National Energy and Climate Plan

Revised version 2023

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List of abbreviations

ACER	Agency for the Cooperation of Energy Regulators
AEO	Annual Energy Outlook Issued by: US Energy Information Administration/US EIA
aFFR	Automatic Frequency Restoration Reserve
AEA	Annual emission allocation
APT	Sophisticated and persistent attack in cyberspace (Advanced Persistent Threat)
ACE	State Audit Office
AT	Austria (Austria)
BE	Belgium (Belgium)
BG	Bulgaria (Bulgaria)
BJU	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) (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
CCUS	carbon capture, storage and storage
CEE	Central and Eastern Europe
CEEGEX	Central European Gas Exchange
CEER	European Council of European Energy Regulators
CEF	Connecting Europe Facility
CERN	European Organisation for Nuclear Research
CESEC	high-Level Group on Central and South-Eastern Europe Connectivity
CHP	combined heat and power
CIGRE	International Council on Large Electric Systems
Climate-ADAPT Information Platform	Climate Adaptation Information Platform

CNG	compressed natural gas
COST	Cooperation in Science and Technology
CY	Cyprus (Cyprus)
CZ	Czech Republic
Core FB MC project	Main Flow Based Market Coupling Project
CNG	compressed natural gas
DAM	day-ahead market
BUT	Germany (Deutschland/Germany)
DK	Denmark (Denmark)
DLR	dynamic Line Rating
DSO	distribution System Operator
DSR	demand response (demand side responses)
DW value	DURBIN Wattson value
EE	Estonia (Estonia)
EIB	European Investment Bank
EB GL	European Balancing Guidline
EBRD	European Bank for Reconstruction and Development
ECG	Electricity Coordination Group
US EIA	US Energy Information Administration
EIF	European Investment Fund
EIT	European Institute of Innovation and Technology
EL	Greece (Greece/Hellas (Ελλάς))
ENTSO	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
EPC	Energy Performance Contracting
EPO	European Patent Office
ERA	European Research Area
ES	Spain (España/Spain)
ESCO	Energy Saving Company or Energy Serving Company
ESCO programme	involuntary third-party funding
ESD	Effort Sharing Decision
ESFRI	European Strategy Forum on Research Infrastructures

ESS	Effort Sharing Regulation
EU	European Union
Unit EUA III	European Emission Allowances issued to installations for ETS III trading period 2013-2020
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
SAD	Electric Vehicle (Electric Vehicle)
ÉCST	Climate Action Plan
SMI	Building Quality Control Innovation Nonprofit Kft.
FEST	Advisory Council on Climate Change
FGSZ Zrt.	FGSZ Natural gas Transmission
FI	Finland (Finland)
FOM cost	Fixed O&M costs/fix operaion and maintenance costs
FR	France (France)
FRL	Forest Reference Level
GCG	Gas Coordination Group
GDP	gross domestic product
GIE	European Gas Infrastructure Europe
EDIOP	Economic Development and Innovation Operational Programme
Hg	mercury
HHI	Herfindhal-Hirschman index
HIPA	National Investment Promotion Agency
HVC	audio frequency central control
HMKE	small household power plant up to 50 kW
HR	Croatia (Hrvatska/Croatia)
EN	Hungary (Hungary)
HUPX	Hungarian Power Exchange
ICIS	International Conference on Information System
ICS	Industrial control system
IDM	Intraday market

IEA	International Energy Agency
IGCC	International Grid Control Cooperation
IE	Ireland (Ireland)
IKOP	Integrated Transport Development Operational Programme
INEA	Innovation and Networks Executive Agency
IT	Italy (Italy)
It technology	Information Technology
ITER	International Thermonuclear Experimental Reactor
ITM	Ministry of Innovation and Technology
SMP	significant market power
Feed-in system	electricity feed-in system
KEHCsT	Transport Energy Efficiency Action Plan
KEHOP	Environmental Energy Efficiency Operational Programme
RDI	research, development and innovation
Networks	low-voltage networks
SME	small and medium-sized enterprises
Köf networks	medium-voltage networks
LNG	liquefied natural gas
LOLE	expected frequency of lost electricity supply (loss of load expectation)
LOLH	loss of electricity supply in hours – 1 year (loss of load hours)
LOLP	loss of load probability
LPG	liquefied petroleum gas
LU	Luxembourg (Luxembourg)
LT	Lithuania (Litvania)
LV	Latvia (Latvia)
MARI	Manual Activated Reserves Initiative
MAVIR Zrt.	MAVIR Magyar Electricity Industry Transmission System Control ZRrt.
HSR	Hungarian State Railways Co.
MCO	market Coupling Operator
MEHI	Hungarian Institute for Energy Efficiency
MEKH	Hungarian Energy and Public Utility Regulatory Authority

METÁR	Renewable support scheme (renewable and alternative sources of heat and electricity)
mFRR	manual frequency restoration reserve
MGT	Hungarian Gas Transit Zrt.
Mol Nyrt.	Hungarian Oil & Gasipari Nyilosan Működő Közvénytársaság (Hungarian Oil and Gasipari Nyilosan Működő)
MRC	Western European Regional Coupling
MT	Malta (Malta)
MTA	Hungarian Academy of Science
NAF network	high-voltage network
NAS	National Adaptation Strategy
NATÉR	National Geo-Information System for Adaptation
NECP	National Energy and Climate Plan
NEMO	nominated Electricity Market Operator
NÉeS	National Building Energy Strategy
NES	National Energy Strategy
ND	National Climate Change Strategy
N° 2	Second National Climate Change Strategy
NF_3	Nitrogen trifluoride
NIS	Network and information systems
NKFI Fund	National Research Development and Innovation Fund
NKFIH	National Agency for Research Development and Innovation
NKI	Research Institute for Population Sciences
NAP	National Transport Strategy
NL	Netherlands (Netherlands)
NO_2	Nitrogen dioxide (and nitrogen monoxide) is mainly generated and released into the atmosphere by burning nitrogen-containing substances (firewood, biomass, coal, lignite, hydrocarbons, plastics). It is an air pollutant, it is also a component of acid rain; it can be toxic at higher concentrations and has a weak greenhouse effect. Nitrogen oxides are summed up as NO_x.
N_2O	Nitrous oxide is formed and released into the atmosphere mainly from a reactor of nitrogen (N2) and oxygen (O2) in the air at high temperatures from thermal processes (e.g. combustion of fuels). Its importance for climate protection is that it is one of the strong greenhouse gases, where a well-

	identified part of agriculture's GHG emissions comes from.
NRA	national Regulatory Authority
NTC	net Transfer Capacity/ network Transfer Capacity
HAEA	Hungarian Atomic Energy Authority
OCG	Oil Coordination Group
OECD	Organisation for Economic Co-operation and Development
OCT	National Environment Council
OMSZ	Hungarian Meteorological Service
OPEX	operational expenditure
OTC market	over the counter
power-to-gas technology	electricity storage technology in which hydrogen is produced with electricity or methane in a further step, which can be converted into electricity if necessary
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)
PRIMES model	Price-Induced Market Equilibrium System
PT	Portugal (PT)
PV	photovoltaic, PV
RDF	The secondary fuel obtained after sorting the residual waste from mixed municipal waste or separate collection. Used in power plants or cement factories. PV (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
REKK	Regional Energy Economy Research Centre
RES	renewable energy sources
RES	renewable energy sources for electricity
RES-H&C	renewable energy sources for heating and cooling

RES	renewable energy sources in transport
RHD	renewable energy sources in transport
RKV	radio Frequency Central Control
RO	Romania (Romania)
RSI	Residual Supply Index
R^2	coefficient of determination
SDAC	single day-ahead coupling
SE	Sweden (Sweeden)
SEE	Southeast Europe or Southeastern Europe
SCADA	Supervision Control and Data Acquisition
SEPS	Slovenská elektrizačná prenosová sústava, a.s. (Slovene system operator)
P.M.	Group on Emergency Questions
Set Plan	Strategic Energy Technology Plan
Script kiddies	"Logging pups": Computer "cybercriminals" is not too knowledgeable. They often cause damage through complementary programmes (scripts) or software written by others. They are often called hackers by the public.
SI	Slovenia (Slovenia)
SK	Slovakia (Slovakia)
SO_2	sulphur dioxide
TAO	Corporation tax
TCO_2e	unit of measurement of GHG emissions in tonnes of CO_2 equivalent
TERRE	Trans-European Replacement Reserves Exchange
Co-operation at stake	Scientific and technological cooperation
Times model	Integrated MARKAL-EFOM (The Integrated MARKAL-EFOM System): The TIMES model adapted to Hungary covers the entire Hungarian energy sector, including transformation sectors, energy use in industry and transport sectors and energy use related to buildings.
OCTEX	total expenditure
TSC	security Coordination of Transmission System Operators
TSO	transmission system operator
TWG	Technical Working Group
TYDP	Ten Year Development Plan

UK	United Kingdom
GHG	greenhouse gas(s)
VEKOP	Competitive Central Hungary Operational Programme
VINTAGE	Act LXXXVI of 2007 on electricity
V4	Visegrad Four (Czechia, Hungary, Slovakia, Poland)
VP	Rural Development Operational Programme
VOLL	value of lost load
Cost of voom	Variable O&M costs/variable operation and maintenance costs
WAM	With additional measures
WEM	With existing maesures
XBID	Cross-border intraday coupling
4M MC	4 Markets Market Coupling

Units of measurement and list of conversions

<u>Energy quantity:</u>

KOE	*kilograms of crude oil equivalent*
toe	*tons of oil equivalent*
ktoe	*thousand tonnes of oil equivalent*
Mtoe	*million tonnes of oil equivalent*
1 mtoe = 1000 ktoe = 1000 000 toe = 1000 000 000 koe	

J	*joules*
KJ	*kilojoule*
MJ	*megajoule*
GJ	*gigajoules*
TJ	*terajoule*
PJ	*petajoule*
1 PJ = 1 000 TJ = 1 000 000 GJ = 1 000 000 000 MJ = 1 000 000 000 000 kJ = 1000 000 000 000 000 J	

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

m^3	*cubic meters*
billion m^3 (bcm)	*billion cubic meters*
1 bcm (1 billion m^3) = 1 000 000 000 m 3	

<u>Conversions between different units:</u>

1 toe= 11 630 kWh = 41 868 MJ = 1 190.45 m 3[1]

1 TWh = 85984,52 toe = 3 600 TJ= 102 359 965.88 m 3

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[1] Conversion values in m^3refer to natural gas. (Gross calorific value = 35.17 MJ/m^3)

1 TJ = 277777.78 KWh = 23,88459 toe = 28 433.32 m 3

1 billion m^3*(1 bcm) = 9.76944 TWh = 35 170 TJ = 840021 toe*

Capacity:

kW	*kilowatt*
MW	*megawatts*
GW	*gigawatts*
TW	*terawatt*
1 TW = 1 000 GW = 1 000 000 MW = 1 000 000 000 kW	

1. OVERVIEW OF THEPLAN AND PROCESS FOR ITS CREATION

1.1. Summary

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

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

The National Energy and Climate Plan (in short: NECP) – in line with the objectives of the National Energy Strategy – its main objectives are to strengthen **energy sovereignty and energy security**, to **sustain the results of** the reduction of public charges and **to decarbonise**. Securityof energy supply and increasing energy sovereignty have become national security issues and reducing dependence on energy imports is an energy policy priority. In this context, reducing the share of natural gas in the energy mix is a strategic priority.

