management systems tailored to regular, shallow water flooding and permanent water storage must be ensured in every reservoir area. Farmers must be helped with trainings, expert advice, and awareness-raising regarding the sustainable, communal use of land.
- Within the framework of water damage prevention through risk prevention, it is necessary to plan and regulate flood protection and land use in an integrated way applying risk mapping. It is important to conduct planning while differentiated safety is ensured, to continuously re-evaluate the Significant Flood Level values, in accordance with the monitoring of environmental changes.
- The timely implementation of the tasks arising from the Water Framework Directive (WFD) is necessary to bring our waters to good quality and quantity. The regular revision and adjustment of the river basin management plans to the changing climatic conditions, as required by the WFD, is also a related task in every 6 years.
- Instead of a water regulation practice based on rapid water drainage, water retention should be encouraged. At the same time, it is recommended to start the development of a sustainable land use through the integration of regional, municipal, nature protection, agricultural and water management aspects, and to create pilot areas as soon as possible. Widespread social dialogue should be started on sustainable land use, the principles of water management and its practical implementation. The task is to improve the relationship between the society and water.
- In the management of water flows affecting groundwater levels it is important to prefer solutions that avoid the groundwater level-Iowering effects of the active and passive lowering of the bed of channels and rivers, including the elimination of channels that,

being causeless today, drain water from a certain area. A related task is to eliminate the infrastructure that helps rapid drainage.

- It is recommended to study the forms of land use in terms of the changing ecological and climatic conditions. It is suggested to eliminate the cultivation of areas that are regularly flooded and cannot be economically utilised for agriculture due to frequent inland water inundation, and to utilise them for purposes that fit their conditions (creation of wetland habitats, creation of semi-natural water-supplying systems, rehabilitation of microregional water cycles, increasing the role of forests, wetland habitats in the retention of waters).
- It is recommended to create pilot areas for floodplain landscape management on suitable territories, with special regard to areas exposed to droughts, inland water inundation and river floods.
- An important tool for adaptation is the dissemination of water-saving irrigation technologies, which is the task of agriculture. Due to the expected increase in irrigation needs, it is necessary to maintain the existing water supply system and developed it, where justified, if negative environmental effects of irrigation can be avoided and its implementation is economically feasible. The integration of nature conservation aspects into the development of the water supply system is of particular importance.
- The water quality risk posed by the effects of sudden rainfalls must be reduced. The systems of small-scale, semi-natural wastewater treatment solutions needs to be spread rapidly in areas where the construction and operation of high-capacity systems and sewerage is not reasonable.
- Urban rainwater and storm flood drainage management is essential to reduce the effects of flash floods and extreme rainfalls in municipal areas. Within this context, the development of municipal stormwater management systems, safe rainwater collection, retention and utilisation of precipitation should be encouraged.
- The efficient use of water resources could be encouraged either with the means of demand management or with economic means and the establishment of right water pricing policy. It is important to involve local stakeholders in the maintenance of water flows and channels. In addition to exploring and disseminating the possibilities of efficient water uses, it is important to research and develop less water-intensive technologies (innovation). There is a need to eliminate water waste and encourage the reuse of domestic gray water. In addition to declining water resources and increasing water needs, the balance of water resources and water demand must be ensured, and the related solutions and legal and economic framework need to be explored and developed[39]. The application of an organizational, interest and pricing system that encourages water retention is recommended in both regional and municipal water management.[40]
- There is a need for more detailed analyses of the expected effects in the water regime and hydrological conditions, which also reveal the interrelationships of these effects, especially with regard to different climate change scenarios.

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[39] Note: according to the order of priority recommended by the European Commission, alternative ways of water supply and the involvement of newer water resources may be planned only after the tools for demand management are exhausted

[40] Kvassay Jenő Plan, 2015

- An important preparatory task is to explore the increasing frequency of extreme floods and the causes of rising flood levels through risk mapping. In mountainous and hilly regions, the opportunities to create floodwater and rainwater reservoirs and the expected effect of these reservoirs on floods must be studied. The planning of the rehabilitation of hilly watercourses for environmental and nature conservation purposes is also a priority.
- In terms of municipal water management (drinking water and wastewater treatment technologies), the task is to explore their climate sensitivity, as well as the increased demands on wastewater treatment, to designate reserve water bases and to map flood risks at settlement level.
- The adaptation measures, their possible alternatives, feasibility and costs must be explored for each climate scenario, identifying the disadvantages for a given region if adaptation does not take place or is delayed; and the consequences and losses of non-acting. It is recommended to explore measures that are justified by non-climatic considerations as well (e.g. water demand regulation, reduction of environmental load) and which contribute considerably to climate adaptation.
- An indicator- and monitoring system must be developed, to follow-up the effects of climate change on flow regimes, water quality and water management. This system could help decision-makers to make a more informed and realistic assessment of the challenges posed by climate change.
- The development of a drought management plan is recommended, in the framework of which it is possible to develop early (drought) warning systems based on an indicator and monitoring system.
- In connection with the inventory of adaptation procedures and the presentation of examples of good practice, it is particularly important to enlist the procedures serving the increase of available water resources and the improvement of water quality.There is a need to explore adaptation processes that can simultaneously respond to adaptation to climate and non-climate impacts, which are also justified by non-climatic considerations, and which are useful even if climate change does not occur or occurs differently as predicted. Knowledge of such procedures can provide decision-makers with greater support and security, helping them to design and implement proper adaptation responses to climate change. Bilateral and multilateral international cooperations are also recommended in order to share the water resources whose availability changing together with the changing climate.

Mid-term action lines

- Comprehensive introduction of a water-retaining water regulation practice in water management.
- Restoration of micro regional water circulation systems.
- Extension of the recultivation programme of floodplain landscape management model areas and deep floodplains.
- Supporting adaptation of land use forms to the changing ecological and climatic conditions.

- Forecasting expected changes in water demand. Transforming the regulatory conditions for demand management to address the issue of "increasing demand-shrinking resources", with a regard to long-term sustainability as well.
- To bring our waters to good quality and quantity by 2027 and to create the conditions for maintaining good status in accordance with the requirements of the EU Water Framework Directive.
- Creation of a sustainable land use that adapts to the climate, by fully integrating spatial planning, nature protection, agriculture and water management planning aspects.

Long-term action lines

- Comprehensive integration of a water management that is aligned to climate change, as a preferential aspect, into the Hungarian water regulation, taking actual changes in the climate into cosideration, and into international forms of cooperation and foreign policy (bi- and multilateral international cooperations to share water resources the availability is expected to change due to climate change).

*Concrete, operational interventions***:**

Water management is one of the most important areas of CCAP-1 and CCAP-2. The measures concern, among other things, the issue of irrigation water, municipal water management, modelling of surface and groundwater, mapping of inland water damage, and underground water-retention and water storage opportunities. The draft version of CCAP-2 (under adoption) includes a large number of additional measures for the next years in the same topics.

The LIFE MICACC[41] project was implemented between 2017 and 2021 to study and disseminate natural water retention solutions. The results of the project will be continued by the LIFE LOGOS 4 WATERS project, which started in 2021.

The **DEEPWATER-CE project, implemented by a consortium led by the former Mining and Geological Survey of Hungary (MGSH)** stared with the aim of developing an integrated **implementation framework for Managed Aquifer Recharge** (MAR) solutions to facilitate the protection of Central European water resources endangered by climate change and user conflicts. Within the project, a **Transnational Decision Support Toolbox** was developed for designating potential MAR locations in Central Europe. The Toolbox, compiled in a Handbook, provides detailed description of principles, benefits, requirements and objectives of MAR systems. Driven by this methodology, partners applied **mapping processes** including general (national) and specific spatial screening, which resulted in designating one pilot site in four partner countries (Poland, Hungary, Slovakia, Croatia) having a very good perspective for a future potential MAR investment. A **feasibility assessment** of these pilot MAR schemes was also carried out.

iii. Agriculture

The examination of the responses to the expected effects of climate change in Hungarian agriculture is based on the concept that agriculture is facing a forced paradigm shift. In addition to the mitigation of the harmful effects of globalisation, the substitution of agricultural

[41] https://vizmegtartomegoldasok.bm.hu/en

methods destructing our bases of existence with sustainable farming and stopping the depopulation and deterioration of rural areas, adaptation to climate change is another urging task. Sustainable farming systems that align to the conditions of the farming location spare natural resources, do not overload the environment, are water- and cost-efficient, knowledge intensive, economically sustainable in the long-run as well, reduce carbon-dioxide and methane getting into the air from the soil, hamper the erosion, are energy-efficient, thus their elaboration and spreading is one of the most significant elements of the adaptation strategy. The creation and further development of such a system assumes a profound restructuring of our current agriculture and the economic and social processes determining life in the countryside. The framework for this, including the tasks related to climatic adaptation, is determined by the National Rural Strategy. Based on NCCS-2, the following action lines can be enlisted:

Short-term action lines

- It is necessary to develop such a use of land and landscape that contributes to the mitigation of the effects of extreme weather events, and to the adaptation to them. Production must be adjusted to the changing climatic and ecological conditions.
- In connection with the adaptation of agriculture, it is necessary to carefully survey, plan and regulate national drinking and irrigation water needs in connection with the increasing difficulties in satisfying water needs.
- Facilitating the infiltration of natural precipitation into the soil and its storage and utilization are also priorities. It is therefore recommended to apply the proper soil-Ioosening technique on the appropriate agricultural areas, in alignment to this need. The solution for deep-Iying areas suffering from inland water inundation, and heavy soils could be a cultivation, applying a rotating land use and the retention of water.
- In areas suffering from water scarcity and droughts, the establishment of a semi-natural water supply (storage of the water surplus from floods, floodplain landscape management schemes) and the spreading of natural alternatives capable of substituting irrigation (floodplain agriculture, oxbow lake fishery, ridging) are of key importance. Less water-intensive crops that are less sensitive to extreme weather events may play an increasing role.The most affected areas (Danube- Tisza Interfluve, the southern part of the Hungarian Great Plains) require water retention, continuous plant coverage and the restoration of wetland habitats. Areas that often face water scarcity and drought require the replacement of water-intensive crop cultivation with other ways of utilisation.
- Due to the increase in the price of food and irrigation water, irrigation is only economical for high value-added crops, so the condition of existing irrigation systems should be reviewed and the installation of new ones should be considered where they are economically justified. In such areas the installation of environmentally sustainable and water-efficient irrigation systems may be initiated, taking the ecological water need of the landscape and of the industrial and residental water needs also into consideration.
- Preventing salinisation can be achieved through adaptive soil cultivation, water management and the growing of plant cultures fitting into the landscape.

- Soil acidification can be prevented by establishing appropriate crops and appropriate farming in areas prone to acidification.Further soil degradation can be avoided by growing suitable crops, adaptive tillage and fertilizing in areas that are inherently acidic.
- The strategic steps of the technical-technological transformation of adaptation are linked to soil cultivation, mechanisation, by reducing the number, merging and abandoning operations, using material- and energy-efficient machines and precision agrotechniques. Enhancing the flexibility and versatility of the production and activity structure and the involvement of new activities can help bear the damage caused by extreme weather, but could also facilitate alignment to market demand. Diversification is a precondition to more balanced and more profitable farming.
- It is recommended to set up an IT system to avoid drought risk, within the National Adaptation Geo-information System (NAGiS). It is important to develop the system of meteorological information, forecasts, alarms and its way to the farmers.
- Within the framework of the NAGiS it is necessary to carry out a forecast of soil quality change at local Ievel, based on natural geographic data and to determine the necessary soil protection measures in order to facilitate the adaptation to the effects of climate change.
- Further development of the Complex Agricultural Risk Assessment System (CARAS) is needed in order to assess agricultural damage caused by climate change; through creating an opportunity to integrate data from CARAS and NAGiS.
- Preparation of the existing expert consultant network for the handling of challenges related to climate change; training of expert consultants in order that they can help preparation, protection and elimination of damages.

Mid-term action lines

- Reserves for water replenishment need to be developed. Its instruments could be: building of multipurpose reservoirs; extension of pond farms; utilisation of tidal reservoirs for water supply, landscape management; competent utilisation of areas affected by regular floods and protected with summer dams, through substitution of plowing, extension of grass cultivation and forestry; revival of oxbow lake fishery and creation of water habitats.
- Reinforcing the rapid adaptation to unexpected changes through the coexistence of different farming methods and organisational forms (modern technique and technology vs. traditional knowledge and landscape-conscious farming) and the parallel presence of the necessary infrastructure and institutional framework.
- Improvement of biological bases and supporting research are of key importance in order to introduce plant varieties that are drought-resistant and can stand extreme effects better. Special attention must be paid to any possible reintroduction of landscape plant varieties that are either indigenous or were introduced a long time ago into production, the basis of which is provided by our gene banks. In case of plantations, the right selection of production site can decrease exposure.
- The strategic role of the products and crops produced, together with biomass, also changes during adaptation. The aim is, on the one hand, to minimise the quantity of waste and, on the other hand, to reintroduce the largest possible portion to the circulation of organic materials, the soil, and that the produced organic material gets

fully utilised, if possible. Production and processing of crops should achieve the least possible amount of carbon-dioxide, methane and other harmful substance getting into the atmosphere, and renewable energy production, especially biogas production and various locally used energy production should increase within the various forms of utilisation.

- Undercapitalised farming and a production structure that often ignores landscape conditions (maintenance of which is partly supported by the EU aid schemes as well) often impose to high burdens onto the farmers, insurers and the state if agricultural damage occurs. As the likelihood of weather extremes increase, the likelihood of damage also will increase. An essential element of a rulal development oriented adaptation strategy is therefore insurance, wich must involve multiple players, and be preventive and encouraging to self-care. Laying new foundations for the agricultural insurance system and harmonising it with the economic impulses of the aid scheme is important. It must be highlighted that the entry into force of Act CLXVIII of 2011 on Handling Weather-Related and Other Natural Risks Affecting Agricultural Production[42] has launched this process.
- Inserting precision farming into the system can help adaptation, which uses GPS to reduce costs and mitigates environmental load.
- Agricultural and rural policies must give high priority to the development and extension of ecological farming, as the most sustainable farming system.
- Studying of adaptation opportunities Iying within the agroecological potential must be intensified.
- Animal breeding must lay emphasis, besides performance and quality, on species adapting to the effects of climate change.
- Reducing the final use of arable land for other purposes in order to preserve the absorption capacity of the soils and the microclimatic effects.

Long-term action lines

- Extension of the integrated systems of local production - local processing - local consumption.
- Comprehensive integration of climate change, as a precondition, into agricultural and rural development policies, taking actual changes in the climate also into consideration.
- The long-term goal is to establish sustainable agriculture in the entire country. Sustainable agricultural production that also helps the adaptation to the changing climate and weather conditions is such a conscious, carefully planned activity in which the farmer, pursuing the undisturbed circulation, repetition and "reproduction" of biological, natural processes, applies such interventions, equipment, materials (pesticides, manures, animai medication, irrigation water), techniques, technologies and protection that satisfies the increasing food demand of people while maintaining a positive expense-yield ratio.

Concrete, operational interventions

[42] Act CLXVIII of 2011 on Handling Weather-Related and Other Natural Risks Affecting Agricultural Production

The CCAP-1 defined 4 specific measures to address the effects of climate change in agriculture. These actions as as follows:

- Ensuring the preparation of irrigation developments in 2020;
- Extension of agricultural irrigation solutions considering environmental and climate protection aspects and elaboration of the conditions for modernisation;
- Promoting land and soil use that supports adaptation to the harmful effects of climate change;
- Integration of the aspects of climate protection into agricultural advisory service.

The draft version of CCAP-2 (under adoption) includes 3 additional measures for the next few years in agriculture.

iv. Forestry

Domestic forestry tasks related to climate change adaptation are included in the National Forest Strategy (2016-2030). These include the following action lines:

Short-term action lines

- Increase the area of forests in accordance with the provisions of the National Afforestation Program. Afforestations will be done by considering the gradual and long-term changes of site conditions as a result of climate change and by using tree species and domestic reproductive material that can be deemed fit for the changing conditions.
- The reduction of fire risk requires measures to prevent forest fires, and the elimination of the tree species of highest fire risk, such as conifers, from the areas of the highest fire risk.
- It is planned to further study and monitor the future development of the effects of climate change on forests, forest habitats and forest microclimate, applying a remote sensing-based system using data from the European Earth observation projects. Results of this monitoring may contribute to the development of possible scenarios to adapt to the changing climatic zones and the expected migration of forestformingforest dwelling species including tree species.

Mid-term action lines

- Further development of models for forest managers, taking into account the requirements for sustainable forest management of the very long production cycles of forests from 20 to 150 years, depending on site and tree species.
- Further development of the decision support system to assist with forest planning and tree species selection, considering the effects of climate change.
- Monitoring, adaptive management and, if necessary, replacement of the stands of the forest areas of vulnerable regions, based on Earth observation data and remote sensing. Restoration of forest areas damaged by natural disasters should be implemented after these disasters as soon as possible.
- Improvement of the water management of forestforested areas, among others by increasing the water retention capacity of forests.
- Facilitating the adaptation of trees with a long life cycle to climate change by applying methods of assisted migration.

- In the context of sustainable forest management, forest management technologies have to be disseminated that increase the resistance, resilience and stability of forests against the effects of climate change. These technologies include the reduction of the risk of forest fires, pests and storms e.g. by improving stand structure and increasing species mixture. The aspects of climate change must be gradually integrated into the system of forest planning and forest management.
- The statistical national forest inventory and other domestic forest monitoring systemsystems must be reinforced, with special regard to the increased utilisation of remote sensing.
- Keeping the stock of game at a sustainable level so that the application of natural regeneration of semi-natural forests becomes and/or remains possible.

Long-term action lines

- Comprehensive integration of actions arising from the need to adapt to climate change, as a preferential aspect, into forestry policies, taking into account the long-term aspects.
- ApplicationOptimizing, in suitable areas, the application of close-to-nature forestry methods that consider natural forest dynamics, the pace of climate change and its expected impacts to gradually improve continuous forest coverage.
- To achieve the highest possible level of afforestation that may guarantee the survival of stands in the long run, the selection of right species, varieties, provenances and clones, as well as the increase of the mixture of species should be improved.
- Maintaining gallery forests inof the highest possible crown closure in areas within the forest-steppe zone, i.e., the plain regions, where fully closed forest stocks may no longer be possible to maintain.
- Conservation of local genetic resources, relying primarilyonprimarily on Hungarianthe domestic genetic resources, by selecting the trees and their propagation material that are deemed to be able to best adapt to future trends environmental changes.

Concrete, operational interventions

There were 3 measures in CCAP-1 for the forestry sector. These are the followings:

- Integration of the research results concerning climate change impacts on forestry into forest management plans;
- Application of climate-resilient forest reproductive materials;
- Further development of the forest condition monitoring system, called Forestry Measurement and Surveillance System.

The draft version of CCAP-2 (under adoption) is expected to include 3 additional measures for the next few years in the forestry sector, dealing with similar topics as those of the CCAP-1.

v. Urban planning

The built environment and the infrastructure of settlements are most endangered by extreme weather phenomena; storms, copious amounts of precipitation and the increased wind speed. The growing frequency of heatwaves and the so-called heat island phenomena are chiefly public health risks, but the development of the building stock, application of the instruments of climate-conscious settlement development and planning, the creation of larger and targeted green areas in the built environment and a more conscious management of rainwater can significantly reduce the effects of heatwaves and droughts as well. The elaboration of adaptation action lines must pay special attention to the mitigation of these effects. In addition to the specific adaptation opportunities of the building stock, the construction sector and certain urban infrastructures, it is important that the regional plans and the urban development and urban planning activities provide complex and efficient responses to the entirety of urban structures and settlement system s in order to improve adaptability.

According to the NCCS-2, the detailed tasks of climate adaptation related to the use of land and the built environment should be defined, amongst others, in Act XXVI of 2003 on the National Spatial Development Plan, and, in accordance with the hierarchical system of the spatial development plans, in the Acts on the Spatial Development Plan of priority regions (Act CXII of 2000 and Act LXIV of 2005), in the decrees of county governments on the county-Ievel spatial development plans, in municipal and regional development plans, in the urban planning instruments. On top of that, the following action lines should be considered in the implementation of the National Transport Infrastructure Development Strategy[43], and the National Waste Management Plan[44] as well:

Short-term action lines

- The integration of the aspects of climate change inti the requirements and regulations on construction and land use should be given priority.
- The Climate Change Action Plans must determine adaptive measures concerning the built environment, urban development and planning in detail, through the elaboration of interventions to improve the adaptability of waste management and the transport infrastructure.
- The aspects of adaptation and sustainability must be integrated into the urban development and urban planning documents, and into the planning documents of construction sector.
- The assessment of areas sensitive to surface movements and the revision of masterplans, building guidelines are of special importance; similarly to the avoiding of construction on areas affected by surface movements and the elaboration of measures to manage already developed land, and potential prevention of future hazards.
- It is recommended to identify the stock of historic buildings endangered by the effects of climate change.
- It is necessary to register and check the condition of urban green areas, to extend and improve the system of green surfaces, including the opportunities of the transformation of brownfield zones of transports (abandoned transport areas), and transform them and the banks of streams in inner areas.
- The protection and competent maintenance of existing urban wooded areas (urban forestry, municipal, institutional and residential management of green surfaces) are essential to increase adaptability.

