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National Energy and Climate Plan

2024 update

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LIST OF ABBREVIATIONS AND MOSAIC WORDS

ACER	Agency for the Cooperation of Energy Regulators
AEO	Annual Energy Outlook Issued by: US Energy Information Administration (US EIA)
AEA	Annual emission allocation
aFFR	Automatic Frequency Restoration Reserve
AFIR	Regulation of the European Parliament and of the Council on alternative on the deployment of fuel infrastructure and amending Regulation (EU) No 2014/94 Repeal of the Directive
WHO	Institute of Agricultural Economics
AM	Ministry of Agriculture
APT	Sophisticated, Persistent Attack in Cyberspace (Advanced Persistent Threat)
SAO	State Audit Office of Hungary
AT	Austria (Austria)
BAVS	Budapest Agglomeration Railway Strategy
BE	Belgium (Belgium)
BG	Bulgaria (Bulgaria)
Commission	European Commission (EC)
BKV	the Budapest Transport Company
°C	degrees Celsius
CACM Regulation	Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance)
CAPEX	Capital expenditure
CCR	Capacity calculation methodology
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CCU	Carbon capture and utilisation (CCU)
CCUS	Carbon capture, utilisation and storage (CCUS)
CEE	Central and Eastern Europe
CEEGEX	Central European Gas Exchange
CEER	Council of European Energy Regulators
CEF	Connecting Europe Facility
CERN	European Organization for Nuclear Research
CESEC	High-Level Group on Central and South-Eastern Europe Connectivity
CHP	Combined heat and power
CIAO	International Civil Aviation Organisatin
CIGRE	International Council on Large Electric Systems
CLIMATE-ADAPT	Climate Adaptation Information Platform
CNG	Compressed natural gas
The CASMOFOR Model	CArbon Sequestration MOdel for FORestations – A model used to predict the carbon balance of carbon pools, developed and applied by the Forest Science Institute of the University of Sopron (Dr. Zoltán Somogyi). CASMOFOR-NFD can predict the carbon balance of existing forests, while CASMOFOR 7.0 can predict the carbon balance of afforestation.
CO_2	Carbon dioxide
CO_2e (t CO_2e, Mt CO_2e)	Carbon dioxide equivalent, uniform unit of measurement for greenhouse gases, usually expressed in tonnes or million tonnes
COST	Cooperation in Science and Technology
Core FB MC project	Main Flow Based Market Coupling Project
CSOK	Family Home Creation Discount
CY	Cyprus (Cyprus)
CZ	Czech Republic
DAM	The day-ahead market
DE	Germany (Deutschland/Germany)
DG ENER	Directorate-General for Energy
DK	Denmark (Denmark)
DLR	Dynamic Line Rating (Dinamic Line Rating)
DNSH	Do Not Significant Harm
DSO	Distribution System Operator
DSR	Demand side responses

DW value	Durbin Wattson Value
EIB (EIB)	European Investment Bank
EB GL	European Balancing Guidline
EBRD	European Bank for Reconstruction and Development
ECAC	European Civil Aviation Conference
ECBC	Electricity Cross-border Committee
ECG	Electricity Coordination Group
EE	Estonia (Estonia)
EF	GHG emission factor, emission factor
(US) EIA	U.S. Energy Information Administration
EIF	European Investment Fund
EIT	European Institute of Innovation and Technology
ERC	Energy efficiency obligation scheme
EL	Greece (Greece /Hellas (Ελλάς))
EM	Ministry of Energy
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
EPBD	Recast of Directive 2010/31/EU on the energy performance of buildings under Directive 2018/844/EU. (Energy Performance of Buildings Directive)
EPC	Energy Performance Contracting
EPO	European Patent Office
ERA	European Research Area
ES	Spain (España / Spain)
ESCO	Energy Saving Company or Energy Serving Company or Energy Service Company
ESCO Programme	Unresponsive third party funding
ESD	Effort Sharing Decision
ESFRI	European Strategy Forum on Research Infrastructures
ESS	Effort Sharing Regulation - REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013
EU	European Union
Unit EUA III	Allowances issued to installations for ETS trading period III (2013-2020) (European Emission Allowances)
EUAA Unit	EU Aviation Allowances
EU ETS	European Union Emissions Trading System
EUREKA	European Research Coordination Agency (European Research Coordinating Agency)
EURELECTRIC	Organisation for the Cooperation of Electricity Companies in Europe
EU27	The European Union, which brings together 27 Member States: Austria; Belgium; Bulgaria; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Greece; The Netherlands; Croatia; Ireland; Poland; Latvia; Lithuania; Luxembourg; Hungary; Malta; Germany; Italy; Portugal; Romania; Spain; Sweden; Slovakia; Slovenia
EV	Electric Vehicle (Electric Vehicle)
ÉCST	Climate Action Plan
CEM	Ministry of Construction and Transport
ÉMI	Construction Quality Control Innovation Nonprofit Ltd.
STAFF	Scientific Advisory Board on Climate Change (HuPCC)
FBMC	Flow-Based Market Coupling
FGSZ Zrt.	FGSZ Natural Gas Transmission Ltd.
FI	Finland (Finland)
FOM cost	Fixed O&M costs / Fixed operaion and maintenance costs
FR	France (France)
FRL	Forest Reference Level
GCG	Gas Coordination Group
GDP	Gross domestic product
GIE	Gas Infrastructure Europe
GINOP	Economic Development and Innovation Operational Programme
GM	Ministry of Economic Development
GoO	Guarantee of Origin (Guarantee og Origin)

Hg	Mercury
HHI	The Herfindhal-Hirschman Index
HIPA	National Investment Promotion Agency
HKV	Voice-frequency central control
HMKE	Small household power plant up to 50 kW
HR	Croatia (Hrvatska / Croatia)
HTFS	Long-term Renovation Strategy
HU	Hungary (Hungary)
HUPX	Hungarian Power Exchange
HVO	Hydrogenated vegetable oil
ICIS	International Conference on Information System
ICS	Industrial control systems
IDM	Intraday market
IE	Ireland (Ireland)
IEA	International Energy Agency
IGCC	International Grid Control Cooperation
IKOP	Integrated Transport Development Operational Programme
ICT	Information and communication technology
INEA	Innovation and Networks Executive Agency
IT	Italy (Italy)
IT	Information Technology (Information Technology)
ITER	International Thermonuclear Experimental Reactor
ITM	Ministry of Innovation and Technology
JPE	Significant market power
CAP	The EU's Common Agricultural Policy
KÁT system	Electricity feed-in system
KEHCsT	Transport Energy Efficiency Action Plan
KEHOP	Environmental Energy Efficiency Operational Programme
RDI	Research, development and innovation
KIF networks	Low Voltage Networks
KKM	Ministry of Foreign Affairs and Trade
Kkt.	Act I of 1988 on road transport
SME	Small and medium-sized enterprises
KÖF networks	Medium Voltage Networks
LIFE	L'Instrument Financier pour l'Environnement
LNG	Liquefied natural gas
LOLE	Expected frequency of loss of electricity supply (loss of load expectation)
LOLH	Loss of electricity supply in hours – one year (loss of load hours)
LOLP	Loss of load probability
LPG	Mixture of liquid hydrocarbon gases (liquefied petroleum gas)
LT	Lithuania (Lithuania)
LU	Luxembourg (Luxembourg)
LULUCF	Land use, land use change and forestry (sector) – based on Regulation (EU) 2018/841
LV	Latvia (Latvia)
MARI	Manually Activated Reserves Initiative, a platform for international coordination of manual frequency restoration (mFRR)
MAVIR Zrt.	MAVIR Hungarian Transmission System Operator Ltd.
MÁV	Hungarian State Railways Ltd.
MCO	Market Coupling Operator
MEHI	Hungarian Institute for Energy Efficiency
MEKH	Hungarian Energy and Public Utility Regulatory Authority
METÁR	Renewable energy support scheme (support scheme for electricity produced from renewable and alternative energy sources)
mFRR	Manual frequency restoration reserve
MFOI	Hungarian Development Promotion Office
MGT	Hungarian Gas Transit Ltd.
MMK	Hungarian Chamber of Engineers
MOL Plc.	Hungarian Oil and Gas Plc.
MRC	Western European Regional Coupling

MSZKSZ	Hungarian Hydrocarbon Stockpiling Association
MT	Malta (Malta)
MTA	the Hungarian Academy of Sciences
NAF network	High Voltage Network
NAS	National Adaptation Strategy
NATURAL	National Adaptation Geoinformation System
NECP	National Energy and Climate Plan
NEMO	Nominated Electricity Market Operator
SNEs	National Building Energy Strategy
NES	National Energy Strategy
NS	National Climate Change Strategy
NÉS-2	Second National Climate Change Strategy
NF_3	Nitrogen trifluoride
NIS	Network and information systems
NRDI Fund	National Research, Development and Innovation Fund
NKFIH	National Research, Development and Innovation Office
NKI	Research Institute of Population Sciences
NKS	National Transport Strategy
NL	Netherlands (Netherlands)
NO_2	Nitrogen dioxide - Nitrogen dioxide (and nitric oxide) is produced and released into the atmosphere mainly when burning nitrogen-containing materials (firewood, biomass, carbon, lignite, hydrocarbons, plastics). Air is considered a pollutant, it is also a component of acid rains, it can be toxic in higher concentrations, it also has a weak greenhouse effect. Nitrogen oxides are collectively referred to as NO_x.
NRA	National Regulatory Authority
NTC	Net Transfer Capacity / Network Transfer Capacity Network Transfer Capacity
NTFS	National Clean Development Strategy
N_2O	Nitrous oxide - Nitrous oxide is formed and released into the atmosphere mainly from the reaction of nitrogen (N_2)and oxygen (O_2) in the air at high temperatures during thermal processes (e.g. combustion of fuels). Its importance for climate protection is that it is one of the strong greenhouse gases, and the well-identified part of the greenhouse gas emissions of agriculture comes from here.
HAEA	Hungarian Atomic Energy Authority
OCG	Oil Coordination Group
OEA	National Forestry Database (NFD)
OECD	Organisation for Economic Co-operation and Development
OKT	the National Environmental Council
OMSZ	National Meteorological Service
OPEX	Operational expenditure
OTC market	Over-the-counter (OTC)
PCIs	Projects of Common Interest
PCR	Price Coupling of Regions
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
PL	Poland (Poland)
PM	Ministry of Finance
The PRIMES model	Price-Induced Market Equilibrium System
PT	Portugal (PT)
PV	Photovoltaic, photovoltaic
P2G	Power-to-gas technology - Electricity storage technology in which hydrogen is produced with electricity or methane is produced in an additional step, which can be converted back into electricity if necessary
RDF	Secondary fuel - which is extracted by mechanical-biological pre-treatment of mixed municipal waste and as the residue of separately collected (packaging) waste sorting. Fuel used in power plants or cement factories. (Refuse derived fuel)
RED	Renewable Energy Directive DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
REFUREC	Renewable Fuels Regulators Club

REKK	Regional Centre for Energy Policy Research
RES	Renewable energy sources
RES-E	Renewable energy sources for electricity
RES-H&C	Renewable energy sources for heating and cooling
RES-T	Renewable energy sources in transport
RFNBO	Renewable fuels of non-biological origin
RHD	System usage fee
RKV	Radio-frequency central control
RO	Romania (Romania)
RSI	Residual Supply Index
R^2	Coefficient of determination
SAF	Sustainable Aviation Fuel
SAP	National Action Plan for Sustainable Aviation Fuel Plan
SCADA	Supervisory Control and Data Acquisition
SDAC	Single day-ahead coupling
SE	Sweden (Sweden)
SEE	Southeast Europe or Southeastern Europe
SEPS	Slovak electricity transmission system operator (Slovenská Elektrizačná Prenosová Sústava, A.S.)
SEQ	Expert Group on Emergency Questions (International Energy Agency)
SET Plan	Strategic Energy Technology Plan
SI	Slovenia (Slovenia)
SK	Slovakia (Slovakia)
SMR	Small Modular Reactor
SEA	Strategic Environmental Assessment (SEA)
SOE-ERTI	University of Sopron Forestry Research Institute
SO_2	Sulphur dioxide
RSA	Supervisory Authority for Regulated Activities
S3	National Smart Specialisation Strategy
TAO (discount)	Corporate tax and corporate tax allowance – based on Act LXXXI of 1996.
t CO_2e	Measurement unit of GHG emissions per tonne of CO2equivalent (1 kt CO_2e = 1 000 t CO_2e)
TERRE	Trans-European Replacement Reserves Exchange
SOT cooperation	Scientific and Technological Cooperation
The TIMES Model	The Integrated MARKAL-EFOM System: The TIMES model adapted for Hungary (HU-TIMES) covers the entire Hungarian energy sector, including the transformation sectors, energy use in the industrial and transport sectors, and energy use related to buildings.
TOTEX	Total expenditure
TSC	Security Cooperation of Transmission System Operators (TSO Security Coordination)
TSO	Transmission system operator
TWG	Technical Working Group
TYDP	Ten Year Development Plan
UDB	Union Database
UK	United Kingdom (United Kingdom)
GHG	Greenhouse gas(es)
VEKOP	Competitive Central Hungary Operational Programme
VET.	Electricity Act - Act LXXXVI of 2007 on Electricity
RDP	Rural Development Operational Programme
VOLL	Value of lost load
VOM cost	Variable O&M costs / Variable operation and maintenance costs
V4	Visegrad Four (Czech Republic, Poland, Slovakia, Hungary)
V4+ Clean Mobility	V4 Conference with Austria and Slovenia on the implementation of the AFIR Regulation
WAM	With additional measures – Scenario of existing and additional measures used in the projections.
WEM	Existing measures (with existing maesures) - A scenario used for forecasts and calculated only with existing measures.
XBID	Intraday market coupling (cross border intraday)
4M MC	Connecting Four Markets (4 Markets Market Coupling)

UNITS OF MEASUREMENT AND LIST OF CONVERSIONS THEREOF

Energy quantity:

koe	kilograms of oil equivalent
toe	tonnes of oil equivalent
ktoe	thousand tonnes of oil equivalent
mtoe	million tonnes of oil equivalent
1 mtoe = 1 000 ktoe = 1 000 000 toe = 1 000 000 000 koe	

J	joule
kJ	kilojoule
MJ	megajoule
GJ	gigajoule
TJ	terajoule
PJ	petajoule
1 PJ = 1 000 TJ = 1 000 000 GJ = 1 000 000 000 MJ = 1 000 000 000 kJ = 1 000 000 000 000 000 J	

kWh	kilowatt-hours
MWh	megawatt hours
GWh	gigawatt hours
TWh	Terawatt hour
1 TWh = 1 000 GWh = 1 000 000 MWh = 1 000 000 000 kWh	

m^3	cubic metres
billion m^3 (bcm)	billion cubic metres
1 bcm (1 billion m^3) = 1 000 000 000 m^3	

Conversions between different units of measurement:

1 toe = 11 630 kWh = 41 868 MJ = 1 190.45 m^3
1 TWh = 85 984.52 toe = 3 600 TJ = 102 359 965.88 m^3
1 TJ = 277 777,78 kWh = 23,88459 toe = 28 433,32 m^3
1 billion m^3 (1 bcm) = 9,76944 TWh = 35 170 TJ = 840 021 toe

Conversion values in m^3refer to natural gas in gross calorific value = 35,17 MJ /m^3 (Net calorific value = 34 MJ /m^3)

Capacity, performance:

kW	kilowatt
MW	megawatt
GW	gigawatt
TW	terawatt
1 TW = 1 000 GW = 1 000 000 MW = 1 000 000 000 kW = 1 000 000 000 000 W	

Primary energy conversion factor

After reviewing the primary energy factor (PEF) value of electricity, Act No. 122/2015 Coll. on the Implementation of the Energy Efficiency Act. The value of **2.1 set out in point 2 of Annex 6 to Government Decree No 155/2014 of 26 May 2014 on conversion factors is set** out in the National Energy and Climate Plan.

The values of Hungary’s primary energy conversion factor, corrected for net imports of electricity at PEF 1.9 and net imports, developed as follows:

	2022	**2023**
net of imports	2,65	2,51
net imports	2,43	2,35

The reason for retaining the value of 2.1 is that Hungary plans to establish a CCGT power plant by 2030 to balance renewable energy production, and thereafter the renewal of nuclear capacities and the expansion of nuclear power plant capacities also justify fixing this value.

1. OVERVIEW AND PROCESS OF THE ESTABLISHMENT OF THE PLAN

1.1. Summary

i. Political, economic, environmental and social context of the plan

The National Energy and Climate Plan 2024, as updated in the context of integrated planning (‘the National Energy and Climate Plan 2024’), NECP) covers the dimensions of the Energy Union: decarbonisation, energy efficiency, energy security, internal energy market and research, innovation and competitiveness.

The NECP – in line with the National Energy Strategy (hereinafter: NES) – its main objective is to **strengthen energy sovereignty and security,** and **to decarbonise while maintaining public support.** Security of energy supply and increasing energy sovereignty have become national security issues, so reducing energy import dependency is a key issue in energy policy. In connection with this, we formulate the reduction of the share of natural gas in the energy mix as a key strategic goal.

We aim to achieve our energy independence through measures to reduce energy consumption and increase efficiency of use, diversification and use of alternative energy sources, as well as electrification. Although we place greater emphasis on security of supply, Hungary remains committed to achieving its short- and long-term climate goals. Our goals can be significantly supported by the increased utilization of domestic energy sources and the developments made for the efficient utilization of energy, which have significant potential especially in the case of the largest domestic energy consumer - the building stock. Greater use of renewable energy sources, be it weather-dependent, day-dependent or weather-independent energy sources such as geothermal energy, is a top priority.

The experience of the energy crisis is that security of supply cannot be based solely on a dominant energy source or technology, so we want to cover our energy needs from a broad portfolio. With the implementation of the diversified technological mix and the more efficient use of alternative energy sources in Hungary, Hungary is taking a step towards achieving energy independence. It is also in Hungary's interest to ensure the widest possible connection to the regional electricity and gas networks, which is also a guarantee of security of supply and effective import competition.

The priority principle of energy efficiency should become an integral part of planning processes, support, funding and investment decisions. The principle is enforced through the integration of energy efficiency considerations into sectoral policies. Increasing energy efficiency is a priority objective, which we plan to achieve by encouraging electrification **and reducing energy use in residential, public institutions, industry and transport.** We promote the energy independence and energy awareness of consumers through the energy renovation of buildings and by supporting self-generation of renewable energy and promoting the uptake of smart meters, as well as the use and development of lower energy-intensive technologies, facilities and equipment. Due to the high efficiency of electric motors, clear end-user energy savings are achieved **with the uptake of electromobility**. The Green Bus

Programme for the greening of transport and the electrification of rail contribute to the development of vehicles and infrastructure for greener local and interurban transport.

We are also expanding the domestic green economy, supporting the decarbonisation of the country both by developing domestic green production capacities, by supporting the development of plant operations and by developing the knowledge required for these.

Hungary aims to ensure that most of Hungary's **electricity production comes from two sources: nuclear energy and renewable energy**, the latter mainly from solar power plants according to domestic conditions. These are not intersecting or mutually exclusive technologies, but mutually supportive solutions, both of which can be considered as clean energy sources. Their efficient operation requires the development of **energy storage**capacities to support demand flexibility – battery and pumped-storage power plant capacities – and the promotion of on-site consumption of renewable generation, as well as the development of the electricity grid. Nearly half of Hungary's electricity production comes from carbon-neutral nuclear energy. With the implementation of the further lifetime extension project of the Paks Nuclear Power Plant and the implementation of the Paks II investment in the years after 2030, this ratio can be maintained in the long term. Carbon-neutral energy production is unthinkable and unfeasible without nuclear power, given Hungary's capabilities. The use of nuclear energy greatly contributes to Hungary's energy security and independence from fossil fuels by providing a clean, practical solution to the **challenges of increasing electricity demand.**

Hungary **is highly exposed to the undesirable effects of climate change,** compared to the rest of Europe, due to its inland location and the specific microclimate of the Carpathian Basin. Hungary is therefore determined to protect both our natural heritage – be it our waters, soil or forests – and our built environment, which requires the protection of the environment and the fight against climate change, as well as protection from the adverse effects of climate change.

The Government must pursue a realistic and responsible policy in the field of climate protection. It should be realistic in terms of the expected results and cost implications of interventions that can be implemented with current technologies. **Hungary attaches particular importance to the implementation of the polluter pays principle:** the costs of decarbonisation must be borne primarily by those countries and companies that are most responsible for the current situation, while contributing to climate protection is also of paramount importance for our country. Hungary's commitments reflect an accurate inventory of assets and costs, on **the basis of which the Government adopts a feasible strategy and action plan with a focus on mitigation.**

The Member States of the European Union, including Hungary, are committed to having an overall climate-neutral economy by 2050. In addition to the above main measures, Hungary aims to achieve the 2050 target on the basis of the following principles:

- "Decarbonisation and maintenance for security of supply": We ensure the achievement of our long-term goals with a coherent goal and action system, involving as many sectors as possible.
- ‘Energy efficiency first’: energy efficiency aspects should be part of energy planning and investment decisions in both final energy consumption and energy conversion sectors.
- ‘Network development for electrification’: develop and strengthen the energy grid and then improve efficiency in all final energy sectors through electrification.
- "Carbon neutralisation mainly by natural means": We will develop carbon sinks through sustainable forest and agricultural management, and then focus artificial sink technologies on the remaining emissions, if necessary.

The goals of economic growth and climate protection are not contradictory. Hungary's gross domestic product has grown since 1990, while total gross greenhouse gas emissions decreased by 32%, primary energy consumption by 13% and final energy consumption by 6% by 2021. Maintaining the improving trend is in the interest of the Hungarian economy. In the case of Hungary, the additional investment cost of additional measures in addition to the existing measures in the period up to 2050 is in the order of HUF 612 billion per year. At the same time, as a result of the investments, operating costs are reduced, so **the annual net additional financing needs are HUF 177 billion**.[1] In Hungary's view, climate neutrality is achievable for Hungary, which, however, also requires a significant financial contribution from the Union.

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

Hungary is a member of the Central and*South East Europe Energy Connectivity (CESEC) High Level Group*,which regularly discusses energy and climate policy topics relevant to the NECP. In the framework *of the Visegrad Cooperation,* a regional consultation on the Member States’ energy and climate plans was also held in the form of an online conference on 23 April 2023, with the participation of Czechia, Poland, Slovakia and Hungary. On 20 February

[1] *In the additional cost calculation, the difference in residual values was also calculated. Thus, if an investment is realised in 2040 and has a lifespan of 20 years, a residual value is accounted for in proportion to part of the total investment cost, which reduces the investment cost.*

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

In preparing the updated NECP, Hungary took into account the existing updated national plans and related existing and planned measures and policies. The NECP is in line with the National Clean Development Strategy, the *Second National Climate Change Strategy (NÉS-2)* and the related previous and planned *Climate Change Action Plans (CAPs)* and the *National Development and Territorial Development Concept, which sets out Hungary's development and territorial development goals for 2030.*

In order to meet the objectives of the *Energy Union, to comply with the Paris Agreement* and to contribute to the EU's climate neutrality objective in line with it, **the Hungarian Government has authorised the Ministry of Energy (hereinafter:** EM) in relation to the energy sector and the priority sectors affected by decarbonisation, thus also determining the future of the country and Hungarian society, which require political decision, the development of appropriate policy programmes, visions, and the setting of national targets and domestic commitments related to energy and climate change, with particular regard to reducing greenhouse gas emissions and, in close connection with this, increasing energy efficiency and increasing the share of renewable energy.

ii. Strategy for the five dimensions of the Energy Union

The Hungarian climate and energy policy quantified objectives are defined on the basis of the 5 dimensions of the Energy Union, the achievement of which we intend to ensure by the systematic selection and implementation of the most cost-effective and multi-territorial policy instruments, taking into account the national frameworks. **The dimensions of the Energy Union can be interpreted in a complex system that interacts with each** other, so their effects extend to each other in terms of objectives and measures.

(1.) Decarbonisation dimension - (1.1) Greenhouse gas emissions and removals[2]

The main indicator of the objectives and measures of the NECP and the relevant strategies is *provided by Act XLIV of 2020 on climate protection*, in which Hungary **set the goal of climate neutrality by 2050 .** To this end, following the scheduled progress, Hungary aims to **reduce gross greenhouse gas (GHG) emissions by at least 50% by 2030 compared to**

[2] *Consistency with the long-term strategies under Article 15 should be ensured.*

1990 . In **the case of Hungary, carbon dioxide (CO2)is the most significant** (~76% in 2021) and the most widely emitted greenhouse gas affecting all sectors, which is why we focus predominantly on this GHG in our actions, which also helps to reduce GHG emissions other than CO2. The reduction and offsetting of GHG emissions by businesses is directly incentivised by the **EU Emissions Trading Scheme (EU ETS)** and the **ESG law derived from EU law to support investor orientation.** [3] According **to the ESS, Hungary should achieve a 18.7% reduction in GHG emissions from the ESS sector compared to the 2005 base year,** i.e. the sum of domestic transport (excluding aviation), buildings, agriculture, 'small industry' and waste management**.**

In the field of transport, we will ensure the reduction of GHG and pollutant emissions, the modernisation of the fleet and industrial processes through transport greening schemes, business greening schemes, including for small industry and ETS installations, and positive and negative legislative incentives. In the case of the building stock, we ensure the same through renovation programmes and awareness-raising.

The objectives of agricultural development are to be achieved primarily by imposing good agricultural practices and providing additional incentives, supported by the various support instruments included in Hungary's Common Agricultural Policy Strategic Plan (CAP ST) for the period 2023-2027. The objectives and measures of waste management *are* set out in the National Waste Management Plan 2021-2027,*which is supported by the new concession framework for waste management. We plan to reduce the related GHG emissions by reducing landfilling of* municipal waste, separate collection, re-use and recycling of recoverable waste.

To reduce GHG emissions and GHG intensity, the decarbonisation of the energy industry is of paramount importance. One of the most important decarbonisation tasks is the transformation of the lignite-fired Mátra power plant based on low-carbon technologies, i.e. phasing **out coal and lignite combustion from domestic electricity generation after the power plant technology supporting its safe replacement becomes operational, but by 2029 at the** latest . It is essential to extend the operation time of the existing units of the Paks Nuclear Power Plant (Paks I.)[4] and to extend the operation time of the existing units of the Paks II. Construction and commissioning of a nuclear power plant to ensure a safe and clean basic supply, paying particular attention to the management of the associated risks. **The** combined output of Paks I and Paks II would be 4.4 GW in the energy mix, which means a decrease in the share of natural gas and a huge decarbonisation potential for Hungary.

However, reducing emissions is not enough, as neutralising **remaining emissions is also a priority to reduce net greenhouse gas emissions, i.e. those calculated in combination with neutralisation,** and to achieve climate neutrality. The 2030 greenhouse gas emissions and

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[3] *Act CVIII of 2023 on the rules of corporate social responsibility taking into account environmental, social and social aspects in order to promote sustainable finance and unified corporate responsibility*

[4] *56/2022. (XII. 8.) OGY resolution*

removals **from natural CO2sinks** related to land use, land use change and forestry (LULUCF sector) are expected under the LULUCF Regulation.[5] According to the LULUCF Regulation, Hungary's **LULUCF sector needs to achieve net e-absorption of 5.724 million tCO2by 2030.** In order to maintain and increase our natural CO2sink capacities in the long term, in line with the National Forest Strategy and taking into account the Do No Significant Harm (DNSH) principle, **we will significantly increase the share of forest and other wood cover.**

However, it is not expected that we will be able to meet the increasingly significant GHG emission reduction targets at a later stage without **artificial neutralisation tools and technologies.** CCUS, as we know it, is the technology we should plan for capturing GHG emissions that will remain after **implementing all emission reduction and removal options that are more cost- and energy-efficient than CCUS.** In this regard, it is necessary to carry out further surveys and analyses based on domestic possibilities and constraints.

In addition to mitigatory measures, the primary objective of climate change **adaptation measures** is to help Hungarian society to adapt to and prepare for changing climatic conditions resulting from climate change by assessing, managing and monitoring risks and vulnerabilities arising from climate change. It is therefore necessary to maintain and develop the overall strategic management and sectoral short-, medium- and long-term action lines of adaptation, including in the fields of human health, water management, disaster management, agriculture, forestry, nature protection, energy infrastructure, urban development and tourism.

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[5] *Regulation (EU) 2018/841*

(1.) Dimension of decarbonisation - (1.2.) Renewable energy

The gradual increase in the scale and share of renewable energy production and use is a cornerstone of Hungary's decarbonisation, for which measures are planned for both the production and the demand side, for both the heating and cooling sector and the electricity sector, including the building stock and businesses, as well as for the transport sector.

Hungary **has set the share of renewable energy in gross final energy consumption at at least 30% by 2030** – highlighting that while renewable energy supply is steadily increasing, its share cannot increase at the pace required by the EU, but that the emission reduction target is met when complemented by the above decarbonisation measures. In order **to further increase the integration of energy from renewable and alternative sources into national and sectoral energy mixes, the development of individual infrastructures, including the system-wide planning and scheduled development of supply networks, the system components of the generation-to-consumer system, is of** paramount importance.

With regard to renewable energy supply, we plan to increase renewable energy production through the possibility of utilising it in several sectors, through legal and financial instruments and the development of sectoral strategies. Renewable **electricity generation is relevant for all sectors,** but is particularly important for the greening of the transport sector due to scarce alternatives. We plan **to increase the production of biogas and biomethane,** primarily by injecting them into the gas grid, supported by biowaste from the waste management sector and the guarantee of origin market for alternative gases. With the latter and other incentives, we plan to facilitate the **production of renewable hydrogen** for use in the transport sector, in addition to replacing industrial grey hydrogen. At the same time, a significant part of this hydrogen demand can be met by imports, given its competitiveness. In addition, we plan to include other alternative and renewable energy sources, according to the following sectoral breakdown.

Heating and cooling - RES-H/C

In the heating and cooling sector, we will increase the share of renewable energy (RES-H/C) on a scheduled basis by increasing **the amount and share of biomass and geothermal (ground** heat), including waste heat and renewable electricity. We support efficient domestic use of biomass, also taking into account its potential for local air pollution, and see great potential for the use of ambient heat and ground heat (shallow geothermal) through heat pumps, therefore we plan to continue to provide **incentives (replacement) for the use of heat pumps and more efficient biomass boilers,** mainly through our modernisation and greening programmes.

In the long term, most domestic district heating will **fall into the category of 'efficient district heating and cooling'.** In **the case of the district heating source mix, it is necessary to reduce the share of natural gas** and to supplement the already significant biomass-based and to a lesser extent geothermal-based district heating with additional renewable-based supply. The aim is to gradually increase the share of renewable energy and waste heat and cold (RES-DH). We exploit domestic resources available to us from thermal waters as much as possible, including by using heat pump assistance where necessary, taking into account **the sustainability and geological risks of geothermal heat energy,** which is supported by the implementation of the Earth Heat Concept. It should be pointed out that in many cases the integration of geothermal energy into district heating systems presupposes a reduction in the heat demand of district heating buildings. These developments must take place in a coordinated manner.

Electricity generation - RES-E

In addition to nuclear power plant projects, with the massive increase of renewable electricity generation capacities, the proportion of carbon-free electricity production may continue to increase, which has a significant impact on all sectors. The **focus of renewable electricity generation is the expansion of solar power generation capacity,** from around 6.8 GW today to nearly 12 GW by 2030. A similar increase of almost threefold is expected for wind turbines, although the installed capacity here is lower – from around 330 MW to 1 000 MW by 2030. Further capacity expansion is foreseen in other areas: we plan to exploit **hydropower, geothermal energy and bioenergy utilization** to a higher degree also in electricity generation. We plan to support the greening of electricity production with a wide range of legal and financial instruments, within which METÁR will remain the instrument for the promotion of centralised, high-performance electricity production from renewable energy sources until 2026, providing a cost-effective level of support within the framework of technology-neutral renewable capacity tenders, after which alternative support may be implemented.

Transport - RES-T

For the development **of the transport sector, it is essential both to support the technological and resource change of the fleet,** including for passenger cars, public transport and vehicles suitable for freight transport, and to support the construction of the necessary **infrastructure.** Under the chosen REDIII option, Hungary aims **to achieve a 25% renewable share of transport fuels by 2030.** In order to reach this target, **the overall share of advanced biofuels and renewable fuels of non-biological origin (RFNBO)** in final energy consumption in transport will be increased to 1% by 2025 and 5.5% by 2030. Accordingly, the share of fuels produced from waste, so-called second generation (or advanced) biofuels, biogas (to min. 4.5%), RFNBO (to 1%) in transport and first generation biofuels (to 3%)[6] will increase by 2030, as well as the more efficient collection and use of used cooking oil **and an increase in the use of electricity and later hydrogen** for transport (4%).

[6] *The share of first-generation food and feed-based biofuels in the RES-T accounts is not expected to exceed the 2020 level by more than 1% (max. 4%), but is not expected to exceed 3%.*

The significant increase in electricity generation from renewable energy sources is therefore particularly significant.[7]

(2.) Energy efficiency dimension

There is significant potential for energy efficiency in several sectors of Hungary. On the one hand, the reduction of final energy consumption is supported by the development and electrification of transport and building stock, and on the other hand, the final energy intensity of GDP can be reduced by improving corporate energy efficiency.

Our main energy efficiency target **is to ensure that the country's final energy consumption does not exceed 740 PJ in 2030.** To support this, in the 2020 NECP, we planned to achieve cumulative final energy savings of 336.3 PJ by 2030, resulting in an overall reduction of 61 PJ in final energy consumption by 2030. We are looking at the feasibility of the indicative cumulative energy savings target of 484.6 PJ set in the new Energy Efficiency Directive, which could be achieved by a reduction of 126 PJ in final energy by 2030.

In line with our EU obligations, the **Long-Term Renovation Strategy** was adopted in[8] 2021 (hereinafter: HTFS) served as the basis for achieving a sustainable, energy-efficient and cost-effective domestic building stock by 2050. The main objective of the current strategy (to be updated) is to reach 90% NZEB buildings by 2050. At **the same time, the update of the HTFS and its targets** has become timely, which we plan to achieve by 2025, as we also need to update our targets for our building stock.

In order to reach the long-term goals, 3% of the designated public buildings will be renovated annually. In addition, **around 2.6 million residential properties need to undergo energy renovation.** Their implementation should be facilitated by financial incentives (e.g. modernisation programmes), the implementation of local regulation, awareness-raising and energy advice. For the remaining energy use, renewable **heating systems should be prioritised during renovations, depending on the characteristics of** the buildings. The Hungarian Chamber of Engineers supports the public in its energy efficiency development plans in the form of **consultancy.** The modernisation of public and residential buildings has been implemented through several support programmes so far, and this plan continues along a long-term programme for the stability of the construction sector. Particular attention should be paid to households affected by lignite-based heating near the Mátra Power Plant. During the revitalization and transition, our goal is to gradually replace residential heating energy with clean energy and reduce energy consumption.

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[7] *The shares are to be understood taking into account the multipliers in the Renewable Energy Directive.*

[8] *Directive 2018/844/EU amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency; and Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.*

We also aim to further improve the **final energy intensity of GDP by ensuring economic development,** which **is planned to fall below HUF 0.429 toe/million (17.96 GJ/MFt) by 2030,** compared to HUF 0.525 toe/million in 2021. Enterprise energy efficiency measures play a significant role in this. Energy efficiency incentives, energy price developments and market competition force companies to carry out energy renovations, facilitated by several support schemes. Support for SMEs is available from both EU funds and national budgets. In addition to the**obligation for energy consultants and electricity meters to be used by entities with significant energy consumption, as well as the obligation for large companies to carry out energy audits and** the possibility for companies to benefit from the **corporate tax allowance** (TAO discount) resulting from their energy efficiency projects, we considered it necessary to introduce a new policy measure. In order to achieve the energy efficiency targets cost-effectively, **we have introduced an energy efficiency obligation scheme (EEOS),** which directs investments on a market-based basis to areas with the highest potential for energy use reduction and energy efficiency. The contribution of the ECS to the domestic energy savings target is 26%, with cumulative energy savings of 88 PJ by 2030, with the remaining 74% to be ensured by other alternative energy efficiency policy measures. Therefore, we consider it of utmost importance to **maintain and renew alternative policy measures that improve energy efficiency.**

The focus of energy efficiency measures in transport is to encourage technological change, in particular electrification, and modal shift, i.e. to encourage the use of public transport and micro-mobility and to encourage transport other than road transport. We plan to ensure these objectives through legal and financial incentives, including the development of services and infrastructure required for technological change.

The large-scale development of the electrification of buildings and transport requires particular attention to the development of the necessary equipment, industrial activities and services. The **energy efficiency of energy supply** is ensured by network developments and related supply-side performance-enhancing investments, which is our **priority goal in electricity supply and district heating** supply.

(3.) Energy security dimension

Hungary's energy supply continues to be **characterised by high import exposure.** [9] The risks of dependence on foreign markets relate mainly to the purchase of nuclear fuel and hydrocarbon fuels. In 2021, the import exposure indicator was 87-87% for both oil and gas, and the supply of nuclear fuel can only be covered by imports.

For a long time, the availability of alternative transport corridors and source actors was sufficient to mitigate the risks of import exposure. Imports of petroleum and petroleum

[9] *In all cases, the exposure of energy supply was measured by the share of imports, the share of non-domestic energy in total primary energy consumption and stockpiling.*

products can be satisfied by several transport routes – in addition to pipeline supply, by rail and road, by tankers and waterborne transport, using barges. Our cross-border capacities for natural gas imports have expanded over the past decade. However, the current Russian-Ukrainian war situation and its consequences have highlighted the **need to pay more attention to the risks arising from import dependency, to address them with a wider range of tools and to mitigate them,** given the need to maintain stable fossil supplies in the short to medium term in the energy transition.

Among secondary energy sources, the import share of domestic electricity supply can be considered high (28% in 2021), compared to current consumption and available generation capacity. With regard to the supply of electricity, Hungary's objective remains to operate an electricity system that is able to meet growing demands, while at the same time guaranteeing a high level of security of supply, being consumer- and climate-friendly, supplying electricity at affordable prices, encouraging the entry of new, flexible products into the market and being open to innovative solutions. It is also a priority objective to reduce electricity import exposure, which can be ensured **by creating the possibility of self-sufficiency in electricity on the capacity side,** also reflecting increasing supply and regulatory needs. The transformation of the electricity sector generates significant market organisation, distribution and transmission network development, human capacity and competence development, and regulatory tasks. Their implementation should prevent the integration of weather-dependent renewable producers into a further large-scale system, in order to ensure the sustainability of system security and the controllability of costs. The development of primarily green industrial capacities to support the country’s economic recovery will lead to an increase **in energy use, which, however, will not be counterbalanced by the integration of additional renewable capacities in the Hungarian energy system beyond the planned renewable capacities,** as this will require further strengthening of the grid and the development of additional flexibility capacities.

The reorganisation of the Mátra power plant also goes beyond the technological issues of the power plant, which must also take into account the social, economic and environmental impacts of the region of Northern Hungary affected by the operation of the power plant. In particular, from the point of view of the security of supply in the eastern part of the country, the **phase-out of coal-based electricity generation at the site of the Mátra Power Plant can only be achieved by installing suitable alternative capacities.**

As a result of the above, security **reserve building, storage and stockpiling, source diversification and related route diversification options, and a reduction in the share of imports are of greater importance for all primary and** secondary energy sources characterised by high import exposure. Accordingly, the aim is to **reduce domestic consumption** and, where possible, **to increase domestic production,** to **increase the use of alternative, domestic energy sources** and, finally, to have a **more balanced technological mix** based on multiple solutions.

(4.1) Dimension of the internal energy market - Energy interconnections

Hungary has a significant number and capacity of cross-border connections with neighbouring countries, including several types of energy, which supports its security of supply efforts and expands its diversification potential.

The Hungarian **electricity system** is directly interconnected with all neighbouring countries, including Slovenia since 2022. The transmission capacity of cross-border high-voltage lines **reaches 48% of the gross installed capacity in Hungary,** which is significantly higher than the 15% target set by the EU. Although the currently available transmission capacities allow for flexibly diversifiable commercial transactions, **we plan to further increase capacities** in cooperation with Serbian, Romanian and Slovak partners.

A substantial amount of **physical natural gas can be transported** to Hungary from six neighbouring countries, totalling more than 144 million m3 per day. Hungary wishes to strengthen its function as **a transit country** for natural gas. After 2020, the Croatian-Hungarian cross-border pipeline was bi-directionalised and, in the interests of diversification, 1 billion m3 of natural gas was booked annually at the Croatian Krk LNG terminal. With regard to natural gas supply, it is an important task to implement the last **Hungarian-Slovenian bi-directional natural gas interconnection** in order to integrate possible southern sources into the Hungarian gas system. In addition, due to the transport of natural gas from both Azerbaijan and Romania (Neptun field) to Hungary, the **expansion of the Romanian-Hungarian cross-border capacity is also justified** in order to better integrate the markets. In addition, we are exploring the possibilities of transporting additional LNG resources to Hungary – e.g. from Italy's terminals via Austria and Slovenia. Furthermore, an **increase in the transmission capacity of the Hungarian-Slovak gas interconnection on the Slovak side is underway,** which would represent a significant step in the development of the North-South gas corridor.

With regard to our oil supply, in order to keep import exposure at manageable levels and diversify supply, the aim is to **expand the capacity of the Adriatic oil pipeline,** while increasing the flexibility of refinery capacities, which also requires Croatia's cooperation.

(4.2) Internal energy market dimension - Energy transmission and transport infrastructure

The development of the domestic and cross-border electricity transmission network and the natural gas transmission pipeline system will be carried out on the basis of **their 10-year network development plans,** which will be developed, updated and licensed by the competent transmission system operators (TSOs), in cooperation with distribution system operators (DSOs), on the basis of the analysis of the systems under their care, the capacity and connection needs and forecasts that have arisen and been submitted to the Hungarian Energy and Public Utility Regulatory Authority (MEKH).

In connection with the gas system, the main focus is on the **mixing of alternative gases** and the related technological challenges and service development, as well as the tasks related to the reduction of the utilization of system components in the long term. However, it will be more significant in the electricity system in order to bring about the transition, achieve the decarbonisation targets and support energy security. The development of transmission infrastructure, regulatory and market environment supporting the integration of renewable energy is essential due to the increase in electricity demand and the spread of electrification. It is necessary to ensure **the adequate availability of electricity generation capacities in a context of increasing electricity demand and increasing system regulation needs.** In the longer term, weather-dependent renewable technologies and state-of-the-art nuclear technology that can be safely applied in the electricity sector form the backbone of the system. During the transition, however, it is essential to use technologies capable of continuous and predictable energy supply, for which a decision has been taken to **install a maximum of 1.65 GW of combined cycle gas power plant (CCGT) capacity , since in Hungary and in the region as a whole, security of supply can be ensured by maintaining reserve capacities during the expected period of** technological change .

The Mátra Power Plant site and/or the region of Northern Hungary hosting it offer a good opportunity to implement **low carbon energy production and energy storage projects** that can relieve the burden on the electricity system, consumers and other areas. The development of new CCGT capacities, the construction of a new photovoltaic power plant and industrial energy storage unit, and the energy recovery of biomass and non-materially recoverable waste (RDF) are also planned in the area of the power plant as a guarantee of security of supply.

Due to the integration of renewable power plants and in order to integrate additional capacities into the system, significant **cost-effective network development** is justified and has already started. Prepare the electricity grid, in particular the distribution grid, for the increasing spread of decentralised capacities. In addition to the transmission system operator, distributors must also be prepared **for active system operation**. It is also necessary to ensure that the**accuracy of weather forecasting is improved and to encourage the construction of electricity storage capacities, both in the form of** integrated components at the system operator and network licensees (which have already started) and in order to increase balancing control capacities. Hungary plans to **build energy storage facilities with a total capacity of 500-600 MW by 2026, which could increase to 1 GW by 2030.** In addition to battery energy storage facilities, it is also advisable to integrate pumped-storage power plants (pumped-storage, SZET) into the system. In the years following 2030, half of the storage capacity of the electricity system should be based on SZET, since on the one hand it is a proven technology with a 100-year history in Europe, which can be applied effectively in Hungary as well. On the other hand, it is one of the most environmentally friendly technologies known today. In addition, in addition to increasing the digitalisation of the electricity system, transparency and economic efficiency **in the allocation of grid connection capacities should be increased,** innovative market organisation practices and **consumer side services should be introduced and the active participation of** consumers in the market should be strengthened.

(4.3) Dimension of the internal energy market – Market integration

The primary condition for energy market integration is the physical connection of supply systems through networks. Interconnection of neighbouring markets with bi-directional cross-border capacity and similar market sizes is recommended, thus increasing competition between operators in the interconnected market. The **physical conditions of the Croatian-Hungarian gas market coupling** are in place, as bi-directional trading is already available at the cross-border point.

Strengthening the integration of the electricity market is a security component of the European coordinated electricity system and at the same time supports the economics of the Member States in the electricity competitive market. Cross-border **auctions were also launched in intraday markets** from July 2024, in parallel with the current continuous trading, and the introduction of flow-based capacity allocation is expected to take place in 2027, also over an intraday time horizon. In the context of the integration of balancing markets, it is appropriate to rapidly implement the connection to **PICASSO**(automatic frequency control reserve market) and **MARI**(manual frequency control reserve market), for which the necessary IT developments are already underway.

(4.4) Internal energy market dimension - Energy poverty

Vulnerable customers/households are those who have **difficulty meeting their household's energy needs.** According to **the Government's policy, the**result of the **overhead protection system is that the number of energy poor within vulnerable consumers is approximately 300,000.** In order to reduce the risks of the population most affected by the vulnerability, we plan long-term housing construction, renovation, heating modernisation and energy efficiency programmes to ensure adequate housing conditions, as well as programmes for the transition to low-cost self-sufficiency.

(5.) Research, innovation and competitiveness dimension

The most important task in terms of energy innovation and R&D is to support our emission reduction and security of supply goals, so our main development directions are primarily: supporting **innovative, longer-term energy storage**in all renewable energy sectors, supporting energy delivery modes and smart technologies and **clean power generation capable of small-scale cord production,** strengthening research and development in the domestic manufacturing and feedstock industry, including its GHG emission reduction, and supporting carbon **capture, storage and utilisation (CCUS)**technologies, as well as developing the scaling up of **carbon-free hydrogen**production and application, supporting innovative solutions to **address climate change adaptation.**

In addition to the above, Hungary's competitiveness can be strengthened by the following. Partially **domestic production of green technology solutions and the expansion of the related domestic construction capacity are essential** for the feasibility of energy investments. This will also increase the competitiveness of the national economy as a whole, as investments will increasingly focus on the use of green technologies in the future. A priority aspect is the realization of the domestic production capacities of the rapidly spreading **technologies, besides which the design and implementation of the related services** must proceed at the same pace. However, for this and for the energy transition as **a whole, it is essential to have a well-prepared and sufficient workforce** in the green economy, which can be achieved by training professionals entering and already present in the labour market. In the interest of the country's competitiveness, the development and scheduled implementation of the related industrial strategy can lead to significant progress.

In particular, the **Mátra power plant has had and continues to** have a significant socio-economic impact within its narrower area. The large-scale site of the Power Plant may be suitable for multi-purpose utilization beyond the energy functions. These include the **expansion and diversification of the industrial park,** the expansion of agricultural or other storage and logistics functions, the preservation and presentation of mining cultural heritage, habitat reconstruction for tourism and nature conservation purposes, or natural water conservation measures.

iii. Overview table of the main objectives, policies and measures of the plan

The table below summarises Hungary's key quantified objectives.

*1Table - Hungary's main objectives and *indicative sub-targets for 2030 with the related 2021 situational picture*[10]

Main dimension	Main objective	State of play (2021)	Objectives set by 2030	Scope of the objective (other dimensions)
1.1.	Gross GHG emission reductions compared to 1990	-32.4% without air transport	-50% 47,5 Mt CO_2e	1.1. → 3.
1.1.	Net GHG emission reductions compared to 1990*	-37.8% without air transport	-55% 41.2 MtCO_2e	1.1. → 3.
1.1.	Net GHG removals in the LULUCF sector	-7,197 Mt CO_2e	-5,724 Mt CO_2e	1.1. → 3.
1.1.	Reduction of ESR emissions compared to 2005	-1.2%	-18.7% 38,34 Mt CO_2e	1.1. → 3.
1.1.	GHG intensity of GDP	1,37 tCO_2e/million HUF	GHG intensity Continuous reduction	1.1. → 3., 5.
1.2.	Share of renewable energy in gross final energy consumption	14.13%	30%	1.2. → 1.1., 3.
1.2.	Share of renewable energy in gross final energy consumption in the electricity sector*	13.66%	32%	1.2. → 1.1., 3.
1.2.	Share of renewable energy in gross final energy consumption in the transport sector	6.16%	25%	1.2. → 1.1., 3.
1.2.	Share of renewable energy in gross final energy consumption of the	17.90%	32%	1.2. → 1.1., 3.

[10] *Note: *Indicative non-binding sub-target*

	heating and cooling sector*			
2.	Primary energy consumption* (Europa 2020-2030)	1042.5 PJ	1010 PJ	2. → 1.1., 1.2., 3., 4.
2.	Final energy consumption (Europa 2020-2030)	799,7 PJ	740 PJ	2. → 1.1., 1.2., 3., 4.
2.	Minimum cumulative final energy savings	-	336 PJ	2. → 1.1., 1.2., 3., 4.
2.	Energy use of the residential building stock compared to the average of 2018-20*	266,9 PJ	-20% 195.1 PJ *2025 – According to the National Building Renovation Plan.*	2. → 1.1., 1.2., 3., 4.
2.	Energy consumption of the public building stock compared to the average of 2018-20*	34,5 PJ	-18% 29 PJ *2025 – According to the National Building Renovation Plan.*	2. → 1.1., 1.2., 3., 4.
2.	Final energy intensity of GDP	0,525 toe/million HUF	0.429 toe/million HUF	2. → 1.1., 1.2., 3., 4.
3.	Increase self-sufficiency in energy supply*	33.7%	Continuous development of self-sufficiency	-
3.	Import exposure – natural gas	87%	80%	-
3.	Maintenance of secure natural gas storage capacities by volume*	1.2 billion m^3	1.2 billion m^3	-
3.	Infrastructure security of natural gas supply (N-1) *	147%	Continuously over 120%	-
3.	Import exposure – oil*	87%	85%	-
3.	Maintenance of emergency oil storage capacities by minimum supply period*	90 days	90 days	-
3.	Import Ratio – Electricity	29%	20%	-
4.	Proportion of electricity interconnections	48%	min. 60%	4. → 1.1., 1.2., 3.
4.	Vulnerable consumers	*According to the Social Climate Plan.*	*According to the Social Climate Plan.*	4. → 1.1., 1.2., 3.
5.	Number of innovation pilot projects implemented	0 pcs	min. 20 pcs	5. ←→ 1.1., 1.2., 2., 3., 4.
5.	Number of international patents registered during the implementation of pilot projects	0 pcs	min. 10 pcs	5. ←→ 1.1., 1.2., 2., 3., 4.
5.	R&D expenditure as a share of GDP*	1.47%	3%	5. ←→ 1.1., 1.2., 2., 3., 4.
5.	Ranking among the world's innovators (GII) *	34.	The Best 25 Among the innovators	5. ←→ 1.1., 1.2., 2., 3., 4

The measures and related information relating to the above objectives are set **out in Annex 1 to the NECP,** dimensionally and thematically according to the main objectives and groups of measures.

1.2. Overview of the current policy situation

i. National and EU energy system and policy context of the national plan

In addition to the needs and demands formulated at national level, the energy system of Hungary and the EU Member States is also influenced by EU Community regulations. The national and EU energy system, and therefore the NECP, is directly affected by the following (consolidated, existing) regulations.

Regulation (EU) 2021/1119 establishing the framework for achieving climate neutrality **(EU Climate Law)** sets out the EU-wide 2050 climate neutrality objective and a 55% reduction in net GHG emissions by 2030. The European Commission (hereinafter: On 15 July 2021, the Commission published *the 'Fit for 55'* package of proposals, which aims to bring EU legislation into line with the EU's net emissions reduction target of 55% by 2030. The package of proposals also has an impact on the following pieces of legislation, which fundamentally define the EU's energy system:

- Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union (EU**ETS)**
- Directive 2009/73/EC concerning common rules for the internal market in **natural gas**
- Directive 2009/119/EC imposing an **obligation on Member States to maintain minimum stocks of crude oil and/or petroleum products**
- Directive 2010/31/EU on the energy performance of buildings **(EPBD)**
- Directive 2012/27/EU and subsequently Directive (EU) 2023/1971 on energy efficiency **(EED)**
- Directive 2014/94/EU followed by Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure **(AFID** followed by **AFIR)**
- Regulation (EU) 2017/1938 concerning measures to **safeguard the security of gas supply**
- on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework **(LULUCF)**
- Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement **(ESR)**
- Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action **(Governance Regulation)**
- Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources **(RED)**
- Regulation (EU) 2019/943 on the internal market for **electricity**
- Regulation (EU) 2020/2093 laying down the multiannual financial framework for the years 2021 to 2027

- Regulation (EU) No 1303/2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund **(ERDF); ESF (ESF); CF (KA); EAFRD (EAFRD)**
- Regulation (EU) 2020/1001 laying down detailed rules for the application of Directive 2003/87/EC of the European Parliament and of the Council as regards the operation of the Modernisation Fund to support investments in modernising the energy systems and improving the energy efficiency of certain Member States **(MF (MA))**
- Regulation (EU) 2021/241 establishing the Recovery and Resilience Facility **(RRF)**
- Regulation (EU) 2021/1056 establishing the Just Transition Fund **(JTF)**
- Regulation (EU) 2021/1153 establishing the Connecting Europe Facility **(CEF)**
- Regulation (EU) 2021/2115 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) **(CAP)**
- Regulation (EU) 2023/955 establishing a Social Climate Fund **(SCF)**

The past years have been and continue to be marked by health, geopolitical and economic events affecting the security of energy supply. ***Hungary's Recovery and Resilience Plan (RRP)*** aims in particular to counter the economic and social impact of the coronavirus pandemic and to increase the resilience, sustainability and preparedness of the economy for the challenges and opportunities related to the 'green and digital transitions'. The Hungarian plan, finalised in constructive negotiations with the Commission, sums up nearly HUF 2,300 billion worth of strategic development projects by 2026. Of this, HUF 526 billion is available to support investments planned under the Energy component ("Green Transition"). While HET primarily aims to promote economic convergence, the ***RePowerEU chapter,*** which will complement it later, specifically promotes the energy transition. Negotiations with the Commission on the chapter were concluded in 2023, which, in addition to the previous HET funds, will provide an additional HUF 1 750 billion of investment funds to achieve the objectives set out in the NECP.

Based on the *Governance Decree,* the NECP presents Hungary's national climate and energy policy goals, measures and the expected energy system in the short and long term in a thematic manner, in line with the above regulations. In the NECP, the national energy policy objectives, which are included in the respective ***National Energy Strategy (NES),*** and the climate policy objectives, which are included in the respective ***National Climate Change Strategy (NCS),*** are aggregated.

The revision of the NES will be carried out in parallel with the NECP and will be finalised after the adoption of the NECP in Hungary. A *77/2011. (X.14.) Parliamentary (OGY) resolutions* and supplementary resolutions contain the energy forecasts, tasks, deadlines and energy policy targets to be reviewed every two years. Due to the revision and finalisation deadline of the NECP, the main energy policy orientations that are also needed to update the NES will be updated in the framework of the 2023-2024 NECP revision.

The *23/2018. According to the* ***Second National Climate Change Strategy*** *(NÉS-2)* for the period 2018-2030 with a 2050 perspective, adopted by OGY Decision (X. 31.), gross greenhouse gas emission reductions between 52 and 85 % shall be achieved by 2050 compared to 1990. In addition to the *Domestic Decarbonisation Roadmap* (HDU), this Strategy also includes the *National Adaptation Strategy (NAS)* and the *Partnership for Climate Awareness-raising Plan* . In order to implement the objectives set out in NÉS-2, *three-year Climate Action Plans (CAPs)* are being prepared with the aim of clarifying the tasks set out in the short-term action lines of NÉS-2 and preparing longer-term measures. An evaluation of the implementation of NÉS-2 was carried out in 2023. Significant progress has been made in the migration, adaptation and awareness-raising measures related to NÉS-2 since 2020. The new measures are set **out in Annex 1 to the NECP** and the measures already implemented are presented in chapter 3.1.1i for completeness.

Hungary's previous energy and climate policy directions were shaped by the scenarios ***of the National Clean Development Strategy (NTFS),*** the topic of which is the same EU regulation as the NECP. The NTFS presents the possible role of all sectors in achieving the climate neutrality target and outlines how Hungary can achieve full climate neutrality by 2050 without its implementation jeopardising economic growth or prosperity.

Annex 1 to the NECP contains both the above strategies defining the NECP and the legislation defining the domestic energy system, and their connection to EU law. In addition to these measures, other domestic strategies and programmes are also intrinsically linked to the domestic policy framework. These include the Climate *and Nature Action Plan (CCA),* the National *Air Pollution Reduction Programme (OLP)* and the *Fifth National Environment Protection Programme (NKP-5).*

The **CCCTB** was announced at the beginning of 2020 with[11] 8 action points. The shortened action plan highlights the primary measures of the NECP aimed at preserving Hungary in good environmental condition for our children and grandchildren, i.e. for future generations.

In 2020, OLP was adopted in accordance with Directive (EU) 2016/2284 on the reduction of national emissions of[12] certain atmospheric pollutants. A 1231/2020. Government Decision (V. 15.) sets targets for the emission of harmful substances by 2030 for industry, agriculture, transport and energy. The programme will guide the desired changes in sectoral regulations and subsidies in the coming years in order to reduce emissions of the

[11] *https://2015-2019.kormany.hu/download/9/d4/c1000/ITM_Klima_es_Termeszetvedelmi_Akcioterv.pdf*
[12] *https://cdn.kormany.hu/uploads/document/4/4a/4af55450145afb03048bad7311e0979c9fc3b5db.pdf*

most important air pollutants. The specific objective of the programme is to reduce Hungary from 2005 levels by 2030:

- Sulphur dioxide emissions by 73% (SO_2, largely derived from energy production, industrial sector, heating of buildings),
- emissions of nitrogen oxides by 66% (NO_2, mostly from transport, heating of buildings, agriculture),
- emissions of non-methane volatile organic matter by 58% (NMVOC, which is largely derived from building heating, agriculture), and
- ammonia emissions by 32% (NH_3, largely from agriculture),
- small particle emissions of 55% ($PM_{2.5,}$ largely derived from building heating).

The NECP is an air pollution control (greenhouse gas: CO_2; N_2O; CH_4; F-gases) in parallel with the objectives of OLP air pollution control (for harmful substances: SO_2, NO_2; NMVOC; NH_3; $PM_{2.5}$), which in many cases come from the same source – therefore, **it is planned to combine the energy modelling of the NECP and the OLP .**

A *62/2022. (XII. 9.)* ***NKP-5,*** [13] *which runs from 2021 to 2026, was adopted by OGY decision,*which treats both energy efficiency and decarbonisation as strategic areas from an environmental point of view:

- Strategic Area 12: Improving energy saving and efficiency, increasing the use of renewable energy;
- Strategic Area 14: Reducing greenhouse gas emissions and preparing for the effects of climate change.

The task of the NKP-5 is to define the country's environmental goals and the tasks and tools necessary to achieve them, taking into account the country's environmental status, the development goals of society and the obligations arising from international cooperation and EU membership. This places particular emphasis on the cross-cutting nature of environmental protection, which applies to all sectors. In-depth consideration of NKP-5 *is provided for in Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (SEA Directive) and hence in Directive 2/2005. The* **Strategic Environmental Assessment (SEA) of the NECP has been prepared** *on the basis of the Government Decree (I.11.).*

ii. Current energy and climate policies and measures for the five dimensions of the Energy Union

Current measures and related information on the 5 dimensions of the Energy Union, classified as WEM (with existing measures), including sectoral strategies, are presented in Annex 1 to the NECP, dimensionally and thematically according to the main objectives and

[13] *https://xn--krnyezetvdelem-jkb3r.hu/sites/default/files/media/docs/nkp-5.pdf*

groups of measures. The measures include measures to support progress towards climate neutrality and to ensure related and interim security of supply, such as transport, buildings, industry, alternative resource supply, networking, technology, adaptation and awareness-raising.

iii. Key issues of cross-border relevance

Hungary is highly exposed to the undesirable effects of climate change due to its location in the interior of the continent (basin location) and the special microclimate of the Carpathian Basin. Thus, the fight against climate change – decarbonisation and energy transition – as well as protection against the adverse effects of climate change, such as the maintenance and safety functions of the built environment and fossil systems, are of particular importance for Hungary. – Although Hungary has significant lignite resources, **its supply of – fossil fuels is** characterised by **high exposure to imports.** Dependence on foreign markets, or on a single foreign market, poses the greatest risk in relation to hydrocarbon energy carriers and nuclear fuel elements. The level of risk was amplified by the effects of the current Russian-Ukrainian war situation. In **addition to increasing self-reliance, risk can be mitigated and managed by purchasing from multiple sources.** The complexity and interconnections of Hungary's energy systems make it possible for the country to perform intermittent **regional security of supply functions** in several types of energy.

Hungary maintains and develops significant natural gas storage capacities and related regulations. In order to diversify sources, **domestic cross-border capacities for the supply of natural gas are gradually expanding,** but it is justified to establish a connection with Slovenia and to further expand its interconnection capacity with Romania in order to increase the import potential of conventional natural gas and LNG sources. Together, domestic gas storage facilities, cross-border capacities and a significant transmission network are also able to **support international gas supply** at the right time and in the right quantity, and are therefore key to supporting regional security of supply. The domestic gas system is of paramount importance for the future as well, as long as we ensure **the mixing of alternative gases** that also contribute to climate protection. That is why it is necessary to develop the transport network.

Looking further ahead, there is also a need to prepare for **a secure supply of hydrogen.** Hungary wishes to be an active part of the *European Hydrogen* Backbone network, the foundations of which it plans to lay in the coming years in order to implement the regional transit country function, on the one hand, and to develop the hydrogen supply routes for imports necessary to meet hydrogen demand, on the other hand.

Hungary has geological formations **considered potentially suitable for carbon storage.** In addition to the pore volume of the harvested reservoirs, some deep saltwater aquifers unsuitable for other uses may theoretically be suitable for storing CO2. Reservoirs are available with lower storage capacity in the short term, while aquifers are available with significant capacity, but only in the longer term. In the interest of efficient pore space utilization, in the case of given geological formations, it is necessary to take into account the utilization options, surface possibilities and limitations. Priority can be the utilization of geothermal energy, storage of carbon dioxide, storage of hydrogen, mining of dissolved metal fluid (and in the case of other porusters, this also includes the increased efficiency of hydrocarbon extraction). The **choice between different technologies to be used** for climate neutrality is necessary, also in view of the difficulties in developing new markets and supply chains, for which international cooperation is a priority. In order to neutralise GHG emissions, the **entry into force** *of the Net Zero Industry Act (NZIA)* **will increase the importance of high-capacity carbon storage capacities.** However, this may apply primarily to the marine potential, since CO2storage requires the designation of storage areas capable of ensuring the protection of life, where appropriate transport pipelines can be built. Ensuring proportionate support for the tasks of storage capacities, including the North Sea potential, and carbon storage is in the common European interest. In view of the annual increase in the volume to be stored, both due to the specific capture capacity and the need to develop additional capture capacities, **the use is not only necessary, but also a priority development** issue in relation to CCUS technologies.

In addition to the maintenance of the Ukrainian-Hungarian Friendship Petroleum Pipeline, **the increase of the southward oil supply - the capacity expansion of** the Adriatic Petroleum Pipeline connecting Hungary and Croatia - is a cost-effective solution supporting source and route diversification at the same time. In close connection with this, it is Hungary's primary responsibility to maintain the region's oil refinery. Increasing the capacity of the Danube Refinery to process alternative sources is also necessary in order to maintain **the security of supply of regional petroleum products.**

A **high degree of integration of the European electricity system** guarantees significant security of supply for all connected countries in Europe. The electricity systems of the interconnected neighbouring States have a significant and direct impact on each other, also due to their balancing capacity, weather-dependent power plant portfolio and possible supply disruptions. This will be addressed through the interconnection of European electricity markets, which will optimise electricity trade between countries and make it more efficient and liquid. For example, **from the point of view of the energy systems of the countries bordering Hungary, the cost-effective off-peak energy supply of the Paks Nuclear Power Plant is** outstanding. As regards electricity market integration, to which Hungary has joined, the following main developments have taken place over the past three years:

- The new market coupling has been successfully launched within the framework of an interim coupling project based on Net Transfer Capacity (NTC). On 17 June 2021, for the first time, day-ahead cross-border capacity was implicitly allocated at the six new borders (PL-DE, PL-CZ, PL-SK, CZ-DE, CZ-AT, HU-AT) using the Euphemia algorithm. Market coupling allows for the parallel calculation of electricity prices and cross-border flows in the region.

- On 8 June 2022, delivery day on 9 June, the Flow-Based Market Coupling (FMBC) of electricity markets in the wider Central Europe (Core) region was successfully launched with a single day-ahead timeframe and flow-based capacity calculation.

The international interconnections and transmission capacities of the Hungarian electricity system allow for a sufficient, secure and flexibly diversifiable trading transaction, but **further market integration steps** – the MARI and PICASSO projects – are needed in relation to balancing markets.

In order to strengthen the supply of clean energy technologies in the EU, it is appropriate to **develop a portfolio of (green) industrial production capacity and services supporting clean energy production and** use. In Hungary, this will be implemented primarily along *the lines of Hungary's* **industrial and technological action plan,** *primarily in areas related to electrification.* Such and similar industrial development practices, while on the one hand increasing energy demand and emissions in the short term, ensure the achievement of long-term goals and thereby also strengthen the country's competitiveness. Due to different product and service needs, **international cooperation within the EU can serve as a safeguard for both domestic, clean supply and use of products and services.**

iv. Administrative set-up for the implementation of the National Energy and Climate Plans

A significant part of the tasks related to the implementation of the NECP are the responsibility **of the Ministry of Energy** (EM).[14] Energy and climate policy planning is carried out in an integrated manner in EM. The duties and responsibilities of the Minister for Energy include, inter alia, the following areas: mining, energy and climate policy, planning and use of related EU funds, sustainable development, waste management, circular economy, environment, water utility sector.

Other major independent regulators, institutions and actors involved in updating, implementing and monitoring the NECP are:

Ministries and background institutions

- Ministry of Agriculture (AM) and its background institution: Institute of Agricultural Economics Nonprofit Ltd. (AKI)
- Ministry of the Interior (BM)
- Ministry of Energy (EM) and its background institution: HungaroMet Hungarian Meteorological Service Nonprofit Ltd. (HungaroMet, formerly: Hungarian Meteorological Service (OMSZ)
- Ministry of Construction and Transport and its background institutions: Construction Quality Control Innovation Nonprofit Ltd. (ÉMI) and Hungarian Institute of Transport Sciences and Logistics Nonprofit Ltd. (KTI)

[14] *Legislative predecessors: Ministry of Innovation and Technology (ITM) and Ministry of Technology and Industry (TIM)*

- Ministry of Public Administration and Regional Development (KTM)
- Ministry of Foreign Affairs and Trade (MFA)
- Ministry for National Economy (NGM, formerly: Ministry of Economic Development, GFM)
- Ministry of Finance (PM)

Authorities

- Hungarian Energy and Public Utility Regulatory Authority (MEKH)
- National Climate Protection Authority (NKH)
- National Research, Development and Innovation Office (NKFIH)
- Hungarian Atomic Energy Authority (HAEA)
- Supervisory Authority for Regulated Activities (SZTFH)

Companies, Associations, Associations:

- Natural gas transmission system operator (FGSZ (TSO))
- Hungarian Hydrocarbon Stockpiling Association (MSZKSZ)
- Hungarian Research Network (HUN-REN), Centre for Energy Research
- Hungarian Chamber of Engineers (MMK)
- Hungarian Oil and Gas Plc. (MOL)
- Hungarian Transmission System Operator for Electricity Industry (MAVIR (TSO))
- Energy exchanges: CEEGEX Zrt., HUPX Zrt., HUDEX Energia Stock Exchange Zrt.
- Other industry players, sectoral research centres and scientific institutes.

The following chapters contain the bodies involved in the preparation of the **NECP, while Annex 1 to the NECP** contains, by measure, the legal person or persons responsible for its implementation.

1.3. Consultation and participation of national and Union bodies and outcome of the consultation

i. Participation of the national parliament

The National Assembly was not consulted on the NECP.

ii. Participation of local and regional authorities

The involvement of local and regional authorities in the finalisation of the NECP was achieved by ensuring the publicity of the consultation documentation, the authorities' feedback and the related consultations. Relevant feedback was managed in a consistent manner in the context of the management of public feedback.

iii. *Consultation of stakeholders, including social partners, and engagement of civil society and the public*

On the updated NECP, the National Environmental Council (hereinafter: It also held talks in May 2023 and 2024. The OKT is the government’s advisory, proposal-making and opinion-giving body for the formulation of decisions with environmental policy content that have a national or regional impact. The OKT consists of three groups of equal size: environmental organisations; professional and economic interest representatives; representatives of academia appointed by the President of the Hungarian Academy of Sciences.

An open public consultation on the shortened version of the draft NECP took place in summer 2023 and was implemented online. Furthermore, a total of 6 consultation sessions were held in person between May and June 2023. The events were attended by environmental and social NGOs, business associations and industry stakeholders. Discussions on the draft NECP took place in two rounds, first in May 2023 and then in parallel with the open public consultation. The participants could send their comments and suggestions in writing. Subsequently, the draft NECP submitted to the European Commission was also reviewed by civil society and industry stakeholders at professional conferences, forums and in the form of written proposals. Furthermore, in the framework of the NECP SEA procedure, the environmental assessment and its open social consultation in the summer of 2024 also provided an opinion on the environmental aspect of the NECP.

On the basis of the strategic environmental assessment, in order to improve the environmental status, it is necessary to take the following into account when implementing the measures of the NECP:

- prioritising brownfield investments and closer-to-nature solutions and preventing extensive land use, saving space and improving existing sites and buildings
- consideration of environmental aspects in procurement and use of local and/or recycled materials in construction, and minimisation of "energy-to-use" and waste generation
- protection of habitats for new energy investments
- covering the electricity demand of heat supply from renewable power plants
- stepping up efforts towards a decentralised, flexible electricity system, increasing the role of energy communities;
- development of the local heat market, covering the electricity demand of the heat supply, preferably with renewable capacities
- use of best available technologies
- identification of sectors where the use of electric vehicles is preferable to hydrogen fuel cell vehicle use
- implementation of projects for the development and utilization of second life batteries

- establishing a framework to maintain a balance between the production of food crops, fodder crops and energy crops
- extending the protection zones of water bodies, improving the quality parameters of the water system by supporting the use of precision materials and disseminating other smart technologies in agricultural holdings
- protection of forest dynamic processes, systematic enforcement of biodiversity aspects with core areas, protection zones, ecological corridors
- prioritising alternative waste water treatment methods in small villages and sparsely populated areas
- Preventive climate risk assessment of technical facilities for the storage of landfills and hazardous waste
- increasing the rate of recovery of household hazardous waste to be collected separately
- in addition to efficiency, measures to encourage savings
- establishing closer cooperation with domestic and international universities, research centres, interest groups during the preparation of investments, involving the tax and planning, research and educational workshops
- development of planning processes reflecting the development of functional areas.

In addition to the European Commission's opinion, a number of feedbacks were received from civil society and civil society organisations, as well as from industry and public authorities on the shortened NECP and the submitted draft NECP available on the Commission's website, both in written form and during face-to-face consultations. Most of these have been addressed, improving the cohesion of the document, clarifying the data and filling any gaps. Feedback was diverse, but some main categories can be distinguished.

Feedback on inaccuracies and minor errors in the text was typically accepted and handled, improving the quality and cohesion of the document. Due to the limited availability of certain data, for the sake of consistency and because of the outliers after 2019, we consider 2019 as the base year, which is the basis of the modelling, and in addition to which we also compare historical data, mainly based on Eurostat, with the year 2021. Feedback was received on the detailed description of the measures needed to achieve the targets in relation to several dimensions of the Energy Union and these have been addressed in the extended list of measures (Annex**1 to the NECP**) that has been drawn up since then. In a number of cases, the feedback communicated by the Commission and civil society actors called for more ambitious targets than those agreed in the NECP, but although the targets were reconsidered and feedback was partially addressed in a number of cases, the achievement of the expected and proposed targets was not considered realistic in a number of cases, a detailed justification and analysis of this is provided in Chapter 5. In some cases, feedback from civil society organisations could not be accepted insofar as it concerned the structure of the NECP and contradicted the relevant provisions of the relevant EU Regulation.

iv. Consultation of other Member States

Hungary is a member **of the Visegrad Group and** the **High Level Group on Energy Connectivity in Central and South-Eastern Europe (CESEC),** where energy and climate policy topics relevant to the NECP are regularly discussed. In addition, several **technical conferences and meetings involving countries bordering neighbouring Member States have taken place and are regularly held in connection with the preparation and implementation of the** NECP.

The Visegrad Group is a regional organisation of the Czech Republic, Poland, Slovakia and Hungary. There is regular consultation between the V4 countries on energy and climate policy issues. On 23 April 2023, the V4 held a regional consultation in Bratislava on the Member States' energy and climate plans. During the meeting, the progress of the preparation of the NECPs of the individual Member States was discussed at regional level and it was possible to get acquainted with the preliminary plans of the Member States. On 14 March 2024, a discussion took place in DG ENER's Energy Poverty and Vulnerable Consumers Coordination Group on the state of play of the NECP.

Management discussions took place in and organised by several neighbouring Member States on the different elements of the NECP. In Poland, the conference on geothermal potential and in Slovenia, the preparation of hydrogen-tolerant gas pipeline construction were discussed. Hungary is participating in negotiations on renewable fuels for the transport sector, in the framework of Sustainable Aviation Fuels (SAF), REFUREC and V4+ Clean Mobility. In September 2023, the Minister of Energy signed a Memorandum of Understanding with the French Framatome for the possibility of replacing Russian nuclear fuel.

v. Iterative procedure with the Commission

Following the submission of Hungary's updated draft NECP, the European Commission published its assessment of Hungary's draft NECP in December 2023 and made recommendations on the Member States' NECPs and their aggregated EU contributions and results. Subsequently, the Commission's Directors-General for Energy and Climate Action launched conferences and workshops, both at EU27 level and on a bilateral basis, to support progress in updating the NECPs and to support Member States' development opportunities. In connection with the workshops, the actual progress was presented at EU27 level, as well as for some Member States' NECPs, and the possibilities and rationalisation of reporting and administrative simplification were discussed. During the bilateral discussions, we discussed the feasibility of the recommendations, realistic options taking into account the expectations and the circumstances of the Member States, and the progress of the transposition of the legislation. These have been addressed as set out in point (iii) of this Chapter.

1.4. Regional cooperation in the preparation of the plan

i. Elements designed jointly and in coordination with other Member States[15]

Regionally coordinated measures related to the development and expansion of cross-border capacities, such as the Cross-Border Electricity Task Force (ECBC) and market integration, have been developed in cooperation between the relevant TSOs, and these elements are set **out in Annex 1 to the NECP.** Potential joint cooperation will also be discussed during Member States' consultations.

ii. Explanation of how regional cooperation is taken into account in the plan

The EU guidelines and recommendations, reports and pilot projects supported by the EU Member States have an information content that makes the Community and regional development directions clear, and the developments in the Member States defined within their framework do not differ significantly in the energy transition. Therefore, Hungary is shaping its energy system and setting different long-term goals, taking into account the opportunities for regional cooperation framed by consistent goals.

Annex 1 to the NECP indicates for each objective and planned measure, if it requires regional cooperation. In some cases, as in the case of the coordinated elements indicated in the previous chapter, regional cooperation and coordinated operation are ensured by a letter of intent or an agreement, membership status in an association or the related codes. In other cases, although there is a need for regional cooperation in relation to some of the planned measures, no substantive results or final decisions have yet been made, so only planned information is provided in relation to them.

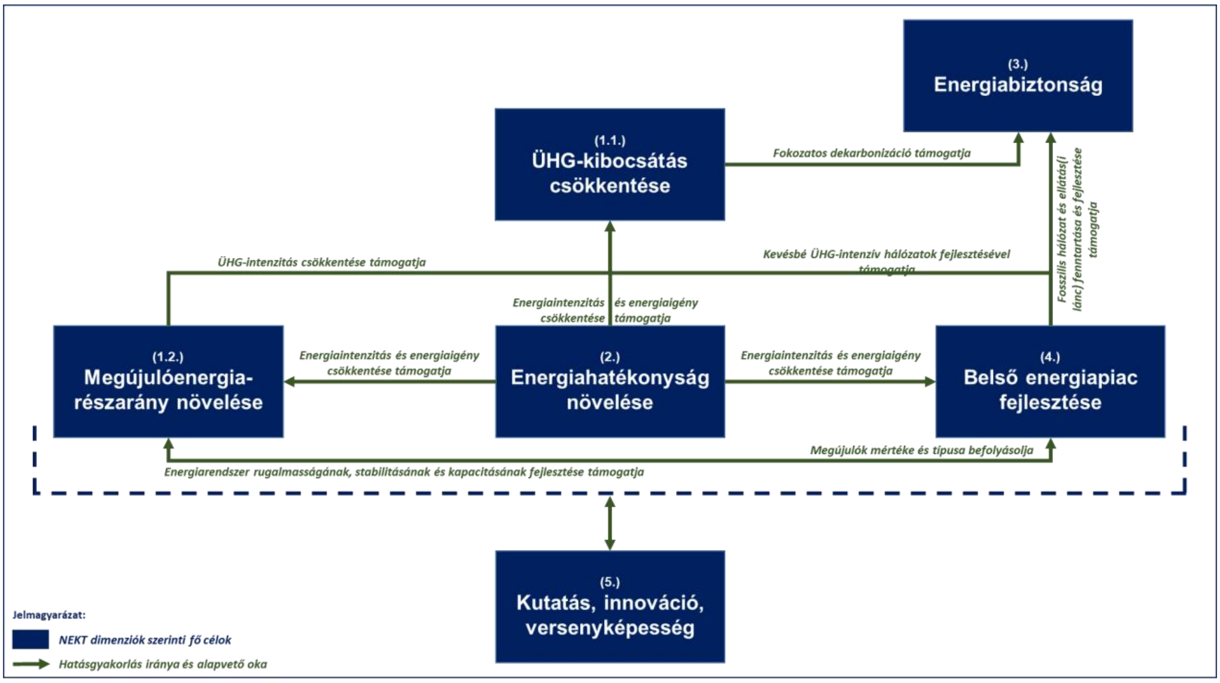
There are several infrastructures available for Hungary that are regionally dominant. In some areas, the need for, and 'forced' by, regional care jointly drive or complicate the setting of Hungary's objectives and the definition of its measures.

[15] *Explained in more detail for each dimension in the relevant points of Chapter 3.*

2. NATIONAL OBJECTIVES AND OBJECTIVES

The following is a summary of the most important directions, objectives and measures of the Hungarian National Energy and Climate Plan. The consistency between the quantified objectives and the actions identified, as well as the selection of the most cost-effective policy instruments to achieve the objectives, were supported by field modelling. The objectives and measures included in the NECP are primarily supported by the results of the REKK HU-TIMES model,[16] the SOE-ERTI CASMOFOR[17] model and the calculations of the Institute of Agricultural Economics, and in some cases supported by the calculations of HungaroMET.

Interacting with each other, the dimensions of the Energy Union can be interpreted as the following system. The impact must therefore be taken into account for the purposes of the objectives and measures under the following scheme.



1Figure - Dimensional target and measure system of the NECP

The mechanism of action of the dimensional target and measure system can be characterized by the following:

- The reduction of GHG emissions (1.1), in addition to direct measures, is impacted by increasing the share of renewable energy in the energy mix (1.2), increasing energy efficiency and in particular reducing energy use (2.) and developing the decarbonising (increasingly less GHG-intensive) elements of the internal energy market (4.), including areas so far only covered by network industries.

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[16] *The HU-TIMES model is managed by the Regional Centre for Energy Policy Research (REKK).*
[17] *CASMOFOR models are provided by the Forest Science Institute (SOE-ERTI) of the University of Sopron.*

- Increasing the share of renewable energy, the needs arising from the integration of renewables (1.2) are affected by energy efficiency measures, in particular the reduction of energy use (2.) and the development of elements of the internal energy market that facilitate the integration of renewable capacities (4.).
- Security of energy supply (3.) is strongly impacted by all dimensions, including all direct and indirect measures leading to GHG emission reductions (and adaptations) (1.1), as well as the necessary maintenance and development of the fossil supply-related elements of the internal energy markets (planned for efficiency gains and rationalisation purposes (4.).
- The functioning of the internal energy market (4) depends on its necessary and sufficient development, which is affected by the degree of and needs for the integration of renewables (1.2), as well as by energy efficiency measures and, in particular, by the reduction in demand (2).
- Increasing energy efficiency (2nd) can have a positive impact on all dimensions (1.1, 1.2, 3, 4) and therefore the *"energy efficiency first principle" is* highlighted.
- Finally, the dimension of research, innovation and competitiveness (5.) has an impact on the individual elements of the target and measure system and their changes, on the one hand, due to its supporting function, and, on the other hand, as a result product, it is also able to reflect on the needs of the complex system, thus affecting the target and measure system as a whole. Energy demand-increasing measures adopted to increase domestic competitiveness may be counterbalanced by measures and innovative technologies interpreted in the above mechanism of action.

2.1. Dimension of decarbonisation

2.1.1. Greenhouse gas emissions and removals[18]

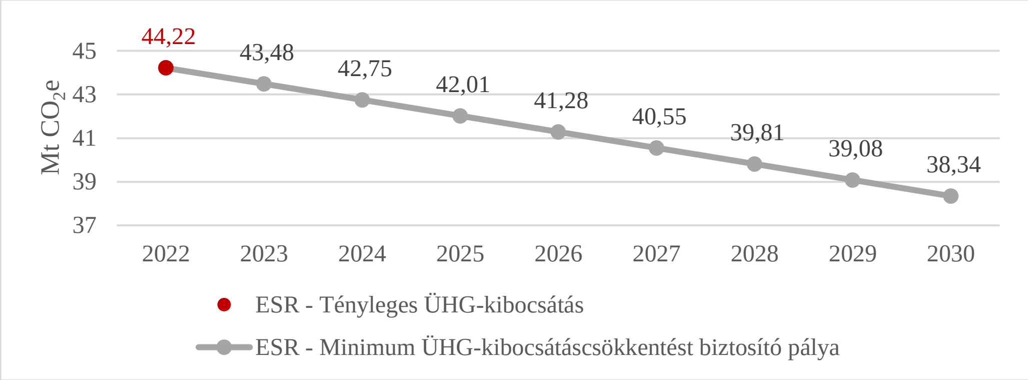
In order to achieve the EU’s gradual GHG emission reduction targets and its 2050 climate neutrality target, each EU Member State should contribute to reducing emissions and removing GHG emissions, according to its individual potential and specificities. In line with this, Hungary aims to gradually achieve climate neutrality by 2050.

i. Elements set out in Article 4(a)(1): ESR and LULUCF targets

Within the set EU and domestic targets, the **Effort Sharing Regulation (ESR)** sets national emission reduction targets in[19] the so-called ESS sector (for non-ETS emissions) in proportion to GDP per capita. Hungary should **achieve a GHG emission reduction of at least 18.7%** by **2030** compared to 2005 as the base year **for the ESR sector:** domestic transport (excluding aviation), buildings, agriculture, "small industry" and waste management.

[18] *Consistency with the long-term strategies under Article 15 should be ensured.*
[19] *Regulation (EU) 2018/842 (https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:02018R0842-20230516)*

This means that it will have to reduce its emissionsfrom47.2 million tonnes **of CO_2 e to 38.3 million tonnes of CO_2e,** keeping a linear reduction trajectory in line with the Regulation.