We want to achieve our energy independence through demand reduction and energy efficiency, diversification and alternative energy sources utilisation and electro-electrification measures.

While more emphasis is placed on security of supply, this is not done by sacrificing sustainability objectives. Hungary remains committed to achieving its short- and long-term climate targets. Making greater use of our renewable energy sources, whether weather-dependent or independent, such as earth heat, is a top priority.

The experience of the energy crisis is that security of supply cannot be built solely on a dominant energy source or technology. This means that we want to cover our energy needs from a broad portfolio. By implementing a diversified technological mix and making more efficient use of domestic alternative energy sources, Hungary is taking steps towards achieving energy independence. To avoid clamping shoes, we are also expanding the domestic green economy.

It is in Hungary's interest to reduce its energy import needs and, at the same time, to ensure its wider connection to the region's electricity and gas networks, which is also a guarantee of security of supply and effective import competition.

Increasing energy efficiency is our priority by using **renewable-based heating/cooling solutions**, reducing the share of natural gas in the district heating sector **and reducing energy use for residential, public, industrial and transport purposes**.

Due to the high efficiency of electric motors, clear end-user energy savings are achieved through **the uptake of electromobility**. The Green Bus Programme for Greening Local Transport will lead to green buses in larger cities.

The **energy independence of families** can be promoted by supporting **home-grown renewable energy production** and by promoting **the uptake of smart meters**.

The government aims to ensure that most of Hungary's electricity production comes from two sources: **nuclear and renewable energy**, mainly solar power plants. These are not technologies which replace or exclude one another, but ones that support each other, and both can be considered clean energy sources. Their efficient operation requires the development of energy storage capacities. Nearly half of Hungary's electricity generation comes from carbon-neutral nuclear energy. With the implementation of the Paks NPP project and the Paks II investment, this ratio can be maintained in the long term. Carbon-neutral energy production without nuclear energy is unthinkable and unfeasible. The use of nuclear energy contributes greatly to Hungary's energy security and independence by providing a clean and practical solution to the challenges of increasing energy demand.

The Government of Hungary is determined to protect our natural heritage and the natural conditions of the way of life we, Hungarians, developed together in this country. It is therefore important for the government to protect the world created, protect the environment and protect against 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 of interventions under current technologies and their cost implications.

Hungary is particularly exposed to the unintended effects of climate change compared to the rest of Europe due to its location inside the continent and the specific microclimate of the Carpathian basin, but in global comparison the consequences of warming are lagging behind the expected changes in other regions of the world, in particular developing regions.

The European Union expects its member countries to have an overall climate-neutral economy by 2050. In the period up to 2035, the **extra investment cost** of the WAM scenario is in the order of **HUF 500 billion per year**. On the other hand, investments reduce operating and quota costs. Thus, **the annual net additional financing needs are HUF 155 billion**[2]. In the view of the Hungarian Government, this objective is achievable for Hungary, but this requires a substantial financial contribution from the European Union. **Hungary attaches particular importance to the implementation of the polluter pays principle:** the costs of decarbonisation should primarily be borne by the countries and companies that are most responsible for the current situation. It is only possible to make concrete commitments for Hungary after **an accurate inventory of assets and costs**. The Hungarian Government therefore adopts a realistic and feasible strategy.

The objectives of economic growth and climate protection are not at odds. Hungary is among the 21 countries in the world where gross domestic product has increased since 1990, while CO2 emissions have fallen by 32 % and energy use by 15 %. Thus, Hungary is not only at the forefront of economic growth and the gross domestic product growth exceeds the average

[2] In the additional cost calculation, we have also calculated the difference between residual values. Thus, if an investment takes place in 2040 and has a life content of 20 years, a residual value is accounted for in proportion to part of the total investment cost, which reduces the investment cost.

GDP growth in the euro area by 2–3 percentage points, but also has an exemplary practice in the field of climate protection.

During the preparation of the NECP, Hungary carried out extensive professional, civil and social consultations to ensure that the plan can be implemented with the support of citizens. The abbreviated version of the revised NECP was open public consultation from 23 June to 7 July 2023. It was also the subject of in-person debate on its draft in a total of six consultation sessions between May and June 2023.

Hungary is a member of the Visegrad Cooperation and the Central and South-Eastern Europe High Level Group on Energy Connectivity (CESEC), where energy and climate policy issues relevant to the NECP are regularly discussed. 3The regional consultation on Member States' Energy and Climate Plans was held in Bratislava on 23 April 2023 with the participation of Czechia, Hungary, Poland and Slovakia. The meeting provided an opportunity to discuss the progress of individual Member States in the preparation of the revised NECPs at regional level, to learn about their draft plans.

In drawing up the NECP and updating this draft, Hungary took into account the current national plans, measures and policies. The design of the draft revised NECP is closely linked to the content and development process of the new National Energy Strategy, updated at the same time as the NECP. The plan is also in line with the policy measures set out in the Second National Climate Change Strategy (NÉS 2) adopted by Parliament in autumn 2018 and its First Climate Change Action Plan (ÉCsT), and with the National Development and Territorial Development Concept, which sets out Hungary's development and territorial development goals by 2030.

With regard to the plan, the Hungarian Government authorised the Ministry of Energy ('the Ministry of Energy') in order to meet the objectives of the Energy Union and to comply with the Paris Agreement. (EM) to develop appropriate policy programmes and visions for issues that require a political decision on the future of the energy sector and other sectors affected by decarbonisation; setting national targets and domestic contributions on energy and climate change, in particular emissions reduction, energy efficiency and increasing the share of renewable energy.

ii. Strategy relating to the five dimensions of the Energy Union

The main objectives of the Hungarian National Energy and Climate Plan are summarised below. **The quantitative objectives are supported by the results of the Hungarian TIMES model**, which also provide the basis for the selection of the most cost-effective policy instruments to achieve the targets.

Decarbonisation dimension

[3] CESEC=Central and South East Eruope Energy Connectivity

GHG emissions and removals4

Hungary **aims to reduce its gross greenhouse gas emissions by at least 50 % by 2030 compared to 1990**, i.e. gross emissions should not exceed 56.19 million t $CO2_{eq}$gross in 2030, i.e. a reduction of 7.6 million t $CO2_{eq}$compared to 2017.

One of the most important decarbonisation tasks is the transformation of the lignite-fired Matra power plant based on low-carbon technologies, thus phasing out coal and lignite from domestic electricity production by 2030 at the latest.

The Mátra power plant is a strategic basic power plant for the domestic electricity system, but also the largest $CO2_{emitter}$ in Hungary, accounting for$_{almost}$50 % of CO2 emissions from the entire energy production sector, which accounts for 14 % of total domestic greenhouse gas emissions. However, the reorganisation of the Mátra power plant goes beyond the technological aspects of the power plant, which must also take into account the socio-economic and environmental impacts of the region of North Hungary affected by the operation of the power plant.

Our plans include the construction of a new gas turbine power plant at the Mátra power plant site, after which coal-based electricity production will be phased out. The power plant is particularly important for the security of supply in the eastern part of the country. In addition, the construction of new photovoltaic power plants and industrial energy storage units, as well as energy recovery of non-recoverable waste (RDF) are planned. The Mátra power plant site and/or the region of North Hungary in which it is located offers a good opportunity to implement low carbon-intensity energy production and energy storage projects to relieve other areas.

- 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 (10000 jobs directly or indirectly linked to the power plant) or local tax revenues. On this basis, the revitalisation should pay particular attention to the diversification of the region's economy and labour market and to a just transition ("Just Transition"), taking advantage of the potential for further use of the site and the power plant value chain.
- In the country, a significant proportion of households affected by residential lignite heating live in the Mátra power plant region. During the revitalisation and transition, we aim to gradually replace residential heating with clean energy and reduce energy consumption.
- The Mátra power plant's large-scale site may be suitable for multi-purpose use beyond energy functions. This includes the expansion and diversification possibilities of the industrial park, the expansion of agricultural or other storage and logistics functions, the

[4] Consistency to be ensured with long-term strategies pursuant to Article 15.

conservation and demonstration of mining cultural heritage, habitat reconstruction for tourism and nature conservation purposes or natural water conservation measures.

It may also be appropriate to use domestic coal assets in the material, e.g. as a raw material in the chemical or construction industry or using so-called clean coal technology, if it can be operated in a cost-effective manner.

The **Effort Sharing Regulation (ESR)** sets national emission reduction targets for Member States for the period 2021-2030 compared to 2005 as a base year. To this end, Member States have set targets ranging from 10 % to 50 % of GDP per capita. The Decree requires Hungary to achieve a 18.7 % reduction.

In December 2022, Parliament adopted Decree 56/2022 on the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant. (XII. In the OGY Decision, it took note, by a large majority, of the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant, 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 a further extension of service can start. Preparatory activities may take between 9 and 10 years based on the experience of the previous extension. In addition, Paks II can already produce two units (with a capacity of 1 200 MW per block) in the next decade, so that the six blocks (if all four units of Paks I. are technically suitable for the extension of the operating time) would already represent a power of 4 400 MW and a huge decarbonisation potential for Hungary. We will also explore the potential for the deployment of small modular reactors (SMRs).[5] Asa result, and with a strong increase in renewable generation capacity for electricity generation, the **share of our carbon-free electricity generation could increase further.**

In the area of transport, we are planning a transport greening **programme**. The primary objective of reducing **agricultural** emissions is the requirement for good agricultural practices and various support instruments. Targets and measures in the field of **waste management** for the period after 2020 will be set out in the upcoming new waste strategy. In order to enhance CO2 absorption capacities**, in line with the National Forest Strategy and taking into account the Do Not Significant Harm principle**, we will significantly increase the share of forest and **other woodland cover** where this does not cause adverse impacts on water, soil strength and biodiversity.

<u>Renewable energy</u>

Hungary would like to achieve a share of at least 29 % of renewable energy sources in gross final consumption of energy.

5All nuclear power plants in operation today are unique products, but the production technology for much smaller SMRs will be standardised. This should allow these series products to be produced at a much lower cost and are expected to be allowed, built and expanded more quickly.

In line with the revised draft Renewable Energy Directive, we increase the share of renewable energy in heating and cooling by 1 percentage point between 2021 and 2025 and at least 1.3 percentage points per year between 2026 and 2030. In addition, the share of renewable energy and waste heat and cold in district heating will be increased by 2.2 percentage points per year.

We see great potential for the use of ambient heat through heat pumps. Hungary has a significant geothermal potential, which we are increasingly exploiting. In**view of the circumstances of our country, the aim is to increase the use of geothermal thermal energy for a wider and wider use**.

The EU Renewable Energy Directive is currently under revision. According to the draft, Hungary should provide one of the following **for transport fuel use**:

- Renewable energy should reach at least 29 % of total energy consumption in the transport sector by 2030;
- a reduction in greenhouse gas intensity of at least 14.5 % in the transport sector should be achieved by 2030.

Hungary sets a target of 29 % renewable energy by 2030. To achieve this target, Hungary will increase the share of so-called first-generation biofuels produced from food and feed crops to almost 4 % by 2030, while the share of waste and second-generation (or advanced) biofuels and biogas is increased to at least 4.5 % and renewable transport fuel of non-biological origin to a minimum of 1 % in final energy consumption in transport.6[7] The remaining part needed to reach the 29 % target will be achieved through a significant increase in the use of electricity and hydrogen for transport in fuel cells.