[43] Government Decision No. 1486/2014. (VIII. 28.) on the National Transport Infrastructure Development Strategy

[44] Government Decision No. 2055/2013. (XII. 31.) on the 2014-2020 National Waste Management Plan

- Within the context of regulating the built environment, detailed rules should be elaborated on the planning, establishment and elimination of green surfaces in a climate conscious manner. The thermaI protection of the transport infrastructure and the reduction of the heat island effect require the launching of a program to plant trees along roads and in public spaces.
- The use of "alternative" and environmentally friendly forms of private transport, the reduction of motorised transport needs should be propagated together with the development of public transport services.
- Comprehensive settlement-level vulnerability analyses of the building stock, the transport and public service infrastructure are recommended.
- The existing landfills, tailing ponds and slag heaps, and areas designated for disposal should be revised in consideration of the risks due to the changing climatic parameters.
- It is recommended to continuously inform the participants of the construction sector, urban development and planning on the importance and opportunities of climate conscious planning and use of materials.
- Preparation of the public transport network for extreme weather phenomena (heatwaves, floods, storms) through the identification of points of intervention and the elaboration of action plans are of key importance.

Mid-term action lines

- Elaboration of appropriate regulations in order that pavement materials that are more resistant to the heat stress are used more widely.
- Extension of the system of green surfaces and the involvement of water surfaces to create a site-specific green infrastructure system that ensures ecological corridors and facilitates the ventilation of the settlements and reduces the thermaI island phenomena.
- Adaptation to the effects of climate change in the construction sector, development and application of new construction solutions, preparation of the building stock for the emergence of extreme weather events (e.g. heatwaves, extreme weather situations, storms) and water scarcity.
- Encouraging the joint strategic planning and development of settlement groups most exposed to the effects of climate change (agglomeration of large cities, agglomerating regions, farmstead regions).
- Protection of fertile soils (especially those of good quality and of valuable location) against uncoordinated sprawl of built-in areas.
- Revision of the degree of building density in the agglomerations, agglomerating regions and significant holiday resorts, prevention of the physical merging of settlements, strengthening the development of multiple centres in agglomerating regions.

  Consideration of the aspects of conscious adaptation to the effects of climate change in urban planning; climate-conscious designation of areas for construction; bearing in mind the goal of creating a compact urban structure divided by green areas and allowing areas free for ventilation.

Long-term action lines

- Comprehensive integration of climate change, as a preferential aspect, into regional, urban development and building policies, taking actual changes in climate also into consideration.

Concrete, operational interventions

The 2018-2020 CCAP-1 contained numerous indirectly relevant measures from the fields of water management, tourism, risk management and health care. These include among other things measures aiming settlement or regional adaptation (e.g. revision and further development of early warning systems of extreme weather events; elaboration of a planning methodology for a climate resilient urban rainwater management); the mitigation of hazardous impacts of climate change on human health (e.g. ensuring thermal regulation of critical hospital rooms, and their protection against UV radiation; preparation of a monitoring system for allergen plants); measures support the preparation of critical infrastructure for climate impacts (development and enforcement the concept of an electricity transmission system guaranteeing adequate security of supply even in the presence of more extreme climatic parameters; assessment of the changing energy needs as a result of climate change); and measures supporting the sustainable use of natural resources (analysis of possible solutions of underground water retention and storage; identification of potential inland water inundation based on remote sensing).

The current CCAP 2 draft takes one step further: beyond the above mentioned indirect areas (water management, tourism, risk management) this time direct settlement development related measures will be part of the plan (e.g. elaboration of settlement level vulnerability assessments, propagation of practical solutions like green roofs and walls; relevant database and decision support system developments, etc.).

vi. Energy infrastructure

The climate change has a direct effect on energy production and consumption and an indirect effect on the energy demand. Through the implementation of the National Energy Strategy and the National Building Energy Strategy the following action lines must be considered, and the detailed tasks of energy infrastructure defined in relation to climate change.

Short-term action lines

- Climatic risks must be integrated into the planning of power plants and the energy infrastructure networks. Climate vulnerability of these developments should be studied also horizontally in the various industries (interaction with other sectors such as rural development and water management) and in terms of vertically spreading effects (along a certain supply chain, in consideration to the effects of production and consumption) as well.
- Information-collection and impact assessment: understanding the real chain of effects and systematically evaluating them.
- Revision and renewal of the energy infrastructure must integrate the aspects of climate into the existing assessment methods (audits, ratings).

- The availability, stock and sustainable utilisation of weather-dependent renewable energy sources (especially the sun, wind and biomass) should be revised in the light of the expected climate change.
- The sharing of experience and best practices should be encouraged within the framework of awareness-raising and knowledge-sharing.

Mid-term action lines

- Revision of action and further modification of legal criteria in the light of the progress of climate change and its impacts.

Long-term action lines

- Comprehensive integration of climate change, as a preferential aspect, into energy policies, taking actual changes in the climate also into consideration.

Concrete, operational interventions:

The CCAP-1 programme defined 2 concrete measures for the climate-adaptive development of the energy infrastructure: 1) During the review of the National Energy Strategy and its action plans the development and implementation of the concept of an electricity transmission and distribution system which guarantees adequate security of supply even in increasingly extreme climatic parameters; 2) Surveying the changes in energy needs as a result of climate change.

As things stand, in the CCAP-2, energy infrastructure’s adaptation remains an important field with its own group of concrete measures. These are expected to concentrate on the elaboration of vulnerability assessments of the related infrastructures; and on the development of a weather forecasting system that more accurately serves renewable energy production.

vii. Tourism

The effects of climate change on tourism consist both of the direct effects due to the changing of the climate as a resource and the indirect effects concerning tourism, and finally the consequences of the socioeconomic changes. The detailed and tourism-related tasks of climate adaptation should be defined in detail both in a national tourism development policy and in the development policies of tourism destinations as well and in the urban and regional development plans. The main development directions should consider the following action lines:

Short-term action lines

- Elaboration of a climate-friendly tourism-development framework is recommended, with special regard to the topics of adaptation and sustainability, considering the relevant documents of Hungarian tourism development.
- The results of the vulnerability assessment of the Hungarian tourism destinations should be applied in practice, on the basis of the National Adaptation Geo-information

System (NAGiS), focusing on the further studying of the adaptation opportunities, tools and adaptation portfolio of the stakeholders.

- Within the framework of awareness-raising, players of the tourism sector should be informed on climate change and its consequences, and their motivation to participate in the related adaptation (and mitigation) processes should be increased. In this connection domestic tourism and leisure activities should be promoted, and the related infrastructure (educational trails, jogging paths, hiking trails, etc.) should be developed and maintained. The elaboration of a climate-friendly tourism trademark and an adaptation guidance can help the achievement of the intended goals.
- The energy consumption of various events that are also tourism attractions should be reduced; carbon-neutrality should be facilitated.
- It is recommended to elaborate adaptation strategies in those Hungarian tourism destinations that are most endangered by the effects of climate change (e.g. Lake Balaton, Lake Tisza).

Mid-term action lines

- Elaboration and application of a risk assessment methodology focusing on climate change related vulnerability in destination management.
- Conduction of studies, examinations, collection of international and Hungarian best practices and the preparation of background materials providing recommendations for the compensation of the negative climatic effects of tourism, in relation to the development of other strategic areas, in the following topics: development and encouragement of public transport in the transportation of tourists and ensuring the access of attractions; setting up and utilisation of alternative energy systems connecting to attractions, accommodation and catering units; improvement of energy efficiency, integration of renewable energy sources.

Long-term action lines

- Comprehensive integration of climate change, as a preferential aspect, into tourism development to create climate-friendly and sustainable Hungarian tourism destinations.

*Concrete, operational interventions***:**

Both the CCAP-1 and the draft CCAP-2 identifies 1-1 measure for tourism adaptation. The first document intended the preparation of a research for the implementation of methodological developments and the sharing of domestic and international good practices related to the study of climate change impacts in the tourism sector, which was implemented in the frameworks of the NAGiS by 2019. The draft CCAP-2 intends to continue these research directions with the national extension of vulnerability assessments and adaptation recommendations as part of the further development of NAGiS between 2021-27.

viii. Public safety

According to researchers, experts and policy-makers climate change is a national security factor, and may become a dominant threat to the security in the 21st century. Disaster management, as an important player in law enforcement handles day-to-day emergency situations. However, responding to new challenges, such as the appearance of the global climate-migration, is an additional task. In terms of disaster management, it would be practical to specify the detailed duties of climate adaptation in the National Disaster Management Strategy and its implementation framework, with the consideration of the following action lines:

Short-term action lines

- The increasing weather variability of the Carpathian Basin and the direct and indirect effects of the emerging extreme climate make it necessary to enhance the (early) forecasting and monitoring capabilities of governmental bodies. Technical and academic organisations must be involved into the research of this topic. In addition, public information must be provided and the people must be protected.
- In order to handie and suppress the more and more frequent diseases, infections and epidemics, the operational framework for the cooperation between public healthcare, police, internal and national security must be improved further.
- Integrated and operational cooperation between civil protection, traffic safety and energy affairs must be created in order to manage and eliminate the mass traffic accidents, national traffic jams, issues in energy supply that occur with extreme weather events (e.g. heat waves, storms, snow, sleet, etc.).
- Buildings and institutes that are of top significance in terms of national security must be designed in a climate-proof manner and their water supply and energy security must be reinforced.
- It is recommended to make a planned and regular risk assessment of natural hazards in order to create a proper basis for the preparation of disaster management.
- Intensifying the cooperation with the neighbouring countries must become a priority in the field of joint setting up of defence systems and their harmonisation.
- Preparation for global climate migration (for the appearance of masses of refugees leaving back their homeland for climatic reasons), development of complex governmental, domestic, foreign measures necessary for handling this challenge in terms of political, police and immigration terms.

Mid-term action lines

- Reinforcing the information, capabilities and tools of disaster management, domestic security and defence in order to efficiently manage the increasing environmental risks and for the appropriate preparation and adaptation.
- Improvement of the complex protection (in terms of infrastructure, transport, rural development and home affairs) of settlements, the critical infrastructure, agriculture, forestry, game management and fishery.
- Studying the effects of climate change on the demographic processes of the Carpathian Basin and the occurrence of internal migration.

Long-term action lines

- Comprehensive integration of climate change, as a preferential aspect, into national security policies, taking actual changes in the climate also into consideration.

- Preparation for the prevention and elimination of direct or indirect economic, political or even armed attacks launched in order to gain control over natural resources, especially the drinking water and arable land.

Concrete, operational interventions:

The CCAP-1 identified 4 concrete measures for disaster management. These include the strengthening of hazard forecasting, and monitoring capabilities of governmental organizations; the identification and classification of geological threats influenced by climate change; Improvement of climate resilience of drinking water supply systems through the integration of climate risk management into water security plans; and a research project was also prepared dealing with building stock vulnerability to extreme rainfalls due to geological movements resulting in sinking/rise. The CCAP-2 draft intends to further improve the hazard risk assessment capabilities of governmental bodies and the development of monitoring networks of preferential geological threats affecting residential areas.

6.4 Available funds and measures for stakeholders in adaptation tasks

Regarding the international and especially the EU-related development policy environment, climate adaptation has been recently elevated by the Paris Agreement (2015) into an equal level with mitigation. Europe, especially the EU undertakes a leading role in handling effects of climate change. Within the community’s development policy environment, as a consequence, climate change was and will be one of the main priorities of both the 2014-20 and 2021-27 programming periods. Between 2021 and 2027 out of the 5 main objectives of Cohesion Policy the 2nd (“*Greener and carbon-free Europe*”) and the 3rd (“*A more connected Europe by enhancing mobility*”) focus on climate and environmental issues directly/indirectly. For countries with GNI below 75% of the EU average or between 75% and 100%, the minimum share of Policy Objective 2 should be 30% of total expenditure. We can see: large supports are intended to be allocated for mitigation and adaptation issues from Operational Programme- and other EU-funds. Additionally, Hungary’s medium- and long-term economic development objectives concentrate on these fields, too.

The Hungarian climate protection can be financed partly by the incomes from EU-ETS quota sale.

- The Energy and Climate Policy Modernization System (ex-Green Economy Financing Scheme) can calculate with 362 billion HUF between 2020 and 2029, supporting mainly mitigation, adaptation and climate-awareness raising project.
- The System of Renewable Energy Support (METÁR) as its name suggests, supports the renewable energy production and its use in consumption.

On the other hand, Hungarian climate policy relies **strongly on EU sources**. The 2021-27 operational programmes ensure funds for supporting public (state, municipal, church and civil) and private energy efficiency and renewable energy developments from the EU budget.

In the frameworks of the 2021-27 OPs approximately 1370 billion HUF support is expected for transformation of the employment, for the implementation of relevant education programmes and trainings, for the transformation of energy production and for network developments. Among the OPs principally the Environment and Energy Efficiency OP Plus is expected to deal with climate adaptation; in its draft the 4th priority axis deals with energy efficiency and climate adaptation related decision support activities; and indirectly priority axes 1 (disaster and flood management), 2 (drinking water and sewage water related developments) and 3 (nature protection) also support relevant activities. Beyond the EEEOP Plus, the Territorial Development OP Plus and the Intelligent Mobility OP Plus include relevant investment areas.

Article 10c of Directive 2003/87/EC support mechanism (hereinafter referred to as Article 10c derogation) is also available to Hungary, for the modernization, diversification and sustainable transformation of the energy sector. The supported investments must consistently promote safe and sustainable, low-cost transition to a low-carbon economy for the period up to 2030 and should be harmonized with Hungary's climate and energy policy documents' objectives and investment directions. The planned support concentrate on replacing coal-fired power generation with smaller GHG-emitter sources (gas, waste) and energy storage.

The Modernization Fund, as a dedicated funding programme to support 10 lower-income EU Member States in their transition to climate neutrality by helping to modernise their energy systems and improve energy efficiency plans, supports Hungary with 400-700 billion HUF between 2021 and 2030. Its main priority is the conversion of the lignite-based economy to being capable to receive renewable energy sources and to promote the development of energy efficiency.

Supports from the Just Transition Fund (103 billion HUF between 2021 and 2027) focus also on transformation of GHG-intensive regions.

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. The planning process of the ***cross-border INTERREG programmes*** is still ongoing. In the framework of ***transnational co-operation***, the institutions of multi-country areas, which can be interpreted as a single territorial unit, jointly seek solutions to the problems affecting them, providing more effective solutions than national responses. 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 programme***: *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). In parallel with the OP planning for 2021-27, the renewal of the Danube Strategy Action Plan had taken place, before the preparations for the embedding of the new actions of the revised Action Plan into the EU funding programs for 2021-2027 started. The enlisted cross-border programmes of Hungary include thematic objectives and fields of development that can contribute to the implementation of the objectives of the NCCS2, such as: environmental protection, combatting the impacts of climate change, facilitating resource efficiency, facilitating sustainable transport, improving water management, cultural and natural heritage protection, biodiversity and soil protection, shifting towards a low carbon economy. Interregional cooperation programmes are also to be highlighted among the programme types, as they lay special emphasis, besides sharing best practices in innovation and urban development, on the issue of energy efficiency as well.

Other direct community funds available in the 2021-2027 programming period can be used for innovation and R&D projects. Among them it is **the Horizon Europe Programme** that is the EU's key funding programme for research and innovation with a budget of €95.5 billion. The programme tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth through facilitation of collaboration and strengthening the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. Legal entities from the EU and associated countries can apply for the funds.

The LIFE Programme[45], which has supported about 4,300 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, will continue during 2021-27 as well. The LIFE is the only one dedicated EU source for nature-, environment- and climate protection providing the 0,3% of the EU budget for such investments. Its whole budget for the 2021-2027 period is 5,45 billion €, out of which 3,5 billion € is for environment protection and 1,95 billion € for climate protection. From 2021 on the „*Clean Energies*" development theme has also emerged. The climate policy related supports consist of 3 main fields: mitigation (CCM); adaptation (CCA) and climate policy-related management and dissemination (GIC). National self-sufficiency support framework for LIFE-CLIMA, according to the Budget Act of 2022 is HUF 100 million. The annual self-support call continues to be managed by the background institute of the Ministry for Energy, the Western Balkans Green Center Nonprofit Ltd.

The following tables summarizes the available measures for stakeholders in adaptation tasks and give an overview of expected sectoral vulnerabilities and adaptation measures.

Stakeholders	**Measures**
Governmental organisations	• Appropriate legal framework • Applications and program structure • Institutional background • Empowerment of regulatory and monitoring organisations (authorities, offices)
Local and regional governments	• Local ordinances and financial incentives (e.g. taxes) • Climate friendly settlement organisation and area development • Climate conscious management of municipal companies • Municipal associations
NGOs and churches	• Organisation of local community respecting traditions and local values • Information dissemination, awareness raising • Demonstration of best practices

[45] L'Instrument Financier pour l'Environnement (LIFE) - Regulation (EU) No 1293/2013 of the European Parliament and of the Council of 11 December 2013 on the establishment of a Programme for the Environment and Climate Action (LIFE)

Stakeholders	Measures
Households	• Formulation of conscious consumption patterns, purchase of local, sustainable products • Economising with resources • Preparation for expected impacts, learning to apply defense techniques and solutions
Business sector	• Climate conscious revision of business plans and business standards • Accepting and incorporating climate innovative solutions in corporate strategies • Voluntary agreements with local stakeholders for adaptation
Media	• Information dissemination, awareness raising • Advertising best practices and disseminating new sustainable behavioural patterns
Education	• Upbringing and education for climate-friendly behaviour • Integration of climate change vulnerability, mitigation, and impact assessment in education • Vocational education and training

Table 6.1: Available adaptation measures by stakeholders

Vulnerable area	Examples/comments/adaptation measures carried out
Human health	• Vulnerability: temperature waves causing heart and respiratory problems in urbanised areas, appearance of new pests and diseases • Adaptation: preventive measures, healthcare development, formation of air conditioned shelters vaccination and irnproved R&D in the field
Water management	• Vulnerability: droughts threatening freshwater supply, floods threatening water defence lines and human settlements • Adaptation: infrastructuraI developments, improved water management practices utilisation of rainwater for irrigation
Forestry	• Vulnerability: high temperatures and droughts impairing forest development, extreme weather events causing tree loss and forest degradation, new diseases and pests • Adaptation: new drought-resistant species, change of species, improved forest management practices and R&D
Agriculture	• Vulnerability: droughts causing irrigation problems thus hindering agricultural production, floods and inundations causing inland water • Adaptation: land use change, organic agriculture on wetlands, improved defences improved irrigation and water use
Urban infrastructure	• Vulnerability: heat waves causing heat island effect • Adaptation: urban area development, afforestation where possible increasing green cover, better engineering practices
Tourism	• Vulnerability: climate change shortening and shifting tourist seasons • Adaptation: climate-friendly tourism
Public safety	• Vulnerability: migration waves, weather related catastrophes (floods, storms, blizzards) • Adaptation: improved civil defences, improved institutional background, preparation measures, preventive measures

Table 6.2: Summary of information on vulnerability and adaptation to climate change

7. FINANCIAL RESOURCES AND TRANSFER OF TECHNOLOGY

Hungary is committed to contribute to the green transition of developing countries. On financial and technology support provided to developing countries, Hungary undergoes the reporting obligation under Article 19 of Regulation (EU) No 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action.[46]

7.1. Provision of 'new and additional' financial resources

1) Investment preparation through a dedicated non-refundable financial instrument focusing on the green transformation of the Western Balkans region. In 2019, the WBGC under the supervision of the Ministry for Innovation and Technology (currently: Ministry for Energy) became operational to contribute to the region's climate protection efforts in line with the nationally determined contributions (NDCs) set forth in the Paris Agreement. The Western Balkans project preparation and capacity development grant program helps green transition and climate efforts of the region. The aim of the program is to prepare bankable projects.