2Figure - Calculated GHG emission limits in the ESS sector up to 2030 (based on 2022 actual data; million tonnes CO_2e/year)
Facts: [Greenhouse gas emissions under the Effort Sharing Legislation (europa.eu)]

The **LULUCF Regulation** [20]requires each Member State to ensure that greenhouse gas emissions do not exceed removals in the land use, land use change and forestry (LULUCF) sector and, taking into account flexibilities, to meet its 2030 greenhouse gas removal target. Hungary has set a target for GHG removals to reach -5.724 Mt CO_2e per year by **2030 in the LULUCF sector.** Absorption in 2021 was an outlier (-7.2 million t CO_2e), meaning that it is necessary to maintain and improve removals compared to the average capacity of natural sinks (~5 Mt). The decreasing absorption capacity is partly due to natural processes in vegetation, which have increased due to the negative effects of climate change. In order to maintain and enhance our natural CO2sinks, in line with the National Forest Strategy and taking into account the Do No Significant Harm (DNSH) principle, we intend to significantly **increase the share of forest and other woodland cover by 2030** (to 27%) where it does not cause adverse impacts in other directions, such as water balance, soil strength and biodiversity.

ii. Other national objectives and targets consistent with the Paris Agreement and existing long-term strategies - Contribution to the overall Union commitment to reduce greenhouse gas emissions, other objectives and targets, including sectoral targets and adaptation goals, where available

Hungary's greenhouse gas emission reduction targets are in line with EU and international commitments. Hungary has set itself the objective of achieving climate neutrality by 2050, which was confirmed *in Act XLIV of 2020 on climate protection.* Alternative avenues for achieving climate neutrality in 2020 are outlined in the *National Clean Development Strategy*

[20] *Regulation (EU) 2018/841 (https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:02018R0841-20230511)*

(NTFS). [21] In order to achieve climate neutrality, following the scheduled progress, Hungary aims to [22] **reduce its gross GHG emissions by at least 50%, to 47.5 million t CO_2e, by 2030 compared to 1990**, which requires an additional 16.7 million t CO_2e GHG emissions reduction compared to 2021.

In **the case of Hungary, carbon dioxide (CO2)is the most significant** (~76% in 2021) and the most widely emitted greenhouse gas affecting all sectors, which is why we focus our actions predominantly on this GHG. These measures will also help to reduce emissions of non-CO2GHGs incidentally and to further reduce them through additional measures, e.g. fluorinated gas emissions linked to industrial processes (F-gases; 3% of GHG emissions), nitrous oxide emissions primarily related to agriculture (N_2O; 7% of GHG emissions) and methane emissions (CH_4; 14% of GHG emissions), which are almost equally linked to waste management, agriculture and the energy sector. On the demand side, the *National Hydrogen Strategy* focuses not only on certain segments of transport, but also on industry. One of the objectives is to use **a significant part of the produced – 16 000 tonnes of carbon-free and 20 000 tonnes of low-carbon hydrogen in industry, primarily to replace grey hydrogen, thus contributing to the decarbonisation of processes in** ammonia production, petroleum refining, petrochemicals and possibly the steel industry. According to REDIII, 42% of hydrogen used as industrial feedstock needs to be replaced by RFNBO by 2030 and 60% by 2035. To meet this demand for hydrogen, there is a significant need for imports, whose supply chain needs to be established as soon as possible, taking into account the long-term cost-effective modes of transport.

Our goal is to reduce the GHG intensity of the Hungarian economy, i.e. to further reduce the GHG emissions associated with the production of unit of GDP, from 1.37 tCO_2e/million HUF in 2021. The reduction and offsetting of GHG emissions by businesses is also directly encouraged by the **EU Emissions Trading Scheme (EU ETS) and the ESG law stemming from EU law[23].** In the case of installations covered by the EU ETS, the expected rising price of the carbon quota and, in the case of undertakings subject to the ESG Act, the establishment and implementation of emission reduction action plans are encouraged on the one hand by reputation and, on the other hand, by making activities more transparent according to sustainability, in addition to which investors are guided by the directions set by the national energy and climate policy target system.

To reduce GHG emissions and GHG intensity, the decarbonisation of the energy industry is of paramount importance. One of the most important decarbonisation tasks is the transformation of the lignite-fired Mátra power plant based on low-carbon technologies,

[21] *https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en*
[22] *Without international aviation. Including aviation, 47.75 million t CO_2e.*
[23] *Act CVIII of 2023 on the rules of corporate social responsibility taking into account environmental, social and social aspects and amending other related acts to promote sustainable finance and unified corporate responsibility*

thereby **phasing out coal and lignite combustion from domestic electricity generation by 2029 at the** latest. The Mátra Power Plant is a strategically important basic power plant of the Hungarian electricity system, but it is also one of the largest greenhouse gas emitters in Hungary (3.2 million t CO_2e/year), which in 2021 accounted for 33% of the total energy production sector's emissions, thus 5% of the total domestic greenhouse gas emissions.

In December 2022, a decision was taken to **further extend the operating time of the existing units of the Paks Nuclear Power Plant (Paks I.),** [24] which serves the country's energy sovereignty, climate protection and security of supply objectives. On this basis, the preparatory activities necessary for the administrative authorisation procedure for the further extension of the operating time can start. Preparatory activities can take 9-10 years, based on the experience of previous service life extensions. In addition, in the next decade, **the Paks II. A nuclear power plant can** also produce two units with a capacity of 1.2 GW per unit, so the six units together represent 4.4 GW of power and a huge decarbonisation potential for Hungary. In addition to the above, we plan **to reduce the share of natural gas in the energy mix.**

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

[24] *56/2022. (XII. 8.) OGY resolution*

necessary, also in view of the difficulties in developing new markets and supply chains. In view of this, it is essential to plan the development of complex solutions, which can be achieved by targeted regulatory and financial means.

In addition to **the above, it is particularly important for Hungary to promote adaptation to the effects of climate change,** the global goal of which and the balance between mitigation and adaptation measures are determined by the Paris Agreement.[25] The module of the NÉS-2 *National Adaptation Strategy (NAS)* defines an adaptation vision, comprehensive and specific strategic goals in connection with the domestic climate adaptation, which include, among others, protecting and restoring ecosystems, the sustainable utilization of natural resources, helping the specific adaptation of vulnerable areas, managing increasing risks, mitigating the expected social impacts, and supporting research and innovations.

2.1.2. Renewable energy

i. Elements set out in Article 4(a)(2): Estimated trajectory for renewable share (RES)

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

2Table - Indicative timeline: Estimated national trajectory for the share of renewable energy in gross final energy consumption 2021-2030 (%) (Data: MEKH, Eurostat)

	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
RES appropriation	14%	15%	17%	20%	22%	23%	25%	26%	28%	30%

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

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

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

3Table - Indicative timeline: Estimated national trajectory for the share of renewable energy in gross final energy consumption by sector from 2021 to 2030 (%)[26] (actual: MEKH, Eurostat)

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

[25] *Article 2.1(b) of the Paris Agreement*
[26] *Note: **Application of multipliers based on REDIII.*

RES-T allocation *with multiplier***	10%	10%	13%	16%	17%	19%	20%	22%	24%	25%

iii. *Estimated trajectories by renewable energy technology that Member States plan to use to achieve the overall and sectorial trajectories for renewable energy from 2021 to 2030, including expected total gross final energy consumption per technology and sector in Mtoe and total planned installed capacity (divided between new capacity and power plant repowering), per technology and sector in MW*

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

4Table - Indicative timeline: Use of renewable energy sources by sector, 2021-2030 (Mtoe/year) (Actual data: MEKH, Eurostat)[27]

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

Electricity

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

5Table - Indicative timeline: Renewable electricity generation, by technology (Mtoe/year) (Actual data: MEKH, Eurostat)[28]

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

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

[27] *Note: *Your Fact **Without Multiplier*
[28] *Note: *Your fact, **Other than: Water and geothermal*

electricity generation capacities, while reducing biomass capacities. This is illustrated in the following table.

6Table - Indicative timeline: Electricity generation capacities installed for the use of renewable energy sources, by technology (MW) (Actuality: Eurostat)[29]

Renewable electricity generation capacity (MW)	2021*	2022*	2 023	2 024	2 025	2 026	2 027	2 028	2 029	2 030
Biomass	438	424	437	450	464	417	371	324	278	232
Biogas	85	84	97	111	124	124	124	124	124	124
PV	2 968	4 235	5 456	6 676	7 897	8 718	9 538	10 359	11 179	12 000
Wind	324	324	434	545	655	740	825	910	995	1 080
Other**	63	63	70	78	85	90	95	100	105	110
Total	**3 878**	**5 130**	**6 495**	**7 860**	**9 225**	**10 089**	**10 953**	**11 817**	**12 681**	**13 546**

Heating and cooling

In the heating and cooling sector, in line *with the Renewable Energy Directive (REDIII)*, we will increase the share of renewable energy (RES-H/C) by 1%points between 2021 and 2025 and by at least 1.3% points per year between2026 and 2030, by increasing the amount and share of biomass and geothermal, including waste heat and renewable electricity.

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

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

[29] *Note: *Your fact, **Other than: Water and geothermal*

7Table - Indicative timeline: Use of renewable energy sources in heating and cooling (Mtoe/year) (Actual data: MEKH, Eurostat)[30]

Renewable based heating and cooling (Mtoe)	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Biogas	0,02	0,03	0,03	0,03	0,03	0,04	0,05	0,07	0,08	0,10
Solid biomass	1,72	1,66	1,73	1,80	1,87	1,90	1,92	1,95	1,96	1,97
Geothermal	0,14	0,15	0,18	0,20	0,22	0,24	0,25	0,27	0,28	0,29
Solar thermal energy	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Renewable waste	0,03	0,04	0,04	0,04	0,04	0,03	0,03	0,03	0,03	0,02
Heat pump - Ambient/Ground Heat**	0,02	0,08	0,15	0,22	0,30	0,36	0,41	0,47	0,52	0,58
Total	**1,9**	**2,0**	**2,1**	**2,3**	**2,5**	**2,6**	**2,7**	**2,8**	**2,9**	**3,0**

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

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

Transport

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

8Table - Renewable energy consumption in transport by fuel (Mtoe/year) (Data: MEKH, Eurostat)[31]

Renewable transport	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030

[30] *Note: *Actual data, **Average total heat output calculated at 3.5 COP. Taken into account for electricity consumption*
[31] *Note: Data plate without taking into account multipliers; *Your fact; **Included in electricity consumption*

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

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

iv. Estimated trajectories for bioenergy demand, disaggregated by heat, electricity and transport, and estimated trajectories for biomass supply, feedstock and origin (distinguishing between domestic production and imports); For forest biomass, its source and impact on LULUCF sinks shall be assessed

Demand

In 2021, Hungary's primary bioenergy consumption (solid biomass, biogas and transport biofuels) amounted to 2.7 Mtoe, while the final bioenergy consumption at the same time was 2.3 Mtoe, two thirds of which was household consumption (1.4 Mtoe direct combustion and 0.12 Mtoe secondary energy use). Overall, considering the total stock of bioenergy, Hungary is a net exporter, so in terms of its supply, the amount of domestic resources is suitable to meet the current bioenergy needs.

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

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

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

9Table - Bioenergy consumption by sector based on the WAM scenario (Mtoe/year)[32]

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

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

Supply

Determining the supply parameters for projections of bioenergy use is essential given the supply constraints of resources and their multi-purpose potential. Potential estimates of bioenergy resources and related agri-economic and forestry plans and strategies include targets and measures for sustainable management that meet regulatory requirements and natural constraints for agriculture, animal husbandry, forestry and land use.

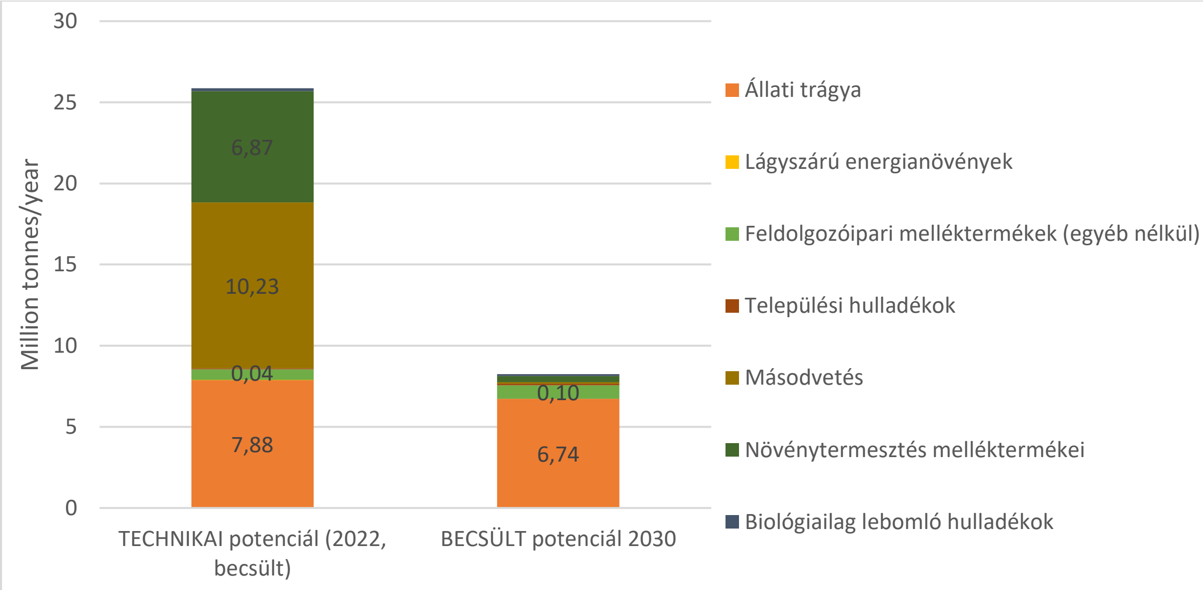
Most of the primary solid biomass used for energy purposes is provided by our forests. In addition to woody biomass, herbaceous agricultural biomass (typically cereal straw) accounts for only a few percent of energy recovery, and the amount of raw materials used is decreasing. These resources can be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

Biogas - Potential of agricultural raw materials

Based on the related agricultural economic scenarios, between 16 % and 32 % of the total estimated technical potential of primary resources, mainly animal manure and, to a lesser extent, crop by-products and manufacturing by-products, and possibly energy crops and secondary crops, can be used to produce biogas according to current knowledge. During the anaerobic fermentation of these raw materials, it is estimated that they may allow the

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

production of ~300-800 Mm^3 biogas, which is illustrated in the figure below. It has a total biomethane content of 150-400 Mm3. The wide intervals, i.e. the 'realistic' and 'optimistic' scenarios, are due to differences in the intensity of support policy, circular economy and, above all, **agro-economic opportunities and measures. Therefore, the national conceptual treatment of biogas production** is significant, according to which it is possible to produce ~600 Mm3 of biogas per year by 2030. Of this, 260 Mm3 is expected to increase direct biogas use and ~340 Mm3 biogas can be used to produce ~184 Mm3 biomethane.



3Figure - Potential of agricultural and other feedstocks for use in biogas plants (Mt/year) Source: Based on AKI and IFUA estimates

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

Biomass - Woody biomass supply potential

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

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

10Table - Expected annual evolution of afforestation by tree stand type and removals by WAM (hectares/year, Mt CO_2e)[33] (Source: SOE-ERTI)

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

11Table – Extent of logging and projection of future net carbon balance of existing forests according to WAM (thousand m^3/year and Mt CO_2e)[34] (Source: SOE-ERTI)

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

However, it is necessary to point out that, on the one hand, climate change has already caused – unprecedented – damage to forests in the region, which disrupts the planned course of forest management. Although the Hungarian deciduous stands and the measures already introduced in forest management and forestry holdings contribute to the prevention of greater damage to forests, it cannot be excluded that such damage may occur, which may result in a temporary, sharp increase in the availability of wood biomass due to the renovation of forests extinct over a large area, and is expected to decrease.

[33] *Including plantations for traditional forestry and industrial purposes.*
[34] *Note: * FRL: under the logging assumptions of the Forest Reference Level required under the so-called LULUCF Regulation; ** Increased logging: a scenario of increased logging compared to current levels; *** Low-level logging (i.e. approximately the level of logging maintained at the current level of logging)*

On the other hand, the amount of biomass that is actually extracted and can be extracted depends on the market and any restrictions on forest management that can be inferred from the above. These include changes expected under the *EU Biodiversity Strategy* under discussion, such as the extent of protected areas in relation to the designation of additional forest areas, and the type and extent of related restrictions.

Finally, sustainable forest management and the effectiveness of forest protection are hampered by small-scale management resulting from private forest management. In *line with the National Forest Strategy,* it is therefore necessary to properly integrate and, where possible, improve the fragmented farming structure by modifying the regulatory environment and other state measures. Appropriate regulation of associated forest management can contribute to this.[35]

v. *Other national trajectories and objectives, including long-term and sectoral ones (e.g. share of renewable energy in district heating, use of renewable energy in buildings, renewable energy produced by cities, renewable energy communities and renewable self-consumers, energy recovered from sludge from waste water treatment)*

The role of renewable energy in district heating, buildings, cities and renewable energy communities, as well as renewable energy production and utilisation by prosumers and recovered from sludge from wastewater treatment, will be encouraged through the above targets.

Increasing the **self-decentralised generation of energy from renewable sources by individual consumers, be they citizens or businesses, for their own use remains a priority objective for Hungary,** thereby also reducing the load on the electricity network. This goal also includes replacing the use of natural gas by pipelines **with the use of earth heat, ambient heat, biogas or renewable electricity.** With the spread of household-scale solar power plants, more and more consumers (prosumers) are able to produce themselves, which, in addition to the possibility of participating in the market even more actively than consciously regulating consumption, also ensure the strengthening of energy independence at household level. In parallel with the expansion of decentralised, locally available production based on renewable resources, it is also necessary to promote Community initiatives to ensure that renewable energy – heat and/or electricity – is used locally by the local community. Our aim is therefore to **encourage the development of energy communities.**

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

2.2. Energy efficiency dimension

i. Elements set out in Article 4(b): Final energy consumption, intensity and savings

Hungary's **final energy consumption in 2030 should not exceed 740 PJ.** [36] This target means that by 2030 Hungary's final energy consumption should be reduced by around 6% compared to 2021 (787 PJ), while offsetting the increase in energy consumption in the industrialisation plan.

*12Table - Indicative Final Energy Consumption Roadmap (PJ) (*Factual: Eurostat)*

	2021*	2022*	2023	2024	2025	2026	2027	2028	2029	2030
Final energy consumption (PJ)	787	752	750	748	747	746	745	744	742	**740**

The reduction of energy use is needed primarily in the building sector, which is the largest energy-consuming sector, and the reduction in the use of buildings provides a wide range of benefits for the country, which has an impact on all dimensional goals. The efficiency improvement of the building sector ensures the reduction of the burden of the domestic population, in addition to public charges, and the increase of its security of supply, which also results in the reduction of primary energy use and the reduction of the need for fossil energy sources, thereby reducing GHG emissions.

Reducing energy use is a priority, but in the interests of economic growth and development, **it is not appropriate to maximise energy use in the services and industrial and transport sectors because of the emergence of new service units and industrial facilities** and innovative new business projects. In these areas, the aim was to encourage increased energy efficiency and to reduce energy intensity. Our goal is to increase the rate of GDP growth more and more than the increase in energy consumption, i.e. **to improve the final energy intensity of GDP, falling below 0.429 toe/million HUF by 2030.** This would represent a decrease of 18% compared to 2021. We ensure the achievement of the goal by strengthening the role of domestic enterprises, which we plan to support by increasing energy awareness, by involving the support of expert energy consultants, by encouraging energy metering and conscious energy consumption, and by encouraging the implementation of projects resulting in final energy savings. However, it is worth noting that the energy crisis caused by the global events of recent years has also acted as an incentive for businesses to achieve the above objectives by reducing their energy supply risks.

In the first NECP, the indicative **cumulative end-use energy savings target to be achieved from 2021 to the end of 2030 was set at 336.3 PJ,** which, assuming a steady annual saving of 0.8% and policy measures with a lifetime covering – the whole period, **can be achieved by achieving a new annual saving of 6.1 PJ** compared to the trajectory

[36] *Calculated by Europe 2020-2030 indicator*

calculated without them. Based *on the increase of the indicative energy savings target provided for in the Energy Efficiency Directive (EU) 2023/1791*, Hungary would need to achieve cumulative final energy savings of 484.6 PJ by 2030.

Energy efficiency programmes and measures introduced before 2020 have resulted in annual final energy savings of around 3-4 PJ for end-users, complemented by the Energy Efficiency Obligation Scheme (EEOS) as of 2021. However, even with the EQS, the final energy savings in 2021 were only 2.05 PJ. For this reason, the results of energy efficiency policies and the decision to strengthen, discontinue or launch new policies will be reviewed in 2024-2025. At the same time, the energy efficiency institutional system needs to be overhauled and transformed – primarily to a building energy focus – in order to be able to effectively support programmes for the energy renovation of buildings.

The *principle of prioritising energy efficiency* is implemented by integrating it into energy planning processes, sectoral and sectoral regulations, relevant sectoral strategies and support programmes. In addition to energy developments and planning related to the energy system, the aim of the principle already included in domestic legislation is to consider energy efficiency solutions and the energy savings they can achieve as primary options for policy, planning and investment decisions in all sectors and at all levels.

ii. Indicative milestones for 2030, 2040 and 2050, domestically defined indicators to measure progress, evidence-based estimation of expected energy savings and wider benefits and their contribution to the Union's energy efficiency targets, as set out in the roadmaps set out in the long-term strategies for the renovation of the national stock of residential and non-residential buildings, both public and private, in accordance with Article 2a of Directive 2010/31/EU

Hungary's *Long-term Renovation Strategy (HTFS)* laid the foundations for achieving the sustainable, energy- and cost-effective development of the domestic building stock by 2050. Achieving the targets can be achieved through HTFS's energy efficiency, value and comfort-enhancing, as well as health-enhancing measures, the use of renewable energy and the use of smart technologies.

The objective of the HTFS was to **achieve energy savings of at least 20% in the energy use of the domestic residential building stock by 2030, based on the average of the** reference years 2018-2020 (i.e. compared to 2021: -71.8 PJ) and **achieve an 18% reduction in energy use in public buildings** (-7 PJ compared to 2021). 60% reduction in GHG emissions related to the energy use of buildings by 2040 compared to the same base year (i.e. compared to 2021: -5.7 Mt CO_2e) and to reach 90% NZEB buildings by 2050. However, less resources could be made available than planned to launch the measures envisaged in the HTFS, and the achievement of the 2030 savings targets should therefore be reviewed along the lines of the relevant updated and recast directives.

In order to support the achievement of efficiency gains **in the building stock, EU (co-)financed programmes aim to reduce primary energy savings by at least 30%.Currently, 3% of the total floor area of the designated central government buildings** should be renovated annually. The new Energy Efficiency Directive extends the obligation to renovate 3% of the useful floor area of public buildings annually from central government buildings to the entire public sector. It raises the level of renovation to be achieved from the cost-optimal level to the level of nearly zero energy demand. Furthermore, the energy consumption of the entire public building stock needs to be reduced by 1.9% per year compared to 2021, with a final energy saving target of 3.41 PJ by 2030. Monitoring the energy consumption of public buildings is essential to achieve the targets, *the regulatory elements of which are already included in Act LVII of 2015 on energy efficiency.* As a priority action, the ERC contributes 26% and 88 PJ of cumulative final energy savings to the indicative national energy savings target. We plan to increase the target of the measure from 2025 onwards, in line with the objectives of the new Energy Efficiency Directive.

As of 2025, the HTFS will be replaced, as a result *of its revision*, **by the so-called National Building Renovation Plan** – *in line with the Energy Performance of Buildings Directive (EPBD, 2010/31/EU),* which provides **higher ambition for the building stock but** also flexibility taking into account national specificities.

The energy efficiency indicator set, in line with the above chapters, is therefore set out in the following table.

13Table 1 - Energy efficiency indicator set (Actuality: Eurostat)[37]

Purpose	Indicator	Indicator value 2019	Indicator value 2021	Indicator target - 2030
Reduction of final energy consumption	Final energy consumption (PJ)	752	787	**740**
Of which residential building stock	Final energy consumption (PJ)	238	267	**201**
Of which public building stock	Final energy consumption (PJ)	33	34	**30**
Reducing energy intensity	Ratio of final energy consumption to GDP (GJ/MFt)*	21,9	21,9	**19,8**

iii. Other national objectives, including long-term goals and strategies and sectoral targets, as well as national objectives, for example in areas such as energy efficiency in the transport sector or in heating and cooling

Sustainable **and climate-friendly energy management is a priority, while preserving and further expanding industrial and service performance.** This is supported by the target system of both ETS and ESG regulations, as well as the obligation to apply an energy audit

[37] *Note: The indicator of the final energy intensity of GDP in 2015, at an exchange rate of 385 HUF/EUR. The natura-based conversion factors can be found at the beginning of this document.*

obligation and an energy management system, as well as the positive incentives provided by the ERA.

With regard to energy use in **transport,**a priority objective is to reduce consumption by reducing the use of fossil fuels. In order to reduce energy use in transport, it is of primary importance to develop and increase the utilisation rate of public transport, and rail freight transport should be provided as a realistic option for freight transport. This requires, in particular, increasing the energy and cost-efficiency of rail transport. Due to the high efficiency of the electric powertrain, clear end-user energy savings are achieved with the spread of electromobility. Thanks to the Green Bus Programme for the greening of local transport, a greater number of environmentally friendly buses will serve local public transport by 2030.

In **heating and cooling , as well as in** district heating systems, it is a goal to use systems with an efficiency above 100% in order to reduce primary energy consumption, so we also support environmental and geothermal technologies, which are supported by the implementation of the Hungarian Earth Heat Concept. The use of shallow geothermal (e.g. soil probe) heat pump systems can be beneficial, which can provide cooling and heating and even domestic hot water supply. Furthermore, in the case of the district heating sector, we plan to improve the efficiency of distribution, and we consider it necessary to modernise the user building stock to improve energy efficiency.   Together with **the NECP, we will notify a comprehensive assessment of the feasibility potential of high-efficiency cogeneration and efficient district heating and cooling,** based on the Energy Efficiency Directive.

2.3. Energy security dimension

i. Elements set out in Article 4(c): Energy independence and risk management

Hungary’s high share of imports continues to dominate its energy supply, which may entail security of supply and price risks, the likelihood of which has increased as a result of recent geopolitical developments. It is therefore of paramount importance to strengthen the country’s self-sufficiency (2021: 33.7%) and source and route diversification of its energy supply.

In order to prevent and manage supply risks, significant progress has already been made, mainly in connection with the construction of international interconnections of networks, but Hungary still faces further tasks in **strengthening energy independence, reducing import dependency, increasing the flexibility of energy systems and developing a more diversified supply portfolio.** The achievement of these goals is supported by the country's dimensional target system, primarily the goals of increasing energy efficiency and "greening" the remaining energy use, the sustainable use of domestic hydrocarbon resources and domestic renewable sources, the development of the efficiency and diversification of the country's power plant portfolio, the development of storage of different types of energy, the expansion of nuclear capacities, and the strengthening of market integration. In addition to measures to reduce GHG emissions, security of supply will be ensured during the energy transition period by meeting the following targets.

14Table - Indicative milestones in the area of energy security (Scope: Eurostat)

Purpose	Indicator	Indicator Value - 2019	Indicator Value - 2021	Indicator target - 2030
Increase self-sufficiency	Self-sufficiency rate	31.7%	33.7%	**Continuous development**
Exposure to electricity supply	Proportion of electricity produced in non-domestic power plants	30.0%	28.0%	**20.0%**
Reduction of oil supply exposure	Proportion of non-domestic crude oil, out of the amount of crude oil used	86.3%	86.9%	**85.0%**
Maintenance of security oil storage capacities	Minimum benefit insurance period	90 days	90 days	**Reservation**
Reduction of exposure to natural gas supply	Proportion of natural gas not produced domestically, out of the amount of natural gas used	84.3%	87.3%	**80.0%**
Infrastructural security of natural gas supply	N-1 value*	142%	147%	**Continuously over 120%**
Maintenance of secure natural gas storage capacities	Quantity to be stored	1.2 billion m^3	1.2 billion m^3	**Reservation**

Exposure is measured by the *import dependency ratio* , i.e. the share of non-domestic energy production in energy consumption. In addition to reducing fossil import exposure and increasing self-sufficiency, the aim is to maintain fossil storage capacities. [38] The establishment of the availability of diversified sources can also address price risks, as, in addition to increasing the flexibility of the energy sector, it provides Hungary with a better bargaining position and a more affordable price by planning a competitive position among suppliers. Key information on the objectives can be found in the following chapters.

Consideration of other relevant factors affecting energy security

Enhancing cybersecurity

With the spread of IT solutions and digitalisation, the rise of artificial intelligence, the number of cyberattacks and the risk factors arising from the interdependence of information systems is expected to increase in all segments of the economy. The activities of attackers with different backgrounds and motivations (script-kiddie,[39] cybercriminals, state-backed attack groups, so-called APT[40] groups) increasingly affect actors in the energy sector as well. Cybersecurity should therefore become one of the most important elements of national security and **cybersecurity measures should also focus on the security of energy supply**.

[38] *Security of supply issues for electricity storage capacities are addressed in the next chapter.*
[39] *'Logging puppies': Computers that are not very knowledgeable are 'cybercriminals'. They often cause damage with additional programs (scripts) or software written by others. People often call them hackers.*
[40] *A Sophisticated, Persistent Attack in Cyberspace*

The combination of new, modern and inherited technological solutions also creates challenges that need to be addressed.[41]

Improving the labour market situation in the energy sector

Based on industry feedback, addressing skills **shortages and competence development in the** energy sector remains a priority. The energy sector requires complex technical, economic and legal competence and flexible know-how due to dynamic technological developments. The maintenance and development of knowledge related to the energy sector is ensured by the various vocational training, higher education and adult education programmes, the maintenance and expansion of which is of utmost importance for climate and energy policy. At the same time, the risks of sustainability and climate change, as well as geopolitical events disrupting the security of energy supply, have made energy, environmental and climate protection aspects and innovative knowledge centres more important and needed in all areas of secondary and higher education. In addition, with the help of the internal training and competence-development systems of enterprises linked to the energy industry in one aspect, specific needs can also be met.

Addressing a restriction or interruption of energy supply

The actors involved in the supply of energy should take into account the dependencies between the different **critical infrastructure sectors when designing** and operating the service. To this end, legal standards ensuring effective protection measures can and should be developed and/or developed following a mapping of the specificities of the sectors.

The **availability of hydrocarbon storage capacities** primarily serves the purpose of a temporary guarantee of supply in a critical situation, which system components, together with the available transmission systems, also play a prominent role regionally and can play a role in the event of a supply restriction. However, **the security of oil supply** needs to be further enhanced in view of the significant dominance of both the supply source and the supply route.

399/2023 on measures to safeguard the security of gas supply in *the event of a gas supply crisis, solidarity measures or disruption. (VIII. 24)* of the Government ensures regulation that meets the requirements of the gas market today and is also in line with the common standards of the EU. Furthermore, Hungary guarantees the **security of gas supply** by continuously complying with[42] the 'N-1' rule. N-1 shows the manageability of the infrastructural security of gas supply, i.e. the potential availability of natural gas (2021: 147%), in case the largest entry source is blocked. Our aim is to maintain the indicator at a level of at least 120%.

[41] *European Commission Recommendation 2019/553 on cybersecurity in the energy sector.*

[42] *The N – 1 formula describes the ability of the technical capacity of the gas infrastructure to fully satisfy gas demand in the calculated area in the event of disruption of its largest element on a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years.; https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:02017R1938-20220701*

According to the update of the Emergency Plan managed by MEKH, Hungary also has a value above 150% for N-2 in 2023.

Preventive preparedness plans and crisis scenarios related to the interruption or limitation of **electricity supply** are described in the *Risk Preparedness Plan (RCP)* published by MEKH. The references of the SAR include other relevant sectoral plans, such as the Crisis Plan or the *Rotary Shutdown Order (RKR).* The RKR defines the measures and scenarios that will prevail if a consumer restriction is imposed. Minor malfunctions, which do not result in a crisis situation, are handled locally by the deployment of the electricity transmission and distribution networks in accordance with the 'N-1 principle' and in accordance with normal operational fault response protocols and internal processes.

ii. National objectives to increase: diversifying energy sources and supplies from third countries and reducing dependency on energy imports from third countries to strengthen the resilience of regional and national energy systems

In diversifying energy sources, Hungary would rely primarily on domestically available sources that increase self-sufficiency, in order to prevent it from facing a new import dependency in the next resource. However, in the energy transition, it is necessary to ensure an adequate supply of the energy sources currently used, with the least possible risk.

Petroleum and natural gas supply

The Hungarian economy is highly dependent on oil and natural gas. These energy carriers account for ~66% of final energy consumption (more than 500 PJ), with roughly the same proportion, which is accompanied by an import exposure of 84-87%.

In the changed geopolitical context, more emphasis should be placed on the security of oil supply. Due to the country's regional petroleum product supply function, it is not only in the interest **of Hungary, but also of the region, to manage the risks arising from import dependency and to diversify oil supply,** thereby avoiding the risk arising from exposure to the dominant supplier, currently the Russian partner.

The need to reduce import exposure is also evident in the case of natural gas, given that domestic natural gas production covers only 15% of consumption and the rest is provided by an import source – Russia. In order to address the risks of natural gas exposure, the aim is to ensure the availability of alternative sources, such **as reducing natural gas consumption** by increasing energy efficiency and the use of renewables, and increasing **domestic production** where possible. The remaining import demand **should be provided from as diversified a source and route** as possible, reducing the risks of dependency on one source and partner. To this end, we plan **to further expand cross-border capacities.**

Electricity market

The best available technologies currently anticipate a change in the final energy mix – a significant increase in electricity demand and weather-dependent capacities – affecting all sectors. Hungary's goal remains to operate an electricity system that is able to meet growing demands, while at the same time guaranteeing a high level of security of supply, is consumer- and climate-friendly, and provides electricity at affordable prices, encourages the entry of new, flexible products into the market, and is open to innovative solutions. Domestic **self-sufficiency and** European market coupling are designed to prevent supply risks. This objective can be achieved by developing the internal energy market and is therefore discussed in the following chapters.

Nuclear energy security

We want to maintain a **high share of nuclear energy** in electricity generation. Clean, domestically produced electricity ensures the security of supply and the uninterrupted supply of clean energy in order to reduce fossil energy dependency. The establishment of the Paks region is based on the nuclear power plant as an energy supplying, employing and supporting partner. Maintaining the value and supply chains and the knowledge base developed in connection with the nuclear power plant is of paramount importance. Security of nuclear energy supply needs to be focused on the diversification **of alternative sources of supply of nuclear fuel.**

iii. Where appropriate, national measures to reduce dependency on energy imports from third countries in order to strengthen the resilience of regional and national energy systems

Hungary's national measures relating to the above objectives are set out in *Annex 3. It is covered in* a chapter on policies and measures and is included in **Annex 1 to the NECP.**

iv. National objectives to increase the flexibility of the national energy system, in particular through domestic energy sources, demand response and energy storage

Hungary strives to increase the share of domestic resources and renewable resources in the remaining final energy consumption, while reducing final energy consumption. The penetration of renewables and the potential of electricity to be stored in large quantities in the long term in a cost-effective manner cannot yet be ensured, therefore, in order to maintain the flexibility and balance of the energy system and guarantee security of supply, it is necessary to maintain and develop certain system components, as well as to integrate new system components and develop the use of flexibility services, such as:

- domestic hydrocarbon and electricity storage facilities, and
- the use of alternative electricity storage options (e.g. hydrogen production, pumped-storage hydropower plants);
- the use of alternative, diversified energy sources (e.g. biogas, biomethane, geothermal, hydrogen);
- the integration into the system of conventional, high-efficiency, dimmable power plants capable of cogeneration of heat and electricity, and
- a more active role for market participants in balancing the electricity system, such as developing markets for system-wide services, developing distribution flexibility

services, offering large customer flexibility services and exploiting the potential of small customer integrated flexibility services (aggregators, energy communities).

Petroleum and natural gas market

Domestic hydrocarbon storage capacities also provide significant support in the management of supply and price risks arising from import exposures and in the flexibility of hydrocarbon systems . It is also necessary to exploit the benefits of coherent European systems and to **develop regional cooperation.** It is in the common interest to reduce the energy consumption of domestically operated system components and to improve their availability.

Another objective is to **improve the availability of alternative gas sources injected into the gas system to** ensure flexibility. Depending on the success of research into new traditional natural gas deposits and the successful production of unconventional natural gas, domestic production could increase by 2030 compared to 2021. Our goal is to replace imports by exploiting this potential in a sustainable manner and taking into account that we only aim to inject gas of sufficient quality into the domestic gas system. In addition, greater use of biogas/biomethane will play a role.

In order to ensure the stability of the supply of petroleum products and the flexibility of the petroleum value chain, it is necessary **to develop system components capable of accepting alternative raw materials.**

Electricity market

Increased penetration of renewables can be achieved in parallel with the development and ‘education’ of transmission and distribution networks, which can also accommodate new, more efficient technological solutions, and the development of distribution plant management as a decentralised intervention capability and its transparent market mechanisms – a distribution flexibility market.

In addition to ageing power plants, in order to replace the back-regulated lignite firing, to supplement our base power plant, due to the significant expansion of renewables and in the interest of supply and system security, **it is necessary to integrate regulated bids into the system.** In order to ensure domestic security of supply, it is advisable to maintain additional capacities that can contribute to domestic electricity generation in critical situations, e.g. during peak demand winter days, or when the availability of imports is limited due to technical reasons. Since the short-term fluctuations in weather-dependent generation can still be compensated for mainly by gas-fired power plants, it is important to prevent the deterioration of the necessary amount of controllable power plant capacities. Therefore, a strategic decision was taken in Hungary to establish combined cycle gas turbine (CCGT) power plants with a planned entry into operation in 2027, at two sites with a total capacity of 1.65 GW, in addition to ageing power plants, to replace the re-regulated lignite fire, to supplement the production of the base-load power plant, due to the significant expansion of renewables and in the interest of supply and system security. In addition, new innovative solutions such as **battery energy storage and demand response (DSR), smart homes, conscious prosumers (prosumers), automated systems, energy communities and aggregators should be promoted to** incentivise energy efficiency – reducing spatially dispersed, fragmented demand and grid congestion – and the integration of renewable energy generation into the electricity grid.

The **development of organised energy markets** (in particular for a short time horizon supporting system flexibility) as well as the development of further electricity interconnections and the strengthening of market integration are also justified in order to improve the functioning and flexibility of the national energy system in a cost-effective manner. Details on flexibility, energy storage and demand response can be found in the next chapter.

2.4. Internal energy market dimension

Annex **1 to the NECP also contains the** measures relevant to the dimension of the internal energy market, the related sub-objectives and the deadline for their implementation, with reference to the indication in the sub-points below.

2.4.1. Electricity interconnectionk

i. Level of electricity interconnection that the Member State intends to achieve by 2030 with respect to the electricity interconnection target of at least 15% by 2030

Cross-border capacities of Hungary's electricity system are available with all neighbouring countries. The **transmission capacity of cross-border high-voltage lines reaches about 48% of the gross installed capacity in Hungary,** which is significantly higher than the 15% target set for 2030.

In addition, for reasons of additional system security, Hungary undertook to **increase theshare of electricity interconnections to around 60% by 2030.** After the completion of the recently completed Hungarian-Slovenian cross-border connection, it is still justified to expand cross-border capacities, as the energy network connected with neighbouring countries improves the security of domestic supply in such a way that the risk of large-area service interruptions is reduced in the event of any malfunction of the domestic electricity system. Furthermore, the creation of market interconnections can also reduce the costs of system operation by making more efficient use of regulatory capacities in cooperation with neighbouring countries.

2.4.2. Energy transmission infrastructure

i. Main electricity and gas transmission infrastructure projects and, where relevant, their modernisation necessary to achieve the objectives and targets under the five dimensions of the Energy Union Strategy

Hungary pays particular attention – and always has – to the establishment, maintenance and development of regional cross-border connections, which are intended to improve security of supply. The EU's so-called Projects of Common Interest (PCI) currently[43] includes a project on the fifth PCI list to develop both gas and electricity market interconnections.

The gas-related projects included in the current PCI list are as follows.

15Table - Natural gas PCI projects

Number	Corridor	Definition
6.2	Priority Corridor: North-South gas interconnections in Central Eastern and South Eastern Europe (“NSI East Gas”)	6.2.13. Developing and strengthening the transmission capacity of the Slovak-Hungarian interconnector
6.24	Priority Corridor: North-South gas interconnections in Central Eastern and South Eastern Europe (“NSI East Gas”)	Capacity increase between Romania and Hungary (currently known as "ROHU/BRUA"), supply of new resources from the Black Sea 6.24.4. ROHU/BRUA – Phase 2, including: – Extension of transmission capacity in Romania to 4.4 billion m3/yearto Hungary from Recas to Horia and expansion of compressor stations in Podisor, Bibesti and Jupa – Pipeline between the Black Sea and Podișor (RO) for the takeover of Black Sea natural gas – Bi-directional infrastructure between Romania and Hungary: Section 2 of the Hungarian section, compressor station in Csanádpalota (HU)

The electricity-related projects included in the current PCI list are as follows.

16Table - Electricity-related PCI projects

Number	Priority area	Definition
-	Priority Corridor: -	The current (fifth) PCI list does not include a Hungarian priority corridor project.
10.7.	Priority thematic area: deployment of smart grids	**Duna InGrid (HU, SK) -** The Hungarian-Slovakian project improves cross-border coordination of electricity grid management, focusing on making data collection and exchange smarter.
10.10.	Priority thematic area: deployment of smart grids	**CARMEN (HU, RO) -** The Hungarian-Romanian project improves the operational efficiency of the distribution network and the quality of service, and enables the safe flow of electricity from new renewable sources.

ii. Main infrastructure projects envisaged, other than projects of common interest[44]

The major infrastructure projects in Hungary are also included in the complex network development plans of the entities responsible for transmission infrastructure, in addition to their other projects developing domestic energy networks.

<u>Hydrocarbon related projects</u>

[43] *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R0564&qid=1663087079030*

[44] *In accordance with Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 (OJ L 115, 25.4.2013, p. 39).*

The ‘Ten-Year **Network Development Plan’** [45](TYNDP) managed by FGSZ includes the gas transmission pipeline projects planned in the next 10 years. In connection with the natural gas system, the priority objective is the development of infrastructure supporting the diversification of sources and routes of imported resources, including the construction of the **missing Hungarian-Slovenian cross-border natural gas pipeline,** which would enable HU-SI and SI-HU bi-directional transport. Although the available capacity is relatively low, the realisation of the investment could mean an increase in security of supply for both countries. It could provide Slovenia with direct access to Hungarian natural gas storage capacity, while it could provide Hungary with an alternative supply route to LNG ports in northern Italy and to future hydrogen ports. We pay attention to the full hydrogen compatibility of the new pipeline to create the possibility of up to 100% hydrogen transport.

In connection with the supply of oil, it is necessary to increase the capacity of the oil pipeline (Adriatic) providing the Hungarian-Croatian connection in order to promote diversification.

Electricity-related projects

Other domestic energy network projects planned to be implemented on the transmission network, which are not included in the PCI list, are included in **the**[46] **document entitled ‘Network Development Plan of the Hungarian Electricity System 2023’.** It is a basic principle that import capacities providing flexibility and room for manoeuvre for the Hungarian electricity system should be available from as many directions as possible. Therefore, **from the point of view of the electricity system interconnections, the expansion of Serbian-Hungarian cross-border capacity** is the most important goal. In addition to large-scale power plants and energy systems based on centralised management, distributed, household-scale small-scale power plants (HMKE) are spreading rapidly. This also poses challenges to the energy grids, which need to be properly addressed and thus the electricity grid needs to be prepared for the increasing spread of decentralised capacities.

To maintain a high level of security of supply, it is necessary to ensure that there is still **sufficient capacity to meet domestic peak demand as a result of shutting down and entering power plants and expanding cross-border capacities**. To do this, we need to have controllable domestic capacities that guarantee safe operation – baseload generation – and balancing – generation capacities that provide flexibility, new types of flexibility services, DSR solutions, energy storage – and sufficient domestic spare capacity, even to deal with extreme market situations.

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[45] *https://fgsz.hu/vallalatunk/projektek/fejlesztesi-javaslatok-dokumentumtar*
[46]*https://www.mavir.hu/documents/10258/239341965/HFT2022_A+Hungarian+VER+h%C3%A1l%C3%B3zatfejlesztésit%C3%A9si+terve.pdf/38a57b3b-1323-abe5-b07e-3c99752facdc?t=1676903159479; https://mavir.hu/web/mavir/development plans from 2021*

Developing **and improving the necessary regulatory and market environment,** exploiting the additional potential of market entry of aggregators and the emergence and functioning of energy communities, and making the integration of renewable investments cost-effective in line with this is also a priority.

2.4.3. Market integration

i. National objectives related to other aspects of the internal energy market, such as increasing system flexibility, in particular in relation to the promotion of competitively determined electricity prices in accordance with relevant sectoral law, market integration and coupling to increase tradable capacity of existing interconnections, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, redispatching and curtailment and real-time price signals, including a timeframe for when the objectives will be met

Regional market integration helps to achieve efficient trade flows, smooth out supply and demand fluctuations between countries and improves security of supply. The three priorities for regional energy market integration **are to increase cross-border capacity, as explained above,** to **develop harmonised Community rules to allow efficient cross-borderflows of electricity and natural gas – to implement the European operational, operational and commercial codes – and to promote projects that enhance the role and liquidity of our electricityand gas markets in the region.**

Natural gas market

Hungary shall endeavour to facilitate the **functioning of the integrated natural gas market enabling the sustainable reduction of user energy costs in accordance with the relevant European Union directives and regulations.** The main guarantee of this is the **diversification of the country's natural gas supply options,** the objectives of which were explained in the previous chapter.

The **integration of the gas market in the region and** the further promotion of the liquidity and price signalling role of the Hungarian gas exchange, CEEGEX, is a strategic goal, in parallel with the promotion of market integration. A market free of cross-border tariffs, with a single wholesale price signal, can offer more effective competition, lower prices and greater security of supply. For this reason, **Hungary is also exploring the possibility of interconnection with the gas markets of Slovakia, Slovenia, Austria and Romania.** A **regional sales model of Hungary's significant domestic natural gas storage capacities is also being developed to support this and to** achieve it as soon as possible.

Electricity market

To ensure the security of the electricity system and to reduce its prices, the development of system flexibility is of utmost importance not only for Hungary but also for the region. This can be achieved by increasing cross-border capacities and strengthening the interconnection of markets, developing internal networks and **maintaining and developing technologies and activities that help the system to be regulated.**

The expansion of cross-border capacities described above, the integrated market and the European harmonised regulations supporting its proper functioning will reduce the Hungarian electricity exchange (HUPX) prices, and at the same time the relevant spread against the wholesale price will be reduced, as was the case with the expansion of the Slovak interconnector. Although the international interconnections and transmission capacities of the Hungarian electricity system allow for sufficient, secure and flexibly diversifiable commercial transactions, **further market integration steps are needed in relation to balancing markets** – the products of MARI and PICASSO.

On the one hand, we are counting on the construction of electricity storage capacities to help controllability. Storage facilities are required both in the form of integrated components at the system operator and network licensees, and in order to increase balancing capacities. Hungary intends to build **energy storage facilities in Hungary with a total capacity of around 500-600 MW by 2026, which could increase to 1 GW by 2030.** In addition to battery energy storage facilities, it is also advisable to integrate pumped-storage power plants (pumped-storage, SZET) into the system. SZET is one of the most environmentally friendly technologies known today, which has a proven history of 100 years in Europe and can be used effectively in Hungary as well. Therefore, in the years after 2030, half of the storage capacity of the electricity system should be based on SZET.

On the other hand, in order to meet the increasing electricity demand in line production (baseload) and to support the flexibility needs of the electricity system, Hungary has decided to **establish a new CCGT capacity of up to 1.65 GW, which it plans to put into operation by 2030 at the** latest.

The ability to regulate can be further enhanced by the active involvement of consumers. The **promotion and integration of demand response (DSR)** supports the activities of active consumers, the use of which is an important tool to increase the flexibility of the internal energy market and to promote the optimal use of networks. In the future, Hungary will assign a much larger role to DSR than it currently does. In order to expand the potential active consumer base, the main priority is to bring together small consumers and to provide regulatory support for their entry into the market as active large consumers. The **aim of the development of the basic legislative background of aggregators was a set task until 2024,** which was achieved as planned.

The aggregation of users from different consumer segments plays an important role in exploiting flexibility on the consumer side. There are also new opportunities for reducing the burden on the network, increasing flexibility and empowering consumers and communities. **The basic legislative framework for energy communities is also planned to be improved by 2024**. Local energy communities are a specific form of organisation based on renewable energy production. They help ensure that all or part of the energy produced on a renewable basis can be used locally, e.g. within a transformer district.

ii. National targets for non-discriminatory participation of renewable energy in all energy markets, including a timeframe for when the targets will be met

In order to ensure a cost-effective level of support, support should only be available through renewable capacity tenders, within the framework **of a technology-neutral renewable energy support scheme (METÁR).** The successful METÁR tenders announced from autumn 2019 showed that the level of support required follows the decrease in investment costs. METÁR will be reviewed by 2026 in view of the fact that the Commission's approval of the aid scheme is valid so far. The review should identify which technologies are already able to operate profitably from 2026 and which are not. It can already be seen that some weather-dependent technologies are able to operate without support, but without support it is not profitable to operate power plants using renewable raw materials from agriculture, forestry and/or agriculture. With this in mind, work should start on the next support scheme.

In order to integrate renewables cost-effectively, it will also be necessary to encourage the uptake of **technologies** and **consumer activities,** as explained in the previous chapter, that help to improve the controllability of the electricity system while minimising the need for (and the cost of) network development investments and allowing the integration of decentralised generation from renewable sources to the greatest extent possible.

In the case of the gas market, it is necessary **to establish the physical and legal feasibility of non-discriminatory incorporation of alternative gases into the gas system.** In this field, Hungary has the task of implementing gas production plants – hydrogen and bigase plants –, creating integration with the gas system and, before that, creating compatibility of gas system elements with alternative gases. The **Hungarian gas system already contains biogas, even if only to a** small extent, so its application in the gas system may be implemented to a greater extent in the future, which may be limited by the availability of biogas. The increase in the availability of biogas is planned to take place along the lines of the Biogas Concept prepared for 2024. However, the **obstacle to be removed in the field of hydrogen** is the low hydrogen tolerance of gas system components – and user equipment – which can be developed at significant additional costs. Thus, hydrogen compatibility will be implemented in phases for some new projects, e.g. during the implementation of the Slovenian-Hungarian interconnector mentioned above. In connection with the non-discriminatory participation of hydrogen, it is necessary to pay special attention to the activities and developments of the energy networks connected to Hungary, since the large-scale blending of hydrogen in the gas system poses a security of supply risk, while significant hydrogen import demand is expected already in the near future.

In the field of fuels, the aim is to have **adequate "fuel-compatible" user tools** to accommodate different renewable fuels, such as different fuel blends, biofuels, electricity, hydrogen. Different types of fuels require a variety of technologies, among which there is currently no best solution. This is especially problematic in the field of driving heavy-duty machines and trucks, in addition to alternatives with limited raw materials. This is a research and development issue. In the field of road passenger cars and track-based transport, the domestic target is fast-paced **electrification through simultaneous, large-scale support for equipment** and infrastructure within a tight timeframe.

iii. National objectives to ensure consumer participation in the energy system and that self-generation and new technologies, including smart meters, benefit consumers

In the electricity and natural gas sectors, the much wider use of smart meters, the proper installation of heat centres in the case of homes with district heating, the controllability of heating systems and the widespread use of cost allocators, as well as the establishment of the active operation management capability of distributors, will enable consumers to obtain accurate information on the evolution of their energy consumption and competitive service package offers from their service provider, while improving the quality of service.

The cost reduction of renewable electricity generation technologies, digitalisation and the increasing affordability of smart metering are leading to a major shift in attitudes: the passive consumer approach is increasingly being replaced by an active – partly self-sufficient – prosumer approach. This requires the development of complex energy policy solutions, differentiated by consumer segments, **a tailor-made, flexible approach and the compilation of diversified service packages.**

One of the basic conditions for the active participation of consumers in the market is the **establishment of controllability of consumption** where it is not yet possible to do so. In this regard, we aim to **deploy at least 1 million smart electricity meters by 2030.** In the future, this will enable consumers to effectively participate in electricity markets through aggregation. It can also ensure that their own consumption is designed in a way that contributes to the optimal functioning of the electricity system as a whole, e.g. through the possibility of introducing time-based remuneration.

In addition to enabling the active participation of consumers in the electricity system, i.e. the provision of flexibility services through demand response (DSR), making it easier for consumers to control their energy use and energy costs. In the case of households, public buildings, smaller corporate consumers, even energy communities, this also requires the **emergence of independent aggregators** who combine several user or generation units for sale or purchase in an organised energy market (exchange, day-ahead market, intraday[47] market,[48] system services market, local distribution flexibility market).

[47] *day-ahead market (DAM)*
[48] *Intraday Market (IDM)*

iv. National objectives for ensuring electricity system adequacy and flexibility of energy systems for renewable energy production, including a timeframe for when the objectives should be met

The Hungarian electricity system is currently characterised by a high level of security of supply, the two pillars of which are a diversified domestic production portfolio and market integration. The **rapid growth of installed solar power plant capacity and electrification generates challenges** in maintaining the adequacy of the electricity system and in managing grid bottlenecks. At the same time, one of the key elements for the efficient integration of **renewables is that in the future renewable producers will have to contribute more to the reliable operation of the** electricity system. It is therefore necessary to develop their scheduling capabilities, to ensure production projection through automation, to reduce deviations from the schedule with battery storage, and to ensure the balance of the decentralised, small-scale production-consumption balance by joining virtual power plants and/or aggregation and/or energy communities.

To address the challenges generated by accelerating electrification, we aim to strengthen the electricity system: increase of conventional and renewable generation capacities, network development, introduction of electricity market regulatory solutions. Among these, measures aimed at the development of the domestic network, as well as the installation of the already mentioned smart meters and the construction of storage capacities are of paramount importance. Hungary has launched and is preparing to continue significant investments in order to facilitate the transformation of the electricity system on a renewable basis. This is a multi-year and multi-device process that, **in addition to classic and digital network development investments, includes regulatory and remuneration reforms and DSI elements.** In order to balance the Hungarian electricity system, **further market integration steps are needed in relation to balancing markets** – MARI and PICASSO products.

v. National objectives to protect energy consumers and improve the competitiveness of the retail energy sector

Hungary undertook to provide a consumer vision in which the flexible, choice-providing service provider side serves the interests of consumers, and in which consumers become low-energy-cost, domestically resourced, even self-sufficient, active users.

Consumers can contribute to cost-effective energy supply and use by encouraging and supporting energy efficiency, promoting the uptake of smart meters, reducing demand through conscious energy use, exploiting the potential of decentralised self-generation of renewable energy and optimising supply modes, and providing different service packages.

On **the part of suppliers and network operators,** strengthening competition in the wholesale market, creating a smart grid and keeping infrastructure operating costs under control will help to reduce energy costs in a sustainable manner. In particular, in the **case of district heating,** the aim is to revise the support system, as the currently applied methodology does not provide incentives for the cost-effective implementation of the investments necessary for the modernisation and greening of the district heating system.

Improving the competitiveness of the sector can be achieved by improving the fullest possible understanding, inclusion and servicing of customer needs, mainly due to the static nature of pricing and its decoupling from cost orientation. That is why our goal **is to improve the service of energy end-consumers and to create the regulatory conditions necessary to improve the customer experience.** The programme includes the development of digital administration channels, the introduction of digital signatures and the development of a consumer-friendly account image.

2.4.4. Energy poverty

i. National targets for energy poverty, including a timeframe for when the targets will be met

Vulnerable consumers are those who have or may have difficulties in meeting their household's energy needs. The concept thus includes the difficulty of financing energy needs in the same way as the property's high specific energy consumption. In order to ensure adequate access to basic energy and water utilities, the Government provides various forms of support to certain vulnerable or vulnerable consumers (Chapter 3.4.4).

Due to Hungary's historical energy conditions, the almost exclusive nature of natural gas heating (the proportion of dwellings connected to the gas network is the highest in Europe), the low degree of energy-efficient construction of residential buildings (panel dwellings, small family houses built under socialism) and the country's low energy supply, **it is essential to reduce the energy vulnerability of the population**.

The objective of the Hungarian overhead protection system is to prevent energy exposure, which is highly dangerous and likely to develop due to the above factors, for the population as consumers to be protected. Because of the above, the Hungarian overhead protection extends to the following social groups:

a) your home is connected to a natural gas network, or
b) your residential building is in need of energy refurbishment, or
c) it is difficult to cover energy costs in addition to the public transfers used, or
d) Participate in the Social Fuel Program.

According to the Government's policy, the result of **the overhead protection system is that the proportion of energy poor is 3%,** with about 300 000 people. Such a household shall be deemed to have the following characteristics:

- lack of adequate home heating in particularly vulnerable populations,
- arrears on utility bills within particularly vulnerable populations,
- particularly vulnerable populations living in dwellings with leaking roofs, damp walls, floors or foundations, or rotting window frames or floors, or
- population below 60% of median equivalised income after social transfers (particularly vulnerable population).

2.5. Research, innovation and competitiveness dimension

i. National objectives and funding targets for public and, where available, private research related to the Energy Union, including a timeframe for when the objectives will be met

Through the value-creating capacity of the RDI ecosystem, the intensive increase of the innovation performance of the corporate sector and the consistent implementation of smart specialisation, Hungary aims to become one of Europe's major innovators, from an emerging position as an innovator. In order to achieve the target, Hungary undertook in its RDI strategy to **increase the R&D expenditure to 3% of GDP by 2030, i.e. it** plans to provide more coverage for the RDI activities of the focus areas also identified in the NECP, compared to 1.64% in 2021.

In order to strengthen the economic impact of RDI expenditures, it was first necessary to define the framework of the RDI focus areas. In June 2023, the new innovation strategy – the *John von Neumann Programme (NJP)* [49]– was adopted, setting out a selection methodology between the focus areas and those to help allocate RDI funds in the next period. One of the 4 focus areas is *'supporting the green transition of the economy and the development of a circular economy',* with priority given to **energy production, agrotechnologies and climate and water technologies.** The aim is to develop solutions that support the **development of a modern, resource-efficient, competitive and sustainable domestic economy** that promotes climate neutrality, ranging from the challenges of climate change and geography – agro-innovations and water management – to increasing energy savings, accelerating the clean energy transition, harnessing indigenous energy sources, sustainable and smart mobility, supporting alternative propulsion and mobility solutions, and energy storage and network innovations, to a sustainable environmental and bio-based economy – waste management, cyclical and recycled technologies, new materials.

Hungary is committed to the innovative transformation of the energy sector, in which the key objective is to increase the RDI performance of the area and to exploit the economic development opportunities inherent in energy innovation and climate change.

17Table - Objectives for innovation and competitiveness

	Targets for 2030
Number of innovation pilot projects implemented	min. 20 pcs
Number of international patents registered during the implementation of pilot projects	min. 10 pcs

We want to encourage innovative solutions to smooth the transformation of energy markets through greening, electrification, decentralisation and digitalisation, and to contribute to the

[49] *https://kormany.hu/hirek/adopted-the-parliament-a-neumann-janos-programme*

objectives of increasing consumer choice, strengthening security of supply and climate-friendly transformation of the energy sector.

ii. National 2050 objectives for the promotion of clean energy technologies and national objectives including long-term targets for the deployment of low-carbon technologies, including technologies for the decarbonisation of energy-intensive and carbon-intensive industrial sectors, and related CO2 transport and storage infrastructure (2050)

The most important task in terms of energy innovation and R&D is to **support our emission reduction and security of supply goals at the same time,** while another aspect is that energy innovation should contribute as much as possible to the performance of the Hungarian economy, increase domestic RDI capacity and create opportunities for industrial development.

The strategic framework and directions of energy innovation are set out in the NES, on the one hand, and in one *of the national economic priorities of the National Smart Specialisation Strategy (S3)* for 2021-2027, on the other – *the Energy and Climate Priority.* [50] The S3 sets out the areas of specialisation with high development potential for the national economy, where the concentration of resources can contribute to increasing the competitiveness of the economy. Among the national economic priorities, the *Energy and Climate Priority* aims to combat climate change and facilitate the transition to a carbon-neutral economy, including activities related to energy production, storage and use, as well as activities to replace or reduce the use of natural gas and oil-based energy production, and to promote the energy-efficient and environmentally friendly operation of enterprises. Furthermore, the priority should cover research and development activities related to the expansion of nuclear energy generation capacity and further nuclear innovations based on them, as well as RDI issues related to the long-term safe use of nuclear energy and the proper storage of radioactive waste. The priority also includes reducing emissions from the largest GHG-emitting industries by reducing energy use and increasing production efficiency, as well as researching technologies for wider deployment of renewables in energy-intensive sectors and residential use. In view of the above, the following areas will be highlighted:

- Electricity and heat are both currently limited in terms of storage, but they are the most necessary type of energy that can be greened. Incentives **for innovative seasonal electricity and heat storage**solutions aim to overcome constraints and facilitate the development of technologies that can store large amounts of energy over longer periods of time, including months.
- **Exploring the potential of utilising land heat – shallow and deep geothermal energy – and biogas,** supporting their best possible and sustainable use and their integration into the energy system can be pioneers of domestic energy production.

[50] *https://nkfih.gov.hu/office/national-smart/national-smart-specialist-strategia-2021-2027*

- **With** regard to the development of hydrogen ecosystems and the production of hydrogen, we want to encourage the satisfaction of large-scale industrial demand through the spread of low-carbon hydrogen and small-scale demand through the spread of decentralised green hydrogen production methods. We also plan to support the production and increase the use of green hydrogen in ways other than electrolysis, e.g. by researching biological production.
- With the support of **nuclear innovation,** services can be developed in Hungary that improve the competitiveness of nuclear energy production and contribute to maintaining and expanding the Hungarian nuclear experience and knowledge base. In[51] addition to solutions for nuclear power generation, such as the potential of the deployment of Small Modular Reactors (SMRs), we also aim at research on nuclear waste cycles.
- **The development of all phases of the electrification process** and the efficient exploitation of the possibilities of electricity network operation are necessary for the proper operation of the entire economy.
- The aim of promoting innovative **ways of supplying energy** is to ensure that electricity generated (from renewable sources) is used locally. This will be supported by the development of "smart regulation", positive incentives for distributors to introduce new products and innovative technologies, as well as energy awareness and participation of consumers in maintaining the balance of the electricity system.
- In the interest of transport greening, the aim is to promote the domestic production of electric and hydrogen-powered vehicles and to support domestic research **related to the energy use of used car batteries.**
- It is necessary **to strengthen the research and development activities related to the domestic manufacturing and raw materials industry,**which support the green transition of the given industrial and consumer circle, the implementation of its circular economy, its digitalisation, and the increase of the competitiveness of domestic companies - primarily, but not exclusively, in the fields of construction and energy industry.
- The **utilization of domestic coal assets in the material may also have a raison d'être in** the future, e.g. as a raw material for the chemical or construction industry, or with the so-called clean coal technology, provided that it can be operated sustainably and cost-effectively.

[51] Each of the nuclear power plants in operation today is a unique product. However, the production technology of SMRs that are much smaller than these will be standardised, which means that these series products will certainly be much cheaper to manufacture and are expected to be approved, built and expanded more quickly.

- Carbon Capture, Storage, Transport and Utilization (CCUS) technologies play an important role in the future of hard-to-decarbonise industrial processes. In the case of **CCUS technologies,** it is necessary to take into account the entire value chain of the carbon neutralisation process.
- It is necessary **to support innovative solutions to adapt to climate change,** including to assess, monitor and manage the likelihood of risks occurring.

iii. National competitiveness objectives

In addition to quantified targets, it is important to strengthen competitiveness based on green innovations and technologies, resulting in more successful and productive businesses, more jobs, greater added value and, ultimately, a higher standard of living and a better quality of life.

In addition to RDI activities, Hungary's competitiveness can be strengthened by: Partially **domestic production of green technology solutions and the expansion of** the related domestic construction capacity are essential for the feasibility of energy investments. This will also increase the competitiveness of the national economy as a whole, as investments will increasingly focus on the use of green technologies in the future. A priority aspect is the realization of the domestic production capacities of the rapidly spreading **technologies, besides which the design and implementation of the related services** must proceed at the same pace.

However, for this and for the energy transition as **a whole, it is essential to have a well-prepared and sufficient workforce** in the green economy, which can be achieved by training professionals entering and already present in the labour market. Retaining and strengthening a workforce with the right skills and training a new generation is essential. The manufacturing and R&D capacity of companies established and operating in Hungary has a significant impact on the demand for professionals, which imposes additional requirements towards higher education courses, so our aim is to increase the number of suitably qualified professionals and R&D staff. It is crucial that the related training activities take place in close proximity to the companies in the industry, thus ensuring more efficient practical training and maintaining a skilled workforce. In addition, cooperation between higher education institutions and companies, the strengthening of innovation attitudes, the strengthening of the innovation ecosystem and the smooth flow of knowledge can be organised more efficiently.

In the interest of the country's competitiveness, the development and scheduled implementation of the related industrial strategy can lead to significant progress. In addition, the NJP ensures that the link between universities, research institutes and the economy can be achieved. Within the framework of 9 measures, the programme defines the directions that enable the development of the innovation pillars of the knowledge-based, high value-added economy and put Hungarian research on an international path. Accordingly, the goal is to make **Hungary one of the top 25 innovators in the world by 2030.**

3. SPOLICIES AND MEASURES

Detailed information on policies and measures can be found in **Annex 1 to the NECP.** The list of actions includes current, ongoing and planned strategies and action plans, legislation and projects identified with funding sources that are aligned with the dimensional target system, of which this chapter provides a brief, summary overview.

3.1. Dimension of decarbonisation

Hungary has set its climate neutrality target for 2050, as set out *in Act XLIV of 2020 on climate protection*, which frames Hungary's short-, medium- and long-term energy and climate policy measures presented in the NECP.

This section outlines current, ongoing and planned policies and measures to reduce Hungary's greenhouse gas emissions directly and to reduce emissions by offsetting them, as well as indirect emission reductions from clean resources.

3.1.1. Greenhouse gas emissions and removals

Annex 1 to the NECP includes measures to reduce GHG emissions indirectly – dimension 1.1 – as well as indirect measures for decarbonised energy production, awareness-raising and adaptation to climate change (together with related measures in additional dimensions).

i. Policies and measures referred to in point 2.1.1 of this document to achieve the target set under Regulation (EU) 2018/842 and policies and measures to comply with Regulation (EU) 2018/841, encompassing all relevant emitting sectors to enhance removals, bearing in mind the climate-neutrality objective set out in Article 2(1) of Regulation (EU) 2021/1119 and having a long-term vision and goal to create a low-carbon economy and achieve a balance between emissions and removals in line with the Paris Agreement

Among the 'emitting sectors', the **energy sector is the largest** emitter (2021: 46 Mt CO_2e, 72% of emissions), thus a large proportion of measures are related to this sector. However, on the one hand, we also need to pay attention to the sector with further lower GHG emissions, such as the industrial and agricultural sectors and the waste management sector (in 2021: 7,2-7,2-3,4 Mt CO_2e), on the one hand, and measures capable of absorbing emissions primarily leading to natural neutralisation (2021: -7.2 Mt CO_2e). In **the case of Hungary, carbon dioxide (CO2)is the most significant** greenhouse gas emitted (~76% in 2021) and it is the most widely emitted greenhouse gas affecting all sectors, which is why we focus predominantly on this GHG in our measures, as these measures also help to reduce non-CO2GHG emissions incidentally, which can be further reduced by additional measures.

GHG **emissions from the use of energy sources** are determined by the amount of energy used in the processes and the *specific emission factor (emission factor) of* the energy sources. The reduction of the amount of primarily fossil energy used, the increase of energy efficiency in energy-intensive areas, the increase of the use of renewable energy sources, the replacement of fossil energy sources, and the replacement of fossil energy sources with higher emission factor by energy sources with lower factor, which is included in the *National*

Energy Strategy (NES) along the National Clean Development Strategy (NTFS) and its updates, will result in a significant reduction in GHG emissions.

The energy sector – in the energy use of energy production and various other sectors, i.e. residential, service and public sectors, industry and transport – is a specific measure to **increase the use of renewable energy and energy efficiency** in Chapters 3.1.2 and 3.2, respectively, with other alternatives to decarbonised energy production having a further significant impact on GHG emission reductions.

The Mátra Power Plant is a strategically important basic power plant of the domestic electricity system, but it is also a significant GHG emitter (2021: 3.2 million t CO2e/year), accounting for 5% of total domestic greenhouse gas emissions. With the transformation of the Mátra power plant based on low-GHG emission technologies, **coal, i.e. lignite, will be phased out from domestic electricity production,** which requires the reorganisation of the area.

The **long-term maintenance and expansion of nuclear capacities** represents a significant decarbonisation potential for Hungary. To this end, preparatory activities are being carried out in connection with Paks I, which are necessary for the administrative authorisation procedure for the further extension of operating time. If its four units are considered suitable for extended operation time, Hungary's increasing line power demand can be supplied with 4.4 GW of nuclear-based power in the next decade, together with the two 1.2 GW new units of Paks II.

In the case of industrial feedstocks, the production of hydrogen is still dominated **by the production of natural gas-based 'grey hydrogen', which needs to be gradually converted to renewable and nuclear-based** production.[52] Hydrogen will need to be used in hard-to-electrify, typically energy-intensive industries, so especially in the chemical, steel, cement, glass and ceramics industries, there may be a solution for decarbonisation, which is also reflected *in the National Hydrogen Strategy.* However, a significant part of this hydrogen demand can be met with imported hydrogen.

Measures **directly targeting GHG emissions other than CO_{2}andCO $_{2}$** include replacing **industrial** grey hydrogen, regulating or updating fluorinated gases, and *complying with the Methane Regulation.* In addition, measures to incentivise emission reductions from **transport**vehicles and measures to reduce emissions from **waste management** reform, to encourage circularity, re-use and recycling, as well as measures to reduce ammonia, methane and N2Oemissions from **livestock** farming and fertilisation. The reduction and offsetting of GHG emissions by businesses is also directly encouraged by the **EU Emissions Trading Scheme (EU ETS) and the ESG law stemming from EU law .**

52As the European Commission's Joint Research Center study shows, the production of nuclear-based electricity has the same low GHG emissions as solar or wind power plants.

Hungary intends to **increase the share of land covered** *by forests and other tree stands in line with the National Forest Strategy* **in order to enhance CO2sink capacities,** focusing primarily on natural sinks, and to improve the resilience of forests to environmental factors in order to preserve the carbon sequestration capacity of forests. Increased CO2sequestration is also encouraged by *the domestic measures of the Common Agricultural Policy* not only in forestry but also in other agricultural land uses – e.g. through subsidies for the maintenance of permanent grassland and wetlands, agro-ecological land use change, mulching and environmentally sound tillage. In addition, due to the clarification of GHG emissions and removals from land use and land use change, **the LULUCF-Matrix project is ongoing, in the framework of** which Hungary intends to update and clarify the classification of its areas and the related GHG inventory, based on its real land cover, which would later be supported by continuous remote sensing monitoring.

In industry, where it is not technically possible or economical for individual technologies to switch to renewable-based electrification or other alternative low-carbon technologies, carbon capture may be justified. Suitable solutions also need to be found in hard-to-decarbonise sectors of industry and large emitting facilities, which may require closer cooperation between government and industry actors. This can be facilitated by climate agreements between the parties. In the future, it is likely that Hungary will have to devote an increased role to **CO2capture technologies,** which is also justified by the entry into force of the NZIA. **Current versions of**these technologies can only be used economically for industrial installations with higher capacity, but cannot be used on their own, as the use and/or long-term, reliable storage (CCUS) of captured CO2 must be ensured. In view of this, it is essential to plan the development of complex solutions, which can be achieved by targeted regulatory and financial means.

The NECP has been prepared in addition to previous and planned policy measures related to NÉS-2 to ensure their consistency. Since 2020, significant progress has also been made in the NÉS-2 actions related to miigration, adaptation and awareness-raising, so it has been implemented:

18Table 1 - Actions taken by NÉS-2 in 2020-2024

Among waste management and migration measures supporting circular management:
• ***Review of the Hungarian waste management legislation necessary for the transposition of the EU circular economy package, which entered into force on 4 July 2018, and the continuation of the implementation of the migration aspects in the course of the amendment***
• ***Mainstreaming mitigatory aspects in the revision and amendment of the domestic waste management legislation necessary for the transposition of Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment***
• ***Promotion of Best Available Techniques (BAT), development of BAT aids and guidance documents, promotion of BAT methods in the waste management sector***
Adaptation measures to promote water management and protection:
• ***Elaboration of an action plan to establish the basis for the mitigation of short-term rainwater flooding in urban areas***
• ***Development and application of methodology for the planning and implementation of urban rainwater management flexibly adapted to climate impacts***
• ***Conducting research for the detection, prevention and management of damage events caused by lightning floods***

- ***Continue reviewing inland hazard mapping***
- ***Determination of inland flooding based on remote sensing***
- ***Continuation of research to investigate groundwater retention and reservoir possibilities***
- ***Developing the development priorities of our domestic waters for complex climate adaptation***
Other adaptation measures:
- ***Strengthening disaster risk assessment capacity***
- ***Development and communication of sectoral strategic proposals based on the assessment and mapping of ecosystem services and the Green Infrastructure Concept***
- ***Creation of ecological and technical conditions for the conservation and maintenance of natural and semi-natural habitats***
- ***Climate protection development of agroforestry systems***
- ***Assessment of the climate and geological vulnerability of critical energy infrastructure elements (electricity, gas, district heating systems)***
- ***Development of a monitoring system for allergenic plants***
- ***Review and development of the heat alarm system***
- ***Developing a criteria system and identifying cost implications in the development of infrastructure in hospitals and social institutions to ensure thermal regulation and protection against UV radiation in critical rooms, as well as optimising other environmental factors (air and water quality)***

In the context **of adaptation to the adverse effects of climate change,** the *National Adaptation Strategy (NAS)* integrates climate change as a fully fledged boundary condition into actions in several policy areas for 2030. The adaptation measures of NÉS-2, including the NECP, include measures supporting the assessment and management of climate risks and energy adaptation, as well as measures ensuring biodiversity, habitat protection and a livable urban environment, aimed at the development of the food industry, soil protection and the development of water management and water protection.

In addition to the above, **a NÉS-2-related programme aimed at creating an energy- and climate-conscious society** serves the achievement of Hungary's goals, including energy and climate awareness campaigns targeting different age groups, as well as educational awareness-raising measures focusing on young generations.

ii. Regional cooperation in this area

In addition to specific EU policy conferences and cooperation in the field of GHG emissions and removals, Hungary **conducts regional technical consultations with** the V4 and its neighbouring countries. The framework of the sectoral discussions is the dimensional framework of the Energy Union, so the subject of the cooperations is the complex strategy and action planning and its elements linked to sectoral policies, which can be found in the following chapters. One element of this is the project for the implementation *of Hungary's National Climate Change Strategy,* which is planned to include the **national monitoring, evaluation and reporting framework related to energy and climate policy,**as well as aspects of the environmental impact assessment, which has already been implemented.

The Ministry of Economy of the Slovak Republic **organised a V4 Energy Working Group,** which took place in Bratislava on 27 April 2023. The aim of the working group was to present the commitments and achievements of the Member States in relation to the NECPs and to discuss issues related to the achievement of the targets. The working group put particular emphasis on energy efficiency and renewable energy sources.

The practice of introducing sustainable components – sustainable aviation fuel (SAF) – will also be introduced for aviation fuels, in which Hungary will participate. In this area, several Hungarian ministries are working together to transpose and comply with EU regulations. The ‘SAP’, i.e. the Hungarian State Action Plan, is being prepared in a broader domestic cooperation to introduce the SAF and its market effects, mapping its potential and challenges. In order to compile SAP and comply with other regulations, Hungary cooperates with international organisations such as the European Commission, the European Civil Aviation Conference (ECAC) and the International Civil Aviation Organisatin (CIAO). The responsible Hungarian authorities have been participating in this cooperation since January 2024, within the framework of which Hungary has already organised several face-to-face and online meetings on the transposition of the ReFuel Aviation Regulation and the SAP project.

REFUREC brings together regulatory experts from the EU27 and third countries. The main topics for face-to-face conferences and online discussions are the exchange of questions, issues and experiences on EU renewable energy regulations in the transport sector. Currently, the main topic is the transposition of the REDIII and related regulations and the discussion of the obstacles encountered. At the last conference in Helsinki, the main topics were: UDB (EU database), RFNBO (renewable fuel of non-biological origin), HVO (hydrogenated vegetable oil), this year's amendment of REDIII Annex IX and discussion of options for REDIII implementation. The Hungarian delegate has been participating in REFUREC events for the second year in a row. The conferences play a particularly important role in the exploration of opportunities and solving problems around the domestic implementation, and are an excellent venue for building international expert relations.

iii. Without prejudice to the applicability of State aid rules, financing measures taken in this area at national level, including Union support and the use of Union funds

The decarbonisation efforts will be greatly supported by the relevant pillars of the **operational programmes** implemented with EU funds, ***as well as by green investments with a GHG reduction impact that are planned to be financed*** **from the Recovery and Resilience Instrument (RRF) and *the Common Agricultural Policy (CAP).***

Under *the Recovery and Resilience Facility, a non-repayable grant of EUR 5.811 billion is*[53] *available for Hungary,* i.e. HUF 2 294.35 billion. The *Energy – Green Transition component* and the *RePowerEU chapter* contribute significantly to increasing the energy transition. Their total support amount is nearly HUF 2 300 billion. The key objectives of the developments are to achieve the key objectives of the NES and the revised NES, such as strengthening energy sovereignty and security, and decarbonisation.

[53] *Calculated at the exchange rate of HUF 394.83/EUR*

Among the relevant operational programmes for the 2021-2027 development period, the Environmental and Energy Efficiency Operational Programme Plus (KEHOP Plus) and the Territorial and Settlement Development Operational Programme Plus (TOP Plus) should be highlighted. In addition, the development resources of the Integrated Transport Development Operational Programme Plus (IKOP Plus), the Digital Renewal Operational Programme Plus (DIMOP Plus) and the Human Resources Development Operational Programme Plus (EFOP Plus) may also be relevant.[54] The programmes aim to increase the use of renewable energy, improve energy efficiency, support sustainable mobility, improve waste management and wastewater treatment, and support the protection of afforestation and forest resources.

CAP resources are also relevant for reducing GHG emissions and improving adaptation. (More information on this is provided in the CAP Strategic Plan.[55])

Despite the fact that Hungary has not yet received RRF funds, Hungary has also provided funds from the national budget for several investments[56]presented *in the already adopted Recovery and Resilience Plan.* In advance, Hungary paid an amount of EUR 779 million corresponding to 20% of the RePowerEU credit line on 28 December 2023, followed by an advance payment of EUR 140 million corresponding to 20% of the REPowerEU additional non-repayable support tranche on 15 January 2024.

The investment in electricity grid development indirectly reduces GHG emissions, while the investment in the installation of residential solar panels and the electrification of heating systems directly reduces GHG emissions. In addition to the non-repayable funds, Hungary intends to use part of the RRF loan pillar through the REPowerEU chapter. We plan to use these resources to strengthen the energy transition while increasing energy security.

In *the fourth trading period of the EU Emissions Trading System (EU ETS)* (2021-2030), all revenues from the sale of allowances will be used under the allocation managed under the Energy ***and Climate Modernisation System (ECMS)***chapter. This appropriation is intended to provide funding for the reduction of greenhouse gas emissions and their sequestration. Payments for electromobility, energy efficiency, innovation and other sustainability improvements, investments, measures, research and awareness-raising activities in the areas of energy efficiency, greening of transport and recycling, within the framework of international cooperation on adaptation to the effects of climate change. The ***Modernisation Fund,*** which will be launched in 2021, will support Hungary among ten Central European Member States in modernising its energy systems and improving energy efficiency. Hungary is also taking steps to modernise its domestic energy system and increase energy efficiency, thereby reducing GHG emissions, using the funds of the *Modernisation Fund* established for

[54] *https://www.palyazat.gov.hu/development_programmes_2021_2027*
[55] *https://cdn.kormany.hu/uploads/document/0/0e/0ec/0ec4a4b0ea4a1f5a0c98ef633503faab726809e0.pdf*
[56] *https://www.palyazat.gov.hu/locreallitasi-es-ellenallokepessegi-eszkoz-rrf*

the period 2021-2030, complemented by the government's envelope for the auctioning of allowances.

For ***the new EU Cohesion Policy,*** an agreement for the period 2021-2027 supports Hungary in relation to balanced territorial development and fair climate and digital transitions, while supporting an innovative and inclusive social market economy. From the point of view of the green transition, the most significant investment plan is KEHOP Plus, which supports the implementation of strategic goals with more than HUF 1,600 billion. Significant investments are also included in TOP Plus, DIMOP Plus and IKOP Plus.

METÁR, which serves to support electricity produced from renewable energy sources and thereby also to reduce GHG emissions, plays a decisive role in the Hungarian energy market, as described in point 3.1.2.

3.1.2. Renewable energy

The measures **to achieve the 2030 target of a 30% share of renewable energy** and the related sub-targets, broken down by sector,**are set out in Annex 1 to the NECP** (together with the related measures in the additional dimensions). One of the most significant, desirable and necessary conditions for achieving the share of renewable energy in each segment is the development of the electrification of the given sector, so the scope of measures for the **supply of electricity** arises separately for each sector, therefore the rapid development of renewable – and clean – electricity generation is of paramount importance.

Measures include renewable transport, heating and cooling, with a special focus on thermal water, land heat and biomass, and electricity generation, with a special focus on solar and wind capacity. In addition, Hungary has horizontal measures such as those relating to the production and use of alternative gases, with particular emphasis on biogas and hydrogen.

i. *Policies and measures necessary to achieve the national contribution to the binding Union-wide target for renewable energy for 2030 and policies and measures[57] supporting the trajectories referred to in Article 4(a)(2) and, where applicable or available, the elements referred to in point 2.1.2 of this document, including sector- and technology-specific measures*

<u>Electricity</u>

In order to ensure a cost-effective level of support in electricity generation, support can only be obtained through technology-neutral renewable capacity tenders, within the framework *of the Renewable Energy Support System (METÁR)*, the maintenance and possible development of which we ensure. **METÁR promotes the growth of renewable-based electricity production produced for the grid,** the technology utilizing weather-dependent renewable sources, the technology utilizing biomass and biogas, and the multi-fired and

[57] *When designing these measures, Member States should take into account the end-of-life of existing installations and the possibility of repowering.*

waste-burning power plants to the extent of renewable energy sources in proportion to the fuel heat. In order to diversify the domestic renewable electricity mix, besides expanding solar power plant capacities, we also plan to increase the installed wind capacity and, besides supporting the production of biogas, the use of biogas in cogeneration.

To facilitate the integration of wind capacity into the system, we implemented **a regulatory reform** in 2023, as it was necessary to ease domestic regulatory barriers. Our goal is to find an optimal balance between social and investor interests. In order to increase renewable electricity generation, it is necessary to facilitate the cost-effective integration of renewable capacities, to maintain security of supply and system regulation, and to prepare the electricity grid for the cost-effective inclusion of decentralised capacities.

By updating the regulatory environment and financial support programmes, we encourage users **to electrify and increase their decentralised use of renewable electricity,** including the installation of solar panel systems and heat pumps (shallow geothermal, utilising ambient heat). In addition to households, the main target group for the deployment of renewable small power plants with an installed capacity of less than 50 kW is businesses, such as small and medium-sized enterprises (SMEs), industrial parks and energy-intensive companies, which are able to generate part of their own energy consumption, thereby reducing the load on the grid.

Energy **efficiency measures** support an increase in the share of renewables, while grid development is justified to integrate renewables into the system, ensure their proper use and regulate their production. See, for example, Commission Regulation No 9/2023 on the definition of the energy performance of *buildings. CCM Regulation (revised 7/2006. In addition* to and in support of energy efficiency, it also encourages the development of renewable capacities. (Chapter 3.2) The integration of renewable capacities into the grid requires the implementation of **internal electricity market developments.** (Chapter 3.4)

<u>Heating-cooling, domestic hot water</u>

In order to achieve and maintain the domestic GHG and pollutant emission targets, the expansion of heating methods using renewable energy sources and ensuring favorable primary energy use is a priority. The source of renewable heating and cooling, in addition to renewable electricity, can be earth heating, thermal water and biogas-based heating systems, as well as efficient biomass heating solutions. In order to encourage their uptake, **the regulatory framework is also being developed and support programmes** are being implemented.

When defining the measures, it is essential to take into account the limitations, opportunities and risks of possible renewable sources, which has led **in several cases to the need to develop guidance in sectoral strategic and/or action plans and in programme plans supporting the exploitation of the resource.**

In connection with the heat supply of the industrial sector and the production of district heat, the **practical exploitation of geothermal potential in Hungary** is one of the main objectives in those parts of the country where this is sustainable and economical, i.e. an appropriate heat transfer medium is available. This can be achieved through the combined application of several regulatory, support and utilisation measures. In this context, the aim, where heat extraction involves water production, is to re-inject water in order to achieve sustainable water use.