Renewable electricity generation focuses on the expansion of solar power generation capacity from the current level of about 5.00 MW to nearly 12.000 MW by 2030. The same increase is expected for wind power plants, although the installed capacity is low (from around 330 MW to 1.000 MW).

The transformation of the electricity sector requires promoting the deployment of innovative and smart solutions that provide greater flexibility and unlocking the potential of demand-side measures, which generates significant market organisation, distribution and transmission grid development, human capacity and competence development and regulatory tasks. Their implementation should precede further large-scale integration of weather-dependent renewable producers into the system in order to ensure that system security is sustainable and costs can be controlled.

The METÁR system remains the primary driver of the promotion of electricity production from renewable energy sources. In order to ensure a cost-effective level of support,

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[6] The shares are taken into account taking into account the multipliers in the Renewable Energy Directive
[7] The share of advanced biofuels and renewable fuels of non-biological origin will be increased to 1 % by 2025 and 5.5 % by 2030. (parts are taken into account taking into account the multipliers in the Renewable Energy Directive.

support under METÁR should only be granted on technology neutral renewable capacity tenders.

Energy efficiency dimension

Our main energy efficiency target **is that the country's final energy consumption in 2030 does not exceed 750 PJ. We also set a**target of **336 PJ of cumulative final energy savings by 2030 – a** new saving of 61 PJ over 10 years. **3 % of the floor area of central government buildings will be renovated each** year to the optimal level of cost.

In line with our EU obligations, in 2021 the8 Government adopted the Long-Term Renovation Strategy (HTFS), which provides the basis for achieving a sustainable, energy and cost-effective domestic building stock by 2050 through energy efficiency, value, comfort and health promotion measures, renewable energy use and the use of smart technologies. The strategy aims to achieve a 20 % saving in the energy use of the domestic residential building stock by 2030, a 60 % reduction in $CO2_{emissions}$ related to the energy use of buildings by 2040 compared to the 2018-2020 average, and nearly zero-energy buildings to reach 90 % by 2050.

The aim is also to further improve the **final energy intensity of GDP,** which will fall below HUF 0.429 toe/million by 2030, while maintaining economic growth.

In order to achieve the energy efficiency targets in a cost-effective manner**, we have put in place an obligation regime** to channel investments on a market-based basis to those areas with the highest energy use and energy efficiency potential. Improving the energy efficiency of the economy is one of the priority projects of the new Energy Strategy. The contribution of the EPS to the national energy savings target is 26 %. Alternative energy efficiency policies should account for 74 % of the target. **Therefore, we consider it of utmost importance to continue and renew alternative policy measures to improve energy efficiency**.

Several measures have already been implemented or are still ongoing, in particular the energy efficiency elements of the Otthon Renovation Support, the Production Rescue Programme for the industrial sector, the Modern Cities Programme, the Catching-up Municipalities Programme, the Hungarian Falu Programme, the dissemination of smart cost sharing, the radiator exchange programme, the Family Otthoncreation Grant, the Falusi CSOK and the company tax allowance. These are complemented by 35 policy actions of the Long-Term Renovation Strategy.

Buildings and technologies used by businesses are considered to be the best energy consumption, as energy price developments and market competition have forced them to carry out energy renovations, which has been facilitated by several support schemes. Grants were available to SMEs both from EU funds and from the national budget. In turn, the **Production**

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[8] Directive (EU) 2018/844 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency; and Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

Programmeprovides support for energy efficiency and energy production investments to large energy-intensive companies.

Energy **consumption in public buildings** accounts for almost 10 % of the energy use of the domestic building stock. The Fit for 55 requires savings of 1.9 % per year compared to consumption two years earlier and a proportional energy renovation of 3 % per year for public buildings. In order to achieve this renovation objective, we envisage making use of the possibilities offered by ESCO-type financing and, secondly, by the obligation scheme up to the amount of the own contribution, for which we intend to provide additional investment aid to the public bodies involved in the renovation.

Some 2.6 million homes **require some kind of energy renovation**, which should be facilitated, among other things, by means of financial incentives. In the case of renovations, renewable heating systems should, where possible, be prioritised according to the characteristics of buildings.

Energy security dimension

Hungary’s energy supply continues to be characterised by high exposure to imports. 74 % of our primary energy supply comes from external sources (including nuclear fuel elements)[9]. This ratio is lower than the values of recent years, driven by a decrease in natural gas exposure.

Dependence on foreign markets is mostly characterised by the sourcing of hydrocarbon energy sources, with import dependency exceeding 80 %.

- In terms of oil supply, our import exposure has been mitigated for a long time by the fact that the transport of oil and petroleum products can be provided by rail, tank wagons and barges in addition to pipeline supply. The current **Russian-Ukrainian war situation and its consequences have highlighted the increased risk.**
- The share of natural gas imports is also high. Exposure is still significant despite the substantial increase in cross-border capacity over the last decade. **The need to reduce import exposure is therefore also evident for the supply of natural gas.**

As regardselectricity supply, Hungary’s objective remains to operate an electricity system capable of meeting growing demand while simultaneously ensuring a high level of security of supply, consumer and climate friendly, providing electricity at affordable prices, encouraging market entry of new flexible products and open to innovative solutions. The reduction of electricity import exposure is also apriority. These targets should be met by a faster -than-expected increase in electricity demand in the coming years, and weather-dependent capacities are expected to grow more rapidly. **As a result, the issue of security of electricity supply is even more prominent.**

[9] In all cases, the energy supply exposure was measured by the share of non-domestically produced energy.

One of the keys to strengthening our security of supply is the reduction of the import share and diversification of imports, as well as the availability of a more balanced technological mix based on multiple solutions. **In order to reduce energy exposure and energy import dependency, Hungary focuses on the following measures:**

i. **Reduction of final energy consumption**

ii. **Increase the share** of **alternative sources** of energy to imported natural gas in energy consumption, while using more diversified energy production and sourcing solutions and making better use of domestic natural gas, geothermal, biogas and other renewable sources (e.g. renewable hydrogen, biomethane).

iii. Increase the **capacity of the Adria oil pipeline** towards Croatia, if implemented by the Croatian side, in order to increase security of oil supply.

iv. **Strengthening the electricity system to address the challenges generated by accelerating electrotrification**: focus on nuclear and renewable-based generation, grid development and power digitalisation, widespread use of electricity market regulatory solutions. This is explained in more detail in the following chapter.

v. While the load on the electricity grid will increase over the coming decades, the **use of natural gas infrastructure** will initially be reduced to a greater extent after 2035 and will need to be prepared in advance.

vi. Despite our efforts, our exposure to imports remains high and Hungary intends to reduce risks by strengthening market integration (see chapter on the internal energy market) and developing a **diversified energy supply portfolio**. This requires the development of new independent gas import sources (e.g. Azeri, LNG, gas traded in Romania, Western European markets). Our short-term options are limited due to geographical conditions and depend on the cooperation of neighbouring countries.

vii. The effects indicated above could be mitigated by increasing the country’s **regional gas transit role by building on its existing storage facilities and the almost all-way pipeline network**. For the more distant future**, a regional transit function should also be established in the supply of hydrogen**.

viii. It is also essential to maintain the quality of our security of supply system based on strategic stockpiling.

Internal energy market dimension

Substantial physical natural gas deliveries can be made to Hungary from six neighbouring countries in total more than 144 million m^{3per} day. After 2020, the Croatian-Hungarian cross-border line was redirected, and we booked 1 billion m^3per year at the Croatian Krk LNG terminal. However**, the Hungarian-Slovenian gas interconnection** is still missing, so it is an important task to achieve it. In addition, it is justified to increase the **Romanian-Hungarian cross-border** capacity in order to better integrate the markets due to the transport of gas from Azerbaijan and Romania (Neptun field) to Hungary. Wewill also look at the possibility of transporting additional LNG sources to Hungary.

In the case of the natural gas market, the primary condition for market integration is the physical connection of gas supply systems. It is recommended to connect neighbouring markets with two-way cross-border capacities and similar market sizes, thus increasing competition between players in the interconnected market. The physical conditions for Croatian-Hungarian market coupling are met, as two-way trading is available at the cross-border point.

The Hungarian electricity system is directly connected to all neighbouring countries, already Slovenia. The transmission capacity of cross-border high-voltage lines reaches around 50 % of gross domestic installed capacity, which is significantly higher than the EU target of 15 %. Currently available **transmission capacities** allow for flexible commercial transactions that can be diversified. Despite this,**we** plan to further increase cross-border capacities by increasing the Serbian-Hungarian cross-border capacity (see section on security of supply).

Another important task is to strengthen market integration:

i. The introduction of cross-border auctions in intraday markets is expected to start in 2024, instead of current continuous trading, and flow-based capacity allocation is expected to be introduced in the course of 2025.

ii. In the context of the integration of balancing markets, timely implementation of the[10] connection to PICASSO (Platform for the International Coordination of Automated Frequency Restoration[11] and Stable System Operation) and MARI (Manually Activated Reserves Initiative) is warranted, for which the necessary IT developments are already underway.

The development of **infrastructure, regulatory and market environments to support the integration of renewable energy is of paramount importance in view** of the increase in electricity demand and the spread of electro-electrification. The main tasks in this context are:

i) **Significant cost-effective grid development** is justified in order to integrate renewable energy, which has already started. The electricity grid, in particular the distribution network, should be prepared for the increasing spread of decentralised capacities. Distributors should also be prepared for active system operation.

ii) Construction of **electricity storage capacities** both in the form of integrated elements at the system operator and network licensees (which have already started) and in order to increase balancing capacity. The Government intends to build energy storage facilities in Hungary with a total capacity of around 500-600 MW by 2026,

[10] Mari is an early implementation project concerning the European platform for exchanging balancing energy from EB GL manually activated frequency restoration reserves, which aims to fulfil EB GL requirements as soon as possible.

[11] PICASSO aims to design and further develop an operational platform that collects tenders from all relevant TSOs (TSOs) and allows for the optimal distribution of the market product (energy settlement from frequency restoration reserve with automatic activation, energy balancing from aFRR) to adequately meet the needs of the participating TSOs.

which could increase to 1 GW by 2030. (The limit to achieving this target by the planned target date may be supply-side constraints.)

iii) Transparency**and economic efficiency in the allocation of grid connection capacities should be increased**.

iv) **The introduction of innovative market organisation practices and the strengthening of consumer services.**

v) **Increase the digitalisation of the electricity system.**

vi) **Improve the accuracy of the weather forecast.**

vii) In the meantime, sufficient availability of **power generation capacity should be ensured in a** context of increasing power demand.

   a. in the longer term, weather-dependent and independent renewable technologies, as well as modern nuclear technology that can be safely deployed in the electricity sector, are the backbone of the system.

   b. during the transition, the use of natural gas-based technologies is essential to ensure a continuous and predictable supply of energy, for which a **decision was taken to deploy 1.500 MW CCGT capacity**.

   c. **ensuring security of supply by maintaining spare capacities** in a period of technological change in our country and in the region as a whole.

Energy-sensitive consumers are considered to be those who have difficulties in securing the basic energy needs of the dwelling/building. A detailed definition of belonging to vulnerable consumers is contained in some supporting policy measures designed to mitigate this.

Research, innovation and competitiveness dimension

The implementation of the measures referred to in the existing NECP remains essential, with new areas such as carbon capture technology, clean technology and hydrogen being highlighted.