The following statistics summarizes the WBGC grant-programme:

- Numbers of beneficiaries: 47 entities (registered in Hungary with legal personality or companies with majority state ownership and universities, research centers, associations and foundations);
- Target countries: Albania (3), Bosnia and Herzegovina (3), Kosovo (3), North-Macedonia (4), Montenegro (8), Serbia (21), transnational (5);
- Eligible activities: Preparation of investment projects (2), Capacity building (19), Business planning (26);
- Supported sectors: Waste Management (3), Water Management and Wastewater Treatment (13), Forestry and Agriculture (5), Energy Efficiency and Renewable Energy (19), Urban Environment (2), multisectoral (5);
- Total grant amount in euro: approx. 4 millions, Total budget in euro: approx. 7 millions.

2) **The Center of Excellence in Green Transition (CEGT) for the Western Balkans**, as established in partnership with the Energy Community Secretariat with a two-year rolling activity, is dedicated to help speed up convergence processes and strengthen efforts to fight climate change. The CEGT aims at facilitating knowledge-exchange and the transfer of international and Hungarian best practices. Serving as a focal point, the CEGT mobilizes expertise in relevant legislation and administration via workshops, webinars, technical assistance and twinning projects. It also helps local banks and financial institutions to develop their sustainability frameworks and regulations such as EU taxonomy for sustainable activities. By the end of the CEGT's first "Clean Air Regions Initiative" (CARI) programme, air quality action plans will offer a wide range of regulatory, urban planning, awareness-raising and sustainable economic development solutions to improve air quality in the region's municipalities. In the second programme: "Sustainable Finance" was about green bonds and its role in the sustainable economy. In the upcoming period, the CEGT plans to bring in green jobs as thematic areas for engagement.

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

7.2. Assistance to developing country Parties that are particularly vulnerable to climate change

Assistance to developing country Parties that are particularly vulnerable to climate change is ensured by continuously providing financial support through bilateral channels:

- Hungary provides tied aid loans financed by the Hungarian Export-Import Bank Plc. (EXIM Bank). These loans have to be paid back in each case entirely, they are not concessional. The discounts on the interest rates (aid elements) of the tied aid loans can be specified as Official Development Assistance (ODA) as follows:
    - Indonesia received tied aid loan to construct 36 automated, energy efficient and low environmental impact water treatment plants in water scarce areas. The project was successfully completed in 2019. The aid element is 61946,194619461946194619461946194.9 M HUF for the duration of the tenor (until the year 2040).
    - Laos receives tied aid loan for the modernization and capacity increase of the water treatment systems in the capital city of Vientiane since 2018. The aid element is 23,752.4 M HUF for the duration of the tenor (until the year 2044).
    - Cabo Verde receives tied aid loan for a complex water and irrigation management project since 2021. The aid element is 6460.1 M HUF for the duration of the tenor (until the year 2043).
- Uganda received 1,143,926 EUR for a sustainable tree plantation from the Ministry of National Development, the first half of the grant was disbursed in 2016 and the second half during 2017.
- 653 M HUF is to be further committed and/or disbursed during the course of 2018 for international climate finance. The recipient countries are countries of Africa, South-East Asia and countries of the Western Balkans.

Furthermore, the EIB EU Africa Trust Fund is to receive 2 M EUR in 2017 (after a contribution of 1 M EUR in 2015) from the Hungarian Export-Import Bank Plc. (EXIM Bank).

Further information is provided in the CTF tables.

7.3. Provision of financial resources

Hungary intends to provide climate finance to developing country parties through bilateral channels in the coming years. This public climate finance is expected to remain at a similar level in this period.

Table: 7.1. Hungary's climate-related ODA 202

(All amounts in EUR)*	2016	2017**	2018**

climate-specific (multilat)	3 320 812	3 000 000	3 000 000
climate spec (bilat)	31 963 926	32 000 000	32 000 000
TOTAL climate specific	35 284 738	35 000 000	35 000 000

**Exchange rate: 303,3 HUF/EUR*
***estimates*

7.4. Activities related to the transfer of technology

Bilateral support provided to developing countries focuses on sharing Hungarian know-how, expertise and available technologies. Hungary is most active in adaptive water management. The most outstanding water projects run by Hungarian companies in developing countries are providing solution for more effective water use in agriculture (irrigation) that could reduce agricultural emission.

Hungary has been actively promoting Hungarian water technology transfer through Budapest based international water summit series called “Budapest Water Summit” (BWS), that has been organized by the Ministry of Foreign Affairs and Trade of Hungary (MFAT) in cooperation with the Hungarian Export Development Agency Nonprofit Ltd. (HEPA) for the third Budapest World Water Summit time in 2019 focusing. This latter event focused on sustainable, innovative, environment-friendly solutions in the field of drinking water production, water treatment and water supply. Based on the success of the BWS, the Planet Budapest 2021 Sustainability Expo and Summit was organised, covered the even wider subject of sustainable development. Being the largest exhibition of the environmental industry in Central Europe, it featured over 160 Hungarian companies displaying their products and services.

Specifically the MFAT also established a dedicated department for Water Diplomacy, water diplomacy, water technology export and the EU Danube Region Strategy.

Hungary also supports the work of the UNFCCC Technology Mechanism, including by delegating an expert as an Annex I member of the Technology Executive Committee.

8. RESEARCH AND SYSTEMATIC OBSERVATION

8.1. General policy on research and systematic observation

The chapter focuses on recent activities in climate related research, systematic observation and their funding.

The Hungarian Parliament adopted the first National Climate Change Strategy (NCCS I) for 2008-2025. The second NCCS was approved by the Parliament in October 2018 by Parliamentary Decree first reviewed in 2013 and later submitted to the Parliament to become the second National Climate Change Strategy for 2014-2025. However, because of the anticipated outcomes of the Paris Agreement in 2015, it was withdrawn so that it could be updated in light of the new approach. The newly updated NCCS II for 2017-2030 was published and opened to public consultation in the spring of 2017. It was accepted by the Government and was submitted to the Parliament in May 2017.

One of the specific objectives of NCCS II is creating geoinformational basis for the territorial assessment of climate vulnerability. The aim is to continuously operate a geoinformational data system based on Hungarian research and the results of Earth observation, which is capable of multipurpose use, such as supporting decision preparation and decision making. Additional information on the National Adaptation Geo-information System (NAGiS) can be found in chapter 8.2.3.

The 4th National Environmental Protection Program for the period 2015-2020 and the NEP-V also set the goal of developing eco-innovation and strengthening environmental research and development by, among others, improving the ability to adapt to the effects of climate change.

2020 was an important year in terms of climate policy-related strategic planning. In January a 5-element climate and energy policy package was adopted by the government, consisting of the updated National Energy Strategy for 2030; the 1st CCAP, the EU-requirement documents „National Energy and Climate Plan" and the „Clean Development Strategy (the Hungarian LTS)". The fifth pillar of the package was the „Carpathian basin Report" (RCB), a scientific report summarizing current and future climate trends and weather-related impacts on the macro region. The report enlists the most important impacts and adaptation responses by sectors/vulnerability topics. In the spring of 2020 a Climate and Nature Protection Action Plan was also approved by the Government with 8 important short time actions. In the same year the Climate Protection Law of the country declared the quantitative objectives of the mitigation policy.

8.1.1. Coordination of research policy

The framework of environmental and climate related research policy is mainly set by the documents mentioned in the introduction of this chapter.

A significant part of all research in Hungary is carried out or coordinated by the Hungarian Academy of Sciences (MTA). In the Academy there are eleven units (scientific sections) responsible for different fields of science. As stated on the Academy's homepage[47] these scientific sections "follow, promote and evaluate all scientific activities conducted within their field of science; take a stand on scientific issues as well as in matters concerning science policy and research organization; submit opinion on the activities of the Academy's research institutes and on those of university chairs and other research units that are supported by the Academy, and participate in the procedure of awarding the title of Doctor of the Hungarian Academy of Sciences". Besides these units there are also specific committees. Regarding climate change, the Scientific Committee on Meteorology –Subcommittee on Climate and the Environmental Sciences Presidential Committee – Subcommittee on Preparation for Climate Change must be noted.

The MTA has a research network[48], which comprises 10 research centres owned by the Academy, 5 independent research institutions and more than 130 research groups.

In 2020, the Hungarian Scientific Panel on Climate Change (HuPCC) was registered, with the aim to summarize the latest knowledge on climate change and the related research results in Hungary in the framework of a scientific assessment report based on the nationally adopted model of the work of the United Nations Intergovernmental Panel on Climate Change (IPCC).

The most important governmental institute dealing with climate change and the implementation of the NCCSs is the Department for Climate Policy at the Ministry of Energy, which department is responsible for:

(1) Codification:

a. of the national regulation related to climate policy ‒ including the preparation of acts on the implementation of the National Climate Change Strategy, the preparation of acts on the detailed operation of the National Adaptation Geo-information System ‒, regulation on the implementation of decarbonization itinerary until 2050;

b. of the regulation related to climate policy on performing community tasks;

c. of the national legislation originated from the international regulation of climate policy ‒ particularly from the Paris Agreement ‒;

d. of the transposition of any other international contracts, agreements regarding greenhouse gases and professional preparation of climate policy laws in this context with the assistance of the relevant departments of the Ministry.

(2) Coordination:

a. of controlling the implementation of the Community's climate policy decisions;

b. of preparation of the National Adaptation Strategy, programs and information system; coordinates the tasks related to climate research, adaptation research and the operation of the National Adaptation Geo-information System;

c. of preparation of national, community and international reports based on the

[47] http://mta.hu/english/scientific-sections-105963
[48] http://mta.hu/english/mtas-research-centres-and-institutes-106085

international and legal obligations;

d. of the Hungarian participation in the activities and research programs of the EU's institutions related to climate policy;

e. of the implementation of national tasks related to the United Nations Framework Convention on Climate Change, particularly tasks related to the flexible mechanisms of the Kyoto Protocol and the Paris Agreement;

f. of the preparation of the medium- and long-term greenhouse gas emissions predictions with the assistance of the other ministries;

g. the work of the inter-ministerial working groups on decarbonisation and adaptation;

h. the use of incomes from the sales of greenhouse gas emissions units for adaptation and international climate financing purposes, and the community and international reporting tasks related to the incomes from the sale of all types of units by the Hungarian State;

i. of the NC/BR reporting and reviewing to the UNFCCC;

j. the Hungarian position in relation to international climate financing;

k. of the preparation of the climate protection measures and climate policy concepts with the assistance of the National Adaptation Division of the Western Balkans Green Centre;

l. some of the reporting tasks related to regulation 2018/1999 of the European Parliament and of the Council and Governmental Decree 278/2014. (XI. 14.);

m. delivers an opinion on legal drafts that concern its competence prepared by other administrative organizations.

(3) Among their international and EU-level tasks:

a. performs the ministerial tasks related to the formation of the community climate policy decisions;

b. performs their tasks related to the EU-Emission Trading System (hereinafter referred to as EU-ETS);

c. Overviews of the national operation of the EU-ETS;

d. follows with attention and controls the national implementation of the Community's decisions, and legislation;

e. follows with attention to the national implementation of the Community's decisions, legislation related to fluorinated gases, the formation, revision and modification of the related legislation;

f. develops and represents the Hungarian position on the EU's comitology work concerning the climate change (CCC, WGs, in TF and TWG working groups);

g. prepares the national position concerning the community and international climate policy negotiations and participates in the community and international climate policy negotiations;

h. represents Hungary in the international organizations dealing with climate change (i.a. UNFCCC, Intergovernmental Panel on Climate Change, OECD Climate Policy Working Group);

i. represents Hungary in the international organizations dealing with fluorinated gases (Montreal Protocol);

j. cooperates with the relevant departments of the Ministry for Agriculture during the performance of reporting, regulatory, community-level and international-level tasks under the Vienna Convention and the Montreal Protocol;

k. cooperates with the relevant departments of the Ministry for Agriculture in the harmonization of the regulation of air protection and greenhouse gases and the related negotiations;

(4) National tasks:

a. follows up the efficiency of the national emission reduction measures based on the National Climate Change Strategy;

b. participates in the preparation of national regulation related to carbon leakage, derogation, ESD, LULUCF and other aspects of climate policy;

c. develops the harmonization of the sectors of effort-sharing decisions to the carbon trading system in cooperation with the relevant ministries;

d. participates in planning, selection of tenders and controlling in relation to the Climate-policy Subprogram for the 2021-2027 financial period based on the Regulation of the European Parliament and of the Council on the establishment of a Programme for the Environment and Climate Action (LIFE). The Department for Climate Policy performs national contact tasks and representation in the permanent committee meetings related to the Climate-policy Subprogram.

e. prepares the regulation on the monitoring, verification, reporting and accreditation in relation to the EU emission-trading system;

f. prepares and makes comments on the contracts, supports provided and tenders in relation to climate policy.

(5) Functional tasks:

a. performs the national, community-level and international tasks related to climate policy in cooperation with other relevant departments;

b. performs the reporting related to the community-level and international account of emission units on behalf of the Hungarian State;

c. elaborate the National Climate Change Strategy, and the related climate policy programs (action plans) and coordinate the implementation of these documents and the implementing laws;

d. performs the monitoring and evaluation of the National Climate Change

Strategy, the yearly control of the implementation of the Strategy and prepares the report on the implementation of the Strategy;

e. follows the operation of the international transaction registry and the community transaction registry;

f. watches the services of the online market systems related to climate policy and the national, community-level and international research;

g. performs the carbon market models related to sectors covered by the effort-sharing decision in cooperation with the relevant ministries;

h. cooperates with the National Climate Protection Authority during the performance of its legislative tasks.

(6) Other tasks:

a. participates in the work of the Ministry for Agriculture in developing the greenhouse gas inventory and forwarding it to the Secretary of the UN Framework Convention on Climate Change;

b. performs the reporting duties covered by the 278/2014. (XI. 14.) Governmental Decree in cooperation with the relevant ministries.

8.1.2. Funding

Funding for climate change research in Hungary mainly stems from European Union sources and the National Research Development and Innovation Fund (NRDI Fund).

International programmes

In the EU Horizon 2020 Climate Change Programme 29 Hungarian organizations participate in EU-wide collaborative research projects receiving 6 million EUR funding. In bilateral scientific and technological cooperation programmes funded by the NRDI Fund, research activities focusing on different aspects of climate change are also supported (among others in bilateral S&T programmes with China, India, Portugal, Slovenia and Morocco).

The LIFE programme is the EU's funding instrument for the environment and climate action. It contributes to the implementation, update and development of EU environmental and climate policy performance and laws by co-financing projects with a high European added value. There are a growing number of succesful Hungarian applicants in the LIFE programs.

Hungarian framework

The source of RDI funds in Hungary are the European Union operational programmes and the National Research, Development and Innovation Fund. For more detail see Chapter 6.4.

8.2. Specific research activities

8.2.1. Main institutions involved in climate change research in Hungary

Main institutions involved in climate change research in Hungary

The most important specialist institution involved in climate change research is the Hungarian Meteorological Service (OMSZ). Its research focuses on regional climate modelling and it also plays an important role in systematic climate observation. In the last two decades, a research group has been established experience of which made it possible to development and application of regional climate models (RCMs). The climate dynamics research is based on the in-house ALADIN and REMO RCMs and European RCM results. ALADIN-Climate and REMO are executed in the professional high-performance computing system of OMSZ. The measurements and model outputs provide input for impact assessments in different sectors, e.g. hydrology, agriculture, urban planning. The regional and urban information produced from measurements and simulations are organized in a database and many climate variables for temperature and precipitation can be visualized and downloaded using the KLIMADAT application.

Development of both the observations and the projections is ongoing with support of the Recovery and Resilience Facility (RRF) of the European Union. The basic meteorological observations data will be provided in higher spatio-temporal resolution and regularly updated for further use. Further essential climate variables and derived climate indicators will be available to support the adaptation to climate change. The information on air quality, agriculture, water management and urban climate change will be tailored according to the needs to different applications and impact studies and support the strategic decisions by policy maker.

In 2021, OMSZ introduced an open data policy, in which it also made long climate data sets available for climate change research (odp.met.hu)

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 the Hungarian Meteorological Service, as well as NGOs and private consultancies and think tanks.

Besides its role in coordinating and initiating research activities, the **MTA** also carries out research through its own institutes as well as through joint research groups attached to Hungarian universities and other scientific institutions. See Annex I for the list of specific research activities by the MTA related to climate change.

OMSZ participates in many international projects by using the grid point data series produced from the observed data. One of the important topics of these projects is dryness and drought, which will probably intensify in our region as a result of climate change. OMSZ participated in the DMCSEE, DriDanube projects, and currently in the Danube Data Cube project, all of them focus on drought.

The National Multidisciplinary Laboratory for Climate Change was established to analyze the effects of climate change in Hungary. In this project OMSZ participates with the production of climate data series, the development of a climate information system, and the development of climate communication and services.

Some smaller state-funded institutions also contribute to climate change-related research, in particular the **National Institute for Environmental Health**, the **Hungarian Forest Research Institute** and the **former Mining and Geological Survey of Hungary**. In December 2021 the latter institute was merged into a new organisation called Controlling Authority of Regulated Activities in its entirety, with the exception of the National Climate Adaptation Centre Department, which, as a governmental background institution of the Hungarian Ministry for Energy, responsible (among other things) for climate change, was integrated into the Western Balkans Green Centre as a separate division. Nonetheless it continues to function as the Ministry's decision supporting organisation in the field of climate change adaptation. The operation and further development of NAGiS and the adaptation related strategic planning, monitoring and evaluation remained the main tasks of the successor organization which also conducts researches in the field of climate adaptation and vulnerability.

An important research project is "AGRICLIMA 2" (Agrárklíma 2), which focuses on the vulnerability of certain agricultural sectors. The aim is to create a scientific background to support decision-making and to prepare the foundation for establishing an Agri-Climate Center. The project ended in 2018.

At the Hungarian University of Agriculture and Life Sciences – Faculty of Agricultural and Environmental Sciences, researches were also made concerning the drought risk in the Danube Region (duration 2017–2019). In addition, at the Faculty of Landscape Architecture, climate change related researches (heat-island analysis, green coverage intensity analysis, city climate, human health risks, rainwater retention with landscape architecture tools, and the adaptation of tree vitality) are also carried out.

There is an Environment and Climate Change Research Group at the Eötvös Lóránd University (ELTE), Faculty of Natural Sciences, Institute of Geography and Earth Sciences, Department of Environmental and Landscape Geography. The relevant researches are the following: Drivers of climate change and environmental impacts in the Carpathian Basin: sustainable lake ecosystems (safe lakes) (duration: 2022-2025); Holocene distribution dynamics of beech and oak forests in the Carpathian Basin (duration: 2018-2023); Past changes in climate and land use and their impact on communities (duration: 2016-2021); Extinction dates of glacial large mammal fauna in the Carpathian Basin in the light of changes in the prehistory and palaeoclimate (duration: 2016-2021); Ecosystem responses to late glacial warming waves in the Carpathians (duration: 2007-) and Holocene climate, vegetation and prehistory in the southern Carpathians (2009-). There are two more climate change related research activities at this university: The effect of salt, heat and drought stress on the photosynthesis and plastids of plants (Plastid Biology Laboratory) (duration: 2016-2023/or further) and the Pilis-ELTE long-term nest box project (Department of Systematic Zoology and Ecology, Institute of Biology) (duration: The project is continuous since 1982).

The Budapest University of Technology and Economics has an important role in technical education. At the Faculty of Chemical Technology and Biotechnology the relevant researches are the following: CO_2 capture of biogas and industrial exhaust gases (duration: 2015-2018), development of environmental friendly processes for the efficient use of renewable energy and raw material sources and for the control led release of their energy content, design of new types of small platinum content and increased lifecycle electrocatalysts for proton-exchange membrane fuel cells (duration: 2017- 2021) and photocatalytically active hollow-structured semiconductor oxides for environmental applications (duration: 2017-2021). At the Faculty of Economics and Social Sciences the relevant research are the following: Spatiotemporal analysis of climate adaptation and urban sustainability (duration: 2021-2024), Life Cycle Sustainability Assessment of road transport technologies and interventions (duration: 2021-2024), ZalaZone Carbon Neutralization Project (duration: 2018-2020).

A particularly strong research focus on climate change can be found at the Department of Meteorology of Eötvös Loránd University in Budapest. Being the only university in Hungary to offer a master's degree programme in meteorology, they are involved in several national and international research projects related to climate change and jointly run observation activities at Hegyhátsál meteorological station together with the Hungarian Meteorological Service. In addition to the previously mentioned AGRICLIMA 2 project, two other recent projects are notable. One is RCMGiS (RCMtér) - New climate scenarios based on the change in radiative forcing over the Carpathian Basin, which were supported by the EEA Grant Fund and where the outcomes were fed into NAGiS (duration: 2014-2016). The second is the "Ag roMo" joint project of MTA and ELTE, where the objective was to create an interdisciplinary research group for sustainable and climate-adaptive agriculture. The main objectives of the project are to achieve progress in the development of Integrated Assessment Model Systems and to support decision making. This support system will be able to manage the specific climatic and soil conditions of the Carpathian Basin and can project the effects of changing environmental conditions on the agriculture sector, on farm and national economy level (duration: 2017-2021).