In the field of district heating, in addition to the modernisation of the district heating sector, increasing the use of geothermal heat sources, biomass and waste heat, as well as increasing the use of renewable electricity and the use of wastewater treatment, landfill gas and agricultural biogas will play a decisive role in replacing natural gas and increasing the use of renewable energy. Overall, the **use of weather-independent renewable energy sources, municipal waste and waste heat for heat generation will therefore play a greater role than in the past .** Incentives for the use of these resources will be developed for each district on the basis **of a detailed analysis, taking into account local conditions,** which will ultimately **enable the creation of 5th generation district heating systems.**

In the area of individual heating, the main direction of intervention, while reducing the heat demand of buildings, **is the deployment of heat pumps with a clean electricity supply**. Before the rapid ramp-up phase, it is appropriate to consider the urban landscape and noise load of the outdoor units of heat pumps, so that they can be regarded as a favourable solution even after the mass spread. Similarly to charging electric cars, it is also appropriate to review and define the role of these devices in the electricity system as a whole, with a view to system security. Furthermore, it should be taken into account that heat pumps can be used for thermally upgraded properties or should be supported in parallel. Biomass **requires strict consideration of the criterion of sustainable forest management** and reduction of local air pollution.

As mentioned above, we also want to create the legal conditions for the establishment of energy communities, in particular **by encouraging the establishment of energy communities with renewable heat production activities.**

Transport

In the transport sector, we aim to mitigate the increase in GHG emissions primarily **by increasing the share of biofuel blending, the uptake of alternatively powered vehicles, and by shifting traffic towards low-emission transport modes, in particular by increasing the competitiveness of rail transport, as well as through legislative incentives, support programmes and the implementation of** the *Jedlik Ányos Plan 2.0.*

Increasing the share of renewable energy is supported by lowering the growth rate of transport energy use. Developing **and increasing the use of renewable technologies, alternative propulsion and related infrastructures is therefore also of primary importance in public transport,** and electrified rail freight transport should be provided as a realistic option for freight transport (Chapter 3.1.3 (iii)). Electrification also contributes to energy efficiency in transport (Chapter 3.2), in addition to which the share of renewables may increase by supplying electricity generation with clean sources, as explained above, and by increasing alternative gas supply, as described in the section below.

Horizontal interventions

Hungary's National Hydrogen Strategy sets out an ambitious but realistic vision for building a hydrogen economy. Hydrogen can contribute to the achievement of the decarbonisation goals with a wide range of applications, including Hungary's focus on **industrial and transport applications.** This requires, on the one hand, the uptake of zero- and low-carbon modes of hydrogen production (production) and the development of the most favourable utilisation routes and the necessary infrastructures. We support the development of gas pipeline infrastructure (transport) and electricity system (storage and system regulation) supporting hydrogen use. In the case of use, the replacement of natural gas-based 'grey hydrogen' (industrial greening) and, in the case of demarcated areas of transport – public transport, transport – the coordinated spread of hydrogen refuelling points and hydrogen-powered vehicles. The value is not the production of green hydrogen per se, but the cost-effective use of green hydrogen. This requires appropriate **regulatory and predictable support measures,** while facilitating **essential infrastructure investments** adapted to the location and scale of the intended use. At the same time, a significant part of hydrogen demand will be met by imports. Achieving hydrogen transport will require major system-reshaping investments, as well as new **hydrogen-compatible pipelines** and underground storage. Connecting to the European hydrogen backbone is an important task in creating the future hydrogen infrastructure. In this context, cooperation with neighbouring countries and other stakeholders should be strengthened. FGSZ is already a member of the *pan-European initiative of the European Hydrogen Backbone,* which plans to implement more than 60% of the planned 53,000 km hydrogen transport network by transforming the current natural gas transmission network.

In order to achieve the decarbonisation targets, we will also explore the **possibility of converting part of the natural gas storage capacities to hydrogen storage.** In this regard, the Hungarian Natural Gas Storage Co. (MFGT) is of crucial importance. The Aquamarine pilot project, although it concerns surface technologies, could be an important milestone in the creation of a hydrogen economy, underpinning the possibility of a 2% hydrogen blending share. As part of the project, the company installed an electrolysis system with a total capacity of 2.5 MW at the underground gas storage facility in Cardoskút. The company is also a member of an international consortium investigating the storage of hydrogen in subsurface porous rock layers.

Biogas and biomethane production follow a similar pathway as hydrogen. With the completion of the Biogas Concept, our measures aim not only at production but also at utilization. In the case of biogas, however, the situation is more fortunate, given that, for example, our gas pipeline systems are suitable for blending biomethane without transformation or development. While the concept of production and use of hydrogen was already developed in 2021, that of biogas was completed in 2024. The **action concept for the production and utilization of biogas and biomethane** supports the increase of the renewable share of the electricity and heat sectors, and the increase of the share of renewable biomethane instead of the natural gas injected into the gas system, which helps to reduce natural gas imports already by 2030. On the one hand, our measures aim to ensure the **availability of raw materials** for biogas production, and on the other hand, to **maximise the amount of raw materials that can be used according to our current knowledge, while meeting environmental and agricultural needs, also beyond 2030.** The Hungarian biogas and biomethane potential offers a realistic opportunity to replace ~3% of the Hungarian natural gas consumption by 2030. We consider the production, purification and feeding into the gas network of biogas from agricultural and food industry by-products, residential green and biowaste, sewage sludge as an option with high potential and medium support needs.

Regulation related to alternative gases and their potential is continuously being developed, with special emphasis on the **development of a guarantee of origin system for alternative gases,** which also covers biogas, biomethane and hydrogen.

ii. Specific measures for regional cooperation and estimated additional production of energy from renewable sources that may be transferred to other Member States to reach the national contributions and trajectories referred to in point 2.1.2 of this document

We are exploring the possibility *of joint projects under the Connecting Europe Facility (CEF)* and are open to cooperation with neighbouring countries.

On 14 March 2024, the V4+ Clean Mobility Conference, together with Austria and Slovenia, was organised by the Czech Republic in Prague. The aim of the consultation is to identify the national implementation possibilities and difficulties *of Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure (AFIR)*, which poses a challenge for Central and Eastern Europe, including Hungary, to exchange best practices and to share experiences in relation to green, environmentally friendly mobility programmes. Participants reported on their readiness to comply with the requirements of AFIR and also discussed the coordination of the designation of recharging points along the borders.

iii. Special measures for financial support, including Union support and the use of Union funds, to promote the production and use of energy from renewable sources in electricity, heating and cooling and transport

METÁR, which supports electricity produced from renewable energy sources, plays a decisive role in the Hungarian energy market, which is described in detail in Section 3.1.2(i). **The instruments and resources referred to in Chapter 3.1.1 may also be available to** support investments that increase the production and consumption of renewable energy. Among these instruments, the following should also be highlighted:

1) **the KEHOP Plus programme,** [58]whose priority axes 4 and 5 will also provide resources to increase renewable energy production and utilisation.

- Priority 4: Renewable energy economy

In the context of promoting the use of renewable energies, the focus is on individual and community-wide electricity generation and community-based heating and cooling on a renewable energy basis. Within the framework of the Operational Programme, we are also striving to make better use of the opportunities offered by non-weather-dependent renewable energy sources.

In addition, we plan to improve the conditions for the production and use of renewable energy in the context of the development of smart energy systems, grids and storage. To this end, it is also necessary to support developments aimed at the flexibility of transmission and distribution networks, to support smart energy systems, and to promote the widespread use of hydrogen and biogas as energy carriers and storage renewable gases.

- Pyrometry 5: Just Transition Fund

The goal is to implement the just transition plan of the counties of Baranya, Heves and Borsod-Abaúj-Zemplén. Eligible areas: development of micro, small and medium-sized enterprises, creation of new enterprises, research, development and innovation, digitalisation, rehabilitation of contaminated sites, energy efficiency and use of renewable energies, promotion of the circular economy and waste management, employment improvement activities, etc.

2) Priority axes[59] 1 and 2 of the**TOP Plus programme:**

The main priority of the Operational Programme is priority 2, which aims to create a Climate-Friendly County. In this context, interventions are targeted at local and municipal energy developments – e.g. energy efficiency upgrading of municipal buildings and spas, and increasing the use of renewable energy.

In addition, priority axis 1 (Liveable County) also provides funds for green development. The framework will support the following activities:

- integrated urban development in local transport infrastructure and services, urban green and blue infrastructure,
- climate adaptation, brownfield regeneration, local community and cultural, sports and leisure spaces and services,
- information and communication technology (ICT) and smart urban development and social urban regeneration.

3) Priority axis[60]2 of the**DIMOP Plus programme**

[58] *https://www.palyazat.gov.hu/kornyezeti_es_energiahatekonysagi_operativ_program_plusz*
[59] *https://www.palyazat.gov.hu/terulet_es_telepulesfejlesztesi_operativ_program_plusz*

In connection with the high-tech and green transition priority, the developments are aimed, among others, at the digitalisation of building energy devices and systems, the IT service of energy communities and aggregators, and the development of digital sensor systems supporting climate change monitoring.

4) IKOP Plus priority axes[61] 1 and 2

Strengthening clean urban-suburban transport, i.e. under priority 1, can support:

- Suburban railway – e.g. HÉV in Budapest – and tramway track developments in large cities
- Acquisition of zero-emission public transport vehicles, e.g. city electric buses, trolleybuses, trams and development of related electric chargers, sites
- P+R, B+R, intermodal node investments
- Project preparation

The development of TEN-T rail and regional intermodal transport, i.e. the following actions are eligible under priority 2:

- Development of TEN-T international rail infrastructure - stations, track and interlocking equipment - electrification
- Acquisition of multiple units
- TEN-T port investments
- Project preparation

5) Recovery and Resistance Plan

We plan to implement the following energy investments and reforms from RRF funds, the implementation of which is partly ongoing. (See also chapter 3.1.1 on this subject.)

Electricity network development: modernization and expansion of transmission lines, transformers and substations, digitalisation, wide dissemination of smart metering, improvement of the accuracy of weather forecasts, establishment of energy storage facilities capable of providing balancing capacity

- Renewable electricity generation on a residential scale, modernisation of heating systems
- Supporting energy efficiency investments in public buildings, businesses and citizens
- Renewable energy production (as an element of several investments): solar, wind, geothermal, renewable hydrogen, biogas/biomethane.

[60] *https://www.palyazat.gov.hu/digitalis_megujulas_operativ_program_plusz*
[61] *https://www.palyazat.gov.hu/integralt_kozlekedesfejlesztesi_operativ_program_plusz*

- Industrial decarbonisation
    - Renewable energy production to cover own energy demand
    - Direct emission reductions (CCUS, renewable hydrogen, etc.)
    - Geothermal based industrial heating

Alternative mobility: corporate electric vehicle procurement, installation of electric charging stations, electrification of railway sections, hydrogen mobility

- Developing green economy manufacturing capacities, services and employee skills

The policy objectives listed here are spread over a number of investments and reform measures under the Energy – Green Transition and REPowerEU components. Under the latter component, Hungary will also make use of a significant amount of concessional loans from Member States to meet the targets. The planned aid amounts to nearly HUF 2 300 billion (see also Section 3.1.1).

6) Swiss Fund

Geothermal subsidies are also included in programmes planned from the RRF and cohesion funds. In addition, it [62]**is worth mentioning the Swiss Fund,** which is also able to contribute to the further and higher utilisation of Hungary's particularly good geothermal potential and to the development of current geothermal energy production opportunities. The resources of the Swiss Fund contribute to the implementation of the NECP, one of the objectives of which is to significantly reduce the share of natural gas used for heating purposes through the production of renewable energy. To this end, the renewable energy programme aims to make better use of the country's good geothermal potential and to develop current geothermal energy production opportunities. We plan to achieve a higher level of exploitation of geothermal energy by implementing the Earth Heat Concept.

7) Modernisation Fund

The Modernisation Fund may also provide the necessary resources to finance investments related to the expansion of renewables. We estimate that more than HUF 750 billion could be available from this source between 2023 and 2030. Since its creation in 2021, we have launched the following development programmes financed by the Modernisation Fund:

- Installation of integrated grid electricity storage facilities
- Energy Community Pilot Projects
- Energy efficiency of district heating and increasing the share of renewable energy

In 2024, Hungary will prepare and submit to the Modernisation Fund Committee for approval its development needs for further district heating subsidies, as well as investment

[62] *https://svajcialap.hu/programmes/energy efficiency-es-megujulo-energy boilers*

proposals to support industrial decarbonisation and the uptake of renewable energy production.

iv. Assessment of support for electricity from renewable energy sources that Member States are required to ensure pursuant to Article 6(4) of Directive (EU) 2018/2001

In order to ensure a cost-effective level of support in electricity generation, support can only be obtained through technology-neutral renewable capacity tenders, within the framework of **METÁR,** as previously mentioned. METÁR promotes the growth of renewable-based electricity produced on the grid by providing operational support. Under the scheme, aid for the construction of capacity above 1 MW will only be allocated in an artificially created competitive situation. Under the tender green premium, in addition to the power plant units linked to the new investment, existing power plant units may also apply for support if they undergo a major renovation or development costing more than 50% of the initial investment cost. The subsidies available depend on the production capacity of the power plant concerned. Mixed-fired and waste-incineration plants may receive support only for the part that qualifies as a renewable energy source, in proportion to the fuel heat (brown premium).

In the mandatory off-take support category of the METÁR tender (METÁR-KÁT) power plants with a capacity of less than 0.5 MW (except wind) and demonstration projects could participate until 26 April 2018. In the case of these power plants, the electricity produced will continue to be taken over by MAVIR, the transmission system operator, from the generators (mandatory off-take) and sold via the organised electricity market (HUPX). Within the framework of METÁR, with the exception of the brown premium, support can only be obtained through tenders, from 1 May 2019. Until 2026, the maximum annual new grant equivalent that can be allocated under METÁR is HUF 45 billion, in accordance with the legislation in force at the time of the preparation of the NECP. The evaluation of METÁR is carried out continuously, and new tenders are announced on the basis of these. The successful METÁR tender also highlighted that the level of support required follows the decrease in investment costs. Under the third METÁR tender published in April 2021, an annual budget of HUF 450 million could be applied for any type of renewable energy-based electricity generation, for a total annual production of 300 GWh. In the METÁR tender published in March 2022, in addition to renewable power plants, the construction of storage capacity was also defined as a tender condition.

In addition to centralised renewable power plants producing directly to the grid, we also support the expansion of decentralised power plants and thus the continuous increase in the number of prosumers, taking into account different beneficiaries, according to which our measures include several different measures already implemented and to be implemented, such as residential solar panel systems and associated modernisation programmes in 2021 and 2024, as well as SME and factory support programmes addressing the energy crisis in 2022-2023.

Support **for residential solar systems and electrification of heating systems in combination with photovoltaic systems** (RRF-6.2.1-2021), announced in 2021, aimed to make renewable energy available to as many families with lower incomes than the national average income, and to convert their heating into a system with lower emissions. Within this framework, you can choose between two technical contents: (1) Establishment of a photovoltaic system placed on a roof structure to cover self-consumption; or (2) The installation of a solar system placed on a roof structure with a specified capacity limit, the electrification of a heating system with a heat pump, the installation of an electricity storage facility and the replacement of doors and windows.

In the framework of the **Home Renovation Support,** in order to ensure the spread of HMKEs, support for the installation of photovoltaic systems was also available from 1 January 2021, in the case of households raising at least one child, a non-refundable amount of HUF 3 million could be accounted for with the support. In the two-year programme with a total budget of over HUF 700 billion, applications for aid could be submitted within 60 days of the completion of all renovation works on the dwelling, but no later than 31 December 2022.

Under **the SME Energy Cost and Investment Support Programme 2022-2023, energy-intensive** small and medium-sized enterprises could apply for a Széchenyi Investment Loan MAX+ loan to contribute to their own resources required for investments increasing energy efficiency and for the implementation of renewable energy investments.

The **Factory Rescue Programme and Factory Rescue Investment Loan Programme (2023)** provided non-repayable support to large companies for energy efficiency and energy generation investments (with a budget of HUF 150 billion). In addition, within the framework of the Factory Rescue Investment Loan Program, Eximbank Zrt. provided state-sponsored, preferential, fixed-rate investment loans for energy efficiency and renewable energy generation investments of domestic producing medium and large enterprises.

The **Solar Energy Plus Programme** has a budget of HUF 75.8 billion and was launched in mid-January 2024. The aim of the programme is to support household-scale small power plant (HMKE) systems to be grossly accounted for, by installing, connecting and commissioning solar panels, storage and other related devices (e.g. inverters, galvanic switches, etc.). The intensity and rate of the aid available under the scheme shall be a maximum of 66% of the eligible costs, and the maximum amount of aid that may be granted shall be HUF 5 000 000.

Overall, together with the above subsidies, **Hungary exceeded the planned 6 GW of solar power plant capacity in 2030 already in 2024 .** Of these systems under 50 kW, more than 277 thousand are in operation in Hungary. Photovoltaic installations above 50 kW account for more than 30% of the installed power of the electricity system.

v. Special measures to introduce one or more contact points, streamline administrative procedures, provide information and training and facilitate PPAs.; Summary of policies *and measures under the enabling framework to be established by Member States pursuant to Articles 21(6) and 22(5) of Directive (EU) 2018/2001 to promote and facilitate the development of self-consumption generation and renewable energy communities*

From 2024, new, complementary regulations for both renewable electricity and alternative gases, as well as for emerging communities, have been put in place to simplify the permitting of generation systems, to incentivise self-generation and the creation of renewable energy communities.

Hungary continues to encourage initiatives to ensure that **locally produced renewable electricity and heat is used locally by consumers**. The regulatory objective is to simplify the permitting procedure for renewable energy investments, to which Hungary has committed itself among the reforms of the Recovery and Resilience Plan. Furthermore, an alternative to cost-effective implementation of local production is self-sufficiency by more powerful collectively owned systems beyond individual systems with economies of scale, i.e. encouraging the development of renewable energy communities. The main task here is to promote the development of energy communities by means of legislation and funding sources. Facilitating the creation of renewable energy communities for consumers, whether for example solar power supply or electricity-based heat supply (using high-performance heat pumps, shallow geothermal energy, ambient heat), is covered by the rules on modified electricity and building authority procedures for *specific industrial buildings. 31/2014. (II. 12.) of the Government.*

In Hungary, when the NECP was finalised, there were 6 licensed renewable electricity communities and 80 licensed aggregators on the market. In addition, there are several settlements in Hungary where land and/or buildings are supplied locally using land heat – and which are not covered by the District Heat Act, through the example of which we further encourage the development of renewable heat communities.

Better use of the potential of the long-term renewable power purchase agreement (renewable PPA) is also needed by assessing regulatory options.

vi. Assessment of the need to build new infrastructure for district heating and cooling from renewable sources

In addition to streamlining existing district heating infrastructure, optimising production capacities and improving systems, the infrastructure needs for district heating from new renewable and alternative sources such as waste heat, geothermal and ambient heat are being assessed. With regard to the already available development needs and infrastructure needs, investment programmes will be launched in the framework of the modernisation of both energy efficiency and district heating production with renewable energy, as well as the development of the infrastructure of district heating supply. In the development plan it is necessary to pay special attention to the technical possibilities, condition and infrastructural supply of the related buildings.

vii. Specific measures to promote the use of energy from biomass, in particular for new biomass mobilisation, taking into account: 1. the availability of biomass, including sustainable biomass: both domestic production and imports from third countries, (2) other biomass uses in other sectors (agriculture, forest-based sectors); and measures for the sustainability of biomass production and use

The **Forest Act** provides and obliges forest owners by[63] law to replace their deforested forests in the required quality and by the required deadline, thereby guaranteeing the sustainability of forests at national level and the continuous provision of their various services.

The criteria[64] laid down in the amended REDIII Directive are basically met by domestic forestry. In addition to the obligation to renovate forests, the legality of logging is based on a system of forest planning and monitoring. Most of the protected natural areas of national importance were declared protected decades ago. Their conservation management plans must be promulgated by law. The forest conservation management requirements laid down in the ministerial decrees containing a conservation management plan must be incorporated into the **district forest plans on which forest management activities are based .** The implementation of the forest plan, including interventions to avoid soil damage, is monitored by the competent forestry and nature conservation authorities. Since the production site is one of the bases for the selection of tree species, during the refurbishment of forests, tree stands corresponding to the production site and capable of adapting to its future change will be established, making best use of it as far as possible, thus ensuring the long-term maintenance of forests and the preservation and improvement of their productive capacity.

The **Social Fuel Programme** provides social biomass fuel support through the local governments of settlements with fewer than 5000 inhabitants, for the local residents applying for it. The type and amount of fuel required, as well as the expected range of beneficiaries, will be determined annually. In addition to the fuel purchase subsidy, local governments provide additional fuel requirements from local sources. The support for the purchase of biomass of HUF 4.5 billion per year concerns at least 150 thousand households.

We will also encourage the use **of efficient biomass boilers for households and businesses through support schemes for the renovation of buildings and heating.** For more information on biomass, see chapter 2.1.2.iv.

[63] *Act XXXVII of 2009 on forests, forest protection and forest management*
[64] *DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance)*

3.1.3. Other elements of the dimension

i. Assessment of national policies and measures affecting the EU Emissions Trading System and their complementarity with and impact on the EU Emissions Trading System

Hungary does not currently apply a national *emissions trading policy or any other measure that complements the EU Emissions Trading System (EU ETS).*

Among the optional elements of the ETS, mechanisms under Article 10c (2013 and 2021-2030) and Article 27a(3) (from 2021) of Directive 2003/87/EC are used.

In addition, as mentioned above, Hungary is also entitled to use the Modernisation Fund. The policy measures to be financed from **the Modernisation Fund are listed in Annex 1 to the NECP.**

ii. Policies and measures to achieve other national targets

Energy **efficiency investments and a shift to cleaner fuel, combined with a shift to cleaner technology, can also lead to** substantial reductions in GHG emissions in industry at a systemic level. Maintaining incentives for energy efficiency company measures (TAO, audit, ECS, desk officer) and switching to electricity-based technology while ensuring renewable energy supply are the primary tools of the latter. Where this is not possible for technical or economic reasons, it may be appropriate to use **carbon capture (CCUS)** or **hydrogen or biogas based technologies.** Suitable solutions also need to be found in hard-to-decarbonise sectors of industry and large emitting **installations, which requires closer cooperation between policy-makers and industry actors**. This can be facilitated by agreements between the parties on climate protection, declarations of intent on technologies and resources, and RDI projects.

iii. Policies and measures to achieve low-emission mobility (including electrification of transport)

We aim to reduce GHG emissions in the transport sector by **increasing the blending rate of biofuels, supporting the uptake of hybrid, electric and hydrogen-powered** means of transport, while encouraging and helping to shift traffic towards low-emission modes of transport. Our measures include different vehicle, powertrain, emission level standards and incentives, procurement obligations, and support schemes for the development of different alternative modes of transport and their infrastructures. The strategic background of the area is significant, which supports long-term traffic management.

The **share of biocomponents in** transport fuels is determined annually and currently stands at 8.4% (6.1% in petrol). We would like to encourage both the use and domestic production of the so-called advanced (second generation) biofuels.

Expectations in the public and municipal sectors – as set out in *Decree 397/2022. (X. 20.) Government Decree* – that at least part of the purchases **should cover energy-efficient and environmentally friendly vehicles.** The provision covers both passenger cars and local urban and suburban buses. Trucks and city buses over 3.5 tonnes covered by the Regulation fall under the category of clean road vehicles, which includes gas-powered, battery-electric, hydrogen-powered and hybrid vehicles. Support for measures to develop alternative fuels infrastructure is **provided through the Alternative Fuel Infrastructure Policy Framework.** As stated *in the Jedlik Ányos 2.0 Plan,* we promote the spread of electric vehicles and the construction of the necessary infrastructure through regulatory, tax policy and financial support instruments. By regulating electromobility services, **we aim to improve the energy efficiency of transport and encourage the uptake of electricity propulsion,** while 'cleaning' the electricity supply.

Another means of rationalising transport energy use **is the development of public transport,** increasing its utilisation rate, increasing the competitiveness of rail transport in freight transport, and developing railway infrastructure. Under the **Green Bus Programme,** around 300 environmentally friendly, electric and hydrogen-powered local buses are expected to be operational by 2025. In addition, more than 2 000 zero-emission buses are planned to be put into operation in the longer term. The aim of the **Green Truck Programme** is to promote the decarbonisation of vehicle traffic related to transport. The planned investments can be supported by KEHOP Plus and RRF funds. Support may be provided for hydrogen production, **the procurement of hydrogen-powered vehicles and the deployment of hydrogen refuelling infrastructure.**

We will establish a targeted state aid scheme to maintain and stimulate domestic rail freight transport, with the aim of connecting small and medium-sized enterprises and large strategic companies to international trade. The essence **of 'single wagon' transport by rail** is that even small quantities of goods, or enough for only one wagon, are transported by rail. The ***Budapest Agglomeration Railway Strategy (BAVS)*** contains the long-term railway development action plan for the period 2021-2040. It aims to maximise the use and efficiency of the rail system in both freight and passenger transport. The development of the railway network can have large-scale urban development, social, economic, environmental, traffic management and operational and organisational effects and can result in significant positive changes in the life of the city and the agglomeration.

In addition to the above, we also support the development of alternative micromobility without energy use. The ***National Cycling Strategy defines*** the objectives, direction and financial background of cycling developments for the period 2023-2030. Its areas of intervention are also aimed at everyday transport, tourism and improving transport safety.

The support schemes and instruments summarised in Chapter 3.1.2 (iii) and included **in Annex 1 to the NECP** also offer funding for the use of renewable energy for transport.

iv. *Planned national policies, roadmaps and measures to phase out energy subsidies, in particular fossil fuel subsidies*

In our funding and support programmes, **support for direct fossil fuel combustion technologies will be phased out** and we will encourage the use of alternative technologies instead of direct fuel combustion in our policies. Intensification and efficiency improvement of combustion plants will be supported, but replacement of combustion plants will no longer be supported. According to the roadmap, from 1 January 2024, no support for economic activities shall be granted for fossil energy generation technology.[65] From 1 January 2025, no financial incentive shall be granted to stand-alone fossil fuel boilers except for the general public. **From 1 January 2026, the development of direct fossil fuel combustion technology in residential buildings shall not be supported.**

Hungary has undertaken to provide a consumer vision in which the flexible, choice-providing supplier side serves the interests of consumers, and in which it is natural for consumers to become low-energy-cost, even self-sufficient, active prosumers, i.e. the aim is **to maintain the results of the legally provided utility cost reduction and to encourage the reduction of utility costs** among further energy consumers.

3.2. Energy efficiency dimension

The planned policies, measures and programmes on energy efficiency, i.e. to achieve the indicative national energy efficiency contributions for 2030 and the other objectives referred to in point 2.2, are set **out in Annex 1 to the NECP,** in particular for the following sub-headings.

i. Energy efficiency obligation schemes and alternative policy measures pursuant to Articles 7a and 7b of Directive 2012/27/EU and to be developed in accordance with Annex II to this Regulation

Hungary has put in place an incentive policy framework to meet its energy efficiency and/or energy savings targets. From 1 January 2021, Hungary introduced ***an Energy Efficiency Obligation Scheme (EECS),*** which aims to result in certified energy savings in domestic final energy consumption, and thus also in primary energy consumption. Instead of self-sufficiency, obligors may choose to pay energy efficiency contributions. The contribution envelope should be used to finance alternative policy measures to improve the energy performance of households or public buildings. The ERA is a policy measure relevant for both industrial processes, transport and the building sector. The savings obligation established for the years 2021 and 2022 was exceeded by the majority of the 833 obligors, only 1.5% of the obligations were not fulfilled.

For the cumulative final energy savings target of 336.3 PJ in 2021-2030, the ECS will contribute 26%. 74% of the target – 248 PJ of cumulative savings – needs to be met by other alternative energy efficiency policy measures. We are examining the possibilities to meet the increased savings target under the new Energy Efficiency Directive, for which we are also reviewing the possibilities for the further development of alternative energy efficiency policies and the EER.

[65] https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:02014R0651-20230701

Hungary plans to support wide-ranging energy efficiency investments in a number of support programmes. According *to the reform undertaken in the Recovery and Resilience Plan,* all partially EU-funded energy efficiency projects **should result in primary energy savings of at least 30%.** From 2024, we will apply this target to all such support, favouring at least a medium-depth level of renovation.

In addition to the EAA, we provide incentives for companies to contribute to increasing energy efficiency by supporting the exploration of energy processes and cost reduction opportunities, such as energy-conscious corporate decision-making, requiring the use of specialist consultants, and providing financial support for energy efficiency improvements (e.g. corporate tax allowance, support schemes).

The ***Long Term Renovation Strategy (LTRS)*** lays the foundations for achieving a sustainable, energy-efficient and cost-effective domestic building stock by 2050. From an energy efficiency point of view, it is of paramount importance that the building stock undergoes deep renovations, including window replacement, insulation and heating modernisation. The modernisation of both residential and public buildings is relevant in the building sector, and the development of other privately owned buildings is supported by measures related to these enterprises. The most important measures of the HTFS for the period 2021-2030 include, among others, *the Home Renovation Support,* the *Factory Rescue Programme* for the industrial sector , *the Modern Cities Programme,* the *Catching-up Settlements Programme, the Hungarian Village Programme,* the dissemination of smart cost sharing, the radiator exchange programme, *the Family Home Creation Benefits* , etc. In addition, the policy framework provides other measures, negative and positive incentives to increase the efficiency of the population and public buildings (e.g. energy certification, measurement, advisory policy). **In addition, we plan to launch further residential energy efficiency programmes**. Thus, in July 2024, the *Home Renovation Programme* was launched, which is expected to reduce primary energy consumption of 20-22,000 family, row and semi-detached houses by at least 30%. From the program, we expect to save 1.5-1.8 PJ of final energy.

9/2023 on the definition of the energy performance of *buildings. The CEM* Decree provides that the **nearly-zero energy building level ('BB') requirement, characterised by a specific primary energy** consumption of 76 kWh/$m^2$and an emission of 20 kg CO_2e/m^2per year, is to apply after 2024 to new buildings and properties[66] undergoing major renovation, which encourages the further expansion of renewable energy production close to consumption. Accordingly, and with a view to streamlining and clarifying energy performance certificates, Government Decree No 176/2008 on the certification of the energy performance of *buildings has been amended. It's* a government order, too. Further

[66] *https://net.jogtar.hu/legal?docid=a0600007.tnm*

development of the latter regulation is being planned in order to define the decarbonisation pathway of a building by acting as a building renovation passport. With the above regulations, a set of requirements based, among other things, on CO_2 emissions has been introduced, which allows for a more flexible and wider range of technology to meet energy requirements than the mandatory renewable share. Simpler, more flexible conditions may even make it more cost-effective to meet requirements that lead to a reduction in energy consumption.

The CAP **helps to improve energy efficiency in agriculture. In order to ensure the efficiency of the final energy use of transport,** domestic policy supports electrification measures and the promotion of the use of public transport (in line with Chapter 3.1.3). The use of electrification, public transport and micromobility solutions is ensured through regulation – positive and negative incentives, as well as obligations – and investment support facilitates the procurement of electric vehicles.

Act No. 122/2015 Coll. on the Implementation of the Energy Efficiency Act Part III of Annex 8 to Government Decree No 159/2011 of 26 May 2011 lists the energy efficiency policy measures for the period 2021-2030:

	A	B
1.	Policy measures	Specific sub-measures
2.	Support from operational programmes and direct support programmes for energy efficiency using funds received to relaunch the economy	Support from operational programmes primarily aimed at energy efficiency (in particular KEHOP (Plus), TOP (Plus), VEKOP, GINOP, VP,)
3.		Support from operational programmes primarily for non-energy efficiency purposes (in particular TOP (Plus), VEKOP, EFOP (Plus), IKOP (Plus), KEHOP (Plus), VP)
4.		Direct support programmes for energy efficiency using funds received to restart the economy (in particular RRF-funded programmes)
5.	National programmes from other energy efficient earmarked resource uses	Quota-based tendering programmes
6.		State Green Bond program revenue-based direct tender programs for energy efficiency
7.		Direct Grant Programmes under EEA and Norwegian Financial Mechanisms
8.		Sectoral development programs (Healthy Budapest Program + Kisfaludy Program)
9.	Other national budget programmes directly supporting national end-use energy savings	Corporate normative tax relief for energy efficiency measures
10.		Integrated results of CSOK Housing Aid and Rural CSOK Development Aid (Primarily Non-Energy Efficiency Programme)
11.		Energy rationalization tender programme for the institutions of the Ministry of Interior
12.		Investments in energy efficiency by fiscal institutions [232/2015. (VIII. (Government Decree No. 20)]
13.		Performing lighting modernization tasks in the member institutions of vocational training centres established and maintained by the minister responsible for vocational education and adult education [239/2019. (X. 16.) Government Decree]
14.		The Shining Smart Institutions Programme [192/2020. [Government Decree No 27/2011 of 8 May 2011]
15.		Other individual support decisions laid down in government decisions
16.		Energy efficiency improvements realised from the savings of the home saving system
17.		Home renovation support
18.		Factory Rescue Program
19.		Automotive Supplier Development Program

	A	B
20.		Competitiveness Support Programme
21.	System of local government-focused energy efficiency improvement measures	Energy efficiency improvement measures with budget support under the Modern Cities Programme
22.		Energy efficiency elements of the Hungarian Village Programme: 1. Building energy developments 2. Developments in transport 3. Awareness-raising
23.		Energy efficiency elements of the long-term programme of catching-up municipalities
24.		Self-sufficient energy efficiency measures by municipalities
25.		New energy efficiency improvement programmes for municipalities to relaunch the economy
26.	VET funds and other market development measures, market regulation	Green Loan Equity Program
27.	Central measures to improve energy efficiency in transport	Improvement of energy efficiency of complex transport development programmes (maintenance of toll systems, establishment of access zones, parking zones, development of railway network, development of cycling facilities, dissemination of eco-driving, speed reduction on expressways, shaping the accounting of car use, development of intelligent transport systems)
28.		State aid for the development of public transport
29.		Promotion of electromobility (Jedlik Ányos Plan) and implementation of Hungary's new bus strategy concept and the Green Bus Programme
30.	Information and motivation measures for counselling and professional skills development	Mandatory use of an energy policy officer
31.		Obligation to install a submeter
32.		National Energy Network - Promoting energy-efficient use of public buildings
33.		Advisory activities provided by the Hungarian Chamber of Engineers in the residential and small and medium-sized enterprises sector
34.	Complex market developments	Complex market development measures by strengthening the energy efficiency market (e.g. innovation aid)

Energy efficiency targets **reinforce the impact of policy measures in all other dimensions, so energy efficiency measures play** an important role in achieving related e.g. direct GHG emission reduction standards.

ii. Long-term renovation strategies to support the renovation of the national stock of residential and non-residential buildings,[67] both public and private, including policies and measures to encourage cost-effective deep renovations for the worst performing segments of the national building stock, in accordance with Article 2a of Directive 2010/31/EU

The ***Long-term Renovation Strategy*** adopted in 2021 laid the foundations for achieving a sustainable, energy-efficient and cost-effective domestic building stock by 2050. The strategy, which includes thirty-five policy measures, aims to achieve a 20% saving in the energy use of the domestic residential building stock by 2030, a 60% reduction in the CO2 emissions related to the energy use of buildings by 2040, from the average level in 2018-2020, and a 90% share of nearly zero-energy buildings by 2050.

Its objectives will be achieved through energy efficiency, value, comfort and health improvement measures, renewable energy utilisation and the use of smart technologies, which will reduce primary energy consumption and CO2emissions at national level. Among the categories of buildings considered, including public buildings, multi-apartment buildings and single-family houses, single-family houses offer the greatest potential for energy savings. Buildings accounted for 49% of final electricity consumption and 63% of district heating in 2021. Nearly three quarters of household final energy consumption in Hungary is spent on heating. The average energy performance of the domestic housing stock falls into the 'FF' category. Around 2.6 million residential properties require some degree of energy modernisation, and the necessary measures to achieve this can be found under the previous point.

At **the same time, the update of the HTFS** has become timely, which we plan to implement by 2025, as our building stock targets also need to be updated. From 2025, the HTFS will be replaced, as a result of its revision, **by the so-called National Building Renovation Plan,** which provides **higher ambition for the building stock but** also flexibility taking into account national specificities.

iii. Description of policies and measures to promote energy efficiency services in the public sector and measures to remove regulatory and non-regulatory barriers that hamper the use of energy performance contracting and other energy efficiency service models[68]

The **energy consumption of public buildings** accounts for nearly 10% of the energy consumption of the domestic building stock. The building stock of around 12 550 public bodies has a significant energy saving potential – around 10% over 5 years. The revised *Energy Efficiency Directive* requires an annual public sector savings obligation of 1.9% and an annual renovation of at least 3% of the total floor area of heated and/or cooled buildings owned by public bodies to transform them **into nearly zero-energy or zero-emission**

[67] *In accordance with Article 2a of Directive 2010/31/EU.*
[68] *In accordance with Article 18 of Directive 2012/27/EU.*

buildings. Deep renovation projects and the widespread use of renewable energy sources can contribute to exploiting the energy saving potential of public buildings.

In order to fulfil the obligations and **to exploit the energy saving potential of the operation of public buildings, the leaders of public institutions are required by law to** shape the energy efficiency attitude of those working in the building. The energy efficiency measures of public bodies are also supported by the *National Energy Network.* The Ministerial Decree on the determination of the energy performance of buildings and the Government Decree on the certification of the energy performance of buildings can further assist in the planning and assessment of renovations. The benefits for the entire building stock, including the public building stock, are explained in Chapter 3.2.i. The total amount of support planned for the energy efficiency development of public buildings in the Recovery and Resilience Plan, as well as in the KEHOP Plus and TOP Plus is more than HUF 420 billion (see also 3.2.viii.)

iv. Other planned policies, measures and programmes to achieve the indicative national energy efficiency contributions for 2030 and other objectives referred to in point 2.2 (such as measures promoting the exemplary role of public bodies, energy efficient public procurement, measures promoting energy audits and energy management systems,[69] consumer information and training measures[70] and other measures promoting energy efficiency[71])

In addition to the modernisation of the building stock – public, private, residential and non-residential buildings, energy efficiency improvements in passenger and freight transport, private transport and agriculture, and corporate energy efficiency programmes, more incentives and additional measures are needed to strengthen the implementation and/or impact of the above measures.

Mandatory reviews have been required for the **building stock,** and support programmes have been launched and are being launched for the population in order to develop smart metering and cost-sharing. The retail tariff system has been amended. In **the transport sector,** electrification measures are supported by the development of electric charging infrastructure and an awareness-raising programme.

We place special emphasis on **education, counselling and awareness-raising.** Our most important measures include the National Energy Network, which provides free energy advisory services to public institutions, and the free energy advisory services of the Hungarian Chamber of Engineers to the general public and small and medium-sized enterprises, with the obligation for companies to use energy consultants.

[69] *In accordance with Article 8 of Directive 2012/27/EU.*
[70] *In accordance with Articles 12 and 17 of Directive 2012/27/EU.*
[71] *In accordance with Article 19 of Directive 2012/27/EU.*

Incentives for companies to contribute to increasing energy efficiency are provided by further supporting **the exploration of energy processes and cost reduction opportunities, in addition to the ERA and the consultant,** e.g. auditing, implementing an energy management system (ISO 50001) and obliging and incentivising energy metering.

We **have launched and plan to launch further programmes supporting energy efficiency,** which will also support SMEs and energy-intensive businesses in a volatile price environment. Its most important actions for the period 2021-2030 include, among others, the Factory Rescue Programme for the industrial sector, the Energy Cost and Investment Support Programme for SMEs and the Hungarian Village Programme. We develop a programme for district heating providers to develop energy-efficient networks. With regard to the economic sector, sustainable and climate-friendly energy management is a priority objective, which is facilitated by the domestic industrial strategy, in addition to preserving and further expanding industrial performance.

Hungary joined the Energy Efficiency Financing Coalition in December 2023.[72] Through our funding programmes, we encourage the use **of ESCO-type financing solutions** that simplify and expand access to financial resources in the residential and public building stock, as well as in the corporate sector (to develop energy production capacities supporting product production). In addition, the services provided by ESCO can increase the share and volume of economically sustainable investments, unify the quality of construction and contribute to an acceptable price level for the demand side. The source of the return on the construction is the surplus funds generated from energy savings or the flat-rate service fee paid by the client. In one case we are talking about the Energy Performance Contracting (EPC)[73] model, while in the other case we are talking about the Shared Savings Contracting (SSC)[74] model. Both models are capable of meeting not only the modernisation but also the energy savings needs and guaranteeing the design and delivery of economically sustainable investments. In addition to the above, the EPC model also commits to the realisation of the savings ratio previously assessed and then specified in the savings contract. ESCO funding can also leverage resources from more favourable financial funds than banks. We are examining the introduction of regulatory measures to support ESCO schemes.

v. Description of policies and measures to promote the role of citizen energy communities in contributing to the implementation of the policies and measures in points (i), (ii), (iii) and (iv) above

In recent years, six renewable electricity communities have been registered by the MEKH in Hungary. The expansion of local electricity and heat communities (explained in Chapter 3.1.2.v.) is encouraged by regulatory changes, as energy communities can ensure the return of

[72] *Energy Efficiency Financing Coalition*

[73] *Energy Efficiency Contract*

[74] *Participation agreement*

their own generation systems through their energy saving activities and increase their competitiveness in the long term. Legislation on energy communities is planned to be streamlined by 2030 to make efficient use of renewable energy as well as energy consumption.

vi. Description of measures to exploit the energy efficiency potential of gas and electricity infrastructure[75]

The issue of the utilization of gas pipelines and, in this context, the evolution of network access tariffs is also relevant at the level of the distribution network. Our goal is 1772/2018. *(XII. 21.) and*[76] the examination of the exit of distribution lines with a low utilisation rate (below 10%) from the public funded system, and the exploration of alternative utilization possibilities of these lines.

In the electricity sector, we aim to develop flexible tariff package offers that encourage consumers to make better use of the network. However, smart metering devices are essential for the application of different tariff packages. As a result, conventional meters can only be replaced by smart meters when their validity expires, provided that certain conditions are met to cover the entire consumer population.

vii. Regional cooperation in this area

Based on the *Connecting Europe Facility*, regional cooperation is essential in relation to complementary elements that also support energy efficiency measures. The development of recharging infrastructure in the transport sector requires consideration of the trans-European transport network and the development of appropriate recharging points along the network for 60 km, which is also affected by the infrastructure of neighbouring countries. The same applies to developments in the use of trans-national energy networks (development elements 3.4.1 and 3.4.2). As a result of regional cooperation, our funding programmes will develop action plans to support the proper use of the infrastructures of the Trans-European transport and energy networks.

viii. Financing measures taken at national level in this area, including Union support and the use of Union funds

From TOP Plus, KEHOP Plus and RRF sources, a total of nearly HUF 1,000 billion in support is available until 2030 for energy efficiency improvements in households, public buildings and companies. Spending these funds until 2030 is an ambitious target, as the volume of investment mobilised will be higher, the construction capacities are finite, and building energy investments are typically concentrated in the spring-summer period due to the temporary loss of function due to renovations (heat retention).

[75] *In accordance with Article 15(2) of Directive 2012/27/EU.*
[76] *Government Decree No 1772/2018. (XII. 21.) on decisions establishing the new National Energy Strategy*

19Table - Financial resources available in the field of energy efficiency

Source	Beneficiaries	Aid amount (HUF billion)	Form of aid
RRF	Population	224	combined credit
	Public buildings	103	non-refundable
	Companies	175	Preferential loan
KEHOP Plus	Population	133	combined credit
	Public buildings	103	non-refundable
	Companies	51	Preferential loan
TOP Plus	Public buildings	208	non-refundable
Total:		997	

In addition, Hungary also has at its disposal the revenues generated by Member States in the context of the auctioning of EU ETS quotas, the revenues of which, according to the previous rules, should be used for at least 50% greening purposes, which will be 100% from 2024. Greening includes, among others, measures to improve energy efficiency, district heating systems and insulation, or to provide financial support to address the social aspects of low- and middle-income households.

In addition, we are counting on the resources of the new *Social Climate Fund* operating between 2026 and 2032, of which Hungary participates by 4.33%, in an amount of approximately EUR 2.816 billion. In order to draw down the source, *a Social Climate Plan* must be drawn up, the preparation of which will begin. Eligible measures shall cover, inter alia, energy efficiency improvements in buildings, renovation of buildings, decarbonisation of heating and cooling of buildings, promotion of the uptake of zero- and low-emission mobility and transport, and direct income support. (For more information, see chapter 3.4.4.)

In addition, pursuant to Section 15/E(2) of Act LVII of 2015 on energy efficiency, revenues from the energy efficiency levy are to be used to finance alternative policy measures to improve the energy efficiency of households or public buildings to be supported.

3.3. Energy security dimension[77]

In order to reduce energy import exposure, Hungary's measures are set out **in Annex 1 to the NECP.** Measures under other dimensions reinforce each other to reduce import exposure. Security of supply is positively impacted by measures ensuring the development and expansion of existing infrastructures and the development of new alternative infrastructures, as well as the reduction of consumption and, primarily, the supply of alternative foreign resources where this is not possible.

[77] *Policies and measures should reflect the energy efficiency first principle.*

i. Policies and measures related to the elements set out in point 2.3[78]

In many cases, the supply of Hungary's current user assets is based on fossil fuels. We ensure the security of energy supply of these equipments, and thus of the different sectors, beyond the diversification of fossil energy sources' routes and sources, as well as the creation of safety reserves, by improving the efficiency of supply, while at the same time encouraging the spread of alternative equipments and supporting the construction of related infrastructures.

Petroleum and natural gas market

Domestic oil exposure can be ensured by increasing domestic oil production, building the new Serbian-Hungarian oil pipeline and increasing the capacity of the Croatian-Hungarian oil pipeline, while increasing the flexibility of oil refining capacities in relation to raw materials. With regard to increasing the flexibility of the Danube Refinery (conversion), the target to be achieved is the ability to process 100% of non-Russian crude oil.

It is also essential to **maintain strategic stockholding and to maintain the level of the security of oil supply system based on it.** In addition to diversification and stockholding, exposure to petroleum products can be supported in the future by the uptake of alternative transport fuels, alternative transport infrastructures and means, mainly due to the scale of use, and the development of alternatives to agricultural machinery. Domestic **petroleum exposure also results in regional exposure** in view of Hungary’s regional petroleum product supply function. That is why we need to pay close attention to the security of oil supply.

Reducing **natural gas consumption by increasing energy efficiency and the use of renewables (Chapters 3.1 and 3.2) and increasing domestic production where possible are means of reducing natural gas** exposure. The remaining import demand **should be provided from as diversified a source and route** as possible, reducing the risks of dependency on one source and partner. To this end, the development of the internal energy market (Chapters 3.4.2 and 3.4.3) is necessary. We plan **to further expand cross-border capacities,** which are capable of transporting several types of alternative gas. Further **guaranteeing the predictability of the concession system and improving the flexibility of the system provide an appropriate basis for increasing the volume of** domestic natural gas production. In order to strengthen domestic production, **new hydrocarbon concession areas are expected to be announced** already in 2024.

In 2022, the ENTSO-G Ten-Year Network Development Plan (TYNDP) already refers to the existing natural gas transmission system as ‘methane’, underlining the expected changing gas composition and decreasing share of natural gas. Hungary also sees biogas and

[78] Consistency should be ensured with the preventive action plans and emergency plans provided for in Regulation (EU) 2017/1938 of the European Parliament and of the Council of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010 (OJ L 280, 28.10.2017, p. 1) and with the preparedness plans provided for in Regulation (EU) 2018/... [as proposed by COM(2016) 862] on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC.

biomethane, as well as ‘clean’ **hydrogen**relays and derivatives, as alternatives to a ‘classical fossil’ gas supply. The composition of the gases in the gas system will gradually change in the future due to alternative and renewable resources injected into the grid. In addition to renewable gases, we also rely on domestic geothermal assets to replace natural gas, primarily in the heating and cooling sector.

The remaining import needs should be provided from as diversified sources as possible, reducing dependency on one source. Hungary, in cooperation with the states of the region, is actively looking for ways to reduce dependence on the Russian supplier in the foreseeable future. This requires new sources of independent gas imports and the development of infrastructure to access them. In order to create a diversified import portfolio, **it is necessary to continue the gas market diversification policy in order to access liquefied natural gas sources from Azerbaijan, the Black Sea and other areas.**

The **use of the high-pressure natural gas transmission system for transit purposes** is also possible to increase the utilisation of the infrastructure, in addition to reducing natural gas consumption. This can be facilitated by significant domestic natural gas storage capacities also at regional level. **It is therefore necessary to strengthen competition in the gas storage market and the regional role of domestic facilities.** The **strategic concepts related to natural gas storage facilities in Hungary serve to guarantee the security of supply in Hungary in the short** term, and in the longer term to adapt the former east-west transport routes to the south-north-west shift. The expansion of cross-border capacities, including the supply of alternative LNG sources and the availability of storage facilities, ensures the security of gas supply and maintains the competitiveness of the pipeline system. If the planned Slovenian-Hungarian pipeline were to be built, storage facilities would be available for Western European traders via a direct route.

Electricity market

To achieve the electricity market vision, security of supply can be ensured through capacity adequacy and reduced import dependency. In addition to the increasing electricity demand resulting primarily from electrification, **there is a need for the integration of reliable, flexible and diversified domestic electricity generation capacities** and their adequate availability. In the longer term, **renewable technologies** (Chapter 3.1.2) and **advanced nuclear technology** (Chapter 3.1.1) provide the necessary capacities for decarbonisation, while, during the transition, the **use of natural gas-based technologies** is necessary to ensure a continuous and predictable energy supply. To this end, and in view of the coal phase-out and the ageing power plant portfolio and the maintenance of controllable capacities, it is necessary to put into operation a CCGT capacity of up to 1.65 GW. In the period of technological change, security of supply can be ensured by maintaining reserve capacities, i.e. those that can contribute to domestic electricity production, e.g. during peak demand winter days, or if the availability of imports is limited due to technical reasons. Thus, with the phasing out of lignite-based electricity generation capacities, the more modern units of the Mátra Power Plant will be placed in a strategic reserve. New types of flexibility services, DSR solutions and energy storage also ensure further improvement of the system's flexibility capability.

Further expansion of cross-border capacities and strengthening regional electricity market integration, as well as the coordination of the functioning of gas and electricity markets, are both security of supply and competitive market issues. (Chapter 3.4) The infrastructure supporting the integration of renewables and the regulatory and market environment ensuring it are being developed continuously, and in some cases the planned measures have already been implemented. In order to ensure that the connection of renewable generators to the grid is not hampered by other blocked capacity bookings, transparency in the allocation of grid connection capacities should be **increased.** It is necessary to better target the network connection procedure in line with current needs (based on the NECP). Substantive consideration should be given to the extent to which the current system tariff (RHD) regulation prevents the uptake of energy storage technologies and what steps can help overcome this obstacle, or to the extent to which a favourable regulatory structure can stimulate the uptake of storage technologies.

Preparing the grid is essential for the expansion of decentralised energy production. Renewable generation is decentralized, often connected to low- or medium-voltage distribution networks. Therefore, **a prerequisite for the rapid growth of renewable penetration is the preparation of the transmission and distribution grid to address the challenges posed by a** decentralised and highly weather-dependent production structure. Increasing the share of renewables can only be achieved in parallel with the development and 'skilling' of transmission and distribution networks **and the development of distribution plant management as a decentralised intervention capability and its transparent market mechanisms** (distribution flexibility market).

<u>Coal market</u>

The key to achieving carbon phase-out is the implementation of a decarbonisation strategy and action plan at regional level, the reorganisation of the area within the framework of the Just Transition Programme, with the involvement of stakeholders. Transforming the capacity of the Mátra Power Plant based on sustainable systems is an issue of strategic importance, and technological change is a major step forward in improving air quality and reducing CO2 emissions (Chapter 3.1.1).

The following parts of the project need to be implemented in order to guarantee the security of supply of the sectoral and regional decarbonisation transition:

1) The Mátra power plant has had a serious socio-economic impact within its narrower area, including the creation and maintenance of jobs, indirect job creation in related enterprises or local tax revenues. Against this background, the revitalisation should pay particular attention to the diversification of the region's economy and labour market

and to a just transition, exploiting the potential of the site's further exploitability and the plant's value chain.

2) A significant proportion of households affected by lignite-based heating in the country live in the Mátra Power Plant region. During the transition, our goal is to provide adequate heating solutions by phasing out lignite and reducing energy consumption.
3) The large-scale site of the Mátra Power Plant may be suitable for multi-purpose utilization beyond the energy functions. These include the expansion and diversification of the industrial park, the expansion of agricultural or other storage and logistics functions, the preservation and presentation of mining cultural heritage, habitat reconstruction for tourism and nature conservation purposes or natural water conservation measures.

Planned investment elements:[79]

- a 500 MW combined cycle gas-fired power plant,
- two solar power plants with a total capacity of 200 MW in the recultivated area of the lignite mines,
- and preparation for the construction of a small mixed-fired power plant.

MVM (owner) approved the long-term development programme of Mátra Power Plant in December 2020. The aim of modernization is to bring all new production units into operation within this decade. During the process and future operation, MVM pays special attention to the further training and employment of employees at the company. At the same time, we also want to ensure that the **possibility of lignite-based production remains available as a strategic reserve, given the significant domestic lignite** assets.

Coal is an important resource of the country, which **we intend to utilize in the future, taking into account sustainability,** and the possibility of using clean coal technology should be examined, also taking into account the economics of raw material supply.

Nuclear safety

According to Act CXVI of 1996 on atomic energy, the use of atomic energy may only take place in possession of the licences specified in the legislation and under continuous official supervision. Safe operation is ensured by multi-layered regulation and multi-stage, complex, interchangeable, complementary systems and operating mechanisms in order to ensure that the use of nuclear energy does not have a detrimental effect on the population. Security is guaranteed by security solutions, technologies and regulations for the physical protection of nuclear facilities, radioactive waste repositories, nuclear and other radioactive materials.

The **construction of new nuclear units is also possible under strict conditions.** A complex, multidisciplinary facility such as a nuclear power plant is licensed and supervised

[79] *https://mert.mvm.hu/en-GB/Media/Hirek/Zold%20jelzest%20received%20a%20matrai%20eromu%20atalakitasa*

by several authorities. Each authority issues the necessary permits in its own licensing procedures and, as a specialist authority, validates its own professional aspects in the procedures of other authorities. The ***Hungarian Atomic Energy Authority (HAEA) is responsible for the nuclear*** safety, security and safeguards licensing of the construction and ***operation of*** the nuclear power plant. Installation-level procedures follow the life cycle of a nuclear installation. Accordingly, the appropriateness of the site must be assessed before the substantial part of the investment starts, the technical plans and safety analyses of the nuclear power plant must be fully developed, reviewed by the authority and, if appropriate, the construction permit issued. The installed installation shall be put into operation, consisting, inter alia, of a functional test of the installed systems and loading and test operation at nominal capacity. If the test operation fully demonstrates that all equipment and processes are operating in accordance with nuclear safety requirements, safety analyses and designs, the licence holder may apply to the authority for a block-by-block operating licence. The HAEA verifies the operation according to the nuclear safety requirements and the issued licences in the framework of inspections. If a discrepancy is detected, it enforces the requirements through a validation procedure.

The fact that Hungary is also a party to **a number of bilateral and multilateral international treaties in the field of the safe use of nuclear energy also contributes to** ensuring nuclear safety. More information is available on the HAEA website.[80] It is also important to mention the **strategy to ensure the long-term supply of nuclear materials and fuels,** in particular with regard to the expansion of nuclear capacity.

Government Decree *44/2002. on the minimum amount of energy carrier stock in power plants with a capacity of 50 MW or more and the rules of stockpiling (XII. Section* 1(1) [81] of the Decree of the Minister for Economy and Transport stipulates that the holder of a producer's operating licence for a power plant with a nominal capacity of 50 MW or more **must constitute a stock of normative and safety energy carriers** per power plant.

- According to paragraph 2(c), the amount of normative stock of energy carriers at the nuclear power plant on 1 February of the calendar year shall be at least the amount of fuel required for the annual average electricity and combined heat production of the nuclear power plant.
- According to paragraph (3)(c), the amount of safety energy carrier stock at a nuclear power plant is the amount of fuel that, together with – the fuel in the normative stock, provides at – least two years of average electricity and combined heat production on 1 February of the calendar year.

[80] *https://www.haea.gov.hu/web/v3/OAHPortal.nsf/web?openagent&menu=04&submenu=4_8*
[81] *Former Ministry of Economy and Transport*

Act II of 2014 promulgated the Agreement on Cooperation in the Peaceful Uses of Nuclear Energy between the Government of Hungary and the Government of the Russian Federation (hereinafter: Hungarian-Russian agreement), which includes the obligations related to the maintenance of the performance of the Paks Nuclear Power Plant and the expansion of capacity, i.e. the construction of new units. The Hungarian-Russian agreement is accompanied by several implementing agreements, including the fuel contract, in which the *Euratom Supply Agency is* co-signatory, and the implementing rules are laid down in the HAEA Decree.

At the same time, the Russo-Ukrainian war accelerated **diversification efforts for nuclear fuel.** In Hungary, the legislation in force provides for the possibility in principle of using a different fuel in a nuclear power plant. In addition, a cooperation agreement has been concluded with France for the provision of an alternative fuel supply.

Digitalisation and Cybersecurity

The operation of the electricity system is already deeply permeated by various digital solutions and applications. With our measures, we intend to increase the level of digitalisation in all subsectors of the electricity system, as well as the spread of data-based operation and the availability of public network data to other energy actors.

In close connection with digitalisation, cybersecurity has become one of the most important elements of national security, so raising the overall level of cybersecurity to the highest possible level is now one of the conditions for preserving our sovereignty. The *EU NIS Directive also highlights*[82]*the* energy sector in ensuring a high common level of security of network and information systems. The Hungarian energy sector must also be ready to address challenges, threats and risks in cyberspace, to guarantee an adequate level of cybersecurity, to perform cyber defence tasks, to develop cyber resilience and to ensure the smooth functioning of the national critical information infrastructure. Our task is to strengthen the protection of electronic IT systems, national critical information infrastructure, classified information and national data assets.

Currently, significant entities involved in the Hungarian electricity system do not fall within the[83]scope *of Act CLXVI of 2012 on the identification, designation and protection of vital systems and facilities, i.e.* they have not been designated as ‘vital system components’. As ‘essential service providers’ are designated in the process of designating national critical components from among the operators of the designated national critical components, the

[82] *Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union*

[83] *Act CLXVI of 2012 on the identification, designation and protection of vital systems and facilities (https://net.jogtar.hu/jogaly?docid=A1200166.TV)*

requirements[84] of the *NIS Directive*on the security of network and information systems do not apply to significant entities involved in the electricity system either. In view of the above, the **legislative environment related to the protection of vital systems and facilities in the domestic energy sector needs to be adapted** in such a way that the thresholds allow for the designation of major entities as vital system elements. Furthermore, the designation of operators of essential services should follow a separate procedure from the procedure for the designation of national essential components. In cooperation with the relevant professional organisations, it is necessary to draw up a **set of sectoral cybersecurity requirements** specifically designed for organisations operating in the electricity industry, in accordance with Act L of *2013 and Government Decree No 41/2015. With the requirements*[85] described in the Decree of the Minister for the Interior – also taking into account that certain provisions of the Decree cannot be interpreted or applied in the case of ICS and SCADA systems used in the electricity industry, due to the operational/use characteristics of these systems. The strategic objective is to continuously improve preventive, sensory and responsiveness by defining a set of requirements, **organising targeted exercises and creating support tools .**

Information sharing between the major organisations involved in the energy sector should be made more effective at both domestic and international level. We intend to start **the regular exchange of information between the major players involved in the Hungarian energy sector (energy producers, suppliers, system operators) with government coordination** in order to ensure the safe and uninterrupted operation of energy systems. This should include the development of possibilities for **automated sharing of** relevant electricity-related cybersecurity information. A **rapid reaction unit should be set up to deal with cybersecurity incidents** and provide on-site support to individual actors in case of incidents. Their tasks include tracking, threat analysis, network security monitoring, incident management, analysis of various attacker tools and methods. Settings that meet the minimum safety requirements set out in the legislation are a priority. To improve the cybersecurity situation, we consider the most important measure to be the continuous provision of cybersecurity operational activities **with trained and experienced professionals.**

Improving the labour market situation in the energy sector

Economic structural changes towards lower carbon intensity energy production and use can bring significant changes in employment needs and opportunities beyond the energy sector. It is therefore necessary to **develop programmes to meet the human needs of the green economy,** which provide opportunities to monitor labour market developments in the energy transition, help to improve the employability of the workforce in the green economy

DIRECTIVE (EU) 2016/1148 OF84 THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 6 July 2016 concerning measures for a high common level of security of network and information systems across the Union (https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:32016L1148&from=EN)

sectors and provide support for the upskilling and reskilling of the vulnerable workforce. (Chapter 3.5) Two significant measures can be linked to this goal, the *priority of the KEHOP Plus Just Transition,* which was created primarily to catch up regions adversely affected by coal phase-out, *and the RRP investment 'Strengthening* the human resources of the green economy', which aims to develop targeted upskilling opportunities focusing on valuable green skills in the labour market.

ii. Regional cooperation in this area

The forums of regional consultations on domestic energy supply (Chapter 3.4) are also suitable for discussing issues related to security of supply. Those responsible for public organisations, domestic energy companies, including system operators, and the Hungarian regulatory authority (MEKH) participate in a number of organisations and working groups, thereby strengthening domestic security of supply.

Natural gas market

- European Commission, Gas Coordination Group (GCG)

As a result *of the EU Security of Gas Supply Regulation (994/2010)*, the *GCG* has been meeting regularly since 2012 to coordinate security of gas supply measures between EU countries. Hungarian participation in the meetings is regular.

- European Network of Transmission System Operators for Gas (ENTSO-G)

FGSZ participates in the work of ENTSO-G as transmission system operator, representing the interests of Hungary. The company actively participates in ENTSO-G projects that directly affect its activities, such as the development of single European network codes and the compilation and annual update of the 10-year development plan defined by the legal requirements.

- Gas Infrastructure Europe (GIE)

The EIG is a Brussels-based non-profit organisation representing gas infrastructure operators from 25 countries, including transmission systems, storage facilities and LNG terminal operators, towards the institutions of the European Union (European Commission, European Parliament, Council of the European Union) and the European regulatory bodies (ACER, CEER[86]). MMBF Hungarian Gas Storage Ltd. is also a member from Hungary. The Hungarian Gas Storage Ltd. chairs the storage organisation of Gas Infrastructure Europe (GIE), so the Hungarian participation in the implementation of the EU decarbonisation efforts affecting the storage market is extremely active, keeping in mind the advantages offered by the current natural gas infrastructure.

- Interconnection between Hungary and Slovenia

[86] *CEER: Council of European Energy Regulators*

Of the neighbouring countries, only Slovenia has not yet completed the natural gas connection, but progress was also made in 2023. On 4 October 2023, Hungary and Slovenia signed a Memorandum of Understanding to build a cross-border pipeline connecting the Hungarian-Slovenian natural gas system. If commissioned, the new pipeline would allow gas to be transported along the Italian-Slovenian-Hungarian gas corridor, thus increasing regional energy security and providing Hungary with another diversification opportunity.

Petroleum market

- Participate in the *work of the European Commission's*Oil Coordination Group (OCG).
- Participate *in the Emergency Mechanism of the International Energy Agency,*including SEQ (Standing Group on Emergency Questions).

Electricity market

- Electricity Coordination Working Group (ECG)
- System Operator (MAVIR ZRt.) participation in various organizations and forums:

On the basis of the Electricity Act and the operating licence issued by the regulatory authority, MAVIR ZRt. has the right and obligation to represent the Hungarian position in international system operator organisations, to continuously coordinate cooperation, to pursue Hungarian interests, and to participate in the work of the management bodies and working groups of each organisation.

MAVIR ZRt. participates in the work of several international organizations and forums. The most important ones are:

- *European Network of Transmission System Operators for Electricity (ENTSO-E)*,
- Cooperation between the 8 system operators of Central and Eastern Europe (CEE),
- cooperation between the system operators of the Southeast Europe or Southeastern Europe (SEE) region,
- TSC - TSO System Security Cooperation,
- *EURELECTRIC* (Organisation for the Cooperation of Electricity Companies in Europe),
- *International Council* on Large Electric Systems (CIGRE).
- At its last meeting in March 2024, the Electricity Cross-border Committee (ECBC) tried to refocus the CACM 2.0 review process, which was interrupted two years ago, on the tasks of cross-border capacity allocation mechanisms, NEMOs (including the Hungarian HUPX).

Cooperation in nuclear matters[87]:

Pursuant to Act CXVI of 1996 on Atomic Energy, the Hungarian Atomic Energy Authority (HAEA):

- cooperate with the International Atomic Energy Agency, the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development, the European Atomic Energy Community and other international and regional intergovernmental organisations active in the peaceful uses of nuclear energy,
- perform tasks for the domestic implementation of intergovernmental agreements in the field of the safe use of nuclear energy,
- ensure compliance with the international obligations assigned to it concerning the safe use of nuclear energy in relation to nuclear safety, the safe management of radioactive waste and spent fuel, nuclear emergency response, nuclear security, non-proliferation of nuclear weapons and liability for nuclear damage,
- prepare national reports to be complied with under international and European Union obligations relating to nuclear safety and the safe management and shipment of radioactive waste and spent fuel.
- As a result of its international activities, Hungary actively participates in all important multilateral international treaties related to the peaceful use of nuclear energy and fully implements their provisions. The HAEA's representatives also play an active role in universal and regional international organisations established on the basis of international treaties on the safety and security of the use of nuclear energy, in organisations[88] and fora established for the implementation of[89] multilateral international treaties, and in other forms of international cooperation.[90]
- Hungary's import exposure is also high in terms of **nuclear fuel,** and the fuel supply of the Paks Nuclear Power Plant is fully ensured by the nuclear fuel of the Russian TVEL company. Due to technological and technical constraints, there is currently no alternative fuel on the market, however, the American Westinghouse and the French Framatome are also working on the development of an alternative fuel for a VVR440 type nuclear reactor. These companies were contacted by Hungary (an agreement with Framatome was signed by the Minister of Energy in September 2023).

[87] *https://www.haea.gov.hu/web/v3/OAHPortal.nsf/web?openagent&menu=02&submenu=2_7*
[88] *Nuclear Suppliers Group, Zangger Committee*
[89] *International Atomic Energy Agency, Nuclear Energy Agency of the Organisation for Economic Cooperation and Development, European Atomic Energy Community, Comprehensive Nuclear-Test-Ban Treaty*
[90] *Western European Nuclear Regulators Association, European Safeguards Research and Development Association, European Nuclear Security Competent Authorities Association, European Radiation Protection Authorities Leaders Meeting, WWER Regulatory Forum, Association of Competent Authorities for the Safe and Sustainable Transport of Radioactive Materials*

Other cooperation

- Participation of a regulatory authority in ACER's activities.
- Regional consultation during the planning and finalisation of the NECP. This is explained in more detail in Chapter 1.4.

iii. Financing measures taken at national level in this area, including Union support and the use of Union funds

Network development projects have a significant cross-border impact. Hungary is committed to significant investments in the development of the electricity grid, which are essential to facilitate the expansion of renewable energy sources. Up to 2030, nearly HUF 800 billion of RRF and cohesion funds will be available for this development goal. It is also necessary to examine the potential for regional development in the area of additional energy infrastructure – gas, oil, etc. For PCI projects, information is provided in Chapter 3.4.2(iii).

Financing measures related to security of supply are included in the relevant chapters of the additional dimensions.

3.4. Internal energy market dimension[91]

A significant number of measures to increase security of supply can essentially be identified as measures to strengthen the internal energy market. In addition to the above, measures more closely related to the issue are presented in this chapter.

3.4.1. Electricityinterconnections

i. Policies and measures to achieve the target level of connectivity set out in point (d) of Article 4

In the area of electricity interconnections, Hungary plans to further increase the level of cross-border **interconnections by 48%, in particular by increasing Serbian-Hungarian cross-border capacity, developing Slovak-Hungarian (PCI) and Romanian-Hungarian (PCI) cross-borders,** which have an impact on both security of supply (Chapter 3.3) and the internal energy market.

Hungary is connected to all neighbouring countries after the Slovenian-Hungarian cross-border pipeline was handed over at the end of 2022. The expansion of capacity in the Slovak direction in April 2021 facilitated the import of electricity at lower prices, as prices on the Hungarian electricity exchange (HUPX) decreased, while the spread against the Slovak and German wholesale prices also decreased. This confirms that system integration and the widening of the electricity competitive market in Europe (European market coupling) provide a significant advantage to Hungary. For this reason, among other things, further plans include the expansion of the Serbian-Hungarian border fence capacity.

[91] *Policies and measures should reflect the energy efficiency first principle.*

ii. Regional cooperation in this area[92]

There is continuous communication between the system operators and there is typically good cooperation during the implementation of the projects, especially in the case of the Slovak-Hungarian electricity system managers (MAVIR ZRt. and SEPS[93]). Further information can be found in the chapter on security of supply. (Chapter 3.3)

iii. Financing measures taken at national level in this area, including Union support and the use of Union funds

The following chapters provide information on measures to further expand the related electricity interconnections.

3.4.2. Energy transmission and distribution network infrastructure

i. Policies and measures related to the elements set out in point 2.4.2, including specific measures to enable the completion of projects of common interest and other key infrastructure projects

Petroleum infrastructure

The capacity expansion of the Adriatic (HR-HU) oil pipeline and the construction of a new Serbian-Hungarian oil pipeline are essential to ensure the security of oil supply.

Natural gas infrastructure / Methane infrastructure projects

Further **expansion of the domestic pipeline system is necessary in connection with the development of cross-border capacities,** in connection with the diversification of supply routes.

- The construction**of a Hungarian-Slovenian cross-border natural gas pipeline,** which would allow two-way transportation between countries.
- Expansion**of Romanian-Hungarian cross-border** capacity. The expansion of the natural gas pipeline in the direction RO > HU with a current capacity of 2.45 billion m^3/ year to a level of 4.4 billion m^3/ year requires significant system development on both the Hungarian and Romanian side, with an implementation time of up to 2-3 years. The possibility for Romanian imports remains important for the availability of stocks in the Black Sea. It would also be important to create the possibility of transporting natural gas of Azerbaijani origin to Hungary via Romania, linked to the planned route forming part of the Solidarity Ring (Bulgaria-Romania-Hungary-Slovakia).
- It is possible to increase the capacity of the Romanian-Hungarian cross-border point in the RO>HU direction from the current 300 000 m3/hto up to 365 000 m3/hwith minimal expansion, which additional quantity could be from **Azerbaijan or from**

[92] *In addition to the regional groups of projects of common interest established under Regulation (EU) No 347/2013.*
[93] *Slovenská elektrizačná prenosová sústava, a. s. (the Slovak system operator)*

Turkish and Greek LNG terminals on the Turkey-Bulgaria-Romania-Hungary route.

- **Possibility to transport additional LNG sources (e.g. Qatar)** from several directions e.g. **Croatian, Greek, Polish LNG** ports.

This leads to an increase and deepening of the liquidity of the domestic natural gas market, which is overall favourable for the consumer. FGSZ's *'Ten-Year Network Development Plan'*[94] includes the pipeline projects planned over the next 10 years. The main task is to **make better use and rationalise the existing infrastructure by** phasing out low-utilisation distribution lines (below 10%) from the public system by offering low-carbon heating alternatives.

Increasing the tolerance level of the 'methane system' to accommodate alternative gases

Making the **grid fit for hydrogen in addition to natural gas and biomethane can also play a decisive role in increasing occupancy and achieving climate protection goals.** Producing hydrogen (and synthetic gases) and feeding it into the distribution system also reduces dependence on natural gas and provides cost-effective, flexible energy storage options. Therefore, our aim is to create the necessary conditions and incentives for the introduction of hydrogen and other "natural gas quality" gases into the system, e.g. in the case of the Slovenian-Hungarian pipeline, we provide a 100% hydrogen tolerance level, besides which, in order to satisfy the clean hydrogen demand, other cross-border pipelines are needed that are suitable for the transport of hydrogen.

Electricity infrastructure projects

In addition to the further increase **of cross-border capacities,** in addition to the expansion of Serbian-Hungarian cross-border capacity and PCI projects (Chapters 3.3, 3.4.1 and 3.4.2), significant **network development is warranted** for the integration of renewable energy producers, which has already started at transmission and distribution network level. In this context, we are preparing the electricity grid, especially the distribution grid, for the increasing spread of decentralised capacities. In addition, **new CCGT capacity** is needed to support the need for flexibility in the electricity system. At the Tisza Power Plant's Tiszaújváros and Mátra Power Plant's Visonta sites, state-of-the-art power generation capacity can be established to serve the increasing electricity demand and to help the aging power plant park, which will enable the more efficient utilization of natural gas and hydrogen and a greater proportion of renewables. In addition, we ensure the **construction of electricity storage capacities** that can be implemented in the form of integrated elements at the system operator and network licensees. We want to boost the current installed battery capacity of

[94] *https://fgsz.hu/vallalatunk/projektek/fejlesztesi-javaslatok-dokumentumtar*

around 20-25 MW through a combination of legislative and financial incentives. We also support **the construction of pumped-storage power plant capacity.**

Measures to support the achievement of electricity infrastructure targets

It is necessary to develop and develop a transparent specific regulatory framework, including grid connection and operating authorisation procedures, in[95] order to facilitate the rapid integration of storage capacities into the grid and to increase the supply side of the balancing market, in particular:

- facilitating and simplifying the operation of energy communities
- supporting independent aggregators to encourage market participation of aggregate demand.
- **promoting demand response** and its integration into the system.

Demand response

There should also be scope for the uptake of new innovative solutions, such as demand response (DSR) solutions, to incentivise the integration of renewable energy generation in the electricity grid**.**

It is necessary to involve in the system-level regulation the already significantly developed consumer-side influence possibilities, the HKV (voice-frequency central control) and RKV (radio-frequency central control) systems connected to the controlled connection points. The main regulatory task is to create incentives, the most obvious tool of which could be the **development of a flexible tariff structure.** In order to further integrate the DSR potential, it may be appropriate to **introduce a specific product** for flexible consumption in the market for system-wide services. The **creation of a legislative environment** conducive to the creation of independent aggregators is also key to unlocking the potential of DSR. Opportunities can **be exploited with the help of digital and smart devices.** The active participation of consumers in the energy market gives them the opportunity to keep their overhead expenditure under control, while at the same time contributing to the maintenance of system balance by providing flexibility services.

Introducing innovative market organisation practices and strengthening consumer side services could be a solution for **the expansion and targeted use of heat storage by the population** as a contribution to balancing the electricity system. This solution is beneficial in several respects, as it generates lower investment costs than storage solutions for electricity, reduces balancing costs and, in combination with a heat pump, makes better use of ambient heat.

Increasing the digitalisation of the electricity system

[95] *By defining the specific market services that storage system operators can provide.*

- The electricity network and the system as a whole have achieved such complexity that can only be monitored and controlled by continuous measurement **and IT processing of the measured data and analysis supported by artificial intelligence.** The necessary improvements should be made to all relevant actors.
- Data must be stored in databases **that are well-structured, protected and integrated into** decision-making. Building up the missing databases (e.g. to manage data from smart meters) is a top priority.
- It is also necessary to continuously improve the operational applications of the major energy actors.
- It is necessary to ensure that the resulting data **is made available to other energy actors.**
- There is a legal requirement for certain consumers to have smart meters installed at their point of consumption. Government Decree No 273/2007 *implementing certain provisions of Act LXXXVI of 2007 on electricity* According to the Government Decree (X. 19.) **smart meters will be installed for** low-voltage connected users in case of annual use of 5 MWh or more, in case of new connections with a power requirement of 3x32 A but not exceeding 3x80 A, and in case of users who already have a household-scale small power plant or will install such a system in the future.

ii. Regional cooperation in this area[96]

Hungary is a member of the *High Level Group on Energy Connectivity in Central and South-Eastern Europe (CESEC)*, [97]where energy and climate policy topics relevant to the NECP are regularly discussed. Established in 2015, **CESEC, which includes 9 Member States of the European Union and 8 other countries among its members, serves to accelerate the integration of electricity and gas markets in the region and to detect related developments.** In the framework of Hungary's EU Presidency, a CESEC ministerial meeting will take place in October 2024.

The *Visegrad Group is a regional organisation of* the Czech Republic, Poland, Slovakia and Hungary. The aim of the cooperation is to jointly represent the economic, diplomatic and political interests of these Central European countries and to coordinate their possible actions. The Visegrád countries are engaged in consultations on **the development directions of the energy sector** and in the interest of scientific research and development cooperation. Within this framework, discussions are underway specifically to develop an **energy RDI cooperation platform.** Cooperation shall provide for the exchange of experience in the development of the energy sector, including cooperation with individual technology suppliers,

[96] *In addition to the regional groups of projects of common interest established under Regulation (EU) No 347/2013.*
[97] *CESEC = Central and South East Eruope Energy Connectivity*

in particular suppliers of nuclear energy technologies. There is also continuous communication between energy market players in various fora. (Chapter 3.3)

iii. Financing measures taken at national level in this area, including Union support and the use of Union funds

The development, digitalisation and installation of energy storage, penetration of renewables and system security of the electricity grid will be of paramount importance in the coming years, as energy transition ambitions require modern and flexible electricity grid operation. Until 2030, the following resources are available in Hungary for these purposes:

Hungary's Recovery and Resilience Plan

The RRF planned a total of more than HUF 700 billion in support for the following elements:

- Classic and smart electricity grid development
- Energy storage capacities for system-wide services
- Installation of smart meters
- Digital developments related to network development
- Dissemination of Smart Measurement
- Improvement of weather forecast accuracy

Environmental and Energy Efficiency Operational Programme Plus

- KEHOP Plusz includes **a total of HUF 170 billion** in support of developments aimed at the flexibility of transmission and distribution networks and systems, as well as the promotion of intelligent energy systems and energy storage.

Modernisation Fund, complemented by national funds

- The fund provides a **total of HUF 33 billion** in support for the installation of energy storage facilities at Hungarian network licensed companies. Investments are already underway.

In total, the Hungarian state and the European Union are contributing more than HUF 900 billion to the construction and development of flexible, modern electricity transmission and distribution networks.

3.4.3. Market integration

Hungary continues to develop regulations that make the operation of wholesale and regulatory markets more efficient, the framework of which is **provided by the implementation of European operational, operational and commercial codes.**

i. Policies and measures related to the elements set out in point 2.4.3

Gas market

Hungary is also examining the **possibility of interconnection with the Slovak, Slovenian, Austrian and Romanian gas markets.** Simultaneously with the promotion of market integration, Hungary aims to further strengthen the liquidity of the Hungarian gas exchange (CEEGEX) and its role as a price indicator in the region. A **regional sales model of Hungary's significant domestic natural gas storage capacities is also being developed to support this and to** achieve it as soon as possible. Further expansion of cross-border capacities is also relevant for security of supply and market integration purposes (Chapter 3.4.2).

<u>Electricity market</u>

The development of **infrastructure elements supporting** the integration of renewable energy producers, such as energy storage facilities, fast-start natural gas-based power plants, regulatory and market environments and, in line with this, making the integration of renewable investments more cost-effective is an important task. The level of support should follow the reduction of investment costs for all technologies, avoiding oversubsidisation. (Chapter 3.4.2)

A **high degree of integration of the European electricity system guarantees significant security of supply** for all connected countries in Europe. The electricity systems of the interconnected neighbouring States have a significant and direct impact on each other, also due to their balancing capacity, weather-dependent power plant portfolio and possible supply disruptions. This will be addressed through the interconnection of European electricity markets, which will optimise electricity trade between countries and make it more efficient and liquid. As regards electricity market integration, to which Hungary has joined, the following main developments have taken place over the past three years:

- **The new market coupling has been successfully launched within the framework of an interim coupling project based on Net Transfer Capacity (NTC).** On 17 June 2021, for the first time, day-ahead cross-border capacity was implicitly allocated at the six new borders (PL-DE, PL-CZ, PL-SK, CZ-DE, CZ-AT, HU-AT) using the Euphemia algorithm. Market coupling allows for the parallel calculation of electricity prices and cross-border flows in the region.
- On 8 June 2022 (delivery **day on 9 June), the electricity market coupling (FBMC, Flow-Based Market Coupling) of the wider Central Europe (Core) region with a single day-ahead timeframe** and flow-based capacity calculation was successfully launched.

The international interconnections and transmission capacities of the Hungarian electricity system allow for a sufficiently secure and flexibly diversifiable trading transaction, but **further market integration steps** are needed in relation to balancing markets. In addition to increasing cross-border capacity, it is necessary to increase market coupling and the efficiency of the functioning of interconnected markets. It is therefore also necessary **to further strengthen the interconnection between intraday and day-ahead** markets and to operate them efficiently. Also in intraday markets, cross-border auctions will be introduced instead of the current continuous trading, and it is expected that flow-based capacity allocation will be introduced in the course of 2025 over an intraday time horizon. In the context of the integration of balancing markets, the timely implementation of the[98] integration with PICASSO (Platform for the International Coordination of Automated Frequency Restoration[99] and Stable System Operation) and MARI (MARI (Manually Activated Reserves Initiative) is warranted, for which the necessary IT developments are already underway.

It is necessary to ensure the availability of flexible capacities to guarantee safe operation and balancing. The need for resources to provide flexibility and regulatory capabilities has increased significantly in recent years. One way to achieve cost-efficiency was to **amend the reserve sizing methodology** in 2023. The new reserve scaling is based on the probability of imbalances occurring over the last two years, complemented by the estimated impact of other factors such as weather conditions. The new methodology meets the preliminary expectations. The new methodology takes into account the IGCC for the amount of aFRR to be committed, which means the netting of simultaneous reverse imbalances in the international region formed by the system operators, without activating regulatory energy. In addition, rotating units that are practically continuously available (in operation) are also taken into account when sizing mFRR reserves. The new methodology met the preliminary expectations for the first month, with the decrease in the volume of reserves purchased (except for the positive mFRR) leading to a decrease in the average FRR capacity fees, which resulted in a significant reduction in the costs of FRR capacity booking.

ii. Measures to increase the flexibility of energy systems in relation to renewable energy generation, such as smart grids, aggregation, demand response, storage, distributed generation, dispatching, redispatching and curtailment mechanisms and real-time price signals, including the roll-out of intraday market coupling and cross-border balancing markets

Chapter 3.4.2 governs **the preparation of the distribution network for the expansion of decentralised energy production.** It is necessary to create the necessary market mechanisms for the active operation of the distribution network, distributors should develop a market for voltage regulation and congestion management distribution flexibility that provides local, regionally developed price indicators. Close cooperation between the transmission system operator, which is responsible for the balancing energy market, and the distributors is necessary in order to ensure that the two markets operate in a mutually supportive manner so as to avoid cross-effects at different voltage levels and thus increase costs.

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[98] MARI (Manually Activated Reserves Initiative) is an early implementation project for a European platform for the exchange of balancing energy from frequency restoration reserves with manual activation according to the EB GL, with the aim of meeting the requirements of the EB GL as soon as possible.

[99] The aim of PICASSO is to design and further develop a functioning platform that collects applications from all relevant TSOs (transmission system operators) and allows for an optimal distribution of the market product (energy balancing from frequency restoration reserves with automatic activation, energy balancing from aFRR) to meet the needs of the participating TSOs.

Making the integration of renewable investments cost-effective

- The efficient scheduling required by Article 5 *of Regulation (EU) 2019/943 on the internal market for electricity* requires high-resolution and reliable meteorological forecasts to enable HungaroMet to provide more accurate weather forecasts. Given that HungaroMet has an indispensable role and task in supporting energy neutrality efforts and the integration of weather-dependent renewable energies, **in the future HungaroMet's activities will be expanded to include scientific and climate research tasks.**
- Revision**of the compensation scheme, i.e. the countervailing subsidy scheme.**
- Provide financial support to market participants for the construction of electricity storage facilities suitable for the provision of system-wide services. (Storage facility)
- Investments in energy storage – battery and pumped-storage power plants – and micro-grid solutions should be encouraged. Regulatory instruments are needed to facilitate the operation of renewables and energy storage facilities on the same site. (Chapter 3.4.2)

iii. Measures to ensure the non-discriminatory participation of renewable energy, demand response and storage, including through aggregation, in all energy markets

In order to ensure that the connection of renewable producers to the grid is not hampered by capacity bookings blocked by 'poor quality' or non-existent power plant projects, transparency and economic efficiency in the allocation of grid connection capacities should be increased. A good tool for this is, for example, non-discriminatory capacity auctions announced at regular intervals, which require a better targeting of the grid connection procedure in line with the NECP. On the one hand, renewable energy producers above 0.4 MW connection power should be included in the voltage regulation.

iv. Measures to protect consumers, in particular vulnerable and, where applicable, energy poor consumers, and to improve the competitiveness and competition of the retail energy market

In addition to energy efficiency measures, encouraging more active consumer participation can contribute to increasing consumer protection and awareness. A key condition for consumers to play an active role in the market is to ensure that consumption can be regulated where it is not yet possible. The use of smart meters in the electricity and natural gas sectors needs to be much wider than at present.