Key challenges for energy innovation:

i. **To ensure system balance**, we want to encourage the uptake of innovative technologies and modes of operation (e.g. energy storage, demand response).

ii. Incentivising **innovative seasonal electricity and heat storage solutions**, the aim is to facilitate the development of technologies that can store large amounts of energy over a longer period (even months).

iii. **The aim of promoting innovative energy supply modes** is to ensure that electricity generated (from renewable sources) is used locally.

iv. **“Smart regulation”** is designed to provide a positive incentive for distributors to introduce new products and innovative technologies.

v. **By supporting nuclear innovation**, innovative services can be developed in Hungary that improve the competitiveness of nuclear power generation and contribute to the maintenance and expansion of domestic nuclear experience.

vi. **The aim of the transport greening programme** is to reduce the growth rate of GHG emissions in the sector by encouraging the uptake of electric vehicles and car use in the Community, as well as the increased use of biofuels. It is also intended to promote the domestic production of electric and hydrogen-powered vehicles and to support domestic research into the energy use of used car batteries.

vii. **Carbon capture, storage and valorisation technologies** play an important role in the future of industrial processes that are difficult to decarbonise.

viii. The National Hydrogen Strategy adopted in 2021 aims to[12] stimulate the domestic deployment of hydrogen and hydrogen technologies and the creation of a back-up base for the hydrogen industry. With regard to the production of hydrogen, we want to stimulate large-scale industrial demand by leveraging low carbon and small demand through the uptake of decentralised green hydrogen production methods. The use of **green hydrogen** is facilitated if hydrogen is produced by other means than electrolysis, e.g. by biological means.

In order for the energy investments described in the NECP to be feasible, it is essential to **produce some of the green technologies domestically** and to increase the related domestic contractor capacity. This will also increase **competitiveness**for the national economy as a whole, as investments will increasingly focus on the use of green technologies in the future.

It is essential to **have a well-prepared and well-sufficient workforce in the green economy**, which can be achieved through the training of professionals entering and already present in the labour market.

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

The table below summarises Hungary's most important quantified objectives.

1table – Main objectives of Hungary

	NECP in force	**Revised NECP**
GHG emission reduction	40 %	50 %
Final energy consumption	not more than 785 PJ	not more than 750 PJ
Final energy savings		Cumulative savings of 336 PJ

[12] https://kormany.hu/dokumentumtar/magyarorszag-nemzeti-hidrogenstrategiaja

Energy consumption of central government buildings		3 % renovation per year to optimal cost
Share of renewable energy in gross final energy consumption	21 %	29 %
Reduction of non-ETS emissions compared to 2005	almost 7 %	18.7 %
GHG intensity of GDP	continuous reduction of GHG intensity	continuous reduction of GHG intensity
Final energy intensity of GDP	up to HUF 0.429 toe/million	up to HUF 0.429 toe/million
Import Exposure – Natural Gas	80 % (based on import dependency rate)	80 % (share of non-domestic production in total consumption)
Import Exposure – Electricity	20 %	20 %
Electricity interconnection ratio*	min. 60 %	min. 60 %
Number of innovation pilot projects implemented	at least 20	at least 20
Number of international patents registered during the implementation of pilot projects	min. 10	min. 10

1.2. Overview of current policy situation

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

In December 2019, the European Council endorsed the objective of making the EU climate neutral by 2050. The European Climate Law enshrines the EU-wide climate neutrality objective by 2050 and a 55 % reduction in net GHG emissions by 2030. On 15 July 2021, the European Commission published *the Fit for 55 package*, which aims to bring EU legislation in line with the EU-wide net emission reduction target of 55 % by 2030.

In the case of Hungary, the most significant national document in line with the EU's 2030 climate and energy targets and orientations is the new National Energy Strategy (NES) prepared in parallel with the NECP and the Second National Climate Change Strategy (NÉS 2). 13

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

IN ACCORDANCE WITH DECREE NO 23/2018 Pursuant to Parliament's Second National Climate Change Strategy 2018-2030, including a 2050 perspective, a gross GHG emission reduction of between 52 % and 85 % by 2050 compared to 1990, adopted by Parliament, is to be achieved. This strategy includes, in addition to the National Decarbonisation Roadmap, the National Adaptation Strategy (NAS) and the 'Partnership for Climate'

[13]http://doc.hjegy.mhk.hu/20184130000023_1.PDF

Demonstration Plan. In order to implement the goals of the Second National Climate Change Strategy, Climate Action Plans are being prepared for a period of three years. The first Climate Change Action Plan to 2020 aims to define precisely the tasks set out in the short-term action lines of NÉS-2 and prepare longer-term actions. 2023 is due to take place 23/2018 on the Second National Climate Change Strategy. (X. 31.) Assessment of the implementation of the Strategy to date on the basis of the OGY Decision. Depending on the forthcoming evaluation report, it will be decided whether an update of NAP2, including the NAS, will be necessary, which may, by definition, also affect the adaptation objectives set.

The Government adopted the **National Air Load Reduction Programme in 2020**, thus fulfilling its obligation under Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants. The Decision sets targets for industry, agriculture, transport and energy by 2030. The programme will guide the necessary changes in sectoral regulations and subsidies in the coming years in order to reduce emissions from the most important air pollutants. The specific objective of the Programme by 2030 is to:

- is the small particle emissions by 55 per cent,
- emissions of ammonia by 32 per cent,
- emissions of sulphur dioxide by 73 per cent,
- emissions of non-methane volatile organic matter by 58 per cent,
- emissions of nitrogen oxides are reduced by 66 % compared to 2005 levels in the country.

At the beginning of 2020, the **Climate and Nature Action Plan** was announced with 8 action points to preserve Hungary in good environmental condition for our children and grandchildren.

According to the **National Clean Development Strategy**, Hungary will achieve full climate neutrality by 2050 without jeopardising economic growth or prosperity. The strategy presents the potential role of all sectors in achieving the climate neutrality target. Both alternative scenarios of climate neutrality by 2050 examined in the Strategy show that the benefits of decarbonising the economy outweigh the investment costs, so that the Hungarian economy could benefit from the climate neutrality transition through appropriate training and retraining programmes.

Hungary's National Hydrogen Strategy paves the way for building a hydrogen economy, setting out an ambitious but realistic vision, thus contributing to our decarbonisation goals. Hydrogen has a multifaceted use option, with the strategy focusing on industrial and transport uses. The 2030 strategy, with a view to 2050, aims to make significant changes in 5 key areas: on the one hand, it aims to significantly increase carbon-free and low-carbon production methods in the production of hydrogen. On the other hand, the "greening" of industry and transport by "clean" hydrogen is an important task. Hydrogen strategic goals include the development of electricity and natural gas infrastructure to support hydrogen use. In particular, the use of hydrogen as an energy storage medium is a priority. The strategy also considers it necessary to strengthen the activities at the crossroads of industrial trends and domestic strengths, exploiting industrial and economic development opportunities, with a view to increasing competitiveness and promoting domestic uptake.

On the one hand**, the National Battery** Strategy aims to create an environmentally and socially sustainable battery value chain in Hungary that supports the extensive use of carbon-free electricity in order to achieve climate neutrality. On the other hand, the aim is to foster the emergence of a competitive national industry, which will help to increase our economic value production and create new job opportunities.

The **Budapest Agglomeration Railway Strategy** (BAVS) was adopted by Government Decision 1994/2021 of 28 December 2021 and contains an indicative action plan to implement the strategy in the period 2021-2040

The **Long-Term Renovation Strategy**, adopted in 2021, which paves the way for a sustainable, energy 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 CO2 emissions related to the energy use of buildings by 2040 from average levels in 2018-2020, and nearly zero-energy buildings to reach 90 % by 2050.

DECISION NO 62/2022 (XII. The **National Environment Programme** until 2026 was adopted by OGY Decision, which treats both energy efficiency and climate protection as a strategic area:

- 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.

During the current budgetary period of the European Union (EU), several operational programmes will be launched in Hungary to support environmental and climate-related tasks and renewable energy sources, including the Environment and Energy Efficiency Operational Programme Plus.

Hungary's Recovery and Resilience Plan aims in particular to counter the economic and social impact of the coronavirus outbreak and to increase its resilience, sustainability and preparedness for the challenges and opportunities related to the green and digital transitions. The Hungarian plan, finalised in constructive negotiations with the Commission, includes a total of HUF 2.300 billion of strategic development projects by 2026. Out of this, HUF 492 billion is available to support the investments planned under the Energy Component ("Green Transition"). The RePowerEU chapter of the Plan is under negotiation with the European Commission, which could provide significant additional resources to achieve the objectives of the NECP.

iii. Key issues of cross-border relevance

– While Hungary has significant lignite assets in terms of – fossil fuels overall, Hungary is among the less well-served countries, which means that ourenergy supply continues to be characterised by a high exposure to imports. In 2022, 74 % of our primary energy supply came from external sources (including nuclear fuel elements). This ratio is lower than in recent years, driven by the decrease in natural gas exposure experienced last year.

Dependence on foreign markets is mostly characterised by the sourcing of hydrocarbon energy sources, with import dependency exceeding 80 %. Fora long time, our exposure to oil supply has mitigated the fact that the transport of oil and petroleum products can be provided by rail, tank wagons and barges in addition to pipeline supply. However, in view of the current Russian-Ukrainian war situation and its consequences, the risk has increased. It would therefore be necessary to expand the capacity of the Adria pipeline. The exposure to natural gas supply is significant despite the substantial increase in cross-border capacities over the last decade. It is appropriate to establish a link with Slovenia and to further expand the Hungarian-Romanian cross-border point.

As regards the electricity market, it should be noted that due to the integration of the electricity systems in Central Europe, the variable production of German renewable-based power plants has a direct and strong impact on the electricity systems of the other States in the region. This is addressed by interconnecting European electricity markets, which will increase or optimise electricity trade between countries, making it more efficient. With regard to electricity market integration, the following main developments have taken place over the past three years:

- The NTC-based interim coupling project successfully launched a new market coupling. On 17 June 2021, the 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 9 June), the Flow-Based Market Coupling (FBMC) with a single day-ahead time horizon with flow-based capacity calculation was successfully launched.

The Hungarian electricity system's international interconnections and transmission capacities (see for the internal energy market dimension) allow for sufficient, secure and flexible commercial transactions, but further market integration steps are needed in the context of balancing markets (MARI and PICASSO products).

There is also a need to prepare for a secure supply of hydrogen for the further future. If Hungary wants to be active in the European hydrogen backbone and to establish a regional transit function, the basis for this should be laid in the coming years. In order to do so, cooperation with relevant international partners is already needed. It is appropriate to establish a regional transit function.

i. *Administrative structure of implementing national energy and climate policies*

A significant part of the tasks related to the implementation of the plan is the responsibility of the Ministry of Energy and its predecessors. Energy and climate policy planning is integrated in the Ministry. The duties and powers of the Minister for Energy and Climate Policy cover, inter alia, the following areas: mining, energy and climate policy, planning and use of EU funds, sustainable development, waste management, circular economy, environment, water utility sector.

Other autonomous regulatory bodies, institutions and actors involved in the implementation and monitoring of the plan:

- Who is the Institute of Agricultural Economics
- Ministry of Agriculture
- Ministry of Foreign Affairs
- Ministry of Construction and Transport
- Building Quality Control Nonprofit Kft.
- Ministry of Economic Development
- Hungarian Energy and Public Utility Regulatory Authority
- Hungarian Hydrocarbon Stockpiling Association
- Eötvös Loránd Research Network (ELKH) Research Centre for Energy Sciences
- Hungarian Chamber of Engineers
- Prime Minister's Office
- National Research, Development and Innovation Office
- Hungarian Atomic Energy Authority
- Hungarian Meteorological Service
- Ministry of Finance

- Supervisory Authority for Regulated Activities.