The Regional Environmental Centre for Central and Eastern Europe (REC) is an international body headquartered in Szentendre, Hungary. It is running a number of programmes related to climate change and other environmental issues for the countries of the Central and Eastern European region. Besides developing its own programmes, it is also participating in numerous projects funded by the European Union and the European Economic Area Grant Fund (EEA Grants).

Climate change related research activities of University of Sopron Forest Research Institute 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), Interreg AT-HU project REIN-Forest (Biodiversity conservation of the native forest in the border region and fostering their ability against the impacts of climate change) (duration: 2020-2022), Increasing the importance of forestry and wood sector in climate change mitigation (duration: 2022-2025), Establishing the Forest Seed Centre to improve of forest adaptation (duration: 2019-2020), Long term trends in invasions of pests and pathogens in the Hungarian forests (duration: 2019-2022), Assessing the extent of areas suitable for afforestation according to climate change scenarios (duration: 2020) and Development of a forestry oriented decision support tool to adaptation (duration: 2020-2021).

The Hungarian University of Agriculture and Life Sciences has also conducted a great number of climate change related research activities which are the following: Frontline Fish Genomics Research Group (duration: 2018-2022), Screening of medicinal and aromatic plants for temperate zone agroforestry cultivation (duration: 2020-2021), Cold tolerance strategy and cold hardiness of the invasive zigzag elm sawfly Aproceros leucopoda (Hymenoptera: Argidae) (duration: 2020-2021), Tomato landraces are competitive with commercial varieties in terms of tolerance to plant pathogens: a case study of Hungarian Gene Bank Accessions on organic farms (duration: 2020-2021), Local characteristics of the standing genetic diversity of European beech with high within-region differentiation at the eastern part of the range (duration: 2020-2021), Adaptation and Validation of a Sentinel-Based Chlorophyll-a Retrieval Software for the Central European Freshwater Lake, Balaton (duration: 2020-2021), Host plant range of Aproceros leucopoda is limited within Ulmaceae (duration: 2020-2021), Long-term effects of conservation tillage on soil erosion in Central Europe: A random forest-based approach (duration: 2020-2021), Wood Anatomical Traits Reveal Different Structure of Peat Bog and Lowland Populations of Pinus sylvestris L. in the Carpathian Region (duration: 2020-2021), Effect of temperature on the sex ratio and life table parameters of the leek- (L1) and tobacco-associated (T) Thrips tabaci lineages (Thysanoptera: Thripidae) (duration: 2020-2021), Long-term frost risk indicator analysis in Sopron wine region (duration: 2020-2021), Mathematical-statistical models of plant responses to climate change (duration: 2020-2021), Mathematical modelling and control of solar collector systems (duration: 2019-2022), Game-theoretic modelling of water management problems (duration: 2018-2023), Development of modelling methodologies for biological control (duration: permanent), Social and organic farming for inclusive and sustainable societies (duration: 2022-2024) and Hortus medicus – horticultural therapy education tools in action (duration: 2022-2025).

Related to climate change significant research and development activity shown up at the engineering faculties (Faculty of Earth Science and Engineering, Faculty of Material Science and Engineering, Faculty of Mechanical Engineering and Informatics) of University of Miskolc. The main topics are the following: environmentally friendly raw material research and production, urban mining, precision farming, CO2 storage, CO2 reduction in raw material production, green and grey Hydrogen production-transportation, chemical industry, development of smart, low-cost sensor networks, climate adaption, waste management, geothermal energy utilisation and renewable energy utilisation.

Within the framework of the University of Miskolc, the Climate Policy and Climate Adaptation Research and Competence Center. The Centre marshals the University's strengths in basic and applied disciplines and expands its resources to understand climate change and its impact on the economy and society. It aims to develop innovative education, support ground-breaking research, and promote the development of fundamental solutions. Its goal is to conduct methodological research on ecological, social, and economic adaptation to climate change and train professionals to support adaptation.

H2020 Projects: KINDRA – Knowledge inventory for hydrogeology research, The overall objective is to create a knowledge inventory for groundwater related research; UNEXMIN – An autonomus underwater explorer for flooded mines; The aim is to develop a submersible robotic system for surveying and exploration of flooded mines; CHPM2030 – Combined-heat, power and metal extraction from ultra-deep ore bodies; GROW Observatory – Demonstrating the concept of "citizen observatories" throug low-cost sensor network; REFLECT – Redifining geothermal fluid properties at extreme conditions. Life Projects: LIFE CLIMCOOP – Cooperation of cities and local companies for climate change adaptation. LIFE IP – HUNGAiry; Improving air quality at eight Hungarian regions through the implementation of air quality plan measures.

H2020 OPTAIN (Optimal strategies to retain and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe) project: the general objective of the OPTAIN project is to identify most efficient and easy-to-implement techniques for the retention and reuse of water and nutrients in small agricultural catchments across three biogeographical regions (Boreal, Continental, Panonian), taking into account potential synergies with existing drainage-irrigation systems. From Hungary the Centre for Agricultural Research, Hungarian Academy of Sciences and the General Directorate of Water Management are the participant organisations. Duration: 2020-2025.

8.2.2. Hungary's contribution to the Intergovernmental Panel on Climate Change (IPCC)

The Hungarian Government aims to encourage scientists from Hungary to participate in as many IPCC activities as possible. In October 2015, prof. Diána Ürge-Vorsatz, Director at Center for Climate Change and Sustainable Energy Policy at the Central European University, was elected as the vice-chair of Working Group III (mitigation of climate change). The Hungarian Member of the IPCC Bureau is committed to represent the interests of scientists from the Central-Eastern European region as Hungary generally believes that it is crucial to have adequate representation from the region in the work of the IPCC. We are continuously encouraging scientists to take part in the preparation of various reports and Hungary submitted several nominations. As a result of that several scientists from Hungary are contributing to the work of the IPCC.

To further strengthen Hungary's involvement in the work of the IPCC and to make sure that the latest scientific findings are fed back into the national climate change policy-making, an informal National IPCC Committee (NIC) has been set up. As of March 2022, the NIC group consists of around 160 experts, mostly university lecturers and researchers, with backgrounds in natural and social sciences. The above-mentioned committee is continuously informed and updated on the latest activities of the IPCC as well as questionnaires or other relevant materials issued by the IPCC. The National Focal Point of the IPCC is Eszter Galambos, climate policy desk officer of the Climate Policy Department at the Ministry of Energy.

The Hungarian Government has continuously supported the work of the IPCC through voluntary financial contributions to the international body every year since 2017.

In late 2018, the Hungarian Ministry for Innovation and Technology launched an initiative to create a National Climate Change Assessment Report, based on the guiding principles, processes and products of the IPCC. The main goals are to permanently support decision-making and implementation with the most up-to-date scientific knowledge; address knowledge gaps using an interdisciplinary approach; and provide up-to-date and scientifically sound information for the general public.

The Ministry already had the scoping meeting of the report (with over 100 scientists, and governmental and non-governmental decision makers) where they agreed on the report's outline. The most active participants and most prominent scientists founded the Hungarian Scientific Panel on Climate Change ("HUPCC") association in January 2020, which will contribute to the preparation of the report and ensure scientific credibility.

8.2.3. Specific Research Activities in Hungary

In December 2012, the Parliament amended Act LX. 2007 on the implementation framework for the United Nations Framework Convention on Climate Change and its Kyoto Protocol and defined new criteria in point of the implementation and supervision of the National Climate Change Strategy.

According to the regulated decree in the course of verification and reformation of NCCS-1 and the implementation of the second National Climate Change Strategy (NCCS-2) mitigation, adaptation and raising awareness measures must be emphasized. To support the mitigation strategy framework the law prescribes the establishment of the **National Adaptation Geo-information System (NAGiS)** and the results of regional and sectoral climate vulnerability research must be introduced in the climate policy strategy planning.

In 2013 the Mining and Geological Survey of Hungary HMGS; former Geological and Geophysical Institute of Hungary, currently the National Adaptation Division of the Western Balkans Green Centre) was awarded a grant from the European Economic Area Grant Fund for establishing the NAGiS. The EEA-C11-1 Project is one of the main elements of the EEA-funded Adaptation to Climate Change programme area. The fund operator for this programme is the Regional Environmental Centre for Central and Eastern Europe (REC), and the donor partner is the Norwegian Directorate for Civil Protection and Emergency Planning (DSB).

The Establishing the NAGiS Project lasted from 24 September 2013 until 30 April 2016. The promoter of the NAGiS project was the HMGS. The National Adaptation Centre Department (NAC), a unit of the Survey was responsible for the implementation process in cooperation with the Climate Policy Department in the Ministry of National Development.

The three main objectives of the NAGiS Project were:

- To support decision-making on the adaptation to climate change by setting up and operating a multifunctional, user-friendly geo-information database based on processed data derived from several other databases.
- Develop the methodology for data collection, processing practices, analytical processes and climate modelling related to the impact and vulnerability assessment of climate change and corresponding adaptation methods in line with INSPIRE requirements, accommodating the Hungarian National Spatial Data Infrastructure.

- Operate a web-based "one-stop-shop", an information hub for all stakeholders concerned to obtain reliable, objective information, and derived and processed data on climate change and other relevant policy areas.

Elements of NAGiS:

The NAGiS database should not be thought of as a single database, but much more as a geo-information system that is built up of several underlying databases in the background.

NAGiS has three different user interfaces: a map view, a database interface and the basic portal. The main parts of the portal system are the following:

- *Map-visualization system*
  It has a resolution of 10×10 km, containing 650 layers which show the way different aspects of climate change can affect certain areas of the country.
  The map-based portal displays the map layers of the project at the https://map.mfgi.hu/nater/ address.
- *GeoDat*
  This is a database containing the calculation results based on modelling (exposure, sensitivity, expected impact, adaptive capacity and vulnerability – 910 data layers)
- *Meta-database*
  A sort of 'data-map' about what to find and where.
- *Nagis.hu portal*
  A basic, traditional web portal available at the http://nagis.hu or the http://mfgi.hu/nater addresses for entering the portal system.

Adaptation to Climate Change Programme Partner Projects:

The NAGiS Project was pioneering in linking numerous Hungarian institutes doing research in the field of climate change. The research expert teams of diverse fields carried out a lively dialogue and formed methodologies and visualization of NAGiS together. The Hungarian Mining and Geological Survey (HMGS), the project promoter involved several state-operated institutes as subcontractors or as partners. Workshops, conferences, and discussions were effective tools of cooperation. This cooperation can be judged as one of the most important outcomes of the project in itself.

The Hungarian Academy of Sciences – Centre for Ecological Research was responsible for research on the vulnerability of natural habitats. The Hungarian Meteorological Service provided climate databases and modelling results. The General Water Directorate and the Danube Regional Waterworks as professional partners provided data for the investigation of the vulnerability assessment of drinking water bases.

Data layers of NAGiS were elaborated by HMGS and the following partner projects funded by the Adaptation to Climate Change programme of EEA Grants:

Project	Project promoter	Project partner(s)	Website

EEA-C12-11, Long-term socio-economic forecasting for Hungary	Hungarian Academy of Sciences, Centre for Economic and Regional Studies (MTA KRTK)		http://nater.rkk.hu
EEA-C12-12, Extension of NAGiS to the agri-sector (AGRAGiS)	Hungarian Academy of Sciences – Centre for Agricultural Research	• Research Institute of Agricultural Economics • National Agricultural Research and Innovation Centre • Hungarian Academy of Sciences – Centre for Ecological Research	http://agrater.hu
EEA-C12-13, Vulnerability and Impact Studies on Tourism and Critical Infrastructure (CRIGiS)	Hungarian Meteorological Service	• National Center of Environmental Health • National Directorate General for Disaster Management • University of Szeged	http://www.met.hu/KRITeR/hu/kezdo/index.php
EEA-C13-10, New climate change scenarios for the Carpathian-basin region based on changes of radiation balance (RCMGiS)	Hungarian Meteorological Service	• Eötvös Loránd University, Department of Meteorology	http://www.met.hu/RCMTeR/hu/kezdo/index.php

Application of the NAGiS results:

NAGiS may directly supported the implementation, supervision and evaluation of the second National Climate Change Strategy (NCCS-2),), the implementation and evaluation of 2014-20 Environment and Energy Operative Programme (EEEOP), and the local and regional strategic planning activities. The NCCS-2 scheme includes the vulnerability assessment results of NAGiS and its partner projects (sanitation vulnerability caused by heatwaves, vulnerability of arable farming, forests, natural habitats, drinking water supply and threat of climate change induced flash floods in hilly regions).

The Hungarian NUTS-3 level county climate strategies were elaborated according toa methodology guideline based on the database and maps of NAGiS in order to have a standardized adaptation status analysis and to use scientific results. Based on the guideline the county planners got help related to vulnerability of drinking water supply, flash flood danger, drought, vulnerability of natural habitats and forests and human vulnerability to heatwaves.

The further development of NAGiS (NAGiS-2) started in November 2016, and completed in the first half of 2020. The HMGS was granted 400 million HUF from measure 1.1.0 of the 'Adaptation to climate change' priority axis of the 2014-20 Environmental and Energy Efficiency Operative Programme (EEEOP). The National Adaptation Centre Department (NAC) of the HMGS was responsible for the development of the NAGiS-2 in cooperation with the Climate Policy Department of the Ministry for Innovation and Technology. By improving the NAGiS-2 the aim is to elaborate a decision support toolbox for underpinning national climate policy and municipal adaptation measures, based on the development of the databases, methodologies and evaluation modules. The final results will help substantiating climate policy and sectoral planning, facilitate the elaboration of policy decision-support studies, settlement and regional climate strategies; and provide professional foundation for setting adaptation goals. Besides these, the results also contribute to the dissemination of knowledge on climate adaptation, and raising climate awareness.

In the framework of the implementation of the project called "***Further development of the National Adaptation Geo-Information System*** (NAGiS)" modules of the NAGiS were improved; while new ones were also developed. From the early autumn of 2018 results have been published. The final outputs are as follows:

- tourism vulnerability analyses
    - a study about the new methodology for complex vulnerability (exposure, sensitivity, impact, adaptation capacity and vulnerability) assessment of 3 different tourism products (nature-based active tourism; lakeside beach tourism; cultural heritage tourism) in Hungary;
    - a publication of 3 pilot studies about special Hungarian destinations (climate change-related attitude analyses);
    - a collection of municipal adaptation response best practices;
- a new module called the Settlement-level Adaptation Barometer (downloadable questionnaire supporting settlement-level situation analyses) and a manual for it;
- a new module called Local Adaptation Decision-support Application (an online tool for settlements to evaluate their condition regarding topics of climate adaptation, to download databases and maps, to make reports and comparisons of their situation to the national average);
- a Management Information System (to support sectoral decision-making at national/regional levels).
- publication of a series of awareness-raising brochures in two different fields. The specific topics of the brochures are the following:
    - Awareness raising:
        - Household energy and water saving possibilities;
        - Climate-secure buildings;
        - Human health and climate change;
        - Conservation of wildlife and biodiversity;
        - Preparing for extreme weather situations.
    - Introduction of NAGiS Methodology:
        - NAGiS as a design tool for strategic planning;
        - NAGiS Management Information System;
        - NAGiS Local Adaptation Decision-support Application;
        - The scientific results of the further development of NAGiS.
- 2 agrarian studies (one of renewal of land use modelling; and one of climate change adaptation research);
- 3 social studies (human health consequences of climate change regarding the vulnerability of the population; expected impacts of climate change on internal migration processes in Hungary; expected impacts of climate change on internal labour market processes in Hungary);

- a handbook on climate-resilient planning and implementation of urban rainwater management;
- a study about the settlement-level methodology of the housing stock's vulnerability in Hungary;
- an elaborated education programme for local governments and stakeholders about the new NAGiS results;
- Development and national extension of direct and indirect climate change impact analyses on shallow groundwater;
- a study on climate vulnerability of drinking water supply in settlements in the case of Hungary's key water utility service providers;
- a final report is about climate change aspects of geological threats;
- Extension of the results of climatological models to the Danube River Basin to harmonize hydrological model data and investigate the vulnerability of surface watercourses;
- Climate vulnerability assessment of critical infrastructures:
    - Climatic assessment of electricity supply in Hungary;
    - Climatic assessment of gas supply in Hungary;
    - Climatic assessment of district heating supply in Hungary;
- Elaboration of a research report on the climate awareness of municipalities.

The development of the system, of course, cannot come to a halt after a given development period. To secure its proper sectoral decision-supporting function, the constant update and further improvement of the system is necessary. **Two directions** of **the** NAGiS' further development were declared after 2020 in the *draft* 2021-27 Environmental and Energy Efficiency Operative Programme (*EEEOP Plus*) as well as in the *Governmental Report on the current and expected climate* impacts *on the Carpathian Basin*. According to these, one

- One direction of development is the ***involvement*** of additional vulnerability topics/modules into the NAGiS or further development of existing ones. These fields are as follows:
- Tourism's complex vulnerability assessment;
- Water regime change analyses of bigger rivers;
- Local vulnerability of the housing stock to extreme weather events;
- Settlements' exposure to geological hazards;
- Analysis of human health-related impacts of climate change.

The other direction of development is the geographical extension of the NAGiS system from the national to the macro-regional scale***.*** This extension which would significantly help to understand the regional climate change processes and improve the efficiency of adaptation in Hungary. In response to this demand the Carpathian Basin module of the NAGiS is planned to be developed (the **Carpathian Basin Adaptation GeoInformation System, CARPAGiS**). The planned system would be used as an effective and interdisciplinary decision support tool, providing the target groups with impact assessments focusing on larger regions and macro-regional adaptation on which development strategies could be established. The system will also encourage the implementation of future cross-border projects as an international good practice. Preparatory studies and examinations on data availability in the neighbouring countries were conducted and a Feasibility Study was completed in 2021. These could form the basis of the future developments. In connection with climate **adaptation the Hungarian Ministry responsible for climate policy** (Ministry of Energy) **and the Western Balkan Green Center's National Adaptation Division are jointly implementing and planning relevant projects.** Among those that had already been started **LIFE-IP North-HU-Trans project** has to be mentioned explicitly. It is introduced more detailed by the subchapter.

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. Runoff models have also been prepared for the five pilot catchments to help identify locations that may be highly affected and vulnerable to the increasing frequency of extreme weather events in the future.

The selected settlements were among the most vulnerable ones in Hungary: they are very prone to extreme weather events such as droughts, floods, flash floods, inland floods, or a combination of these. The water retention measures designed and implemented in the project were adapted to the climatic challenges and conditions of the municipalities. The municipal model projects/model solutions/prototypes thus developed can serve as good examples for other municipalities (taking into account the needs and potential of the given municipality of course). 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, training and e-learning materials were also elaborated and training sessions were held to introduce the different municipalities' participants to 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. Participants prepared vulnerability assessments for their municipality/watershed and assessed the climatic situation, challenges and opportunities in their municipality. The elaborated e-learning materials are available free of charge on the project website for all interested parties after the project is completed (in Hungarian). It covers the topics of local adaptation to climate change and water conservation through 6 modules and interactive exercises. 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, 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. Sharing project results and transferring knowledge was also a priority to raise awareness as widely as possible, focusing on target groups from residents, through the leaders of other municipalities and water professionals, to the media. For more information on current project events and activities, please visit https://vizmegtartomegoldasok.bm.hu/en

LIFE LOGOS

The successor of the MICACC is the **LIFE LOGOS 4 WATERS project**, which runs from 2021 to 2025. Its ovearching 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.