"Smart **regulation"** is designed to positively incentivise distributors to introduce new products and innovative technologies and to empower service providers to prioritise digital administration. (For more details, see chapter 3.3.5.iii.) The most important technological task is the **introduction of smart meters** – and the necessary developments – capable of managing time-based tariffs. Due to the large number of installations of smart meters, it is worth considering the domestic possibilities of their production. Encouraging more active consumer participation can contribute to increasing the level of consumer protection.

v. Description of the measures through which demand response is enabled and developed, including those addressing tariffs to support dynamic pricing[100]

The descriptions in Chapters 3.4.2(i) and 3.3(i) are relevant to this question.

3.4.4. Energy poverty

i. Where applicable, policies and measures to achieve the objectives set out in point 2.4.4.

The most important public transfer is the **official pricing of energy costs**. 8 out of 10 households are entitled to use energy at a cost corresponding to the official tariff in the field of electricity supply. The same rate is 92% for gas supply and 100% for district heating supply. Thus, 3.95 million households benefit from official tariffs for the supply of electricity, 3.05 million for the supply of gas and 0.65 million for the supply of district heating.

The **Social Fuel Programme** provides social fuel support through the local governments of settlements with fewer than 5000 inhabitants, for the local residents applying for it. At the same time, the program also pursues the objective of air cleanliness, since it prevents the burning of materials from unknown sources that contribute significantly to the air pollution of the household and the surrounding area. The scheme provides additional support to around 200,000 households each year to reduce their fuel costs.

In Hungary, 71% of households (3.25 million households) use natural gas as their primary fuel and are exposed to fluctuations in import prices.

According to the 2022 census, there are 4.48 million dwellings in Hungary. The majority of the domestic real estate stock, 3.85 million **households, is classified as 'DD' or worse, i.e. it** is outdated from an energy point of view and needs to be modernised. After deducting the number of modern properties reaching at least the 'BB' energy level and properties no longer worth renovating, some 2.6 million residential properties are in need of renovation in Hungary today, about half of which are family homes. Detailed definitions, supplemented by indicators, have been defined for each supporting policy measure in order to determine whether consumers belong to vulnerable groups. Among these measures, the Catching-up Settlements Programme and the Just Transition Plans include energy renovation elements targeting residential buildings.

In order to reduce the risks of the population most affected by the vulnerability, we plan long-term housing construction, renovation, heating modernisation and energy efficiency programmes to ensure adequate housing conditions, as well as programmes for the transition to low-cost self-sufficiency. We maintain the established forms of support. In order to further

[100] *In accordance with Article 15(8) of Directive 2012/27/EU.*

reduce the risks of vulnerability, ***Hungary shall develop its National Social Climate Plan,*** in particular with regard to the target group indicated in Chapter 2.4.4.

3.5. Research, innovation and competitiveness dimension

The most important tasks for energy innovation are to support research and innovation activities in the focus areas outlined in point 2.5.ii. Hungary's related measures are set out **in Annex 1 to the NECP.**

i. Policies and measures related to the elements set out in point 2.5

Hungary supports the development of research laboratories, university and other scientific activities and the spread of theoretical and practical research, development and innovation (RDI). Along these lines, it helps to launch energy innovation pilot projects and demonstration projects, to continue pilot projects for climate adaptation, and to cooperate with cities and local industries. In order to make better use of the opportunities offered by funding sources, the provision of information to domestic stakeholders can strengthen the innovation capacity and competitiveness of domestic enterprises – this can be achieved by providing awareness-raising and consultancy services under Chapter 3.2.

The RDI and competitiveness measures have a significant impact on the other elements of the dimensional target and measure system, and the elements of the additional dimensions have repercussions on the activities of this dimension as well. The policy will address scientific needs that have a prominent security of supply and/or sustainability role in the ongoing energy transition, e.g. by launching a new research programme on radioactive waste management, reduction of decomposition time and waste recycling. Scientific activities are **supported by the National Research, Development and Innovation Fund**, and **close international cooperation and sharing of experience can help** spread innovative technologies and service modes, as well as smart solutions (Chapter 3.5.ii).

The **implementation of domestic manufacturing and related service units has** a competitiveness-enhancing effect on the domestic economy as a whole. In order to realise the energy investments outlined in **the previous chapters, the partly domestic production of green technologies** and the expansion of the related domestic construction capacity, as well as **the development of related services,** are indispensable. In addition to domestic production capacities and service development, we pay special attention to the technological renewal of SMEs and the development of entrepreneurial skills. The **development and training of human resources, professionals entering and already present on the labour market is also** an important task. As a result of strengthening competitiveness, by making knowledge production more efficient, we intend to increase the number of professionals needed for the energy transition, by expanding training courses – both in vocational and higher education – and by developing curricula. In addition, **research and development cooperation within industry and with universities should be further strengthened and made more effective.**

The implementation ***of the above will be supported by the preparation and implementation of Hungary's Industrial and Technological Action Plan,*** which, on the one hand, aims at the industrial and service development orientation required to achieve climate neutrality, technological development and the creation of environmentally and socially sustainable value chains in Hungary. On the other hand, it facilitates the development of competitive industries – a new green industry and an existing cleaner national industry – which contribute to increasing economic value creation and creating new job opportunities.

Improving the labour market situation in the energy sector is also necessary for security of supply and competitiveness. It is in the interest of Hungary to raise the level of vocational education and to better exploit the potential of the dual education system. Following **the assessment of educational needs and the identification of shortage occupations,** it is necessary to increase the number of students in the field of energy technology with the help of **career guidance programmes.** In order to mitigate the draining effect of other industries, corporate wage developments and the development of a secure vision may play a role in the first place. Economic structural changes towards lower carbon intensity energy production and use can bring significant changes in employment needs and opportunities beyond the energy sector. It is therefore necessary ***to develop a programme to meet the human needs of the green economy,*** which will provide an opportunity to monitor labour market developments in the energy transition and help improve the employability of the workforce in the green economy sectors, as well as support for upskilling and reskilling of the workforce.

ii. Cooperation with other Member States in this area, including information on how SET Plan objectives and policies are integrated into the national context

the Visegrad Four

At the regular meetings of the V4, they are working on increasing the economic and scientific diplomacy awareness of the region. Regional cooperation between the V4 countries will enable members to participate more effectively in joint international programmes, make better use of their resources and become more attractive to long-term cooperation with foreign partners. The scientific institutes for nuclear research in the V4 countries established the ALLEGRO project in 2010 with the aim of building a fourth generation gas-cooled rapid reactor and demonstrating the incineration of high-level waste in spent fuel. Members meet 2-3 times a year. The design of the rapid reactor is currently underway. Another scientific supporter of the V4 cooperation is the French *CEA Institute.* The scientific work of the ALLEGRO project is supported by EURATOM.European Strategic Energy Technology Plan (SET Plan)

The European Commission intends to boost the Energy Union's R&D and lead in renewable energy technologies through the implementation of the revised SET-Plan. **Hungary is represented in five of the current 10 Technology Working Groups (TWGs):**

- SET Plan High Voltage Direct Current (HVDC) and Direct Current (DC) technologies (SET Plan – HVDC & DC TWG)
- SET Plan Batteries (TWG)
- SET Plan (Wind Energy TWG)

- SET Plan CCUS Working Group (SET Plan - CCUS TWG),
- SET Plan – Nuclaer safety TWG

Other nuclear RDI cooperation

International relations, in particular participation in the EURATOM programme of the European Union and in the work of the *International Atomic Energy Agency* (IAEA), are important elements in the training of professionals. Related cooperation:

Participation in the work of the European Organisation for Nuclear Research (CERN)

- Hungary joined *the Geneva-based European Organization for Nuclear Research (CERN)*in[101] 1992. In recent years, Hungarian participation in the construction and operation of CERN experiments, in the evaluation of the obtained data and in the understanding of the physical results has increased significantly.

Research and development of thermonuclear plasma physics in the framework of EURATOM

- The research and development of thermonuclear plasma physics is carried out in the framework of EURATOM, in international cooperation, primarily on and in connection with large European installations. Our Hungarian researchers have achieved significant results by international standards in researching the turbulent state of plasma and the plasma behaviour of macroscopic fragments injected into plasma.[102]

Participation of the HAEA in the European Association for Safeguards Research and Development

- Founded in 1969, the European Safeguards Research and Development Association brings together European organisations active in the field of nuclear safeguards, of which the Hungarian Atomic Energy Authority (HAEA) is also a member. The main objective of the organisation is to coordinate and promote research and development activities in the field of nuclear safeguards.

Participation in the work of the OECD Nuclear Energy Agency (NEA)

- Hungarian experts actively participate in OECD NEA working groups and research projects on the safe, environmentally friendly and economical use of nuclear energy. World-class activities are carried out in these working groups and projects, the results of which are also used in domestic nuclear developments. The international

[101] *The world's largest particle physics laboratory*
[102] *http://www.rmki.kfki.hu/plasma/rolunk.html*

coordination role of the OECD NEA is of paramount importance in the development of new generations of nuclear reactors.

Participation in the work of the International Atomic Energy Agency (IAEA)

- In the framework of the IAEA research projects, Hungarian experts have been successfully involved in the development of accident-resistant nuclear fuels and activities in the nuclear forensic field. The IAEA provides an important opportunity for Hungarian experts to learn about the operational experience of other nuclear power plants, including the introduction of new types of fuels, ageing management and extending the lifespan of nuclear power plants. The IAEA has chosen the Budapest-based HUN-REN *Centre for Energy Research as* its cooperating partner in the field of nuclear forensic analysis.

Participation in the European Network of Experts of Background Institutions supporting the Authority

- Technical Support Organisations (TSOs) play an important role in nuclear safety and security. Their main task is to provide competent, reliable and impartial technical expertise to the national nuclear regulatory authority. In addition, many TSOs are strongly involved in the development of science and technology through research and development (R&D), thus providing the knowledge and analytical tools necessary to ensure a high level of nuclear safety and security. Established in 2006 and an independent legal entity since 2011, *the European Technical Support Organisation Network* (ETSON) serves as a common platform for member organisations. The Hungarian TSO organisations are represented in the ETSON Expert Network by the HUN-REN Centre for Energy Research.

Participation in the work of the European Energy Research Alliance

- The *European Energy Research Alliance* (EERA) is a membership-based, non-profit association that forms Europe's largest low-carbon energy research community and is a key player *in the European Union's Strategic Energy Technology Plan* (SET). The Alliance was set up in 2008 by leading research institutes to expand and optimise the EU's energy research capacities. Today, it brings together more than 250 organisations from 30 countries.EERA coordinates its activities through 18 joint programmes, which provide world-leading scientific expertise across three pillars: low-carbon technologies, materials and systems.

International partnerships under Horizon Europe

Horizon Europe European Partnerships are large-scale research and innovation initiatives and programmes linked to major societal challenges, which are implemented in cooperation and mostly co-financed by the European Commission and public and private actors. They contribute to strengthening the coordination of research and innovation programmes in

Europe and to making investment in research and development more efficient by encouraging cooperation between the Commission, national research funding organisations and relevant industry actors, and are one of the main instruments for completing the *European Research Area.* They also aim to contribute to the EU's policy objectives. Partnerships are an integral part of the different types of partnership initiatives launched in *Horizon 2020:* ERA-Net Cofund, European Joint Programme Cofund, Joint Programmes, Joint Technology Initiatives, Contracted Public-Private Partnerships, EIT KICs, etc. The toolkit underwent a major transformation at the start of the new Framework Programme. Partnerships can be divided into three categories: co-programmed, co-financed and institutionalised partnerships.

Hungary is linked *to the following partnerships under the Climate, Energy and Mobility cluster:*

- Partnership for Sustainable Urban Transitions (DUT)
- Clean Energy Transition Partnership (CETP)
- People-centric sustainable built environment (Built4People)
- Towards a competitive European industrial battery value chain for stationary applications and emobility (BATT4EU)
- Clean Hydrogen Partnership (CHP)
- Towards zero-emission road transport Partnership (2Zero)
- Connected, Cooperative and Automated Mobility (CCAM) Partnership
- European Partnership for Zero-Emission Waterbone Transport (ZEWT)
- Partnership for the safe management of radioactive waste and coordination of research programmes (EURAD)

LIFE CB project

The sub-programme of Horizon Europe is the LIFE programme. The Ministry of Energy, together with the Ministry of Agriculture and the Hungarian Development Promotion Office (MFOI, Chief Coordinator) submitted an application for the LIFE Programme 2021 Capacity Building Call (LIFE-2021-TA-CAP). Under the signed Grant Agreement, the *LIFE - Enhanced Capacity Building in Hungary,* a three-year Hungarian LIFE Capacity Building Project, was launched on 1 June 2023. A total EU grant of EUR 403 560 was received to support the achievement of the objectives. The main objective of the LIFE HUNCAPBUILD22 project, in addition to analysing the reasons behind Hungary's moderate participation in LIFE projects, is to provide detailed and targeted information and training to potential LIFE applicants on LIFE projects. Another priority is to enhance the existing competences and knowledge of the LIFE National Contact Points. Under the auspices of the project, it was identified as a feasible activity in the form of exchange of best practices, consultation and study visits with a number of Member State representatives with a high success rate in applying to the LIFE Programme. Such a visit to Spain took place in spring 2024. During the Spanish bilateral consultation and study trip, project visits, consultation with LIFE-related institutes and exchange of experience took place on the topics of nature conservation, renewable energy, circular economy and climate change. Based on the new experience, the Hungarian National Contact Points will be able to provide more effective assistance to Hungarian applicants from the Member State side.

During the project, the Netherlands, Italy, France and Germany will contact the LIFE contact points of the following countries to organise the Hungarian LIFE national contact points, further bilateral consultations and study visits: Netherlands, Italy, France, Germany.Participation in QUANT-ERA, FLAG-ERA and M-ERA-NET[103]

The main objectives of the ERA-NET (European Research Area-Network) programmes are to improve the coordination of public research programmes implemented at national and regional level, to network national and regional research activities and to open up research programmes at national and regional level.

- **Participation in the M-ERA-NET programme:** The aim of the M-ERA-NET programme is, through joint calls, to strengthen the coordination of European research programmes in the fields of materials science and engineering.
- **Participation in the FLAG-ERA II programme:** The European Union provides long-term support for certain large-scale, interdisciplinary research activities addressing scientific and technological challenges through the so-called FET (Future and Emerging Technologies) flagship initiatives.
- **Participation in the QuantERA program:** In May 2016, the European Commission announced the launch of a new flagship research initiative in the field of quantum technology under the Horizon 2020 FET programme. The flagship initiatives will be supported by EU, national and own-fund projects, with an annual budget of €100 million for international research cooperation over 10 years. The QuantERA Consortium’s annual calls for proposals support international research projects linked to the flagship initiative.

European Institute of Innovation and Technology (EIT)

The *European Institute of Innovation and Technology (EIT)* is the EU's institution for education (higher education), research and innovation, which coordinates education, industry, business and research in specific fields in order to promote a European knowledge-based economy and increase competitiveness. In accordance with *Decision 2008/634/EC,* the EIT shall have its seat in Budapest. The Institute works primarily through the creation of Knowledge and Innovation Communities (KICs) across the continent. Cooperation shall be based on *Scientific and Innovation Associations (KICs), which bring together higher education institutions, research organisations and* enterprises, and on partners working with them. Domestic institutions are not involved as main partners, but indirectly in all KICs:

[103] *ERA: European Research Area*

- EIT Climate-KIC: Budapest University of Technology and Economics
- EIT Raw Materials: University of Miskolc, Bay Zoltán Nonprofit Research Center
- EIT InnoEnergy: Green Brother

Intergovernmental Scientific and Technological (S&T) Cooperation[104]

Hungary has signed intergovernmental and interinstitutional science and technology (S&T) cooperation agreements with 36 countries and 10 countries. The *National Research, Development and Innovation Office (NKFIH)* is responsible for their implementation. The NRDI Office and its predecessor institutions have also signed interinstitutional cooperation agreements with organisations responsible for research and development policy or funding in 9 other countries.

One of the key objectives of bilateral S&T relations is to support RDI cooperation between the two participating countries through tenders. International S&T relations are also supported by external S&T attachés, whose task is to collect information on the RDI policy of the host country, to promote domestic scientific and technological results, to help networking between the research and innovation communities of the two countries, and to support the launching of cooperation. There are currently 15 stations (Berlin, Brussels, Vienna, London, Moscow, New York, San Francisco, Paris, Beijing, Seoul, Sao Paulo, Stuttgart, Tel Aviv, Tokyo and New Delhi). The NRDI Office together with KKM operates the network of S&T attachés performing scientific and technological diplomacy activities.

In addition to the above, the NRDI Office participates and represents Hungary's interests[105] in relation to EUREKA, and ensures participation in the work of ESFRI and its working groups coordinating European research infrastructures, as well as in the work of the EURATOM programme. It also coordinates the professional tasks, representation and coordination of expert work related to domestic participation in specific international research infrastructures (ITER, CERN, ICOS ERIC, etc.). Policy cooperation in the field of research and development (OECD) supports the development of domestic policy.

In order for Hungary to have an innovative energy industry that is successful on international markets, it is necessary to further encourage international cooperation on energy technologies and energy RDI activities and to establish new relationships. Accordingly, international cooperation on RDI activities that are successful at international level and are important for domestic priorities should be prioritised, but new opportunities should also be explored.

[104] *https://nkfih.gov.hu/office/national contacts*
[105] *European market-oriented R&D cooperation*

iii. Financing measures taken at national level in this area, including Union support and the use of Union funds

The ***National Research, Development and Innovation Fund (NRDI Fund) plays an important role in the financing of domestic RDI,*** which is a dedicated public fund providing public support for R&D and innovation from domestic sources. The NRDI Fund promotes exploratory research, targeted development and innovative enterprises in a balanced way. For the time being, there is no dedicated fund to support energy-related projects, which will be announced every year. The Hungarian calls for research, development and innovation projects financed by the NRDI Fund for a given year are included in the annual *Programme Strategy* adopted by the Government. We will examine the possibility of encouraging domestic energy RDI activities with thematic tenders specifically dedicated to energy issues.

When adopting **the** *Annual Development Framework (EDF), the Government shall decide on the timing and financial allocations of the non-refundable* **RDI grant schemes of the EDIOP Plus.** 1300/2021 establishing the annual development framework for *GINOP Plus. Government Decision (V. 21.)* contains the GINOP Plusz framework.

Further pilot projects will be launched to promote energy innovation, financed from quota revenues. We decide on the extension of innovative solutions based on the experience of pilot projects, and we plan the funding using the funds **of the Operational Programmes for the period 2021-27 and the Modernisation Fund.**

Hungary intends to take an active role in promoting opportunities offered by **direct EU tenders** to domestic market players, universities and research institutes, *e.g. through the CEF, Horizon Europe, InvestEU, EUROSTAR and EURATOM* programmes, promoting their participation in international consortia. Maximising the potential of the **Innovation Fund** is also an objective. For high emission reduction projects focusing on high innovative technologies and major projects with European added value, the Fund could create opportunities for risk sharing to help realise highly innovative ideas.

The *European Investment Bank (EIB)* can provide loans to finance efforts to combat climate change. The *European Investment Fund (EIF,* member of the European Investment Bank Group) can help micro, small and medium-sized enterprises access finance for innovation, research and development, entrepreneurship, growth and jobs through venture capital and risk finance instruments.

In addition, an even stronger involvement of **foreign private capital** is warranted. The ***Hungarian Investment Promotion Agency (HIPA),*** set up to support working capital investments, can play an important role in this.

4. CURRENT SITUATION AND FORECASTS WITH EXISTING POLICIES AND MEASURES

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

4.1. Projected evolution of key external factors affecting the energy system and greenhouse gas emissions

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

i. Macroeconomic projections (GDP and population growth)

GDP and population change are very important factors in terms of energy use and GHG emissions. In addition to oil prices, these factors are the ones that most determine the future performance of each sector.

For the key inputs, the values recommended by the Commission were used. These include **population and GDP,** while **exchange rates have** been taken to be constant throughout the period.

20Table - Key input data used to project GHG emissions (Source: COM (March 2024): Annex II GHG projection parameters 2025)

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

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

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

Factors Affecting Residential Energy Consumption

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

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

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

The modelling of the Hungarian residential building stock was based on the most commonly used residential building typology, which includes 23 building types, of which 12 are family houses and 11 are condominiums. In the case of building types, the construction method, the construction time and the size of the building are decisive. [106]Based on a number of studies, questionnaires and other data sources, we have determined the typical technical parameters and fuel consumption of these 23 building types. The following table summarizes the Hungarian building typology and its main characteristics.

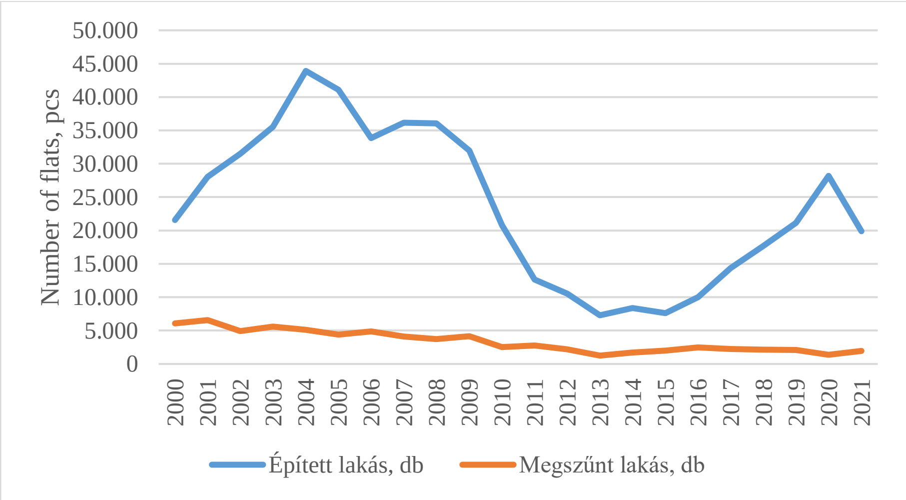
21Table 1 - Building typology of Hungary

Type of building	Characteristics of the building	Year of construction	Size	Number of dwellings occupied, pcs	Average dwelling size, sqm
1	Abscess without foundation		-	150 023	66
2	With abscess foundation		-	385 772	66
3	family	-1944	-	213 256	74
4	family	1945-1959	-	190 106	75
5	family	1960-1979	Below 119 nm	532 069	75
6	family	1960-1979	Above 120 nm	87 245	148
7	family	1980-1989	Below 119 nm	247 816	74
8	family	1980-1989	Above 120 nm	91 987	153
9	family	1990-2005	Below 119 nm	198 028	75
10	family	1990-2005	Above 120 nm	102 110	166
11	family	2006 - 2020	Below 119 nm	44 464	80
12	family	2006 - 2020	Above 120 nm	90 576	161
13	condominium, 4-9 flats	-1945	-	72 027	55
14	condominium, 4-9 flats	1945-1989	-	100 247	57
15	condominium, 4-9 flats	1990-2005	-	41 607	65
16	condominium, 4-9 flats	2006 - 2020	-	24 150	64
17	large condominium (10+ flats)	-1944	-	179 424	58
18	large condominium (10+ flats)	1945-1989	-	241 509	50
19	large condominium (10+ flats)	Block	-	163 771	50
20	Panel	-1979	-	290 941	50
21	Panel	1980-	-	163 780	50
22	large condominium (10+ flats)	1990-2005	-	68 772	53

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

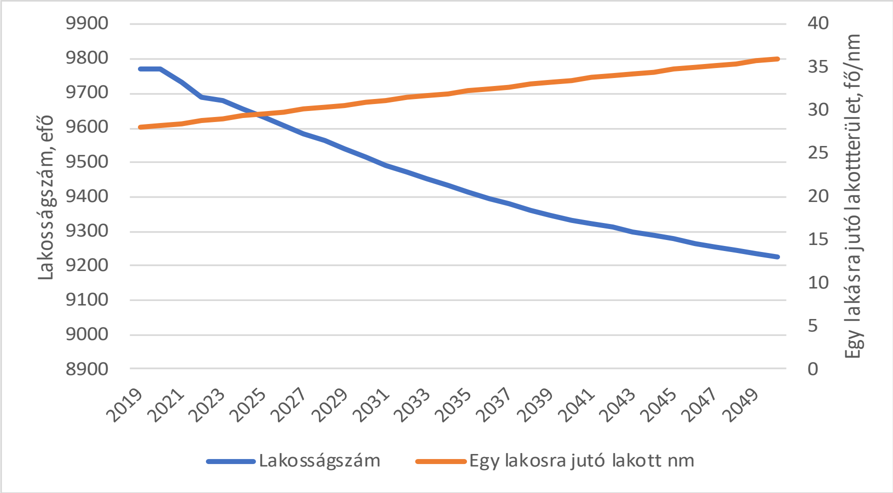
23	large condominium (10+ flats)	2006 - 2020	-	47 484	54

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



4Figure - Housing construction and demolition developments 2000-2021 (pcs/year) (Source: KSH)

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



5Figure - Population and population per inhabitant (m2) projections, 2019-2050 (Source: KSH, REKK estimate)

Factors affecting energy use in household appliances

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

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

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

Public and commercial buildings

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

In view of the limited availability of energy data on buildings other than public buildings, our estimates were based on the building types included *in the Long-term Renovation*

Strategy, supplemented by an 'other' building type, the specific consumption of which was determined by the nationwide floor-weighted consumption of the typology used. The total floor area of the 'other' type is determined in such a way that it gives the measured, aggregated energy consumption from the energy balance. The resulting value is 70 million m^{2}. This gives a total floor area of 126 million m2 for the total stock, which is a good approximation of the official EU statistics on the building stock in the services sector, which is 125 million m2. As we have little information about these buildings, we started from the investment options for residential buildings and determined the renovation options and their costs based on them.

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

22Table 1 - Typisation of public and commercial buildings (Source: HTFS, REKK estimation)

Épület típusa	Építés éve	Darabszám, db	Átlagos méret, nm	Összes nm	Szigetelt
EGYÉB ÉPÜLETEK	Minden korszak	33 958	2 179	74 000 000	Nem
Egészségügyi, szociális és lakóépület	1990 előtt	4 381	1 263	5 533 203	Nem
Egészségügyi, szociális és lakóépület	1990 -	619	1 263	781 797	Igen
Igazgatási- és irodaépületek	1990 előtt	5 282	1 060	5 598 920	Nem
Igazgatási- és irodaépületek	1990 -	539	1 060	571 340	Igen
Kereskedelmi épületek (pl. áruház, üzlet, raktár)	1990 előtt	529	1 097	580 313	Nem
Kereskedelmi épületek (pl. áruház, üzlet, raktár)	1990 -	111	1 097	121 767	Igen
Kulturális épületek (pl. múzeum, színház, könyvtár, művelődési ház)	1990 előtt	826	1 097	906 120	Nem
Kulturális épületek (pl. múzeum, színház, könyvtár, művelődési ház)	1990 -	97	1 848	179 262	Igen
Oktatási épületek (pl. Óvoda, iskola, főiskola, egyetem)	1990 előtt	9 150	3 066	28 053 900	Nem
Oktatási épületek (pl. Óvoda, iskola, főiskola, egyetem)	1990 -	954	3 826	3 649 688	Igen
Kórházak	1990 előtt	725	5 068	3 674 300	Nem
Kórházak	1990 -	82	3 442	282 245	Igen
Sportlétesítmények	1990 előtt	524	767	401 908	Nem
Sportlétesítmények	1990 -	1 546	1 263	1 952 598	Igen

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

We made the following assumptions about the future increase in floor space. In the case of buildings that have not been fully renovated, a loss rate of 2% per year has been assumed,[107] while within each category (e.g. hospitals, educational buildings, etc.), the change in the floor area of new buildings is proportional to the change in population. The exception to the latter is other buildings, where the increase in the floor area of new buildings increases by 30% of GDP growth. Thus, with the current GDP trajectory, the increase in the total surface area of public and commercial buildings between 2019 and 2050 is 9.3%.

<u>Transport</u>

[107] *This affects 97% of the initial building stock*

In order to be able to compare the results of the modelling of transport emissions with domestic greenhouse gas emission trends, it is necessary to use data consistent with the national GHG inventory to determine [108] *transport demand, so we started from transport statistics based on the so-called territoriality principle,*which contains data monitored and published[109]by *Eurostat* and *DG MOVE.* However, the available transport performance time series are incomplete for several categories and only available for a few years, which makes it impossible to estimate future demand on the basis of historical data. Therefore, in some cases the forecast was made on the basis of the statistical data of domestic companies, i.e. not according to the principle of territoriality, which was corrected by an estimate.[110]

Data were calculated for passenger-kilometres (ukm) for passenger transport and tonne-kilometres for freight transport (tkm). For the modelling, a separate prognosis was made for each mode of transport. The ukm and tkm values were[111] predicted *using the Cochrane-Orcutt econometric method.* Based on these projections, the initial baseline scenario without modal shift is modelled. By incorporating modal shift, the demand defined per mode of transport may vary to a certain extent, so modelling may result in a more efficient modal split. The data used and assumptions used to forecast demand are presented below.

Passenger transport

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

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

In the case **of motorcycles,** a similar approach was taken with regard to the share of local transport, but no basic statistical data were available to determine future demand, i.e. the passenger-kilometre value for the starting year had to be estimated. Three sources were used for this. For motorcycles, only stock data are available in the HCSO database, and based on our studies, these stock data do not include vehicles with an engine capacity of less than 50 cm^3 and an engine power of less than 4 kW, i.e. mopeds. The National GHG Inventory

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

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

[110] *HCSO, Transport sector situation, 2020, https://www.ksh.hu/docs/hun/xftp/temporary/jelszall/2020/index.html*

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

provides annual energy consumption data for two-wheeled motor vehicles.[112] However, statistics on mopeds are not available in either the HCSO or Eurostat databases, so the number of mopeds has been estimated[113] on the basis of the latest *TRACCS (2013)* stock data for 2010, which are closest to current estimates.[114] Based[115]on *the National Transport Strategy (NKT) Transport Energy Efficiency Improvement Action Plan (KEHCsT)* [116]and *EC (2022b),* we took the average consumption of motorcycles to be around 3 l/100 km and the average number of people transported to be 1.1. The trend in future demand (ukm) is assumed to be mainly determined by the development of the number of motorcycles and mopeds, therefore we estimated the development of the vehicle fleet based on the trend of the 16 years after the crisis. The average annual run calculated from the energy consumption in the GHG Inventory was 2,102 km. The values obtained in this way were used to predict future passenger-kilometre values for motorised two-wheeled vehicles.

Consolidated statistics on **local bus, suburban train, metro, tram and trolleybus** transport were available for a few years. Since we did not see any significant change in their temporal trend, except for a one-off increase due to the entry of a new metro line, we assumed that by default their future share of local transport would be the same as in the starting year.[117]

When forecasting long-distance or **interurban passenger transport,** we acted similarly to local transport. From *the EC (2022a)* [118]area-based bus transport statistics, we deducted local bus transport performance data and calculated the future demand for interurban bus transport assuming similar proportions. For rail transport, statistics follow the territorial principle from the outset. Passenger-kilometre data for passenger cars and motorcycles are calculated as a proportion of traffic statistics for extra-urban vehicle-kilometres, similar to local transport.

Among the other sectors, waterborne, airborne and pipeline transport, the **availability of historical passenger-kilometre data for domestic statistics only on the performance of local businesses and the data reported by Eurostat are also incompatible with energy consumption and GHG emissions data make it difficult to predict demand for air passenger transport.** [119] Therefore, we accepted the estimate of the *EU 2020 Reference Scenario.*

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[112] UNFCCC (2021): National Inventory Report for Hungary, 2019 https://unfccc.int/ghg-inventories-annex-i-parties/2021?gclid=Cj0KCQiA6fafBhC1ARIsAIJjL8lYU52ZBhjCdmZ8k4-r8-l4WgD4bDAtfdbNPP96u76l8u48fHfQ6iAaq8-EALw_wcB
[113] TRACCS (2013): Transport data collection supporting the quantitative analysis of measures relating to transport and climate change, https://traccs.emisia.com/index.php
[114] https://hvg.hu/cegauto/20190416_robogo_safety_accident_karesemeny
[115] EC (2022b): Study on New Mobility Patterns in European Cities Task C, https://transport.ec.europa.eu/system/files/2022-12/2022%20New%20Mobility%20Patterns%20in%20European%20Cities%20Task%20C%20Final%20Report.pdf
[116] National Transport Strategy, Transport Energy Efficiency Action Plan 2013-2020 (2050)
[117] HCSO Stadat, local passenger transport data HCSO Stadat, https://www.ksh.hu/stadat_files/sza/hu/sza0021.html
[118] EC (2022a): EU transport in figures, Statistical pocketbook 2022, DG Mobility and Transport, https://transport.ec.europa.eu/media-corner/publications/statistical-pocketbook-2022_en and Eurostat transport measurement data
[119] EUROSTAT, https://ec.europa.eu/eurostat/cache/metadata/en/avia_tp_esms.htm

Transport of goods

For freight transport, broken down by required vehicle size, data on the activity of freight vehicles on the national territory is not available, but only for the total (foreign and domestic) performance of transport undertakings. Therefore, based [120] on Eurostat statistics and *EC (2022a)*,we estimated the distribution of tonne-kilometre data for the size categories based on the maximum payload. Another obstacle is that for LCVs only information on the number of vehicles is available, and the statistical data collection on freight transport performance ignores this category. Therefore, as for motorcycles, we estimated the tonne-kilometre data for **LCVs** based on GHG inventory energy consumption data, assuming an average annual mileage of 22 000 km, an average capacity utilisation rate of 70% and an empty road share of 50%. The short- and long-term transport performance was determined on the basis of Eurostat traffic data as a proportion of vehicle-kilometres measured in built-up areas and other roads.[121]

The transport performance **of larger vehicles – heavy goods vehicles –** on domestic roads was determined on the[122]basis of tonne-kilometre ratios estimated on the basis of HCSO and Eurostat transport performance data, *Eurostat traffic data and average occupancy (EC, 2022b).* The tonne-kilometre data for short- and long-distance transport were determined on the basis of Eurostat transport statistics broken down by distance, taking into account transport performances below 50 km for short-distance transport.[123]

The future demand for **waterborne and pipeline transport** was estimated by means of a regression, the trend of which was mainly determined by the development of economic activity – the change in GDP.[124]

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

23Table 1 - Forecast of transport demand (Source: EUROSTAT, HCSO, REKK estimation)

	2019	2020	2030	2040	2050
Passenger transport, local (million ukm)					
Bus (local)	4574	3116	3407	3354	4115
Tram	1284	844	956	942	1155
Trolleybus	206	140	153	151	185
Subway	1523	1001	1134	1117	1370

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

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

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

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

[124] *HCSO Stadat: ksh.hu/stadat_files/sza/sza/sza0002.html*

WEEK	474	316	353	348	426
Motorcycle (local)	594	601	670	746	822
Car (local)	15176	14 651	18527	21988	25198
Passenger transport, interurban (million ukm)					
Bus (interurban)	14147	9309	9810	9231	8888
Car (interurban)	51857	50066	61532	72317	84462
Passenger train	7752	4854	5382	5064	4876
Motorcycle (interurban)	1135	1147	1279	1425	1570
Freight transport, short distance (million tkm)					
LCV (up to 3.5 t)	1114	1055	1540	1826	2173
Truck (max. 12 t)	206	195	285	338	402
Truck (over 12 t)	1595	1510	2204	2615	3111
Freight transport, long distance (million tkm)					
LCV (up to 3.5 t)	4808	4551	6645	7882	9378
Truck (max. 12 t)	655	629	919	1090	1297
Truck (over 12 t)	25230	23883	34868	41361	49210
Freight train	10625	11595	13935	16299	18493
Other Demands					
Waterborne transport (million tkm)	2120	1998	2950	3645	4397
Pipeline transport (million tkm)	8901	6739	7413	5272	2740
Air transport (million ukm)	3285	2193	6147	7500	8802

Industry

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

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

24Table 1 - Parameter estimates for fitted models and model characteristics

the Dependent Variable	R2	Constant	GDP Volume Index	Population Number Thousands	Oil Price Dollar/Barrel	Delay	Correction Parameter	DW	Durbin h
Volume index of agricultural production 1995=100	54,6	576,856		-0,045689	-0,230205		0,002	1,75	
Construction output volume index 1995=100	90,8	-4140,33	4,15	0,37294			0,106	1,78	
Cars at the end of the year	97,9	126231	19936,8		-177,915		0,024	1,9	

Total transport capacity (M freight tonne)	97,5	-14233,7	262,782		56,5807	0,39198	0,087		2,347
Rail transport capacity (M freight tonne)	83,3	2482,82	49,0334		-4,3949		0,05	1,88	
Road transport capacity (M freight tonne)	96,8	-1287,85	206,55		46,8		0,54	0,91	
Water transport capacity (M freight tonne)	58,1	-169,479	5,657			0,626	0,051		0,449
Pipeline transport capacity (M freight tonne)	63,4	1440,32	28,8242				0,264	1,29	
Passenger transport interurban (passenger-kilometre M)	29,1	-45276,4		7,02873			0,085	1,8	
Passenger transport local (Passenger-km M)	86,3	-145693	56,6511	14,552			0,45	1,096	
Passenger-kilometre passenger car (Passenger-kilometre M)		5309,99	201,675			0,3476	-0,16		-1,44
Volume index of mining and quarrying 1995=100	45,5	-1740,8	1,34729	0,161873			0	1,88	
Production volume index of food, beverages and tobacco products 1995=100	83,8	142,621		-0,0136095		0,92811	0,12		0,9
Production volume index of textiles, clothing, leather and leather products 1995=100	80	-1260,21	0,524149	0,127556			0,47	1,05	
Manufacture of wood and paper products, volume index of printing activities 1995=100	97,1	-77,5294	1,98393			-0,155561	0,088		0,718
Volume index of coke production and petroleum processing 1995=100	75,3	-1147,54	0,5547	0,115	0,111		0,01	1,975	
Volume index of production of chemicals and products 1995=100	83,7	15,9486	0,623331				-0,005	1,97	
Pharmaceutical production volume index 1995=100	90	1445,9		-0,132996	0,374		-0,13	2,258	
Production volume index of rubber, plastic and non-metallic mineral products 1995=100	98	-276,788	3,61595				0,15	1,67	
Production volume index of basic metals and fabricated metal products 1995=100	86,7	-1971,37	2,28898	0,179108			0,124	1,744	
Volume index of manufacture of computer, electronic and optical products 1995=100	89,5	-2131,43	2,19964	0,189409		0,667942	-0,135		-0,749
Volume index of electrical equipment production 1995=100	84,4	-1561,64	19,2646				0,47	1,05	
Volume index of the manufacture of machinery and equipment 1995=100	96,6	10244,5	-3,84133	-0,954288	1,21699	0,426724	-0,2		-4,77
Volume index of vehicle production 1995=100	97,3	-630,919	12,0555		-1,30935		0,386	1,2	

Other manufacturing; volume index of installation and repair of industrial machinery and equipment 1995=100	97,8	2411,18		-0,231217		0,589196	-0,0038		-0,062
Manufacturing Volume Index 1995=100	98,6	-216,65	3,8544				0,0666	1,8	
Electricity, volume index of gas, steam and air conditioning supply 1995=100	72,9	-680,016	0,44322	0,0682883		0,425674	-0,026		-0,358
Volume index of industry without water and waste management 1995=100	98,7	-162,289	3,12173				0,057	1,83	

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

25Table - Production or energy use of industrial subsectors in 2019, 2030 and 2050[125] (Source:REKK estimate)

Industrial sector	**Subsector**	**Unit of measurement**	**2019**	**2030**	**2050**
Iron and steel industry	Iron and steel production - blast furnace	Mt	1,15	0	0
	Manufacture of iron and steel - electric arc furnaces (EAF)	Mt	0,35	1,57	1,77
	Other	PJ	5,37	6,45	9,38
Chemical and pharmaceutical industry	Manufacture of ammonia	Mt	0,51	0,60	0,77
	Olefin production	Mt	0,91	1,07	1,37
	Manufacture of chlorine	Mt	0,27	0,32	0,41
	Other	PJ	27,51	32,37	41,62
Manufacture of basic non-ferrous metals		PJ	4,88	4,88	5,38
Manufacture of non-metallic mineral products	Cement / clinker	Mt	2,43	3,29	4,88
	Glass - Flat glass	Mt	0,30	0,41	0,60
	Glass - Hollow glass	Mt	0,14	0,18	0,27
	Glass - Light source, lamp	Mt	0,08	0,11	0,16
	Glass - insulation material	Mt	0,05	0,07	0,10
	Ceramic - Brick	Mt	0,67	0,91	1,35
	Ceramics - Tiles	Mt	0,02	0,03	0,04
	Ceramics - Sanitary	Mt	0,02	0,03	0,04

[125] *Unit of measurement: Mt: million tonnes production volume, PJ: petajule energy consumption*

	Ceramics - Fireproof	Mt	0,01	0,01	0,02
	Other	PJ	13,02	17,59	26,11
Manufacture of vehicles		PJ	9,70	9,70	12,42
Manufacture of machinery		PJ	18,71	18,71	27,33
Mining and quarrying		PJ	1,57	1,57	1,81
Manufacture of food, beverages and tobacco products		PJ	27,81	27,81	39,28
Manufacture of paper and paperboard	Paper ETS	Mt	0,71	0,88	1,22
	Pulp, pulp ETS	Mt	0,02	0,03	0,04
	Paper and pulp NETS, printing	Mt	2,91	3,63	5,03
Manufacture of wood (excluding furniture)		PJ	5,05	6,49	9,00
Construction		PJ	12,24	17,24	26,88
Textile and leather industry		PJ	1,69	1,35	1,35
Other industrial sector		PJ	12,79	16,65	22,48
Material use		PJ	41,81	49,18	63,24

Primary solid biomass

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

The supply of forest firewood was modelled using the *bio-economy (FOX) model developed by REKK.* [126] This was based on the *National Forest Data Repository and* Sopp's increment tables and forest management statistics published by the *National Land Centre (NFK),* such as harvests, tree selections, assortment prices and operating costs. We also assumed that the forestry sector, as part of the LULUCF sector, would have to play a significant role in meeting the CO2removal target set by the European Union in April 2023. Compared to the reference period (2016-2018), the average value of -4 791 kt CO_2e reported in the emissions inventory[127] under the LULUCF Regulation should be increased by almost one million tonnes (-5 724 kt CO_2e by 2030). Therefore, during the modelling, we assumed a

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

[127] *Consolidated: REGULATION (EU) 2018/841 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018*

climate policy regulation that ensures that the Hungarian forestry sector approaches this target by 2030.

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

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

26Table . - Estimates of capacity limits for primary solid biomass in the heel years considered (Source: REKK)

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

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

Agriculture

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

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

Waste management (including sewage treatment)

We used the Tier 2 methodology to project GHG emissions from waste management, such as the calculation of methane emissions from waste disposal in the IPCC Waste Model (2019). With regard to activity data, i.e. the amount of waste disposed of, measures taken in the field of waste management have the effect of reducing the amount of waste landfilled, which is also supported by the Biogas Concept. In addition, on the input side, biological treatment of waste, composting of municipal waste and sewage sludge were taken into account. Tier 1 methodology was used with default emission factors, the trend was determined by changes in activity data. (HungaroMet WEM modelling)

Industrial processes and material use

In the Hungarian IPPU sector, compliance with air quality standards and the *Methane Ordinance* provides the most important regulatory framework, and the replacement of grey hydrogen also has a significant impact. The GHG and air pollutant forecasting systems have been harmonised. The input data used to predict IPPU emissions[128] comes from the National Clean Development Strategy 2020-2050. The calculation of the forecasts is based on the HU-TIMES model.

In the case of material uses, in the mineral sector according to IPCC codes, cement was calculated using the GAINS model. Additional emissions from the mineral sector have been calculated on the basis of time series for energy use in non-metallic mineral production. In the case of ammonia and nitric acid, natural gas use in the WEM scenario was used as a non-energy trend for the calculation of activity data. The CO_2 and N_2O emissions have been calculated using the plant-specific emission factors. In the petrochemical sub-sector, because of the wide range of substances involved, $CO_2$and CH_4emissions have been calculated on the basis of fuel consumption trends. The calculation of the metal sector was based on the production of steel calculated on the basis of the production forecast. $CO_2$and CH_4emissions have been calculated based on the use of natural gas, coke and COG in pig iron and sinter production.

Land use, land use change

The project describes the GHG emissions of the LULUCF sector. In the land sector, CO2emissions are predominant. The WEM projection assumes the continuation of measures under the Common Agricultural Policy for 2014-2022, taking into account FAO forecasts for 2018. The assumptions of the WAM projection until 2027 are based on the measures of the

[128] *https://unfccc.int/sites/default/files/resource/LTS_1_Hungary_2021_EN.pdf*

CAP Strategic Plan, and in the following period we assume further changes due to the development of carbon farming incentives (certification schemes, carbon markets). Depending on the emission category, a Tier 1 Tier 2 methodology was used for the projection.

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

Forestry

Forests are characterised by a trend-increasing annual GHG balance between 1990 and 2020 according to the GHG inventory, with relatively large annual fluctuations. Among the many reasons for the latter, the methods used to monitor forests and to update the data stored *in the Forest Stock Repository* also play a role. In line with the methodological requirements to achieve the climate targets set out in the relevant EU regulations, estimates limited to carbon emissions have been supplemented with estimates for all emission sources included in the GHG inventory, such as forest fires, burning of waste, forest abandonment and carbon dioxide from organic soils.

For the projection of existing forests, both scenarios were based on the state of the areas considered as forests in the Forest Stock Database under the Forest Act as known at the end of 2021. Every year we simulated the processes that take place in the forests that change the carbon stock of the individual carbon pools of the forests, and with the[129] help of the CASMOFOR model we quantified the effect of these processes on the amount of carbon sequestered. Assumptions have been developed for the application of the model, for the modelling of processes directly related to forest management, and for the amount of logging. A trend line has been added to the time series of values for 2020, 2021 and 2022 reported for the carbon balance of our forests in the GHG inventory, thus projecting the value of carbon sequestration in 2023. Subsequently, taking into account the afforestation, the projected value of the CASMOFOR and CASMOFOR-NFD model results for 2023 was adjusted to the value of the trend line for 2023. The difference between the WEM and WAM scenarios is that WAM assumes a gradual reduction in logging with higher planting rates. We also assume that mortality will not increase significantly due to climate change or any other reason, but will

[129] *https://www.scientia.hu/casmofor/index.php*

follow the trends so far, and the growth of trees will continue at the pace of the recent past. The effects of climate change may increase over time and take different forms, but due to the uncertainty of the occurrence of damage, we use the assumption that their extent will remain at the same level as before. (SOE modeling)

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

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

27Table 1 - Factor price forecasts (Source: EC (2023) and REKK analysis and estimation)

	2019	2025	2030	2035	2040	2045	2050
Oil price, $/barrel	64,3	76	85	94	97	105	121
Natural gas price, €/MWh	16	33,8	32,4	29,5	36,4	35,6	34,6
Coal price, €/GJ	2,1	4,1	3,1	3,8	3,8	4,0	4,0
CO_2quota price (ETS), €/t	25	95	95	100	100	160	190
Biomass price, HUF/GJ	1 940	2 200	2 200	2 200	2 200	2 200	2 200

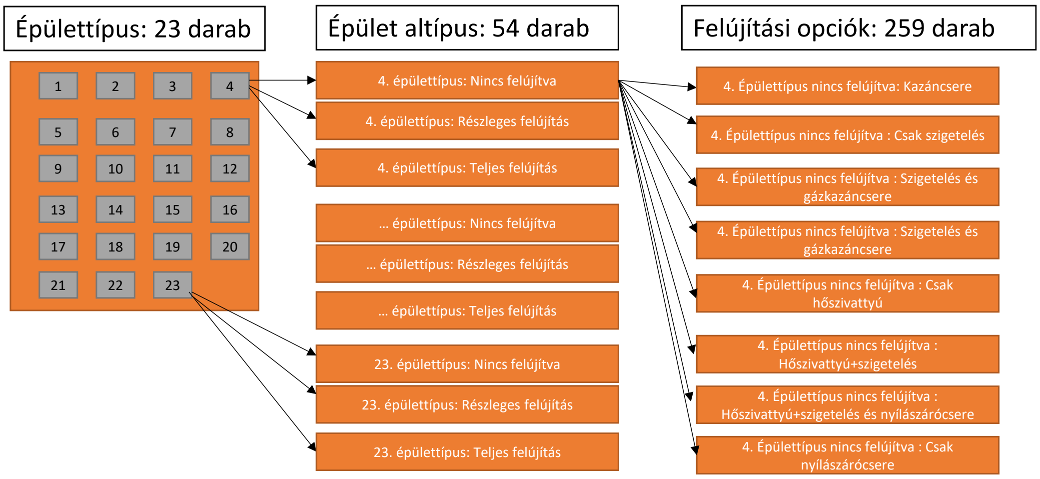
In addition to wholesale prices, the extent of **other retail price components** – taxes, network charges, wholesale and retail margins – also has a significant impact on the results of the modelling. They are defined individually for each fuel and each sector. We assumed that the extent of these changes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

iv. Evolution of technology costs

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

Building sector

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



6Figure - Renovation options for building types (Source: REKK)

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

28Table 1 - Specific cost per floor area of each renovation element (HUF/m^2) (Source: BME)

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

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

In the case of the building sector, neither changes in renovation costs nor their efficiency gains were taken into account, so the change in technology costs is not reflected in this sector.

Electricity and heat generation

A total of 24 different technologies were distinguished for the electricity and heat production sectors. Of these, 16 technologies relate only to electricity generation, 5 to combined heat and power (CHP) installations and three to heat-only technologies. With the exception of six technologies, they are already available on the market, so they can be used in modelling as early as the first year. Renovation of wind power plants can only be achieved by the end of the lifetime of the 330 MW wind power plant capacity currently in operation, while power plants with carbon sequestration (CCUS) have only been made available from 2030 onwards.

29Table - Estimated lifetime and change in efficiency of electricity and heat generation installations between 2020 and 2050 (Source: (REKK)[130]

	Technology	Lifetime	Efficacy, %			
			2020	2030	2040	2050
Renewable electricity producers	Geothermal	30	36%	36%	36%	36%
	Wind power plant - new	25	-*	-*	-*	-*
	Wind power plant - renovation	25	-*	-*	-*	-*
	Solid biomass	40	47%	49%	51%	53%
	Solid biomass - CCUS	40	42.3%	44.3%	46.3%	48.3%
	PV - household size	25	-*	-*	-*	-*
	PV - medium size < 1 MW	25	-*	-*	-*	-*
	PV - large > 1 MW	25	-*	-*	-*	-*
Conventional power plants	Coal power plant, without CCUS	55	42%	44%	46%	48%
	Coal power plant using CCUS	55	42%	44%	46%	48%
	OCGT, without CCUS	40	47%	49%	51%	53%
	Using OCGT, CCUS	40	47%	49%	51%	53%
	CCGT, without CCUS	30	56%	58%	60%	62%
	Using CCGT, CCUS	30	56%	58%	60%	62%
	Nuclear	50	33%	33%	33%	33%
Combined heat and power plants (electricity efficiency)	Natural gas	15	32%	33%	34%	35%
	Solid biomass	15	20%	20%	20%	20%
	Biogas - landfill	25	57%	57%	57%	57%
	Biogas - wastewater	25	46%	46%	46%	46%
	Biogas - agricultural	25	50%	50%	50%	50%
Heat producers	Gas boiler	30	92%	92%	92%	92%
	Geothermal	20	100%	100%	100%	100%
	Biomass boiler	15	85%	85%	85%	85%

[130] *Note: * Not relevant, no transformation loss in energy balance, no fuel cost*

30Table - Typical cost data for electricity and heat generation installations (Source: REKK data collection)[131]

	Technology	Investment cost, €/kW				Fixed annual cost, €/kW	Annual variable cost, €/GJ
		2020	2030	2040	2050	Unchanged over time	
Renewable electricity producers	Geothermal	5 217	5 217	5 217	5 217	95,7	0,0
	Wind power plant - new	1 670	1 572	1 480	1398	35,0	0,0
	Wind power plant - renovation	1 069	1 006	947	892	35,0	0,0
	Solid biomass	870	870	870	870	34,8	0,0
	PV - household size	1 332	1 080	891	750	10,0	0,0
	PV - medium size	922	747	616	519	7,0	0,0
	PV - large	717	581	479	404	5,0	0,0
Conventional power plants	Coal power plant, without CCUS	2 586	2 460	2 339	2 225	28,3	1,3
	Coal power plant using CCUS	5 726	5 726	5 726	5 726	66,2	1,3
	OCGT, without CCUS *	879	877	876	874	6,7	0,7
	Using OCGT, CCUS *	1 700	1 700	1 700	1 700	13,8	0,7
	CCGT, without CCUS *	922	918	913	909	14,0	1,3
	Using CCGT, CCUS *	1 827	1 827	1 827	1 827	28,9	1,3
	Nuclear	7 000	7 000	7 000	7 000	108,0	2,2
Cogeneration plants	Natural gas	820	816	812	808	19,3	5,6
	Solid biomass	3 000	3 000	3 000	3 000	3,3	4,9
	Biogas - landfill	1 750	1 750	1 750	1 750	262,5	0,0
	Biogas - wastewater	5 625	5 625	5 625	5 625	281,3	0,0
	Biogas - agricultural	3 008	3 008	3 008	3 008	423,8	0,0
Heat producers	Gas boiler	94	94	94	94	5,8	0,3
	Geothermal	1 400	1 400	1 400	1 400	17,2	0,0
	Biomass boiler	281	281	281	281	10,6	0,3

Transport

When defining transport technologies and costs for **motorcycles, we assumed that the current and expected future role of diesel propulsion** for powered two-wheelers (three-wheelers) would be very limited. Hybrid vehicles also exist, but their uptake is currently very slow, mainly concentrated in Asia, and their future role is questionable. The reason for this is that in the case of relatively smaller vehicles, the doubled drive system can mean extra weight and complexity, which is also reflected in the service costs. In addition, especially in the higher-performance segment, some models are expected to appear, as the range of electric propulsion for shorter-distance vehicles in local traffic will mostly meet demand, and the range is likely to increase further in the future. For this reason, only gasoline and electric

[131] *Note: * For OCGT, only variable costs other than fuel costs are included in the table. As OCGT is a significantly simpler technology than CCGT, it has lower operating costs.; Source: REKK data collection*

technologies are currently considered as options in the model. Technological progress is reflected in the increased efficiency of motorcycles and the cost reduction potential of electric vehicles, in line with the expected reduction in battery costs of 25% of the value of the vehicle.

As **a new technology for passenger cars,** hydrogen fuel cell passenger cars will appear in the model, which will be available from 2025. In addition, current technologies are constantly evolving until 2030, which means lower consumption and changes in procurement costs. In line with the literature, the cost of electric and hydrogen fuel cell vehicles is slightly decreasing and the cost of vehicles equipped with internal combustion engines is increasing, as increasingly complex technological solutions need to be used to meet the ever-increasing emission requirements.

In addition **to modern diesel, hybrid, CNG and electric vehicles for buses,** hydrogen fuel cell vehicles for long-distance transport and new diesel buses for long-distance transport, hybrid and fuel cell vehicles were also expected. Of the hybrid technologies, only conventional hybrid propulsion was considered. This is because, in long-distance transport, the distance travelled in the electric shift may be low due to the time lost due to charging time, and in local transport, the increase in range and new charging solutions, such as fast chargers at stops, may make the installation of two types of propulsion systems unnecessary over time.

According to information provided by transport service providers (BKK, MÁV-Start), no alternative fuel technology (e.g. hydrogen) is expected to be available for **track-based vehicles** by 2030, and no substantial reduction in consumption is expected for more modern electric technologies compared to current young (0-5 years old) vehicles. As a result, no new tram and metro technology will appear in the model, instead the use of devices equivalent to those currently in circulation (CAF, Alstom) is expected. In the case of suburban railways, a new fictitious technology will be available, which will be more efficient than the older suburban railway technology in the case of other railway vehicles. The new technology will be available in the model from 2025, as no new vehicles have yet been purchased in 2023. In the case of new rolling stock, the consumption of rolling stock will not change until 2030, and in the case of suburban railways, the improvement observed for other rolling stock is expected. Analog technology with KISS multiple units will be available in the model from 2020. Since diesel passenger trains aged 0-5 years are not in circulation, it was necessary to define a new technology that consumes less energy in line with the observed efficiency gains in track-based vehicles.

The new vehicles that can be entered by the model can be petrol, diesel, electric, plug-in hybrid, hydrogen fuel cell and CNG powered vehicles for the light commercial vehicle category, and petrol, diesel, electric and hydrogen powered vehicles for short-distance and long-distance transport. For the higher load categories, the rechargeable (diesel) hybrid version is not included in the options, for the reasons mentioned for buses, but is calculated using conventional hybrid technology. As far as natural gas propulsion is concerned, CNG propulsion was taken into account in the category below 12 tonnes, while LNG propulsion was taken into account for vehicles above 12 tonnes. Following the emergence of new models in the heavy goods vehicle category, it was assumed that electric and hydrogen propulsion could also appear as possible alternatives in the future for vehicles above 3.5 tonnes.

Industrial sectors

The table below shows the industrial sub-sectors where technology-level analysis was carried out. This approach has been applied in sectors where existing data has made this possible. For cases not included in the table, the subsector was examined on an aggregate basis. The table below shows how many different technologies the model can choose as an investment option for the sectors analysed in detail.

31Table - Number of new technology options for the industrial sectors analysed in detail (Source: REKK)

		Standard technology	Advanced technology
Iron and steel industry	Blast furnace	1	5
	Electric arc furnace	1	2
Chemical and pharmaceutical industry	Ammonia	2	3
	Olefi	2	2
	Chlorine	2	1
Manufacture of non-metallic mineral products	Cement	1	1
	Glass - Flat glass	1	4
	Glass - Hollow glass	1	4
	Glass - Light source, lamp	1	3
	Glass - insulation material	1	2
	Ceramic - Brick	1	5
	Ceramics - Tiles	1	5
	Ceramics - Sanitary	1	2
	Ceramics - Fireproof	1	4
Manufacture of food, beverages and tobacco products		1	0
Manufacture of paper and paperboard	Paper ETS	2	5
	Pulp, pulp ETS	1	3
	Paper and pulp NETS, printing	1	1

4.2. Dimension of decarbonisation

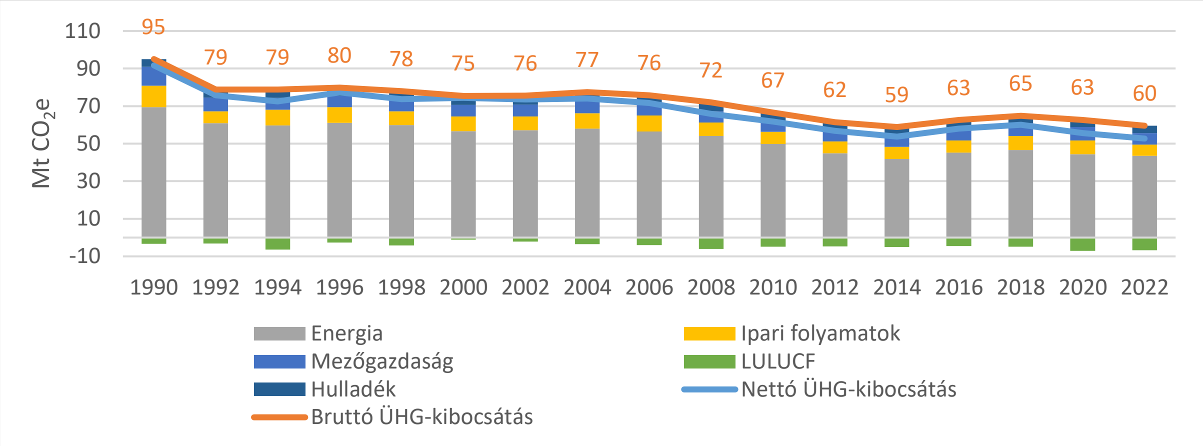
4.2.1. Greenhouse gas emissions and removals

i. Current trends in greenhouse gas emissions and removals in the EU Emissions Trading System, Effort Sharing Regulation sectors and LULUCF sectors and different energy sectors

Detailed information on historical GHG emissions can[132] be found *in Hungary's 2023 National Inventory Report*, which is briefly summarised in this chapter. The most prominent anthropogenic greenhouse gas is **carbon dioxide (CO2),** which accounts for 76% of all emissions. The majority of CO2 is generated in the energy sector by burning fossil fuels.

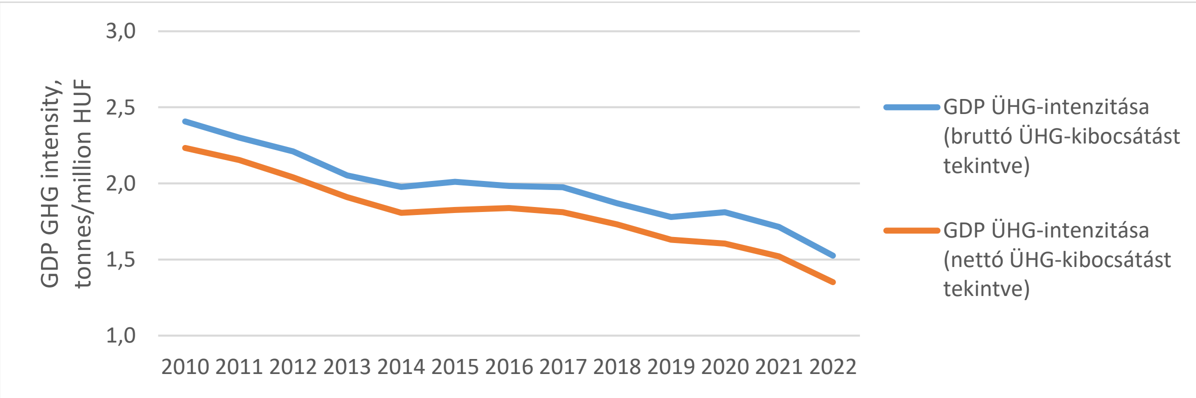
[132] *National Inventory Report of Hungary, 2023, UNFCCC, https://unfccc.int/documents/627849*

According to the GHG Inventory calculations for 2021, Hungary's GHG emissions net of land use, land use change and forestry (gross) in[133] 2021 were 63.7 million tonnes of CO_2equivalent (CO_2e). This is 32.9% lower than the 95.06 million tonnes of CO2e in 1990. Including the land use, land use change and forestry (LULUCF) sector, (net) GHG emissions reached 56.5 million tonnes of CO_2e, a 38.3% reduction compared to 91.7 tonnes of CO_2e in 1990. Gross emissions per capita in 2021 were 6.6 tonnes, below the EU average (7.8 tonnes per capita).[134]



7Figure - Evolution of greenhouse gas emissions by sector (1990-2021, Mt CO_2e/year) Source: Eurostat

Although emissions have stagnated in recent years, it is positive that the GHG intensity of the Hungarian economy, i.e. the GHG emissions associated with the production of unit GDP, has improved by 28.8% since 2010, indicating that **climate protection does not hinder economic growth and may even strengthen it**.



8Figure - GHG intensity of GDP (2010-2021) Source: Eurostat

<u>Energy sector</u>

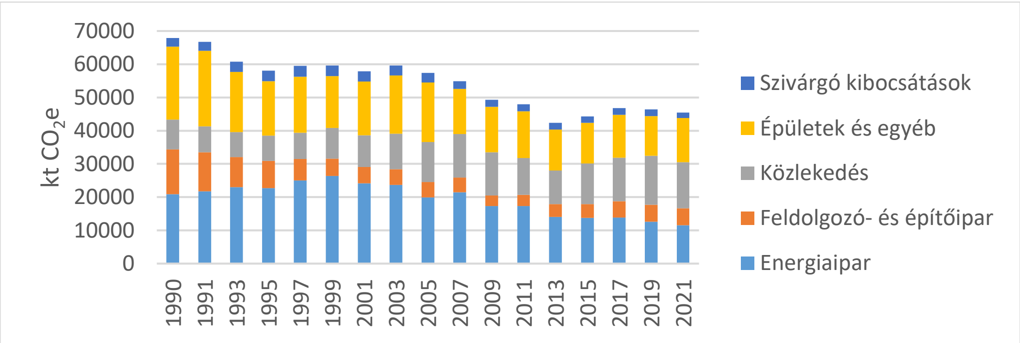
The largest share of total emissions, 72%, came from the energy sector in 2021. In the energy sector, fossil fuel combustion is the largest source of carbon dioxide, accounting for

[133] *In addition to the LULUCF sector, the value does not include memo items (e.g. bunker fuels, biomass emissions, etc.).*

94.6% of greenhouse gas emissions. Fossil gases contributed 48%, liquid fuels 31% and solid fuels (lignite) 6% to GHG emissions from fossil fuel combustion in 2021.

The most prominent sector in the energy sector is **transport,** with a share of 31%, followed by the group **of 'other sectors'** – residential and commercial buildings, agriculture, forestry, fisheries combustion of fuels – **and related emissions,** with 29%. The **energy sector,** which includes the power and heat generation sector, petroleum refining and solid fuel production, was the largest segment until 2018, but in 2021 it ranked third in the energy sector and emitted 25% of GHG. Autoproducer production in the **manufacturing sector** contributed 11% to emissions in the energy sector. Leaking emissions from the extraction, processing, transformation and distribution of oil and natural gas accounted for 4%. GHG emissions from sub-sectors of the energy sector have decreased by 40-62% since 1990, except for **transport,** which has increased by more than one and a half times over the same period. The transport sector reached its highest emissions in 2019, the year before the COVID-19 outbreak, and started to rise again after a temporary downturn in 2020.

Looking at the trend over the past 5 years, the reduction **in emissions in the energy sector** is visible despite the fact that gross electricity production increased by 13% between 2016 and 2021 and the amount of district heating production is about the same as in 2015. This is due to the increase in the share of natural gas-based and renewable production in the production mix. While the share of renewable electricity generation increased from 10% to 19% and the share of natural gas-based electricity generation increased from 20% to 27%, the share of coal-based generation decreased from 18% to 8% over the same period. The re-arrangement of production by fuel can also be observed in heat production, the share of natural gas-based heat production increased from 69% to 74%, and coal-based heat production decreased from 5% to 2%.



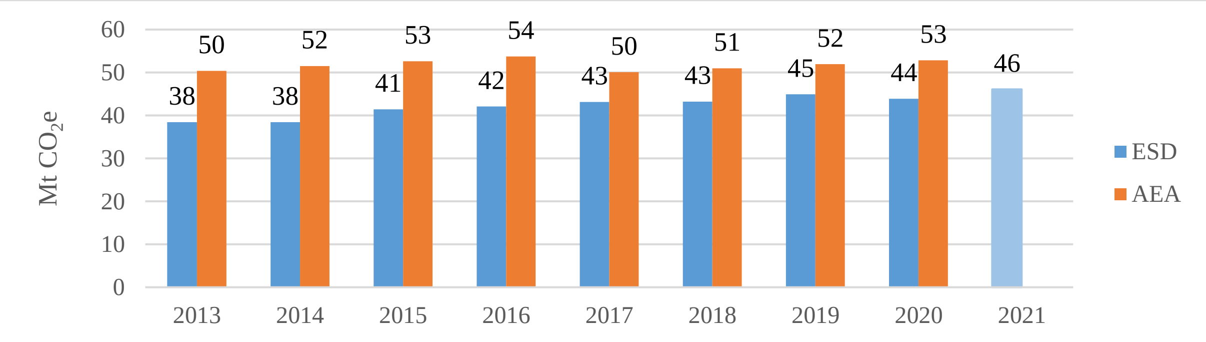
9Figure - Emissions from the energy sector by source (1990-2021, kt CO_2e/year) Source: Eurostat

'Other**sectors'** – the residential, commercial and public sectors, as well as agriculture, forestry and fisheries – have seen a 40% reduction in GHG emissions since 1990, but the trend for 2016-2021 shows an increase of 4%. This is driven by an 8% increase in emissions from households and agriculture, forestry and fisheries, offset by a 9% reduction in emissions from the commercial and public sectors.

<u>Effort Sharing Decision and Regulation (ESD and ESS)</u>

Emissions in sectors not covered by the ETS were regulated by the *EU Effort Sharing Decision (ESD)* for the period 2013-2020, which will be replaced by a Regulation *(Effort Sharing Regulation, ESS)* from 2021.[135] The two sets of rules ensure the emission reductions required by Member States for the sectors they cover by setting annual emission allocations. Detailed emissions data are currently available for the ESD coverage period 2013-2020. Transport, buildings, agriculture and waste were responsible for the largest share of emissions under ESD, but also (small) industrial energy use and F-gas emissions.

The *European Environment Agency (EEA)* calculated that the ESD/ESR sector emitted a total of 46.6 million tonnes of CO2e GHG in 2021. The figure below shows the total emissions of *the sector and the evolution of the allocated emission allocations (AEAs)* since the introduction of the regulation in 2013. It can be seen that Hungary complied with the legislation in the given years, i.e. emissions did not reach the level of allocated entitlements. However, with the exception of the temporary fall caused by the COVID-19 outbreak in 2020, total ESD/ESR sector output has been steadily increasing, meaning that it has not yet been put on a downward path. The 2021 emission value shown in the figure is already covered by the Regulation (ESR) that entered into force in 2020, so the amount of emission allocation for 2021 will change in line with the above-mentioned 2023 regulatory amendment.[136]



10Figure - Evolution of annual emission allocations (AEA) and GHG emissions (ESD) under the Effort Sharing Decision (2013-2021, Mt CO_2e/year) Source: EUTL and EEA[137]

Household, commercial and institutional **(building) sectors and the transport sector contributed** the most to the emissions covered by the ESS in 2020, with 29% and 28% respectively. Transport GHG emissions in 2020 were only 4.2% higher than in 2005 due to reduced transport activity as a result of the COVID-19 outbreak. Buildings, on the other hand, emitted 41% less GHG in 2020 than in 2005, partly due to energy efficiency measures and partly due to the use of cleaner energy sources.

[135] *Effort Sharing Decision, 406/2009/EC and Effort Sharing Regulation, Regulation (EU) 2018/842, as amended by Regulation (EU) 2023/857.*

[136] *Through the 2023 revision, the 7% emission reduction target initially set for Hungary for 2020-2030 has been increased to 18.7%.*

[137] *Source: EUTL, https://ec.europa.eu/clima/ets/transactionsCompliance.do?languageCode=en and EEA, https://www.eea.europa.eu/data-and-maps/data/esd-4 (11.10.2023)*

Emissions from **agriculture** increased by 18% compared to 2005 and contributed 17% to total emissions from the ESS sector in 2020. Agricultural activities emit $CH_4$and N_2O. N_2This sector accounts for the largest share of our O emissions, 83%, including the LULUCF sector. Greenhouse gas emissions from agriculture have been increasing almost continuously since 2011, mainly due to the use of fertilisers and the increase in cattle numbers.

The **waste management sector**contributed 8% to the overall ESS emissions. Landfilling generates the bulk of the sector's emissions (86%), while waste water treatment accounts for 9%, composting for 4% and incineration for non-energy purposes for 1%. Emissions have stopped growing in the previous decade and have already fallen by 23% between 2005 and 2017.

According[138] to EEA data, emissions from **energy installations** covered by the ESS increased by 40% between 2005 and 2020, and this segment of industrial installations emitted 45% more GHG in 2020 than in 2005.

Emissions **of F-gases** accounted for 8% of total emissions in 2020. It reached its highest level of F-gas emissions in 2015 and, after a significant reduction, started to rise again in 2017. Compared to 2005, it was 80% higher in 2021.[139]

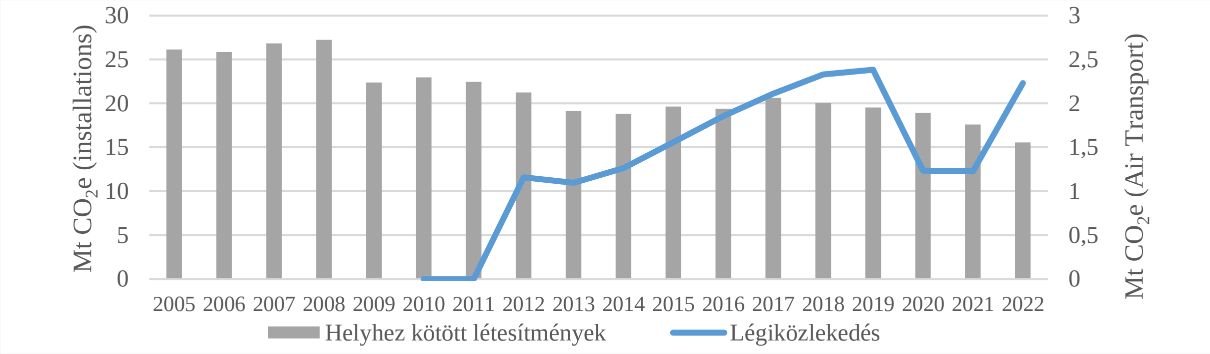
Overall, therefore, the sectors covered by the ESD/ESR, with the exception of buildings and the waste management sector, have seen an increase in emissions.

EU ETS

Hungary's GHG emissions under the EU ETS (excluding aviation) amounted to 15.6 million tonnes of CO2e in 2022, 41% less than in 2005. The country's GHG emissions under the EU ETS decreased steadily between 2009 and 2014, with the exception of a minor correction in 2010. After 2014, the trend was reversed and overall emissions increased by almost 10% until 2017. However, after 2018, total emissions returned to a downward trajectory.

Aviation **emissions almost** doubled between 2012 and 2022, from 1.2 million tonnes to 2.2 million tonnes of CO2e. The COVID-19 pandemic was the only impediment to continued growth in 2020 and 2021, but the trend quickly reversed and GHG emissions returned to their pre-pandemic levels in 2022.

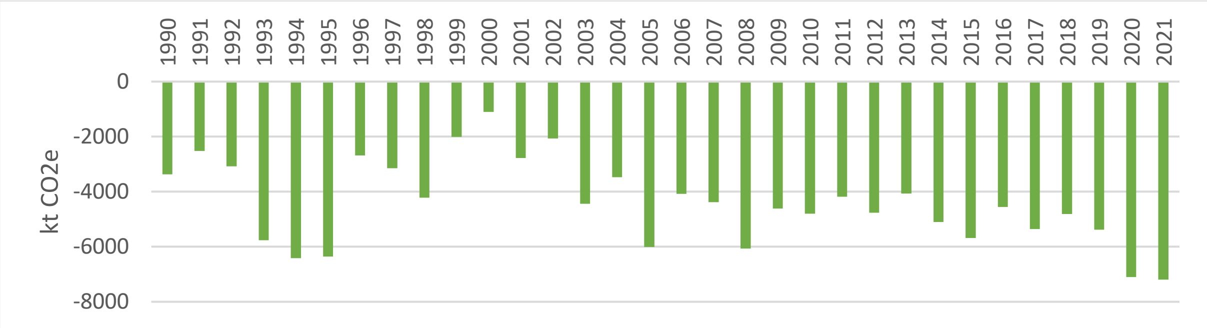
[138] *Source: EEA, https://www.eea.europa.eu/data-and-maps/data/data-viewers/eea-greenhouse-gas-projections-data-viewer*
[139] *Source: EEA, https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer*



11Figure - Evolution of emissions under the EU ETS (2008-2022, Mt CO_2e/year)[140]

<u>Land use, land use change and forestry sector (LULUCF)</u>

Overall, *the land use, land use change and forestry (LULUCF) sector* is considered a sink due to the CO2sequestration of forests resulting from afforestation and sustainable forest management in recent decades. After 2000, the net removals from the LULUCF sector increased from -1.1 million tonnes in 2000 to -7.2 million tonnes of CO_2e in 2022.



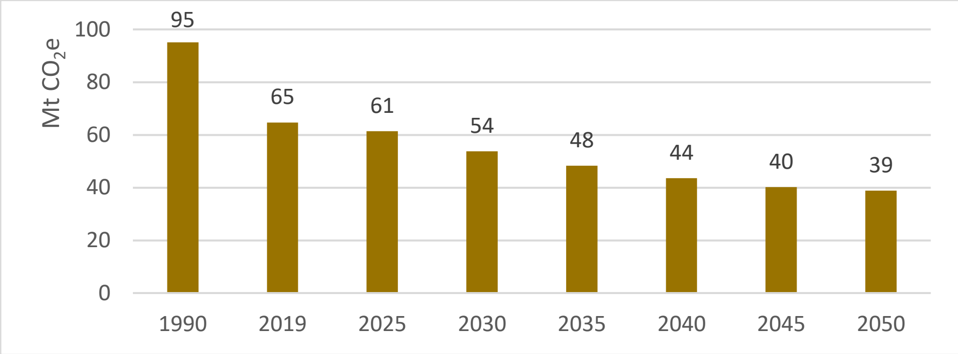
12Figure . Evolution of carbon sequestration in the LULUCF sector (1990-2021, kt CO_2e/year) Source: National Inventory Report 2023

ii. Projection of sectoral developments based on existing national and Union policies and measures at least until 2040 (including the year 2030)

The detailed results of the GHG projections are presented in Annex 4. For the energy, LULUCF and agriculture categories, a scenario taking into account the effects of existing measures (WEM) and a scenario taking into account the effects of additional measures (WAM) has been prepared. For industrial processes and product use, only existing measures have been taken into account.

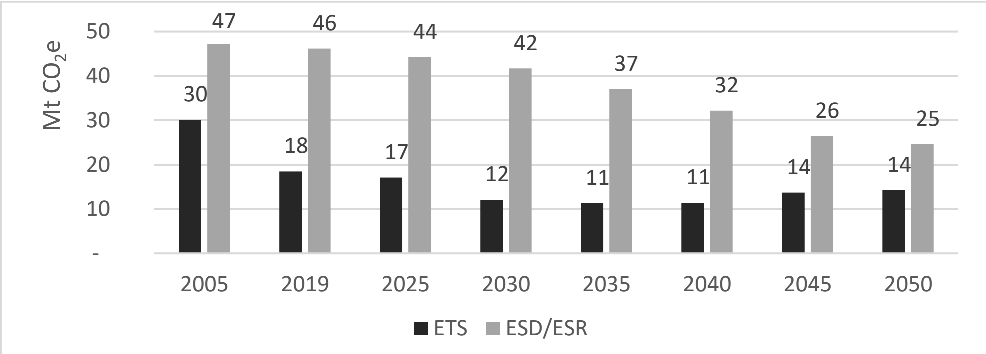
Hungary's total gross GHG emissions excluding the land use, land use change and forestry sector are expected to decrease to 53.7 Mt CO_2e by 2030 in the WEM scenario, representing a 17% reduction compared to 2019 and a 43% reduction compared to 1990.

[140] *Source: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1*



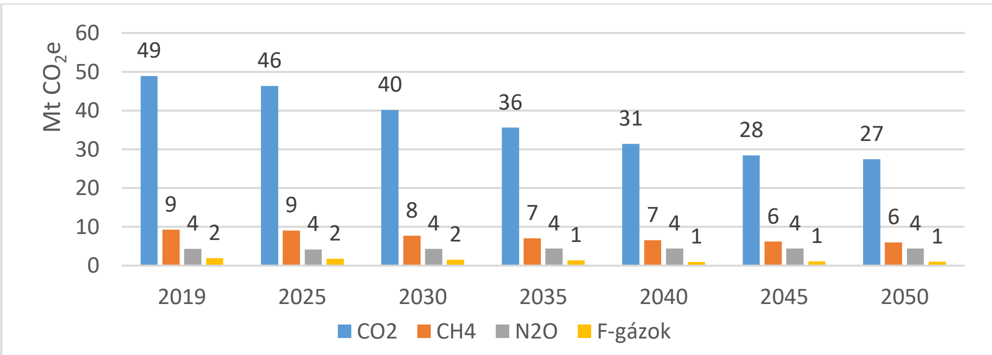
13Figure - Total gross GHG emissions with existing policies and measures (1990-2050, Mt $CO_{2}e$/year)

Emissions under the EU ETS will be reduced by 35% by 2030 compared to 2019, while emissions under the ESD/ESR will be reduced by 10%.



14Figure - ETS and ESS emissions with existing policies and measures (2019-2050, Mt $CO_{2}e$/year) Source: REKK, Eurostat

In the WEM scenario, CO2 remains the most significant GHG. CO2 emissions will be reduced by 18% by 2030 compared to 2019, while CH4 emissions will be reduced by 17% and F-gases by 21%. Meanwhile, N_2O emissions increase by 0.02%. NF_3 emissions are not among the domestic emissions and are not expected to appear in the Hungarian GHG inventory.

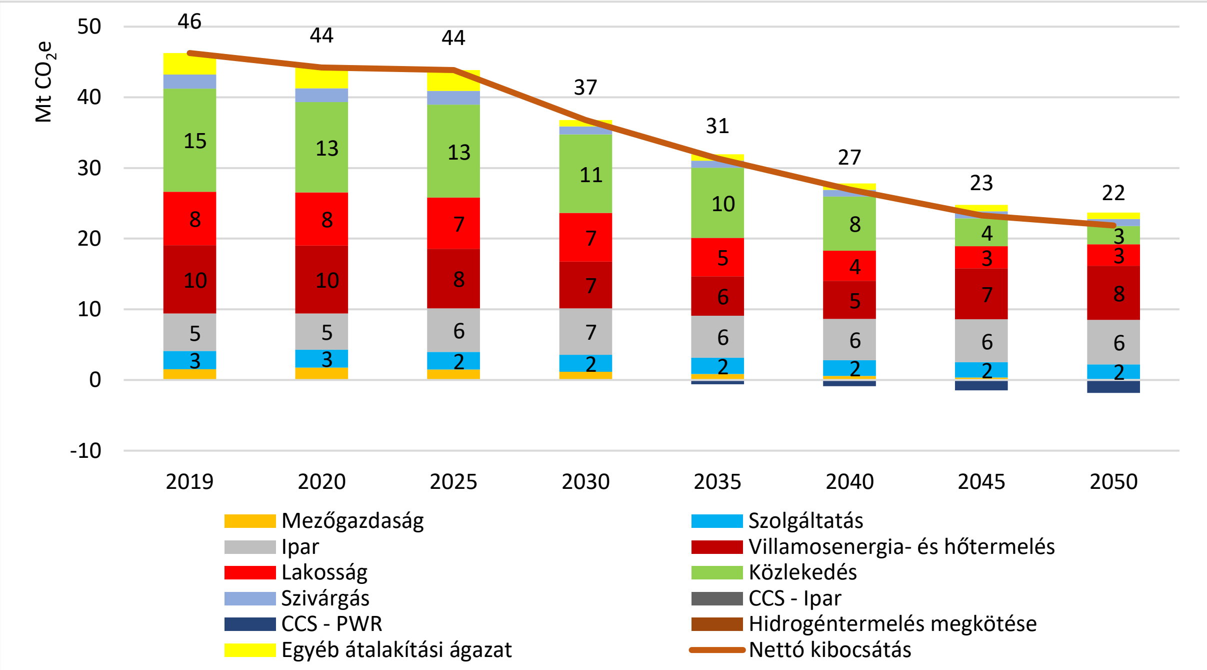


15Figure - Evolution of net greenhouse gas emissions in the WEM scenario, by gas (2019-2050, Mt $CO_{2}e$/year) Source: REKK, AKI, HungaroMet, Eurostat

Energy sector

Greenhouse gas emissions from the energy sector will change significantly by 2050, including in the WEM scenario. Compared to 2019 (gross), the reduction will be close to 21% by 2030 and 49% by 2050.

Transport (29%), energy (22%), population (17%) and manufacturing and construction (12%) were the main contributors to energy-related emissions in the base year. By 2050, the contribution of each sector to total emissions will change significantly. By 2030, although with reduced emissions, transport will retain its weight (30%), while the energy industry will only be responsible for 18% of energy-related emissions. Industry will play an increasingly important role in emissions across the energy sector by 2030 and 2050, accounting for 18% by 2030 and 29% by 2050. Emissions from the residential sector will be reduced by ~60% by 2050 and its share of total energy emissions will be 14%, compared to 19% in 2030. By contrast, the services sector's emissions will decrease by 19% by 2050, compared to 2019, and its share will be 7% by 2030 and 9% by 2050.