1.3. Consultations and involvement of national and Union entities and their outcome

i. *Involvement of the national parliament*

The draft NECP was not discussed in Parliament's plenary session, but the draft was discussed by the Parliament's Sustainable Development Committee.

ii. *Involvement of local and regional authorities*

The involvement of local and regional authorities in the development of the NECP is planned for the second half of 2023, the first half of 2024.

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

The draft NECP was discussed by the National Environment Council in May 2023. The OKT is the government's advisory, proposing or consulting body in the preparation of decisions containing environmental policy and resulting in a national or regional impact. The Council is composed of three equal groups: environmental organisations; trade and economic interest representatives; academic representatives appointed by the President of the Hungarian Academy of Sciences.

An open public consultation on the draft NECP took place between 23 June and 7 July 2023, where an abbreviated version of the draft was consulted online. A total of 6 in-person debates took place between May and June 2023. Environmental NGOs, business associations and industry stakeholders participated in the events. The discussions took place in two rounds, first in May 2023 and then in parallel to the open social consultation. The participants were able to submit their comments and suggestions in writing.

iv. *Consultation of other Member States*

Hungary is a member of the Visegrad Cooperation and the Central and South-Eastern Europe High Level Group on Energy Connectivity (CESEC), where energy and climate policy issues relevant to the NECP are regularly discussed. 14

The High Level Group on Energy Connectivity in Central and South-Eastern Europe (CESEC), set up in 2015, brings together 9 EU Member States and 8 other countries, to accelerate the integration of electricity and gas markets in the region.

Visegrad Cooperation is a regional organisation of Czechia, Hungary, Poland and Slovakia. The purpose of cooperation shall be to jointly represent the economic, diplomatic and political interests of these Central European countries and to coordinate their possible actions.

The regional consultation on Member States' energy and climate plans was held in Bratislava on 23 April 2023 with the participation of Czechia, Hungary, Poland and Slovakia. The meeting provided an opportunity to discuss the progress of each Member State in the preparation of the NECP at regional level to learn about the Member States' draft plans.

v. *Iterative process with the Commission*

The procedure takes place after the draft NECP has been submitted in accordance with the rules of procedure laid down.

1.4. **Regional cooperation in preparing the plan**

i. *Elements subject to joint or coordinated planning with other Member States15*

[14] CESEC=Central and South East Eruope Energy Connectivity
[15] More detailed for each dimension in the relevant sections of Chapter 3.

The NECP was consulted as described in point 1.3.iv.

ii. Explanation of how regional cooperation is considered in the plan

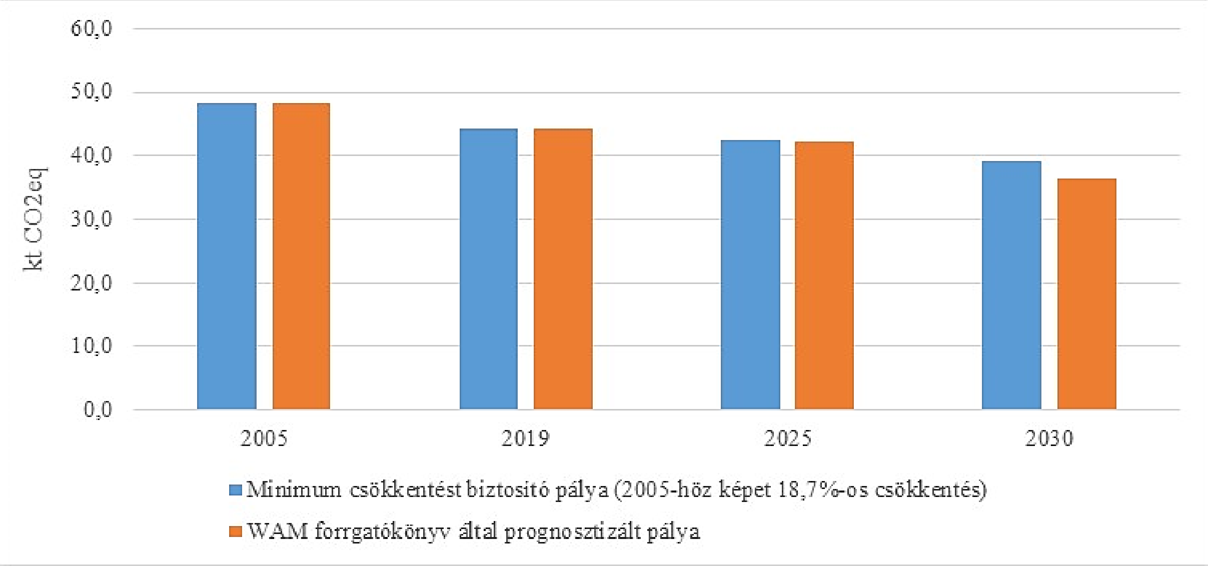
2. GOALS AND OBJECTIVES

2.1. Decarbonisation dimension

2.1.1. GHG emissions and removals16

i. The elements set out in point (a)(1) of Article 4

The **Effort Sharing Regulation (ESR)** sets national emission reduction targets for[17] Member States up to 2030 compared to 2005 as a base year. According to the Decree, Hungary must achieve a **reduction of at least 18.7 %**. I.e. reduce emissions from 47.8 million tonnes of CO2 eq to 38.9 million tonnes of CO2 eq.



1figure – GHG emissions in the ESS sector, million tonnes of CO2eq/year

Factual information: Eurostat

Regulation (EU) 2018/841[18]requires each Member State to ensure that emissions do not exceed removals for the periods from 2021 to 2025 and from 2026 to 2030. Emissions and removals shall mean the quantities determined as the sum of total emissions and total removals on the territory of a Member State in any of the land accounting categories referred to in Article 2 and accounted for jointly in accordance with this Regulation.

ii. Where applicable, other national objectives and targets consistent with the Paris Agreement and the existing long-term strategies. Where applicable for the contribution to the overall Union commitment of reducing the GHG emissions, other objectives and targets, including sector targets and adaptation goals, if available

[16] Consistency to be ensured with long-term strategies pursuant to Article 15.
[17] Regulation (EU) 2018/842 (https://eur-lex.europa.eu/legal-content/HU/TXT/?uri=celex%3A32018R1999)
[18] https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:32018R0841#d1e477-1-1

In December 2019, the European Council endorsed the objective of making the EU climate neutral by 2050 and reducing net GHG emissions by 55 % by 2030. On 15 July 2021, the European Commission published the Fit for 55 package, which aims to bring EU legislation in line with the EU-wide net emission reduction target of 55 % by 2030.

Hungary's greenhouse gas emission reduction targets are in line with EU and international commitments. **Hungary has set the objective of achieving climate neutrality by 2050**, which Hungary confirmed in Act XLIV of 2020 on climate protection. The path towards climate neutrality is described in the National Clean Development Strategy.[19]

The objective of this document is to reduce gross greenhouse gas emissions by at least 50 % by 2030 compared to 1990. This means that emissions in 2030 should not exceed a gross 47.5 million t CO_2e, i.e. a reduction of 16.7 million t CO2$_{in}$2021 is required.

It is also intended to further reduce the GHG intensity of the Hungarian economy(i.e. GHG emissions that generate per unit GDP).

In addition to reducing greenhouse gas emissions and improving GHG intensity, it is **also a priority for Hungary to promote adaptation to the impacts of climate change**. At international level, the Paris Agreement sets out the global goal of [20]adaptation and the objective of balance between mitigation and adaptation measures. In the EU context, the **"EU Strategy on Adaptation to Climate Change** ***(EU Adaptation Strategy)" adopted by the European Commission in April 2013 is a guiding document for Member States'*** adaptation policies.

Currently adopted in Hungary, the valid adaptation policy is the Module of the Second National Climate Change Strategy 2018-2030 (NÉS-2) National Adaptation Strategy (NAS), which provides an adaptation vision and comprehensive and specific (strategic) targets for domestic climate adaptation (6). It also sets out short, medium and long-term lines of action, broken down by sector, in the fields of human health, water management, disaster management, agriculture, forestry, nature conservation, energy infrastructure, urban development and tourism. 2023 is due to take place 23/2018 on the Second National Climate Change Strategy. (X. 31.) Assessment of the implementation of the Strategy to date on the basis of the OGY Decision. Depending on the forthcoming evaluation report, it will be decided whether an update of NAP2, including the NAS, will be necessary, which may, by definition, also affect the adaptation objectives set.

2.1.2. Renewable energy

i. The elements set out in point (a)(2) of Article 4

[19]https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en

[20] Paris Agreement Article 2.1(b)

Increase the share of renewables to at least 29 % by 2030 as a share of gross final energy consumption.21

Electricity

According to our calculations, the share of renewable energy production in electricity consumption could reach 31 % by 2030. **Taking into account**domestic circumstances and needs as well as future regional capacity policy, **our renewable electricity generation** focuses on the expansion of solar power generation.

The current version of the NECP assumes 6 GW of solar panel capacity by 2030, with the WAM scenario increasing PV capacities from the current around 5 GW to nearly 12 GW by 2030. A similar increase is expected for wind power plants, although the installed capacity is low (from around 330 MW to 1.000 MW).

Heating and cooling

In line with the revised draft Renewable Energy Directive, we increase the share of renewable energy in heating and cooling by 1 percentage point between 2021 and 2025 and at least 1.3 percentage points per year between 2026 and 2030. In addition, the share of renewable energy, residual heat and waste cooling in district heating will be increased by 2.2 percentage points per year.

We see great potential for the use of ambient heat through heat pumps. Hungary has a significant geothermal potential, which we are increasingly exploiting. In**view of the circumstances of our country, the goal is to increase the use of geothermal thermal energy for a wider and wider use of geothermal energy in the 2030 horizon**.

Transport

The Renewable Energy Directive is currently under revision and Hungary chooses to achieve at least 29 % of total energy consumption in the transport sector by 2030. To achievethis target, Hungary will increase the share of so-called first-generation biofuels produced from food and feed crops to almost 4 % by 2030, while the share of waste and second-generation (or advanced) biofuels and biogas is increased to at least 4.5 % and renewable transport fuel of non-biological origin to a minimum of 1 % in final energy consumption in transport.22[23] The remaining part needed to reach the 29 % target will be achieved through a significant increase in the use of electricity and hydrogen for transport in fuel cells.

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[21]Padditional renewable energy capacity building can be achieved at increasing costs. Our current estimates show that the specific support needs for domestic renewable energy use increase significantly above a 20 % share of renewable energy. (Source: REKK (2018): Estimate of the cost of reaching the renewable energy share in 2030 https://rekk.hu/downloads/projects/2019_REKK_NEKT_megujulo_final.pdf)

[22] The shares are taken into account taking into account the multipliers in the Renewable Energy Directive

[23] The share of advanced biofuels and renewable fuels of non-biological origin will be increased to 1 % by 2025 and 5.5 % by 2030. (parts are taken into account taking into account the multipliers in the Renewable Energy Directive.

ii. estimated trajectories for the sectoral share of renewable energy in final energy consumption from 2021 to 2030 in the electricity, heating and cooling, and transport sector

2table – Estimated national trajectory for the sectorial share of renewable energy in gross final energy consumption 2021-2030 (%)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RES	13,7	15,2**	18,5	21,8	23,9	25,4	26,9	28,3	29,8	31,2
RES-H&C	17,19	19,7***	22,3	24,8	26,0	27,1	28,2	29,3	30,4	31,5
RES-T (with multiplier)	6,2	7,1***	8	9	9,3	13,4	17,6	21,7	25,9	30,0

*Fact (MEKH)
**Preliminary MEKH data
***estimated 2022 values
Projects from 2023 onwards

iii. Estimated trajectories per renewable energy technology planned to be used by Member States to achieve overall and sectorial trajectories for renewable energy between 2021 and 2030, including expected gross final consumption of energy by technology and sector, in Mtoe/ktoe, and total planned installed capacity (divided between new capacity and repowering), broken down by technology and sector, in MW.