DEEPWATER-CE

Another project that had been led by the former MGSH's NAC Department (currently National Adaptation Knowledge Center of the Western Balkans Green Center Non-profit Ltd.) was the **DEEPWATER-CE project**. It aimed to develop an integrated **implementation framework for Managed Aquifer Recharge** (MAR) solutions to facilitate the protection of Central European water resources endangered by climate change and user conflicts and develop a comprehensive transnational approach to water resources and adoption of MAR solutions in Central European countries as a solution to water scarcity and decreasing usage conflicts with other social and economic sectors. Within the 3-year-long (2019-2021) project,

- a *Transnational Decision Support Toolbox was developed* for designating potential MAR locations in Central Europe. The Toolbox, compiled in a Handbook, provides a detailed description of MAR systems' principles, benefits, requirements, and objectives.
- a *MAR site selection process* was conducted, based on assessing geological and hydrogeological conditions, current and future (modelled) climate conditions, and exposure and sensitivity of different MAR types to climate extremes.
- *designation of pilot sites* in the four partner countries (Poland, Hungary, Slovakia, Croatia, 1-1 site in each country) also occurred with an excellent perspective for a future potential MAR investment. This policy area is not yet regulated at the EU level. Therefore, *elaborating a gap-filling Central European level guidance on policy integration of MAR solutions* became the final project outcome.
- Moreover, the *partners developed relevant country-specific policy recommendations and action plans*, advocating their adoption by the competent water management authorities. The EU Deepwater-CE project closed on the 31st of April. For more details please visit the new website of the project (https://www.interreg-central.eu/)

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 2020 September and is expected to end in 10/31/2029. Mátra Power Plant (MPP) is the second largest power plant in the Hungarian electricity production system. The project, to catalyse the full implementation of the NECP and the **reduction of the GHG emissions of the Hungarian electricity production system by nearly 50%** (equal to the 14% share of total CO_2 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 multistakeholder 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 program 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 will be various studies describing the current situation and problems.

LIFE-CLIMCOOP

The LIFE-CLIMCOOP project is implemented by a consortium led by the University of Miskolc. The project aims to implement joint municipal-industrial adaptation actions in cooperation in a medium-sized town and its main industrial site. The duration of the project is 4 years from September 2020 until August 2024. Some significant results of the project so far:

1) A climate vulnerability analysis for both the townand the company had been elaborated, based on field works and desk researches. These latters consists of a comprehensive preliminary analysis of the relevant settlement, county and national level strategic planning and development policy documents and an executive study of the existing climate change adaptation-related policy goals, objectives and measures. Furthermore it comprises a preliminary situation analysis about the town's climate change related situation, covering the geographical position, natural environment, social and economic situation and the relevant climate impacts. During 2021 September field studies were conducted to assess the climate risks of thetown. In two phases (on 14-16 and on 21-23 September) altogether 30 interviews were made with local and regional stakeholders in the town and its hinterland, in the industrial site and in the neighbouring settlements with majors, notaries, members of the local governments, leaders of social /educational /health care institutions, operators of critical infrastructure and organizations tackling natural resources, leaders of economic organizations, etc. The processing of the information and risk analysis- and vulnerability assessment workshops resulted in elaborated impacts chains identified vulnerability subtopics in 3 different fields (settlement development; flash floods; heatwaves and human health).

2) Based on the risk assessments and vulnerability assessments a joint municipal-company Adaptation Strategy will be elaborated by the beginning of 2023. The strategy is being planned currently. The situation analysis and evaluation phase of the strategy was planned to be completed by the end of June. During summer and autumn the elaboration of the Vision, the Objective System and the Measures, and the Implementation Frameworks have been finalized. Currently the planning process of the measures and the implementation framework are under way.

3) One of the main goals of the project is to extend the project's positive effects and results are accomplished in the focus region, to the whole river catchment area. To reach this goal, the identification of the main and mostly exposed water users in the catchment area of the river were identified and questionnaires for the 40 local interviews were elaborated. With their involvement a mentor program will start to help them to assess their own climate-related risks - mainly in connection with water - and to facilitate further cooperations between other cities and local companies, as well as among all the stakeholders to form a water-related climate partnership in the river basin.

4) Furthermore, a feasibility study and an impact assessment were prepared by the company to develop a prototype equipment, with the aim to clean the different types of industrial wastewater and rainwater, which later can be reused as industrial water or irrigation water for public green spaces. The implementation of the prototype is currently under way.

5) To develop public-private partnerships, urban-corporate cooperation, and to make the cooperation between the town and its industrial site easier, the partners developed and jointly operate collaboration mechanisms to promote collective Climate Change Adaptation measures. A Climate Platform was set up as a coordinating body, a Future Research Group was set up as a climate science interface and a unique Climate Fund was launched to support the implementation of small-scale and low-cost adaptation measures locally.

8.3. Systematic observation

The bulk of observation activities are still carried out by the Hungarian Meteorological Service (OMSZ) and partly by the Department of Meteorology at Eötvös Loránd University (ELTE).

The Hungarian Meteorological Service is a central budget institution; 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. OMSZ operates the surface meteorological observation network all over the territory of Hungary, including 162 automatic weather stations and 142 hydrometeorological stations. The regular calibration and maintenance activities of the measurement equipment are also carried out by OMSZ annually. The network has been extended by several sites during the last years in 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.

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. Eötvös Loránd University, with over 25,000 students, is one of the major universities in Hungary. MSc degree in meteorology can exclusively be obtained at ELTE. The 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.

Besides short-range, medium-range, and monthly weather forecasts, OMSZ 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 OMSZ and ELTE were utilised for impact studies of hydrology, agriculture, tourism and critical infrastructure. OMSZ 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 database [49] 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.

The activity of OMSZ is based on the extended national and international infrastructures including the surface observational network and remote sensing instruments over Hungary, the running of 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. OMSZ 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).

OMSZ 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.

8.3.1. Atmospheric observation

One of the Hungary's most important observation sites for atmospheric constituents is the Hegyhátsál greenhouse gas monitoring station[50], 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

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49 http://nimbus.elte.hu/FORESEE

50 http://nimbus.elte.hu/hhs/

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)[51]. 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, OMSZ 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 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.

8.3.2. 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 OMSZ 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"[52] 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.

OMSZ 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

[51] https://icos.atomki.hu/

[52] http://www.carboeurope.org/

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, OMSZ and ELTE participated in IMECC EU FP6[53] (2007-2011) and InGOS EU FP7[54] (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, OMSZ 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 OMSZ 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.

Through OMSZ 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.

8.3.3. Additional related international activities

Since the 1990s, the Hungarian Meteorological Service has been providing daily data to the WMO-GAW program:

- 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

[53] http://imecc.ipsl.jussieu.fr/index.html
[54] http://www.ingos-infrastructure.eu/

The Hungarian Meteorological Service 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.

OMSZ 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.

OMSZ 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 OMSZ 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.[55]

OMSZ participated between 2017-2020 in the European project called Copernicus Climate Change Service (C3S) 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 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 OMSZ represents the country in the organization. OMSZ also is a member of EUMETNET Climate Programme, which coordinates the climate data and services of the national meteorological services in Europe.

In regard to the support for developing countries to establish and maintain observing systems and related data, OMSZ has taken the following actions:

Six Turkish experts visited OMSZ 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.

[55] The dataset is publicly available on the project homepage: http://www.carpatclim-eu.org

In the framework of the bilateral agreement between the Hungarian Meteorological Service and the Ukrainian Hydrometeorological Center, OMSZ 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.

9. EDUCATION, TRAINING AND PUBLIC AWARENESS

9.1. General policy towards education, training, and public awareness

The National Environmental Programme defines the comprehensive framework of the environmental policy objectives and actions of Hungary. The fifth NEP[56] identifies the environmental objectives, tasks and instruments required for their achievement up to 2026. Programme

The NEP-V has four strategic objectives and two horizontal objectives:

- Improving the quality of life and the environmental conditions of human health, reducing the effects of environmental pressure.
- Protection and recovery of natural values and resources and their sustainable use.
- Improving resource efficiency and making steps toward a green and circular economy.
- Improving environmental safety.
- The horizontal objective of the fifth NEP is to strengthen the environmental awareness of society and includes several measures to foster environmental awareness, education, and training.
- Strengthening the ability to adapt to climate change.

The Hungarian government initiated an online survey late 2019 regarding the National Clean Development Strategy where we received the result that the public is very much interested in climate issues, and over 90% of the respondents would personally be open to changing their lifestyle choices to protect the climate.

In the online survey named as 'Hungary is on the green path' organised by the Hungarian Government in 2021, 95,1 % of the respondents agreed that climate change awareness-raising and education has to start at an early age, preferably from childhood.

The first National Climate Change Strategy was adopted by the Parliament Decree No. 29 of 2008 (III. 20.). As mentioned earlier, the NCCS was first reviewed in 2013 and little later submitted to the Parliament to become the second National Climate Change Strategy for 2014-2025, but close to the upcoming Paris Agreement in 2015 it was withdrawn to be updated

[56] Resolution of the Parliament 62/2022 (XII. 9) OGY

again in light of the new approach set out in the final Agreement. The newly updated NCCS II for 2017-2030 was published and opened to public consultation in the spring of 2017. It was accepted by the Government and submitted to the Parliament in May 2017.

Beside the Low Carbon Development Strategy and the National Adaptation Strategy, the NCCS II contains a "Partnership for Climate" Awareness-Raising Plan too. The aim of climate change related awareness-raising is to integrate climate awareness and sustainability into the planning process, decision-making and actions on all levels of society.

NCCS II states that the issues of sustainability are of particular significance in the awareness-raising through education. Information that draws attention and teaches conscious thinking about sustainable development should be incorporated into the curriculum. Being committed to environmental protection, future professionals will have to implement ideas that consider the effects of their actions on the environment. Therefore, it defines the following actions:

Short-term action lines

- Climate change information must be integrated into the public and higher education. Special attention must be paid to the presentation of the economic and social side of the human made ecological crisis, in which the approach of ecosystem-services can be an important communication tool. The presentation of actions related to the mitigation of climate change and adaptation to climate change, and the related exemplary behaviour of educational institutes must be made an integral part of the educational work.
- The approach of sustainability should be integrated into preschool and schoolwork.[57] It is especially important that science, technology and sustainability have a complex interconnection within the training and education. Students and pupils should look for answers to real problems. Primary schools should be encouraged in the first place to participate in forest schools where direct practical examples can be acquired of conscious and thrifty lifeforms.
- In order to enforce the aspects of sustainability in education, the framework curricula and all their subjects need to be revised and continuously updated, so that the schools can respond with reality-based learning material to actual issues.
- Information on climate change, sustainability and awareness-raising methodology, new procedures of learning-methodology must be made an important part of teacher-training, paying special attention to the acquisition of "green" competences.
- Further reinforcement of awareness-raising about climate change and sustainability in higher education and vocational education and training, incorporation of programme-specific methodological elements into the training and activities aimed at their application, encouraging the spreading of good solutions.

[57]Preschools that have been given the title "Green Preschool" do an exemplary work in the field of pedagogy about sustainability, numerous good practices can be found in schools with the title "Eco-school". Forest schools and preschools provide changes of various real learning situations.

- All these tools can be used efficiently if their implementation is supported by the coordinated support system of governmental actions.
- Cost-efficient implementation requires the involvement of private resources, and other non-public resources, which is already urged by the international community.
- Educational institutions should be encouraged to go beyond the general issues of climate change, and to show locally relevant knowledge, issues, and possible solutions to the students. They should be involved in local nature and climate protection activities.

Mid-term action lines

- The inland and international experience acquisition of teachers and teacher-students must be facilitated, so that they can apply the good practices in the education of sustainability in their future work.

Long-term action lines

- Comprehensive integration of climate change, as a boundary condition, into education policy, taking actual changes in the climate also into consideration and under the requirement that the approach of sustainability must be made a basic value on all levels of education (including non-formal and informal learning as well).

Furthermore, we have an appointed ACE – Action for Climate Empowerment focal point, who is actively working on the development of national level awareness-raising actions and climate-related education.

9.2. Primary and secondary education

The National Core Curriculum, renewed in 2020, includes 'building a commitment to a sustainable future' in the 12 priority development areas and goals of learning.

The curriculum expectations regarding sustainability in the core curriculum are included in the framework curricula, assigned to the knowledge requirements in each subject, thus ensuring that the horizontal educational objectives set out in the core curriculum are sufficiently embedded in the school practice with a variety of teaching and learning activities, using approaches from different subjects and disciplines together.

The topics of sustainability are also included in the renewed graduation requirements: among others, in the detailed requirements of Civic Studies, Economics, Geography, Biology, Physics, Chemistry and Science. Sustainability as a new examination was also introduced, to which and a new subject curriculum and textbook as well as exam requirements were also made available.

Climate Change education – apart from the official educational programme - appears in many other school activities.

Sustainability Thematic Week is a program coordinated by the Ministry of Human Capacities[58], operating since 2016, with an increasing number of schools joining each year. In the past five

[58] Since May 24th 2022 the government ministry responsible for public education has been the Ministry of Interior Affairs.

years, the program has reached about half of the schools overall. In 2021, despite the threat posed by the coronavirus epidemic, nearly 400,000 students participated in the Sustainability Thematic Week. The program uses active learning, community action, and helps schoolwork through lesson plans, campaigns, and teacher training programs.

With the support of the Ministry of Human Capacities, a one-week event called The World's Largest Lesson is also organized, which in 2021 was joined by nearly 5,000 classes nationwide. The main goal of the program is to draw students' attention to the Sustainable Development Goals.

The values, the ways of action and operation and the topics of sustainability are integrated into the daily life of the approximately 1,300 public education institutions participating in the now 22-year-old Hungarian Eco-School Network. Most eco-schools have a so-called "energy commando": in these institutions, the energy-saving operation of the school building is realized with the active participation of the students. The Green Kindergarten Network, coordinated by the Ministry of Energy, has more than 1,100 kindergartens nationwide. Thus, every third child or student in Hungary is educated for sustainability according to one of the pillars of the UNESCO ESD for 2030 Roadmap, the model of whole-institutional practice.

In Hungary, education for sustainability competences is integrated into the preparation of teachers and the evaluation of their work. The necessary aids, guidelines and recommendations were developed for all groups involved (from kindergarten teachers to school psychologists to dormitory educators or school principals, in 31 versions!). Educators should also report on how they apply environmental attitudes in their daily work during the qualification process and during professional visits. In developing the competence framework for education for sustainable development, the results of a recent joint European research based on the UNESCO framework were used by the multi-stakeholder expert to develop teacher competence indicators.

In recent years, in the field of education for sustainable development, Hungary has actively participated in international professional and policy co-operation. In 2019, in collaboration with the UNEP Vienna Office, Hungary hosted for the first time an international transdisciplinary seminar on education for sustainable development for the Parties to the Carpathian Convention. As a result, Hungary became the initiator of the establishment of an ESD expert regional network in the Carpathians.

Summary:

Hungary has effectuated several measures to integrate sustainability into its Lifelong learning systems, such as:

(1) Sustainability topics, values and competences got integrated in central content regulators (including curricula and textbooks) as well as in outcome requirements (such as matriculation examinations standards).

(2) Education for sustainability competences is part of both the training curricula and the output criteria of initial teacher education (in all higher education institutions, in all professional areas, from early childhood education to specialist teachers).

(3) Education for sustainability competences is also part of the competency framework used in the in-service teacher qualification process and assessment. The competence model used for this is completely in line with the GreenComp framework.

(4) Hungary has a twin excellence network on whole-institutional education for sustainability (Eco School Network, Green Kindergarten Network) where sustainability is part of the daily operation and the school ethos.

(5) There are central programs such as the Sustainability Thematic week in which schools can participate: in the past 6 years, the program is estimated to have reached every second student in the country. Connected research evidenced the efficiency of these programs.

(6) Sustainability is a priority in infrastructural development in education and in the development of disadvantaged regions.

(7) Hungary is active in networking in learning for sustainability at regional, European, and international levels.

9.3. Higher education

Aspects of climate change are more and more widely taught at Hungarian universities and colleges, either as part of degree programmes on broader subjects such as environmental science, environmental engineering, earth sciences etc., or as elective courses freely available to students of any subject. The Faculty of Earth Science and Engineering, University of Miskolc is offering the Climate change adaptation engineering postgraduate specialist training course programme and the Climate referent is offered by the University of Debrecen.

Also important to note that in the cooperation of the Corvinus University of Budapest (BCE) and the National Adaptation Division of the Western Balkans Green Centre a climate policy specialization programme started. Today the BCE the only university in Hungary where both bachelor's and master's students can learn about the latest national and international climate policy improvements, including climate adaptation.

Hungary follows the Bologna process. As of autumn 2022, there are about 64 state recognised higher education institutions in the country.

We initiated the planning on a climate change higher education pilot project. The aim of this project is to establish a Climate Change Curricula in several areas of study with an extensive set of courses. Currently, comprehensive climate change curricula is not yet available in Hungary, therefore it is a forward-looking project to train future experts.

9.3.1. Meteorology and climate science

At the Hungarian higher education institutions, meteorology can be found at the faculties of natural sciences. Three scientific undergraduates/bachelors courses, namely earth sciences, environmental science and physics can include meteorology as a specialization, depending on the university.

Eötvös Loránd University (ELTE), based in Budapest, is the only educational institution in Hungary with a master's degree programme in meteorology. ELTE also has a meteorology specialization for all the three previously mentioned bachelor programmes. Graduates from other related bachelor programmes can apply to the MSc programme too, with the condition of completing additional courses.

The University of Debrecen also offers a meteorology branch on bachelor level in its earth sciences BSc programme, but it doesn't have a full degree programme in meteorology[59]. After being introduced to meteorology and climatology they are taught several subjects related to climate change, such as environmental climatology, global climate change and agricultural climatology. This university has a Department for Meteorology as well.

Since 2016, the University of Szeged[60] has a meteorology specialization in its Earth Sciences Bsc course. Despite of not having a master's programme, many climatology courses are taught, and the university has a department for climatology and landscape ecology.

At the Hungarian University of Agriculture and Life Sciences an individual department has been established under the Institute of Environmental Sciences, namely the Department of Water Management and Climate Adaptation, offering several meteorology and climate related subjects on BSc and MSc level.

Óbuda University has a special interest in environmental engineering programme with both Hungarian and English courses at bachelor level. Under the Environmental Engineering and Natural Sciences Institute of the Rejtő Sándor Faculty of Light Industry and Environmental Engineering four specializations are run, focusing on global change and sustainable issues such as environmental management systems, environmental protection in the public administration, green energy, and municipal water management.

Since 2022, the Széchenyi István University offers the Agricultural Water Management and Environmental Technology Engineering bachelor's programme which focuses on agricultural water management and environmental technology methods which helps students to be able to participate in the development and implementation of climate adaptation solutions.

The Eszterházy Károly Catholic University (ECKU) has different research and education activities in climate change-related studies. Among the ongoing education programs the Geography BSc has a – nationally unique – specialization, named "Renewable Energy Resources". At the Geography MSc level a similarly unique specialization, the "Resource and Risk Analyst" is a traditional and popular education program.

At the ECKU, a new postgraduate specialist training course, named "Climate-change expert" will be started in September 2022 for staff members of different relevant interest groups (municipalities, corporations, NGOs). As an additional important higher education-related innovation, an education program was elaborated and started to operate in 2021. In the cooperation of the Corvinus University of Budapest (BCE) and the National Adaptation Knowledge Center of Hungary, a climate policy-related specialization was started after its

[59] https://ttk.unideb.hu/hu

[60] http://www.sci.u-szeged.hu/

curriculum and courses had been elaborated within the "regional and environmental economics" major. The responsible unit within BCE is Corvinus University's Department of Geography, Geo-economy, and Sustainable Development. The BCE has become the only university in Hungary where bachelor's and master's students can learn about the latest national and international climate policy improvements, including climate adaptation. The education of the first two courses (International, domestic, and urban climate policies; Climatology) within the specialization started in 2021; the second 2 courses (Climate policy related MRE; Environmental Assessment methodologies) started in thespring semester in 2022.

At PhD level, meteorology and climate related programmes can be found at the doctoral schools of earth sciences. Six universities[61], namely ELTE, the University of Debrecen, the University of Pécs, the University of Szeged, the University of Miskolc and the Budapest University of Technology and Economics have such doctoral school, however not all institutions have meteorological and climatic research topics.

9.3.2. Climate change-related studies in other degree programmes, programmes focusing on environmental issues

Degree programmes which focus on environmental issues, at both bachelor's and master's level as well as in PhD programmes continued to be more and more widespread at Hungarian universities and colleges. These courses can be found in a wide variety of faculties, for example natural sciences, engineering, economics, agriculture in the many universities and colleges of Hungary.