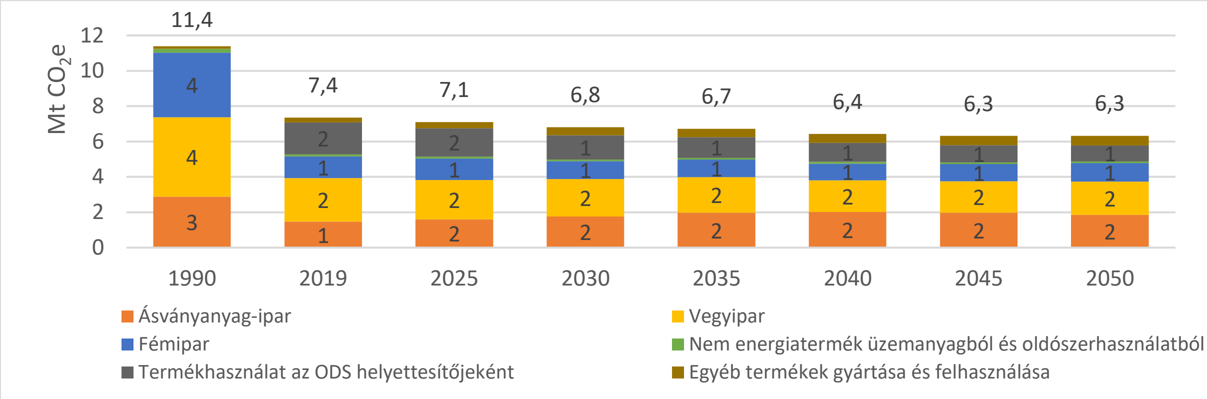


16Figure – Sectoral composition of greenhouse gas emissions in the energy sector, WEM scenario (Mt CO_2e/year)

Source: REKK, Eurostat

Industrial processes and product use

Based on existing measures, total GHG emissions from the industrial processes and product use sector (IPPU) show a larger reduction of 7% by 2030 compared to 2019, followed by a further 7% reduction over the next 20 years.

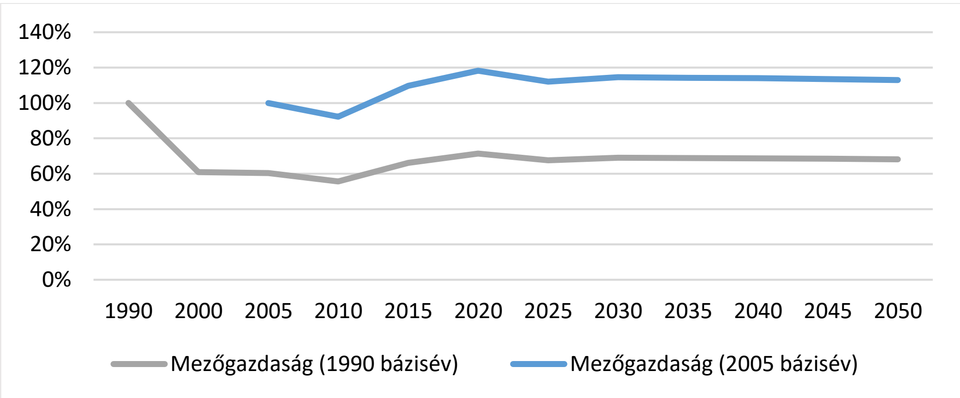


17Figure - Composition of IPPU greenhouse gas emissions, WEM scenario (Mt CO_2e/year)

Total GHG emissions from the categories ‘Non-energy products from the use of fuels and solvents’ and ‘Use of products replacing ODS’ are expected to be halved by 2050. While GHG emissions from the minerals industry are on an increasing trajectory until 2030, emissions from these sectors, as well as from the chemical and mainly metals sectors, are projected to decline more significantly, leading to an overall reduction in industrial (non-energy) emissions. At the same time, the reduction will slow down between 2030 and 2050, as mature industrial emission reduction solutions currently available will have been implemented by then.

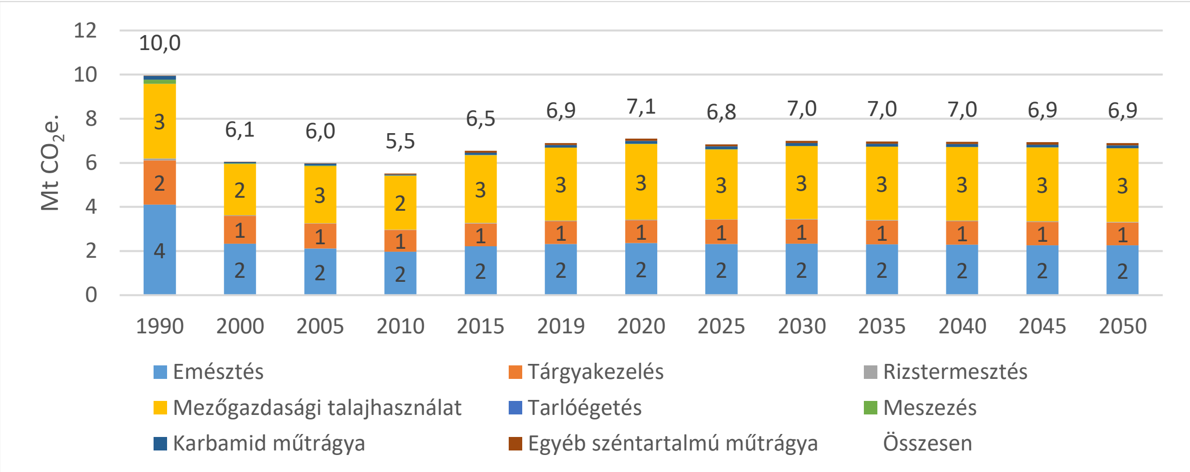
Non-energy emissions from agriculture

Agricultural GHG emissions under the WEM scenario are expected to be 7 Mt CO2e in 2030 and 6.9 Mt CO2e in 2050. Emissions are slightly reduced (-0.6%) between 2019 and 2030, which translates into reductions of 30.9% and 31.9% between 1990-2030 and 1990-2050. Significant emission reductions are due to the livestock digestion and manure treatment categories, both of which fell by 45.1% and 50.1%, respectively, between 1990 and 2050.



18Figure – Greenhouse gas emissions from the agricultural sector compared to 1990 and 2005 levels in the WEM scenario between 2000 and 2050 Source: AKI, Eurostat

Emissions **from soil use** account for 48.4% (3.3 Mt CO_2e) of total GHG emissions from the agricultural sector in 2050. Emissions from tillage in the WEM scenario will be slightly below 1990 levels in 2050 as a result of reduced livestock and livestock manure use, compensated by increased fertiliser use. These emissions are 4% lower in 2030 than in 1990, while an increase of 26.3% is expected over the period 2005-2030 due to increasing fertiliser use. Emissions **from the digestion of farmed animals represent a significant share (32.7%) of the total sector's** GHG emissions in 2050 and are expected to be 2.3 Mt CO_2e. Emissions from this category will decrease significantly (-45.1%) over the period 1990-2050. Emissions are 43.2% lower in 2030 than in 1990 and slightly increasing between 2005 and 2030 (+10.5%). GHG emissions **from manure treatment** in 2050 are only 1 Mt CO_2e, which is 50.1% less than in 1990. This is expected to decrease by 47.7% between 1990 and 2030 and by 9.8% between 2005 and 2030. The significant decrease is due to changes in dairy cow and pig herds. GHG emissions from **the use of urea-based** fertilisers will be reduced by 24.2% by 2050 to 0.13 Mt CO_2e, compared to 1990. Emissions are expected to increase one and a half times between 2005 and 2030.



19Figure – Greenhouse gas emissions from the agricultural sector in the WEM scenario between 1990 and 2050 Source: AKI, Eurostat

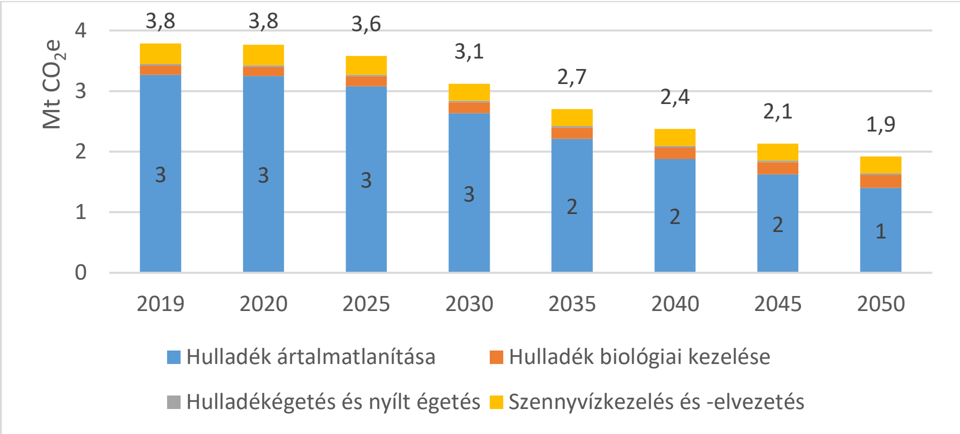
Total agricultural **CH_4emissions** in the WEM scenario are 3 Mt CO_2e in 2050, which is 46.3% less than in 1990. CH_4emissions will slightly increase between 2005 and 2030 (+5.5%). Digestion **emissions** account for more than 75% of the sector's total CH_4emissions, i.e. 2.3 Mt CO_2e in 2050. CH4emissions from animal digestion, although decreasing by 45.1% between 1990 and 2050, are expected to increase slightly between 2005-2030 and 2005-2050 (+10.5% and +6.8% respectively). **CH_4emissions from manure treatment** also represent a significant proportion. Despite increasing emission levels from poultry farming, the decline in pig population has led to a 48% reduction over the period 1990-2050, i.e. a 7.8% reduction over 2005-2030 and an 11.8% reduction over 2005-2050.

In the WEM scenario, **N2Oemissions from** the agricultural sector are expected to decrease by 12.3% to 3.7 Mt CO2e between 1990 and 2050 and increase by 21.1% between 2005 and 2050. By 2030, emissions are 12.5% lower than in 1990 and 20.8% higher than in 2005. Despite the decrease in livestock, the slight decrease can be explained by the negligible reduction due to tillage. Soil **use accounts** for more than 90% of N2Oemissions in 2050, 3.3 Mt CO2e.

The CO2 emissions of the agricultural sector under the WEM scenario are expected to decrease by 37.5% between 1990 and 2050 to 0.24 Mt CO_2e. However, due **to the increase in the use of urea and other carbon fertilisers,** emissions will increase by 65.8% between 2005 and 2030. However, emissions from the use of urea fertilisers are still 23.5% lower in 2030 than in 1990.

Waste management sector (including waste water treatment)

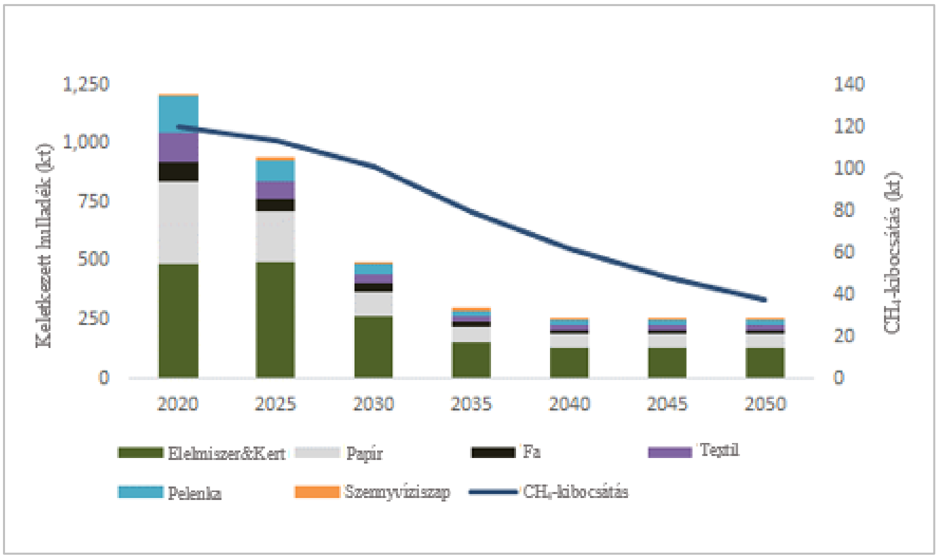
GHG emissions from the waste management sector are expected to be halved by 2050 compared to 1990 and reduced by 18% by 2030.



20Figure – GHG emissions of the waste (and waste water) sector under the WEM scenario (Mt CO_2e/year) Source: Eurostat, HungaroMet

Although methane emissions **from landfilling** are expected to decrease the most (-57% from 1990 to 2050), this source category remains the most important for emissions from the waste management sector. Its shares are 86%, 84% and 73% in 2019, 2030 and 2050. Both the expected increase in composting and biogas production will lead to increased emissions in the source category **of biological treatment of waste.** In the current WEM scenario, emissions are already increasing by 21% by 2030 and by 43% by 2050 compared to 2019. As regards waste water treatment, we expect a steady increase in the energy recovery of sewage sludge, which could increase methane leakage, and on the other hand, a higher connection speed to centralised, tertiary treated waste water treatment plants would result in higher nitrogen removals and thus lower N2Oemissions. As a result, greenhouse gas emissions **from wastewater treatment** would be reduced by 18% between 2019 and 2050, most of which (i.e. 17%) would already be achieved by 2030.

For municipal waste, **landfilling will be reduced from over 2 million tonnes to 0.8 million tonnes in 2030 and 0.4 million tonnes in** 2040 . One of the reasons for this is the improvement of the separate collection of waste and the pre-treatment system of waste, thus reducing the amount of waste disposed of by landfilling and shifting it towards recycling, biogas production and recovery in thermal incineration (with increased capacity). The planned amount of disposal by landfill of the main types of degradable waste (food, paper, etc.) and the resulting CH_4emissions are as follows.



21Figure - Quantity of waste disposed of by landfilling (kt) Source: HungaroMet

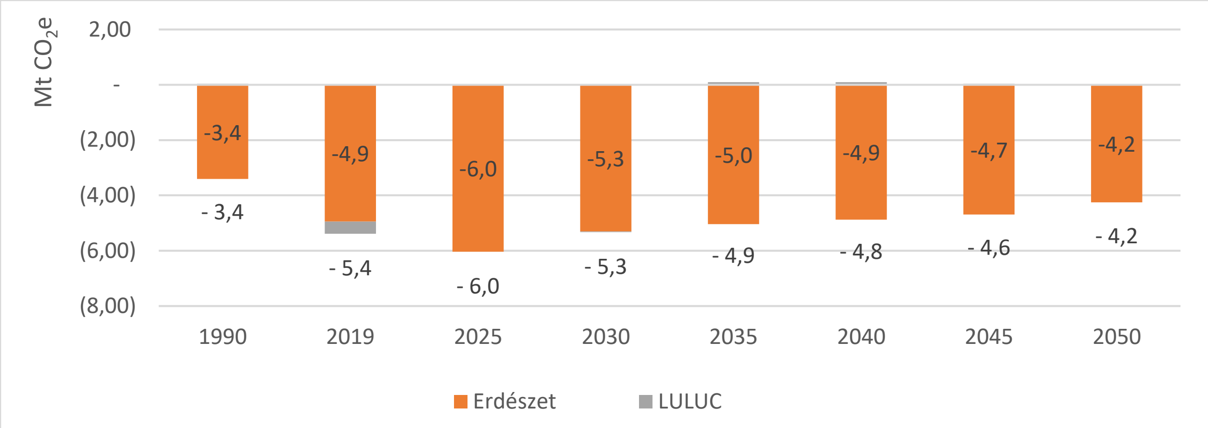
The sources included biological treatment of waste, composting of municipal waste and sewage sludge. The amount **of composted municipal waste** is assumed to increase from 0.4 Mt in 2020 to 0.6 Mt in 2030 and to remain unchanged thereafter. Incineration **without energy recovery currently** accounts for only 1% of emissions in the waste sector and no significant change is expected. We assumed an increase of 4.4% in **the composting of sewage sludge** every 5 years, taking into account leaks from other biogas production. Methane emissions from wastewater treatment and discharges are largely determined by the proportion of dwellings connected to the public sewerage network, which is expected to increase further by 2030 (by 4-8%$_{\text{points}}$). In parallel, the utilization of sewage sludge gas would increase by 11% and overall by about 30% by 2050.

In terms of **N2Oemissions,** no significant change in per capita protein consumption is expected. However, tertiary treatment would reach 99% by 2035 (from the current 89%), which would increase the removal of nitorgen from waste water and consequently reduce N2Oemissions.

LULUCF sector

In order to model the CO2sink capacity of the LULUCF sector, existing forests, afforestations[141] and non-forest land uses have been modelled using different methodologies reflecting the domestic situation, due to[142] their different nature and different projection data needs.

[141] *CASMOFOR (2001; 2023) and CASMOFOR-NFD (2019): Dr Z. Somogyi, SOE-ERTI (http://www.scientia.hu/casmofor)*
[142] *Institute of Agricultural Economics*



22Figure - Net GHG removals of the LULUCF sector under the WEM scenario, 1990-2050 (Mt CO_2e) Source: AKI, SOE ERTI, Eurostat

For forestry, net removals of 4.9 Mt CO2e are projected by 2030 based on the WEM scenario. In addition, in terms of land use and land use changes, the WEM project projects low GHG emissions (94.21 kt CO_2e) by 2030, which will be gradually reduced and balanced by 2050.

Forestry

A CASMOFOR-NFD **model was used to predict the carbon absorption capacity of existing** forests in order to determine the so-called forest reference level. The projection of changes in the carbon stock of individual forest carbon pools is based on the state of forests as known at the end of 2021, followed by a quantified simulation of annual natural and forest management processes. The model is compatible with the methodology of the IPCC (2006, 2019) and the Hungarian GHG inventory, which can be found in the National Forest Stock Database (OEA; It manages forests registered in the National Forestry Database (NFD) and some of its parameters have been determined based on its data. CASMOFOR-NFD is a dynamic growth model that estimates woody biomass (above and below ground) and deadwood carbon pool for all forests in Hungary. The following data and assumptions were applied during the modelling.

During the modelling, the characteristics of the forest area are recalculated annually. The data required for quantification are available at varying depths. Most measurement data are available **for above-ground wood biomass** and more recently **for dead wood quantity,** while the magnitude of carbon stock change for **underground wood biomass** can be calculated using the scale factor used in the GHG inventory. However, we do not have adequate data for the avar and **soil** carbon pools, so in the case of avar, we assume that the amount of carbon captured in the avar correlates with that of woody biomass, i.e. it grows slowly, while in the case of the soil of existing forests, we assume a carbon stock change of

0.[143] Emissions from forests, which are accounted for in the GHG inventory, such as CH_4 and N_2O emissions from the incineration of slaughterhouse waste or forest fires, and CO_2emissions from organic soils, are assumed to be the same and perpetuated at the 2020 level.

In connection with forestry, the **reduction in the stock of live trees associated with nursery cuttings and end-use** and the planned tree species for forest regeneration have been established. With **regard to logging,** we assume that the average annual upward trend in recent years remains unchanged.

32Table - Scale of logging assumed in the WEM scenario (thousand m3/year,2021-2050) (Source: SOE ERTI)

	2021	2025	2030	2035	2040	2045	2050
Logging (e m^3/year)	7523	8032	8280	8528	8776	9024	9272

As the annual increments will be much higher than the total logging resulting from this increase by 2050, the assumed annual logging shown in the table above meets the criteria for **sustainable wood use.** The same assumption is used for the development of forests, i.e. the growth rate of trees is based on recent trends.

The forest area used in the model is the same as the areas identified as forest parcels in the OEA at the end of 2021, for which data on **area (ha) and stocks of live trees (m^3) were available by age group (150), group of tree species (22) and harvest class (6-6 FTO).** The characteristics of tree stands (area and stock of live trees) and their changes over time are described in the model as a function of these three groups. The areas affected by the final use are placed in the minus three-year age group determined by experts before the first age group, thus mapping the assumed average time needed to start forest restoration. From these basic data, the parameters of the annual timber stock and the 132 Chapman-Richards function can be calculated, from which the differential factors of the timber volume can be derived.[144]

Although the carbon sequestration capacity of the 2021 living wood stock is much higher than that of the deadwood carbon pool, this capacity may decrease significantly over time. This decrease is due to (1) an increase in the volume of logging, (2) a significant change in the age distribution of forests over time. The reason for the change in age distribution is, on the one hand, the different types of end-uses and the distribution of past afforestations by time, tree yield classes and tree species. Net **carbon sequestration is not a permanent** feature of forests. From this, the forestry sector still needs to find a way to at least postpone the reduction of carbon sequestration in order to approximate the carbon neutrality targets. In **addition to reduced logging, increasing afforestation,** among other things, can help.

In addition to the CO2 absorption capacity of existing forests, WEM forecasting of **the LULUCF sector requires forecasting of the CO2 absorption capacity of afforestations**

[143] According to the demonstration carried out under the Kyoto Protocol, the soil of domestic forests is not carbon-emitting.
[144] The R program was based on the so-called robustbase module, e.g. on this website: https://blogg.slu.se/forest-biometrics/2017/03/11/the-chapman-richards-growth-function/).

resulting from existing policies. The projection of afforestation was made with CASMOFOR model, which is compatible with the currently used IPCC (2006, 2019) guidelines and the methodology of the domestic greenhouse gas (GHG) inventory (NIR, 2023).

The model calculates, in an annual step, **the changes resulting from the modelled processes for each forest carbon pool – living wood, dead wood, mulch cover, soil –** and **for wood products carbon pool,** based on harvesting tables, literature and expert estimates, according to the data and methods presented below. The best estimate can be made for above-ground biomass because most and most accurate data are available in this area. The growth of the above-ground carcass is modelled using standard tree yield tables. The forest management model tables have been updated on the basis of forest economic calculations and expert estimates. Mortality is calculated based on forest inventory and other information using an expert-estimated rate (mortality at a given age is equal to the current stock of trees multiplied by that rate). The decomposition of dead organic matter is modelled with simplified functions based on literature data. The dynamics of foliage and root system are modelled on the basis of literature data, the IPCC (2006) Guidelines and expert estimates.

It should also be borne in mind that the implementation of projects designed to neutralise emissions is affected, inter alia, by climate change. The growth and death of trees, as well as all other forest processes that are important for forest carbon turnover, depend on how environmental factors, including some climatic factors, change. Few results have yet been achieved in this field under domestic circumstances, so the projection was made on the assumption that no significant changes in forest processes and growth laws will occur – they will develop in line with those modelled in the tree yield tables. In the case of afforestation, the amount of carbon sequestered in the soil can be significant and has been estimated based on the methodology and carbon stock change factors of the GHG inventory (NIR, 2023).

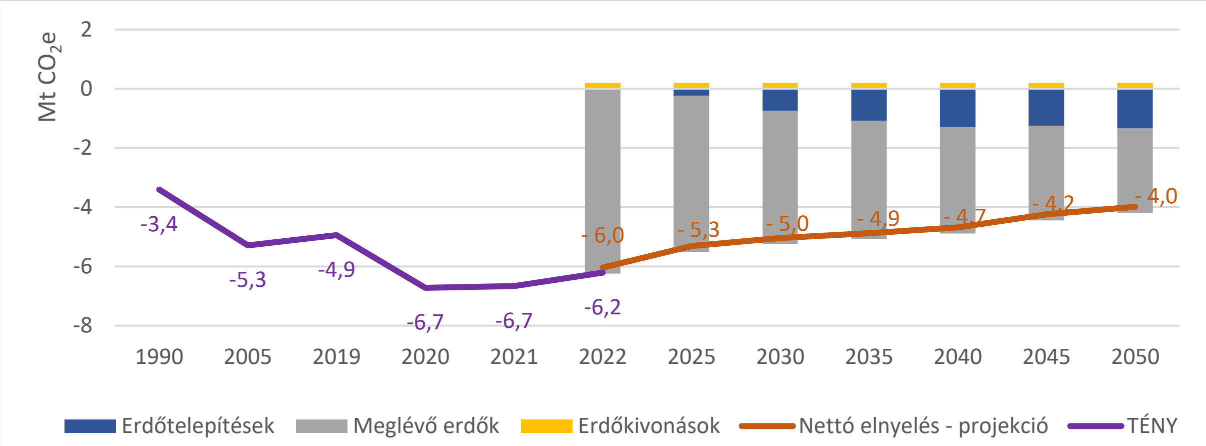
In view of the fact that there is no separate tree production or forest management model available for each domestic tree species, it was necessary to use models derived for each tree species or group of tree species specified in the scenario, as shown in the table below.

33. Table - List of tree species and groups of tree species used in afforestation and the tree yield table and tree yield class used for them, according to the purpose of planting (Source: SOE-ERTI)

Purpose of afforestation	Tree species – groups of tree species	Model of applied tree species
Conventional forest management	Black locust	Acacia (timber class 4)
	Unsedged oak (KTT)	SAC (timber class 4)
	Cherry and other hard leafy (Cser + EKL)	Shrub (timber class 3)
	Forest pine and Black pine (EF + FF)	EF (timber class 3)
	Domestic Poplar and Other Soft Leafy (HNY + ELL)	HNY (timber class 4)
	Noble poplar and white willow (NNY + DDA)	NNY (timber class 3)
Industrial (cylindrical wood plantations)	Black locust	Acacia (timber class 3)
	Noble poplar and white willow (NNY + DDA)	NNY (timber class 2)

The settings of the model tree species used also determine other required model parameters (e.g. tree density). The area of plantation of industrial plantations accounts for one tenth of total afforestation. The planting of plantations further increases the area of tree species that are also dominant in traditional forestry forests – acacia, poplar and white willow.[145]

The above is illustrated in the diagram below.



23Figure – Expected evolution of CO2emissions and removals (net carbon balance) of the forestry sector, based on the WEM scenario (Mt CO_2e, 1990-2050) Source: SOE-ERTI

4.2.2. Renewable energy

i. Current share of renewable energy in gross final energy consumption and in different sectors (heating and cooling, electricity and transport) and by technology in each of these sectors

In 2021, the share of renewables in gross final energy consumption was[146] 14.1% in Hungary. Between 2010 and 2021, the share of renewable energy in total gross final energy consumption increased from 7.1% to 13.7%[147] (RES-E) in electricity consumption and from 0.2% to 6.2% (RES-T) in transport. In the area of heating and cooling, the renewable energy share (RES-H/C) slightly decreased from 18.1% to 17.9%. According to statistics, the heating sector in Hungary uses the most renewable energy, mainly through the combustion of solid biomass (firewood) by households, but unlike the electricity and transport sectors, the use of renewable energy in the heating sector has not been able to increase recently. 69.2% of renewable energy use in2021 was for heating and cooling, 20.2% for electricity generation and 10.6% for transport.

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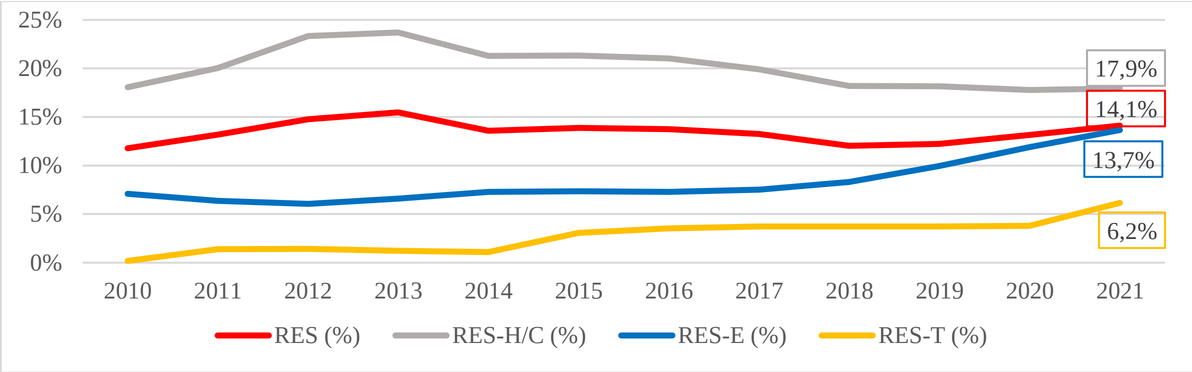
[145] *The results are always interpreted as net sequestration, because it is true for every carbon pool that there are processes that increase the size of the given carbon pool, but there are also processes that decrease it, so the presented quantities are always the result of these processes with opposite effect.*

[146] *The indicator 'share of renewable energy sources in gross final energy consumption' is the official indicator for monitoring the 2030 target set out in Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources.*

From[147] 2021, the use of new multipliers in line with RED II rules also increased the share of renewable energy in the transport sector, mainly due to biofuels.



24Figure – Evolution of the renewable energy share in each sector (RES – cumulative renewable energy share, RES-H/C – renewable energy share in heating and cooling, RES-E – renewable energy share in electricity consumption, RES-T – renewable energy share in transport) (2010-2021, %) Source: Eurostat

The actual use of **solid biomass,** which is the backbone of renewable energy use, depends to a large extent on the price and consumption of other energy carriers. A strong substitution effect has been observed in the residential use of natural gas and solid biomass for years. Until 2021, the natural gas consumption of the population increased, while the solid biomass consumption of the population showed a decreasing trend. Although domestic use of both natural gas and biomass declined in 2022 in the global political and economic context of the war, the substitution effect remains, based on preliminary data, with a renewed increase in the demand for firewood due to increased natural gas prices.

34Table – Share of renewable energy use in gross final energy consumption by sector (2021) (Source: Eurostat)

	Total renewable energy use in gross final energy consumption PJ	**Share of renewables in gross final energy consumption %**
Total renewable energy consumption in gross final energy consumption (2021)	116,6	14,1
Electricity	23,57	13,7
Heating and cooling	80,73	17,9
Transport	12,31	6,2

In the area of heating and cooling, the share of biomass in renewables has increased the most as a result of the 2020-2022 energy crisis, given that the residential sector has either fully switched or used firewood heating as an additional solution for heating.

Solar power generation, biomass and geothermal based district heating production, as well as heat pump systems and the use of biofuels with mandatory blending rates have increased dynamically in recent years.

35Table – Consumption of renewable energy in gross final energy consumption by sector and technology (2010 – 2021) (Source: Eurostat)[148]

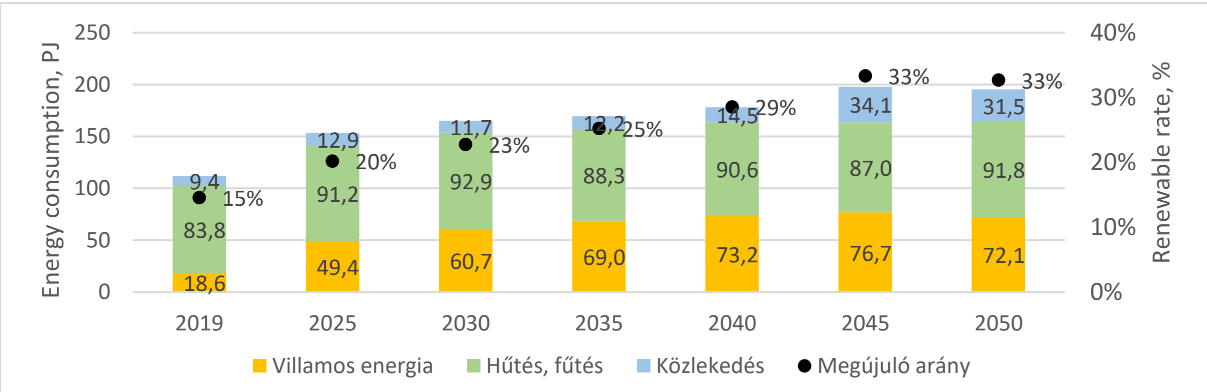
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Electricity (GWh)												
Water	208,5	215,4	216,7	222,5	228,3	229,8	232,3	231,6	234,4	237,0	237,3	244,4

[148] *Note: * Other renewable energy production e.g. ** The decrease is due to a methodological change*

Wind	517,5	645,2	700,7	703,9	703,9	701,1	705,5	702,7	679,7	689,1	677,7	677,2
Day	0,9	1,4	7,9	24,6	67,0	141,0	244,0	349,0	629,0	1497,0	2459,0	3796,0
Solid biomass	2034,3	1526,9	1333,0	1429,2	1702,0	1661,0	1492,8	1645,0	1798,0	1769,0	1664,0	1654,0
All other renewables*	262,2	332,1	321,8	402,8	424,4	500,3	578,3	512,0	513,8	480,9	511,8	304,6
Total	3023,4	2721,0	2580,1	2783,0	3125,6	3233,1	3253,0	3440,3	3854,9	4673,0	5549,9	6676,2
Transport (PJ)												
Electricity in road transport	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0**
Electricity in rail transport	0,7	0,8	0,8	1,0	1,0	1,1	1,2	1,3	1,3	1,3	1,3	0,4**
Electricity in all other modes of transport	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0**
Biofuels	7,3	6,9	6,5	6,0	8,1	7,3	7,8	6,9	8,0	8,4	11,6	11,9
Total	8,0	7,7	7,2	7,0	9,1	8,4	9,0	8,2	9,3	9,8	13,0	12,3
Heating-cooling (PJ)												
Final energy consumption	75,4	86,0	92,1	95,8	78,9	83,8	82,5	80,6	70,7	68,4	68,1	72,4
Derived energy	3,3	3,5	3,2	4,8	5,1	6,8	8,5	8,0	7,3	7,1	7,3	7,3
Heat pumps	0,0	0,0	0,1	0,1	0,2	0,2	0,2	0,3	0,3	0,5	0,5	0,9
Total	78,6	89,5	95,4	100,8	84,2	90,8	91,2	88,9	78,3	76,0	75,9	80,6

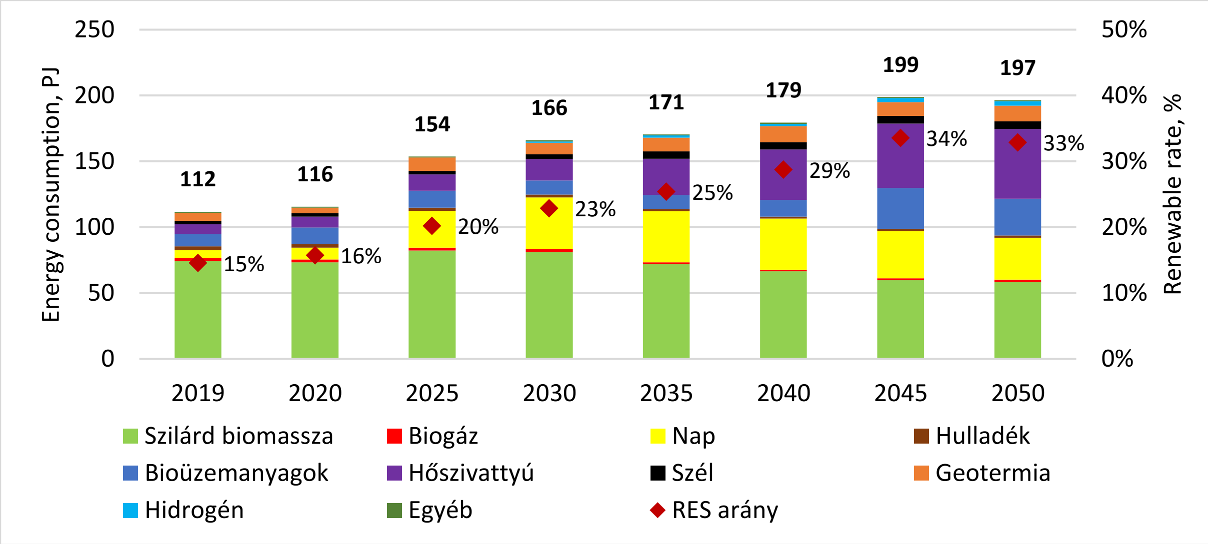
ii. *Indicative projection of progress based on existing policies up to 2030 (with an outlook to 2040)*

Currently, therefore, the majority of renewable energy use comes from the heat sector, but we can see a significant shift in the time horizon under consideration. The electricity sector has an increasing share of total renewable energy use, accounting for more than a third by 2050, thanks to PV and biomass-based electricity generation. The increasing use of biofuels in the transport sector will also contribute to a much more balanced use of renewable energy in the three segments in 2050. The share of the heat sector in renewable energy use will decrease from an initial 75% to 47%.



25Figure – Sectoral composition of renewable energy use, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

In the WEM scenario, total renewable energy consumption will be around 195 PJ in 2050, which is already significant compared to the current value of 116 PJ. As final energy consumption decreases, this will also contribute to increasing the share of renewable energy use. The renewable share will increase from the current level of 14.1% to 22.8% by 2030 and 32.7% by 2050, without additional measures.



26Figure – Source composition of renewable energy use, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

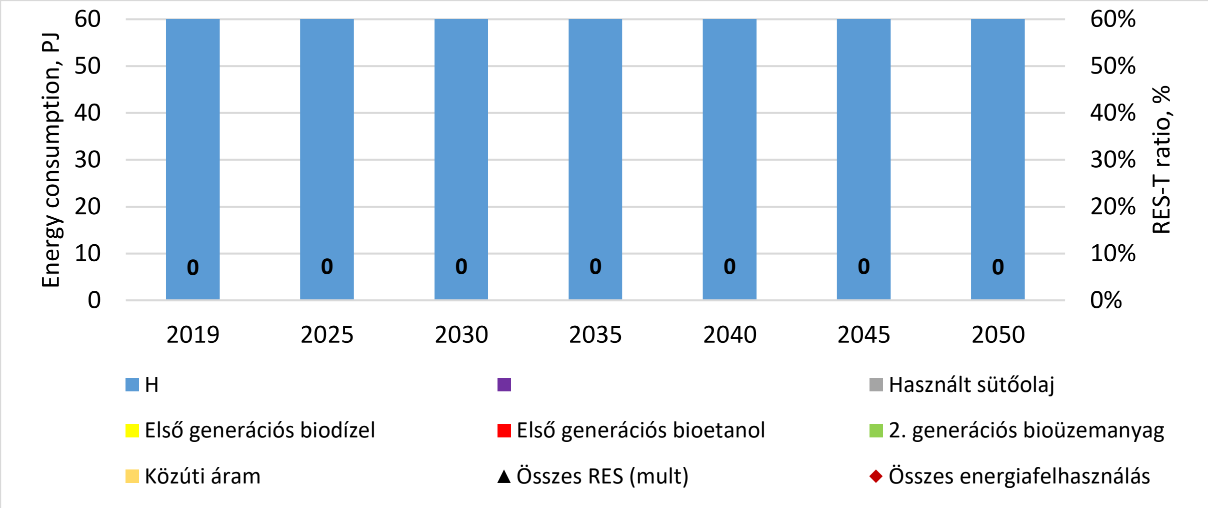
The composition of renewable energy use in 2050 paints a diversified picture compared to the current biomass-based situation. Solid biomass use falls to 30%, energy supply from heat pumps (shallow geothermal, ambient heat recovery) to 27% and the share of biofuels in renewables to 14%. Also significant is the energy generated by solar power plants, which will have a share of more than 16% in 2050, without additional measures.

Renewable energy use in the transport sector

The share of renewables in the transport sector is increasing significantly, mainly as a result of **biofuels** and sector **electrification.** By 2030, the current renewable share of around 7% will increase to 15.3%. This is mainly due to the use of second-generation biofuels, an increase in the use of electricity by the still low number of road vehicles, an increase in the use of electricity by rail through a partial shift of freight to rail, and a slight increase in hydrogen**.** The growth of the transport sector is underpinned by the miigatory incentive regime, which is reinforced by the higher excise duty levels calculated from 2026 onwards, in line with the EU minimum tax levels.[149]

The two main renewable energy sources by 2050 could therefore be second generation biofuels and electricity, but without additional measures, the share of renewable energy in the transport sector remains low in 2050.

[149] *In line with the 2023 amendment to the Directive on the taxation of energy products and electricity (2003/96/EC).*

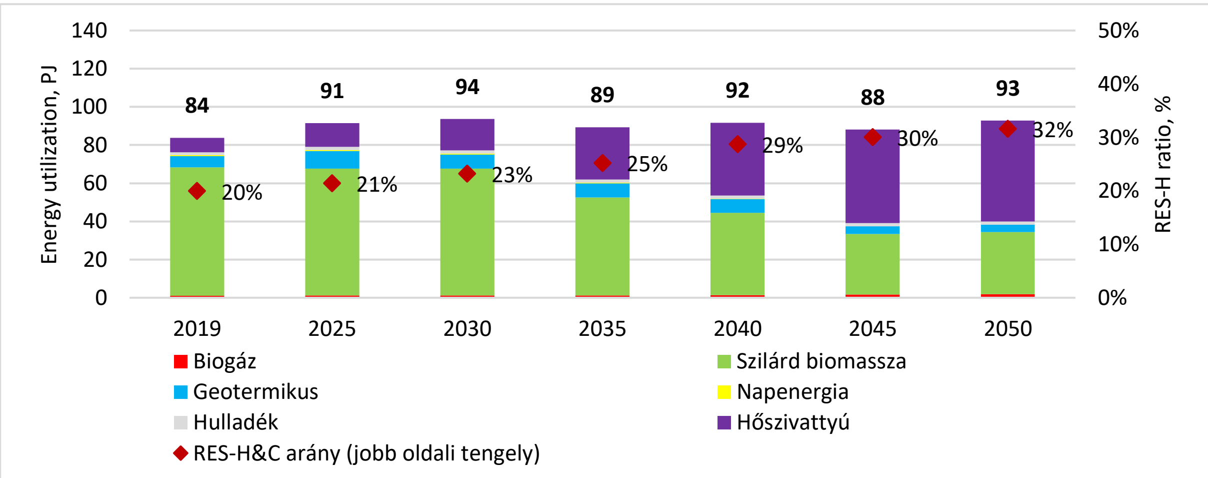


27Figure – Resource mix of renewable energy use in the transport sector, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Renewable energy use in the heating and cooling sector

In the heating and cooling sector, **solid biomass** currently accounts for more than 81% of renewable energy use. Although the WEM projections show a slight (3.3%) reduction in solid biomass use by 2030 for the population, a significant increase in solid biomass use in the industrial segment can be expected. However, due to the parallel proliferation of heat pump technologies and the increased use of geothermal energy, the share of solid biomass use among renewables in the heating and cooling sector will become less important and will decrease to 71% by 2030. After 2030, however, biomass use will be drastically reduced, mainly due to residential energy efficiency measures and fuel switching, and by 2050 it will be halved from today's use. Although the role of heat pumps and geothermal energy continues to grow between 2030 and 2050, renewable energy use in the heating and cooling sector in 2050 would be only 12% higher than today's levels.

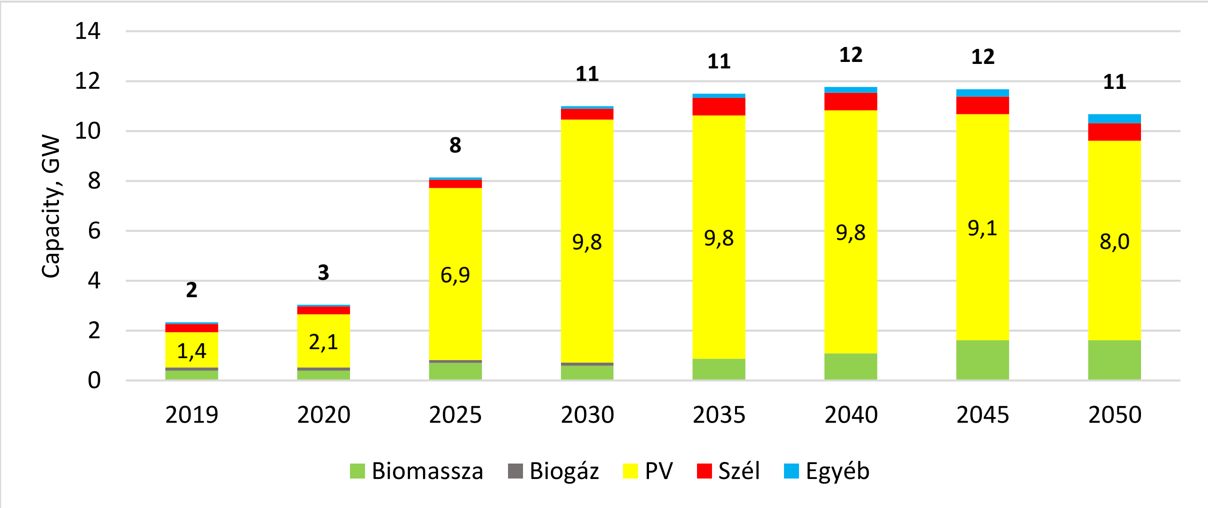
The renewable share will increase from 19.8% in 2019 to 23% in 2030 and 31.6% by 2050. Significant reductions in final energy consumption by 2050 have a major role to play in keeping the share of renewable energy consumed at the same level.



28Figure – Source composition of renewable energy use in the heating and cooling sector, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

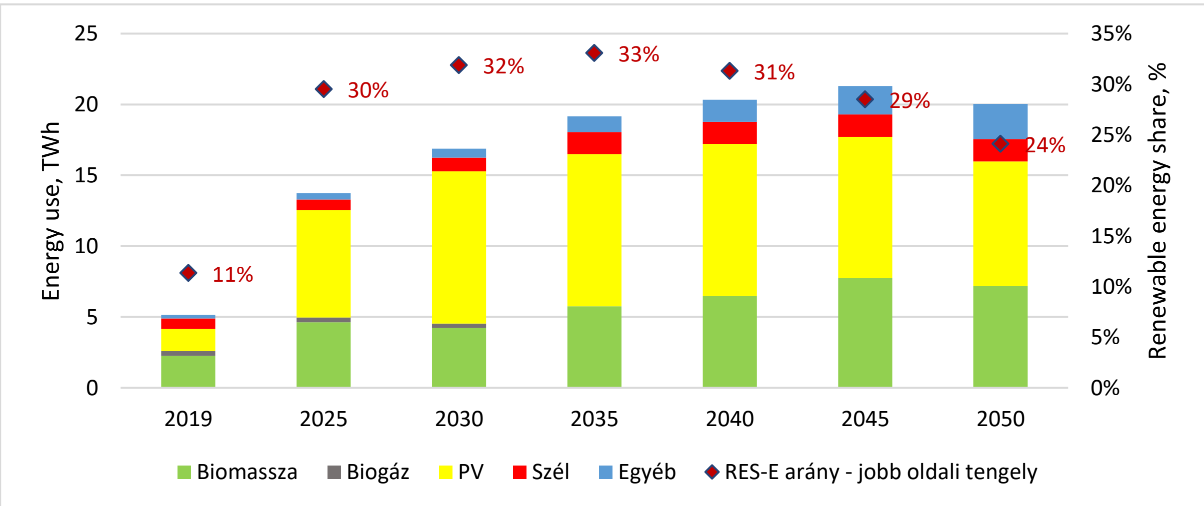
Renewable energy use in the electricity sector

In the case of the electricity sector, the biggest change can be observed in the spread of PV. Although a maximum limit of 13 GW was set for PV capacities in modelling by 2030, penetration remains significantly below this level. In addition, capacity will stagnate and then decline slightly from 2030. By contrast, the use of solid biomass will continue to increase slightly beyond 2030, although it will not reach 2 GW even in 2050. The installation of household-scale small power plants has been dynamic in recent years. By 2030, the target of **having at least 200,000 households equipped with rooftop solar panels with an average power of 4 kW will be** significantly exceeded.



29Figure – Evolution of renewable electricity generation capacities, WEM scenario (2019-2050, GW) Source: REKK, Eurostat

As a result of these capacities, the sun and biomass also play a crucial role in renewable-based production. In 2030, total renewable electricity generation will be around 17 TWh, representing 32% of total electricity consumption.



30Figure – Resource mix of renewable energy use in the electricity sector, WEM scenario (2019-2050, TWh/year)
Source: REKK, Eurostat

4.3. Energy efficiency dimension

Buildings account for 44% of final energy use in Hungary, with residential buildings accounting for the largest share, accounting for nearly 75%.[150] The total final energy consumption of residential buildings is ~250 PJ (1 GJ/m2/year),while non-residential buildings consume approximately 87 PJ (0.7 GJ/m2/year),of which public buildings represent ~39% (0.8 GJ/year).

In terms of final energy consumption, the household sector (residential buildings) accounts for around 33% of total final energy consumption in recent years.[151] 72% of residential energy consumption (~180 PJ) is accounted for by heating energy consumption, which, in addition to the energy consumption required for domestic hot water supply, reaches 85% (~212 PJ).[152] Household heating energy use is predominantly provided on a natural gas basis. Depending on the winter weather, residential natural gas consumption represents 17-20% of the total domestic final energy consumption, 47-50% of the total domestic natural gas consumption and 54-58% of the total domestic household energy consumption.[153] For heating, natural gas supplies account for 76% of the housing stock and 80% of the public building stock. The other two main areas of energy use are domestic hot water production and the use of lighting and electrical equipment (approximately one tenth to one tenth share). With the modernisation of the residential building stock to improve energy efficiency and the shift to alternative heating methods, we estimate that **up to a quarter of natural gas imports – around 2 billion m3 of natural gas consumption per year – can be replaced.**

The energy consumption of public buildings accounts for nearly 10% of the energy consumption of the Hungarian building stock (~33 PJ/year, of which nearly 27 PJ is the consumption of electricity (6 PJ), natural gas (14 PJ) and district heating (7 PJ). Following Fit for 55, Member States will be guided by an energy renovation of public buildings up to a nearly zero-energy-demand level of 3% of floor area per year and an obligation to reduce energy consumption by 1.9% per year, compared to consumption two years earlier. As there is no regional governance in Hungary, the basis of the two obligations is essentially the same, but it is also necessary to fulfil them separately. Based on the state of the Hungarian public institution building stock, **savings of 18% (-6.6 PJ/10 years) can be achieved by 2030**

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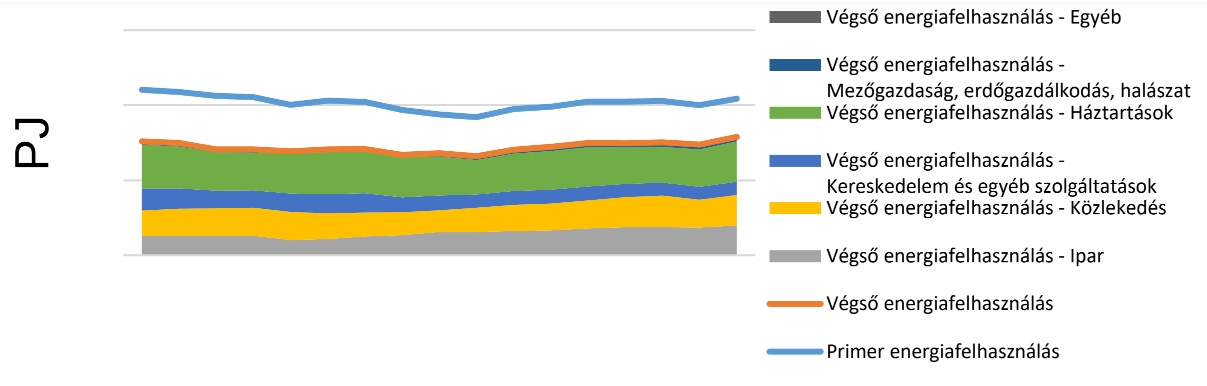
[150] *National Building Energy Strategy (2015), https://www.kormany.hu/download/d/85/40000/Nemzeti%20E%CC%81pu%CC%88letenergetikai%20Strate%CC%81gia%20150225.pdf*
[151] *Eurostat: https://ec.europa.eu/eurostat/databrowser/view/TEN00124/default/table?lang=en and https://ec.europa.eu/eurostat/databrowser/view/NRG_D_HHQ/default/table?lang=en*
[152] *Eurostat: https://ec.europa.eu/eurostat/databrowser/view/NRG_D_HHQ_custom_7284518/default/table?lang=en*
[153] *Eurostat: https://ec.europa.eu/eurostat/databrowser/view/NRG_D_HHQ_custom_7284518/default/table?lang=en and https://ec.europa.eu/eurostat/databrowser/view/NRG_CB_GAS__custom_7285416/default/table?lang=en*

through cost-optimal renovation, based on a linear trajectory. Compared to this, new savings of approximately 14.6 PJ/10 years are required for near-zero energy use.

i. *Current primary and final energy consumption in the economy and by sector (including industrial, residential, services and transport)*

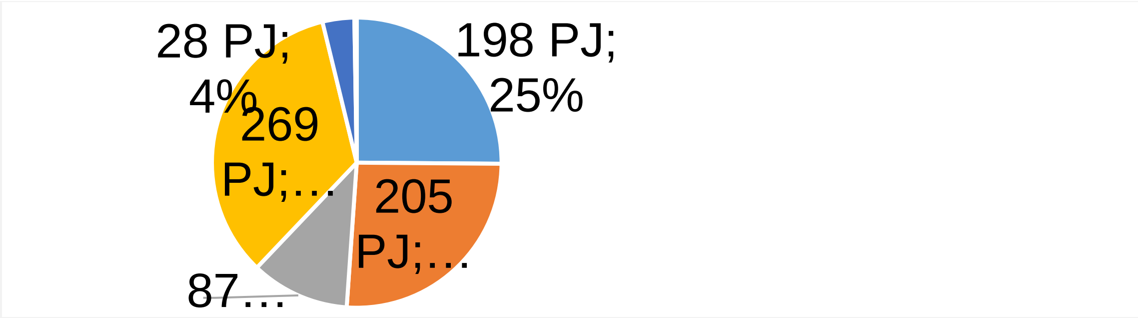
Hungary's **primary energy consumption (2020-2030)** in 2021 was 1 044 PJ, 6% lower than in 2005 (around 60 PJ). The country's primary energy consumption gradually decreased over the period 2005-2014, from just 921 PJ in 2014 to a slight increase from 2014 onwards, which was somewhat reduced in 2020 by the COVID-19 outbreak. Basically, a similar pattern can be observed for final energy consumption, but for this indicator the figure for 2021 (787 PJ) is already higher than the figure for 2005 (761 PJ), meaning that, overall, consumers receive a higher share of primary energy consumption than in 2005. The increase in final energy consumption of 26 PJ cannot be considered significant, especially in light of the average annual GDP growth of 3.5% over this period. Compared with 2005 and 2021, final energy consumption increased by 4% and GDP by 69%.

According to *the methodology to be used to assess the achievement of the targets set under the Energy Efficiency Directive* (FEC 2020-2030), **final energy consumption** was 802 PJ in 2021 compared to 785 PJ in 2005.



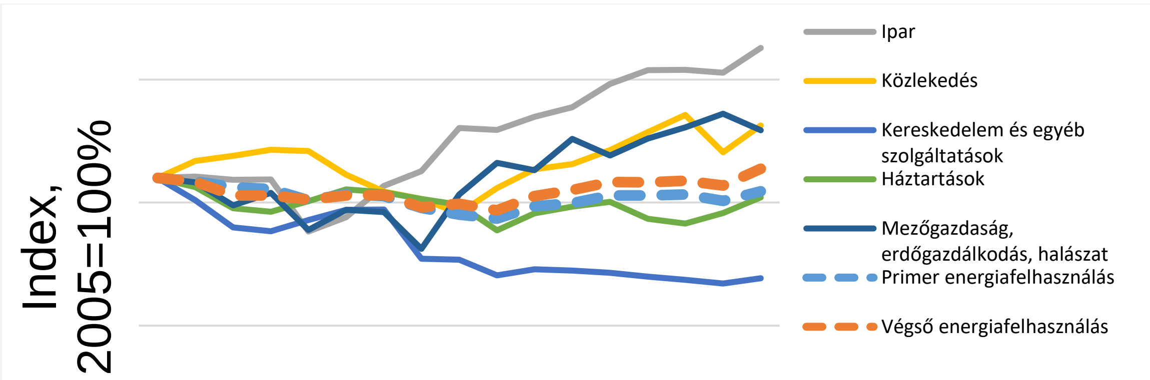
31Figure – Primary and final energy consumption 2005-2021 Factual data: Eurostat

Looking at the sectoral distribution of final energy consumption, it can be concluded that the most significant amount of energy consumed still belongs to the residential sector. In 2021, the final energy consumption of the residential sector excluding transport was 269 PJ, because the transport energy consumption of the residential sector is reflected in the transport sector. This is followed by the transport sector (2021: 205 PJ), followed by the industrial sector (2021: 198 PJ), whose energy consumption has gradually increased since 2009. By contrast, energy use linked to trade and other services has been decreasing since 2005 (2021: 87 PJ). Energy use related to agriculture, forestry and fisheries is not significant (2021: 28 PJ). The share of final energy consumption in 2021 was 25% for industry, 26% for transport, 34% for the population and 11% for services.



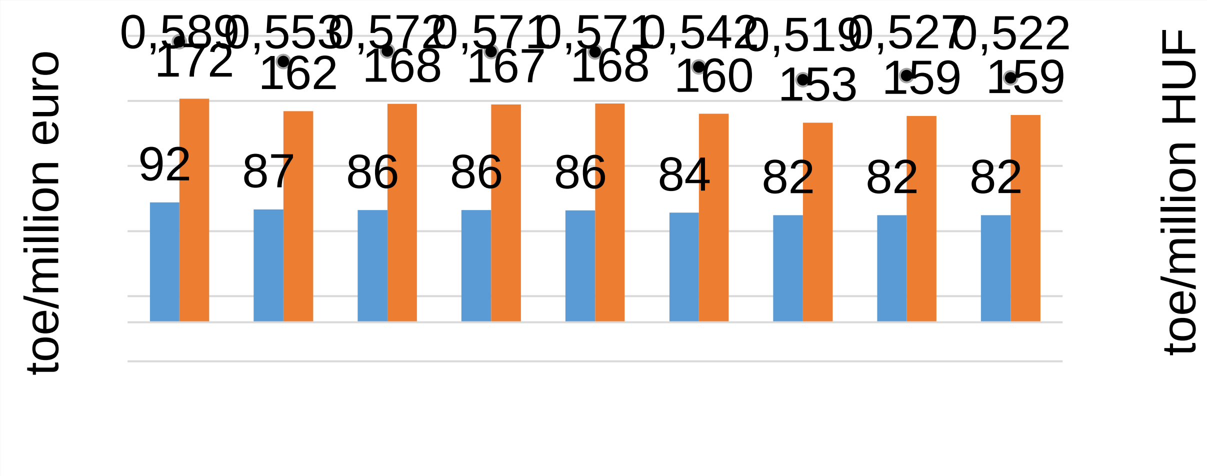
32Figure – Breakdown of final energy consumption by sector (2021, %) Source: Eurostat

Energy consumption in the industrial sector has increased almost every year since 2009, with consumption in 2021 being 53% higher than in 2005, an outlier than in all other sectors. Energy use in transport and agriculture has increased by around 20-20% compared to 2005. Household energy use decreased by 5%, while service-related energy use reached 60% of 2005 levels. In official statistics, consumption in the services and other sectors declined significantly from 2011 to 2012, while industrial consumption increased. The main reason for this was the change in the statistical methodology, which also slightly modifies the picture in the energy intensity indicators to be presented later.



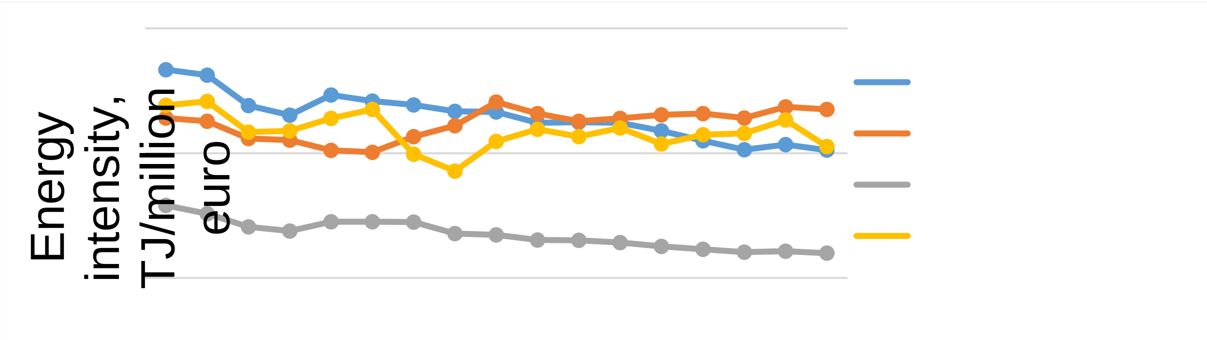
33Figure – Evolution of final energy consumption by sector (2005-2021, %) Source: Eurostat

The **energy intensity of the** Hungarian economy (the final energy intensity of GDP) is high compared to the overall performance of the European Union, but it is continuously decreasing. Although the EU energy intensity indicator is also decreasing, the Hungarian value is decreasing at a faster pace, so the gap decreased in absolute terms (the difference was 77 toe/million EUR in 2021).



34Figure – Evolution of final energy intensity in Hungary and the EU27[154] Source: Eurostat

Looking at **energy efficiency** developments at sectoral level, mixed trends emerge. In the services sector, the improving trend is clear and can be considered practically continuous between 2005 and 2021, in the industrial sector with higher energy consumption, this trend is not observed, and in fact energy intensity increased by around 6% in 2021 compared to 2005. The energy intensity of the industrial sector increased sharply after the 2008 crisis and then stagnated over the last decade.



35Figure – Evolution of the energy intensity of the national economy, industry, agriculture and services between 2005 and 2021 Source: Eurostat

In the transport sector, a positive trend started after the 2008 economic crisis, as the sector's energy consumption remained stable and declined significantly in specific terms, at passenger-kilometres and tonne-kilometres of goods, until 2013. However, from 2014 onwards, the sector's energy consumption started to increase again, although the volume of passenger and freight transport also increased slightly. The sector's performance and energy use were significantly dampened by COVID-19 lockdowns in 2020, but it can be seen that this decline was only temporary, which does not substantially change the increasing trend of previous years. Despite the decline, energy consumption in 2021 in the sector was 21% higher than in 2005, while the tonne-kilometre indicator increased by 32%, while in the area of

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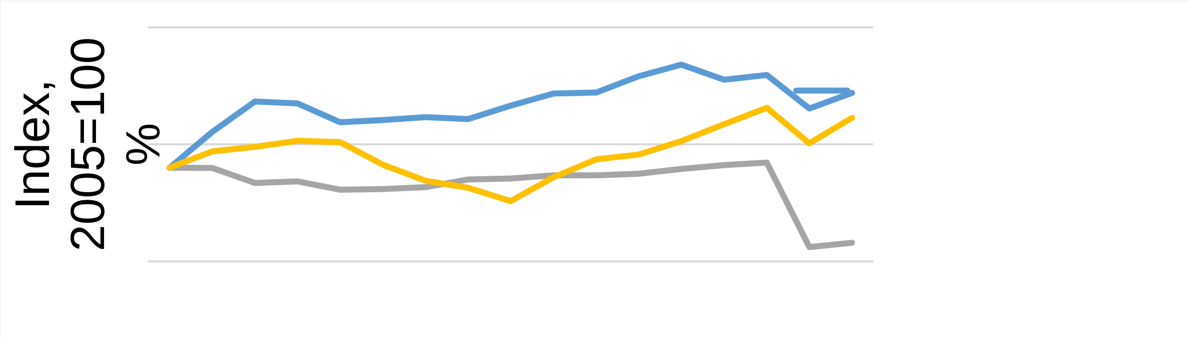
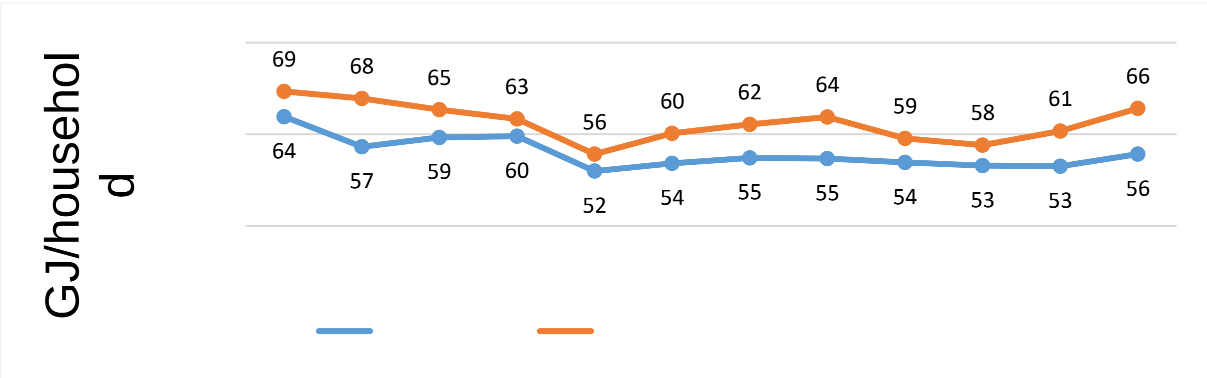
[154] *GDP at 2010 prices, final energy consumption calculated according to the new methodology*

passenger transport, due to the aforementioned lockdowns, the value of 2021 cannot be considered relevant.



36Figure – Passenger and freight transport (excluding aviation) and change in final energy consumption for transport between 2005 and 2021 Source: Passenger and freight transport: KSH, Transport energy consumption: Eurostat

In the household sector, the positive impact of energy efficiency investments is offset by an increase in energy demand. This is illustrated by the fact that energy consumption per household decreased only minimally by 2021 (65.6 GJ) compared to 2010 (69.3 GJ) and has started to increase again in recent years. Over the past decade, the energy consumption of Hungarian households has always been higher than the European Union average, and the gap between the two has widened since 2019.



37Figure – Average household energy use in Hungary and the European Union between 2010 and 2021 Source: Eurostat

ii. Current potential for the use of high-efficiency cogeneration and efficient district heating and cooling[155]

The survey pursuant to Article 14(1) of Directive 2012/27/EU was carried out in 2015 and updated again in 2023[156] following its update in 2020. The report now builds on only two of the scenarios set out in the NTFS. The baseline scenario is FIVE (Hand in Kill) and the alternative scenario is KCs (Early Action) because it is more forward-looking than HCs (Deferred Action) in terms of achieving energy transition and decarbonisation over time. Compared to the ÖTK, NTFS estimates the total additional investment needs of KCs to be

[155] *In accordance with Article 14(1) of Directive 2012/27/EU.*
[156] *https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en*

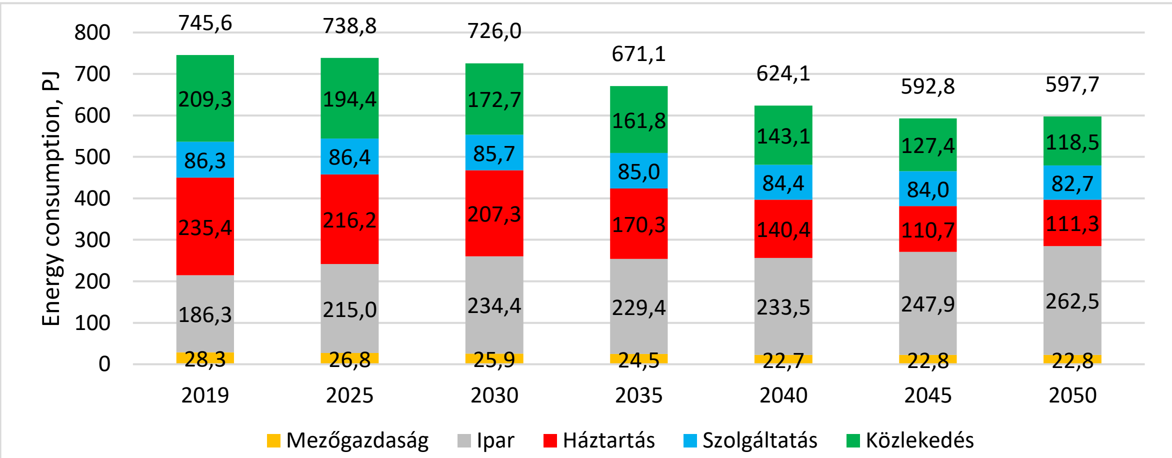
HUF 24 700 billion by 2050. The residential sector accounts for 33% of the total additional investment needs, HUF 213 billion per year, which means almost exclusively relevant investments in cooling and heating, mainly modernisations aimed at increasing the energy efficiency of heating systems and buildings. In the service sector, the KCs scenario foresees savings in additional operating costs (HUF -27 billion per year), which, if extended over 50 years, will cover about 50% of the nominal investment costs. Although this represents two and a half times as much return as for the population, without subsidies this would not be able to make the investment profitable for the operators in the sector. Due to the high level of electrification expected by 2050, the return on investment is significantly influenced by the ratio of future electricity and natural gas prices to each other.

The report estimates that investments in cooling and heating in the alternative scenario will pay off by 2050: applying a 5% rate to discounting, the net present value of the investments is nearly HUF 645,000 billion. The most significant positive item is additional GDP, which is mainly related to green energy investments and electrification.

iii. Projections considering existing energy efficiency policies, measures and programmes as described in point 1.2.(ii) for primary and final energy consumption, covering each sector at least until 2040 (including the year 2030)[157]

Final energy consumption

Under the current measures (WEM) scenario, gross domestic final energy consumption will decrease by 3% to 726 PJ by 2030 compared to 2019.



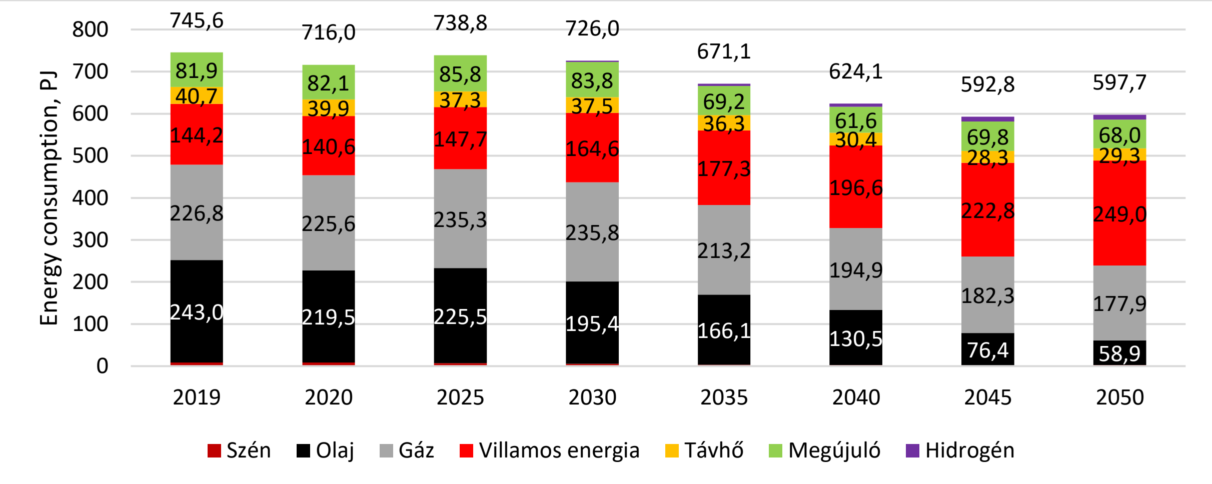
38Figure – Evolution of the composition of gross final energy consumption by sector, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

The largest increase during this period is expected to be in industry, where energy consumption is expected to increase by nearly 26%. Despite the increasing efficiency of industrial and technical building equipment, this effect cannot fully counterbalance the large

[157] *This reference forecast shall serve as a basis for the 2030 final and primary energy consumption target (point 2.3) and conversion factors.*

increase in demand. A moderate decline (0.7%) can be observed in the services sector. In the residential sector, on the other hand, even in the no-additional-measures scenario, energy consumption will decrease by almost 12% by 2030, and the pace of the downward trend is even more pronounced during the 2030s and 2040s. In the transport sector, we see a 17% decrease between 2019 and 2030, surpassing residential buildings, followed by a further decline in consumption to 57% of 2019 levels by 2050.

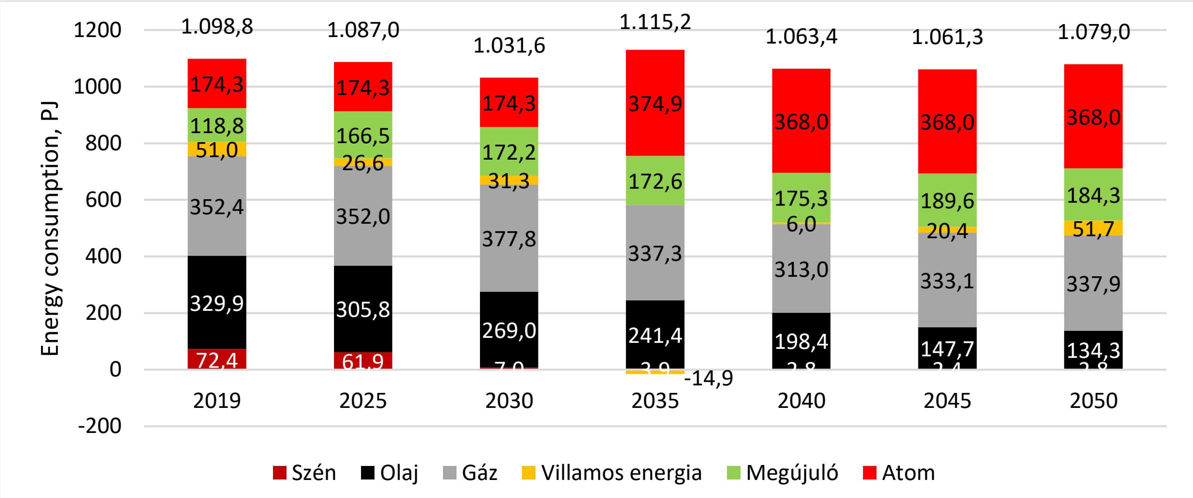
Looking at the type of energy used, there is a significant increase in electricity consumption (14%) between 2019 and 2030. The use of coal-based products is decreasing (33.6%), bringing the share of coal to 0.8% in 2030. Natural gas consumption is increasing by 3.9% in the period 2019-2030, increasing its share to 32.5%. Meanwhile, consumption of petroleum products will decrease by 19.6% by 2030 compared to 2019, bringing their share of total final energy consumption to 26.9%. The use of district heating will be 8% lower by 2030. The role of hydrogen – a 0.4% share of total final energy consumption – is still negligible. The use of renewable energy sources is almost unchanged – 2.3% higher in 2030 than in 2019 – their share exceeds 11% in 2030.



39Figure – Evolution of the composition of gross final energy consumption by energy carrier, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Primary energy consumption

We can see a significant increase in primary energy consumption by 2030, mainly due to the entry of new units in Paks that increase transformation losses, and then, due to the decrease in final energy consumption, the value of this indicator will decrease somewhat by 2050. In addition to the increase in transformation losses, there is a visible increase in distribution losses and industrial final energy consumption, which can be offset in the longer term by decreasing final energy demand in the transport, residential and agricultural sectors with stagnating material use. Looking at the fuel mix, it can be seen that coal, due to its marginalising role in electricity generation, is losing importance, so its consumption will be reduced by more than 99% by 2030 and its total share of primary energy consumption could be around 0.7%. There is a significant increase in nuclear power in 2035, when it is assumed that the new and the old Paks units will operate in parallel. Nuclear energy use will increase by 115% by 2035 compared to 2019, with its share approaching 34%. Significant growth is also expected in renewable energy deployment: By 2030, consumption will increase by around 45% compared to 2019, accounting for almost 16% of total primary energy consumption. Electricity imports will decrease sharply in 2030, Hungary will become φυλλψ self-sufficient on an annual basis when τηε Πακσ blocks operate in parallel, and then, as domestic electricity consumption increases, imports will increase again in the 2030s and 2040s.



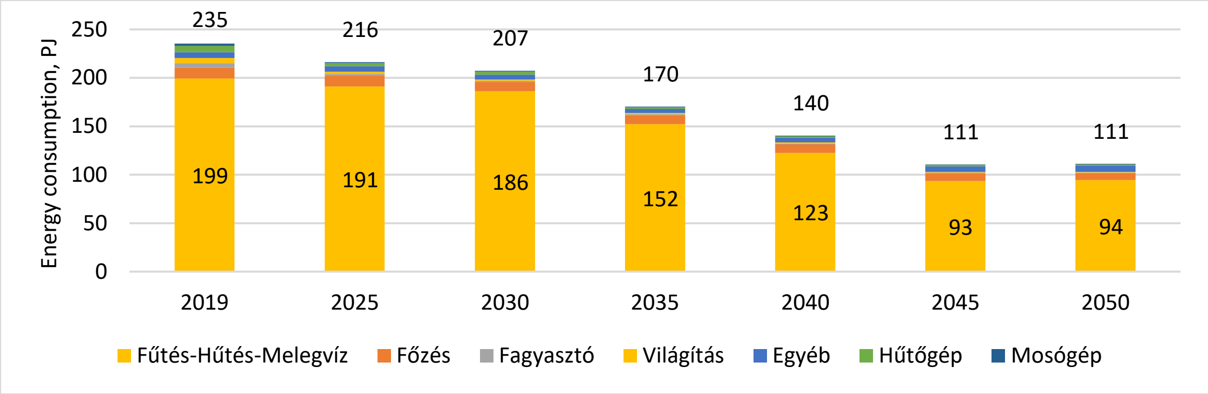
40Figure – Evolution of primary energy consumption composition by energy carrier, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

The evolution of the fuel mix in each gross end-user segment and the significant consumer sub-segments in that sector are described in detail below.

Population

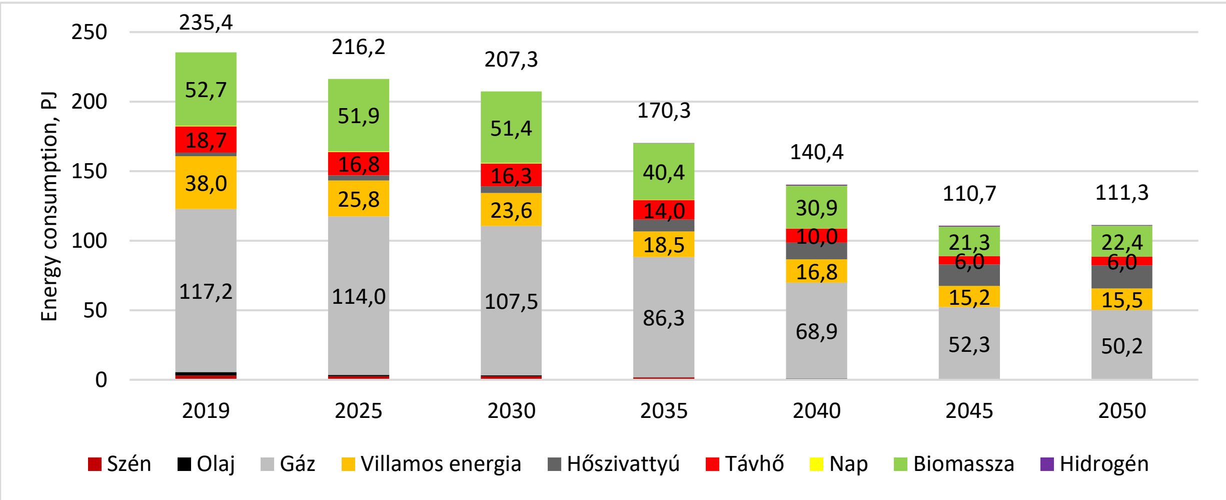
With energy prices rising due to the energy crisis, energy efficiency investments are becoming more competitive, resulting in a significant reduction in total energy use for heating purposes. Energy use for heating, cooling and hot water production will fall by nearly 7% by 2030 compared to 2019. Total residential final energy consumption will decrease by around 12% to 207 PJ by 2030. Residential energy consumption will continue to decline beyond 2030, and by 2050, consumption in 2019 will be halved with current measures. Expected energy prices increase the demand for energy efficiency investments.

In addition to the decrease in energy consumption for heating, cooling and hot water, we can also see a significant decrease in the energy consumption of household appliances. The energy consumption of refrigerators, freezers and washing machines is significantly reduced as these devices have relatively high rotation speeds and the new devices are significantly more energy efficient than the previous ones. A similar trend can be expected in the field of lighting. The energy use of other assets increases in line with economic development, but the magnitude of this increase is not significant.



41Figure – Evolution of the composition of residential energy use by uses, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Natural gas and biomass are the most important fuels for residential energy consumption.

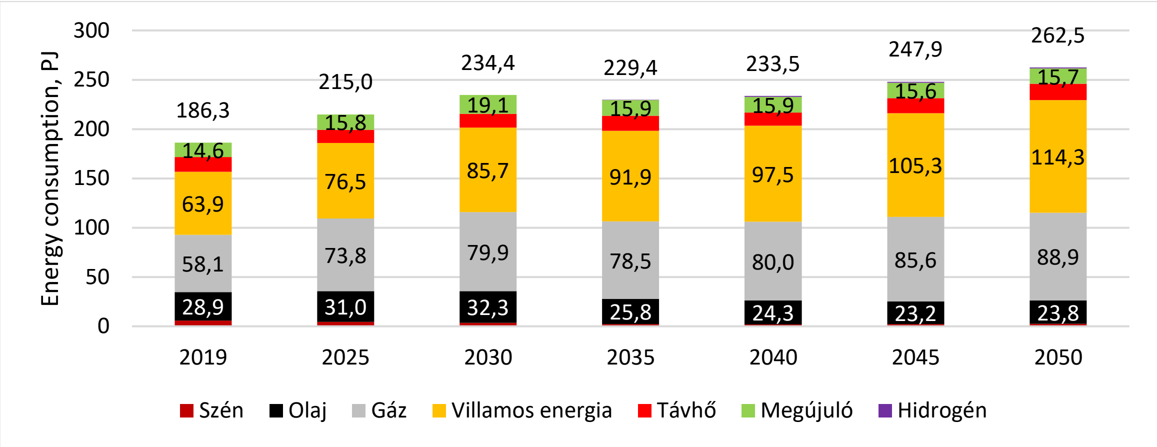


42Figure – Evolution of the composition of residential energy use by fuel, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Consumption will decrease for both fuels by 2030, more for natural gas (8%) and less for biomass (3%). Electricity use will also be significantly reduced by around 38% by 2030, thanks to improved energy efficiency of new devices. By 2050, with a significant increase in the take-up of new energy-efficient household appliances, electricity consumption will fall by less than half. District heating consumption is also expected to decrease significantly, with consumption decreasing by nearly 13% by 2030. Coal and oil use will completely disappear by 2050, with only a few PJ consumed by the residential sector already in 2030. In contrast, we can see the increasing energy consumption of energy-efficient heat pumps already in 2030, with their electricity consumption nearly doubling compared to 2019. Energy consumption of heat pumps in 2050 is six times higher than in 2019, with a share of more than 14% of total household final energy consumption (shallow geothermal, using ambient heat).

Industry

Despite energy efficiency investments, energy use in industry is increasing significantly to reach 234 PJ by 2030, an increase of 26% compared to 2019. Growth is slowing slightly in the 2030s and 2040s, but total industrial final energy consumption in 2050 is more than 40% higher than in 2019.



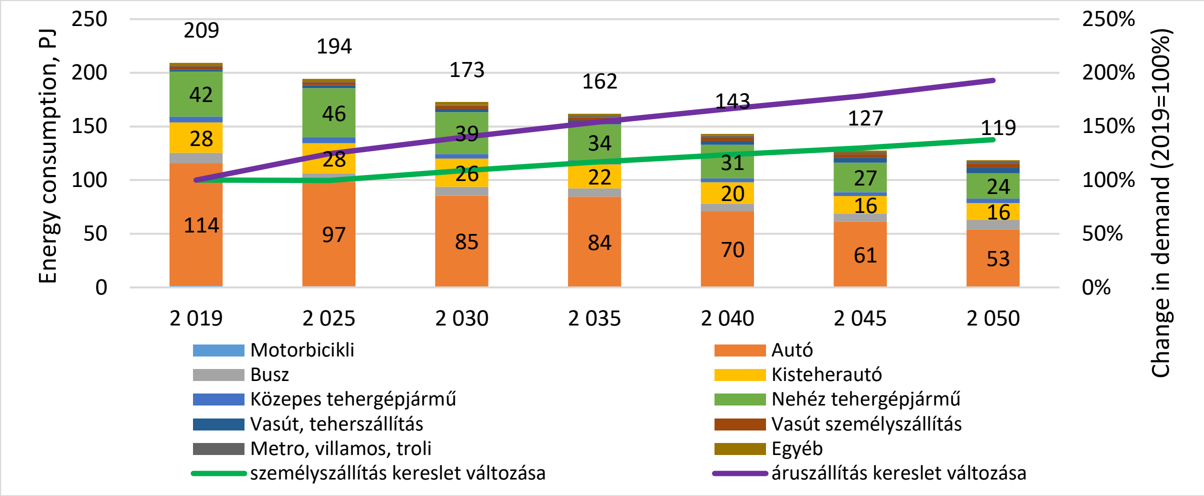
43Figure – Evolution of the energy consumption composition of the industrial sector by fuel, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Thanks to expanding industrial production and new investments, oil, gas and electricity use will also increase significantly, by 11.8%, 37.6% and 34.1% respectively by 2030 compared to 2019. By 2050, the trend for oil will reverse and decrease by almost 17.6% compared to 2019 levels, while natural gas and electricity growth will already reach 53.1% and 78.8%, respectively. The use of coal has been consistently declining: 41% by 2030 and 58% by 2050 compared to 2019. The use of renewable energy, mainly primary solid biomass, will increase significantly by 2030, 31% higher than in 2019. At the same time, the use of this energy carrier will decrease after 2030 due to the scarcity of primary solid biomass.