The following tables provide information on this issue.

3table – Use of renewable energy sources in each sector 2021-2030 (ktoe)

	2021*	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	574	674	773	873	972	1 064	1 157	1 249	1 342	1 434
Cooling and heating	1928	2 099	2 271	2 442	2 613	2 707	2 802	2 896	2 991	3 086
Transport**	308	309,25	310,5	311,75	313	408	503	598	693	788

*factual
** no multiplier

4table – Renewable electricity consumption by technology (electricity consumption: ktoe)

Production of renewable energy (ktoe)	2021*	2022**	2023	2024	2025	2026	2027	2028	2029	2030
Solid biomass	153	146	144	136	128	102	77	51	26	—
Waste	14	11	23	22	21	19	16	13	11	8
Biogas	25	27	14	10	5	10	14	19	23	28
PV	326	403	472	562	652	749	845	942	1 038	1 135
Wind	57	52	102	114	127	143	160	176	192	209
Other	52	43	32	35	39	42	45	48	51	55
Total	603	695	787	880	972	1 064	1 157	1 249	1 342	1 434

*MEKH factual information

**MEKH provisional data

5table 1 – Renewable electricity generation capacities by technology (built-in capacity, MW)

Renewable electricity generation capacity (MW)	2021*	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass	438	409	381	352	323	277	231	184	138	91
Biogas	85	95	105	114	124	124	124	124	124	124
PV	2 968	3 950	4 933	5 915	6 897	7 918	8 938	9 959	10 979	12 000
Wind	324	407	490	572	655	740	825	910	995	1 080
Other	63	69	74	80	85	90	95	100	105	110
Total	4 047	5 056	6 066	7 075	8 084	9 149	10 213	11 277	12 341	13 405

*Eurostat fact data

6table 1 – Use of renewable energy sources in cooling and heating (ktoe)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biogas	9	10	10	10	10	26	41	56	71	87
Solid biomass	1 683	1 782	1 881	1 979	2 078	2 115	2 153	2 190	2 227	2 265
Geothermal	124	148	173	198	223	237	251	264	278	292
Solar	13	12	12	12	11	11	10	10	9	8
Waste	144	151	158	165	172	174	176	177	179	181
Heat pump	79	89	99	108	118	145	172	199	226	253

7table 1 – Renewable energy consumption in transport by fuel excluding multipliers (ktoe)

	2021*	2022	2023	2024	2025	2026	2027	2028	2029	2030
Used cooking oil	10	15,5	21	26,5	32	35,5	39,1	42,6	46,2	49,7
First generation biodiesel	193	184,75	176,5	168,25	160	169	177	186	194	203
First generation bioethanol	84	82	80	78	76	75	74	72	71	70
2nd generation biofuel	15	22,5	30	37,5	45	114	183	252	321	390
Renewable basis for road electricity	7	9,25	11,5	13,75	16	32	48	65	81	97
Renewable fund railway electricity	99	102,5	106	109,5	113	117	122	126	130	134
Renewable-based hydrogen	0	0	0	0	0	5	23	41	59	78
Total (without mul.)	408	330	333	336	340	429	519	608	697	788

*fact (MEKH)

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

Demand

In 2021, primary bioenergy consumption amounted to 2715 ktoe. At the same time, final energy consumption was 2279 ktoe (EUROSTAT), two thirds of which were used by households.

According to our calculations, the use of bioenergy could increase sharply if additional measures were taken into account. Most of the increase comes from the production of heat. By contrast, residential biomass use will be significantly reduced by 30 % by 2030. The use of bioenergy peaks in the 2030s, after which it is on a mild downward path.

8table 1 – Bioenergy use in three key areas (ktoe)

Bioenergy consumption (ktoe)	2021*	2025	2030
Electricity	204	131	29
Cooling-heating	1911	2089	2352
Transport	292	313	712

*facts (Eurostat)

Supply

In our country's forests, potential uses of the forests taking into account the sustainability criteria are determined within the framework of forest planning (except for forests under free disposal). The majority of state forests are managed by state-owned forest companies under the ownership rights of the Ministry of Agriculture. Determining the annual logging volume of state forest holdings is an ecological issue. The planning of logging activities which are in accordance with the objectives of forest maintenance and silviculture, and which acquire the necessary resources therefore and ensure the sustainability of forest management takes place in multiple stages. The ten-year forest plans form the basis thereof, based on which three-year strategic plans and annual plans are developed.

On the basis of more than ten years of the National Forest Programme, farming in small-scale areas remains the main problem of private forest management. This will, on the one hand, reduce the efficiency of management and forest protection and, on the other hand, significantly increase the administrative burden. According to the National Forest Strategy, the regulatory environment and other state measures should achieve the proper integration and, as far as possible, improvement of the fragmented farming structure. Appropriate regulation of associated forest management can contribute to this. 24

In neighbouring countries, climate change has already – caused – unprecedented damage to forests, which disrupts the planned course of forest management. Although the measures already being introduced in the management of deciduous tree stocks and forest management, as well as in forestry businesses, contribute to the prevention of greater forest damage, the occurrence of such damage cannot be ruled out,which (due to the necessary harvest of dead trees) may result in a temporary, sharp increase in the availability of wood biomass, and then a decrease in the availability thereof.

[24] National Forest Strategy 2016-2030. Prepared by the Department of Forestry and Wildlife Management of the Ministry of Agriculture. September 2016 (https://www.kormany.hu/download/a/1a/d0000/Nemzeti_Erd%C5%91strat%C3%A9gia.pdf)

9table 1 – Perspective annual development of afforestation by type of tree stand (hectare)

			WEM scenario[25] (ha)			
Types of flocks	**2017**	**2021**	**2022**	**2025**	**2027**	**2030**
Oak	133	600	600	600	600	600
Chers and other hard foliage	53	300	300	300	300	300
Beech	0					
Acacia	464	1 000	1 000	1 000	1 000	1 000
Noble summers and white cane	95	100	100	100	100	100
Domestic summers and other soft foliage	106	500	500	500	500	500
Pine	4					
Black pine	1					
Spruce and other pines	0					
Total	855	2 500	2 500	2 500	2 500	2 500
			WAM scenario [26] **(ha)**			
Oak	133	600	600	800	900	900
Chers and other hard foliage	53	300	300	300	300	400
Beech	0					
Acacia	464	1 000	1 000	1 400	1 400	1 400
Noble summers and white cane	95	100	100	300	300	300
Domestic summers and other soft foliage	106	500	500	800	800	800
Pine	4					
Black pine	1					
Spruce and other pines	0					
Total	855	2 500	2 500	3 600	3 700	3 800

10table 1 – Projection of the future net carbon balance of existing forests

Script		**2017**	**2021**	**2022**	**2025**	**2027**	**2030**
Forest Reference Level (FRL*)	logging (m^3/year)	8 214 933	8 407 166	8 533 025	8 901 248	9 094 494	9 462 459
	net carbon balance (kt CO_2)	—2 210 405	—1 744 639	—1 513 178	—902 025	—514 890	207 142
Increased logging **	logging (m^3/year)	7 519 615	7 861 951	7 971 424	8 244 473	8 462 816	8 754 144
	net carbon balance (kt CO_2)	—3 145 222	—2 460 281	—2 240 596	—1 750 015	—1 403 683	—814 878
Low level logging ***	logging (m^3/year)	7 519 615	7 295 296	7 310 638	7 300 791	7 330 677	7 339 032
	net carbon balance (kt CO_2)	—3 145 222	—3 120 377	—3 002 615	—2 811 168	—2 653 964	—2 327 608

*: FRL: forest Reference under the so-called LULUCF Regulation, subject to forest harvesting assumptions
**: Increased logging: a scenario of increased logging compared to current levels

[25] WEM=with existing measures
[26] Additional measures scenario (WAM=with additional measures)

***: Low level logging: approx. logging at the current level of logging)

11table 1 – Perspective evolution of cylindrical wood plantations for industrial purposes (hectare)

Tree species	2021	2022	2025	2027	2030
WEM scenario					
Acacia	500	500	500	500	500
Poplar	500	500	500	500	500
Total	1 000	1 000	1 000	1 000	1 000
WAM scenario					
Acacia	750	750	750	750	750
Poplar	750	750	750	750	750
Total	1 500	1 500	1 500	1 500	1 500

v. Where relevant, 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, energy communities and prosumers, energy recovered from sludge from wastewater treatment);

With the increased use of residential solar panels, more and more consumers are able to generate power for themselves, which – in addition to providing the possibility of even more active market participation in the conscious regulation of consumption – ensures the strengthening of energy independence at household level. **Increasing self-generation based on renewable sources by individual consumers (be they citizens or businesses) remains an objective**, thereby reducing the load on the electricity grid. This objective also includes replacing the use of pipeline gas with the use of earth heat, ambient heat or biogas.

In parallel to the expansion of decentralised generation based on locally available renewable resources**, publicity initiatives should be promoted to ensure that electricity is consumed locally by the local community.** In this area, the **priority** is to encourage and support the development of energy communities. With regard to **district heating**, the aim is that, in the longer term, the majority of domestic district heating, 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 under the category of 27 'efficient district heating and cooling' under the relevant EU Directive, which can significantly reduce energy consumption and greenhouse gas emissions associated with buildings. Efficiency within the meaning of the Directive requires district heating and cooling using at least 50 % renewable energy, 50 % residual heat, 75 % cogenerated heat or 50 % by a combination of such energy sources.

[27] Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

Exploiting the potential of gases produced from renewable sources is also a goal. Biogas, biomethane and hydrogen produced on a non-fossil basis, as well as synthetic gases, can also be important players in energy independence. The production of renewable gases can complement weather-dependent energy production and electrotrification. They also have the advantage that they are typically produced in decentralised systems, thus reducing the pressure on national networks and enabling active local participation.

The Hungarian Government adopted its National Hydrogen Strategy in 2021. The strategy aims to produce 36 thousand tonnes of carbon-free and 16 thousand tonnes of low-carbon hydrogen by 2030. The strategy envisages the installation of 240 MW of water dismantling capacity for renewable hydrogen production. The draft Renewable Directive is significantly more renewable hydrogen (more precisely renewable fuels of non-biological origin, un. RFNBO) for 2030, partly covered by imports.

On the demand side, the strategy focuses on transport segments that are difficult to decarbonise and industry (primarily, but not exclusively, industries that already use grey hydrogen). More than half of the carbon-free or low-carbon hydrogen used can be used in industry (ammonia, oil-feinomy, possibly steel), but specific targets have also been set for the decarbonisation of the transport sector. The target is that in 2030, 4800 fuel cell vehicles (mainly buses and freight vehicles) will run on Hungarian roads.