Some examples are the following:

- Environmental Sciences (both BSc and MSc level), an interdisciplinary programme with a strong focus on natural and life sciences.
- Environmental Engineering (both BSc and MSc level) familiarizes students with a wide range of environmental technologies relevant for areas such as waste management or nuclear safety.
- Landscape and Garden Engineering (BSc) and Landscape Architect (MSc) programmes have the objective to train modern landscape engineers, also focusing on sustainability issues.
- Geography (both Bsc and Msc level) is an interdisciplinary programme covering many branches of social and natural sciences, with the possibility to specialize in environmental research
- Agricultural-environmental Management Engineering (both BSc and MSc levels) combines agricultural studies with a strong focus on sustainability and protection of the environment

[61] https://doktori.hu/index.php?menuid=110&lang=EN

- Agricultural Water Management Engineering (MSc) focuses on sustainable integrated water management in the field of agriculture
- Regional and Environmental Economic Studies (MSc/MA) which prepares students to analyse ecological and social processes from an economic point of view.
- Agricultural Water Management and Environmental Technology Engineering (BSc) which prepares students to be able to participate in the development and implementation of climate adaptation solutions by using appropriate agricultural water management and suitable environmental technology methods.
- Rural Development Enginering (both BSc and MSc level) familiarizes students with the environmental and nature protection aspects of rural development and the related contexts of environmental policy.
- Climate change adaptation (engineering or specialist) specialisation programme (POSTGRAD), have to provide students with knowledge about local changes and anomalies resulting from global climate change that affect the population, businesses and other municipal, economic organisations and the infrastructure, moreover they will be able to develop costumised climate adaptation actions on macro scale.
- Agricultural Economics (MA) which prepares students to be capable of making comprehensive analysis regarding the domestic and international food sector and of solving complex development tasks.
- Supply Chain Management (MA) have the objective to train supply chain managers focusing on how to analyse and develop logistic processes effectively.
- Circular Economy Management (MSc) which prepares students to achieve a circular economy problem-solving and innovative systems-minded thinking.
- Business Economics (MSc) combines business economics with the economic-socio-ecological sense of sustainability and focuses on the principles of innovative developments in the economy.
- Design and Development Engineering for a Circular Economy (MSc) is an interdisciplinary programme with a strong focus on environmental regulation, quality management, consumer protection and product liability processes
- Biochemical Engineering (BSc, MSc) familiarizes students with the circular water and waste management and circular renewable practices related to energy management for the design of environmental technology systems.

The above-mentioned programmes are not specifically geared to climate change but usually include individual courses related to climate change either in the core curriculum or as elective subjects.

There are also several PhD programmes focusing on environmental research: Seven[62] Hungarian universities have established specific doctoral schools in the field of environmental

[62] https://doktori.hu/index.php?menuid=110&lang=EN

sciences. Eötvös Loránd University in Budapest, Corvinus University of Budapest, the University of Pannonia in Veszprém, the University of Debrecen, the University of Szeged, Hungarian University of Agriculture and Life Sciencies in Gödöllő and the University of Sopron.

The Wittmann Antal Multidisciplinary Doctoral School of Plant, Animal and Food Sciences of Széchenyi István University in Győr also has doctoral research themes related to climate change.

At the Eszterházy Károly Catholic University, the Doctoral School of Education has a branch of "Environmental Education" with a relevant focus on climate-change awareness-raising processes and methods.

At the ECKU the possibility of getting a "Green Diploma" (a branch of environment and climate-change-related subjects) is an opportunity for any students.

9.4. Awareness-raising

There are awareness-raising and educational projects on climate change in collaboration with the media which is supported by the Ministry of Energy:

The Big Student Climate Test was first organized in 2020 spring in partnership with the DUE Media Network. The aim of the Test was to survey and expand the awareness on sustainability and climate change among youth between the ages of 14-25. The first round of the game was an online test, or the participants could download an application for the easier access to the test. More than 30.000 students participated in this online game. The best 1000 students were invited to an in-person round, where they needed to provide answers on the stage to questions related to sustainability and climate change. After the huge success, the Second Big Student Climate Test was launched in December 2021 through spring 2022.

9.4.2. Complex campaigns for climate-consciousness

The Awareness Raising Plan identifies the main partners in climate action, where youth and education are mentioned as key stakeholders. Including climate aspects in education, having discussions and organizing school and university events on climate change raise climate awareness among students and teachers which is an essential part of combatting climate change.

- The following events and mechanisms are focusing on youth engagement in the framework of the above mentioned "Partnership for Climate" Awareness-Raising Plan.
- Youth's Climate Breakfast (Fiatalok Klímareggelije)
- On the 16th of September 2020 the Ministry of Energy invited representatives of organizations that transfer the importance of climate protection to the future generation and actively participate in shaping a sustainable future to the „Climate Breakfast" series of events in relation to the further development of the National Clean Development

Strategy. During the event the participants discussed the possible ways of achieving the 2050 climate neutrality target announced by the European Union, undertaken by Hungary as well, and reviewed the most important issues of the Hungarian long-term strategy, the National Clean Development Strategy.

- The Climate Breakfast was attended by Ms. Zsófia Rácz Deputy State Secretary for Youth of the Prime Minister's Office, and by the representatives of the Visegrad for Sustainability organization (V4SDG), the Youth Section of the Hungarian Energy Society, the Energy College of the Budapest University of Technology and Economics, the National Students' Union, and the Future is in Your Hands! project.
- Throughout the meeting the participants also discussed the importance of climate conscious individual choices. The representatives emphasized that environmental awareness could be increased through simple, clear and plain communication that would give a clear answer to the necessity of climate protection and would alleviate the increasing climate anxiety among young people. To achieve the ambitious goals, there is a need for comprehensive and long-lasting awareness-raising activities, where there is an important role for the youth and social media.
- The suggestions with additional remarks have been integrated to the National Clean Development Strategy.
- Climate-Friendly Open Day (Klímabarát Nyílt Nap)
- On the occasion of Earth Day, the Ministry for Innovation and Technology (currently: Ministry of Energy) organized a Climate-Friendly Open Day on the 26th of April 2019. More than forty vocational high-school students attended the one-day awareness-raising event. The aim of the Open Day was to emphasize the importance of climate protection, drawing the attention of the students to the fact that they themselves can do something to reduce the harmful effects.
- During the first part of the programme the staff of the National Adaptation Center of the Mining and Geological Survey of Hungary held a presentation to the students on the role of human activity in the environmental and climate change processes, what are the negative effects of this activity and what will these become in the future. With regard to this matter, participants discussed in more detailes, how the development of transportation has changed our lives. At the second part the staff of the Climate Policy Department made a presentation on the domestic climate protection activities, including the 2nd National Climate Change Strategy adopted by the Parliament in October 2018 and the main international mechanisms and trends. The students also had the opportunity to have an informal conversation with the Deputy State Secretary and the head of the Climate Policy Department. At the end of the program through a simulation session students each played the role of a country representative to get an insight of the international climate negotiation process. During the two-and-a-half-hour simulation they needed to make decisions regarding questions on how and by what amount will they reduce their CO2 emissions, how would they support reforestation and how would they use the financial resources provided through international climate finance.
- ACE Network, Burgenland ACE Declaration

- Action for Climate Empowerment (ACE) is a term adopted by the United Nations Framework Convention on Climate Change to denote work under Article 6 of the Convention and Article 12 of the Paris Agreement. The Doha Work Programme adopted at COP18 invites Parties to assign a National Focal Point in order to support the achievement of the overall goal of ACE: to empower all members of the society to engage in climate action through education, training, public awareness, public participation, and to strengthen the consultation between the society and governments on climate change matters. Within the ACE there is an emphasis on youth engagement since young people play a key role in shaping a sustainable, climate friendly future.
- The Hungarian ACE National Focal Point has contributed to awareness-raising activities including organizing the Climate-Friendly Open Day, giving presentations in schools, and participating in the international ACE processes. Hungary is one of the first countries who signed the regional Burgenland ACE Declaration in 2019 in order to emphasize the importance of awareness-raising and to strengthen the role of ACE in the region.

9.4.3. Regional and local level

According to Annex II. to Government Decree No. 1084/2016. (II. 29.), in the framework of the 2014-2020 Environmental and Energy Efficiency Operational Programme (EEE OP), call EEE OP 1.2.0., climate strategies for all counties and for the capital will be prepared. In addition climate platforms will be established.

Supported by call EEE OP 1.2.1., local authorities will have the possibility to submit tenders in connection with adaptation to the effects of climate change, risk prevention and improving public climate-consciousness. Within its framework municipal climate strategies, reaching out to 3 million people, will also be created.

9.5. Training

Several organisations in Hungary offer trainings related to climate change and a large number of conferences and expert workshops are taking place to address such topics. These are geared towards the general public, professionals and members of local authorities. Some major institutions and activities addressing this need are introduced below, but there are many more one-off or smaller-scale training activities taking place in addition to these.

Climate Policy Thematic Trainings – LIFE Capacity Building in Hungary (LIFE14 CAP/HU/000010 - LIFECapHUN)

The Hungarian Ministry for Innovation and Technology (currently: Ministry of Energy) and the Swedish Environmental Protection Agency implemented a project between November 2019 and July 2021 financed by the EU Technical Support Instrument with the aim of strengthening the implementation of Hungary's National Climate Change Strategy. One of the main goals of the project was to hold a climate change related training of trainers to environmental engineers and to governmental officers who are in charge of evaluation of environmental impact assessments. In February of 2021 we held this two-day online training with the help of the Swedish Environmental Protection Agency. The feedback on this training were very positive, our goal is to hold trainings to the governmental officers in the future.

The Hungarian Chamber of Engineers launched a climate protection verification system in 2021, which is a training for its members with exam. The Climate Policy Department of the Ministry of Energy used to actively participate in the training and hold presentations during these two-day courses.

In 2015 Hungary was awarded with a Capacity Building Project within the framework of the EU's funding instrument for the environment and climate action (LIFE). The coordinating beneficiary of the project is the Ministry of National Development, which is responsible for climate policy in Hungary. In line with the signed Grant Agreement, six thematic climate policy trainings already took place in the Ministry of National Development, three in 2016 and three in 2017. Another two trainings are scheduled for 2018.

These were the following:

- 1st Climate Policy Training – General knowledge sharing on LIFE Climate Action sub-programme (28th April 2016)
- 2nd Climate Policy Training – Brainstorming on project ideas (30th June 2016)
- 3rd Climate Policy Training – Thematic training on Climate Change Adaptation (1st September 2016)
- 4th Climate Policy Training – Knowledge sharing on Climate Change and awareness-raising and LIFE Climate Governance and Information projects (16th February 2017)
- 5th Climate Policy Training – Knowledge sharing on LIFE Climate Change Mitigation projects and brainstorming on project ideas (13th April 2017)
- 6th Climate Policy Training – Changes and novelties in the new LIFE Multiannual Work Programme for 2018-2020 (11th December 2017)

In the near future, the National Adaptation Division of the Western Balkans Green Centre is planning to have two training projects. One is an educational programme about NAGiS, which will be held for local authorities, policy makers and registered users. The other targets mayors and is connected to the climatic aspects of municipal strategic planning. In the latter, NGOs with relevant experience will be involved as well. Guidelines for residents about adaptation to the effects of climate change have also been prepared within the framework of NATéR/NAGiS project, which are also available on the website (nagis.hu).

Energia Klub (Energy Club)

Its main goal is to provide information to the public and plays a role in education, be it trainings related to civil service, elementary school education or presentation of a project arranged according to the requirements of the actual administration.[63] Energia Klub also had a training for members of local governments addressing the issues of climate change on a municipal

[63] http://energiaklub.hu/szolgaltatasok

level. In recent years, the Energy Club has helped local governments in more than 20 Hungarian settlements to prepare a local Sustainable Energy Action Plan (SEAP). The organization implemented a number of projects, including training for energy-conscious workers, promoting awareness-raising in kindergartens and supporting the energy modernization of homes as part of the RenoHUb project.

Hungarian Green Buildings Council (HuGBC)64

Provides trainings for engineers with the main message of environment and energy friendly design, also, on building evaluation.

Based on the experience of 2019/2020, HuGBC has compiled an online training material for construction industry professionals who want to learn about and apply the environmentally conscious approach comprehensively in their profession.

The Green Talk series of events was launched in 2012 and has been held regularly since then to share ideas and good practices that drive innovative, green and sustainable, people-oriented construction.

KÖVET (Association for Sustainable Economies)

One of the main goals of KÖVET, a non-profit organisation and Hungarian member of the International Network for Environmental Management (INEM), is training and education for companies about sustainable development, including climate change mitigation, through conferences, seminars and publications. One of their most successful programmes is "Green Office", which comprises of distance learning materials on improving workplace sustainability and a yearly competition among offices for the most successful greening efforts. This scheme is supported by the Leonardo da Vinci programme of the European Union.

The association launched the "Pass Back Brother!" campaign, which will continue in 2022. The aim of the campaign is to collect used mobile phones and use them to save habitats from destruction.

In the period from 2018 to 2020, KÖVET participated in the Assistance of Local Energy Saving Collaborations. The overarching goal of the project is to explore cost reduction opportunities in the use of energy, water and materials, as well as wastewater and waste, in order to reduce greenhouse gas emissions.

KÖVET actively participates in the promotion of the ETV - voluntary environmental certification scheme in Hungary, which provides technology providers, purchasers, regulatory organizations, authorities, investors and support organizations with independent and reliable evidence of the performance and benefits of innovative environmental technologies. The certification system was introduced by the European Commission. The LIFEproETV program (2020) aims to make ETV Europe's leading certification scheme for innovative environmental technologies.

HuPCC (Hungarian Panel on Climate Change)

[64] www.hugbc.hu

In November 2018, the HuPCC was established based on the model of the United Nations Intergovernmental Panel on Climate Change (IPCC). The aim of this Hungarian, independent, non-profit organization is to summarize the latest research results related to climate change in Hungary in scientific evaluation reports and to present them at cross-disciplinary conferences. In terms of its target audience, it is mostly policy and municipal decision-makers who are involved in defining the topics of the report, peer reviewing it, and finalizing it. In April 2021, the First National Interdisciplinary Scientific Conference on Climate Change was organized by the HuPCC. Almost three hundred lectures were given at the online event, which also covered the basics of science, impacts, adaptation and mitigation.

Ministry for Innovation and Technology (currently: Ministry of Energy) *- Planet 2021*

With the support of MIT, the Planet Budapest 2021 Sustainability Expo and World Meeting on the joint sustainable development of the Visegrad countries was held in 2021. It aimed to raise public awareness of adverse environmental, social and economic developments and to show that these negative changes are still reversible.

Institute of Climate Policy

In 2020, the Institute of Climate Policy was established, which examines environmental protection and climate protection issues at the domestic level. The institute has sought to create the most complex group of experts possible, so that biologists, environmental lawyers, agricultural engineers, economists, energy specialists and social researchers work together to achieve common goals. In addition to research, the institute places great emphasis on educational and dissemination activities and organizes community actions.

Association of Climate-Friendly Municipalities

More than 80 local governments belong to the Association, their common goal is to share good practices and opportunities for adaptation to climate change and help each other. The Association intends to support its partners with professional conferences, trainings, lectures and a monthly newsletter with application opportunities and professional news. In 2020, it launched the Climate-Friendly Award competition, where award-winning municipalities receive professional training and comprehensive communication support. For the population and non-governmental organizations interested in the environment and climate protection, the Association will also announce the Climate-Friendly Photo Competition every year from 2021 onwards.

Hungarian Chamber of Engineers

The Environmental Protection Section of the Hungarian Chamber of Engineers regularly organizes further training for its members entitled The Methodology of Climate Protection Analysis of Environmental Investigations. In addition, in recent years, several guidelines have been developed on the subject of climate change, which are available on their website.

ANNEX I. SPECIFIC RESEARCH ACTIVITIES OF THE EÖTVÖS LORÁND RESEARCH NETWORK (ELKH) RELATED TO CLIMATE CHANGE

I.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Centre for Agriculture Research	Agricultural Institute	1	The basis of physiological, genetic and production biological tolerance against abiotic stress caused by climate change	2005	2021.
		2	The genetic foundations of environmental adaptation and its correlation with fruiting	2008	2015.
		3	Identifying epidermal traits suitable for identifying the drought tolerance of wheat	2010	2013.
		4	Effects of heat stress, drought stress and heat and drought co-stress on vegetative and reproductive development in cereals	2014	2026.
		5	Research on improving climate change adaptability of wheat	2016	2018.
		6	Effect of heat stress on meiotic stabilisation and fertilisation of wheat	2017	2021.
		7	Effects of climate change related extreme weather events on agriculture and the possibilities for compensation in the upcoming centuries	2012	2015.
		8	Research on maize drought tolerance – DROPS project	2011	2015.
		9	Studying the genetic background of chilling tolerance of maize	2017	continuous
		10	Studying the effects of UV-B radiation on the physiological properties of maize	2000	continuous
		11	Effects of heat and drought stress on the content and composition of wheat fiber	2010	2014.
		12	Effects of drought stress on the content and compositions of wheat/Aegilops additive lines fiber	2014	2018.
		13	Plants that can be utilized in multiple ways as alternatives in the service of sustainable agriculture which can adapt to the changing climate	2017	2021.
		14	Developing strategies to improve the sustainability of agricultural productivity under changing environmental and economic conditions	2017	2021.
		15	Comprehensive analysis of changes in global gene expression, full metabolome, lipid and hormone content to elucidate the mechanisms of light induced frost tolerance in cereals and in lower model plants	2018	2022
		16	Development of integrated and sustainable cropping systems and breeding of eco-stable maize hybrids and cereal varieties	2021	2025
		17	Studying the water demand and water use efficiency of cereals completed with the in-situ determination of the root development	2017	continuous
		18	Interdisciplinary Research Group for Promoting Climate-Smart and Sustainable Agriculture	2017	2022
	Plant Protection Institute	19	Alien invasive species appearing due to climate change	1985	continuous
		20	Effects of heat and drought stress	2017	continuous
		21	Studying diseases brought in by vectors which appear due to climate change	2017	continuous
	Institute for Soil Science	22	Innovative utilization of the energy and raw material content of municipal wastewater and sewage sludge	2017	2023
		23	Indication of soil organic carbon stock quality	2021	2023
		24	Spatial redistribution of organic matter and soil moisture in a small watershed and their impact on greenhouse gas emissions	2019	2023
		25	WJPI An integrative information aqueduct to close the gaps between global satellite observation of water cycle and local sustainable management of water resources - iAqueduct	2019	2022
		26	OPtimal strategies to retAIN and re-use water and nutrients in small agricultural catchments across different soil-climatic regions in Europe - OPTAIN	2020	2025
		27	European Joint Programme on agricultural soil management	2020	2025
		28	TUdi -Transforming Unsustainable management of soils in key agricultural systems in EU and China. Developing an integrated platform of alternatives to reverse soil degradation	2021	2025

		29	Laying the foundations for the introduction of the measures set out in the National Air Pollution Reduction Programme (establishing the conditions for carbamid application, examining the role of agrotechnical factors and nutrient utilisation)	2022	2022
		30	Definition of data needs based on cooperation with the LRTAP Convention Impacts Working Group, participation in international modelling work and preparation of sensitivity maps for 2022 to establish critical load exceedances	2022	2022
		31	National Laboratory for Water Science and Water Safety	2022	2026

II.	Project	Number	Subject of the research	Start of research period	End of research period
Institute for Nuclear Research	Isotope Climatology and Environmental Research Project/ Climatology-palaeoclimatology	32	Carbon in the atmosphere (greenhouse gases and aerosol). Besides CO2, other components like carbon monoxide, methane and aerosol will be investigated focusing on the 13C and 14C isotope composition.	2016.	continuous
		33	High precision carbon isotope analyses of tree rings sequences of thousands of years		
		34	The reconstruction of climatic events and human impact in the past 15 kyr preserved by the sediments, accumulated in high mountain lakes.		
		35	Water temperature reconstruction for the late Miocene Pannonian Lake.		
		36	Paleoclimate reconstruction with carbonate formations from caves		
		37	Analysis continental ice layers: age profiling and searching for the link between cosmogenic tritium and the solar cycle		
		38	Exposure age dating of rock surfaces using in-situ produced cosmogenic C-14 nuclide for a better understanding of past landscape evolution and laboratory development		
		39	Research on buried paleosoils- the reconstruction of climatic and environmental changes occurred during/around the termination of the last glacial period and early Holocene.		
		40	Relation between extinction times of the megafauna members and environmental and climate changes.		
		41	Reconstruction of the changes in the Tethys Ocean during the Triassic, Jurassic and Cretaceous period.		
	Isotope Climatology and Environmental Research Project / Hydrology-palaeohydrology	42	Palaeoclimate reconstruction using groundwater as an archive		
		43	Changes in the age distribution of the water bases of Great Plain influenced by the extraction of water.		
		44	Studying the drivers of isotope composition of the water cycle		
		45	Change of groundwater discharge to River Tisza during the climate change in the previous decades		
	Isotope Climatology and Environmental Research Project / Geochemistry-Environchemistry-Geology	46	Identification and characterization of atmospheric aerosol sources and their contributions.		
		47	Studying the subsidence and exhumation history of the crystalline basement of the Great Hungarian Plain		
		48	Studying upper mantle rocks – exploring the small- and large –scale heterogeneity and defining their origin, consequences and evolution of volatiles		

III.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Research Centre for The Humanities	Institute of Ethnology	49	International Arctic Science Committee; International Permafrost Association; Permafrost and Culture Action Group	2014.	2016.
		50	The role of traditional ecological knowledge in natural resource management	2009.	2020.