Transport

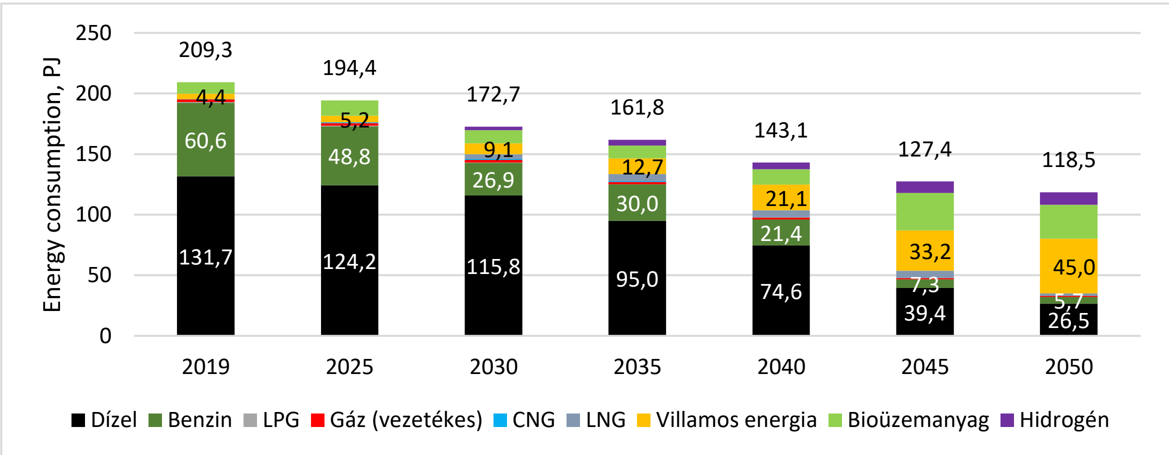
For **passenger transport,** the estimated passenger-kilometre increase is lower, with 9% by 2030 and 38% by 2050 compared to 2019. At the same time, the estimated **freight transport performance** is significantly above 2019 levels by around 40% and 93% by 2030 and 2050.

With increasing demand, decreasing energy consumption is due to a combination of several factors. In part, there will be a modal shift, whereby individual motor transport will be partially shifted towards public transport by 2030. The share of energy used by passenger cars will decrease from 55% in 2019 to 49% by 2030 and 45% by 2050. At the same time, the share of buses, rail and track-based urban public transport modes will increase to 7% by 2030 and 12.2% by 2050, up from 6.4% today. In terms of freight transport, we can also see a lesser modal shift from road to track-based transport. The latter will increase from 0.9% in 2019 to 1.7% by 2030 and 4.5% by 2050.



44Figure – Evolution of the energy consumption composition of the transport sector by main modes (PJ) and change in estimated passenger and freight transport demand (%), WEM scenario (2019-2050) Source: REKK, Eurostat

In addition to mode change, the reduction of energy intensity also contributes to the reduction of energy use. On average, passenger cars will have nearly 26% lower energy use by 2030 and more than 53% lower energy use by 2050 than in 2019. This is mainly due to the proliferation of more advanced internal combustion and electric vehicles. On average, the energy consumption of trucks will decrease by 8% and 43% respectively by 2030 and 2050. Rail and urban track-based transport will see a 16% increase in consumption by 2030, and buses will experience a decline in energy consumption, also due to a decrease in energy intensity.

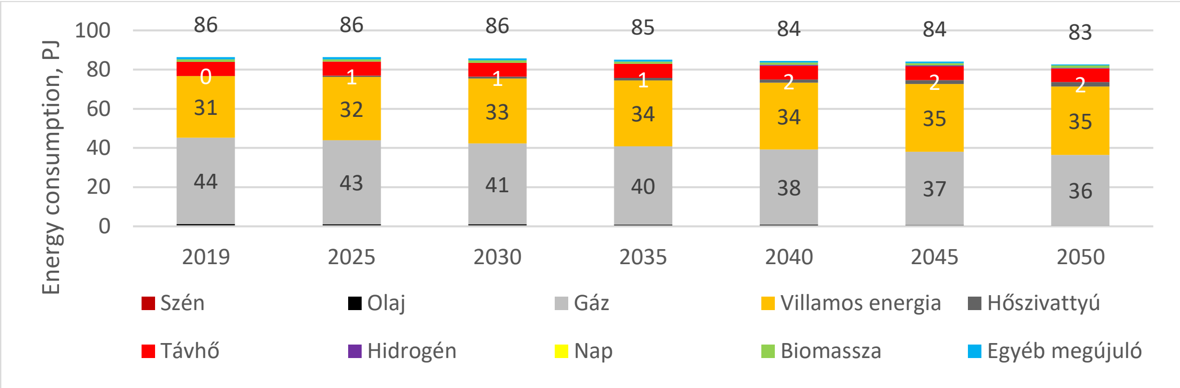


45Figure – Evolution of the energy consumption composition of the transport sector by fuel used, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

In the transport sector, petrol consumption will fall significantly by almost 56% by 2030, and diesel consumption will also fall by more than 12%. Biofuel use will increase by 13% and electricity use by more than 105% by 2030. Based on modelling results, final energy consumption in the transport sector will decrease by 17% by 2030 and by 43% by 2050 compared to 2019. Incentives for energy efficiency regulation will make the transition to more efficient and less greenhouse gas-emitting technologies more competitive.

<u>Services sector</u>

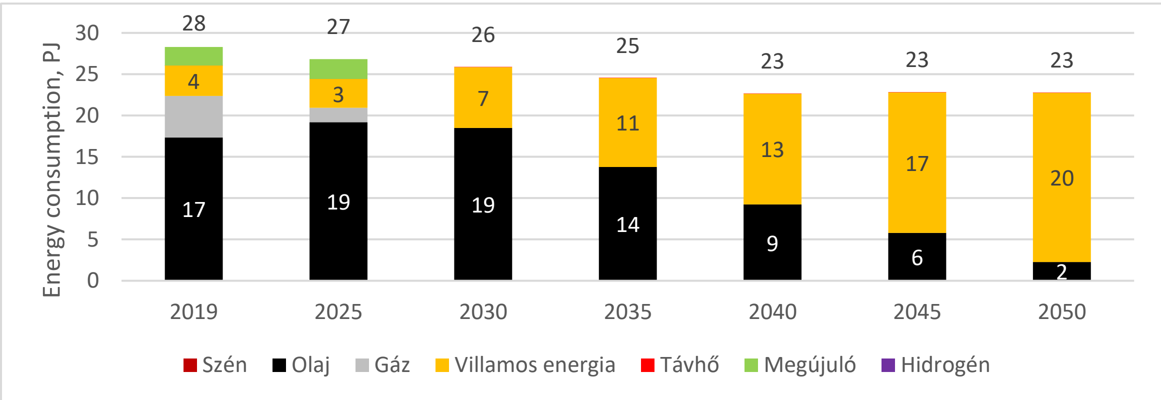
In the services sector, energy consumption declined slightly in the WEM scenario. Compared to 2019 levels, actual energy use will be reduced by 0.7% by 2030 and by 4.3% by 2050. In terms of fuel composition, the use of natural gas is decreasing, the use of electricity is increasing and the use of heat pump technology is gaining ground.



46Figure – Evolution of the fuel composition of energy use in the services sector, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

Agriculture, forestry and fishing

Energy use in the agriculture, forestry and fisheries sectors will decrease by nearly 9% by 2030 and by nearly 20% by 2050 compared to 2019. The share of electricity in the sectorial energy mix, which is currently over-oil-rich, is increasing and could reach 90% by 2050.



47Figure – Evolution of the fuel composition of energy use in the agricultural sector, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

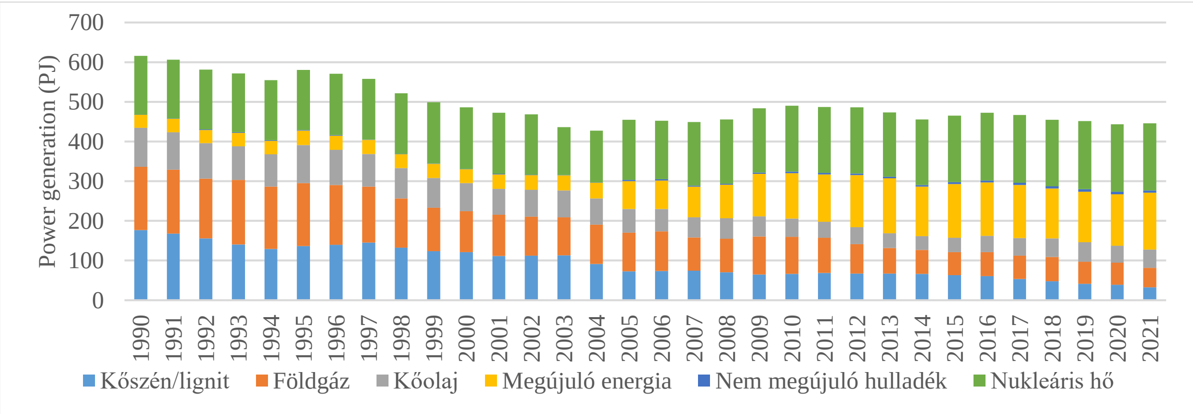
4.4. Energy security dimension

i. Current energy mix, indigenous energy sources, import dependency, including associated risks

In Hungary, the production of fossil fuels is on an overall downward trend. Coal **mining** (black coal, brown coal, lignite) was dominant in the country's energy supply until the 1960s, when the amount of coal mined decreased drastically. The decline of coal mining was initially caused by the decline of heavy industry. Later on, the impact of the tightening of pollutant emission standards became more and more pronounced. As a result, in 2021, only 32.4 PJ of coal/lignite was extracted in the country (resulting in 56% of domestic demand), far below the 176.8 PJ extracted in 1990.

Hydrocarbon **production** peaked in Hungary in the 1980s, and since then there has been a decline with minor or major fluctuations. In recent years, however, as a result of successful concession tenders, the decline in domestic hydrocarbon production has come to a halt, and there has even been an increase in this area in recent years. Natural gas extraction amounted to 49.3 PJ (1.18 Mtoe) in 2021. Oil production in 2021 was around 43-45 PJ.

The increase in nuclear energy production, and even more **so in renewable energy production,** facilitates the climate-friendly transformation of the Hungarian energy system. Within renewable energy sources, considering Hungary's geography, biogenic energy production – solar energy, biomass from forestry and agriculture, biogas, agrofuels – and geothermal energy are the most important. As a result of all these processes, the composition of Hungarian energy production has changed significantly.



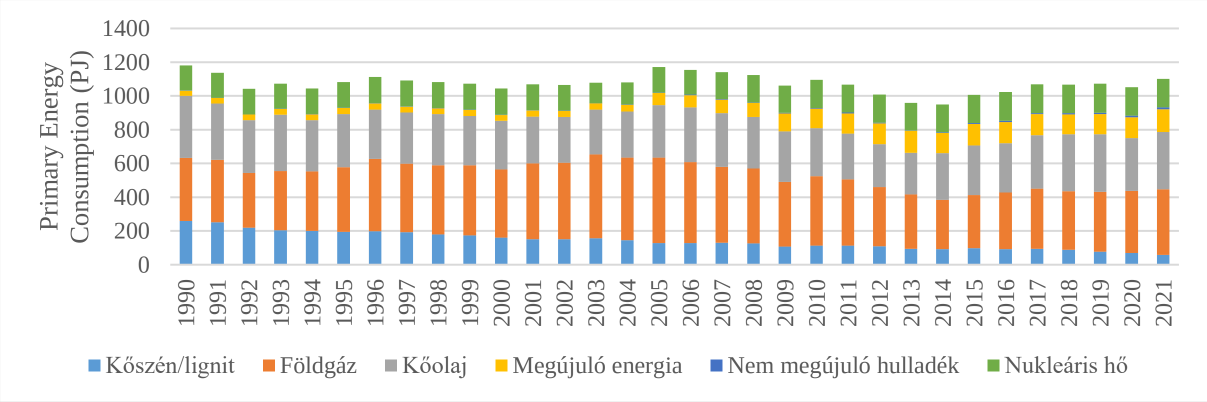
48Figure – Composition of Hungarian primary energy production between 1990 and 2021 (PJ/year) Source: Eurostat

While the share of lignite in energy production was 29% in 1990 and 16% in 2005, today the share of lignite in energy production has fallen below 7.3%. A similar trend has been observed in the share of hydrocarbons in recent years: the weight of natural gas, which still accounted for 26% in 1990, fell to 21% in 2005 and 11% in 2021, from 16% in 1990 to 13% in 2005 and 7.7% in 2014, but remained around 10% in the years after 2017-18. At the same time, the importance of nuclear and renewable energy production has increased significantly: their combined share reached ~70% in 2021 (37.9% nuclear, 32% renewable energy).

<u>Gross domestic energy consumption</u>

By fuel type, fossil fuels continue to dominate gross domestic energy consumption. Natural gas, our most important source of energy in 2021, accounted for 34% of crude oil's share of gross inland energy consumption. However, the share of lignite – the domestic structure of coal use is primarily based on lignite – fell significantly between 1990 and 2021, with minor fluctuations, from 21% to 5%, as domestic deep-mining coal extraction declined. Meanwhile, renewable energy sources play an increasingly important role in Hungary's energy use: The share of renewables multiplied between 1990 and 2007 and between 2007 and 2013 (1990: 2.6%, 2007: 6.8%, 2013: 13%), but it has fallen slightly since 2013 and ranges from 10.5 to

12%, with a value of 11.8% in 2021. In addition to renewables, the other energy source involved in the decarbonisation transition is nuclear energy, the share of which has been around 15% for years. Imported electricity accounted for 4% of total primary energy consumption in 2021.

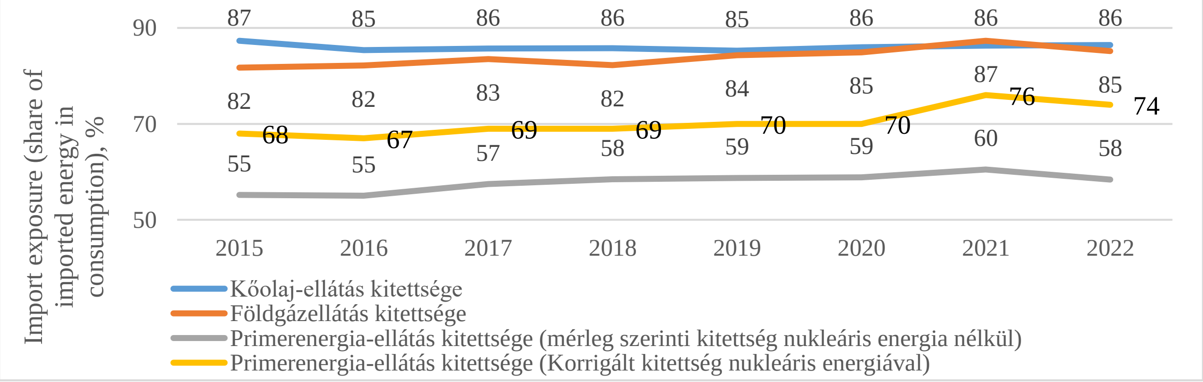


49Figure – Gross inland energy consumption (1990-2021, PJ/year) Source: Eurostat

Import exposure

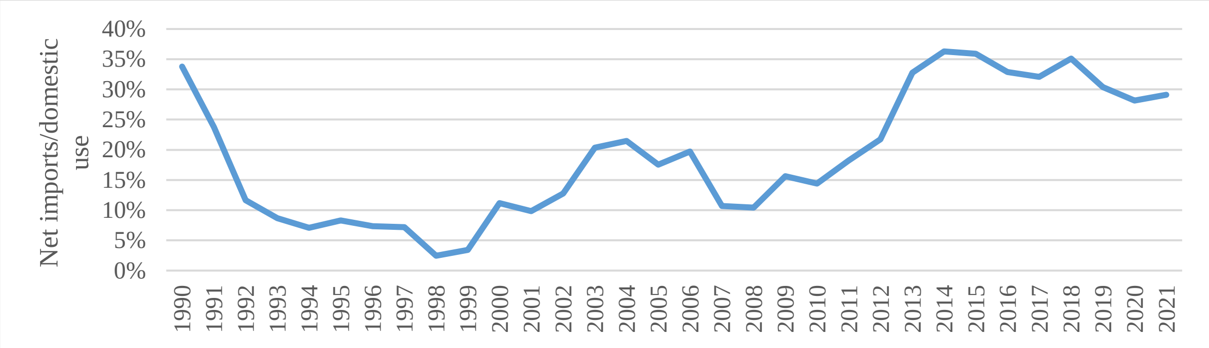
Hungary can independently supply only 46.3%of its primary energy demand (38.7% in 2005), so the high share of imports continues to be decisive in Hungary's energy supply. The composition of primary energy use increases the risks to the country's energy security. Reliance on foreign markets is most prevalent in the supply of hydrocarbon energy, with import dependency exceeding 80% in recent years.

Our lignite reserves and lignite mining are significant compared to our own consumption, however, on average one third of our coal/lignite consumption is covered by imports. Hungary's energy supply continues to be *characterised by high exposure to imports, i.e. the share of non-domestically produced energy sources.* 74% of our primary energy supply comes from external sources (including nuclear fuel). This share is lower than in recent years, driven by a decrease in natural gas use. Our import exposure is mostly related to hydrocarbon supply, but the exposure is also significant in the electricity market. The country's high dependence on energy imports can pose security of supply and price risks.



50Figure – Import dependency of Hungary between 2000 and 2021 (%) Source: Eurostat and HCSO

The exposure of our electricity supply is slowly but steadily decreasing**.** The share of net imported electricity in total domestic consumption, excluding self-consumption by domestic power plants and grid losses, decreased from 36% in 2014 to 28% in 2022.



51Figure – Net share of imports in relation to electricity consumption (%) Source: KSH

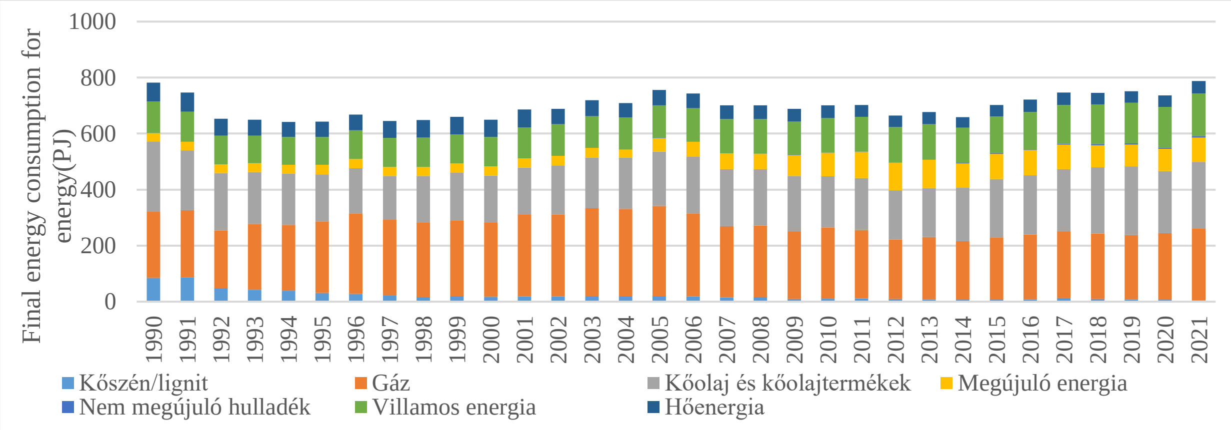
Given that seasonal electricity storage is not yet solved, this share can still be considered high. Nevertheless, domestic demand for electricity is expected to expand in the next 6-10 years beyond previous expectations. This can be partly offset by the planned expansion of electricity generation capacity, both renewable and natural gas-based. At certain times, however, a relatively high import ratio may have to be taken into account, mainly on the basis of economic decisions.

Final energy consumption

Following the drastic fall after the change of regime and the recovery from it, the energy consumption of the Hungarian economy returned to a downward trajectory between 2005 and 2014. In recent years, however, there has been a renewed upward trend. Domestic final energy consumption was 793.9 PJ in 1990 and although it decreased to 660 PJ in 2014 (similar to the trough of 650 PJ in the second half of the 1990s), it has been growing almost continuously since 2015 and in 2021 it was almost identical to the ’90 level, at 787 PJ, which represents 68% of primary energy consumption.

The largest increases were for oil (49 PJ) and natural gas (46 PJ) over the period 2014-2021, while electricity consumption increased by 27 PJ. In addition, the use of district heating has been increasing since 2014: Our heat consumption increased from 38 PJ to 44 PJ by 2021.

The composition of final energy consumption, even the composition of primary energy production, has changed significantly over the last almost two decades. While in 1990 Hungary covered 11% of its final energy consumption from coal, today the share of coal/lignite has decreased to a few percent. Along with the decline in coal use, the use of natural gas has gained significant ground. Natural gas reached its highest share in the energy mix in 2004 (44.2%) and the share of natural gas in final energy consumption decreased to 32% in 2021, with minor fluctuations. The share of oil in the energy mix typically varied between 25% and 30% in the period under review, but has increased to 30-33% in recent years (since 2017). The contribution of electricity increased from 14.3% to 19% between 1990 and 2021, while the share of renewable energy in final energy consumption increased from 3.7% to 11% over the same period.[158] It peaked at 14.9% in 2013. The country's district heating consumption has accounted for 5-6% of final energy consumption in recent years.



52Figure – Final energy consumption by type of energy (1990-2021, PJ/year) Source: Eurostat

The three sectors with the highest share of energy use structure are the household sector (residential), transport and industry. The household sector's share of final[159] energy consumption is the highest, accounting for 34.1% of total final energy consumption in 2021 (268.9 PJ), 4.3%lower than in 2005 (38.4%, 291.8 PJ). The second most important area is transport, with a share of 26% in 2021, followed closely by the industrial sector, with 25.1% in 2021. The services sector accounts for 11% of final energy consumption, while the combined contribution of the other sectors was only 2.6% in 2021.

Natural gas (51.8%), renewable energy sources (21.1%), primarily solid biomass, and electricity (17.4%) accounted for the largest share of **household** energy consumption in 2021. This is followed by district heating (7.8%) and finally coal and petroleum products with values of around 1-1% (the latter is practically LPG consumption, with a contribution of 1.2%). [160]According to HCSO data, nearly three quarters of Hungarian households' energy consumption (72.7% in 2021) was used for heating. Another typical area of energy use is the production of domestic hot water (11.8%). The use of lighting and electrical devices accounts for 10.2% of energy consumption. Cooking accounts for 4.8% and cooling for 0.3%. For the latter, a significant increase is expected, almost tripling in absolute terms since 2015, although still marginal in proportion.

According to Eurostat data, the **transport** sector is still predominantly oil-based, with the share of oil and petroleum products in final energy consumption standing at 91.3% in 2021. In

[158] *The share of renewables in final energy consumption should not be confused with the share of renewables in gross final energy consumption, which is the official indicator for monitoring the 2020 target set out in Directive 2009/28/ECon the promotion of the use of energy from renewable sources. Gross final energy consumption is defined by EUROSTAT as the country's total energy demand, energy consumption, including final energy consumption, power plant self-consumption, grid losses and the so-called statistical deviation. (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Gross_inland_energy_consumption)*

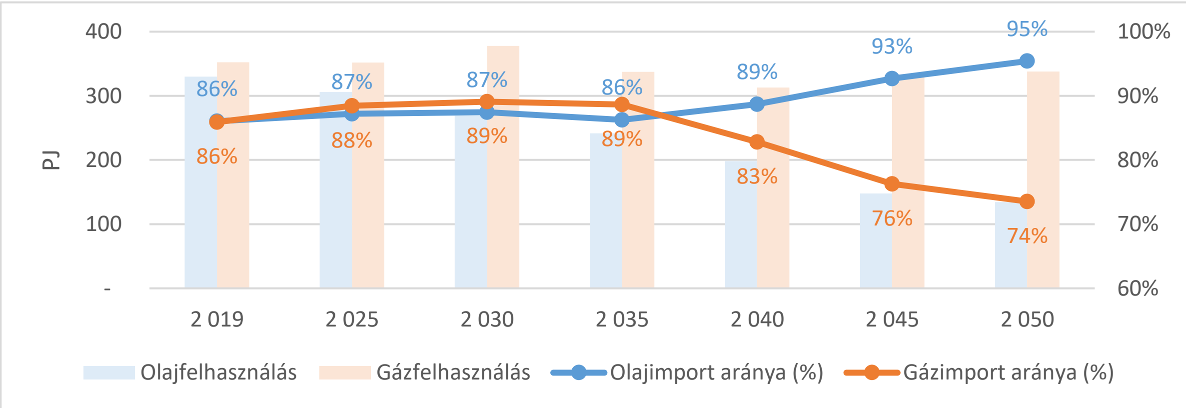
[159] *It does not include residential transport, as the use of private consumers for this purpose is counted towards transport.*

[160] *https://www.ksh.hu/stadat_files/ene/en/ene0007.html*

addition to oil, renewable energy (5.8%), electricity (2.2%) and natural gas (0.7%) play a role. Electricity (34.1%) and gas (30.8%) are dominant in **industrial** energy use. Oil accounted for 15.3%, district heating for 8%, renewables for 6.6%, non-renewable waste for 2.9% and coal for 1.6% of final energy consumption in 2021. The **service sector is dominated by natural gas** (53.6%), but the share of electricity (33.8%) and district heating (8.1%) is also significant. The share of renewables was only 2.7% and the combined share of oil and non-renewable waste was below 1% in 2021.

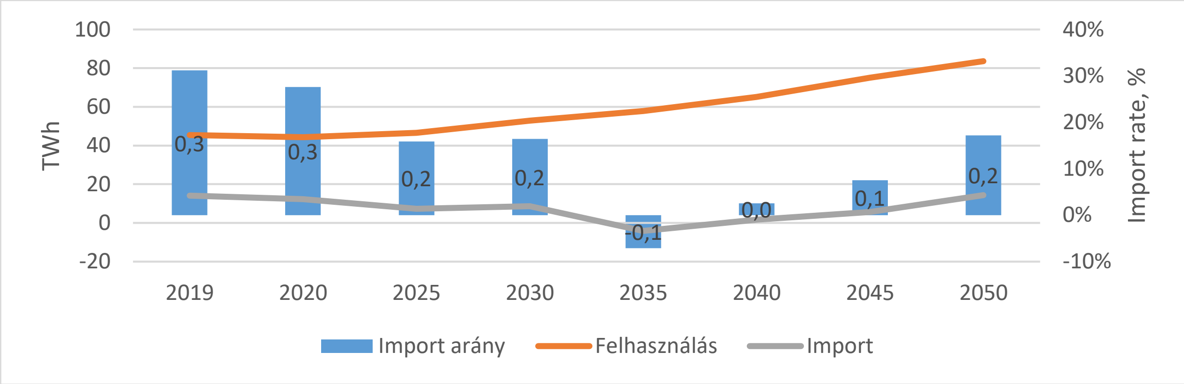
ii. Projection of progress based on existing policies and measures at least until 2040 (including the year 2030)

Import dependency is mainly based on three energy sources: in the case of oil, natural gas or electricity, it is necessary to analyse it. In the course of the modelling, we have quantified how oil and natural gas consumption will develop in Hungary in the WEM scenario. Assuming that domestic extraction of both raw materials will develop at 2021 levels over the 2050 horizon, we can determine how net imports of the two energy sources will develop. Oil **consumption** will fall drastically from the current level of 330 PJ in the period under review to 269 PJ in 2030 and 134 PJ in 2050, which will also improve the net import position, bringing the current import ratio above 86% down to 74% by 2050. There is no significant decline **in natural gas consumption:** 352 PJ consumption decreases to 338 PJ by 2050 in the WEM scenario.



53Figure – Primary energy consumption (PJ) and net imports (%) of natural gas and oil, WEM scenario (2019-2050)
Source: REKK, Eurostat

In **the electricity sector, the** current net import ratio of 31% may decrease significantly already by 2025, mainly due to the emergence of solar power plants, while with the entry into operation of the Paks II units Hungary will become a net exporter. Although we also calculate with the extension of Paks1, due to the significant increase in electricity consumption, the net exporter position will be replaced by net imports after 2035, but the ratio will not exceed 18% even in 2050.



54Figure – Electricity consumption and net imports evolution (TWh) and net import share (%), WEM scenario (2019-2050) Source: REKK, Eurostat

4.5. Internal energy market dimension

4.5.1. Interconnection of electricity and gas networks

i. Current level of interconnection and main interconnectors[161]

The Hungarian electricity system has a direct connection to all neighbouring countries, as shown in the map below, which allows for commercial transactions that can be diversified flexibly. The evolution of the annual physical turnover is summarised in the following table.

36Table – Annual physical turnover (2022) (Source: MAVIR Zrt.)

Border section	Annual turnover, GWh		
	Import	Export	Saldo
Ukraine	3 552,45	565,97	2 986,48
Slovakia	13 168,80	85,48	13 083,32
Romania	429,33	1 378,36	-949,03
Serbia	611,53	739,99	-128,47
Croatia	236,28	4 789,52	-4 553,24
Austria	3 571,58	757,03	2 814,55
Slovenia	18,57	1 121,48	-1 102,91
Total	21 588,53	9 437,82	12 150,71

ii. Projections of interconnector expansion requirements (incl. year 2030)[162]

Although Hungary is significantly above the EU target in terms of interconnections, the expansion of interconnection is justified, as the scarcity of cross-border capacities limits the import of more cost-efficient electricity from the Austrian and Slovak directions, as well as from the Romanian direction. At the other boundary points, the positive and negative price differentials occur alternately. Due to scarcity, the annual average Hungarian wholesale electricity price level (day-ahead markets, hourly averages) has been higher than in neighbouring countries for years. Looking at the wider region, Hungarian wholesale prices are relatively high. Therefore, the expansion of Serbian-Hungarian cross-border capacity is planned.

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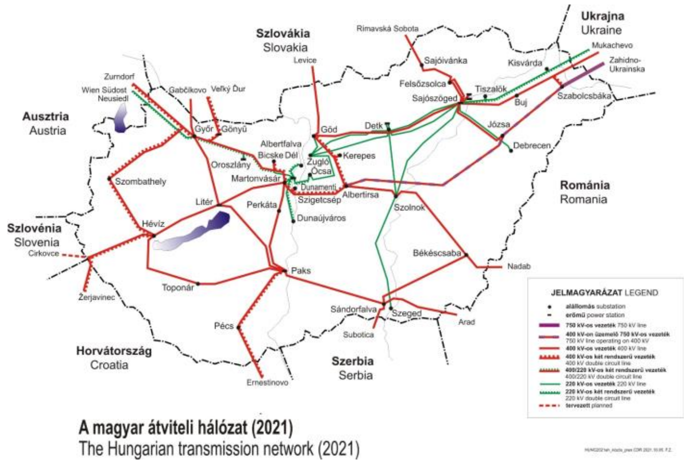
[161] *Based on an overview of current transmission infrastructures carried out by transmission system operators.*
[162] *Based on national network development plans and regional investment plans of TSOs.*

4.5.2. Energy transmission infrastructure

i. Main characteristics of the current electricity and gas transmission infrastructure[163]

Electricity transmission network

The transmission network of the Hungarian electricity system is shown in the map and table below.



55Figure – The Hungarian electricity transmission network as at 31 December 2021 Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER)

The length of the route of the transmission network is indicated in the table below.

37Table – Trail length of transmission networks (Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER))

	2017	2018	2019	2020	2021
	km	km	km	km	km
Total high voltage overhead and cable lines	3813,00	3813,00	3821,75	3821,65	3846,79
Total high voltage overhead line	3797,00	3797,00	3805,11	3805,01	3830,15
Of which:					
750 kV overhead line	268,00	268,00	266,16	266,16	266,16
400 kV overhead line	2287,00	2287,00	2297,59	2297,59	2322,72
220 kV overhead line	1099,00	1099,00	1099,32	1099,32	1099,32
132 kV overhead line	142,00	142,00	142,04	141,95	141,95
High voltage cable line (132 kV) total	17,00	16,64	16,64	16,64	16,64

Further details can be found in MAVIR ZRt.'s 2021data of the Hungarian electricity system (VER)[164] and related statistical tables, as well as in the VER LEPORELLO publication.[165]

Natural gas transmission network

[163] *Based on an overview of the current transmission infrastructure carried out by the TSOs.*
[164] *https://www.mavir.hu/documents/10258/45985073/VER_%C3%B6sszegoglal%C3%B3_2022_MAVIR.pdf*
[165] *https://www.mavir.hu/web/mavir/mavir-ver-leporello*

Hungary has a well-preserved natural gas distribution network with a length of more than 85,000 km and significant capacity. The capacity data of the Hungarian natural gas transmission system and the daily peak entry capacity data of the Hungarian natural gas transmission system are summarised in the tables below.

38Table – Natural gas transmission system capacity data (2021) (Source: FGSZ (2022): 2021 data of the Hungarian natural gas system)[166]

Capacity data	Annual firm capacity (billion m3)	Daily firm capacity (million m3)	Annual interruptible capacity (billion m3)	Daily interruptible capacity (million m3)	Daily peak capacity (million m3)	Of which interruptible (million m3)
Entry points						
Ukrainian/Hungarian interconnector entry point (Beregdaróc)	17,5	48,0	8,5	23,3	71,3	23,3
Austrian/Hungarian interconnector entry point (Mosonmagyaróvár)	5,3	14,4	0,0	0,0	14,4	0,0
Hungarian/Romanian connecting pipeline entry point (Csanádpalota)	1,75	4,8	0,0	0,0	4,8	0,0
Hungarian/Croatian connecting pipeline entry point (Drávaszerdahely)	1,75	4,8	5,3	14,4	19,2	14,4
Hungarian/Slovak interconnector entry point (Balassagyarmat)	4,4	12,0			12,0	0,0
Domestic net production	8,4	22,9			22,9	0,0
Underground gas storage for commercial purposes	1,56	4,9			4,9	0,0
Strategic underground gas storage	4,87	48,3		6,5	54,8	6,5
Total entry points, excluding strategic storage	1,46	20,0			20,0	0,0
Release points						
Hungarian/Serbian interconnector output point (Kiskundorozsma)	45,5	160,1	13,8	44,2	204,3	44,2
Hungarian/Romanian connecting pipeline exit point (Csanádpalota)	4,8	13,2			13,2	0,0
Hungarian/Ukrainian interconnector exit point (Beregdaróc)	2,6	7,2			7,2	0,0
Hungarian/Croatian connecting pipeline exit point (Drávaszerdahely)	0,0	0,0	7,0	19,2	19,2	19,2
Hungarian/Slovak interconnector exit point (Balassagyarmat)	2,6	7,2	4,4	12	19,2	12,0
Gas delivery stations	1,75	4,8	0,0	0	4,8	0,0
Total Expenditure Points	72,7	199,3	2,9	7,9	207,2	7,9

[166] *Note: * Release points do not include mixing circuit expenses, storage and cross-border release points*

39Table - Total daily peak entry capacity of the natural gas transmission system (2018) (Source: FGSZ (2022): 2021 data of the Hungarian natural gas system)

Total (at 15°C and Nm3)	**204,3**
- Of which interruptible	44,2
Import	121,7
- Of which interruptible	37,7
Transit	11,3
Commercial storage	54,8
- Of which interruptible	6,5
Strategic storage	20,0
Production	4,9

Accordingto *Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply*, transmission system operators are to establish permanent physical bi-directional capacity on all interconnections between Member States. Hungary has interconnection points with bi-directional capacity with Romania, Croatia and Slovakia among the EU Member States. Hungary has an indefinite exemption for the Hungarian-Austrian cross-border point.[167]

That regulation also refers to the 'N-1' principle in relation to security of supply. The results of the calculation carried out for the year 2022 are[168] summarised in the following two tables:

40Table – N-1 calculation results for Hungary without UA points (2022)

2022, without UA/HU points			
EPm1	Ossetian/Hungarian Border Feeding (Mosonmagyaróvár)	Mm^3/day	14,4
EPm2	Serbian/Hungarian border feed (Kiskundorozsma)	Mm^3/day	22,9
EPm3	Slovak/Hungarian border entry (Balassagyarmat)	Mm^3/day	12
EPm4	Romanian/Hungarian border feed (Csanádpalota)	Mm^3/day	6,72
EPm5	Croatian/Hungarian cross-border capacity (Drávaszerdahely)	Mm^3/day	4,8
EPm6	Other (unplanned feed-in)	Mm^3/day	0
EPm summa	Total supply capacity	Mm^3/day	60,82
Pm	Maximum technical production capacity	Mm^3/day	4,4
Sm	Maximum technical removal capacity (100%)	Mm^3/day	74,8
LNGm	Maximum technical LNG facility capacity	Mm^3/day	0
Im	Maximum entry capacity (EPm2-Serbian-Hungarian)	Mm^3/day	22,9

[167] *https://ec.europa.eu/energy/sites/ener/files/table_reverse_flows_-for_publication.pdf*
[168] *The main details of the calculations are as follows:*

- *Im: the largest element of the Hungarian gas infrastructure, the loss of which was taken into account in the calculation, is the Ukrainian/Hungarian border entry point (Beregdaróc)*
- *Dmax: the calculation of the total daily gas demand occurring once every 20 years with a statistical probability used in the calculation was based on two assessments:*
    - *As a first step, the relationship between Hungarian natural gas use and temperature was examined using linear regression using data from the 2011/2012 to 2017/2018 gas years. (We did not examine the previous years because they represented a significantly different natural gas consumption pattern from the current one due to changes in market structure, consumption patterns and targets.)*
    - *As a second step, usage data for extreme cold days were estimated using a generalized extreme value distribution (GEV) methodology.*

Dmax	Total daily gas demand (1/20)	Mm^3/day	79,7
N-1			146,95
N-1 (%) (without UA/HU points)			147%
N (%) (Full board)			176%

Based on the calculation carried out, in the case of Hungary, the value of N-1 exceeds 100% for both calculations, thus Hungary meets the requirements of the SoS Decree on infrastructure requirements and its own targets with values above 120%.

ii. Projections of network expansion requirements until at least 2040 (including the year 2030)[169]

The System Operators (TSOs: The electricity and gas projects planned by MAVIR (FGSZ) in the next ten years are described in Section 2.4.2 below. However, the forecast until 2040 carries with it countless uncertainties.

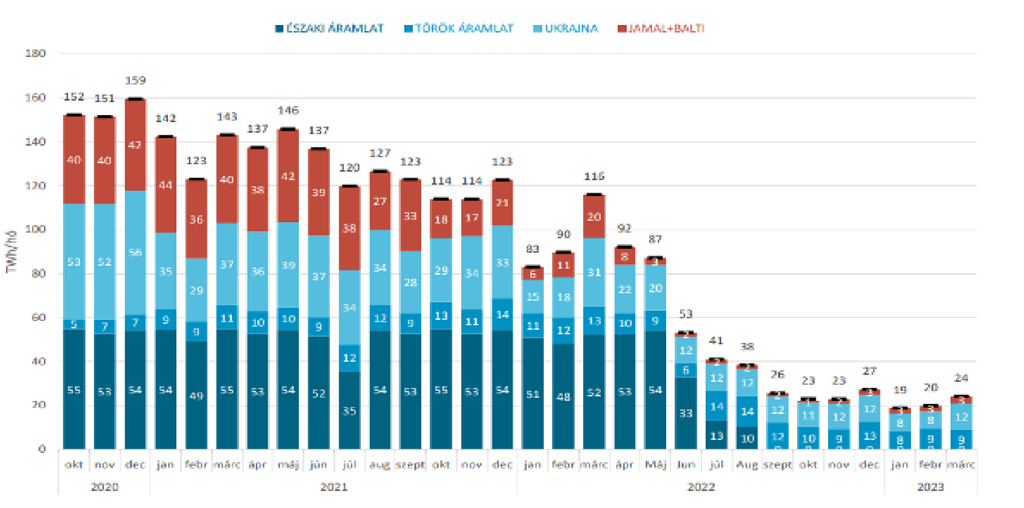
4.5.3. Electricity and gas markets, energy prices

i. State of play of electricity and gas markets, including energy prices

<u>Natural gas market</u>

<u>International Summary</u>

As a result of the European energy crisis, the share of Russian transport in the European source mix decreased from 41% in August 2021 to 9% in August 2022.



56Figure – Volume of Russian deliveries via different transit pipelines towards Europe (October 2020 to March 2023, TWh/month) Source: MEKH Monitoring Report March 2023

The Hungarian transport was continuous through the *Turkish Stream* pipeline, through Bulgaria and Serbia. European prices have risen to unprecedented levels. At the same time,

[169] *Based on national network development plans and regional investment plans of TSOs.*

supply was not disrupted in the winter of 2022 due to an appropriate purchasing policy and a drop in consumption.

The European Union has responded to this challenge by adopting the *REPowerEU* Strategy Paper, which aims to significantly reduce Russian gas dependency, already in the short term, by diversifying resources, reducing consumption and accelerated deployment of renewable energy sources.[170] For the first time in its history, the European Union has imposed a storage obligation on Member States and, in preparation for the winter, has proposed to achieve a 15% saving over the winter of 2022/23 compared to their average winter consumption over the previous five years.[171] Hungary fulfilled its storage obligation and continuously monitored the security of supply situation. Consumption decreased by 20% between August 2022 and March 2023. By May 2023, wholesale natural gas prices in European markets had returned to the usual €25/MWh range. From the point of view of the security of supply in Hungary, it is crucial that due to the excellent infrastructural connections it is able to adapt flexibly to the changed transport tasks.

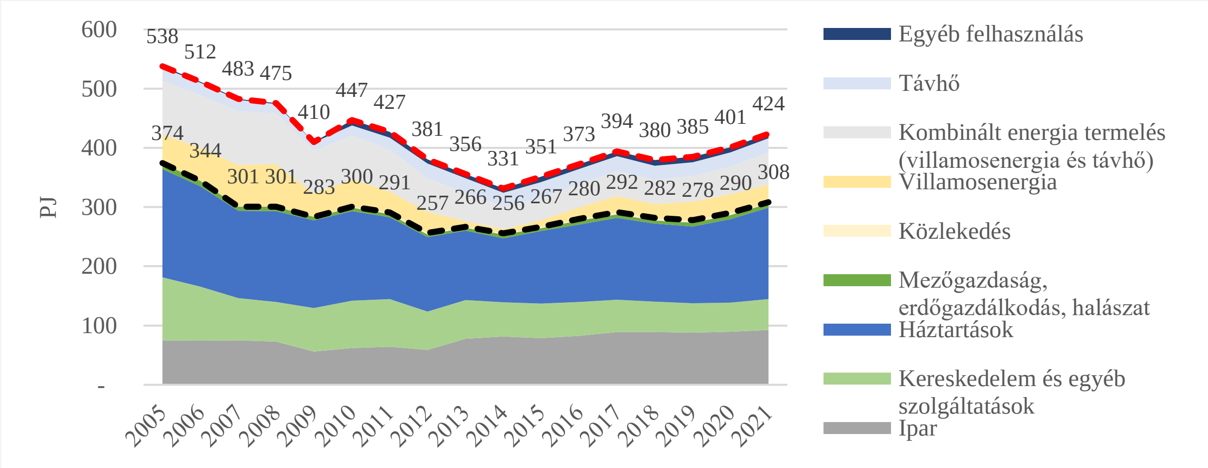
Source structure and gas consumption in Hungary

In Hungary, the share of natural gas in total energy use in 2021 was 34 %, of which more than 80 % was imported. While the share of natural gas in total energy consumption decreased by 43% compared to 2005, the share of imports increased slightly (2005: 81%), this is primarily due to the fact that domestic production halved from 2005 (108 PJ) to 2021 (55 PJ), but the country's natural gas consumption did not decrease to this extent. Total gas consumption in Hungary, including the electricity and district heating sectors, totalled 424 PJ in 2021, a decrease of 21% compared to 2005.

The combined use of natural gas by electricity and heat/electricity cogeneration plants was highly volatile between 2005 and 2021, with a combined consumption of 85 PJ, compared to 24 PJ for district heat-only units in 2021. Natural gas used only for electricity generation has gradually increased since 2014 (2014: 7 PJ, 2021: 31 PJ).

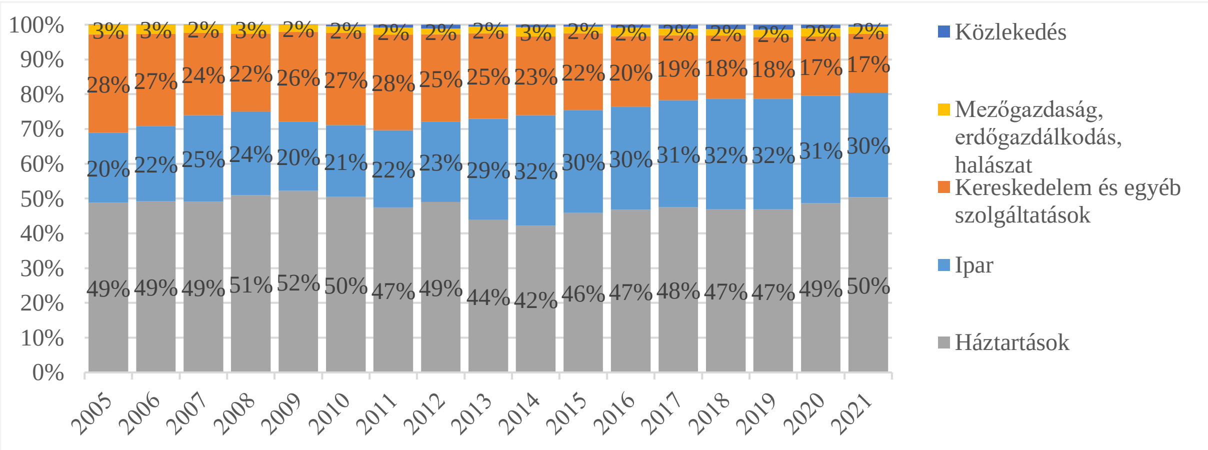
[170] *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, REPowerEU Plan Brussels, 18.5.2022. COM(2022) 230 final https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0016.02/DOC_1&format=PDFand Annexes 1-3 Brussels, 18.5.2022. COM(2022) 230 final https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0016.02/DOC_2&format=PDF*

[171] *COUNCIL REGULATION on coordinated demand-reduction measures for gas, Brussels, 20.7.2022. COM(2022) 361 final 2022/0225 (NLE) - Article 3 on voluntary demand reduction Source: https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:52022PC0361*



57Figure – Evolution of total gas consumption by sector 2005-2021 in Hungary Source: Eurostat

In 2021, consumption did not decrease despite the higher price environment. Currently, the role of gas power plants in the reserve market and in the provision of positive and negative regulatory energy is also significant, they cannot be dispensed with in the short term in the upstream reserve market, however, their role in the downstream direction can be reduced by the expansion of alternative technologies (renewables, storage, DSM).

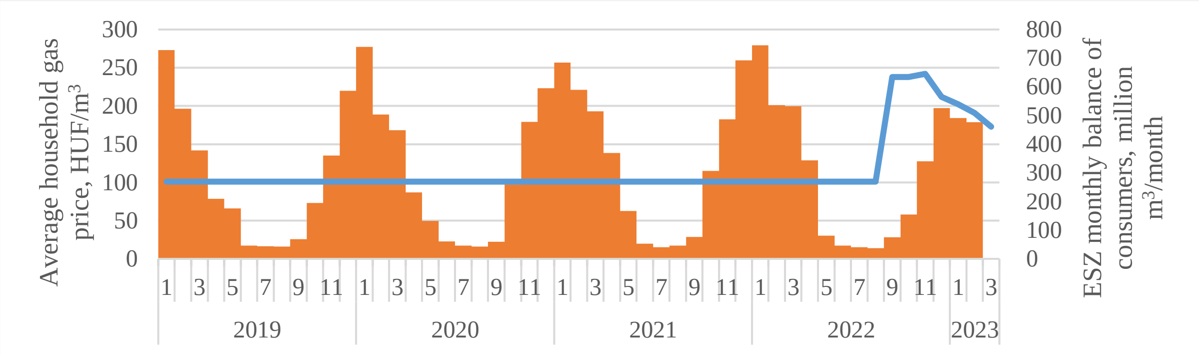


58Figure – Sectoral breakdown of final gas consumption, 2005-2021, Hungary Source: Eurostat

Looking at the gas consumption of individual sectors, it can be seen that the most significant consumption is related to households. The share of household natural gas consumption in domestic final gas consumption has gradually increased since 2013, from 44% to 50%, which is approximately the same as in 2005.

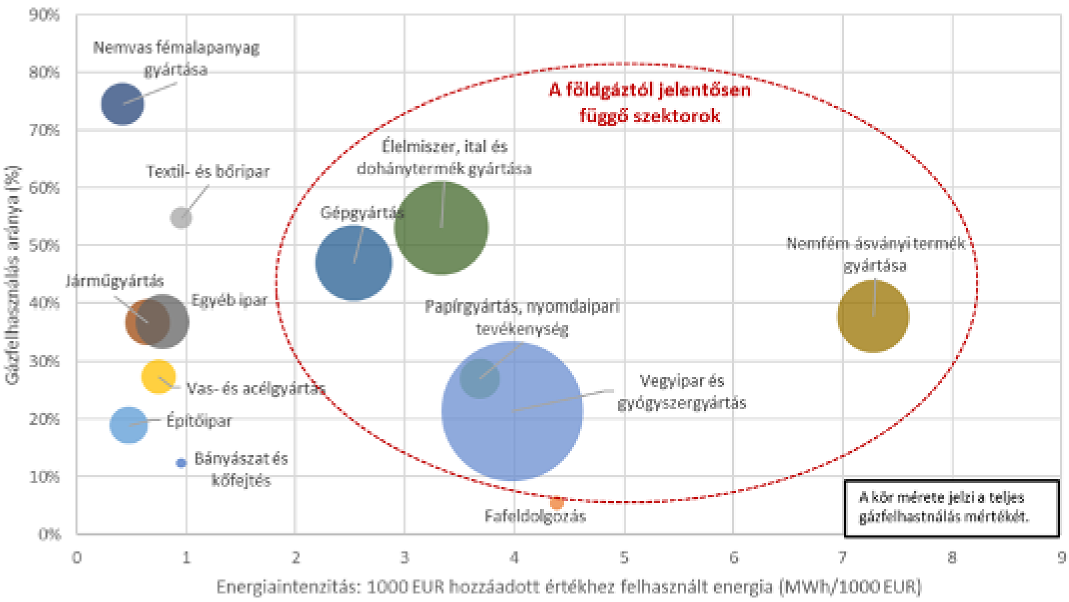
The household **utility price** protection system was transformed in 2022 due to a significant increase in wholesale natural gas prices: From August 2022, a two-tier tariff system was introduced for household consumers, under which quantities consumed above a given consumption threshold (currently 1 729 m3/year)are charged almost 7,5 times the base price. The tariff system introduced in 2022 therefore provides a strong price signal for households with above-average gas consumption. The monthly price statistics of the HCSO suggest that consumers paid higher prices for 15-20% of consumption in the fourth quarter of 2022 and the first quarter of 2023. As a result of the price increase due to the change in regulations, the

Hungarian household consumption of natural gas started to decrease significantly. The affected households reacted practically immediately to the price increases they also experienced.



59Figure – Evolution of residential pipeline natural gas prices (HUF/m3/month)and changes in the volume of residential (ES) natural gas consumption (million m3/month) Source: HCSO, MEKH

Consumption in **the industrial sector** has increased since 2005, both in absolute terms and as a share of final gas consumption: In 2005, the consumption related to the sector was 75 PJ, while in 2021 it was 93 PJ, its share of final consumption increased from 20% to 30%.



60Figure – Characteristics of gas use in industrial subsectors[172] (2021) Source: HCSO, MEKH

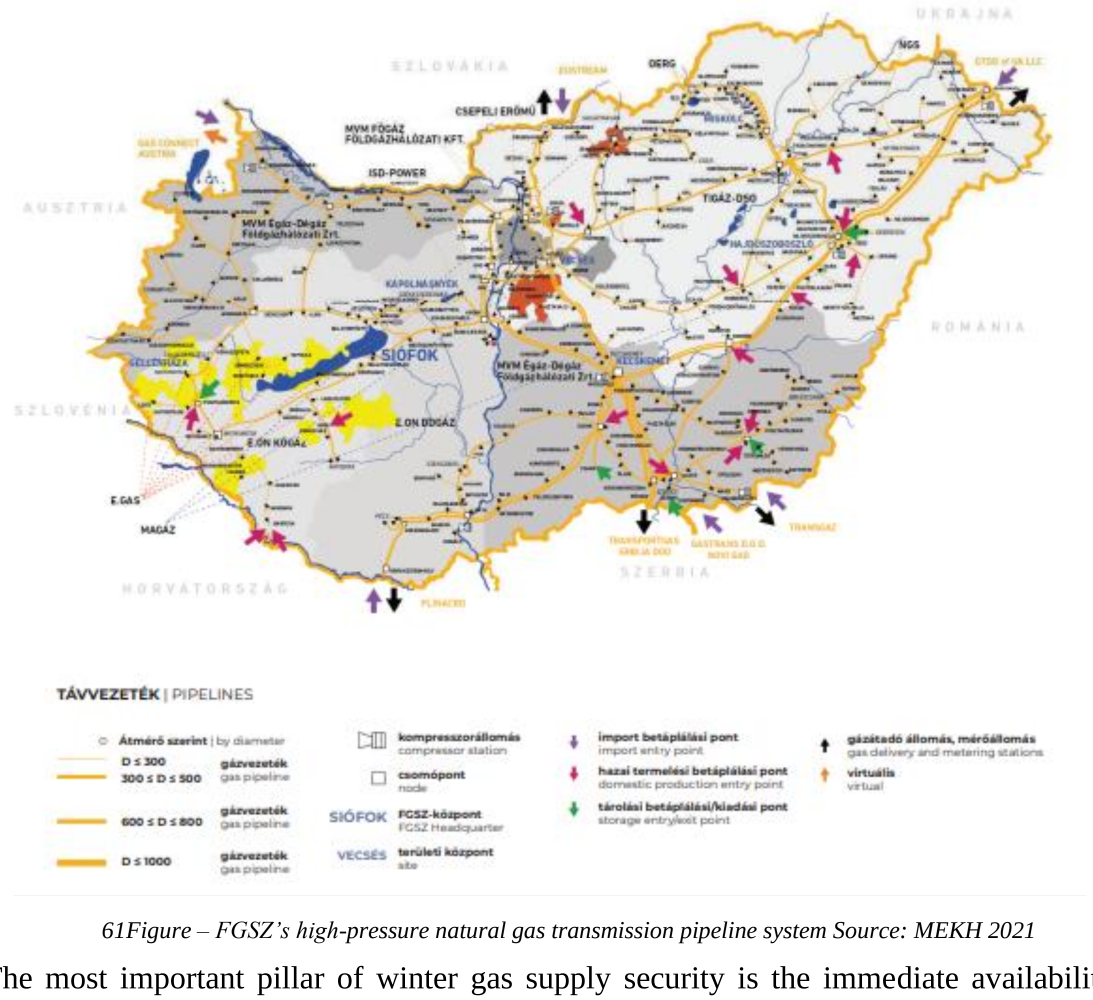
The most important sub-sectors in terms of gas consumption and exposure to natural gas are the chemical and pharmaceutical industries, the manufacture of food, beverages and tobacco products, the manufacture of non-metallic mineral products and the manufacture of machinery. The use of natural gas in these four sectors accounted for 77% of the total consumption of the industrial sector in 2021. In the case of the chemical industry, natural gas plays an important role not only as an energy carrier, but also as a key raw material (fertilizer

[172] *For use, including material use of natural gas.*

production, hydrogen production). In the case of the subsector, almost a quarter (23%) of total consumption is made up of natural gas used as a raw material. In the field of mechanical engineering, further growth is expected in the future due to the newly built battery factories and their associated plants, as their energy consumption and natural gas consumption are significant. Gas demand in the industrial sector has reacted flexibly to high prices by partially and temporarily halting production (e.g. fertilizer production), transforming technology, accelerating renewable and energy efficiency investments and saving money.

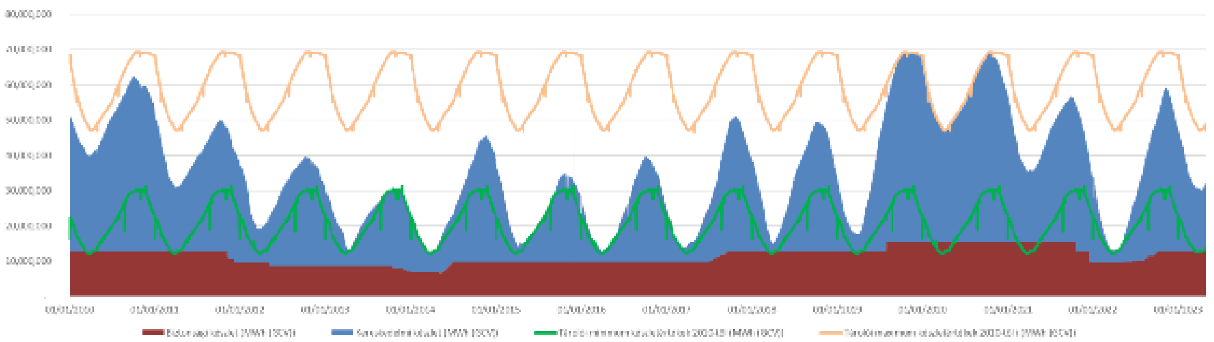
<u>Security of supply and storage obligation</u>

In Hungary, the security of natural gas supply is a priority issue in view of the high import dependency and the key role of gas in the heat and electricity markets. In the interests of security of supply, the Hungarian gas system is **highly interconnected with** the gas systems of neighbouring countries. While earlier the typical main entry direction was from Ukraine and Austria, from October 2021 this role was taken over by the new bi-directional pipeline, which transports Russian gas to Hungary from Serbia via the Turkish Stream pipeline.



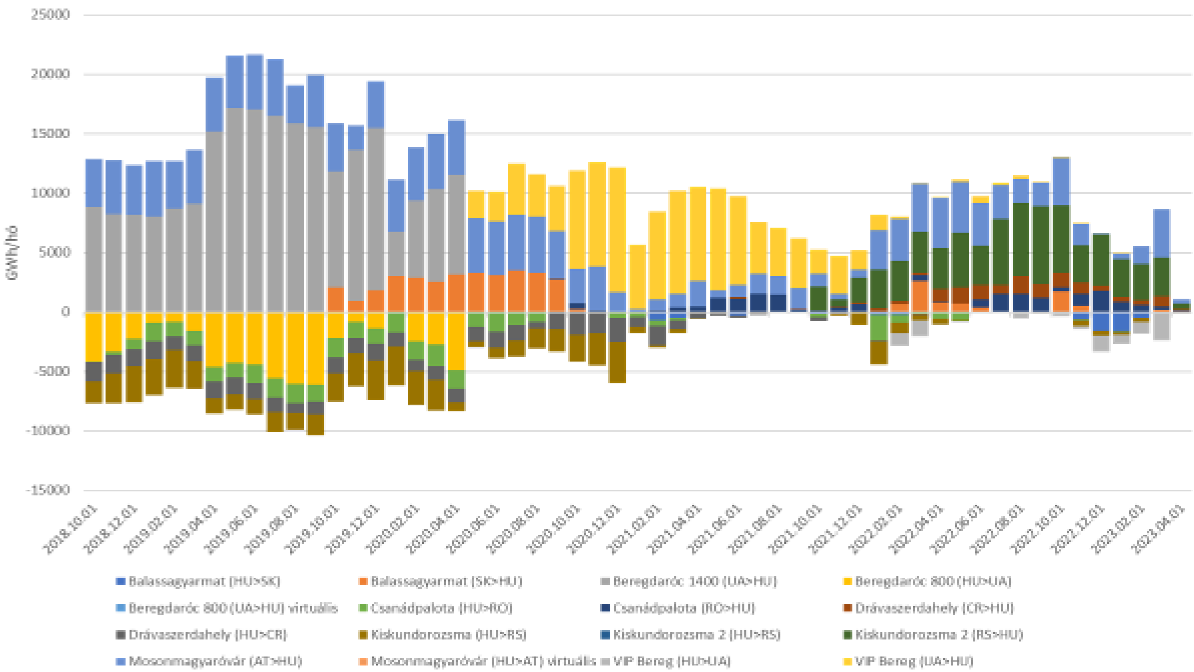
61Figure – FGSZ's high-pressure natural gas transmission pipeline system Source: MEKH 2021

The most important pillar of winter gas supply security is the immediate availability of stored stock **in the storage facility.** Hungarian (commercial and strategic) storage capacities (6.3 billion m3/year)are very significant compared to domestic consumption (between 9-11 billion m3/year). As shown in the graph below, storage capacities were typically underused until 2019. The Ukrainian-Russian transit contract expired at the end of 2019 and therefore a higher volume of Russian long-term contracted volumes was delivered bilaterally over two years to mitigate risks. Following the outbreak of the war on 24 February 2022, the European Union also imposed a storage obligation, the fulfilment of which also resulted in a higher than usual state of charge. Due to the mild winter of 2022/23, storage stocks remained at a high level at the end of the winter, but the EU storage obligation remains in place and requires a 90% charge by 1 November 2023.



62Figure – Evolution of natural gas storage stocks Source: MEKH 2023

In recent years, the structure and direction of pipeline gas flows in Hungary have changed significantly due to changes in the Russian transport strategy.

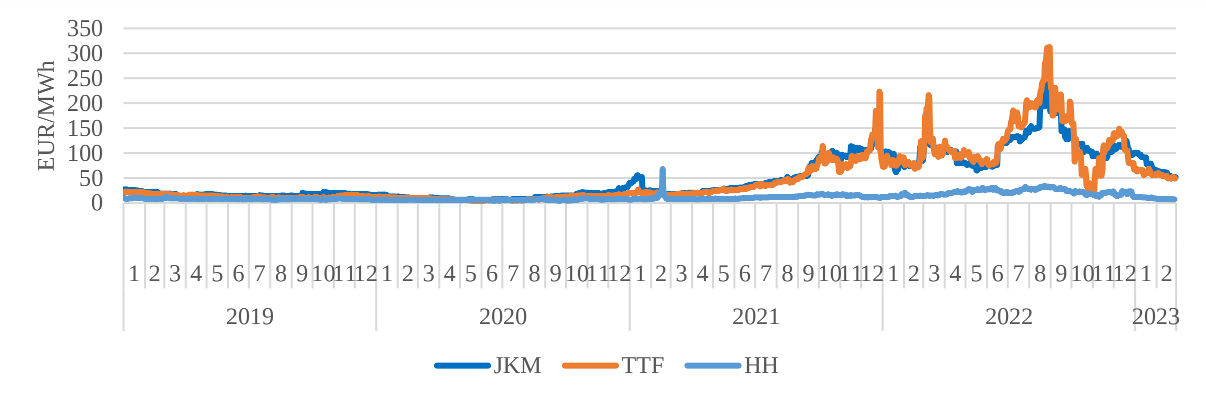


63Figure – Monthly gas flows at each cross-border entry and exit point Source: FGSZ

From the end of 2021, the previously dominant **imports via Ukraine,** under the new Hungarian long-term contract concluded in 2021 for 15 years, will be transported partly via Serbia and partly from Austria. Hungarian traders with a reservation at the Croatian LNG terminal Krk can deliver gas via the Croatian-Hungarian pipeline (Drávaszerdahely). At the Romanian entry point, Azerbaijani gas also arrived in smaller quantities, but the possibility of importing the extraction of the Neptun fields in Romania remains, if the necessary investments are made. In the interests of security of supply, over the past year Hungary has seized every opportunity to be able to diversify its gas supply, as evidenced by the fact that in 2023 natural gas from Azerbaijani and LNG sources also appeared in the Hungarian system.

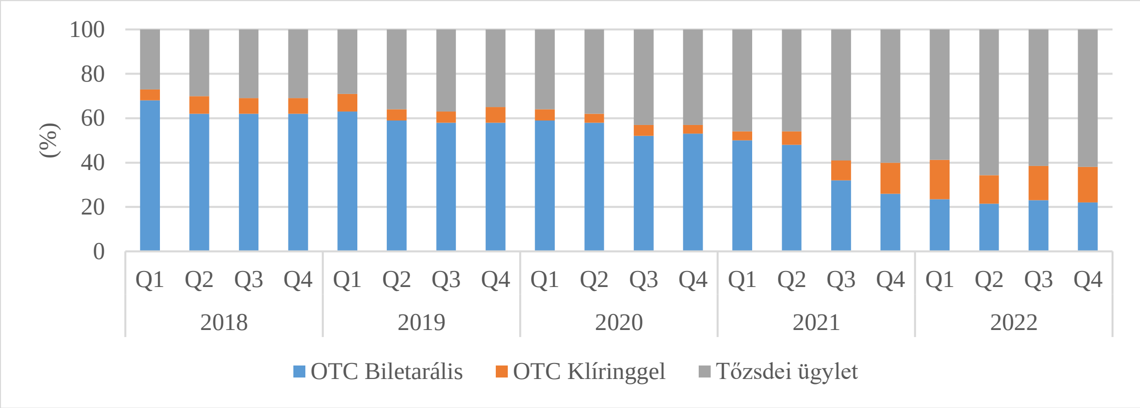
Natural gas prices and trade

In 2021, wholesale **natural gas prices** in Europe left the 20-25 €/MWh band that they had been accustomed to for years in a scarce market, before reaching a height of €300/MWh in August 2022, also reflecting the geopolitical situation and huge security of supply uncertainties. The leading Dutch gas price index (TTF) in Europe surpassed the Japanese Korea Marker (JKM), which served as the Asian price signal, during the energy crisis, and both were far removed from the North American gas price (Henry Hub - HH). After reaching the target filling level of the storage facilities, prices gradually decreased. At the same time, the situation continues to depend on maintaining a fragile supply-demand balance.



64Figure – Wholesale natural gas prices in Europe, the US and the Far East Source: EEX, EIA, Investing.com

With the operation of the Hungarian gas exchange (CEEGEX), Hungary will contribute to the improvement of its energy and energy policy position in the medium and long term. The previously defined objective of the Hungarian wholesale natural gas market is to become a hub, which is subject to a number of necessary conditions (e.g. cross-border infrastructure, storage capacities), but further sufficient conditions are in the process of being met, such as exchange trading, regional competition, gas market integrations and partnerships. As a result of the energy crisis, the promotion of trade in renewable gases, the improvement of clearing house and settlement conditions and the change in the pricing of domestic end-consumer contracts were also on the agenda in Hungary.The energy crisis served as a catalyst for the restructuring of energy trade that had already begun, in connection with which more and more bilateral trade shifted to the stock exchanges. During the turbulent period, market participants turned to safer forms of trading to guard against increasing counterparty and default risks, despite higher collateral requirements.



65Figure – Percentage of trade in liquid and advanced European gas hubs Source: European Commission

In addition to the steady increase in liquidity in spot markets, it is crucial to ramp up futures markets. For the time being, transactions have moved further towards closer maturities and spot markets, but the aim is to shift a significant part of domestic bilateral trade to the stock exchange platform. In addition to the already liquid domestic spot gas market, the aim is to create a stable and widely used price signal based on actual trading from the next monthly delivery period until the end of the next gas year. Appropriate cooperation is also of key importance, as international examples show that liquid futures markets could only be realised through the development of appropriate international cooperation. There is currently no meaningful competition in **the area of retail sales to end-users,** the number of companies ranged from 2-3 between 2017 and 2021, with a single company accounting for 99.8% of the market in both 2020 and 2021.

In the market for sales to non-residential end-users, the number of companies was relatively stable between 2017 and 2021 (26-29 companies). However, in addition to the larger number of market participants, it is worth highlighting that the three largest players accounted for around 50% of the market in 2021, the highest figure in the period 2017-2021.

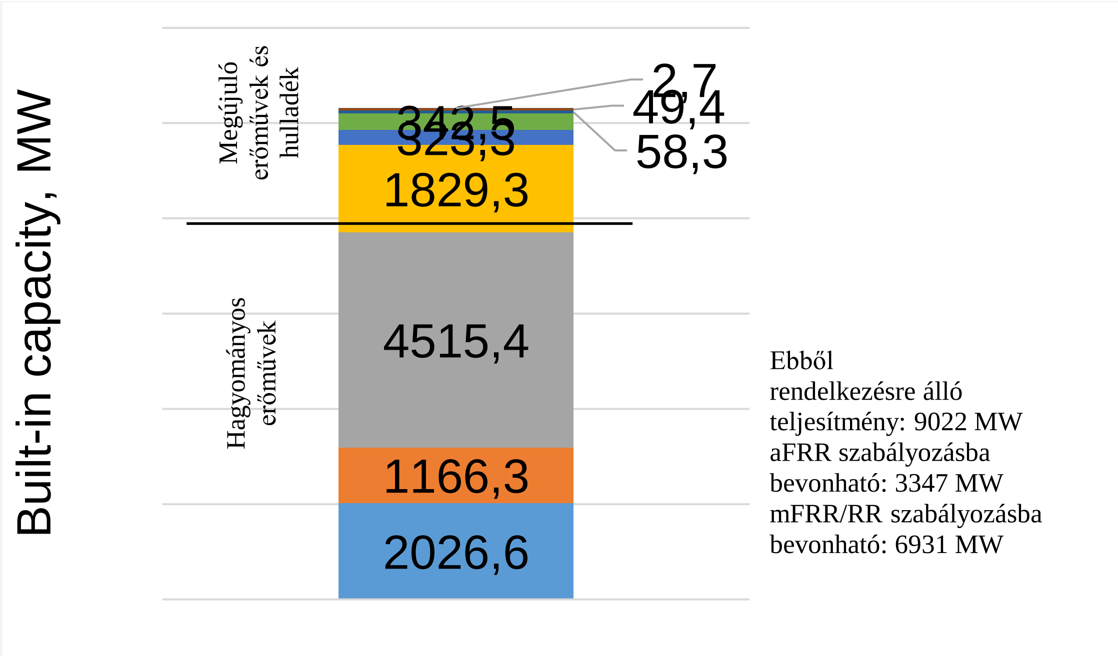
The number of companies selling on the wholesale market has decreased in recent years, with 40 such companies in 2021. In 2021, four out of the 40 companies had a market share of more than 5%, with the three largest market players having a market share of 65%, unchanged from 2019 and 2020.

Electricity market

The Hungarian electricity system is currently characterised by a high level of security of supply, the two pillars of which are a diversified domestic production portfolio and market integration.

Production and consumption

The gross installed capacity of the power plants at 31 December 2021 was 10 314 MW, of which the **available capacity** was 9 022 MW. The detailed evolution of installed and available capacities in 2021 is summarised in the chart below.

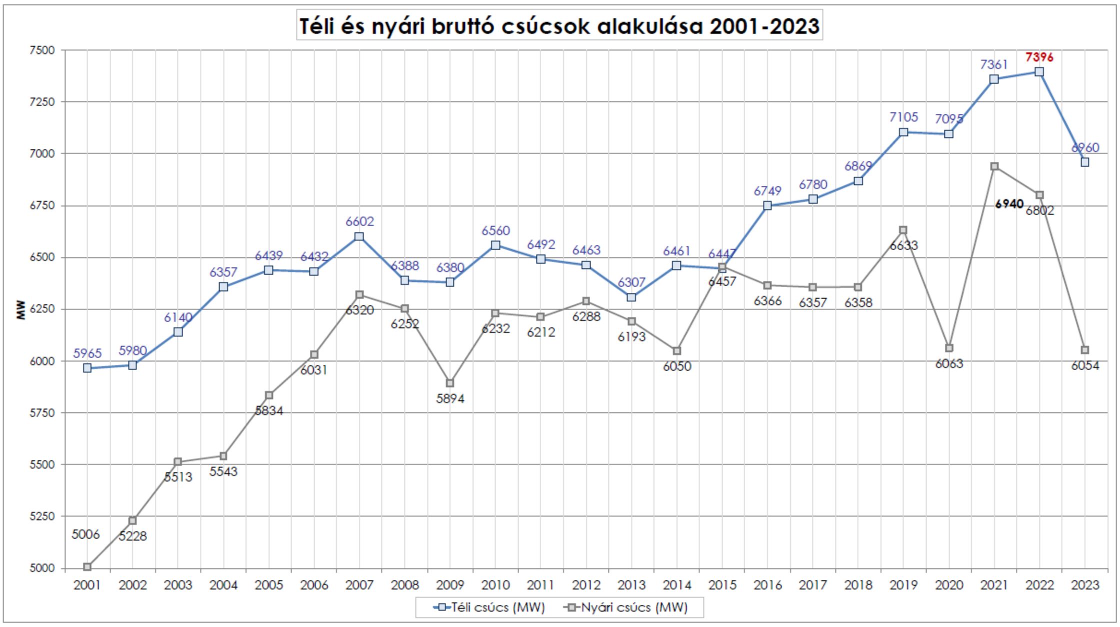


66Figure – Distribution of installed capacity of all domestic power plants by primary source Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER)

The largest market player in the domestic electricity market – the MVM Group – plays a decisive role primarily through the Paks Nuclear Power Plant and the Mátra Power Plant. In addition, MVM owns MAVIR, which operates the transmission network and performs the functions of system operator, two of the six distribution network companies (in 2021) and has a share of more than 40% on the retail market. The combined market share of the four largest groups of companies after MVM (MET, Veolia, Uniper and Alpiq) in the domestic electricity generation was 25%.[173]

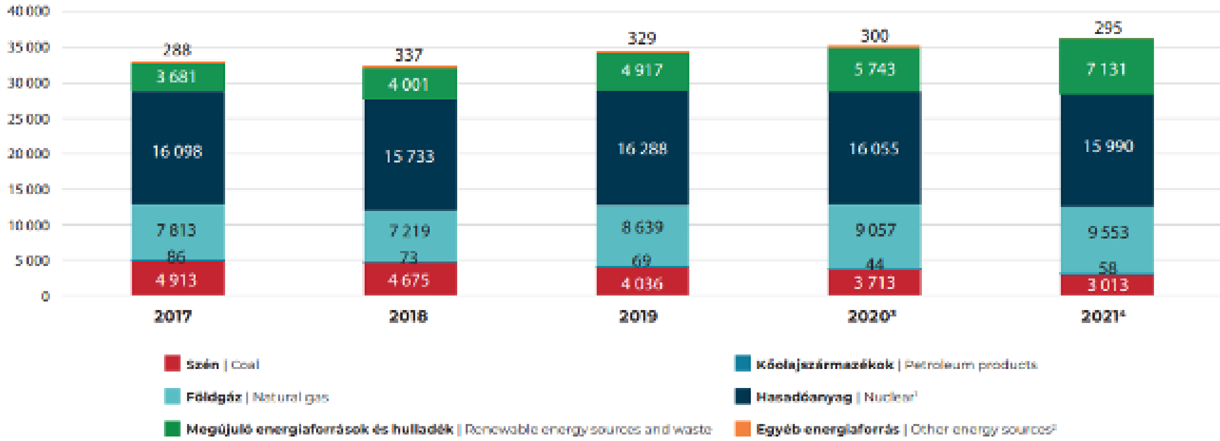
Built-in PV capacity is growing rapidly, currently exceeding 5 GW. Additional PV capacity of about 4.5 GW has some level of commitment (accession contract or binding plan – technical and economic information (MGT)), in addition, 3.8 GW of MGT has been emitted in the recent period, so that by 2030 the total PV capacity could reach 12 GW.[174] This capacity is particularly high in view of the magnitude of the system load. The peak winter and annual gross system load has been on an increasing trend for years, reaching a much higher level of 7 396 MW in 2022 than in previous years, while the summer daily peak load was 6 802 MW in 2022, 14% higher than in the previous year.[175] The peak system load in the summer of 2021 was 6,940 MW, which is the highest system load recorded in the summer so far. This year, there has been a marked decline in both system load data and total gross electricity consumption.

[173] *MEKH Parliamentary Report, 2021*
[174] *Source: MAVIR*
[175] *MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER)*



67Figure – Evolution of winter and summer peaks of electricity system load (2001-2023, MW) Source: MAVIR Ltd.

In terms of production, the distribution of **the resource composition** is shown in the figure below.



68Figure – Source distribution of domestic electricity generation (2017-2021, GWh) Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER)

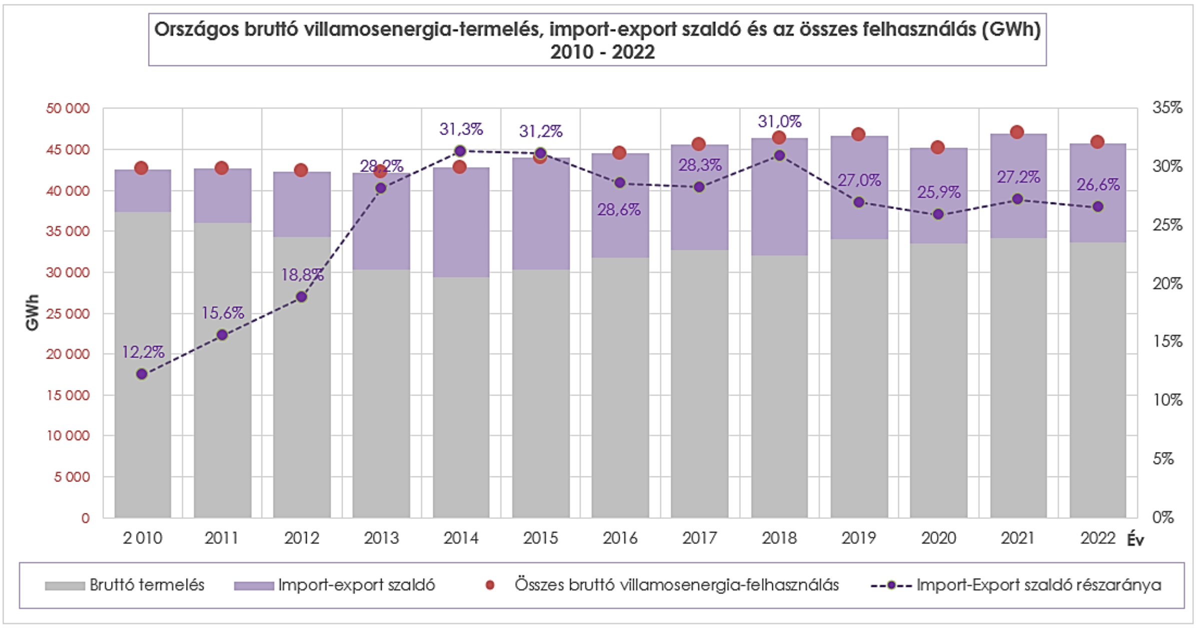
In 2022, 44% of domestic electricity generation came from the Paks Nuclear Power Plant, while the share of renewable electricity generation amounted to almost 20% and is expected to increase further with the incorporation of PV capacities. Overall, 64% of domestic electricity production already came from GHG-neutral sources in 2021, exceeding the EU average.

Gas-fired power plants with relatively high marginal costs also account for a significant share of domestic capacities, which also play a significant role in the regulatory markets. At the end of the 2010s, fuel prices and the price of greenhouse gas emission allowances (EUA) resulted in the production cost of gas-fired power plants in Europe falling permanently below the production cost of coal-fired power plants. However, this was reversed in 2022 due to the spike in gas prices, whereby the production of natural gas-fired power plants was partly taken over by coal-fired power plants: the share of coal and lignite fired in EU27 production increased from 12.3% to 14.2%, again exceeding the 13.9% contribution of gas-fired power plants.[176] In Hungary, these **gas-charcoal production shift trends** have been less pronounced: the production of the lignite-fired Mátrai Power Plant has been steadily decreasing since 2017, and although this decrease stopped last year, there has been no significant fuel change in the Hungarian electricity system. This decrease in gas-based production across Europe was only slightly observed in Hungary in 2022, but in the first half of 2023 the utilisation rate of Hungarian gas power plants was significantly lower than in previous years. In an increasing number of periods, gas power plants are not producing for the product market, but only for the regulatory markets.

The **increase in electricity demand** from 2016 to 2019, slightly above 1% per annum, was interrupted in 2020 due to the containment measures taken due to the pandemic. Subsequently, electricity consumption increased by 4.9% in 2021, an increase of 4.3% compared to 2019.[177] Gross electricity consumption, excluding production data from household-scale producers, was 46.9 TWh in 2021, of which 73% was domestic production and 27% was imported, while it decreased to 45.8 TWh in 2022, of which 26.6% was imported energy.

Total gross electricity consumption declined markedly both at the end of the previous year and in the first half of 2023. At the end of 2022, there was a decrease of around 2.5% compared to the end of 2021, compared to a downward average trend of 7.9% between 1 January 2022 and 30 June 2023, compared to the first half of last year.

[176] *Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf*
[177] *Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf*



69Figure – Gross national electricity production, import-export flows and total consumption (excluding UAA) Source: MAVIR Ltd.178

The domestic electricity system typically operates **with net imports:** over the last 5 years, the net import share has fluctuated between 26 % and 32 % on an annual basis. Import demand currently poses no significant security of supply risk, as cross-border capacities are also strong internationally. Hungary's electricity market is quite open, as it has cross-border connections with all neighbouring countries, and market integration ensures the efficient functioning of the common European electricity market. That being said, according to the reference scenario of ENTSO-E’s 2022 resource adequacy analysis, the *number of unattended hours (LOLE)* in Hungary is expected to be 6.3 hours in 2025, which is also high in European comparison. There is no capacity mechanism for security of supply purposes in Hungary, but due to its ownership role, the State has a direct influence on significant power plant investment decisions. These include, for example, the planned service life extension of the existing units of the Paks Nuclear Power Plant or the construction of new nuclear power plant units.

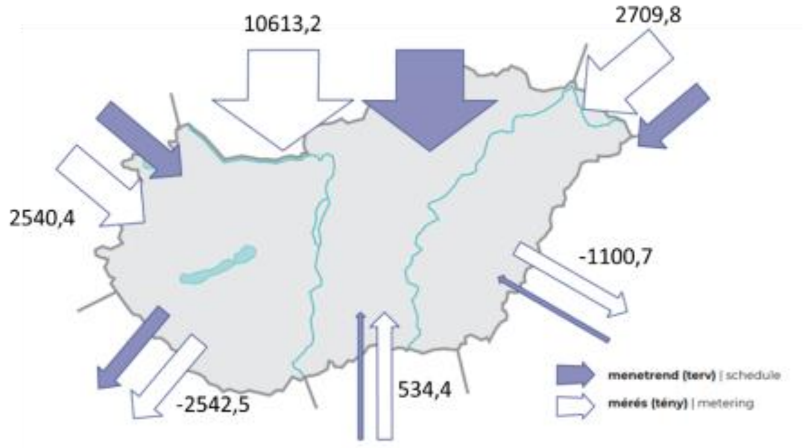
Retail and wholesale, market integration

Cross-border capacity increased significantly in 2021, with 800 MW available at the Slovak cross-border, around 140 MW available at the Romanian cross-border and around 250 MW available at the export. Despite the significant capacity increase, the frequent scarcity of cross-border capacity has become characteristic not only on the Slovak and Austrian pipelines, but also from the Romanian import direction.[179]

[178] *https://www.mavir.hu/web/mavir/a-full-brutto-electricity-use-sharing*

[179] *Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf*

The following chart shows the development of international electricity sales and actual flows on each cross-border pipeline in 2021.



70Figure – Actual electricity flows, import flows (2021, GWh) Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER)

The most valuable import capacities are typically the Slovak and Austrian cross-border pipelines, while the most significant exports have traditionally been to Croatia (and, more recently, Slovenia). However, the structure of foreign trade has changed somewhat in recent years. While the volume of imports also increased further with the expansion of the Slovak-Hungarian import capacity (Slovak imports practically doubled in 5 years), imports from Austria practically halved in 2021 compared to previous years. In 2022, with the delivery of the Slovenian pipeline and the strong increase in traffic in relation to Croatia, there was a very significant increase in exports in relation to the south-west.