2.2. Dimension energy efficiency

i. The elements set out in point (b) of Article 4

Our main energy efficiency target is that the country's final energy consumption (calculated in Europe 2020- **2030) does not exceed 750 PJ in 2030.** This also means reducing our final energy consumption by around 6 % by 2030 compared to 2021 (802 PJ).

By definition, reducing energy use is a priority. However, in the event of economic growth, the use of energy in industry and transport cannot be limited. Our goal is to increase GDP growth beyond the increase in energy use and to further improve the final energy intensity of GDP, falling below HUF 0.429 toe/million by 2030.

Eurostat has developed the indicator of final energy consumption for 2020–2030 in order to calculate energy efficiency targets of the Member States according to the same methodological basis and to make them comparable to the previous planning period. According to this, the cumulative end-use energy savings obligation for the period from 2021 to end-2030 can be achieved by setting new savings of 10 PJ per year, assuming a steady annual saving of 0.8 % and life-cycle policy measures without – them, without reduction possibilities.

Achieving the energy savings target 28 laid down in the EED Directive poses a serious challenge in every area. Energy efficiency programmes and measures introduced in the 2014-

[28] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

2020 period will result in final energy savings of around 3-4 PJ per year for end-users. The ongoing revision of the Energy Efficiency Directive is expected to further increase savings obligations.

ii. Milestones without commitments for the years 2030, 2040 and 2050, measurable result indicators developed at national level, and their contribution to the energy efficiency targets of the European Union, as set out in the roadmaps specified in the long-term strategies for the renovation of the national stock of privately and publicly owned residential and non-residential buildings, in line with Article 2a of Directive 2010/31/EU

In line with our EU obligations, in 2021 the29 Government prepared the Long-Term Renovation Strategy (HTFS), which provides the basis for achieving a sustainable, energy and cost-effective domestic building stock by 2050 through energy efficiency, value, comfort and health promotion measures, renewable energy use and the use of smart technologies. The strategy, comprising 35 policy measures, aims to achieve 20 % savings in the energy use of the domestic residential building stock by 2030.

According to the draft revised Building Energy Directive (EPBD), the HTFS will be replaced by the so-called National Building Renovation Plan, which will be a revised version of the HTFS and aims to reflect higher ambitions while giving Member States the flexibility needed to take into account the differences in the building stock across Europe.

According to the current National Building Energy Strategy (NÉeS), around 42 % of primary energy use in Hungary takes place in buildings, of which residential buildings account for the largest share.30 In terms of final energy consumption, according to31 Eurostat data, the share of the residential sector in energy consumption is estimated at around 35 %, most of which is the energy use of buildings.

32According to MEKH's data on energy use by households, three quarters of the energy consumption of Hungarian households is used for heating, which is predominantly ensured on the basis of natural gas (almost half of the national gas consumption is residential). The other two major areas of energy use are the production of domestic hot water and the use of lighting and electrical equipment (shared in one tenth to one tenth). **With the modernisation of the residential building stock to improve energy efficiency and the shift to alternative heating**

[29] Directive (EU) 2018/844 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency; and Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.
[30] National Building Energy Strategy 2015, page 24
https://www.kormany.hu/download/d/85/40000/Nemzeti%20E%CC%81pu%CC%88letenergetikai%20Strate%CC%81gia%20150225.pdf
[31] https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[32] http://mekh.hu/download/5/13/90000/8_1_Haztartasok_felhasznalasa_eves.xlsx

methods, we estimate that up to a quarter of natural gas imports (around ~2 billion m^3 natural gas use per year) could be replaced.

Energy consumption in public buildings accounts for almost 10 % of the energy use of the domestic building stock. The Fit for 55 requires savings of 1.9 % per year compared to consumption two years earlier and a proportional energy renovation of 3 % per year for public buildings. In order to achieve this renovation goal, we envisage making use of the possibilities offered by ESCO-type funding and, secondly, from the obligation scheme up to the amount of the own contribution.

Energy modernisation of housing should be facilitated, among other things, by means of predictable financial incentives and technical assistance. Investment should be directed towards complex energy upgrades. In the case of renovations, renewable heating systems should, where possible, be prioritised according to the characteristics of buildings.

Deep renovation of the floor area of the central government building stock by 3 % per year is also a strategic goal. Energy consumption in public buildings accounts for almost 10 % of the energy consumption of domestic buildings (33.5 PJ/year in 2020, of which close to 26.5 PJ are electricity consumption (6 PJ), natural gas (14 PJ) and district heating (6.5 PJ).

The Fit for 55 programme extends the target for central government buildings to all public buildings and provides for annual savings of 1.9 % compared to consumption two years earlier, as well as 3 % annual renovation to nearly zero energy in public buildings. As there is no regional government in Hungary, the basis for the two obligations is essentially the same. The two targets should also be met separately. Based on the state of the Hungarian public building stock, the cost can be saved by optimal renovation of 20 % by 2030, which assumes 6.6 PJ/10 years of new savings based on a linear trajectory. Fit for 55 aims to achieve nearly zero energy use in public buildings, which requires a new saving of approximately 14,615/10 years PJ over 10 years. These cumulative savings of approximately 80 PJ correspond to the savings of 88 PJ expected from the energy efficiency obligation scheme.

iii. Where applicable, other national objectives, including long-term targets or strategies and sectoral targets, and national objectives in areas such as energy efficiency in the transport sector and with regard to heating and cooling

Sustainable and climate-friendly energy management is a priority in addition to preserving and further expanding industrial performance. The competitiveness of energy- and GHG-intensive industrial activities depends on their ability to produce up to the level of specific energy and GHG emissions of European industrial competitors.

With regard to energy use for transport, the priority is to reduce consumption by reducing fossil fuel consumption. In order to reduce the use of energy in transport, it is a priority to develop and increase the use of public transport; furthermore, freight transport by rail should be a realistic option. Due to the high efficiency of the electric power train, clear end-use energy savings are achieved through the uptake of electromobility. Thanks to the Green Bus programme for the greening of local transport, by 2030, only environmentally friendly buses will be used for local public transport.

The targets for district heating are described in Chapter 2.1.2.

2.3. Dimension energy security

i. The elements set out in point (c) of Article 4

The Hungarian Government continues to consider **strengthening energy independence as its main task, and** we want to increase our self-sufficiency**.**

Although we have done more than all governments to diversify since 2010, the high share of imports in Hungary's energy supply remains dominated by the high share of imports (chapter 4.4) and this may entail security of supplyand price risks (the latter as a consequence of recent geopolitical developments). We must therefore continue to work on **strengthening energy independence, reducing import dependency** and developing a **more diversified supply portfolio. In reducing its dependence on energy imports and strengthening geopolitical independence,**Hungary puts emphasis on **increasing energy efficiency** (Chapter 2.2), **sustainable utilisation of domestic hydrocarbon and renewable resources** (Chapter 2.1.2), **maintaining at least nuclear capacities** and **strengthening market integration.**

Supply of petroleum and natural gas

The Hungarian economy is highly dependent on oil and gas. This dependency is accompanied by an import exposure (see section 4.4). The import exposure targets for our oil and natural gas supply are shown in the table below. In the current NECP, the exposure is illustrated by the import dependency rate published by Eurostat. In the review, the import exposure is measured by "the share of non-domestically produced energy consumption", which better reflects the reality.

12table – Exposure of Eneriga Supply

Objective	**Indicator**	**Indicator value 2019**	**Indicator value 2022**	**Indicator target – 2030**
Reducing exposure to oil supply	Non-domestically produced crude oil, %	85	86	up to 85
Reduction of natural gas supply exposure	Share of non-domestic natural gas, %	84	85	80
Infrastructure compliance	N-1 value, % (100 % storage capacity – including UA cross-border)	142	176	keep indicator value higher than 120 %

Despite the exposure, the NECP developed in 2018-2019 did not take into account any serious risks in oil supply due to an efficient global and regional oil market, the existence of transport alternatives (pipeline or rail/road), alternative pipeline supply options (Barátság and

Adria pipelines) and the oil emergency stockpiling system. **However, in the changed geopolitical context, more emphasis should also be placed on the security of oil supply.** Maintaining import dependency at a manageable level remains justified. In addition, the **aim is to further diversify**our oil supplies,**thereby** avoiding the risk of exposure to the Russian supplier.

The share of natural gas imports is also high (Chapter 4.4). Exposure is significant despite the substantial increase in cross-border capacities over the last decade. In recent years, domestic natural gas production has covered around 15 % of consumption, the rest being imported by the country. **The need to reduce import exposure is therefore also evident in the case of natural gas.**

One of the challenges ahead is to increase **domestic extraction** as far as possible. **If research into new**conventional natural gas deposits is successful, and if non-conventional natural gas inputs are successfully brought into production, domestic production could increase to 1.8-2 bcm per year by 2030. In addition, natural gas demand should be reduced by using alternative sources of energy (e.g. biogas).

Reducing energy consumption, **including natural gas consumption (Chapter 2.2), through investments in energy efficiency and the use of renewable technologies, contributes to reducing the import exposure of natural** gas. The population is an important target group. The share of natural gas in district heating production could be reduced to 50 % by effectively exploiting the potential of alternative sources.

The remaining import demand can still be significant and should be ensured from the most diversified source and route as possible, reducing dependence on one source and partner. It is also necessary to ensure the availability of additional resources to further strengthen flexibility. In addition to increasing the flexibility of the Hungarian gas sector, this strengthens security of supply by ensuring a more affordable gas price for Hungary and Hungarian consumers by creating a better bargaining power in international gas markets.

One of the objectives set for the security of gas supply should be the continued[33] compliance with the 'N-1' rule, which can guarantee the security of gas supply and the availability of natural gas, even in the event of the loss of the largest feed-in source. In this respect, the objective is to ensure that the value of the indicator always reaches a minimum of 120 %.

In the event of a large-scale reduction in natural gas consumption or in the volume of natural gas distributed on the network, infrastructure may also need to be rationalised.

Electricity market

[33] The N – 1 formula describes the ability of the technical capacity of the gas infrastructure to satisfy total gas demand in the calculated area in the event of disruption of the single largest gas infrastructure during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years.

Hungary's objective remains to operate an electricity system capable of meeting growing needs, while simultaneously ensuring a high level of security of supply, consumer and climate friendly, providing electricity at affordable prices, encouraging the entry of new flexible products into the market and open to innovative solutions. It is also a priority to reduce the import exposure of electricity.

These targets should be met by increasing demand for electricity more rapidly in the coming years and weather-dependent capacities are expected to grow more rapidly. **As a result, the issue of electricity security of supply is even more prominent.**

13table -: Share of import exposure in electricity supply

Objective	Indicator	Indicator value 2019	Indicator value 2022	Indicator target – 2030
Exposure to electricity supply	Share of electricity produced in a non-domestic power plant	30	28	20

Source. MEKH

Main electricity market objectives in more detail:

i) Targets for capacity adequacy and reduction of import dependency:

- ***Ensuring reliable, flexible and diversified domestic capacities:***
  - In order 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 stationary and incoming power plants and expanding cross-border capacities.
  - It is essential that the domestic electricity system **has controllable capacities to guarantee safe operation (e.g. baseload generation) and balancing** (e.g. generation capacities providing flexibility, new types of flexibility services, DSR solutions, energy storage).
  - It is important to **have sufficient domestic reserve production capacity** to deal with extreme market situations.
  - As a matter of principle, **import capacities allowing flexibility and room for manoeuvre for the Hungarian electricity system should also be available** (if possible from as many directions as possible).
- As regards capacity adequacy**, the aim is to further decarbonise and diversify the electricity mix**. In addition to renewable capacities, nuclear power plants with low CO2 emissions should also be built on.

ii) Creating a regulatory and market environment for infrastructure supporting the integration ofrenewables (energy storages, fast start-up natural gas power plants), exploiting the additional potential of aggregators entering the market and, in line with this, making the integration of renewable investments a cost-effective priority.

iii) The electricity grid needs to be preparedfor the increasing spread of decentralised capacities. In addition to large power plants and energy systems based on centralised management, distributed household-scale small power plants (HMKEs) are growing rapidly. This also poses challenges to energy networks, which need to be adequately addressed.

iv) The aim is to reduce the import exposure of electricity.

v) Ensuring security of supply by maintaining reserve capacities: In order to ensure domestic security of supply, it is appropriate to maintain overcapacity that can contribute to domestic electricity production in critical situations, e.g. during winter days with peak demand, or where the availability of imports is limited due to technical reasons.

vi) Strengthening regional electricity and gas market integration, better coordination and interconnection of the functioning of the gas and electricity markets will further strengthen the country's security of supply.