IV.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Research Centre for Astronomy and Earth Sciences	Geography Research Institute	51	Biosphere lithosphere interaction (Geography research group)	2019	2021
		52	Quaternary and evolution of the surface (Research group for Quaternary and evolution of the surface)	2019	2021
		53	Recent climate research related to the role of the atmospheric mineral powder (Quaternary and evolution of the surface research group)	2019	2021
	Institute for Geological and Geochemical Research	54	Application of the geochemistry in palaeoclimatology	2019	2021
	Konkoly Observatory	55	Solar physics, terrestrial impact of cosmic effects and risks	2019	2021
	Research action carried out under the direct management of the research center	56	Water quality monitoring and management	2019	2021

V.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Centre for Economic and Regional Studies	Institute for Regional Studies	57	REGPHOSYS Photovoltaic systems as Actuators of Regional Development IPA HUHR 1101/2.1.3/0002	2007	2014
		58	SEERISK – Joint Disaster Management Risk Assessment and Preparedness in the Danube Macro-Region SEE/C/0002/2.2/X	2012	2014
		59	Long-term socio-economic forecasting for Hungary (NATéR)	2015	2015
		60	Long-term regional socio-economic forecasting for Hungary: developing a regional model on Hungarian datas (NATéR)	2016	2019
		61	Depopulating areas in Bulgaria and Hungary – impacts of depopulation on the changes of rural settlements and their environment	2016	2018
		62	NATURVATION – NATure-based Urban innoVATION	2016	2020
		63	REPAiR H2020 Resource Management in Peri-urban areas: Going Beyond Urban Metabolism	2017	2020
		64	RURES Renewable energy sources and energy efficiency in a function of rural development HUHR/1601/3.1.1/0033	2017	2018
		65	The effects of suburbanization, urban sprawl on the environmental change of suburbs in Central European middle-sized urban regions	2018	2022
		66	Potention of building up networks of energy-efficiency in Hungary	2019	2020
		67	The Urban Systems in the Age of Globalization. Geographical Studies with focus on Hungarian and Romanian Cities	2019	2021
		68	European Shrinking Rural Areas: Challenges, Actions and Perspectives for Territorial Governance	2019	2021
		69	WaterSteam: Landscape, water and active citizenship: a nature-based STEAM teaching methodology	2019	2022
		70	Opportunities of climate adaptation in Hungary	2021	2023
		71	Developing of a monitoring network in urban ecology	2021	2022

		72	Environmental effects of the urban and rural sprawl around the middle-sized cities in Hungary and Bulgaria	2022	2024
		73	Cross-border Cooperation in the Middle and Lower Danube Basin. Geographical Studies with focus on Hungarian and Romanian Danubian Cities	2022	2024
		74	Strengthening Social Sciences & Humanities (SSH) for Climate, Energy aNd Transport Research Excellence, Horizon Europe	2022	2025
		75	P2GreeN Closing the gap between fork and farm for circular nutrient flows, Horizon Europe	2022	2025
		76	The development processes of Central and Southeast European cities	2020	2023
	Institute of Economics	77	The effect of changing climate on birth outcomes and mortality in Hungary	2017	2021
		78	Climate change and human health in Hungary	2021	2024
		79	Impacts of climate change on Hungarian agriculture: a complex view	2020	2024
	Institute of World Economics	80	Just Transition in the European Car Industry: Combining climate change mitigation with social justice by setting a just transition of the European car industry in motion	2020	2023

VI.	**Research Institute**	**Number**	**Subject of the research**	**Start of research period**	**End of research period**
Centre for Ecological Research	Institute of Ecology and Botany	81	Experimental study of the ecological effects of extreme droughts and long-lasting precipitation change	2014.	continuous
		82	The effect of the drought and soil disturbance in terms of the success of invasive plant species	2016.	continuous
		83	The ecological effect of the drought and warming in a sand steppe	2001.	continuous
		84	The effect of different forestry management on micro-climate	2014.	continuous
		85	Change of pasture vegetation in Mongolia and its perception by local traditional herders	2017	continuous
		86	Effect of weather fluctuation on grasslands: community and species-level approach	2021	2024
		87	Bridging the gap between an applied map and the scientific needs: how to visualize plant hardiness zone maps, their differences and their uncertainties?	2020	continuous
		88	Hotspots of climate discontinuity – global assessment of CMIP6 predictions for impact modelers	2020	continuous
		89	Assessment of climate analogy for vegetation between future climates of Hungary and current climate of surrounding areas	2021	continuous
		90	Assessment of future potential natural vegetation of Hungary	2021	continuous
		91	The ecological background and consequences of the emergence and spread of invasive species in Hungary	2019	continuous
	Institute of Aquatic Ecology	92	The examination of phytoplankton in Danube	1979	continuous
		93	Modelling of the effects of climate change on surface waters	2018	continuous
		94	Effect of climate change-related drought on structuring aquatic macroinvertebrate communities	2020	2025
		95	Modelling the effects of climate change on growth strategy of native and alien aquatic plants	2018	2023
		96	Benthic algal composition-extreme climatic events' relations in the Carpathian Basin	2019	2024
		97	Smart monitoring of intermittency in small streams	2022	2022
		98	Influence of extreme water regime on benthic communities - benthic algae in crosshairs	2020	2023

		99	Community-level responses of plankton to climate change based on mesocosm experiments	2019	continuous
		100	Interaction of climate change and invasive aquatic species	2020	continuous
		101	Tree hole biodiversity and the role of management across climatic gradients	2021	continuous
	Institute of Evolution	102	Effect of climate change on emerging infectious diseases	2018	continuous
		103	Monitoring ticks and tick-borne pathogens emerging due to climate change	2018	continuous
		104	Climate crisis, inequality, social dilemmas	2020	continuous

VII.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Centre for Social Sciences		105	Climate change and health	2020	2021
		106	10 years after. The social consequences of the red sludge disaster in Hungary	2020	2020.
		107	The sociology of the urban planning – urban planning and society	2017	continuous
		108	Sustainable consumption patterns,behavioral strategies and knowledge use in the Hungarian society. A social scientific analysis of sustainable food and energy consumption	2021	2024
		109	Rural resilience and local identity: Qualitative and quantitative analysis of the relationship between rural image, local identity, and living strategies in the Hungarian countryside	2020	2023
		110	Ruptures in Hungarian social structure: impacts of consumption, institutions and territorial differences	2018	. continuous
		111	IJOTEN Online Legal Encyclopedia – Environmental law - editor	2021	continuous
		112	Precision agriculture and AI	2021	continuous
		113	Ruralization: The opening of rural areas to renew rural generations, jobs and farms	2019	2023
		114	Co-deciding Europe: Working together for a green, competitive and inclusive Europe.	01/01/2022	31/12/2022
		115	"Circular City Re.Solution": Implementing nature based solutions for creating a resourceful circular city	2018	2022s
		116	European Network for Environmental Citizenship	2018	2022
		117	Climate activism in Austria and Hungary	2019	continuous

VIII.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Research Center for Natural Sciences	Institute of Materials and Environmental Chemistry	118	Development of components for Proton Exchange Membrane (PEM) fuel cells	2022.	2026.
		119	Investigation of thermal decomposition of biomass	2022.	2026.
		120	Research and development of biorefinery technologies	2022.	2026.
		121	Development of phase-change heat storage materials and processes	2022.	2026.
		122	Research and development of new generation of batteries	2022.	2026.
		123	Solid phase storage of hydrogen	2022.	2026.

IX.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Centre for Energy Research	Surface Chemistry and Catalysis Lab	124	Water oxidation, Oxygen Evolution: The main focus of this project is the development of new first row transition metal compounds to be utilized in efficient electro- and photoelectrochemical systems as water oxidation catalysts. A fundamental part of the work aims at the morphology preserving and gentle grafting of these catalysts onto electrode surfaces and their operando and post-catalytic analysis.	2014	
		125	New Electrodes for Hydrogen Evolution Reaction In this project we develop new type of electrocatalysts for Electrochemical water splitting based on 2D materials. The aim to reach the efficiency of the platinum, with catalysts lack of platinum, or with strongly decreased content of platinum.	2016	
		126	Reducing carbon dioxide (CO2) emissions by prioritizing the diversification of energy resources is a great challenge for world economy. Two catalytic methane conversion processes may contribute to resolve this problem. The catalytic dry reforming of methane (DRM: CH4+CO2⇌2CO+2H2) is of high importance in mitigation of CO2 via transforming the two greenhouse gases, CO2 and CH4, into value-added products through synthesis gas formation. Methane pyrolysis is a perspective alternative method for hydrogen and carbon by-product production without formation of carbon oxides (CO2 and CO). The recent dominant technology of methane steam reforming produces large volume CO2 with hydrogen.	2020	

X.	Research Institute	Number	Subject of the research	Start of research period	End of research period
Office of Supported Research Groups	Evolution Ecology Research Group	127	Effects of urbanization, climate change and social surroundings on the evolution of behavioural and reproductive characteristics	2017.	2022.
	Atmospheric Chemistry Research Group	128	Expected effects of climate change on air quality	2017.	2022.

Specific research activities of the Hungarian Academy of Sciences related to climate change

Multidisciplinary, synthetic approach to climate change and the associated sustainability issues
In 2021 a new committee was formed at the Hungarian Academy of Sciences under the name "Presidential Committee for Sustainable Development". The committee operates with a multidisciplinary approach and aims to discuss matters of sustainability and make prudent recommendations for scientists and policy-makers while it promotes the mutual understanding of different actors in the field.

The working groups of the Presidential Committee for Sustainable Development and their respective focus are as follows:

Agriculture and food security
Hungary has a high agricultural potential that is expected to be threatened by an especially strong climate change. Several steps should be taken to maintain diversified and appropriately modified and also biodiversity-friendly food production and its preconditions (e.g. even water supply).

Biodiversity

The world is suffering from a new wave of Mass Extinction. Measures should be taken to ensure that ecosystem services do not decline further. This includes fighting against harmful pioneer species, unsustainable investments and short-term profit maximization.

Health
Climate change is a main driver behind Emerging Infectious Diseases. A key goal is the implementation of the DAMA protocol (Document, Assess, Monitor, Act). In short "anticipate to mitigate", or "prevention is better than cure", but now applied at the epidemiological level. Modernization of the entire health system is urgent.

Energetics
Hungary is not rich in sources of energy. Diversification of international sources and green energy production are enormous challenges that we have to meet. CO2 production should be reduced significantly and as fast as possible. Planning a manageable transition to green energy is far from trivial.

Sustainable Economy
Circular economy is one of the targets. Incentive systems (e.g. promoted by the Hungarian National Bank) are seen as one of the key necessary developments.

Sustainable Society
Climate change is not reversible, but mitigation of its adverse effects is possible. It seems that without adequate self-restraint on behalf of all stakeholders (from individuals up to governments) is a necessary step. Such a transformation is difficult since it affects every segment of societal life from education through psychology to national politics. Appropriate legal instruments must be strengthened and developed. The fact of urgency makes this challenge even bigger.

Climate
Hungary is especially expected to suffer from climate change. An indispensable task is the increase in the awareness of the population of what this entails, and that some measures are necessary in order to mitigate the consequences.

Water security
Hungary receives considerable fresh water from incoming rivers. Avoiding even mild and more so catastrophic pollution is a daunting task that necessitates international collaboration. Protection of water reservoirs below ground level is a major task. Storage of waters from flash floods calls for massive investment in appropriate infrastructure. Protection of big lakes (including Balaton) against drought, pollution and overuse by tourists and builders is mandatory.

National Programme for Sustainable Technology of the Hungarian Academy of Sciences
The Hungarian Academy of Sciences has announced a programme to boost research for multidisciplinary technological development (including societal aspects) in the service of sustainability. The national programme is being launched in 2022 with a duration of 4 years and with an annual budget of 1 billion HUF with the participation of several universities and research institutes.

ANNEX II. FIFTH BIENNIAL REPORT

1. Information on greenhouse gas emissions and trends

In 2021, total emissions of greenhouse gases in Hungary were ***64.2 million tonnes*** carbon dioxide equivalents (CO_2-eq) excluding the LULUCF sector. (For the first time, GHGs were aggregated applying the global warming potentials from the IPCC Fifth Assessment Report.) Taking into account also the mostly carbon absorbing processes in the LULUCF sector, the net emissions of Hungary were 57.0 million tonnes CO_2-eq in 2021. Being about 6 tonnes, the Hungarian per capita emissions are below the European average.

For more detailed information, please see chapter 3 of the 8th National Communication of Hungary.

In 2015, the division responsible for inventory compilation within the Hungarian Meteorological Service was renamed to Unit of National Emissions Inventories. Apart from that, there have been no other changes since the last submission.

2. Quantified economy-wide emission reduction target (QEWER)

2.1. The EU's target under the Convention until 2020

Hungary's emission reduction target under the Convention is part of the joint target of the European Union.

In 2010, the EU submitted a pledge to reduce its GHG emissions by 2020 by 20 % compared to 1990 levels, in order to contribute to achieving the ultimate objective of the UNFCCC: 'to stabilise GHG concentrations at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system'[65], or, in other words, to limit the global temperature increase to less than 2°C compared to temperature levels before industrialization (FCCC/CP/2010/7/Add.1). The EU had also committed to raising this target to a 30 % emission reduction by 2020 compared with 1990 levels, provided that other developed countries also commit to achieving comparable emission reductions, and that developing countries contribute adequately, according to their responsibilities and respective capabilities. This offer was reiterated in the submission to the UNFCCC by the EU-28 and Iceland on 30 April 2014.

The definition of the Convention target for 2020 is documented in the revised note provided by the UNFCCC Secretariat on the 'Compilation of economy-wide emission reduction targets to be implemented by Parties included in Annex I to the Convention' (FCCC/SB/2011/INF.1/Rev.1 of 7

[65] First steps to a safer future: Introducing the United Nations Framework Convention on Climate Change http://unfccc.int/essential/_background/convention/items/6036.php

June 2011). In addition, the EU provided additional information relating to its quantified economy wide emission reduction target in a submission as part of the process of clarifying the developed country Parties' targets in 2012 (FCCC/AWGLCA/2012/MISC.1).

The EU’s accounting rules for the target under the UNFCCC are more ambitious than the current rules under the Kyoto Protocol, for example, including international aviation, and adding an annual compliance cycle for emissions under the Effort Sharing Decision (ESD; see section 2.2.1 of the EU’s 3rd Biennial Report) or higher Clean Development Mechanism (CDM) quality standards under the EU Emissions Trading System (EU ETS) (FCCC/TP/2013/7). Accordingly, the following assumptions and conditions apply to the EU's 20 % target under the UNFCCC:

- The EU Convention pledge does not include emissions/removals from Land Use, Land Use Change and Forestry, but it is estimated to be a net sink over the relevant period. EU inventories also include information on emissions and removals from LULUCF in accordance with relevant reporting commitments under the UNFCCC. Accounting for LULUCF activities only takes place under the Kyoto Protocol.
- The target covers the gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.
- The target refers to 1990 as a single base year for all covered gases and all Member States. Emissions from international aviation to the extent it is included in the EU ETS are included in the target[66].
- A limited number of CERs, ERUs and units from new market-based mechanisms may be used to achieve the target (see section 2.2.2.3): in the ETS, the use of international credits is capped (up to 50 % of the reduction required from EU ETS sectors by 2020). Quality standards also apply to the use of international credits in the EU ETS, including a ban on credits from LULUCF projects and certain industrial gas projects. In the ESD sectors, the annual use of international credits is limited to up to 3 % of each Member State's ESD emissions in 2005, with a limited number of Member States being permitted to use an additional 1 % from projects in Least Developed Countries (LDCs) or Small Island Developing States (SIDS), subject to conditions.
- The Global Warming Potentials (GWPs) used to aggregate GHG emissions up to 2020 under EU legislation were those based on the Second Assessment Report of the IPCC when the target was submitted. In accordance with the CMP Decision to revise the GWPs to those from the IPCC Fourth Assessment Report (AR4) revised GWPs from AR4 were adopted for the EU ETS. The revised GWPs were taken into account for the revision of the ESD target. For the implementation until 2020, GWPs from AR4 will be used consistently with the UNFCCC reporting guidelines for GHG inventories.

Parameters	Target

[66] In the EU, the sum of emissions covered by categories 1.A.3.a 'domestic aviation' and memo item 'international bunkers - aviation' go beyond the scope of the EU target, as emissions from international aviation are included in the EU Climate and Energy Package and the EU target under the UNFCCC to the extent to which aviation is part of the EU ETS.

Base Year	1990
Target Year	2020
Emission Reduction target	-20% in 2020 compared to 1990
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6
Global Warming Potential	AR4
Sectors Covered	All IPCC sources and sectors, as measured by the full annual inventory and international aviation to the extent it is included in the EU ETS.
Land Use, Land-Use Change, and Forests (LULUCF)	Accounted under KP, reported in EU inventories under the Convention. Assumed to produce net removals
Use of international credits (JI and CDM)	Possible subject to quantitative and qualitative limits.
Other	Conditional offer to move to a 30% reduction by 2020 compared to 1990 levels as part of a global and comprehensive agreement for the period beyond 2012, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.

Table Key facts of the Convention target of the EU-28

2.1.1. The EU's target compliance architecture

2.1.1.1. The 2020 climate and energy package

In 2009 the EU established internal rules under its "2020 climate and energy package"[67] - these underpin the EU implementation of the target under the Convention. The package introduced a clear approach to achieving the 20 % reduction of total GHG emissions from 1990 levels, which is equivalent to a 14 % reduction compared to 2005 levels. This 14 % reduction objective is divided between the ETS and ESD sectors. These two sub-targets are:

- a 21 % reduction target compared to 2005 for emissions covered by the ETS (including domestic and international aviation);
- a 10 % reduction target compared to 2005 for ESD sectors, shared between the 28 Member States (MS) through individual national GHG targets.

Under the revised EU ETS Directive (Directive 2009/29/EC), a single ETS cap covers the EU Member States and three participating non-EU countries (Norway, Iceland and Liechtenstein), and

[67] http://ec.europa.eu/clima/policies/package/index_en.htm

there are no further individual caps by country. On 1 January 2020, Switzerland became the first country to successfully link its greenhouse gas emissions trading system with the EU emissions trading system (EU ETS). After the BREXIT, a "UK Emissions Trading Scheme (UK ETS)" replaced the UK's participation in the EU ETS on 1 January 2021. Allowances allocated in the EU ETS from 2013 to 2020 decrease by 1.74 % annually, starting from the average level of allowances issued by Member States for the second trading period (2008–2012). For more information on ETS and on the recent changes please see section 3.2 of the EU's 3rd Biennial Report.

About half of the emissions within the EU which fall outside the scope of the EU ETS are addressed under the Effort Sharing Decision (ESD) (Decision No 406/2009/EC). The ESD covers emissions from all sources outside the EU ETS, except for emissions from domestic and international aviation (which were included in the EU ETS from 1 January 2012), international maritime emissions, and emissions and removals from land use, land-use change and forestry (LULUCF). It thus includes a diverse range of small-scale emitters in a wide range of sectors: transport (cars, trucks), buildings (in particular heating), services, small industrial installations, fugitive emissions from the energy sector, emissions of fluorinated gases from appliances and other sources, agriculture and waste. Such sources accounted for 55 % of total GHG emissions in the EU in 2013[68].

While the EU ETS target is to be achieved by the EU as a whole, the ESD target was divided into national targets to be achieved individually by each Member State (see Figure 3-2). Under the Effort Sharing Decision, national emission targets for 2020 are set, expressed as percentage changes from 2005 levels. These changes have been transferred into binding quantified annual reduction targets for the period from 2013 to 2020 (Commission Decisions 2013/162/EU and 2013/634/EU), denominated in Annual Emission Allocations (AEAs). At country level, 2020 targets under the ESD range from -20 % to +20 %, compared to 2005 levels.

The target levels have been set on the basis of Member States' relative Gross Domestic Product per capita. In addition, different levels of development in the EU-28 are taken into account by the provision of several flexibility options. Up to certain limitations, the ESD allows Member States to make use of flexibility provisions for meeting their annual targets: carry-over of over-achievements to subsequent years within each Member State, transfers of AEAs between Member States and the use of international credits (credits from Joint Implementation and the Clean Development Mechanism). MS exceeding their annual AEA, even after taking into account the flexibility provisions and the use of JI/CDM credits, will face inter alia a penalty – a deduction from their emission allocation of the following year (excess emissions, multiplied by 1.08).

Under the ESD Hungary can increase its emissions by 10% compared to the 2005 level.