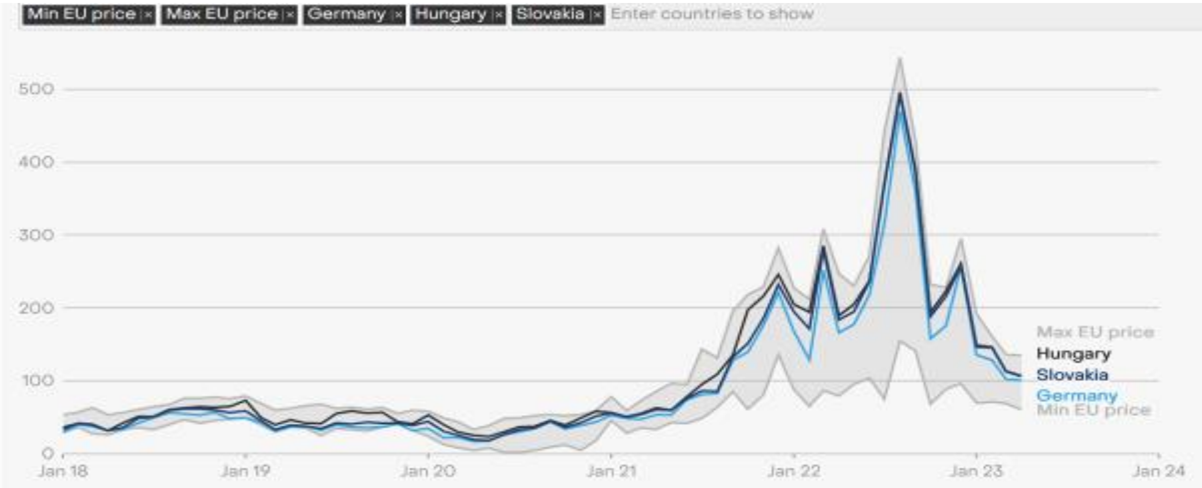
As part *of the EU's so-called Third Energy Package* adopted in 2009, *Regulation (EC) No 714/2009* provided for the creation of interconnected electricity markets. Accordingly, significant **market integration developments affecting the Hungarian market have taken place in** recent years. Initially, only the Czech-Slovak day-ahead market coupling was operational in our region, to which Hungary joined in September 2012 as a result of the Czech-Slovak-Hungarian market coupling project, which triggered the implicit day-ahead allocation based on *net transmission capacity (NTC)* also at the Hungarian-Slovak border. Subsequently, the so-called *4M MC market coupling was launched with the accession of Romania* on 19 November 2014. As a next big step, the *so-called Interim Coupling project* was launched in December 2018, resulting in the realisation of a pan-European integrated market in the day-ahead timeframe.[180]

Finally, the *Core Flow-based market coupling project* was launched in June 2022, changing capacity allocation from NTC-based to flow-based, allowing for a more efficient use of network elements. The experience with the introduction of flow-based capacity

[180] *Source:* https://www.mavir.hu/web/mavir/day-to-market connection

calculation is positive, with the frequency of exceptionally high price differences decreasing, while the frequency of overall price convergence increased slightly. Following the launch of the flow-based project, HUPX's turnover seems to have stabilised at around 2 TWh per month, but the liquidity of the market in forward trading remains very low.

Electricity **prices** increased significantly from the second half of 2021, mainly driven by increases in the price of natural gas and GHG emission allowances, and further increased by the Russian-Ukrainian war that erupted in 2022. As a result of the strong price increase, the price premium of the Hungarian electricity market has also increased compared to the surrounding markets. Hungarian day-ahead prices typically range between Italian and German prices, and we are among the higher-priced countries in the region: Compared to wholesale prices in Austria and Slovakia, the Hungarian market typically traded at a surcharge of 5-10 €/MWh. In the second half of 2021, these spreads not infrequently jumped to a level of €60/MWh, while the liquidity of the Hungarian OTC markets (which has been declining strongly since 2018) declined drastically in 2022.



71Figure – Wholesale prices of domestic and regional electricity, €/MWh, distribution of sources of electricity generation (2018-2023) Source: HUMAN

Increasingly significant intraday price fluctuations can be observed on stock exchanges, which bring new business strategy opportunities for traders.

For intraday markets, *the XBID project* was implemented[181] in Hungary in November 2019. As a result, the Hungarian intraday market also became an international market, with all of Hungary's EU borders becoming part of the market coupling (both in the day-ahead and intraday timeframes). Thereafter, volumes traded on the intraday market show a steady increase, apart from a halt after the start of the day-ahead flow-based project, and currently represent a quarter of the day-ahead market in volume.[182] This shows that there is still potential in this market. This is an important development in light of the fact that the

[181] *Cross-Border Intraday Project*
[182] *Source: HUPX, https://hupx.hu/uploads/Market%20data/DAM/monthly/2023/HUPX_Spot_April_Report_2023.pdf*

integration of large volumes of renewable capacity can be effectively supported by the intraday market.

It is important to note that the market integration measures already implemented have had a number of positive results: improve security of supply, increase market efficiency and liquidity, and have also led to price convergence and more stable electricity prices in the regional energy market. Further positive developments can be brought about by the expected developments in the Hungarian electricity markets in the near future, as well as by the integration of the regulatory energy markets expected next year.

The **retail market** has a dual structure: whereas users eligible for universal service (mainly residential and small consumers) can obtain electricity at a regulated maximum price, in the free market segment prices are driven by the market. One third of total end-user consumption is met by universal service (official price) and two thirds by the free market segment (market price). In 2021, 13 199 GWh of electricity was sold by traders to universal service customers. 54% of these customers were supplied by MVM Next and 46% by E.ON Power. In 2021, traders sold 27 172 GWh of electricity to consumers supplied from the free market. Although several traders are active in this market segment, there is also a high concentration: MVM serves 54% of consumers on the competitive market alone and 97% together with E.ON.[183]

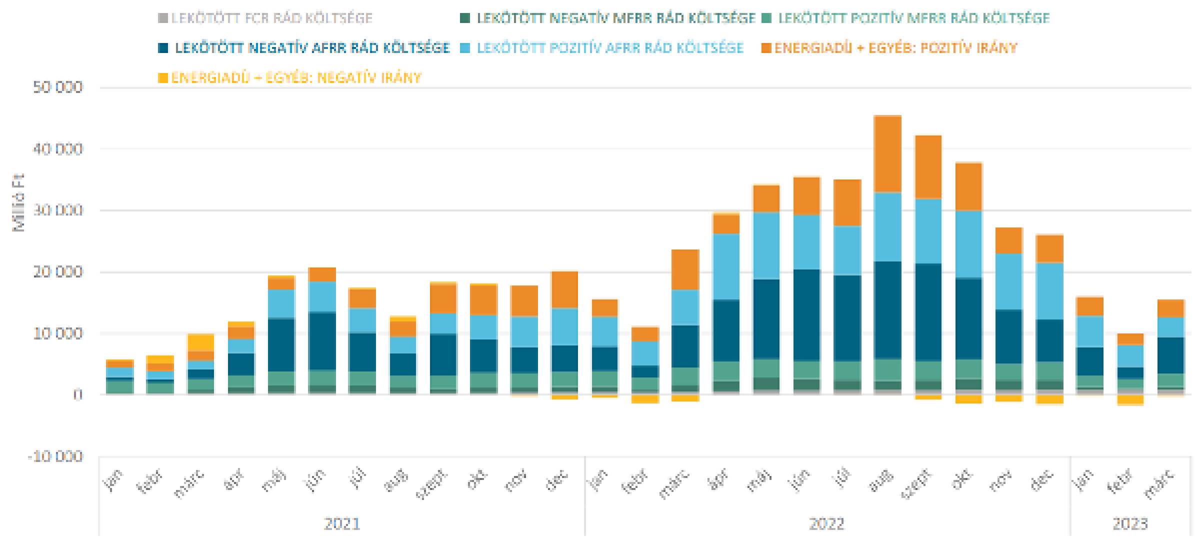
In the universal service segment, the Hungarian government implemented a step-by-step price reduction by 2013 and these so-called ‘reduced overhead’ prices were in force until summer 2022. The unprecedented price increase on European electricity markets has led to some changes in universal service: while sales to the extent of the so-called ‘average’ private consumption are made at constant prices, above this level official prices are set at ‘market prices’. As a result, electricity tariffs paid by domestic household consumers are still the lowest in the European Union. In addition, the government has reduced the number of non-residential consumers eligible for universal service: consumers excluded from official price supply are temporarily supplied by a last resort supplier and subsequently by a free market trader at a free market price. Non-residential consumers who left the universal service and were granted the status of last resort moved from the status of last resort ending at the end of 2022 to the so-called promissory note-fixed status, facilitating their transition to the free market. This status is also granted for a limited period of time – the end of the gas year 2023 for gas and the end of the electricity year 2023 for electricity – as it is also intended to support the transition.

Regulatory Capacity and Energy Market

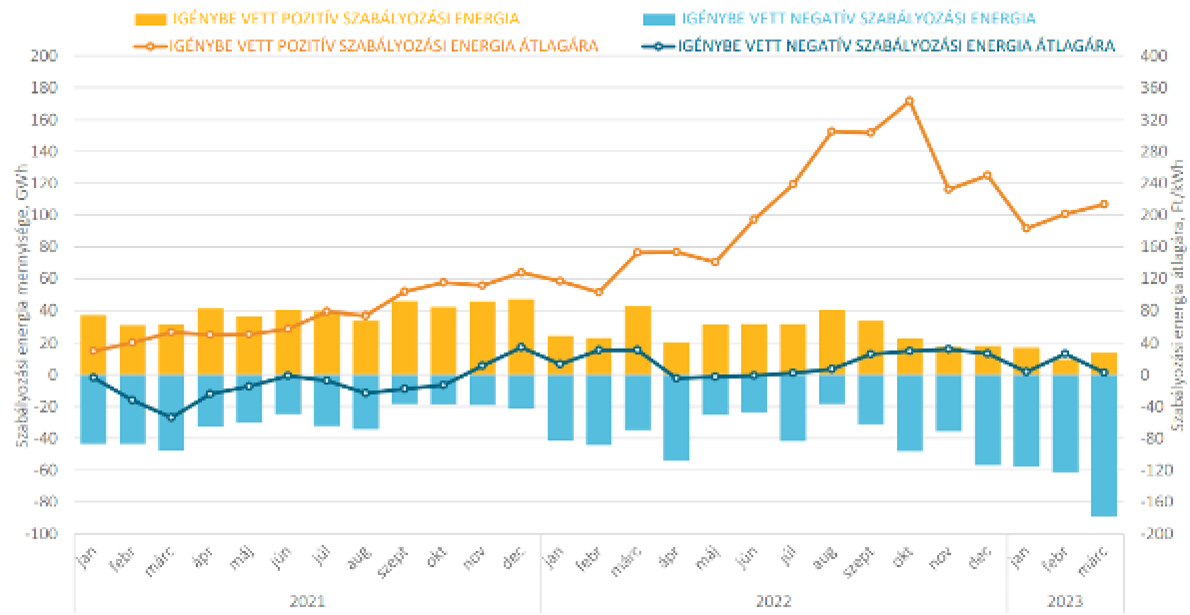
The **total cost of regulation used by the** system operator doubled from 2020 to 2021 and again from 2021 to 2022. This may be due to a number of cumulative reasons. On the one

[183] *Source: MAVIR Ltd. (2022): 2021 data of the Hungarian electricity system (VER) and MEKH Parliamentary Report, 2021*

hand, the capacity fee for committed reserves and regulatory energy prices were strongly affected by exceptionally high market prices, and on the other hand, the amount of “downstream” committed reserves increased significantly in 2022.



72Figure – Total cost of regulation used by the electricity system operator (2021-2023) Source - MEKH monthly report 184



73Figure – Monthly amount and average price of regulatory energy consumed (2021-2023) Source: MEKH monthly report

In summary, in the area of systemic services, exponentially increasing annual costs in terms of availability charges and regulatory energy charges have emerged in recent years. However, according to 2023 data, costs appear to have decreased compared to last year's

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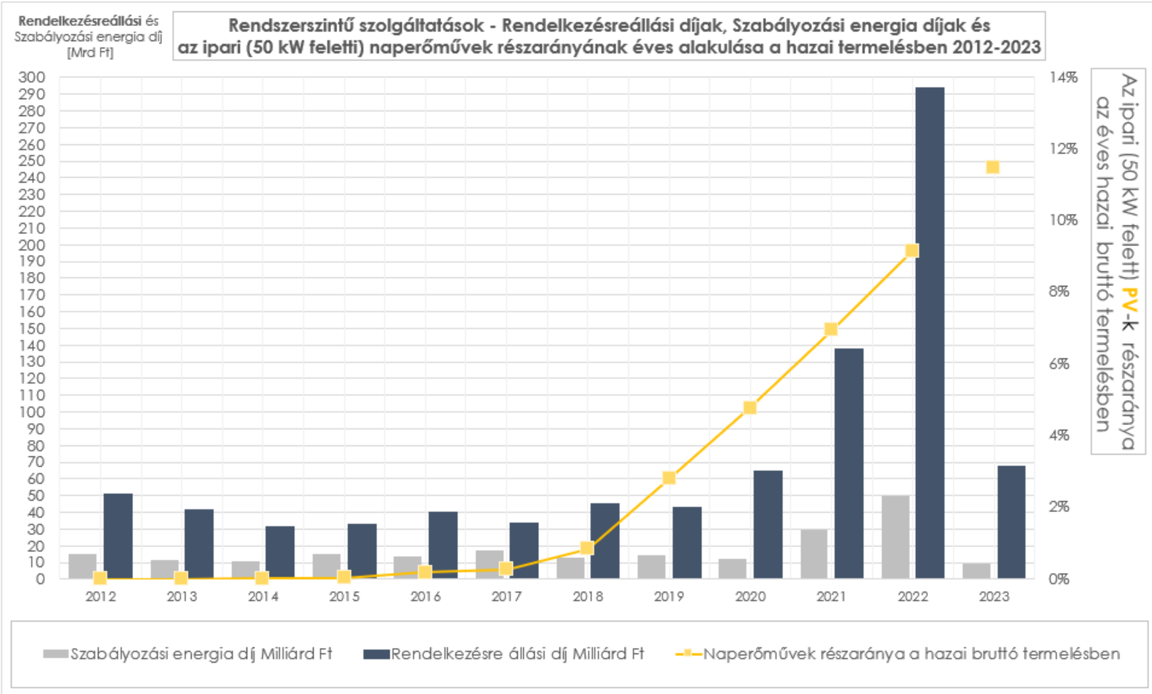
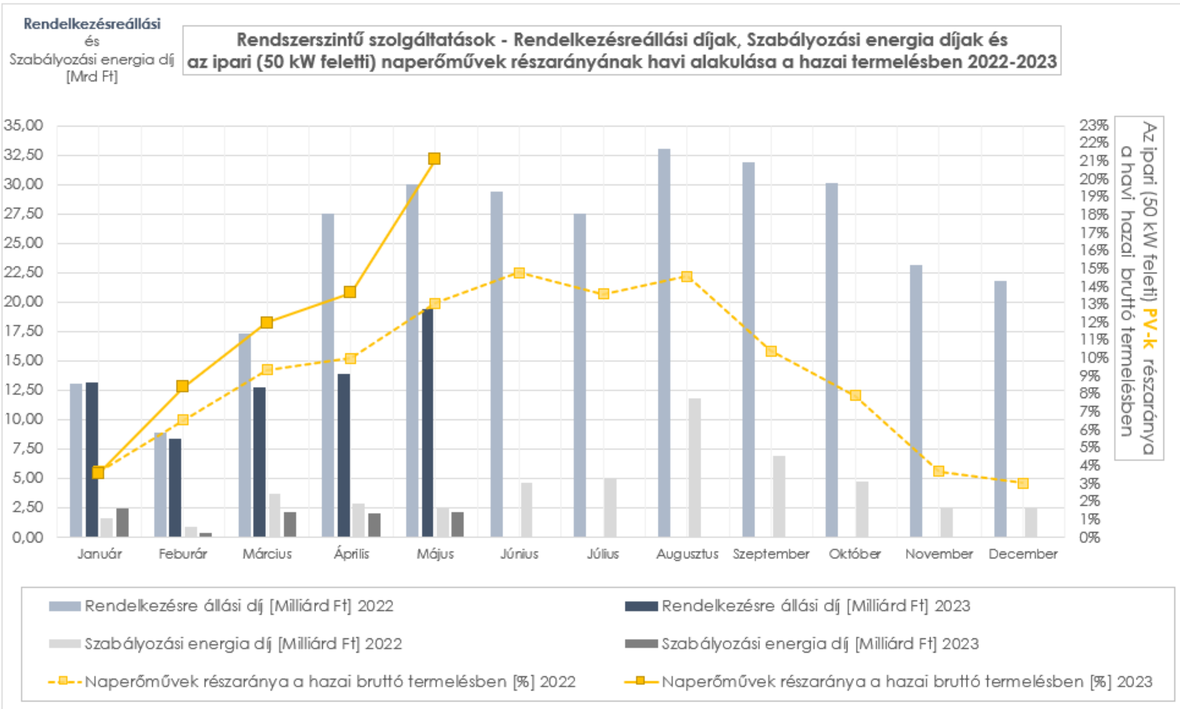
184 https://www.mekh.hu/download/6/14/41000/HaviRiport_villamosenergia-piacok_2023_3_vegso.pdf

figures. In addition to costs, the production share of solar power plants plays an important role, as well as the increasing number of solar power plant producers being involved in the market for system-wide services.



74Figure – Systemic services, regulatory energy charge, availability charge, share of solar power plants in gross production (2012-2023) Source: MEKH monthly report



75Figure – Monthly amount and average price of regulatory energy consumed (2022-2023) Source: MEKH monthly report *ii. Projection of progress based on existing policies and measures at least until 2040 (including the year 2030)*

Natural gas market

A strong stock exchange and market integration processes can result in lower prices for domestic consumers, as the market size and the number of suppliers are increasing, so the competition between them is also increasing. Due to its position, Hungary maintains active trade relations with a number of non-EU countries. This is why it is important that not only EU operators can enter the domestic market, but also non-EU operators such as Serbian, British, Swiss or Ukrainian operators. This process is supported by the fact that many countries have started to harmonise their regulatory environment on the basis of EU rules.

Gas market integrations and partnerships

The utilisation rate of the Hungarian cross-border points increased significantly following the expansion of the North-South gas corridor (Baltic Pipe, GIPS, GIPL, IGB, Polish, Croatian and Greek LNG terminals), of which Hungary is at the centre both in terms of geography and gas trade. An important element of market coupling projects is to capitalise on the experience gained in the electricity and Baltic gas markets. In practice, this is the creation of a shared order book, which can be implemented with non-zero tariffs, primarily in the timeframe of day-ahead and intraday products.

The primary condition for market integration is the physical connection of gas supply systems. Interconnection of neighbouring markets with bi-directional cross-border capacity and similar market sizes is recommended, thus increasing competition between operators in the interconnected market. The physical conditions of the Croatian-Hungarian market coupling are given, as two-way trading is available at the cross-border point.

Improving clearing house and settlement conditions

Record high natural gas prices in 2022 led to record high financial expectations for traders in the form of guarantees. This has had a direct impact on the financing of natural gas traders across Europe, but overall an over-secured system has been developed where the European settlement system is prepared for more than 100% defaults without aggregation of risks.

A number of minor improvements have been made in recent years to address the problem and further significant improvements can be achieved through appropriate partnerships. Decentralised netting of buying and selling positions is one of the directions under consideration, which would significantly help traders and ultimately lower consumer prices. The clearing house conditions of domestic gas exchange trading can be improved through the expansion of eligible assets, whether it is a bank guarantee or the use of underlying contracts (e.g. end-consumers) in the case of financial custody.

Facilitating trade in renewable gases

In order to further diversify gas sources, it has become necessary to expand the tools and accelerate the processes supporting the achievement of the earlier targets of the domestic biomethane potential.

Based on international examples, one of the most effective ways to do this is to build up and integrate the GoO register of biomethane fed into the grid in Hungary into the international environment. Building on the GoO experience in the electricity market, where Hungary became one of Europe's liquid marketplaces by 2023, a gas market system for appropriate certificates can be developed. An important feature of trading these GoOs, certificates and renewable gases is that trading is separated from physical transportation. Therefore, Hungary can support the trade of European biogas beyond its domestic biogas potential with a careful regulatory environment.

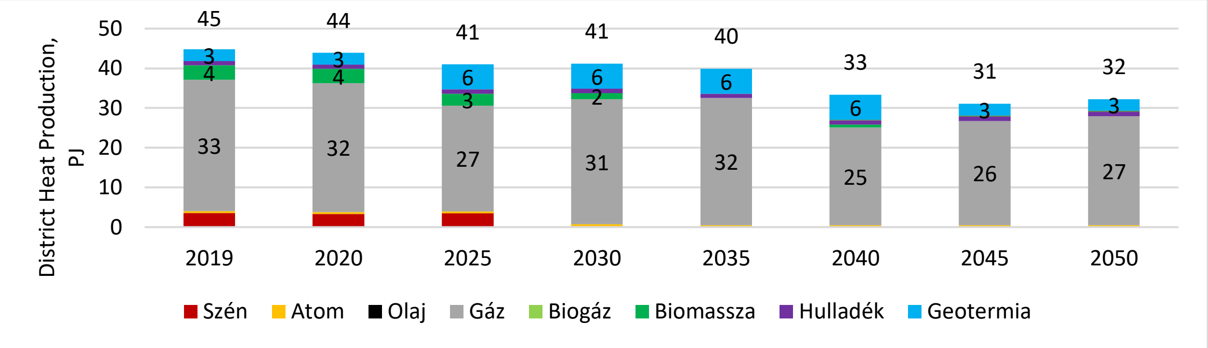
Changes in domestic end-consumer contracts

The year 2022 also changed traders' pricing and risk management practices. Since the 2010s, TTF indexation has spread in commercial contracts across Europe in addition to fixed prices, and this practice has also become established in Hungary, which is reflected in numerous legal references. When these laws were enacted, the domestic gas exchange did not yet have sufficient liquidity, but today this situation has been reversed.

As a result of the energy crisis, fixed-price constructions were typically phased out from market end-consumer contracts, and index-linked pricing with lower price risk became available to traders, primarily spot-indexed constructions. Concepts previously unknown to consumers have become the new norm and CEEGEX indexed consumer contracts have emerged. The latter arrangement is more advantageous for both the consumer and the trader as it allows for pricing reflecting domestic supply and demand conditions. As a next step in the spread of CEEGEX indexation, domestic forward prices may appear alongside the TTF in the case of hedging transactions, which would create the possibility of price fixing in advance for the participants of the domestic natural gas market.

The role of natural gas in the district heating market and the energy mix

In the case of derived heat, including district heating, the use of natural gas is already expected to decrease in the WEM scenario due to the replacement of natural gas with renewable alternatives.

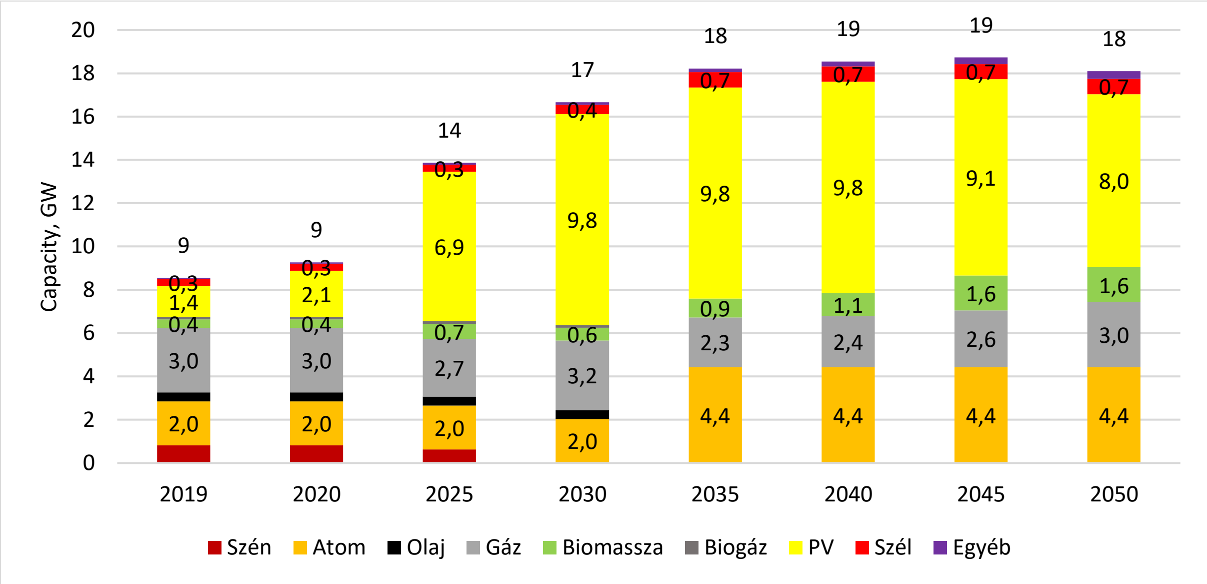


76Figure – Expected evolution of derived heat supply – and district heating production within it – by fuel composition, WEM scenario (2019-2050, PJ/year) Source: REKK, Eurostat

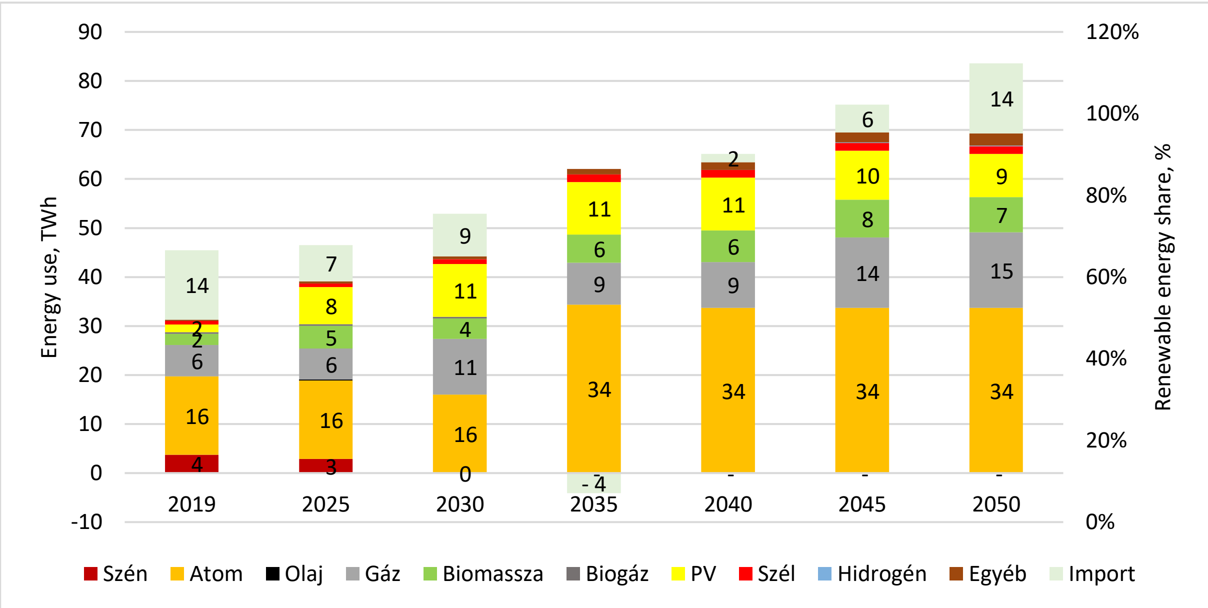
Figures showing the expected future evolution of the role of gases in the energy mix, taking into account the impact of current measures, are provided in Chapter 4.2.

Electricity market

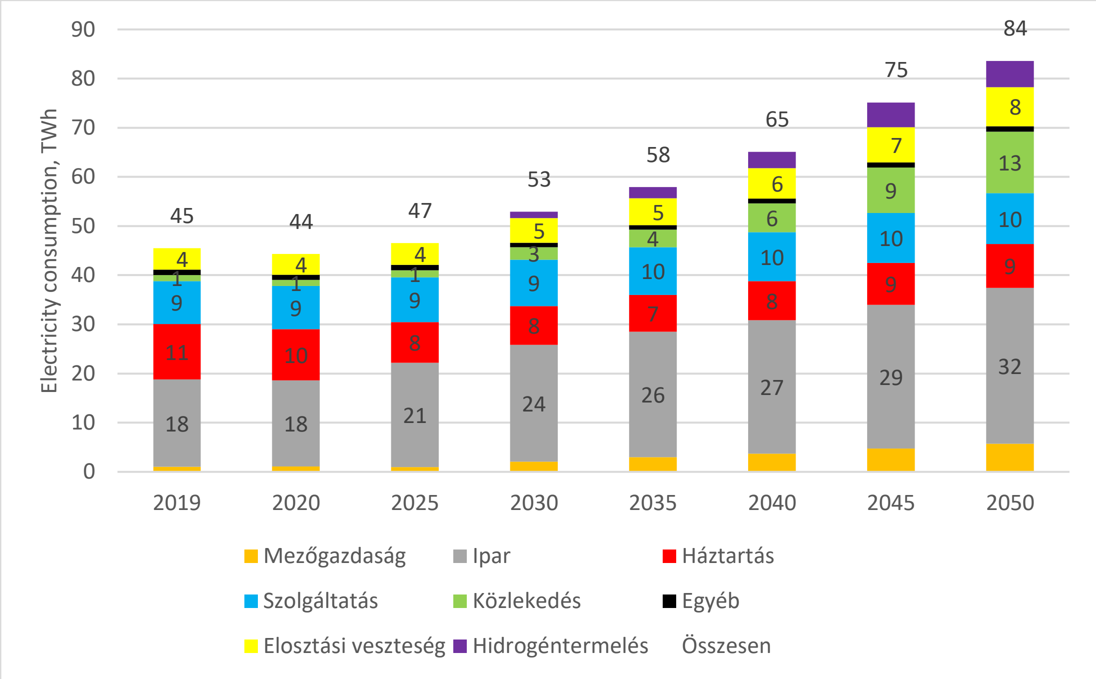
Existing policies and measures are expected to be affected by the electricity capacity mix and the generation mix shown in the graphs below.



77Figure – Expected evolution of electricity capacities, WEM scenario (2019-2050, GW) Source: REKK, Eurostat



78Figure – Expected evolution of electricity mix and consumption, WEM scenario (2019-2050, TWh/year) Source: REKK, Eurostat



79Figure – Expected evolution of electricity consumption by sector, WEM scenario (2019, GWh/year) Source: REKK, Eurostat

Figures showing the expected future evolution of the role of electricity in the energy mix, taking into account the impact of the current measures, are provided in Chapter 4.2.

Joining **platforms that facilitate the cross-border exchange of regulatory energy, such as PICASSO[185] and MARI, can make a significant difference[186] in regulatory energy prices,** creating an integrated European market also in the regulatory energy market. Platforms can lead to lower prices for a number of reasons. On the one hand, the potential for imbalance netting is expected to increase, reducing the demand for regulatory energy. On the other hand, as regulatory energy offers are activated on the basis of a common European merit order, market participants will be forced to compete with market participants from other European countries.

However, regulatory reserve markets tend to remain national markets, meaning that the supply side of reserve capacity needs to be expanded with the participation of domestic actors. In recent years, there have been positive changes in this direction. Renewable producers are increasingly involved in regulation (although their role is still negligible) and industry has begun to think about involving consumers as much as possible. Thanks to the storage support scheme, a significant amount of storage is expected to enter the regulatory markets in the future. The product structure of the reserve market has also been restructured to support market participation by new types of operators: As of Q2 2023, in addition to baseload products purchased in monthly tenders and peakload products purchased in weekly

[185] *Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation*
[186] *Manually Activated Reserves Initiative*

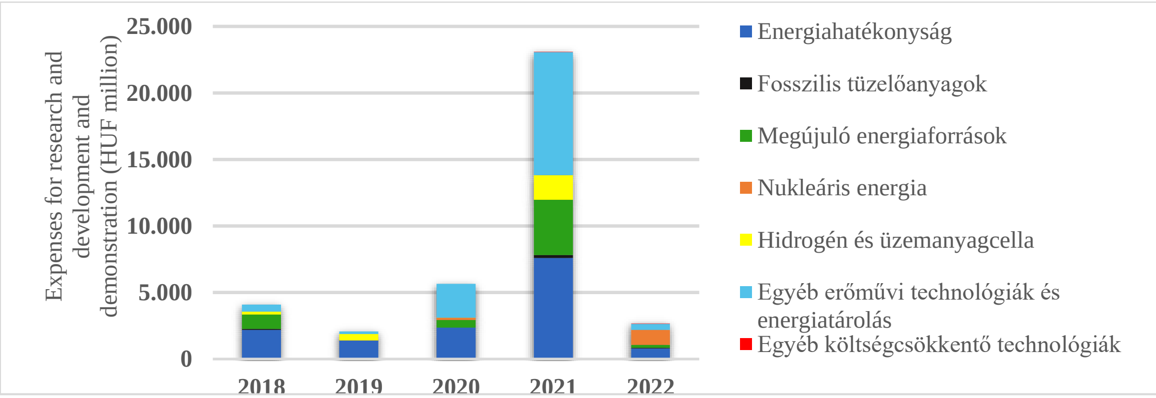
tenders, hourly products will also be purchased in daily tenders and intraday capacity tenders will be introduced within a short period of time.

2021 was an important step forward in meeting the objective of the Clean Energy Package to enable consumers to become active participants in the electricity market. To this end, new market players and activities such as active customers, aggregators or energy communities, flexibility services or electricity sharing have been defined and refined in domestic legislation. The integration of new types of players in the market requires a rethinking of the market's operating model, which could be an important challenge in the coming years.

4.6. Research, innovation and competitiveness dimension

i. State of play and, to the extent possible, position of the low-carbon technologies sector on the global market

The most important energy RDI development directions were explored on the basis of the distribution of public R&D and development expenditures, which were reviewed from the data provided to the *International Energy Agency (IEA).* We do not have precise information on aid from private investments. Hungary's energy R&D priorities in 2021 continue to be **energy efficiency, alternative propulsion in transport, renewable energy** and, in particular, solar energy developments; and **areas of energy production, transport and storage.** We have only an estimate of spending in 2022, but we can see that nuclear **development spending is** catching up with the above priorities.



80Figure – Breakdown of public R&D and development expenditure by technology (2018-2022, HUF million) 187 188

Source: IEA 189

Between 2018 and 2022, Hungary spent an average of HUF 7.5 billion annually on energy R&D and demonstration expenditures from domestic sources. The energy efficiency development directions are still decisive, but in 2021 the other power plant technologies and energy storage development directions were also decisive, thanks to the subsidies spent on demonstration projects.

[187] *There is no reliable detailed breakdown of energy efficiency.*
[188] *Other cost-reducing technologies: Energy system analysis, fundamental research, other activities not elsewhere classified*
[189] *http://wds.iea.org/WDS/TableViewer/tableView.aspx*

In 2021, energy innovation pilot projects were announced, the financial resources of which were provided by **a green economy financing system for the use of revenues from the sale of CO_2quotas** for climate protection purposes. The primary aim of the tenders was to encourage the development and mass application of innovative solutions that promote the increased use of domestic renewable energy sources in electricity generation and in the field of locally available renewable energy sources. Six energy innovation tenders were announced from the funds, and the implementation of the projects is still ongoing.

<u>Horizon 2020 and Horizon Europe</u>

When assessing Hungary's energy R&D activities, mention should be made of the European Union's seven-year framework programmes for research and innovation, **Horizon 2020 (2014-2020) and, as an integral continuation thereof, Horizon Europe (2021-2027).** In the context of the clean energy transition, Pillar III 'Societal challenges' of Horizon 2020 offers support. Among the activities of the Pillar, the following thematic areas are relevant: *Safe, clean and efficient energy; Smart, green and integrated transport; Climate change, environment, resource efficiency and raw materials.* In the case of Horizon Europe, the Cluster Climate, Energy and Mobility of Pillar II 'Global Challenges and Competitiveness of European Industry' has focused on promoting the green and digital transitions and the Framework Programme is expected to use 35% of its budget in relation to climate change objectives. Information on the European comparison can be found in the table below.

41Table – Grants awarded to projects with energy and climate objectives under Horizon 2020 and Horizon Europe (Source: Horizon Dashboard) [190]

Horizon 2020										
	HU	AT	CZ	DE	PL	SK	SI	RO	Other EU	Total EU
Safe, clean and efficient energy (EUR million)	22,2	165,1	29,7	698,4	45,3	9,4	56,5	30,6	3 504,6	4561,8
Smart, green and integrated transport (EUR million)	23,2	184,6	70,4	1 054,9	40,9	7,1	29,2	28,6	4 132,5	5571,3
Climate change, environment, resource efficiency and raw materials (EUR million)	16,6	82,2	14,2	404,3	40,0	6,5	26,8	20,8	2 021,7	2813,0
Euratom (EUR million)	11,5	8,6	25,4	284,5	15,4	4,7	9,5	6,4	677,0	1043,0
Other non-energy and climate priority projects (EUR million)	295,8	1 514,5	373,2	7 687,2	602,5	109,0	256,5	215,1	36 841,7	47 715,5

[190] *Note: * Data not available for Euratom Training Programme 2021-2025; Source: Horizon Dashboard (https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/1213b8cd-3ebe-4730-b0f5-fa4e326df2e2/sheet/d23bba31-e385-4cc0-975e-a67059972142/state/analysis)*

	HU	AT	CZ	DE	PL	SK	SI	RO	Other EU	Total EU
Share of energy and climate protection grants in total H2020 grants awarded to applicants in the given country (%)	19,9	22,5	27,2	24,1	19,0	20,3	32,2	28,6	21,9	22,7
Horizon Europe										
	HU	AT	CZ	DE	PL	SK	SI	RO	Other EU	Total EU
Climate, energy and mobility (EUR million)	12,1	146,7	49,9	706,5	46,1	7,1	40,8	31,2	2 871,5	3 912,0
Other non-energy and climate priority projects (EUR million)	76,5	547,9	203,3	2863	241	40,5	138,1	109	11 568,4	15 786,9
Share of energy and climate protection grants in total Horizon Europe grants awarded to applicants from the given country (%)	13,6	21,1	19,7	19,8	16,1	15,0	22,8	22,3	19,9	19,9

Under Horizon 2020, the number of supported Hungarian grant participations was 377 in the above-mentioned 3 areas and in the Euratom Research and Training Programme (2014-2018 and 2019-2020 training periods). The Hungarian project members received a total of EUR 73.5 million in EU funding. The diagram below gives an overview of the distribution between the areas.

The **Euratom Research and Training Programme** is a complementary funding programme to the above Framework Programmes, covering nuclear research and innovation. Three training programme periods have been launched recently (2014-2018, 2019-2020 and 2021-2025).

The experience *of the Hungarian Investment Promotion Agency (HIPA)* can also help to determine the position of clean energy technologies. HIPA highlights that in the field of electromobility, which is the technology of the near future, Hungary occupies a unique position not only in the region, but in the whole of Europe. Significant research and development capacities related to electric propulsion (AVL, Bosch, Thyssenkrupp) have been built in Hungary. In order to strengthen domestic cooperation, the NRDI Office, with the policy support of the predecessor of the Ministry of Energy, [191]*established the National Laboratories Programme, the objectives of* which are: 1) concentrating the Hungarian professional workshops of a given topic area, 2) developing competences capable of responding to significant global problems on an international level, 3) knowledge transfer. The National Laboratories intend to create a new, collaborative, institutionalized space for exploratory and experimental research that opens up an international dimension for the social,

[191] https://nkfih.gov.hu/nemzeti-laboratoriumok-program

economic and environmental utilization of research results. Five of these topics are relevant from an energy or climate point of view. The related National Laboratories and their research areas are:

Climate Change Multidisciplinary National Laboratory

81Figure - Breakdown of funding received by Hungarian participants in the clean transition categories of the H2020 programme (%) Source: Horizon Dashboard

Their focus area is mapping the climate impacts of soot particles, climate change-related impacts of planktonic organisms, solutions for the preservation of biological diversity, and the design and application of bioaccumulators.

the National Laboratory for Renewable Energy

The decarbonisation objectives undertaken by Hungary are highlighted in their research and development directions. In order for the country to be the winner of the "Green Economy", it is necessary to create a knowledge base and a set of competences that will enable domestic economic actors to be competitive in various decarbonisation technologies. To this end, the National Laboratory participates in building the scientific and technological, legal, economic and industrial property rights base of low-footprint energy technologies, in particular H_2 production, transport, storage and use, and CO_2 utilisation. In particular, H_2 developer and CO_2 converter electrolysers and catalytic technologies; research on disruptive H_2 production/storage and CCU processes and test stations comparing the lifetimes of the two technologies. On the other hand, recycling of fuel cells and new generation Li-ion batteries and examining their manufacturing aspects; and the design of a pilot plant for the production of syngas.

Nanoplasmonic Laser Fusion Laboratory

The laboratory is exploring new ways of nanotechnological preparation and laser irradiation of the fusion target, which can increase the efficiency of energy absorption and avoid the development of instability during ultrashort pulses. The expected results of the research can contribute to the development of efficient and clean fusion energy production, which can also be applied on a transportable power plant scale.

the National Laser Transmutation Laboratory

The primary objective of the project is to create fusion neutrons generated by ultrashort laser pulses and to conduct further series of experiments to increase neutron yield, as well as to conduct experimental and simulation studies to promote radioactive waste transmutation (spent fuel) of laser generated neutrons.

National Laboratory for Water Science and Water Safety

Taking into account Hungary's location, water management and water resources, the National Laboratory aims to implement water science and water safety innovations that contribute to the protection of water quality. The Laboratory assesses the status of the various surface and groundwater bodies in detail, using laboratory measurements, computer simulations and taking into account the complexity and centrality of climate change, in order to ensure the safety of groundwater resources, territorial and agricultural water management, to make urban water management 'smart', and to modernise water and wastewater treatment.

ii. Current level of public and, where relevant, private research and innovation spending on low-carbon technologies, current number of patents and current number of researchers

Funding for research and development

In 2021, an average of 2.27% of GDP was spent on R&D in the EU27. In Hungary, this rate was 1.64%, which puts us at the 13th place in the ranking of the EU Member States. The amount spent on research and development in 2021 exceeded HUF 900 billion at the level of the national economy. 76% of R&D expenditure, nearly HUF 685 billion, was spent on business research organisations, another 14% (HUF 125 billion) on higher education and 10% (HUF 93 billion) on research and development institutions and other budgetary research organisations in the general government sector.

In the field of engineering, R&D expenditure has risen most dynamically in recent years. The funds used here accounted for 63% of total R&D expenditure. Within the engineering disciplines, R&D was the highest in the pharmaceutical, electrical, electronic and IT engineering disciplines.[192] These two disciplines accounted for more than one third of total R&D expenditure in 2021.

In Hungary, in most cases, R&D funds are not allocated to a specific field of science, but to different projects through a tender, so energy obligations may vary from year to year. Although the HCSO provides data on the R&D efforts of enterprises, these data are not available for the entire energy sector. Within the energy sector, however, the HCSO publishes data for the electricity, gas, steam and air conditioning sectors. These are set out in the table below.

[192] *No further breakdown is available.*

42Table – R&D expenses of research and development sites in the electricity, natural gas, steam and air conditioning sectors (Source: KSH)[193]

Indicators	2021
Total R&D expenditure of the business sector (within walls) (HUF million)	3687
Total R&D costs of the business sector (HUF million)	2128
Foreign sources of R&D expenditure in the business sector (HUF million)	257
Non-profit sources of R&D expenditure in the business sector (HUF million)	
Higher education sources of R&D expenditure in the business sector (HUF million)	
Public budgetary resources for R&D expenditures in the business sector (HUF million)	1019
Total sources of enterprise R&D expenditure in the enterprise sector (HUF million)	2412
Total R&D investment in the business sector (HUF million)	1559

Investments in energy RDI activities may be significant mainly, but not exclusively, in the technical and scientific fields. This type of expenditure for the total economy is shown in the table below.

43Table 1 – Main data on R&D expenditure of research and development sites in enterprises by discipline (Source: KSH)[194]

Indicators	Total Discipline '07	Of which natural sciences	Of which engineering	Of which other
Total R&D expenditure of the business sector (within walls) (HUF million)	684723	108445	534604	41674
Total R&D costs of the business sector (HUF million)	521758	96535	391300	33923
Total R&D investment in the business sector (HUF million)	162965	11910	143303	7752
Total sources of enterprise R&D expenditure in the enterprise sector (HUF million)	452641	73665	358764	20212
Public budgetary resources for R&D expenditures in the business sector (HUF million)	119734	21817	82576	15341
Higher education sources of R&D expenditure in the business sector (HUF million)	283	26	123	134
Non-profit sources of R&D expenditure in the business sector (HUF million)	689	98	45	546
Foreign sources of R&D expenditure in the business sector (HUF million)	111376	12839	93096	5441

Research and development headcount

There is no database available for the number of researchers and developers focusing only on energy developments. The HCSO only aggregates the number of researchers of companies

[193] *Source: KSH (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)*
[194] *Source: KSH (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)*

falling into the categories of electricity, gas, steam and air conditioning supply. Data for this sector are summarised in the table below.

44Table – Key data on research and development sites in enterprises for electricity, natural gas, steam and air conditioning supply (Source: KSH)[195]

Indicators	2021
Number of research and development sites in the enterprise sector (pcs)	8
Total effective headcount of enterprise sector R&D (persons)	234
Total effective number of researchers in the enterprise sector (persons)	173
Total number of R&D personnel in the enterprise sector (persons)	137
Total number of researchers in the enterprise sector (persons)	97

Researchers working mainly, but not exclusively, in the technical and scientific fields may be the background for RDI activity in the field of energy. In 2021, the number of registered technical researchers was 19 838, while the number of scientific staff was 7 820.

45Table – Main data on research and development sites in enterprises by discipline (Source: KSH)[196]

Indicators	Total Discipline '07	Of which natural sciences	Of which engineering	Of which other
Number of research and development sites in the enterprise sector (pcs)	2305	680	1238	387
Total effective headcount of enterprise sector R&D (persons)	42692	10180	28629	3883
Number of actual R&D personnel in the enterprise sector, women (persons)	9649	2060	6113	1476
Total effective number of researchers in the enterprise sector (persons)	29771	7820	19838	2113
Actual number of researchers in the enterprise sector, women	5470	1253	3511	706
Total number of R&D personnel in the enterprise sector (persons)	34991	8766	23117	3108
Calculated number of R&D personnel in the enterprise sector, women (persons)	8254	1824	5180	1250
Total number of researchers in the enterprise sector (persons)	24811	6802	16271	1738
Number of researchers in the enterprise sector, women (persons)	4677	1117	2954	606

Patent data

[195] *Source: KSH (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)*
[196] *Source: KSH (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)*

Patent data relating to low-carbon energy technologies registered in Hungary are summarised in the table below.

46Table – Patent data on low-carbon energy technologies registered in Hungary (2020-2022) (Source: Hungarian Intellectual Property Office)197

Technical areas, technologies	Number of notifications in Hungary			European patents in force in Hungary			Applications with definitive patent protection as at 31.12.2022
	2020	2021	2022	2020	2021	2022	2022
Wind energy	1	3	7	1	0	0	3
Solar and geothermal energy	8	9	14	8	2	0	9
Sea water energy	0	0	0	0	0	0	4
Hydropower	2	1	6	1	0	0	3
Biomass	4	13	8	3	0	0	27
Waste recovery for energy purposes	2	16	6	1	0	0	32
Automotive technologies	1	5	0	1	0	0	65
Energy efficiency	2	1	0	0	0	0	29
Storage, battery technology	1	2	1	3	0	0	18
Other technologies relevant to climate change (methane sequestration, nuclear energy)	1	1	0	0	0	0	10

The international comparison is based on the number *of applications received by the European Patent Office*. The data comes from the OECD, which aggregates environmental and clean energy patents.

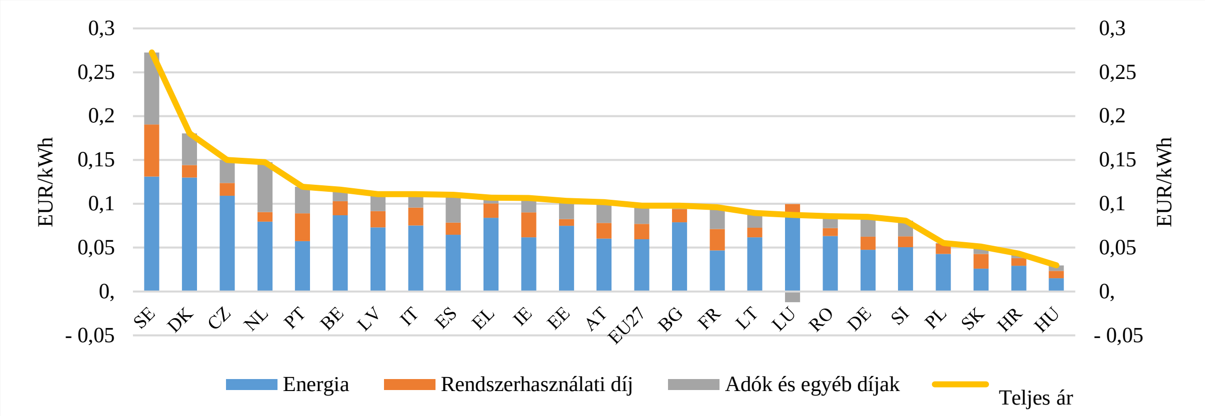
iii. Breakdown of the three most important current elements of prices (energy, grid, taxes/levies)

Natural gas price

While electricity prices are partly driven by fossil fuel prices (in combination with other, typically national or regional, price-setting factors), natural gas prices are exclusively based on global fossil fuel prices, including oil.

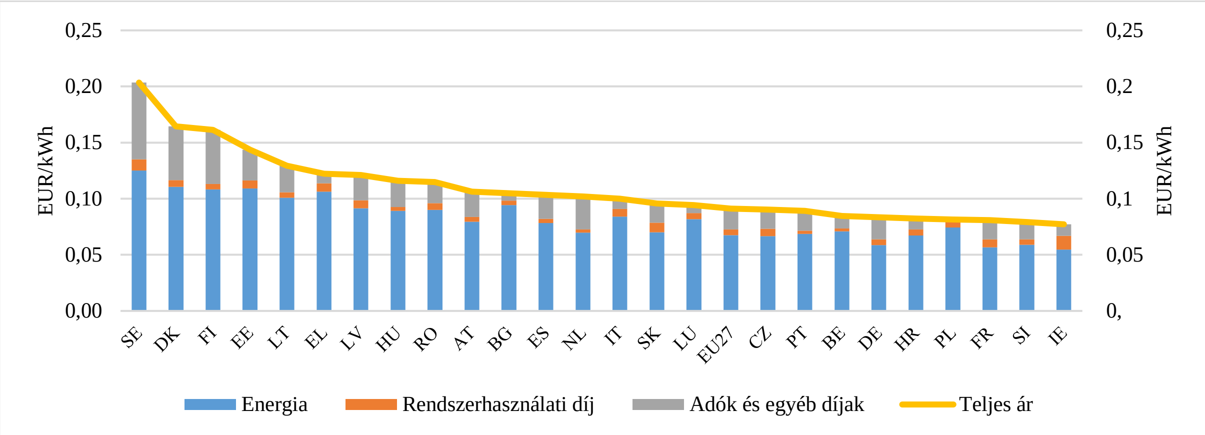
Thanks to price regulation, **natural gas prices for households in Hungary are the lowest in Europe**. Information on the elements of the residential (regulated) natural gas price is provided in the figure below.

[197] *Note: The table can only be interpreted horizontally, as an invention may belong to several technical fields at the same time.; Source: Hungarian Intellectual Property Office*



82Figure – Residential natural gas prices in 2022 (all consumption bands, EUR/kWh) Source: Eurostat

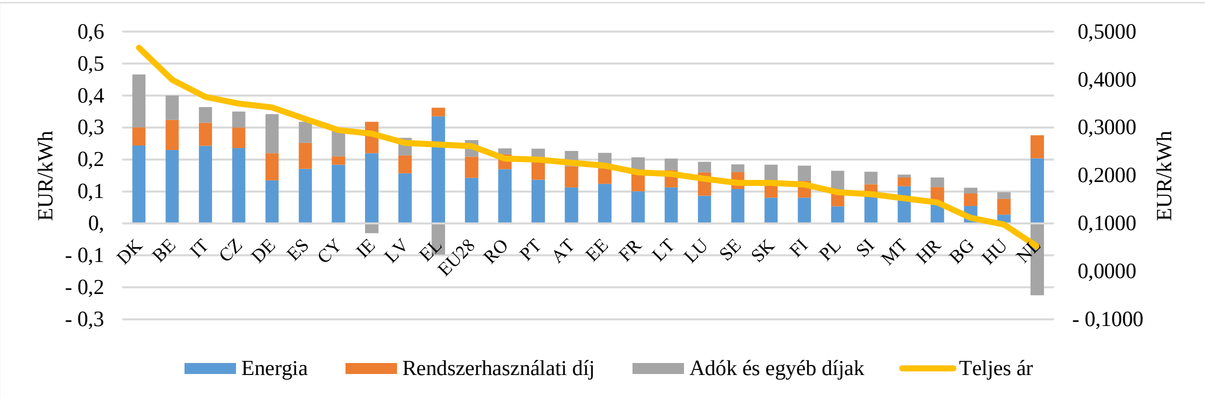
The market prices for natural gas are shown in the figure below.



83Figure – Market (non-residential) gas prices in 2022 (all consumption bands, EUR/kWh) Source: Eurostat

Electricity prices

Due to price regulation, **the Hungarian retail electricity price is one of the lowest in Europe**. In December 2022, the second lowest price was in Hungary, with only the Netherlands having a lower household electricity price.



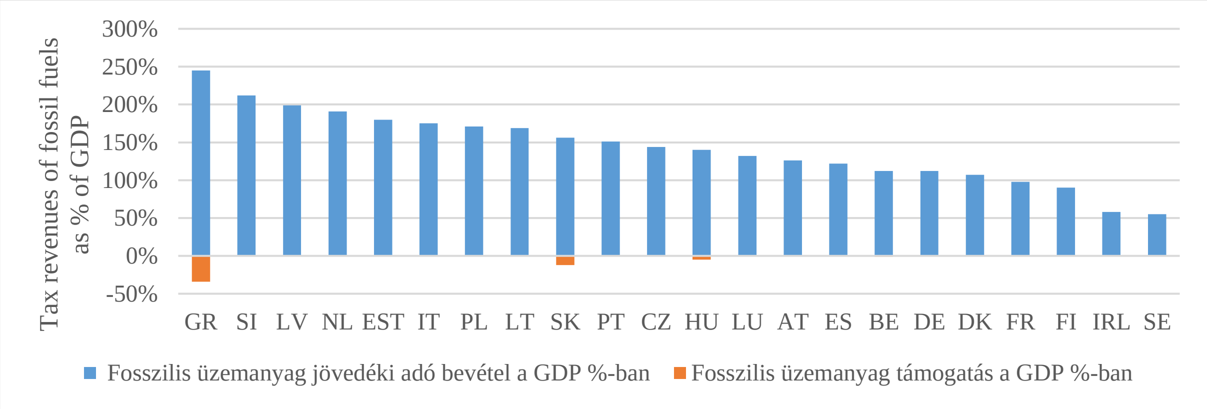
84Figure – Residential electricity prices in 2022 (all consumption bands, EUR/kWh) Source: Eurostat

iv. Description of energy subsidies, including fossil fuels

On 1 January 2017, the Renewable Energy Support Scheme (METÁR)[198] for the support of electricity produced from renewable energy sources entered into force. Section 3.2.1 provides information on METÁR. EU-funded renewable energy funding programmes and the domestically funded NRDI Fund also indirectly support investments in the sector (details under point (i) of this chapter).

In Hungary, fossil fuels are not directly subsidised, but products and services on the market are subsidised. Support for specific sectors and social groups is justified in the interests of society as a whole and complies with the legal requirements in force. More information on fossil subsidies is available in Chapter 3.1.3.iv.

The level of indirect fossil fuel subsidies (subsidies as a percentage of tax revenues) in Hungary is broadly in line with the OECD average.



85Figure – Fossil grants (2021) Source: OECD199

[198] *13/2017. (XI. 8.) on the amount of operating aid for electricity produced from renewable energy sources*
[199] *https://stats.oecd.org/*

5. IMPACT ASSESSMENT OF THE PLANNED POLICIES AND MEASURES

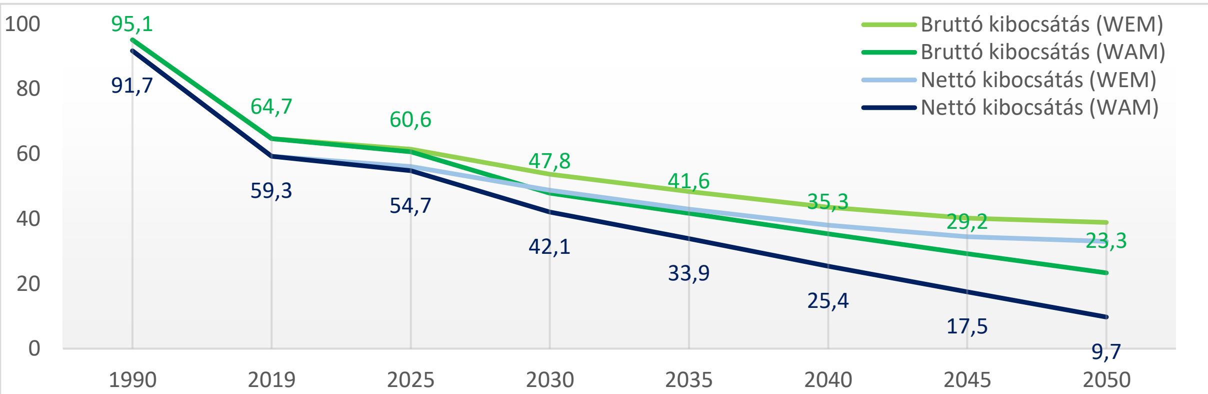
Projections prepared according to the scenario (WAM scenario) supplemented by the planned energy and climate policy measures will be presented in the next chapter. The parameters and variables used (and to be reported) for the analysis in Chapters 4 to 5 are set **out in Annex 2 to the NECP.** The detailed results of the WEM and WAM scenarios are presented in **Annex 3 to the NECP.**

5.1. Impact of planned policies and measures described in Chapter 3 on energy systems and greenhouse gas emissions and removals, including comparison with projections based on existing policies and measures (as described in Chapter 4)

Additional measures under the WAM scenario on which the projections are based are set **out in Annex 1 to the NECP.** This chapter presents Hungary's planned energy and decarbonisation progress with additional measures compared to 2019 and the WEM scenario along the 5 dimensions of the Energy Union, i.e. the projections under the WAM scenario and their expected impacts are analysed in the following chapters. In the WEM scenario, which is also the WAM scenario, the projection assumptions are set out in Chapter 4.1. For the projections, we use the data from the Commission Recommendation of March 2024, with the addition that the WAM scenario is also calculated with WEM ETS prices, given that the recommended WAM pricing can be interpreted as a sensitivity analysis (additional incentive).

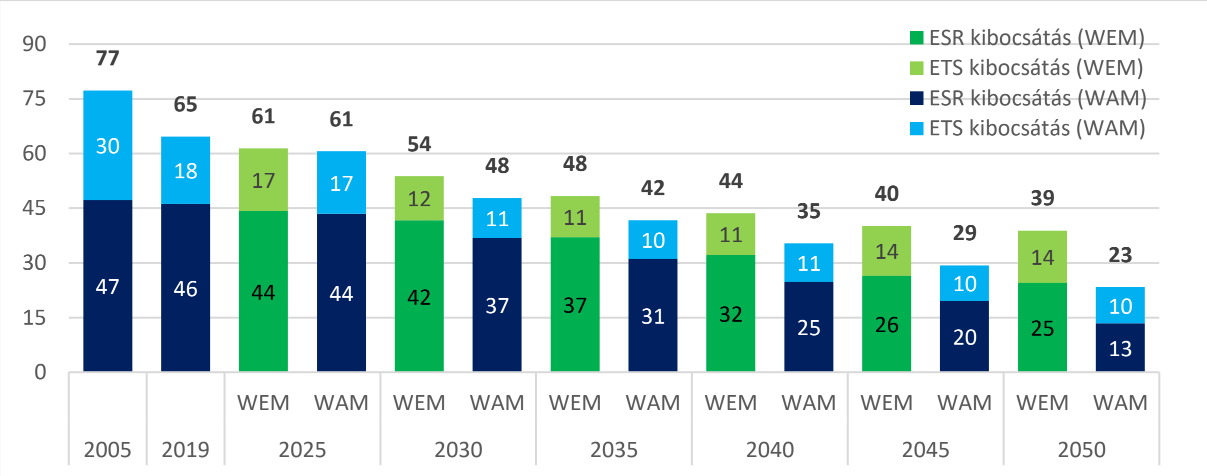
i. Projections of the development of energy systems and of greenhouse gas emissions and removals and of emissions of air pollutants, based on planned policies and measures in accordance with Directive (EU) 2016/2284, for at least ten years after the period covered by the plan (including the last year of the period covered by the plan), including relevant Union policies and measures

In the WAM scenario, gross greenhouse gas emissions will be reduced by 50% by 2030 compared to 1990, and additional measures will be needed by 2040 and 2050 to achieve climate neutrality on a scheduled basis.



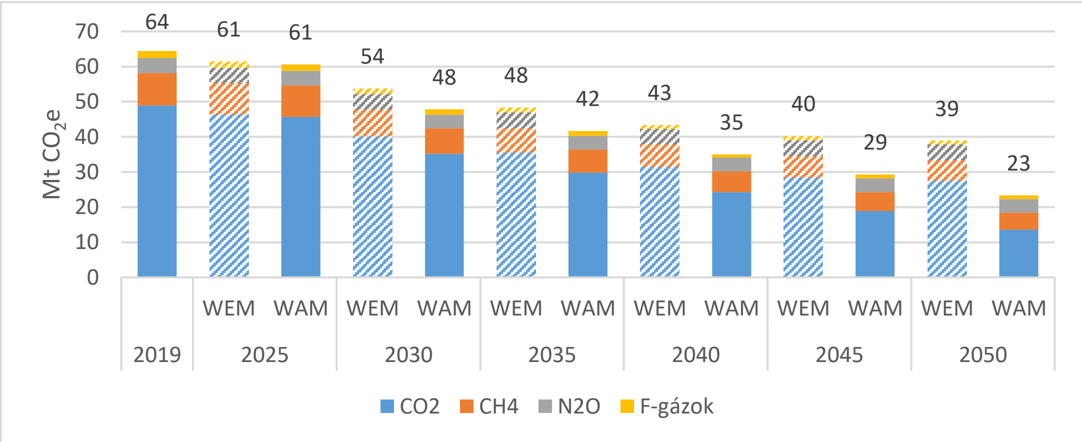
86Figure – Projected evolution of gross and net greenhouse gas emissions (1990, 2019-2050, Mt CO_2e/year) Source: Fact 1: Eurostat, forecast: REKK, AKI, HungaroMet, SOE

Compared to 2019, in the WAM scenario, emissions under the ETS are projected to decrease by 40% and emissions under the ESR by more than 20% by 2030, reaching almost 22% compared to 2005, overachieving the ESR target of 18.7%.



87Figure – Evolution of gross emissions in the ETS and ESS sectors (2005, 2019-2050, Mt CO_2e/year) Source: Fact 1: Eurostat, forecast: REKK, AKI, HungaroMet

Looking at individual greenhouse gas emissions, emissions of all gases except F-gases are lower in the WAM scenario than in the WEM in both 2030 and 2050.



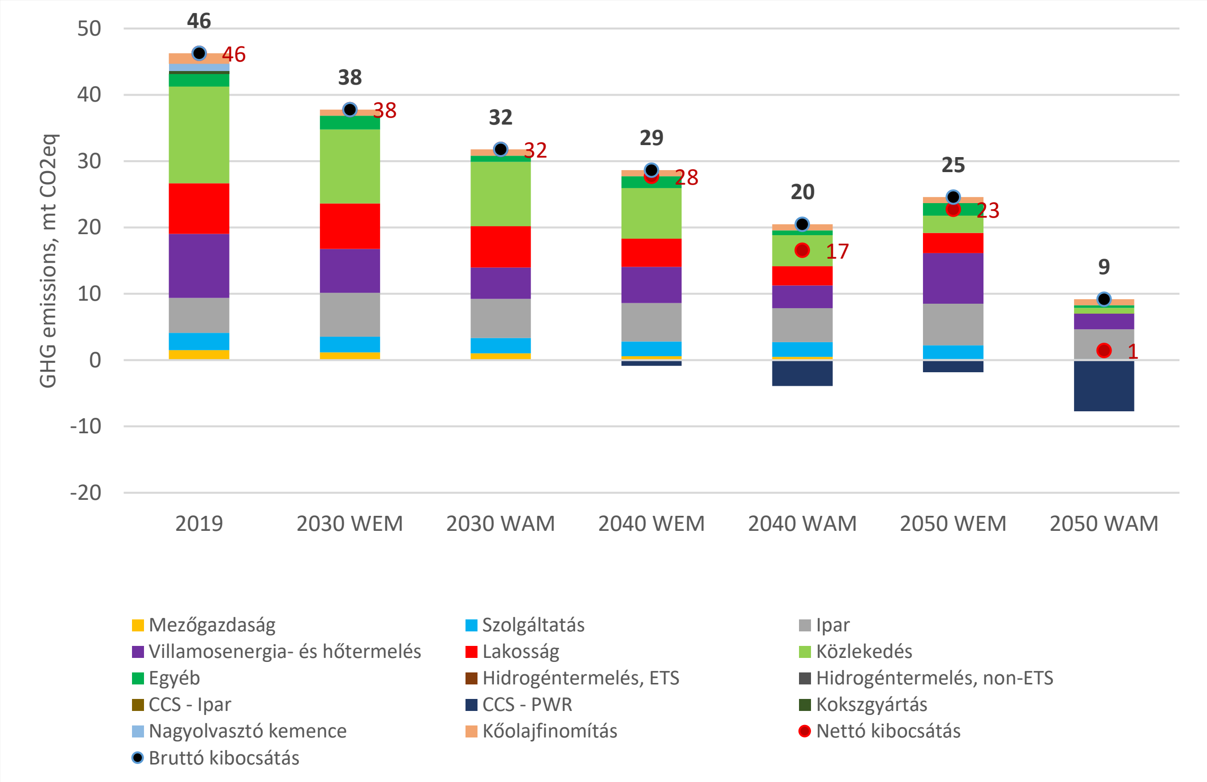
88Figure – Expected evolution of net greenhouse gas emissions by gas (2019-2050, Mt CO_2e/year) Source: Fact 1: Eurostat, forecast: REKK, AKI, HungaroMet

In terms of proportions, the gap between WEM and WAM 2030 is the most significant for CO2in 2030, at 10%. Compared to 2019, WAM CO2emissions are 28% lower in 2030, CH4 emissions 22% lower, N2Oemissions 8.5% lower and F-gases (PFC, HFC, SF_6) 20.6% lower. Compared to 1990, the largest share of total gross emissions by 2030 and 2050 remains CO_2, but while no artificial sink capacity (CCUS) is planned for 2030, 8 Mt $CO_2$of 23 Mt CO_2e could be neutralised by CCUS by 2050.

<u>Energy sector</u>

<u>GHG emissions and removals</u>

For GHG emissions, the WAM scenario assumes a cap *of 2 Mt CO_2applied to the energy sector in the National Clean Development Strategy (NTFS)* Early Action scenario by 2050. Furthermore, for the maximum GHG emissions of the energy sector in 2030, the modelling is based on the assumption that a 50% reduction in emissions for the entire Hungarian national economy compared to 1990 would result ιν ~47.5 Mt CO_2e by 2030. The share of this value for the energy sector in 2030, as assessed by the HU-TIMES model, was taken into account with the share for the energy sector, which represents 66% of total domestic emissions. Thus, with a maximum of 2 Mt CO_2e-emissions in 2050, a maximum of 34.5 Mt CO_2e-e was set for 2030, while a linearly decreasing limit was assumed for the intermediate period. In addition, for the non-ETS sectors, a cap of 30.8 Mt CO_2has been set for 2030, representing a decrease of 18.7% compared to 2005 levels. Within the energy sector, the evolution of GHG emissions by subsector is shown in the following chart in the WEM and WAM scenarios.



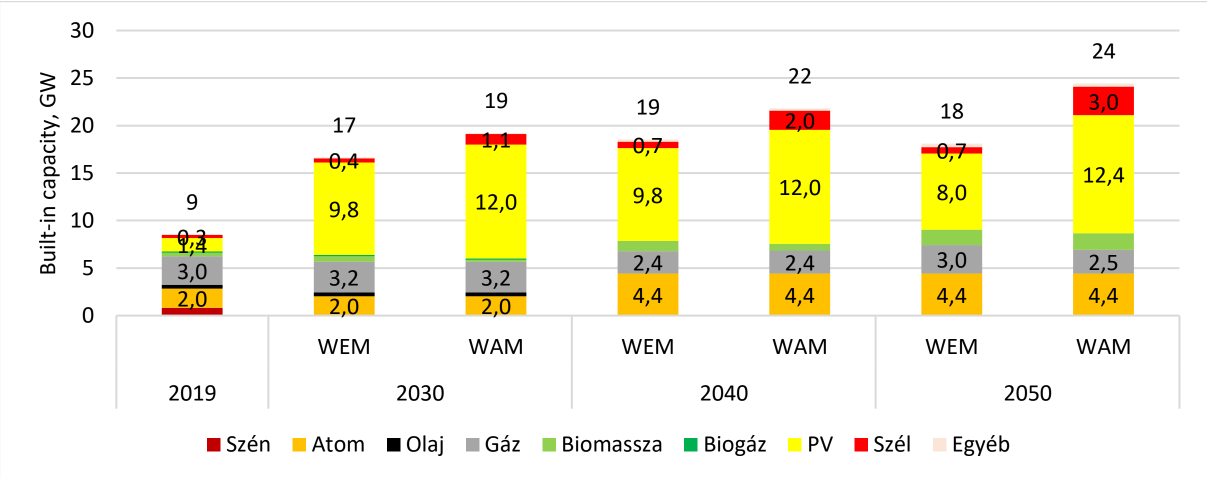
89Figure – Projected evolution of greenhouse gas emissions by sector , WEM and WAM scenarios (2019-2050, mt CO_2e/year) Source: Fact 1: Eurostat, forecast: REKK

In the WAM scenario, there is a significant reduction in net emissions of energy-sourced greenhouse gases by 2050, also in line with pre-defined limits. By 2030, gross GHG emissions are projected to decrease by 27% compared to 2019, and by 2050, overall, they are expected to decrease by almost 80% gross and 97% net.

Of the priority sectors, transport will remain the largest emitter by 2030 (31%), maintaining its high share today. Emissions from the transport sector will gradually decrease to 0.9 Mt CO_2e by 2050. At the same time, the highest GHG emissions in 2050 are expected to come from **industry,**with 4.5 Mt CO2at this level. While industrial emissions will only increase by 11% by 2030 compared to 2019, industrialisation investments that increase the competitiveness of the country will fall below 2019 levels by 2050, thanks to energy efficiency measures and less emission-intensive technological solutions, as well as increased use of renewable energy and artificial sinks. All this can be achieved, according to the forecast, if the industry will cover the energy needs of the increasing demand mainly from electricity and a smaller part from natural gas, which is expected to be achieved by the implemented EU and domestic measures together. Significant reductions in GHG emissions are expected for **electricity and heat generation.** By 2030, emissions can be reduced by 51%, which will continue to decrease even with increased electricity demand, thanks to the simultaneous operation of existing and new nuclear power plants, as well as renewable electricity generation. Net GHG emissions from the power generation sub-sector could become negative already by 2040, thanks to the carbon capture, storage and utilisation (CCUS) technology of power generators. In addition, **greenhouse gas emissions in the residential, services and agricultural sectors** will continue to reach 6.2 Mt, 2.3 Mt and 1 Mt CO_2e in 2030, while further increasing energy efficiency measures and electrification will result in aggregate emissions from these sectors not exceeding 0.2 Mt CO_2e in 2050, in the interest of climate neutrality.

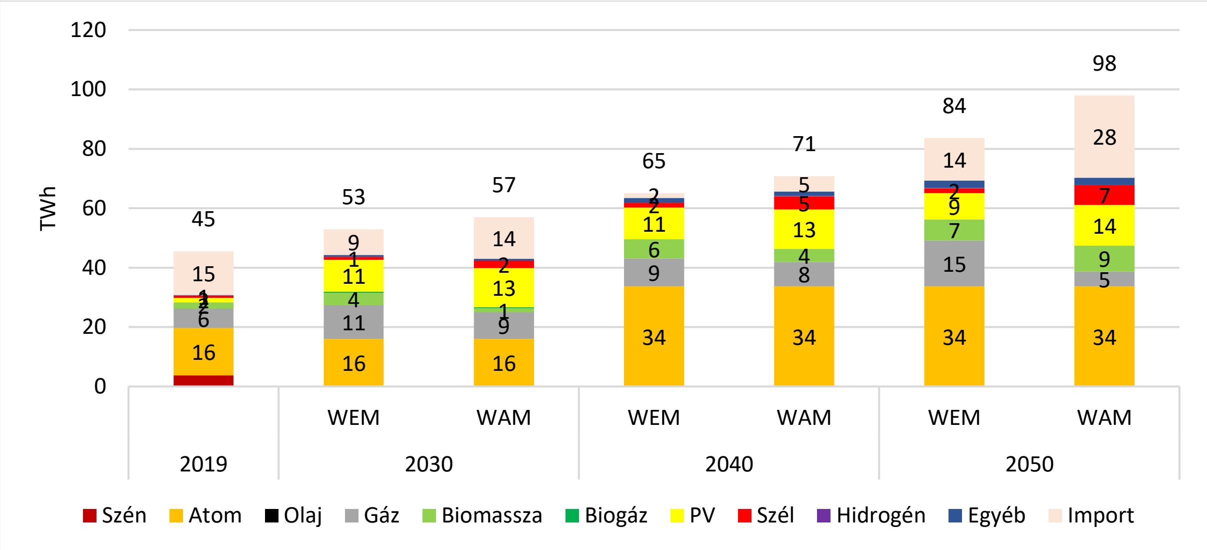
Production and use of electricity

As a result of the additional measures, the electricity sector is likely to see the largest expansion of substantially significant solar power capacity, accounting for almost two thirds (12 GW) of the total installed capacity in 2030. 11% of the capacity (2 GW) will be provided by nuclear capacity and 17% by gas capacity (3.2 GW) due to the extension of Paks I. In the years following 2030, Paks II will also be operational, so from 2040 the nuclear capacity will be 4.4 GW (20%), which represents 18% of the 2050 capacity mix. The capacity of wind and solar power plants (15.4 GW) and their share of total capacity (64%) could increase further by 2050. At the same time, the share of biomass capacities equipped with CCUS is estimated at 7% and the share of gas capacities at 10%.



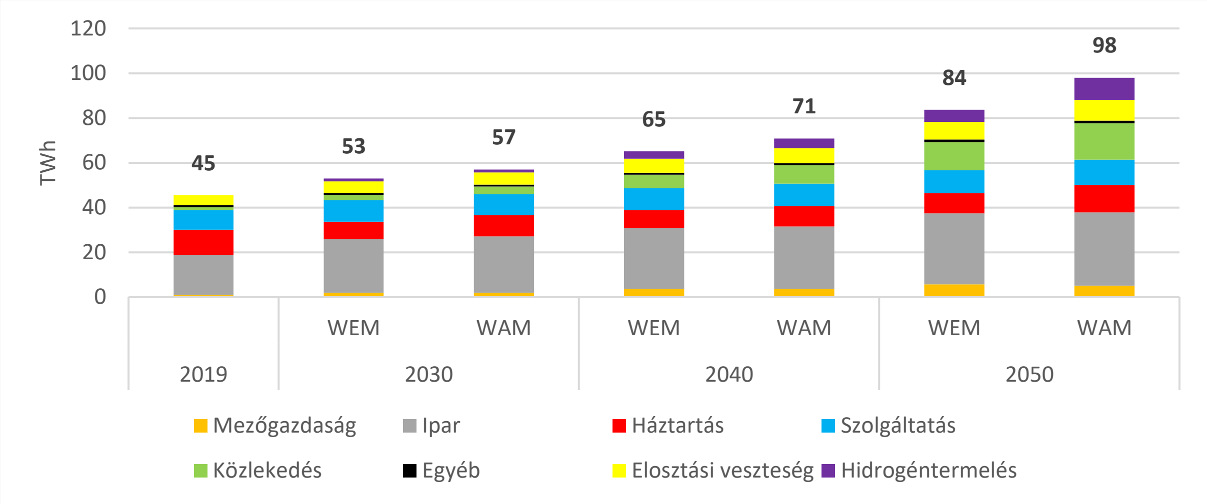
90Figure – Expected evolution of installed electricity generation capacity under the WEM and WAM scenarios (2019-2050, GW) Source: Fact 1: Eurostat, forecast: REKK

Nuclear capacity will generate around 28% of the electricity produced in 2030. Photovoltaic capacity contributes an additional 23% to domestic electricity consumption. Electricity demand will increase to 57 TWh over this time horizon, while production will be at 43 TWh. By 2040, the share of electricity generated on a nuclear basis will be 48%, which will be reduced to 35% by 2050. At the same time, the share of electricity generated by PV is estimated at 14%. The share of biomass and gas-based electricity in total production is estimated at 2% and 16% in 2030 and 9% and 5% in 2050, respectively. Meanwhile, total consumption is expected to increase to 98 TWh by 2050 as a result of increasingly clean, efficient and therefore intensified electrification. Almost three-quarters of this can be provided by domestic power plant production. The development of water- and geothermal-based electricity generation capacities under the 'Others' category may also be significant. A significant part of the current geothermal energy research projects is aimed at the production of electricity, which can result in significant renewable geothermal electricity production in the domestic energy portfolio under appropriate conditions.



91Figure – Expected evolution of electricity generation, consumption and imports under the WEM and WAM scenarios (2019-2050, TWh/year) Source: Facts: Eurostat, Forecast: REKK

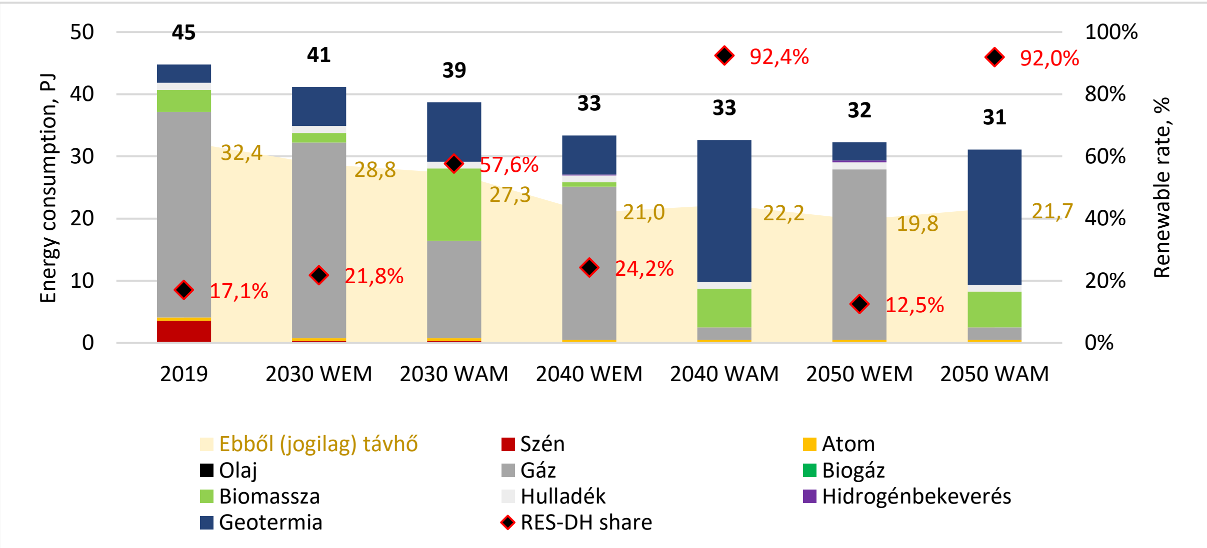
It can be seen that the gradual increase in electricity consumption, in addition to energy efficiency efforts, affects all sectors, while clean electricity production is relevant for all sectors.



92Figure – Expected evolution of electricity consumption by sector in the WEM and WAM scenarios (2019-2050, TWh/year) Source: Facts: Eurostat, Forecast: REKK

District heating production

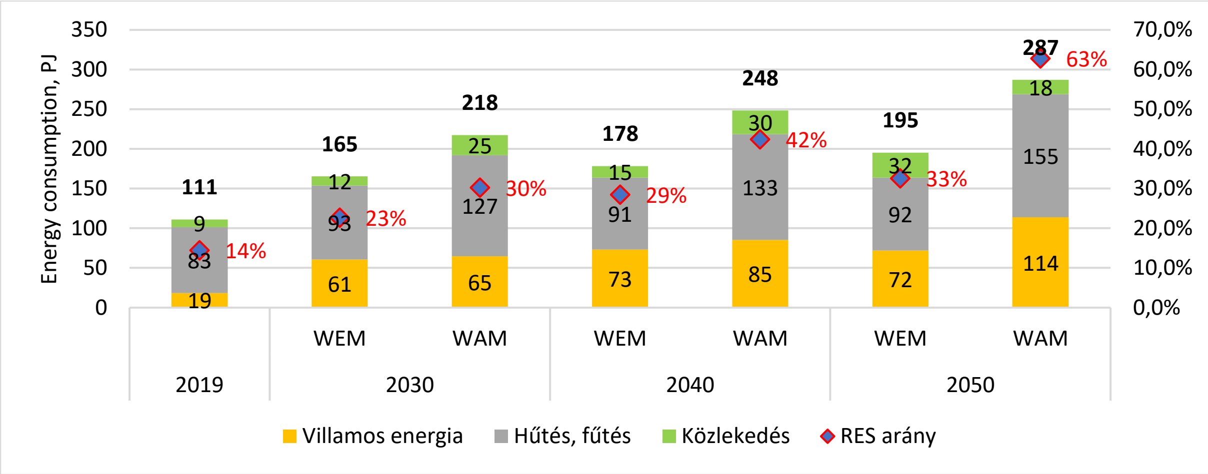
Although district heating production will decrease by 2030, as energy efficiency measures will reduce demand, the thermal sector will become more efficient, providing consumers with a cleaner mix of sources, as the share of fossil fuels will fall below 50%. By 2050, district heating generation (including derived heat generation) will meet the definition of an 'efficient district heating supply' with emissions of 0 tCO_2e on a scheduled basis.



93Figure – Expected evolution of district heating and derived heat supply in WEM and WAM scenarios (2019-2050, PJ/year) Source: Facts: Eurostat

Renewable energy

Looking ahead, in the WAM scenario, including additional measures, the sectoral and aggregate renewable energy use rates will also increase significantly by 2030. For district heating, a renewable share of at least 50% is required for 30% renewable energy use in final energy consumption. Achieving a renewable energy use rate of 32-32% in the electricity and heat generation sector and a minimum of 25% in the transport sector can be achieved as follows.

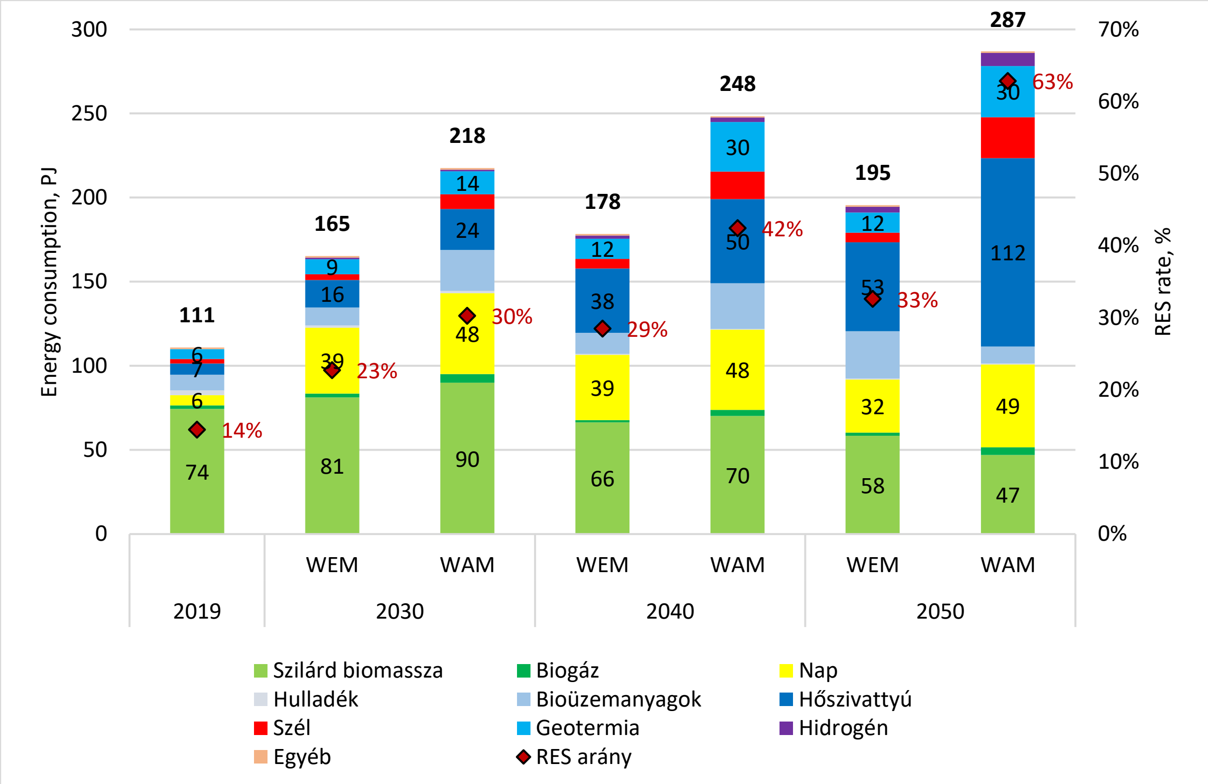


94Figure – Renewable energy use by sector, WEM and WAM scenarios (2019-2050, PJ/year) Source: Fact 1: Eurostat, forecast: REKK

In the WAM scenario, the renewable energy use rate in final energy consumption will increase to 30% by 2030. The development of renewables is linear. Total renewable energy consumption growth will nearly double between 2019 and 2030 and increase by 2.6 times by 2050, which could exceed 62% in terms of renewable share by 2050, thanks to efficiency gains in energy use.