[68] European Commission. Commission Staff Working Document - Accompanying the document: Report from the Commission to the European Parliament and the Council on evaluating the implementation of Decision No. 406/2009/EC pursuant to its Article 14. (SWD(2016) 251 final). 2016. https://ec.europa.eu/transparency/regdoc/rep/10102/2016/EN/10102-2016-251-EN-F1-1-ANNEX-1.PDF

Country	Annual Emission Allocation (tonnes of carbon dioxide equivalent)							
	2013	2014	2015	2016	2017	2018	2019	2020
Hungary	50 398 977	51 516 636	52 634 296	53 751 955	50 064 250	50 986 355	51 908 461	52 30 567

2.2. The EU's target under the Convention until 2030

The Climate and Energy Framework of the European Union until 2030 was put in place to ensure that the EU and its Member States achieve their climate change mitigation commitments under the Paris Agreement. The European climate law makes reaching the EU's climate goal of reducing EU emissions by at least 55% by 2030 a legal obligation. EU countries are working on new legislation to achieve this goal and make the EU climate neutral by 2050.

A comprehensive set of proposals was presented by the European Commission in July 2021. The key elements of these proposals are:

- more rapid emission reductions in the period up to 2030 under the EU ETS;
- a strengthening of the emission reductions to be achieved by EU Member States by 2030 under the Effort Sharing Regulation;
- The Commission aims to strengthen the contribution of the land use, land-use change and forestry (LULUCF) sector to the EU's increased overall climate ambition. It is necessary to reverse the current declining trend of carbon removals and enhance the natural carbon sink throughout the EU.
- simplify the rules on accounting and compliance and enhance monitoring
- strengthened renewable energy and energy efficiency targets;
- various updates to existing legislation, such as stricter CO_2 emission standards for cars and
- new proposals, including a carbon border adjustment mechanism and a social climate fund.

Based on the above mentioned Climate and Energy Framework of the European Union, the following table provides an overview of the main elements.

Parameters	Target
Base Year	1990
Target Year	2030

Emission Reduction target	**Originally:** at least -40%, **Updated:** at least -55%
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3
Global Warming Potential	IPCC AR5
Sectors Covered	All IPCC sources and sectors, as measured by the full annual inventory and aviation within the scope of the EU ETS included (practically all aviation included)
Sectors affected	Energy, industrial processes and product use, agriculture, waste, LULUCF
Use of international credits (JI and CDM)	Excluded
Other	-

2.3. 2030 and -2050 EU-targets

Hungary's mitigation actions, as a Member State of the European Union, are determined to a great extent by the policies and regulations of the EU. The European Union's climate policy is guided by two major objectives: to reduce net greenhouse gas emissions by at least 55% by 2030, and to achieve climate neutrality in the EU by 2050.

At its October 2014 meeting, the European Council committed to reducing the EU's total greenhouse gas emissions by at least 40% gross by 2030 compared to 1990 levels. In December 2019, the European Commission adopted the Communication on the European Green Deal, which proposes the EU-wide goal of becoming climate neutral by 2050 and sets out a roadmap for the transition to a clean, circular economy. Meanwhile, at the European Council in December 2019, heads of state and government also set the EU-level target to achieve climate neutrality by 2050. In December 2020, the European Council agreed to increase the EU's 2030 climate target to at least -55% net emission reductions, compared to 1990 levels, a substantial improvement from the previous -40% target.

The 2050 climate neutrality goal and the new 2030 target have since been enshrined in EU legislation, in the so-called European Climate Law [Regulation (EU) 2021/1119 of the European Parliament and of the Council].

In July 2021, the European Commission adopted a series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050, including the new EU-wide intermediate target of an at least 55% net reduction in greenhouse gas emissions. The "Fit for 55" package aims to revise all relevant policy instruments. The Commission proposals are still under discussion by the member states. The legal acts under the Fit for 55! package are expected to be formally adopted in 2023.

Beyond the EU legislation the National Climate Change Strategy gives a framework to the country's climate policy.

2.4. Monitoring on progress to EU and Member State targets

For the monitoring of GHG emissions at the EU and the Member State level, the Monitoring Mechanism Regulation has been adopted. Also for the effective operation of the EU ETS, robust, transparent, consistent and accurate monitoring and reporting of greenhouse gas emissions are essential, therefore an annual procedure of monitoring, reporting and verification (MRV) at the installation level is implemented. For a description of the requirements contained therein, please refer to the EU's second Biennial Report. Installation and aircraft operators have to monitor, report and verify their annual emissions in accordance with two EU Regulations, the Monitoring and Reporting Regulation (MRR) and the Accreditation and Verification Regulation (AVR). For a description of the requirements contained therein, please refer to the EU's second Biennial Report.

Monitoring, reporting and verification of the ESD targets mainly takes place through the submission of the national GHG inventories by MS. Chapter III of the Commission Implementing Regulation 749/2014 sets out strict criteria by which MS national GHG inventories GHG emissions are reviewed annually at the EU-level. Based on this review, the European Commission issues an implementing decision on MS ESD emissions in the given year, which might lead to MS inter alia facing penalties as described above.

On 11 December 2018, the Regulation (EU) 2018/1999 of the European Parliament and the Council on the Governance of the Energy Union and Climate Action was adopted, which replaced the MMR Regulation. The Governance Regulation enables the achievement of emission reduction targets to be monitored at both EU and Member States level. Furthermore, Member States shall prepare national energy and climate plans (NECPs). These plans cover planned national policies and measures towards GHG emission reduction target in non-ETS sectors and also include renewable energy and energy efficiency targets. Under the Governance Regulation, historical GHG emissions, GHG emission projections, policies and measures undertaken to reduce GHG emissions, long-term strategies, assistance provided to developing countries, use of EU ETS revenues, climate change adaptation, are reported to the European Commission. The compliance cycle of targets under ESR Regulation (2018/842) takes place every 5 years. Member States report yearly on intended use of flexibility mechanisms and concluded AEA transfers between MS.

The EU also introduced a number of regulations on the monitoring, reporting and verification of emissions by aircraft operators and stationary installations covered by the EU ETS system. The EU Member States implemented these provisions into their legislation.

2.5. Use of international market-based mechanisms

The ESD allows Member States to make use of flexibility provisions for meeting their annual targets, with certain limitations. In the ESD sectors, the annual use of carbon credits is limited to up to 3 % of each Member State's ESD emissions in 2005. Member States that do not use their 3 % limit for the use of international credits in any specific year can transfer the unused part of their limit to another Member State or bank it for their own use until 2020. In the 2013-2020 period, Hungary will not use CER/ERU units for ESD compliance. The EU's climate and energy package 2030 excludes the use of international credits from compliance for the years 2021-2030.

3. Progress in achievement of quantified economy-wide emission reduction targets and relevant information

3.1 Mitigation actions and their effects.

Information on implemented, adopted and planned policies and measures can be found in Chapter 4 of the 8th National Communication of Hungary.

As a Member State of the European Union, Hungary established its self-assessment process for evaluating compliance of emission reduction commitments within the regulatory framework of the European Union. The achievement of the EU internal compliance under the 2020 Climate and Energy Package including the national targets under the Effort Sharing Decision (ESD) is not subject to the UNFCCC assessment of the EU's joint commitment under the Convention. It is up to each Member State to decide how these targets will be achieved, which national policies and measures are needed to fulfil the targets. The monitoring process is harmonized for all European Member States, especially laid down in the Monitoring Mechanism Regulation (EC) No. 525/2013.

Hungary's national strategic documents, laying down the national targets, are updated and reviewed regularly by the Parliament.

3.2 Changes in domestic institutional arrangements

As Hungary is a Member State of the EU, the monitoring and evaluation of progress towards the GHG targets is driven by the Governance Regulation[69], adopted in 2018. The monitoring and reporting of GHG emissions under the EU ETS prescribed in two Commission Regulations, which

[69] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018R1999&from=HU

were introduced for Phase III of the system starting on 1st January 2013.[70] Since the last biennial report no changes were made in these legislations.

The ETS and ESD (ESR from 2021) systems employed EU-wide, almost exactly cover the national CO_2, N_2O and PFC emissions reported in the NIR. Both systems have their own non-compliance measures imposed on the participants of the respective systems. ETS was established by Directive 2003/87/EC and is transposed into HU legislation via law 217/2012. Non-compliance measures are defined for operators of stationary installations and airline operators. ESD was established by Decision No 406/2009/EC, and ESR by Regulation (EU) 2018/842, both directly applicable to EU member states. Non-compliance measures are defined for EU member-states.

Due to reorganization of governmental institutions, the former registry administrator organization (National Inspectorate for Environment and Nature - NIEN) had been abolished. Successor of NIEN as the registry administrator is the National Climate Protection Authority (NCPA). NCPA operates as a department of the Ministry of Energy.

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.

3.3 Information on the assessment of the economic and social consequences of response measures

Information on how Hungary as a Party included in Annex I of the Convention is striving, under Article 3, paragraph 14, of the Kyoto Protocol, to implement its commitments mentioned in Article 3, paragraph 1, of the Kyoto Protocol in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention.

In accordance with Article 3, paragraph 1 of the Kyoto Protocol, Hungary is committed to limit its anthropogenic carbon dioxide equivalent emissions of greenhouse gases listed in Annex A of the Protocol to such level that they are in line with Hungary’s reduction targets while aiming at further emission reduction. Hungary is guided by the principle that ambitious national reduction targets shall be supported by a climate policy ensuring that adverse impacts on developing countries, such as carbon leakage are avoided. Hungary fully supports the endeavours, measures and

70 For more information please see the 6th National Communication and 3rd BIennial Reporrt of the EU.

implements regulations of the European Union targeting the avoidance of such impacts and fostering sustainable development, while in the same time also a specific policy framework has been put into practice.

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 former Ministry for the Environment and Water developed Hungary's First National Climate Change Strategy for 2008-2025, which entered into force via the Parliamentary Resolution 29/2008. This strategy covered three major areas of action: mitigation, adaptation and awarenessraising.

Successive revisions of the National Climate Change Strategy, and global climate policy developments (leading i.a. to the Paris Agreement), eventually led the Hungarian Government to revise the second strategy and also updated its timeline. The updated Second National Climate Change Strategy for 2018-2030[71] with an outlook to 2050 was approved by the Parliament in October 2018. The updated strategy includes a National Decarbonisation Roadmap, a National Adaptation Strategy and a "Partnership for Climate"Awareness-Raising Plan The strategy guarantees that in accordance with the principle of integration, climate policy is integrated into development policy as well, safeguarding that emission mitigation projects, cooperation fostering technological transfer and enhanced funding options for climate change related projects will play an integral role among future development projects. Climate research shall be integrated into other scientific studies and research activities and the business sphere shall be involved in climate friendly investments in developing countries.

For the time being Hungary alone does not take part in large scale development projects relating to climate change, however as a Member State, it fully supports the EU's activities in this regard.

3.4. Estimates of emission reductions and removals and the use of units from the market-based mechanisms and land use, land-use change and forestry activities

As Hungary is a Member State of the European Union, our target is set on the EU level, consequently we refer to 1990 as our base year in this report. The LULUCF Regulation currently in force (February 2023) of the EU had been set to generate no less than -225 Mt CO2 equivalent of net removals (so-called 'no-debit' commitment) and basically the sector wasn't included in the EU target. However, based on the Fit for 55 package, as for the 2030 EU climate targets, LULUCF is now included in the EU target. The main goal of the sector is to reach net removal target to -310 Mt of CO2 equivalent at EU level.

In the period 2019-2022, no AAU, CER, ERU, RMU units were sold or bought by Hungary. In February 2021, Hungary has issued the total amount of AAU units for CP2, in September 2021, surplus CP1 AAUs have been carried over to CP2, into the PPSR account.

[71] The Second National Climate Change Strategy is available only in Hungarian: https://nakfo.mbfsz.gov.hu/sites/default/files/files/N%C3%89S_Ogy%20%C3%A1ltal%20elfogadott.PDF

Concerning the intra-EU market based mechanism under the Effort Sharing Decision (ESD – Decision No 406/2009/EC), which is operating since 2013, for the compliance years 2017-2019, no AEA units were sold or bought by Hungary. In all years of the 2013-2020 ESD period Hungary had a significant amount of AEA surplus. In relation to compliance year 2020, Hungary sold AEA units to Germany, and as consequence an equal amount of AAU units will be transferred to DE during the ESD clearing period.

4. Projections

Projections of greenhouse gas emissions are included in chapter 5 of Hungary's 8th National Communication.

5. Provision of financial, technological and capacity-building support to developing country Parties

Financial, technological and capacity building support to developing country Parties was provided as described in the National Communications 8, chapter 7. The methodology used is according to the Governance Regulation report of the European Union in accordance with the Common tabular format for "UNFCCC biennial reporting guidelines for developed country Parties".

LIST OF ABBREVIATIONS

AAU Assigned Amount Units

ACCCT Accurate, complete, consistent, comparable and transparent

AD Activity Data

ADCS Agrarian Damage Compensation System

AEA Annual Emission Allocation

AQRC Air Quality Reference Centre

AR Afforestation

AR 4 IPCC Fourth Assessment Report

AR 5 IPCC Fifth Assessment Report

AVR Accreditation and Verification Regulation

B+R Bike and ride

BAT Best Available Technology

BCM Billion cubic metre

BSc Bachelor of Science

CADSES Central Adriatic, Danubian and South-eastern European Space

CAI Current Annual Increment

CASMOFOR Carbon Sequestration Model for Forestations

CCC Competitive Central Hungary Operational Programme (VEKOP - Versenyképes Közép-Magyarország Operatív Program)

CDM Clean Development Mechanism

CER Certified Emission Reduction

CEU Central European University

CFB Clean Fuel Box

CIS Commonwealth of Independent States

CLRTAP Convention on Long-range, Transboundary Air Pollution

CNG Compressed natural gas

COST European Cooperation in the Field of Scientific and Technical Research

DMCSEE Drought Management Centre for South-eastern Europe

DOC Degradable Organic carbon

DSB Norwegian Directorate for Civil Protection and Emergency Planning

EAFRD European Agricultural Fund for Rural Development

EAGF European Agricultural Guarantee Fund

EC European Commission

EDIOP Economic Development and Innovation Operative Programme (GINOP- Gazdaságfejlesztési és Innovációs Operatív Program)

EEA Grants European Economic Area Grant Fund

EEEF European Energy Efficiency Fund

EEOP Environment and Energy Operational Programme (KEOP - Környezet és Energia Operatív Program)

EEEOP Environment and Energy Efficiency Operational Programme (KEHOP - Környezet és Energiahatékonysági Operatív Program)

EF Emission factors

EFA Hungarian Institute for Educational Research and Development - Eszterházy Károly University

EIB European Investment Bank

EKE - OFI Hungarian Institute for Educational Research and Development - Eszterházy Károly University

ELTE Eötvös Loránd University

EMEP European Monitoring and Evaluation Programme

ERDF European Regional Development Fund

ERU Emission Reduction Unit

ESI European structural and investment funds (ESB – Európai strukturális és beruházási alapok)

ESD Effort Sharing Decision

EU European Union

EUA EU Allowance Unit

EUAA EU Aviation Allowances

EUBREWNET European Brewer Network

EU ETS European Union Emission Trading System

EUMETSAT European Organisation for the Exploitation of Meteorological Satellites

EUR Euro

EXIM Bank Hungarian Export-Import Bank Plc.

FDI Foreign direct investment

FM Managed Forest

GCOS Global Climate Observing System

GDP Gross Domestic Product

GEFS Green Economy Financing Scheme

GHG Greenhouse Gas

GIS Green Investment Scheme

GWP Global Warming Potential

HCSO Hungarian Central Statistical Office

HDV Heavy-duty Vehicle

HMS Hungarian Meteorological Service

ICOS Integrated Carbon Observation System

ICTP International Centre for Theoretical Physics

IEA International Energy Agency

IED Industrial Emissions Directive

IPCC Intergovernmental Panel on Climate Change

IISI International Iron and Steel Institute

INEM International Network for Environmental Management

ITOP Integrated Transport Development Operational Program

JU Fuel Cells and Hydrogen Joint Undertaking

KÁT Compulsory take-over of renewable based power at subsidized prices (Kötelező Átvételi Rendszer)

KOKOSZ Association of Environmental and Wildlife Conservation Educational Centers

KP Kyoto Protocol

KSH Hungarian Central Statistical Office (Központi Statisztikai Hivatal)

KTI Institute for Transport Sciences Non-Profit Ltd. (Közlekedéstudományi Intézet)

LDCs Least Developed Countries

LCNG Liquefied-compressed natural gas

LIFE Programme for the Environment and Climate Action

LNG Liquefied natural gas

LULUCF Land Use, Land-Use Change and Forestry

M Million

MAC Mobile Air Conditioning Systems

MAVIR Hungarian Transmission System Operator Company (Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság)

MBFSZ Mining and Geological Survey of Hungary (Magyar Bányászati és Földtani Szolgálat)

MCM Million cubic metres

MEE Hungarian Electrotechnical Association (Magyar Elektrotechnikai Egyesület)

METAR Hungarian support scheme for renewable electricity

MESPOM Masters of Environmental Science, Policy and Management

MFA Ministry of Foreign Affairs and Trade

MMR Monitoring and Reporting Regulation

MNB Central Bank of Hungary (Magyar Nemzeti Bank)

MRV Monitoring, reporting and verification

MS Member State

MSc Master of Science

MTA Hungarian Academy of Sciences (Magyar Tudományos Akadémia)

Mtoe Million tons of oil equivalent

MW Megawatt

MWe Megawatt electrical

NAC National Adaptation Center

NAGiS National Adaptation Geo-information System

NARIC National Agricultural Research and Innovation Centre

NBEPS National Building Energy Performance Strategy

NDGDM Disaster Management, Ministry of the Interior

NC4 Fourth National Communication to the UNFCCC

NC5 Fifth National Communication to the UNFCCC

NC6 Sixth National Communication to the UNFCCC

NCPA National Climate Protection Authority

NCCS I First National Climate Change Strategy

NCSS II Second National Climate Change Strategy

NFCSO FD Forestry Directorate of the National Food Chain Safety Office

NFR Nomenclature for Reporting

NEEAP National Energy Efficiency Action Plan

NEESPI Northern Eurasia Earth Science Partnership Initiative

NEP National Environmental Programme

NES 2030 National Energy Strategy 2030

NIEN National Inspectorate for Environment and Nature

NGO Non-governmental Organization

NIC National IPCC Committee

NIF National Infrastructure Development Corporation (Nemzeti Infrastruktúra Fejlesztő Zrt.)

NMS New EU Member States

NRDI Fund National Research, Development and Innovation Fund

NRDI Office National Research Development and Innovation Office

NREAP National Renewable Energy Action Plan

NUTS Nomenclature of Territorial Units for Statistics

NWMAP National Waste Management Action Plan

NWMPSP National Waste Management Public Services Plan

NWP National Waste Management Plan

ODA Official Development Assistance

ODS Ozone Depleting Substances

OECD Organisation for Economic Co-operation and Development

OGY Hungarian National Assembly (Országgyűlés)

OMSZ Hungarian Meteorological Services (Országos Meteorológiai Szolgálat)

OMKT-HMBC Hungarian Monitoring and Certification Body

PaMs Policies and Measures

PDA EU Project Development Assistance

PhD Doctor of Philosophy

PJ Petajoule

PMO Prime Minister's Office

PPS Purchasing Power Standards

PWR Pressurized Water Reactor

R&D Research and Developments

RDI Research, development and innovation

RDP Rural Development Programme (VP - Vidékfejlesztési Program)

REC Regional Environmental Center for Central and Eastern Europe

REKK Regional Centre for Energy Policy Research (Regionális Energiagazdasági Kutatóközpont)

RMU Removal Unit

SIDS Small Island Developing States

SME Small and Medium Enterprise

TF Task Force

TFC Total Final Consumption

TNA Transitional National Aid

TPES Total Primary Energy Supply

TSDOP Territorial and Settlement Development Operational Programme (TOP - Terület- és Településfejlesztési Operatív Program)

TSO Transmission system operator

TWG Technical Working Group

TWh Terawatt-hour

UNFCCC United Nations Framework Convention on Climate Change

USD United States Dollar

VAHAVA Változás-Hatás-Válaszadás (Change-impact-response) Research Project

VAT Value-added Tax

WCDMP World Climate Data and Monitoring Programme

WDCGG World Data Centre for Greenhouse Gases

WDCRG World Data Centre for Reactive Gases

WEEE Waste electrical and electronic equipment

WAM With additional measures

WEM With existing measures

WFD Water Framework Directive

WG Working Group

WHO/ECEH World Health Organization - European Centre for Environment and Health

WMO World Meteorological Organization

WMO GAW WMO Global Atmosphere Watch

WMO WIGOS WMO Integrated Global Observing System

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