The main driver of the expansion of renewable energy use is the electricity sector. While in 2019 the sector's renewable energy production amounted to 19 PJ, this will increase to 65 PJ by 2030. In 2050, with 114 PJ of renewable energy consumed, the electricity sector accounts for almost 40% of renewable energy consumption. At the same time, given that electrification is also a significant player in the heating and cooling and transport sectors, Hungary will continue to use the most significant share of energy use, including renewable energy consumption (58%), for heating and cooling in 2030, although this is reflected in the above figure in the electricity sector (as a source supplier). In the transport sector, growth can be expected primarily in the use of advanced biofuels, although its source-based assessment and possibilities are limited, and later on in the use of road and rail electricity, which is also reflected in the above figure, as well as in the supply of hydrogen.

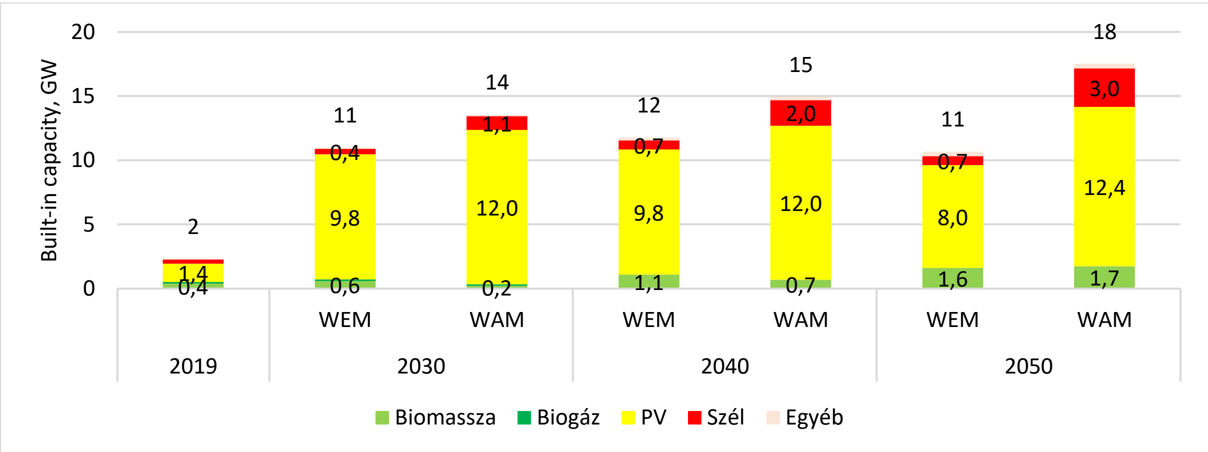
As two thirds of total renewable energy use in 2019 came from biomass, Hungary has set itself the objective of diversifying the composition of renewable energy use. With the rise of solar energy and biofuels and the uptake of heat pumps, the dominance of biomass could be reduced by 2030. In addition to the increase in solar energy use, the use of both geothermal energy and other renewable energy sources is increasing in the WAM scenario. In addition, biomass use in 2030 is now barely 41% of total renewable energy use. Renewable energy produced in 2050 comes mainly from solar energy (17%), heat pump use (shallow geothermal, using ambient heat) (39%), solid biomass (16%), deep geothermal (10%) and wind energy (8%).



95Figure – Renewable energy use by source, WEM and WAM scenarios (2019-2050, PJ/year) Source: Fact 1: Eurostat, forecast: REKK

Renewable energy use in the electricity sector

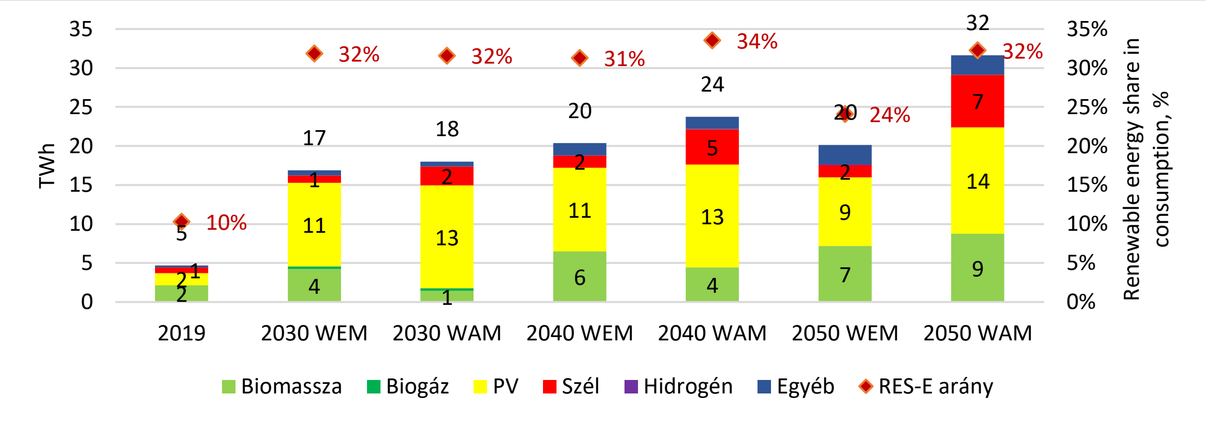
The renewable share of the electricity sector (RES-E) is approaching 32% with additional measures.



96Figure – Expected evolution of installed renewable capacity under the WEM and WAM scenarios (2019-2050, GW) Source: Fact 1: Eurostat, forecast: REKK

Thanks to the additional measures, the total installed photovoltaic capacity in the electricity sector is expected to increase from over 1 GW in 2019 to 12 GW in 2030, which will be maintained until 2050. Among other capacities (geothermal and hydroelectric), a gradual expansion of geothermal capacities is expected, but their role in 2050 is also marginal due to the expansion of additional clean capacities (1%). Biomass capacity is on a downward trend until 2030 due to the phasing out of existing capacities. According to the results of the modelling, about 10% of the domestic renewable capacity could be biomass-based electricity capacity by 2050 if it is equipped with CCUS technology. While in the WEM scenario with existing measures only a doubling of the current wind capacity level (approximately 0,3 GW) is envisaged, in the additional measures scenario a slightly increased wind capacity is calculated, i.e. 1 GW by 2030 and 3 GW by 2050.

In 2019, electricity generation from renewable sources was close to 5 TWh. In the WAM scenario, including additional measures, this could increase to 18 TWh by 2030 and exceed 32 TWh in 2050. Compared to 2030, domestic power plants can thus generate around 6% (1 TWh) more renewable electricity in the WAM scenario and 60% (12 TWh) more in 2050 than in the WEM scenario. With the planned additional measures, the share of renewable energy in total electricity consumption could increase from 10% in 2019 to 32% in 2030 under the WAM scenario.

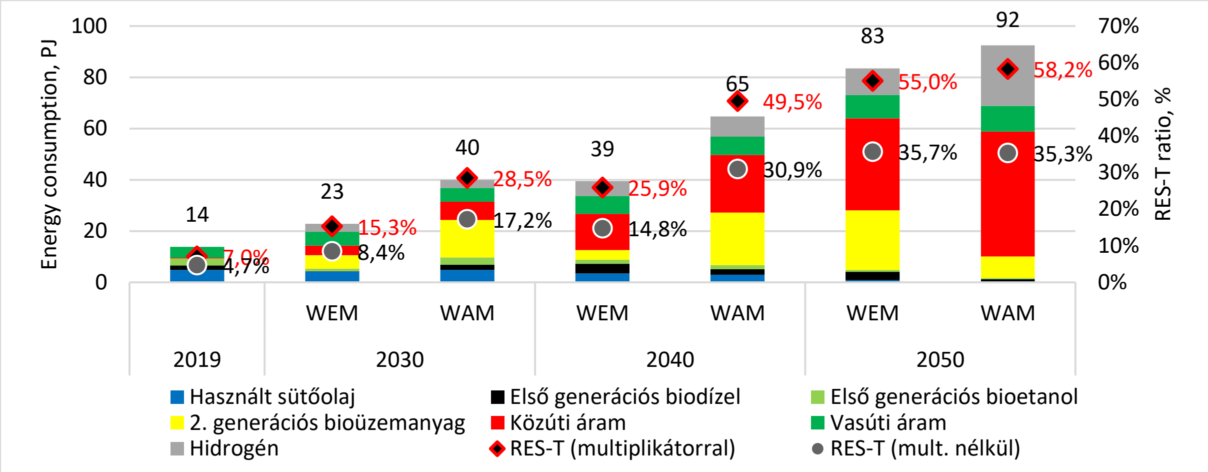


97Figure – Renewable electricity generation (TWh) and renewable electricity share in consumption (RES-E, %), WEM and WAM scenarios (2019-2050) Source: Fact 1: Eurostat, forecast: REKK

This represents a small decrease (-0.3% points) in 2030 compared to the WEM scenario, given the significant increase in electric energy consumption, but a +8% point increase in the RES-E ratio in 2050. In 2030, more than 70% of renewable electricity is already produced by photovoltaic (PV) power plants, and in 2050 it will fall below 44% as a result of biomass-based energy production and wind energy production. The share of biomass will decrease from 40% in 2019 to 6% in 2030 and increase to 28% in 2050 to meet increasing energy demand. Renewable energy is supported by clean nuclear capacities to meet the increase in electricity demand in order to reduce GHG emissions.

Renewable energy use in the transport sector

Biofuels currently account for the majority of renewable energy use in the transport sector, and to a lesser extent rail electricity use. Although the number of electric vehicles has recently increased, their role in "clean" transport is still limited – their supply of renewable energy depends on the source side of the electricity supply.

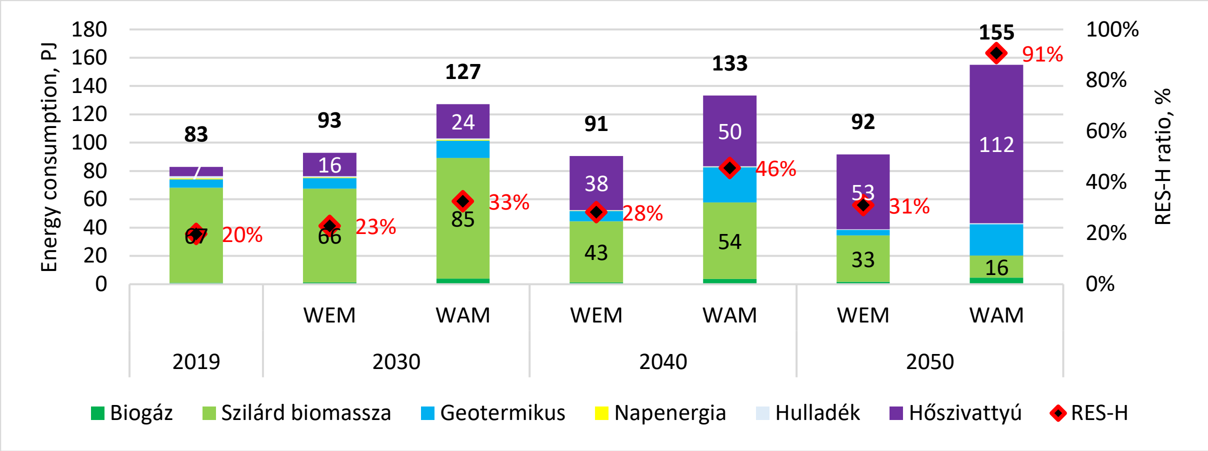


98Figure – Renewable energy use in the transport sector (PJ) and share of renewables in transport (RES-T, %) including multipliers, WEM and WAM scenarios (2019-2050) Source: Fact 1: Eurostat, forecast: REKK

In the WAM scenario, the gross final consumption of energy from renewable sources in transport increases significantly. In transport, the share of renewables in 2019 was 7%, including multipliers, which could rise to 29% by 2030 as a result of additional measures, depending on the availability of feedstock and the uptake of user equipment. The transport target has been reduced from the modelled value to 25% for this reason. In the modelled WAM scenario, the value resulting from the 29% renewable share is 13% points higher (or 10% points for the reduced value) than indicated in the WEM scenario for 2030. The higher increase compared to the WEM scenario is due to the significant uptake of second generation (advanced) biofuels – where second generation biofuels are given double weight due to the methodology, but the availability of these feedstocks is currently questionable. There is also a significant increase in first-generation biofuels, but their use could be at the expense of other sectors and thus be taken into account to a limited extent (3%). In the future, however, the use of renewable electricity on the road will increase, on the one hand due to the increase in the number of electric vehicles in absolute terms and, on the other hand, the share of renewable electricity will increase significantly in the coming decades. This factor is also behind the increase in the use of renewable energy in rail. Advanced biofuels could account for 37% (24% with a reduced target) and first-generation biofuels could account for 13% of the sector's renewable energy use in 2030, exploiting the 28.5% potential. We plan to increase the share of frying oil consumption in gross final energy consumption (up to 3%). Hydrogen's role is growing, accounting for a quarter of total use in the WAM scenario by 2050.

Renewable energy use in the heating and cooling sector

The share of biomass in renewable energy use in the heating and cooling sector is currently very high and biomass demand has continued to increase as a result of the energy crisis. Diversification will be possible mainly from the 2030s onwards, for both the WEM and WAM scenarios.



99Figure – Renewable energy use in the heating and cooling sector (PJ) and the renewable share (RES – H/C, %), WEM and WAM scenarios (2019-2050) Source: Fact 1: Eurostat, forecast: REKK

Biomass-based thermal energy production will increase by 27% between 2019 and 2030, but there will be a decline after 2030, driven partly by energy efficiency investments, mainly in the residential sector, and partly by the use of limited solid biomass resources in biomass-based CCUS production. The use of geothermal energy will double by 2030. The use of heat pumps (shallow geothermal, ambient heat) in the cooling and heating sector will increase significantly, with a share of 19% of renewable energy use already by 2030, and could reach 79% by 2050, in the absence of other more efficient and cleaner alternatives. The use of biogas is also increasing, but even with planned measures, it will be negligible by 2050.

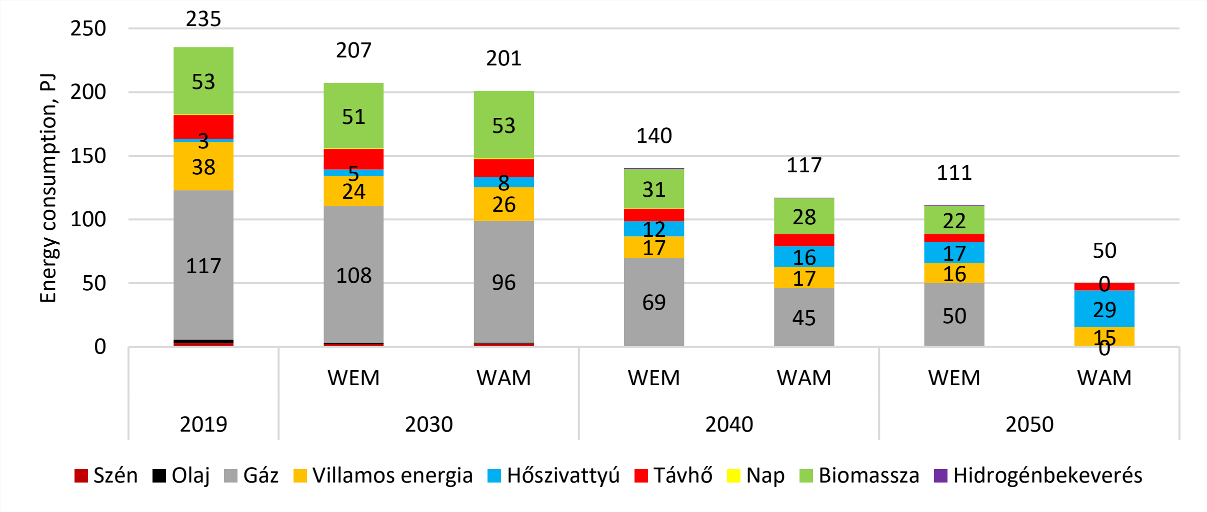
As a result of the above, the share of renewable energy use in the cooling and heating sector will increase from around the current 20% to 23% WEM and is expected to reach more than 32% in the WAM scenario by 2030. Assuming no further action (WEM), the RES-H may exceed 30% by 2050, but in the WAM scenario it could increase significantly to 91% by 2050 due to unchanged production intensity but decreasing final energy consumption (heat pumps and energy efficiency).

Energy efficiency dimension

Final energy consumption

Combined implementation of the policy measures described **in Chapter 3 will lead to higher energy savings in the residential sector** than induced by the current policy framework. The final energy consumption in 2030 under the WAM scenario is 3% lower than the projected final energy consumption under the current measures.

As a result of the implementation of the planned additional measures (WAM scenario), final energy consumption in the residential sector could decrease by 14% in 2030.

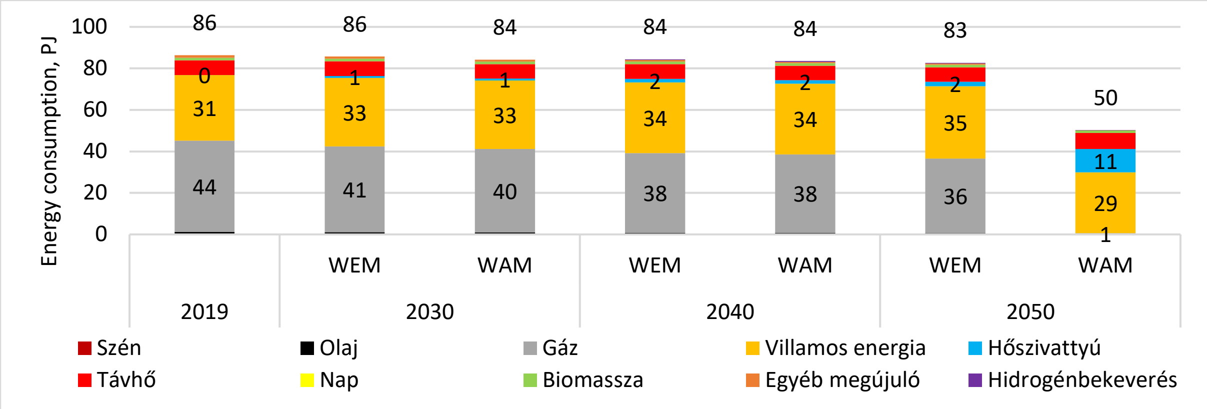


100Figure – Expected evolution of residential final energy consumption, expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ/year) Source: Fact 1: Eurostat, forecast: REKK

In general, the minimum tax on fossil fuels already generates a high level of energy investment measures in the WEM scenario. In addition, the gradual uptake of new efficient technologies, in particular heat pumps, leads to lower energy consumption. In terms of proportion, the reduction in household final energy consumption will be the most significant for natural gas use, with the planned measures expected to lead to a reduction in household natural gas use of around 18% between 2019 and 2030, while it should be phased out by 2050 in order to be climate neutral, according to our current technological knowledge and potential. Consumption patterns will change between 2019 and 2030. Thanks to energy efficiency investments, electricity consumption will decrease more significantly, the amount of energy used by heat pumps will almost double (WEM) or triple (WAM) by 2030, compared to 2019.

As regards final energy consumption in the **tertiary/services sector,** a stagnation is projected in the WAM scenario until 2030. For the growing tertiary sector, this can be achieved with a high degree of energy efficiency stimulus in the context of increasing demand.

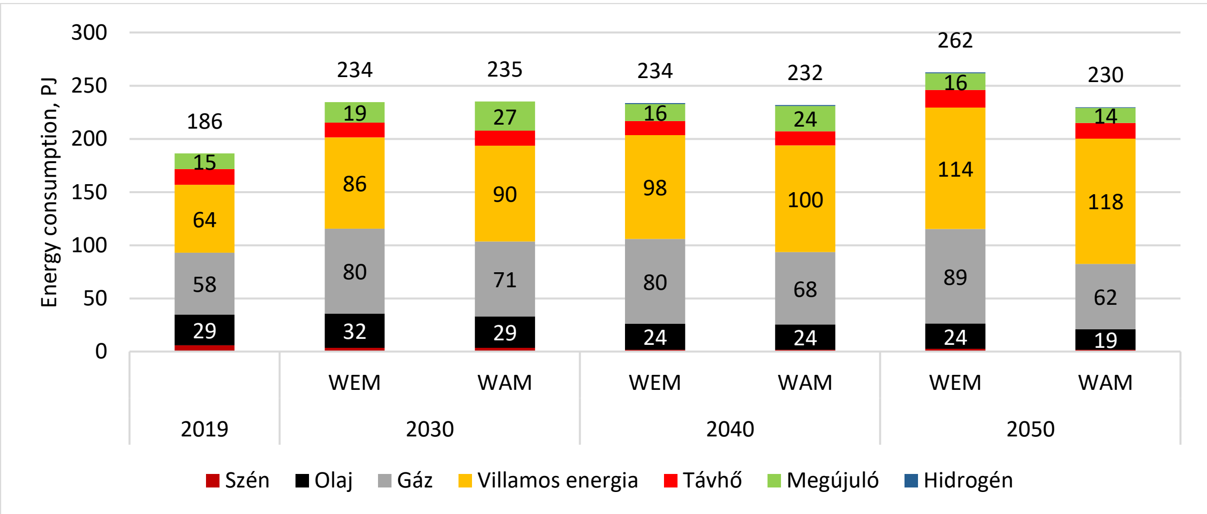
By 2030, natural gas consumption will decrease to a lesser extent, while electricity consumption will increase. Considering the projections of the two scenarios, a substantial difference can only be expected in 2050, where natural gas should be phased out in order to be climate neutral under the conditions mentioned for the residential sector.



101Figure – Expected evolution of final energy consumption in the tertiary sector, expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ) Source: Fact 1: Eurostat, forecast: REKK

This result demonstrates that achieving net GHG emissions of up to 2 Mt CO2e for the energy sector requires almost complete decarbonisation of the tertiary sector, which can be achieved mainly through energy efficiency interventions and technology change. It is also important to highlight the role of heat pumps in the service sector in the longer term, increasing their share from 0.1% in 2019 to 1% in 2030 and 13% in 2050. In addition, electricity consumption is gradually increasing, except in the WAM scenario for 2050, where high energy efficiency investments could lead to a decrease in electricity consumption.

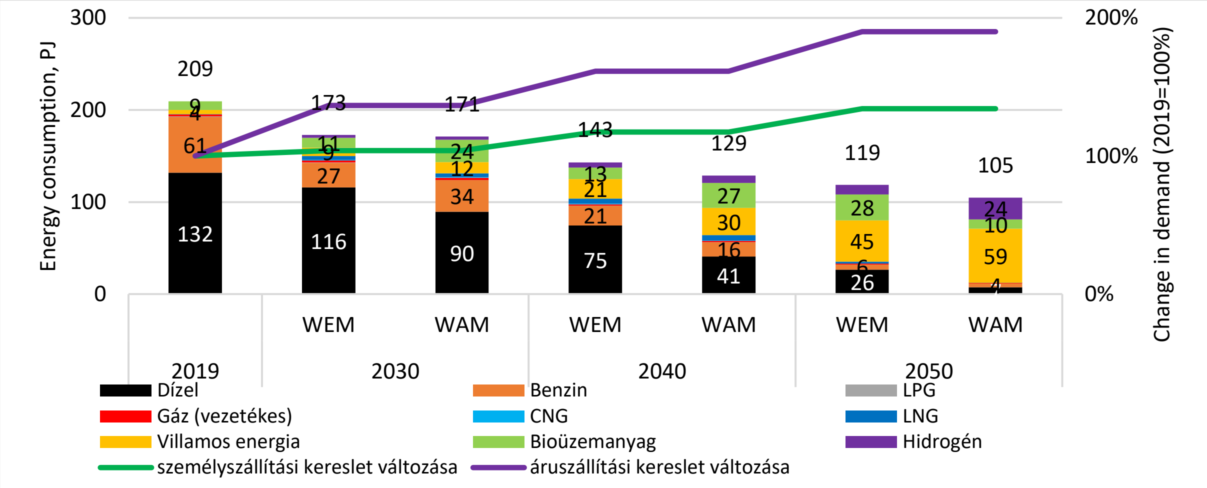
For the **industrial sector,** final energy consumption is projected to increase significantly in both WEM and WAM scenarios, respectively by 26 % to 26 % in 2030 and by 41 % and 24 % in 2050 compared to 2019 levels. In the new policy measures scenario, the increase in energy use compared to WEM results from the transition to cleaner technologies with lower emissions.



102Figure – Expected evolution of final energy consumption in the industry sector, expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ/year) Source: Fact 1: Eurostat, forecast: REKK

Looking at the growth of industrial energy consumption by composition, renewable energy consumption shows the largest (and almost double) increase between 2019 and 2030, but electricity and natural gas consumption is also expected to grow relatively high (by 40 and 22 %). Comparing the results of the two scenarios over the longer term, we find that the role of natural gas is decreasing due to the new policy measures, with the subsequent spread of CCUS-based technologies being, according to our current knowledge, the best way to separate the increase of the country's competitiveness and the development of its GHG emissions.

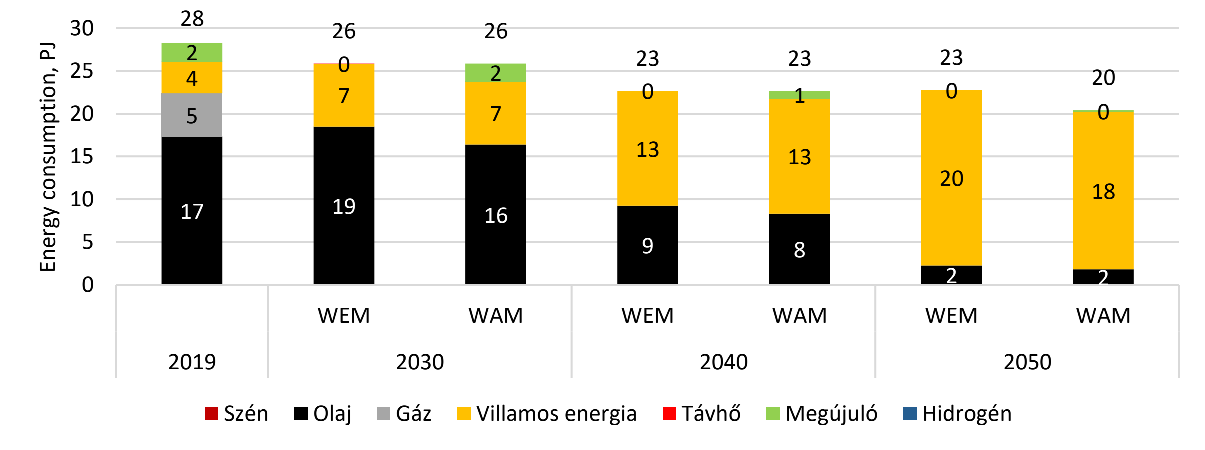
In the **transport sector,** incentivising regulation and excise duties on fossil fuels are leading to a significant drop in energy consumption, despite a significant increase in demand.



103Figure – Expected evolution of final energy consumption in transport, expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ/year) Source: Fact 1: Eurostat, forecast: REKK

Compared to 2019, transport energy use in the WEM and WAM scenarios will decrease by 17% and 16% respectively by 2030, which could decrease by 43% and 50% respectively by 2050. In addition to a minor switch to public transport for passenger transport and to track-based transport for freight transport, it is also desirable to replace the existing old fleet of vehicles with new and more efficient technology in order to achieve a high degree of decarbonisation of the sector. New policy measures will replace petrol and diesel vehicles for passenger and freight transport by 2030. This goes hand in hand with greater blending of biofuels and the uptake of electricity-powered technologies. By 2050, the combined share of diesel and petrol use should be reduced to 10% in the WAM scenario in order to achieve climate neutrality, while the share of electricity, biofuels and hydrogen use should be 56%, 10% and 23% respectively.

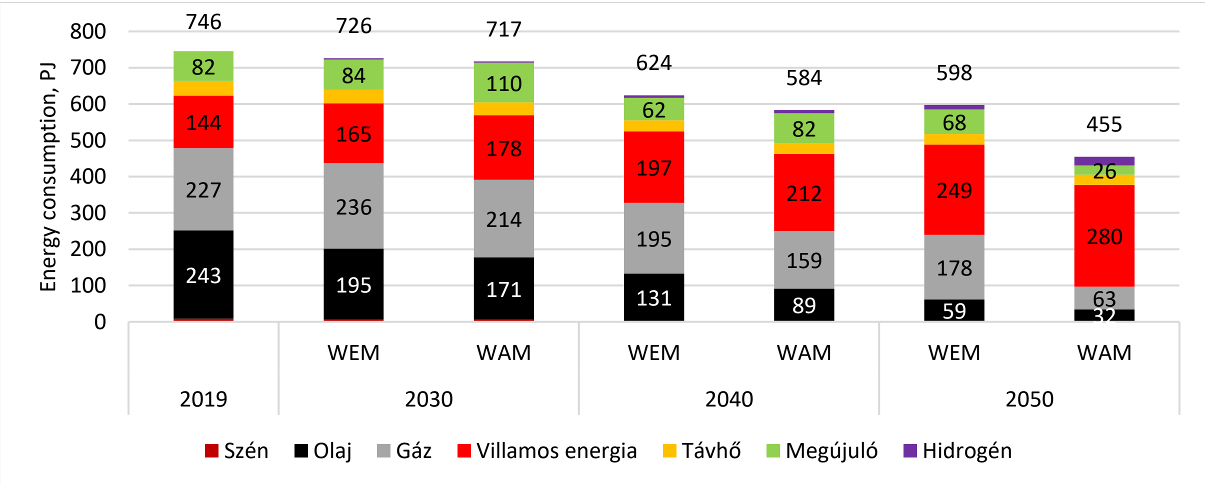
In **the case of energy use in the agriculture, forestry and fisheries sectors,** there is no substantial difference between the forecasts of the WEM and WAM scenarios.



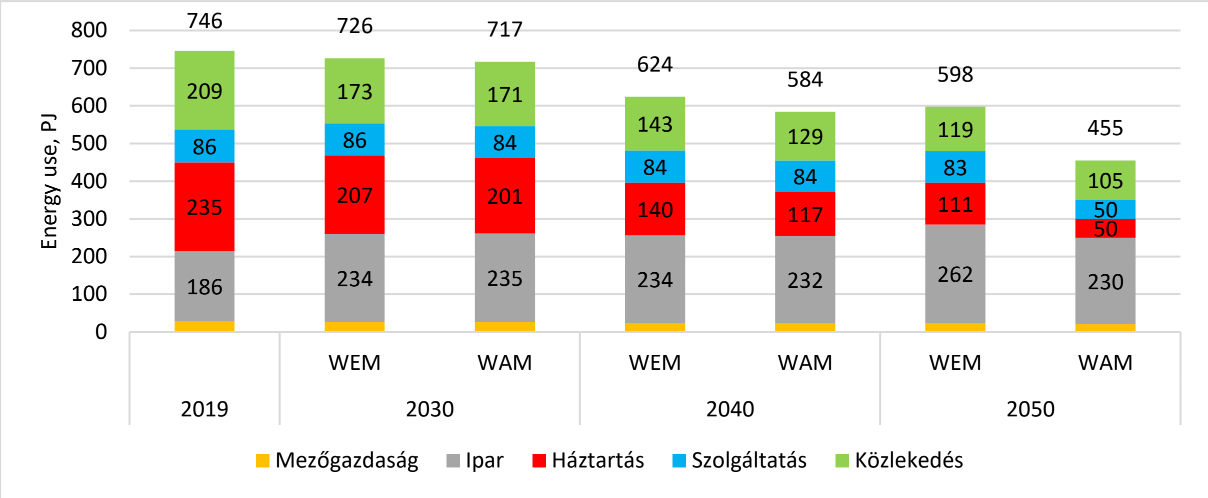
104Figure – Expected evolution of final energy consumption in the agriculture, forestry and fisheries sector, expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ)
Source: Fact 1: Eurostat, forecast: REKK

Both scenarios project a decrease of 7% between 2019 and 2030, which should decrease by 29% by 2050. Achieving the short- and long-term decarbonisation targets also requires energy efficiency investments in this sector and electrification to gradually replace fossil fuels. In the longer term, with additional measures, total final energy consumption will decrease. There is a significant difference in the composition of final energy consumption between the two scenarios, with a greater reduction in oil and gas consumption and a 4.5-fold increase in electricity consumption compared to 2019 in the WAM scenario and a higher increase in electricity consumption in the WEM scenario by 2050.

Aggregate final energy consumption results, as explained above, are presented in the following diagarms in WEM-WAM comparison.



105Figure – Expected evolution of final energy consumption, by fuel and expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ) Source: Fact 1: Eurostat, forecast: REKK



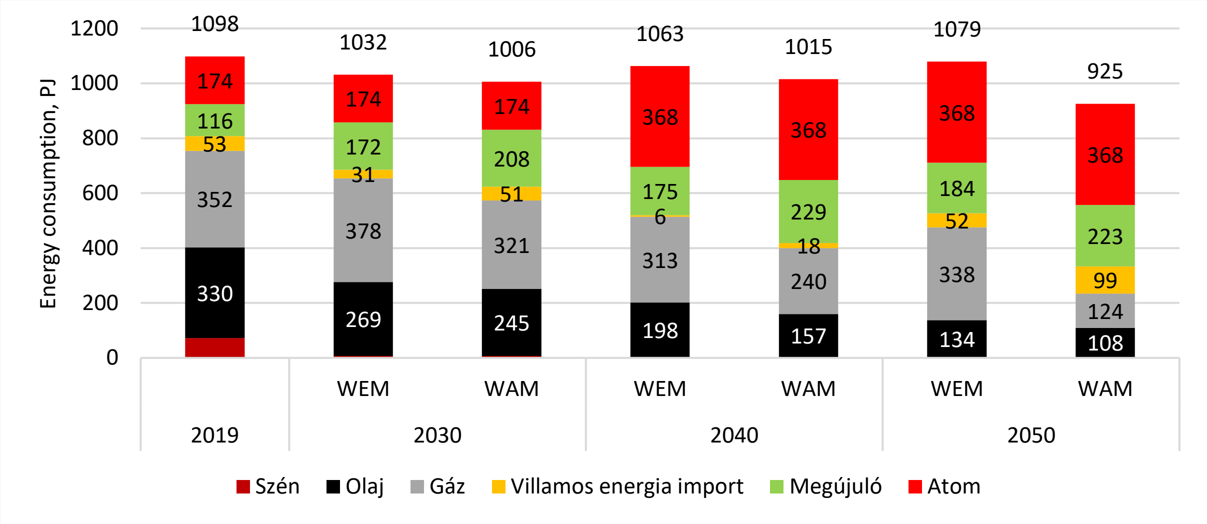
106Figure – Expected evolution of final energy consumption, by sector and expected change in its composition for the WEM and WAM scenarios (2019-2050, PJ) Source: Fact 1: Eurostat, forecast: REKK

Overall, achieving the 2030 and 2050 maximum GHG emission targets requires a combination of the following conditions:

- Encouraging energy efficiency investments in all final energy consumption sectors.
- Electrification across all final energy consumption sectors and decarbonisation of electricity and heat production.
- Operation of biomass-based 'net GHG sink' electricity generation incorporating CCUS technology.
- Reduced spread of hydrogen.
- RDI projects to eliminate remaining emissions in a cost-effective manner.

Primary energy consumption

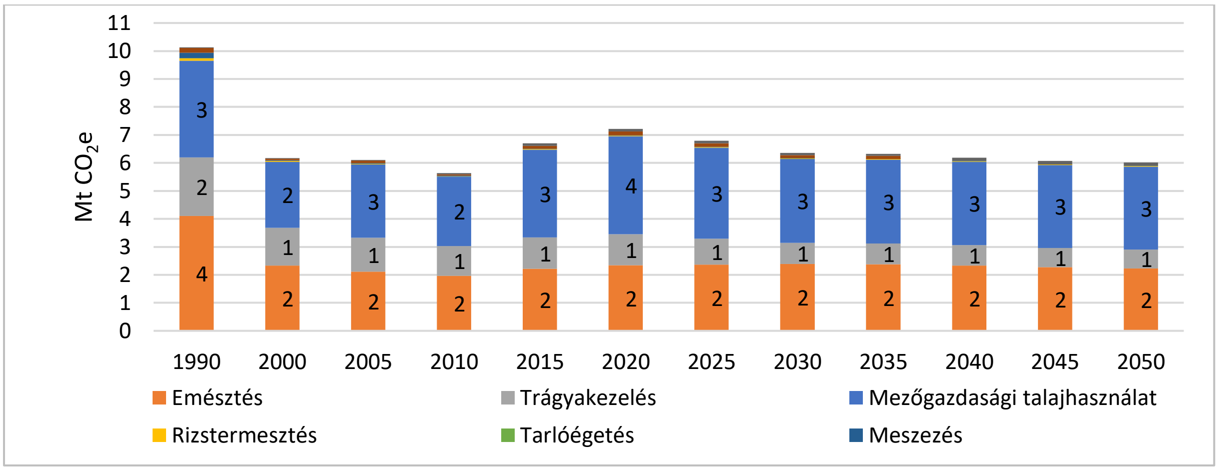
The high level of primary energy use that remains in the longer term is the result of renewable and nuclear capacity. The capacity utilisation of renewable generators is predominantly dependent on the weather, while in the case of nuclear power generation the resulting transformation loss is increased by the entry into operation of the new Paks units. The increase in consumption can be partly offset by energy efficiency in final energy consumption, with a 8% reduction in primary energy use in WAM scenarios by 2050 compared to 2019, and a slight increase of 6% in WEM.



107Figure – Expected evolution of primary energy consumption, by fuel and its composition in the WEM and WAM scenarios – impact of new policy measures (2019-2050, PJ)
Source of fact: Eurostat

Non-energy emissions from agriculture

For non-energy emissions from agriculture, additional emission reductions are driven by the CAP and the OLP.



108Figure – Expected evolution of GHG emissions from agriculture under the WAM scenario (1990-2050;Mt CO_2e/year)
Source: WHO

Agricultural GHG emissions under the WAM scenario are expected to be 6.4 Mt in 2030 and 6 Mt CO_2e in 2050. Emissions will decrease throughout the period after the 2020 peak, but will increase slightly (by 4.1%) between 2005 and 2030 due to the increase in agricultural production after EU accession. This trend still represents a decrease of 37.2% and 40.6% between 1990-2030 and 1990-2050. The decrease in emissions in the livestock digestion category is due to a decrease in livestock, a decrease in methane emissions from the digestion of cattle, while the main reasons for the decrease in emissions from manure treatment are due to a significant increase in biogas utilisation and ammonia abatement techniques related to manure storage, in addition to a decrease in livestock. In addition, the decline in fertiliser use is a major contributor to the reduction in emissions in the agricultural land use category.

Emissions **from soil use** (mainly N_2O) are 13.2% lower in 2030 than in 1990, but represent an increase of 14.2% over the period 2005-2030. Soil use accounts for 49.2% (3 Mt CO_2e) of total GHG emissions from the agricultural sector in 2050. In addition to the decrease in fertiliser use, the reduction in livestock manure use and the expected decrease in wheat and maize yields due to the negative effects of climate change may reduce the emissions of tillage.

Digestion **emissions** (mainly CH_4) represent 37.1% of the total sector in 2050 (2.2 Mt CO_2e). The corresponding emissions are 41.9% lower in 2030 than in 1990, but an increase of 13.2% can be observed between 2005 and 2030. Changes in breeds and improvements in feeding related to the cattle sector are expected to make a demonstrable contribution to reducing methane emissions from digestion after 2035.

GHG emissions from manure management are projected to decrease by 37.3% over the period 2005-2030 due to changes in dairy cow and pig herds and a significant increase in biogas utilisation of livestock manure. GHG emissions from the use of urea-based fertilisers will increase by 24.9% between 2005 and 2030, but the ban on the use of urea will reduce them to 0 Mt CO_2e from 2040.

While measures in the WAM scenario can reduce GHG emissions from agriculture, the reduction potential of the sector is limited, as the reduction should be achieved at the same time as maintaining or increasing the current level of agricultural production.

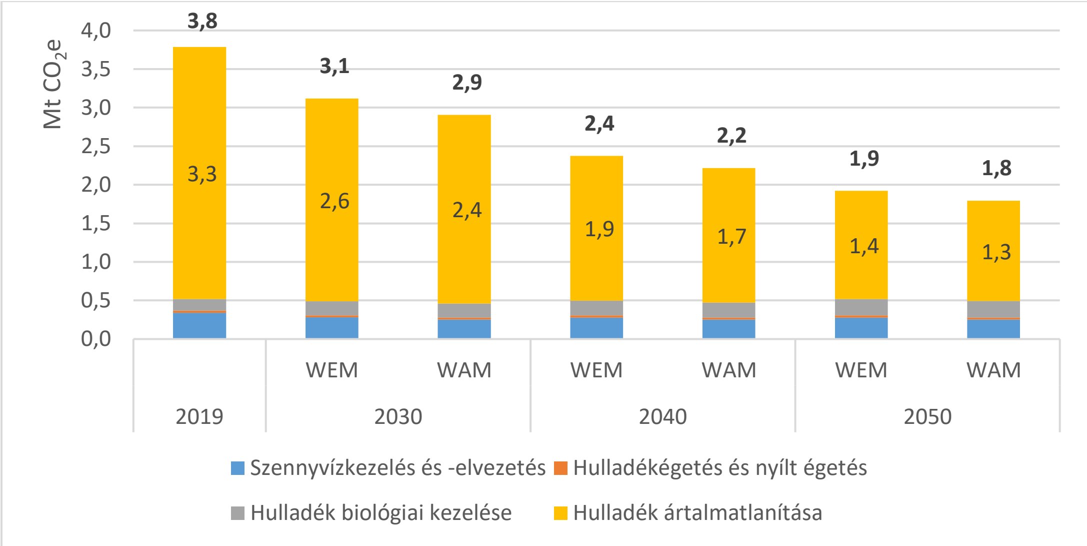
Non-energy emissions from industrial processes and material use

In the case of the sector, we do not currently calculate with additional measures in view of the changes in the ETS regulation and the monitoring of the effects of the already implemented ESG regulation. In the coming years, given the incentive nature of these regulations, we will monitor developments in industrial emissions and take additional measures if the existing sub-sector regulation does not live up to expectations.

From industrial processes, material and product use, we expect the 2030 values in the above WEM scenario (see Chapter 4.2.1(ii)) and the increase in production volume to decouple GHG emissions. Given the wide range of companies involved in these emissions and the dynamically developing EU regulations, we assume that emission installations are increasingly interested in averting emissions, starting with emission reductions in the energy sector and secondly process emissions.

Waste management GHG emissions (including wastewater treatment)

In the case of the waste management sector, on the basis of the new institutional structure – the national waste management concession system – and the expectations placed on the concessionaire, and taking into account the provision of raw materials for biogas production, the amount of landfilled waste will be significantly reduced under the WAM scenario.

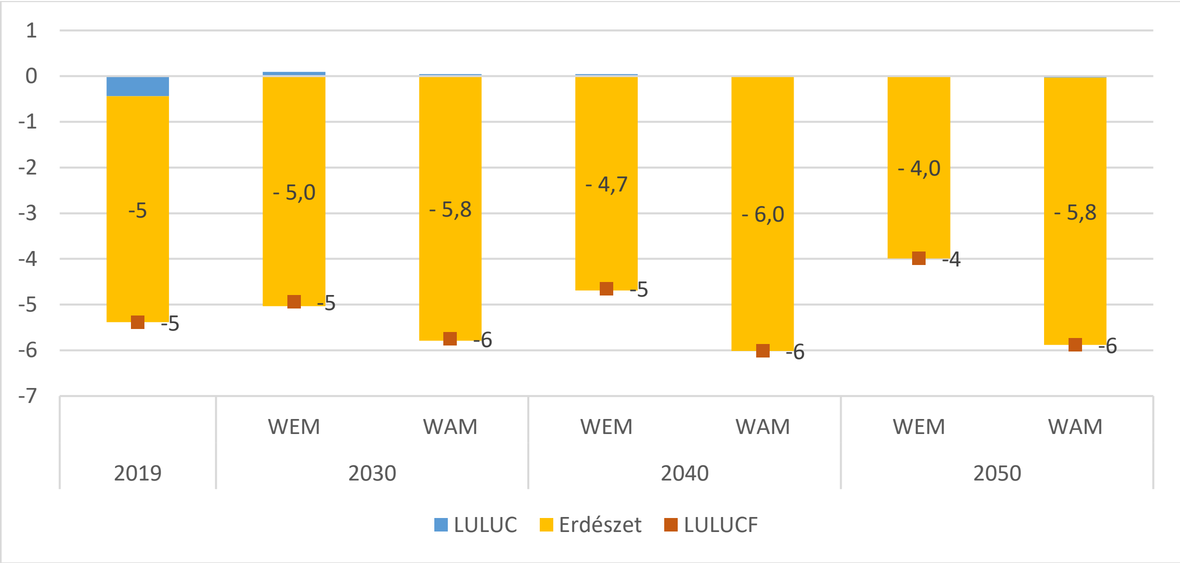


109Figure - GHG emissions from waste management (and wastewater treatment) according to WEM and WAM scenarios by source category (Mt CO_2e/year) Source: HungaroMet

Overall, GHG emissions from the waste management sector are expected to decrease by 24% by 2030 and 53% by 2050. While methane emissions from waste disposal are expected to decrease significantly (-54% by 2050), this source category remains the most important in the waste management sector, with a share of 87% in 2019 and 83% in 2030 and 72% in 2050. Both the expected increase in composting and biogas production will lead to increased emissions in the source category **of biological treatment** of waste by 2030. Incineration **(hazardous) without energy recovery is not** expected to have a significantly different trend. **As regards wastewater treatment,** we expect a steady and more significant increase in the energy recovery of sewage sludge compared to WEM, which could increase methane leakage, but an accelerated connection schedule to centrally treated wastewater treatment plants would result in even higher nitrogen removals and thus lower N2Oemissions.

LULUCF GHG emissions – net removals

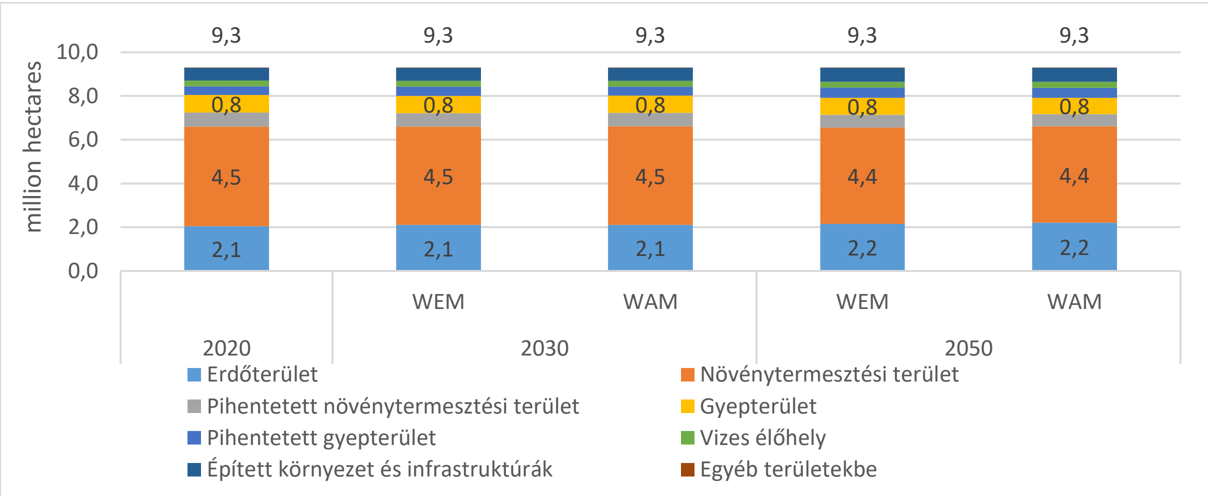
Emissions from the LULUCF sector can be fluid due to the effects of climate change and economic emergency situations. Both LULUC (land use and land use change) and forestry (F) show high volatility in terms of actual data, which also makes modelling difficult due to: the sector’s high risks of external impacts, as well as the long-term impact of the sector’s measures, and both natural and economic emergency situations. Overall, emissions and removals from the LULUCF sector are as follows for the WEM and WAM scenarios.



110Figure - LULUCF sector emissions (net removals), including margins of error, under the WEM and WAM scenarios (Mt CO_2e, 2019-2050)

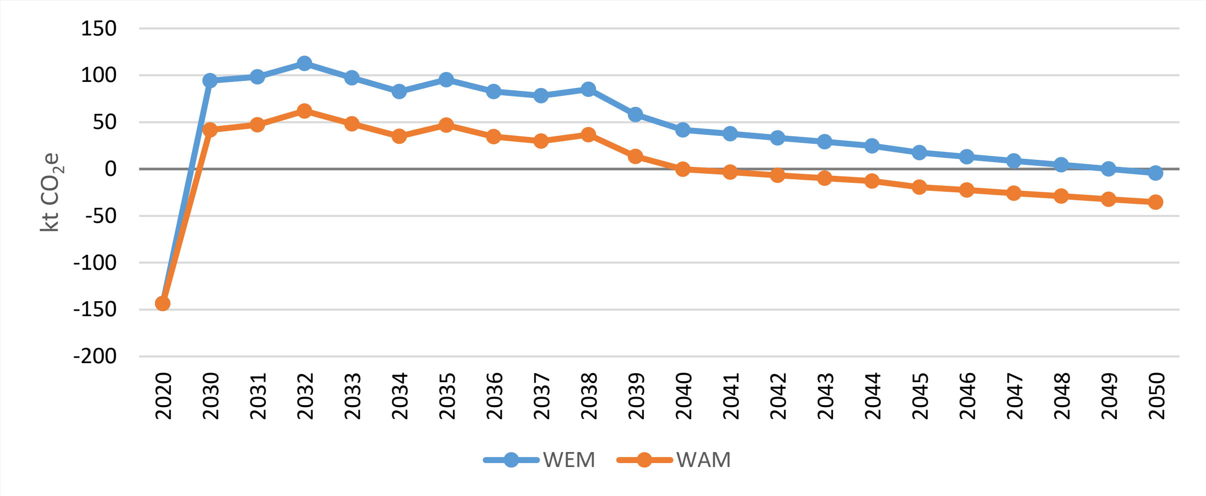
The LULUCF sector could absorb 4-5 Mt CO2in the WEM scenario and 5-6 Mt CO2 in the WAM scenario over the 2019-2050 time horizon.

In relation to **land use and land use change,** the scenarios for the 30-year projection period do not foresee a significant deviation, the trend of the changes is the same, only the extent of the changes differs. In the case of forest areas, built-up areas and wetlands, an increase is expected, while in the case of agricultural areas, a slight decrease is expected.



111Figure . - Forecast of the change of each land use category according to WEM and WAM scenarios (2020-2050) Source: WHO

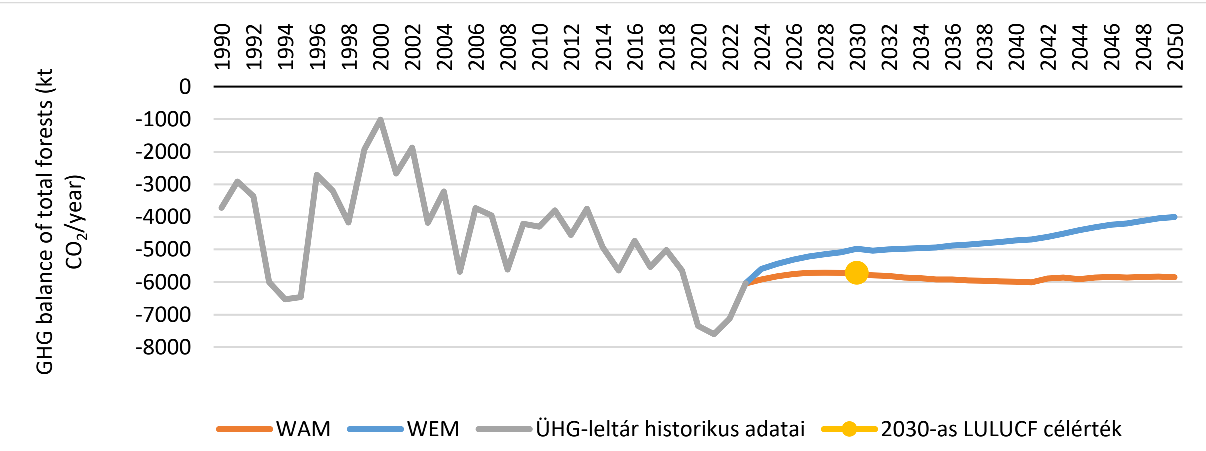
Both scenarios foresee a reduction in GHG emissions in the LULUC sector between 2020 and 2050, with the sector sinking in 2040 in the WAM scenario and ten years later in 2050 in the WEM scenario.



112Figure - Figure 3 GHG emissions of the LULUC sector according to WEM and WAM projections (2020-2050) Source: WHO

The GHG emissions of the sector in 2050 are expected to be around -4.2 kt CO_2e in the WEM scenario and -35.5 kt CO_2e in the WAM projection. The biggest change is in crop production areas due to the spread of environmentally beneficial farming practices. Looking at GHG emissions per gas, it can be concluded that the modelled changes have an effect on CO2emissions. The LULUCF sector remains an emitter in both scenarios throughout the period up to 2030 and therefore the fulfilment of Member States' obligations under the LULUCF Regulation depends on forest emissions/sinks.

In relation to the **forestry sector,** according to the GHG inventory, forests have a trend-increasing annual GHG balance between 1990 and 2020, with relatively large annual fluctuations.

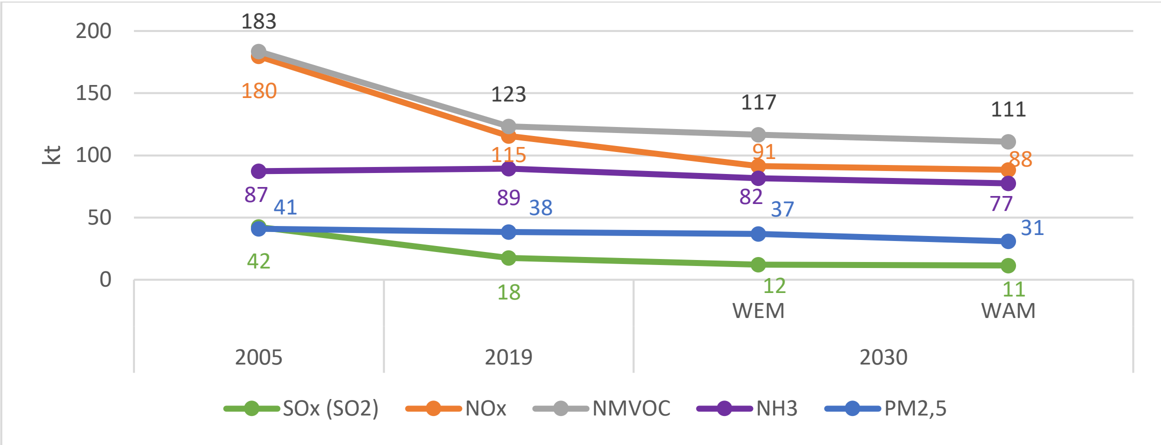


113Figure - Matching GHG inventory data with projection curves and 2030 target Source: SOE

The reasons for the fluctuations include the methods used to monitor forests and to update the data stored in the Forest Stock Repository. Generally, forests in Central and Southern Europe are characterised by decreasing average annual tree sludge resulting from changes in rainfall distribution due to climate change and higher aging forests caused by nature conservation regulations. In addition, forest degradation caused by natural damage and mass invasive pests has increased significantly, and an increasing amount of deadwood abandonment obligations have to be taken into account in order to increase biodiversity. The WAM scenario assumes that the level of afforestation will be higher compared to the WEM, which reflects the trend of recent years, while the level of annual logging will remain constant (i.e. non-increasing) instead of increasing according to the trend so far.

Emissions of air pollutants

Every two years, a forecast of the expected evolution of emissions of the major pollutants is prepared along the lines of Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants.



114Figure - Emissions of air pollutants by WEM and WAM scenarios (2005-2030) - 2021 forecast Source: HungaroMet

Although our sulphur dioxide emissions (SO_2) have been reduced by almost 60% compared to 2005 levels, additional measures were needed for ammonia (NH_3) and small particles ($PM_{2.5}$) and for all additional pollutants to reach the 2030 targets. In addition to greenhouse gases, these measures also have an impact on emissions of air pollutants. In line with the measures in the updated NECP, the following projections for 2021 may also be revised.

ii. Assessment of the interaction between policies (between existing and planned policies and measures within a policy dimension and existing and planned policies and measures across different dimensions) at least until the last year of the period covered by the plan, in particular to ensure a thorough understanding of the impacts of energy efficiency/energy savings policies on energy system scaling and to reduce the risk of unprofitable investments in energy supply

From the point of view of energy efficiency, it is a priority to preserve industrial performance as a guarantee of economic development and to develop sustainable and climate-friendly energy management while further expanding production. To this end, it is also essential to raise awareness of what most of the planned measures seek to achieve, namely that ‘the cheapest energy is energy that is not consumed’. Among the measures, Hungary optimises interventions for complex developments so that a systems approach can be applied to all policies. For example, it is essential that, in the case of investment aid for energy saving, which is aimed at comprehensive energy efficiency improvements, some form of renewable-based energy production, decarbonisation of heating and cooling or specifically building energy investments should be implemented taking into account climate adaptation.

The recovery in weather-dependent renewable energy production is a welcome development and should not be diminished, but it still represents an additional burden on the electricity grid. Inhomogeneous production entails increasing balancing needs, especially with regard to frequency and voltage regulation. In order to maintain the stability of the energy system, in particular electricity transmission and distribution infrastructure, and the quality of service, and to keep the future development needs of this infrastructure as low as possible, policy planning should take into account the need to ensure comprehensive developments. In the economic sector, it is of paramount importance that the expansion of production has the least possible impact on the energy system – i.e. when planning energy demand, developers exploit all the technological possibilities that can be used to achieve energy savings, and also take into account the investments in renewable energy technology that can create a higher level of self-sufficiency in companies – thus placing a lower consumption burden on the energy system. On the economic side, Hungary can enforce this not only in terms of network tariffs but also in support policy, as in the case of such investments the market can be steered towards comprehensive developments with incentives for energy efficiency and renewable energy production, especially with regard to investment elements that do not pay off or only pay off in the long term.

Subsidies for renewable energy production also have the most positive economic impact by shifting sectors – corporate, public and private – towards self-sufficiency. There are several tools and technological solutions available for this, which we can support with a wide range of incentives: pricing, tax policy/regulation, subsidy policy, etc.

iii. Assessment of the interaction between existing and planned policies and measures and between them and Union climate and energy policy measures

The updated NECP offers a comprehensive response to the energy transition, our nature conservation and climate protection goals. Energy efficiency comes first in policy design, as most measures are interpreted in the light of energy demand. In addition to economic production and reindustrialisation, Hungary is devoting significant resources to achieving a further reduction in final energy consumption by 2030. Existing needs need to be met as much as possible by renewable and zero-emission energy production, preferably in a way that moves towards decentralised energy systems – which promise to be more sustainable. At the same time, the development of energy networks should not be neglected so that they are future-proof and resilient. A comprehensive response to all these aspects is provided in the extended list of measures (Annex 1 to the NECP), which is summarised in Chapter 3 and the impacts have been described in detail in the previous sub-chapters. However, there are a number of cross-cutting contributions that underpin our sectoral efforts to achieve our goals.

It is necessary to strengthen the skills of the domestic workforce to ensure that human resources are always available in the economic structure on the path to decarbonisation that are able to help the transition through their work. Through training, attitudes can also be effectively shaped, which can have a wide social impact.

In order to create an energy transition and increase our energy sovereignty, we also need to focus on technology sovereignty, by strengthening the domestic manufacturing base of clean technologies. Strengthening the domestic and European development and production of clean energy technologies is a key task for us. This is not just a question of competitiveness, without the accessibility of the necessary green technologies we cannot achieve our goals set here, so like many others in Europe, we want to create a clean technology manufacturing base in our country, to which we want to contribute with targeted subsidies. This can give significant impetus to the achievement of the NECP targets and ultimately GHG neutrality.

5.2. Macroeconomic and, to the extent feasible, health, environmental, employment, education, skills and social impact of planned policies and measures described in Chapter 3, including transitional aspects (in terms of costs and benefits achieved and cost-effectiveness), at least up to the last year of the period covered by the plan, including comparison with projections based on existing policies and measures

The macroeconomic effects were modelled for the updated NECP in relation to energy modelling. HÉTFA examines the increase in gross value added and the employment forecasts, as well as the short- and medium-term macroeconomic effects of the package of proposals. The period under review is 2024-2035, since beyond 2035, due to population changes and changes in the structure of the economy, the accuracy of the calculations would be drastically reduced. Of all the variables of the model used, the results are presented for the most important ones, which are:

- % of GDP, which is the impact of changes in demand on GDP;
- Changes in the number of people employed (in headcount), mainly due to demand in labour-intensive construction;
- Evolution of government tax revenues, where direct tax revenues in the model are derived from the taxation of capital and labour income, and indirect tax revenues are the tax content of the use of products.

47Table – Macroeconomic effects of the NECP under the WAM scenario (Source: HÉTFA analysis and estimation)

	GDP (%)	Employment (persons)	Tax revenues (HUF billion)
NECP	0,02	3426	172,3

As the effects mainly affect sectoral demand, they do not have long-term supply effects, so GDP effects are relatively low. Overall, operating costs at macroeconomic level are decreasing, with no significant cost increases expected in either sector, contrary to previous modelling.

The decline in operating demand, i.e. the overall increase in energy efficiency, has a positive impact on GDP, which is amplified by the increase in investment demand, with an overall positive impact on the GDP trajectory of 0.10%. The largest share (0.06%) of this is driven by operational GDP growth, while investment and household expenditure have an impact of 0.02% and 0.01%, respectively, between 2024 and 2035.

In addition to the positive GDP effects, the total employment effect is also positive, with an average of 4,000 more people in employment than without the NECP. The main reason for this is that the number of employees in the labour-intensive construction sector increases, thus creating a draining effect on other sectors.

The NECP **would also have a significant impact on revenues, i.e. the amount of indirect and direct tax revenues.** As a result, revenues would increase on average by more than HUF 192 billion in 2022 prices, which is **0.92% of the revenues of the 2022 central budget according to the data of the State Treasury.** Some of the increased tax revenues stem from the fact that employment growth directly provides revenue to the general government through taxes on labour, and on the other hand, higher flows of goods (excess production) also result in an increase in tax revenues through indirect taxes.-

i. Current investments and assumptions for future investments for planned policies and measures

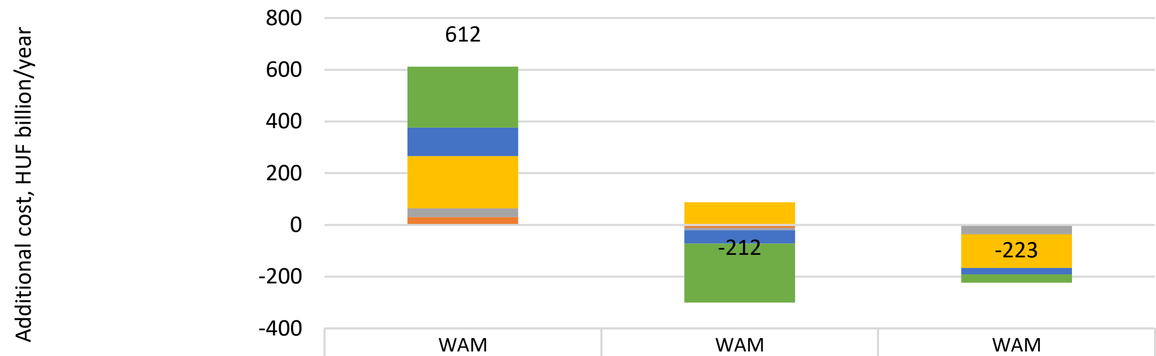
In addition to investment costs, the TIMES model used to prepare the NECP also takes into account changes in operating costs in the energy sector. The model calculates the additional cost of implementing measures to achieve the objectives of the energy strategy, as outlined in this document, i.e. the difference between the cost of the NECP WAM scenarios (with additional measures) and the reference WEM scenarios (with existing measures).

The model includes the energy conversion sectors, the energy use of the household and tertiary sectors, the transport sector, as well as the industrial and agricultural sectors. According to its operational logic, it seeks the most cost-effective way to meet a given end-user demand (e.g. million passenger kilometres, amount of cement produced, lighting needs, etc.), which can be considered as the cost of the WEM scenario. The WAM scenario, on the other hand, includes predefined targets (GHG limits, renewable targets, other targets) as a constraint for the model and looks for the cost-optimal taking them into account. The discounted value of the estimated total cost over the whole period, the so-called total system cost in the WAM scenario, is higher because more expensive technologies have to be used, e.g. to achieve higher emission reduction targets.

Modelling results

In the period between 2019 and 2050, the additional total cost surplus of the WAM scenario at the initial discounted value for the year 2019 is ~6,500 billion forints, divided over the years, resulting in an additional cost of 177 billion forints.[200]

Costs can be divided into three broad categories: investment costs, operating costs and quota costs, the sum of which determines the total additional costs. The latter two cost categories show that accelerating the energy transition to an energy-efficient, renewable-based economy, decarbonisation and compliance with the set climate targets are not only environmental issues, but also result in significant economic and social benefits, GDP growth and the creation of new permanent jobs.



	WAM Beruházási költség	WAM Működési költség	WAM Kvótaköltség
Közlekedés	236	-228	-32
Háztartások	110	-52	-24
Villamosenergia- és hőtermelés	201	88	-130
Ipar	34	-8	-35
Szolgáltatás	30	-7	-1
Mezőgazdaság	1	-4	-1
Összesen	612	-212	-223

115Figure – Additional investment cost needs of the WAM and WEM scenarios by sector[201] (2019-2050, present value, HUF billion)

In the WAM scenario, the additional investment needs compared to WEM are in the order of HUF 612 billion per year. The vast majority of this is made up of three main sectors: transport (HUF 236 billion per year), the electricity and district heating sector (HUF 201 billion per year), and households (HUF 110 billion per year). It is important to underline that these represent the difference between the two scenarios and not the total investment cost needs.

The operating and maintenance costs in the WAM scenario are lower than in the WEM scenario. It is important to stress that the cost of electricity consumed in each sector is not

[200] In the additional cost calculation, the difference in residual values was also calculated. Thus, if an investment is realised in 2040 and has a lifespan of 20 years, a residual value is accounted for in proportion to part of the total investment cost, which reduces the investment cost.

[201] The figures shown in the figure are calculated with the total investment costs incurred, but not with the residual value in this case.

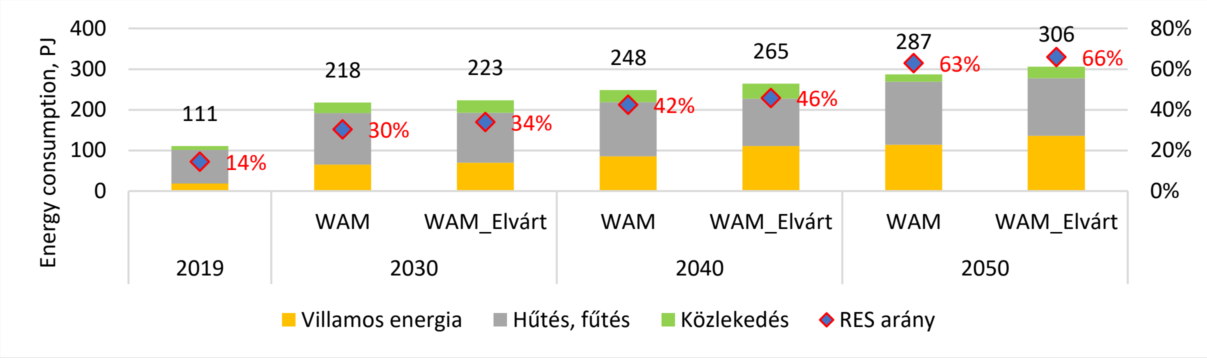
recorded in that sector, but in the electricity sector. For example, if there is an increase in electricity consumption in the industrial sector, it follows from the logic of modelling that this increase in costs is recorded in the electricity sector and not in industry.

ii. Sectoral or market risk factors or barriers in a national or regional context

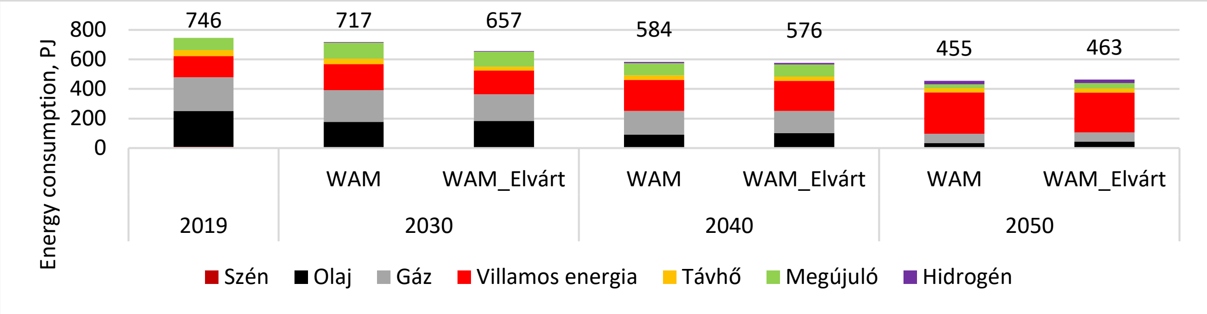
We consider it realistic to achieve the objectives set out in this document, taking into account the economic events of recent years and the available thematic funding sources, as well as the deadlines and physical constraints of the available funds – the combined constraints of the time factor and the workforce, the relevance of the mutualisation of investments – and the sectoral sub-objectives.

The Member State's contribution in terms of the share of final energy consumption and renewable energy in gross final energy consumption falls short of the targets expected in the EU directives and regulations, however, it should be taken into account that along the domestic alternative road map Hungary is expected to be able to contribute -55% to the overall -55% net greenhouse gas emission reduction of the EU27. We carried out a gap analysis in relation to the achievement of the main objectives set and expected in order to select realistic action scenarios. Applying both the expected energy use and the renewable share as caps, the outcome of the WAM and the alternative 'WAM_Required' scenarios can be characterised as follows:

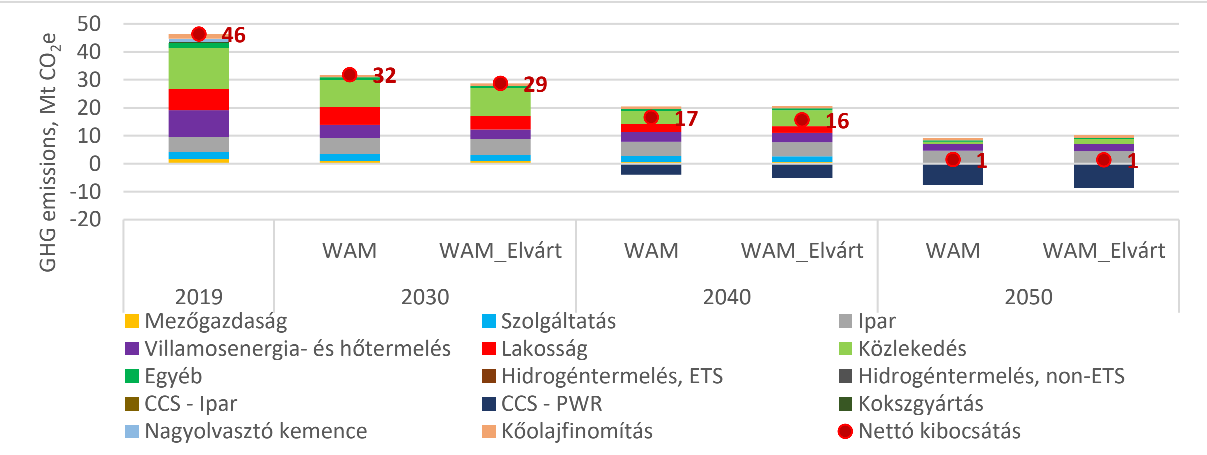
In terms of the renewable share, there is no significant change in the structure of the sectoral breakdown, however, in addition to this limit, final energy consumption automatically projects significantly lower energy consumption than expected. This would primarily require activities related to further equipping the building sector with heat pumps (shallow geothermal energy, utilising ambient heat) as well as more substantial activities related to the modernisation of the boundary structure of buildings, which would, however, raise the above-mentioned time factor and labour availability issue. It would also require more activity in the electricity sector, which would, however, raise a time constraint – an investment chain problem – on the need to develop the electricity network. Furthermore, the implementation of the WAM_expected scenario would require a significant change in the financing side of the measures to the detriment of the energy use and cleaning of transport, given that the cost-optimal model would divert investments from transport to other sectors for more significant targets, while the development of transport would also be a priority area in the field of fossil fuel supply and the target of renewable transport use of REDIII would also be neglected. By contrast, the main target – which also meets the expected target of 55% – would hardly change by 2030 if the above targets were integrated into modelling, while the WAM_Expected scenario would add an additional HUF 73 billion (total: 177+73 billion HUF) would be an additional cost. The main results of GAP modelling are illustrated in the following diagrams.



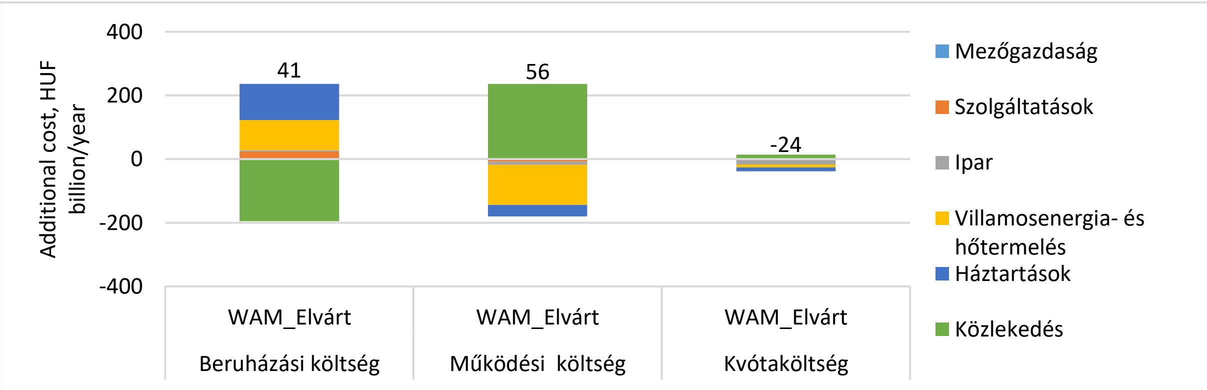
116Figure - Renewable energy use according to GAP analysis between set and expected targets (2019-2050, PJ) Source: REKK



117Figure - Final energy consumption according to GAP analysis between set and expected targets (2019-2050, PJ) Source: REKK



118Figure - GHG emissions according to the GAP analysis between targets set and expected (2019-2050, Mt $CO_{2}e$) Source: REKK



119Figure - Additional costs according to the GAP analysis between set and expected objectives (2019-2050, PJ)
Source: REKK

iii. Analysis of additional public funding support or resources to address the identified shortcomings set out in point (ii)

The availability of financing sources is not the primary concern in achieving the NECP objectives, however, we expect that the measures and planned regulatory changes set out in the NECP may result in a higher share of private capital raising, which is of paramount importance for the implementation of the necessary investments in the coming years, thus accelerating the energy transition.

5.3. Impact of planned policies and measures described in Chapter 3 on other Member States and regional cooperation at least up to the last year of the period covered by the plan, including comparison with projections based on existing policies and measures

i. Impact on the energy system of neighbouring Member States and other Member States in the region to the extent possible

Natural units in Hungary, such as our rivers, large lakes and mountains, typically extend beyond its administrative boundaries. As a result, **resources removed from the natural environment** for energy production and use are also important for neighbouring countries. **Joint exploitation of deep geothermal** reservoirs (e.g. along the Croatian border) can only be based on appropriate cooperation. **In the case of solid biomass,** there is also a cross-border supply of raw materials, so its environmental impacts are partly realised in neighbouring countries. **In the case of biofuels,** Hungary also appears as an exporter, as a result of which the environmental burden in Hungary, and the advantage from replacing fossil fuels, arises in the importing country. **Within transport, waterborne** transport of goods and passengers can cause transboundary pollution of our watercourses in the event of a disaster.

One of the strategic objectives of the NECP is to interconnect **the electricity and gas markets of** the region, which has a significant impact on energy trade with neighbouring countries and on enhancing security of supply. The investments will deepen Hungary's integration into the European energy system (electricity, gas supply), so changes in domestic consumption can increase or reduce environmental pressures beyond national borders.

The environmental impact of **the extraction of raw materials and energy carriers related to domestic energy** production and use (e.g. transport) and **the production of imported electricity** is an important aspect that arises outside national borders. The NECP's measures to reduce import dependency (both in terms of energy carrier and electricity) also reduce these externalities. The equipment required for the use of solar energy is typically imported products, and mining related to the raw material of rare earths is also realized outside the country borders.

ii. Impact on energy prices, utilities and energy market integration

Reducing dependence on energy imports and fossil fuels has become a priority. In many cases, the means of security of supply and climate neutrality are the same. Domestically produced energy, in particular renewable electricity, can be sold at significantly more favourable prices than imported energy carriers (natural gas) and electricity converted from them. However, this needs to be addressed taking into account the fact that, due to its technical characteristics, the use of natural gas can be reduced but, at the same time, it is undeniable from the energy system in the short and medium term. Biomass and solar energy are the most widely used renewable energy sources in Hungary today, but with our measures we want to give more space to other alternative energy sources as well. A diverse yet sustainable energy technology mix can ensure stable, competitive pricing.

The development of public utility systems has been discussed a lot in the chapters of the NECP to date, as the continuous improvement of the service is in our elementary interest not only in terms of security of supply, but also in terms of the quality of supply and the smooth facilitation of the energy transition. The water utility network should be highlighted, where there is a significant energy saving potential – we would like to exploit this in the short term as well, so in addition to the quality and security of supply, the cost of the service can also be reduced due to the reduction of the amount of energy used.

The NECP contains a number of measures with a direct cross-border impact (e.g. Danube InGrid project), which overall contribute to the integration of energy systems, which is an important prerequisite for future-proofing. One of the strategic objectives of the NECP is to interconnect the electricity and gas markets of the region, which has a significant impact on energy trade with neighbouring countries and on enhancing security of supply. The investments will deepen Hungary's integration into the European energy system (electricity, gas supply), so changes in domestic consumption can increase or reduce environmental pressures beyond national borders.

iii. Impact on regional cooperation

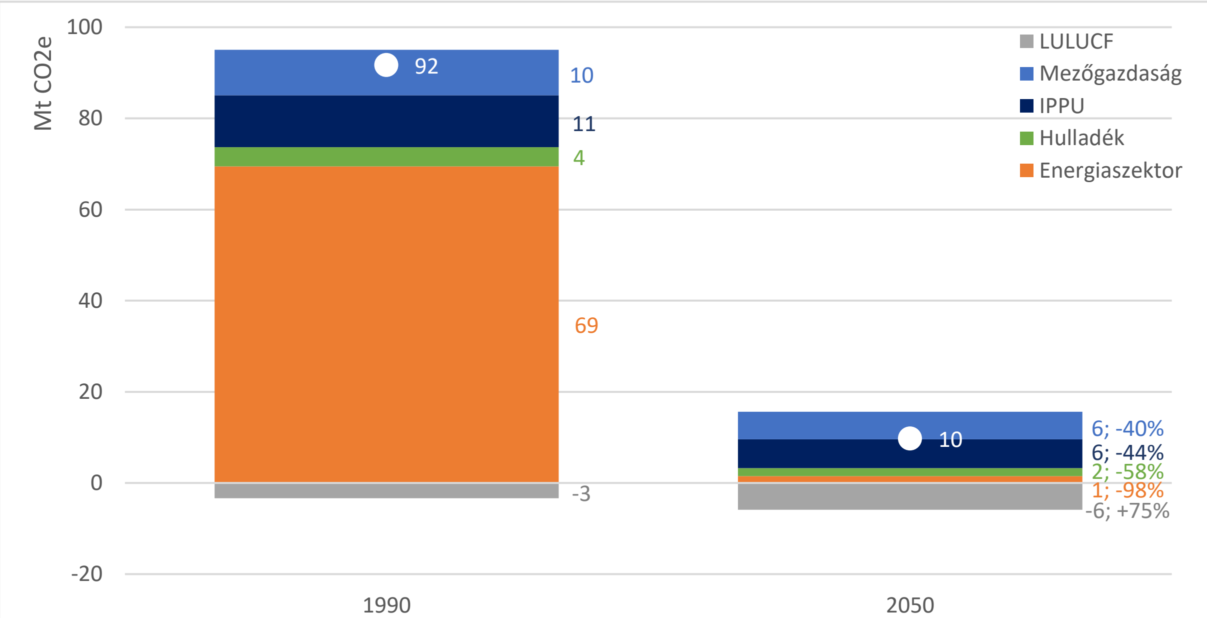
Opportunities for regional cooperation have been explained for each measure under the relevant points of Chapters 4 and 5. The significant decrease in nationally produced energy and final energy consumption has the potential to reduce the import exposure of Hungary and thus of the Union as a whole. Achieving the targets requires comprehensive, thoughtful and predictable regulation at EU level, which can be applied easily and easily by all Member States.

5.4. Contribution of planned policies and measures to the achievement of the Union’s climate-neutrality objective set out in Article 2(1) of Regulation (EU) 2021/1119

By 2050, *Hungary will become climate neutral in accordance with Act XLIV of 2020 on climate protection.* The Act sets out the objectives to be achieved by 2030 and designates the Government – in line with the principle of subsidiarity and the wide-ranging need for cross-sectoral solutions – as responsible for planning the related strategy and action planning and related aid policy developments. In addition, **we have set a gross emissions reduction target of 50% by 2030**.

In accordance with the Climate Neutrality Act, emissions from the largest emitter, i.e. the energy sector – energy production and use – broadly understood, have already been modelled by demonstrating climate neutrality by 2050, by determining the necessary energy mix, maximum use and emission levels to be taken into account in the planning process. Climate neutrality in the energy sector is, according to current knowledge, associated with an additional cost of ~612 billion HUF/year by 2050. In addition, security of fossil energy supply, which is unavoidable for the current supply, and measures to adapt to the climate change we are currently experiencing, in particular security measures, entail significant additional investment and operating costs.

In addition to the energy sector, for additional sectors contributing to greenhouse gas emissions, in order to achieve climate neutrality for the entire national economy, it **is up to the following years to identify the additional contribution needs towards the scheduled achievement of climate neutrality by 2050**. Particular attention should be paid to the possibility and limitation of additional contributions from the LULUCF and agricultural sectors, which are primarily influenced by natural processes, and to the need for alternative balancing due to the low level of contributions. Against this background, it is necessary to address the potential for further emission reductions from industrial processes, material use and waste management, as well as the potential for artificial removals, which are currently linked to the energy sector but are fundamentally widely applicable, in order to achieve climate neutrality at the national economy level.



120Figure - Contribution to climate neutrality in 2050 based on 2024 long-term measures, by sector (Mt CO_2e)