Carbon market

The share of coal in domestic electricity generation decreased significantly. Today, only one large coal-fired power plant, the Mátra power plant, is operating in Hungary and is currently producing lignite in Visonta and Bükkábrány. As the second largest electricity producer in thecountry, the power plant accounts for around 10-15 % of total domestic electricity production.

The **Mátra power plant is an important actor not only in terms of energy production but also in terms of employment:** in the eastern part of the country, the only operating large power plant, as well as a significant regional employer, given that a significant part of the population of the districts concerned (Göngyösi and Mezkövesdi) works directly or indirectly in this industry or in related enterprises (10000 jobs directly or indirectly linked to the power plant; the number of family members concerned is at least 27000). At the same time, the plant is also the country's largest carbon dioxide (CO_2) emitter, accounting for **almost50 % of CO2 emissions from the entire energy sector and 14%of total domestic CO2 emissions.** The power plant and the household heating with approximately 15-20 thousand lignite in the area also contributes significantly to the concentration of other air pollutants: it accounts for around one third of SO_2, more than one-tenth of Hg and 4-5 % of NO_2.

The power plant plays a significant role in the domestic electricity supply. Therefore, the aim is to replace some of the capacities with other technologies, to retrain employees in the region concerned and to adapt the various industrial activities based on the technological systems of the power plant. We also want to ensure that, given the substantial domestic lignite wealth, lignite-based production remains available as a strategic reserve. However, it can be used inother ways to use domestic coal assets, such as chemical or construction materials or so-called clean coal technology, provided that it is cost-effectively sustainable.

Nuclear safety

We want to maintain a high share of nuclear energy in electricity generation.

Strengthening cybersecurity

With the spread of IT solutions and digitalisation, the rise of artificial intelligence, the number of risk factors stemming from the interdependence of cyber-attacks and information systems is expected to increase in all segments of the economy. The activities of attackers with different backgrounds and motivations (34script-kiddies, cybercriminals, attack groups with state backgrounds, APT35 groups) increasingly affect energy actors. Cybersecurity must therefore become one of the most important elements of national security. The combination of new, modern and inherited technological solutions also poses challenges that need to be addressed.36

Improving the labour market situation in the energy sector

ii. According to industry feedback, addressing skills shortages and competence development in the energy sector remains a priority. National objectives with regard to*increasing: greater diversification of energy sources and energy supplies from third countries to increase the resilience of regional and national energy systems*

Given that this area is also covered by Article 4(c) of the Regulation on the Governance of the Energy Union, the reply has been integrated in the reply under point (i).

iii. Where appropriate, national objectives to reduce dependence on energy imports from third countries in order to increase the resilience of regional and national energy systems

iv. National objectives to increase the flexibility of the national energy system, primarily through domestic renewable energy use, demand response and energy storage

Hungary aims to increase the share of renewable resources in final energy consumption. The targets for the use of domestic renewable energy sources are set out in Chapter 2.1.2.

[34] "Logging pups": Computer "cybercriminals" is not too knowledgeable. They often cause damage through complementary programmes (scripts) or software written by others. They are often called hackers by the public.
[35] Sophisticated ongoing attack in cyberspace
[36] European Commission Recommendation 2019/553 on cybersecurity in the energy sector.

Gas market

In terms of flexibility, we rely mostly on natural gas storage facilities, but **more use of biogas/biomethane in addition to storage may also play a role in increasing flexibility, as well as ensuring the availability of an additional alternative source of natural gas.**

Nevertheless**, our aim is to improve the system to reduce the energy use and increase the availability of underground gas storage facilities operated in Hungary**. The objective is also **to strengthen competition in the gas storage market and the regional role of domestic installations.**

Electricity market

The penetration of renewables can only be achieved in parallel with the development and "development" of the transmission and distribution grids, which can also accommodate new, more efficient technological solutions, and by developing distribution plant management as a decentralised intervention capability and its transparent market mechanisms (distribution flexibility market).

Since the short-term fluctuations in weather-dependent production are still mainly met by gas-fired power plants, it is important to prevent the necessary level of regulatory capacity from being decommissioned, with a strategic decision being taken in Hungary that CCGT plants will be built with commissioning in 2027 at two sites with a total capacity of 1 500 MW. In addition, there should be scope for the uptake of new innovative solutions such as energy storage and demand response (DSR) solutions to stimulate the integration of renewable energy production in the electricity grid.

The development of organised energy markets (in particular for a short time horizon supporting system flexibility) and the development of further electricity interconnections and the strengthening of market integration are also justified in a cost-effective manner in order to improve the functioning and flexibility of the national energy system.

For details on flexibility, energy storage and demand response, see chapter 2.4.

2.4. Dimension internal energy market

2.4.1. Electricity interconnections

i. The level of electricity interconnection that the Member State aims to achieve by 2030 with regard to the electricity interconnection target of at least 15 % by 2030, together with a strategy including the level from 2021 onwards set in close cooperation with the Member States concerned, taking into account the target of at least 10 % by 2020 and the following indicators of urgency of action:

Cross-border capacities are now available from all neighbouring countries. The transmission capacity of cross-border high-voltage lines reaches around 50 % of gross domestic installed capacity, which is significantly higher than the 15 % target foreseen by the EU. Nevertheless, Hungary has committed to increasing the share of electricity interconnections to around 60 % by 2030. Even after the completion of the Hungarian-Slovenian cross-border connection, it is justified to increase cross-border capacity, as the energy network connected with neighbouring countries improves the security of domestic supply by reducing the risk of service disruptions in large areas in the event of any disruption of the domestic system. Furthermore, creating market interconnections can reduce the costs of system management by working together with neighbouring countries to make more efficient use of regulatory capacities.

In the short term, the Serbian-Hungarian cross-border capacity is planned.

2.4.2. Energy transmission infrastructure

i. Key electricity and gas transmission infrastructure projects, and, where relevant, modernisation projects, that are necessary for the achievement of objectives and targets under the five dimensions of the Energy Union Strategy

Gas market

Natural gas projects on the current (fifth) PCI list:

14table 1 – Gas PCI projects

Number	Corridor	Definition
6.2	Priority Corridor: North-South gas interconnections Central East and South East Europe ("NSI East Gas")	6.2.13. Development and enhancement of transmission capacity of Slovak-Hungarian interconnector
6.24	Priority Corridor: North-South gas interconnections Central East and South East Europe ("NSI East Gas")	Capacity increase between Romania and Hungary (currently known as "ROHU/BRUA") to enable bidirectional capacity of of 4,4 bcm/a, and including new resources from the Black Sea: 6.24.4. ROHU/BRUA –2nd phase, including: Extension of transmission capacity in Romania to 4.4 bcm/year towards Hungary, from Recast to Horia and expansion of compressor stations in Podisor, Bibesti and Jupa − Pipeline between the Black Sea and Podișor (RO) for the acceptance of Black Sea natural gas Infrastructure suitable for reverse flow between Romania and Hungary: Hungarian section 2nd stage compressor station at Csanádpalota (HU)

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

Electricity market

<u>Priority corridor project:</u>

The current (fifth) PCI list[37] does not include a Hungarian project linked to a priority corridor.

Other projects in the list:

Thematic priority area: smart grids deployment:

Danube InGrid (Hungary, Slovakia) – the project improves the cross-border coordination of electricity grid management, with a focus on smartening data collection and exchange (project No 10.7)

(II) CARMEN (HU, RO) – the project improves the operational efficiency of the distribution network and the quality of service and enables a secure flow of electricity from new renewable energy sources. (Project No 10.10)

ii. *Where applicable, main infrastructure projects envisaged other than Projects of Common Interest (PCIs)*

Natural gas projects

The FGSZ's 'Ten Annual Network Development Plan'[38] includes projects for the transmission pipeline planned over the next 10 years.

Further expansion of cross-border natural gas capacities is justified. The construction of the missing Hungarian-Slovene cross-border gas pipeline, which would allow HU-SI bi-directional transport, is an important objective for the development of infrastructure for import diversification. While the available capacity is relatively low, both countries may benefit from increased security of supply. For Slovenia, it may constitute direct access to Hungarian natural gas storage capacity, while for Hungary an alternative sourcing route to LNG in northern Italy and future hydrogen ports. The new pipeline will be fully hydrogen compatible.

Electricity projects

The document entitled 'Magyar Electricity System Network Development Plan 20221' sets out other important transmission projects planned for the transmission network in the future, which are not included in the PCI list. The plan published in English and Hungarian is also available to the general public on the website of MAVIR ZRt39..

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 set electricity prices in accordance with relevant sectoral law,*

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

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

[39]https://www.mavir.hu/documents/10258/239341965/HFT2022_A+magyar+VER+h%C3%A1l%C3%B3zatfejleszt%C3%A9si+terve.pdf/38a57b3b-1323-abe5-b07e-3c99752facdc?t=1676903159479

__market integration and market coupling__ to increase the 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 meeting the objectives

Regional market integration helps to achieve efficient trade flows, smooth supply and demand fluctuations across countries and improves security of supply. Two key priorities for regional energy market integration are the **expansion of cross-border capacities** and the **development of harmonised rules allowing efficient flows of electricity and natural gas between countries**. Further development of regulations to improve the functioning of wholesale and regulatory markets should be pursued through the implementation of European operational and operational codes. In addition, it is necessary **topromote projects that increase the regional role and liquidity** of our electricity and gas markets.

Gas market

Hungary will continue its efforts to facilitate the functioning of an **integrated gas market** allowing for a sustainable reduction of user energy costs in line with the relevant EU directives and regulations**.** The main guarantee of this is the diversification of the country’s gas supply options.

Regulatory changes and investments in infrastructure over the last decade have led to a multi-route supply model. Hungary has established gas interconnections with all neighbouring countries except Slovenia. Our aim is also to make the **Hungarian-Slovenian connection** a reality.

Ensuring the **availability of additional resources needed to further strengthen flexibility.** In addition to increasing the flexibility of the Hungarian gas sector, it also strengthens security of supply.

Promoting gas market integration in the region is also a strategic objective: a market with single wholesale price signals free of cross-border tariffs can provide more effective competition, lower prices and a higher level of security of supply. Therefore, Hungary is also investigating the possibility of interconnecting with the Slovak, Slovenian, Austrian and Romanian markets.

In parallel to promoting market integration, the aim is to further strengthen the domestic gas stock exchange, CEEGEX, its liquidity and its role as a regional price indicator. In addition, Hungary intends to promote integration into the natural gas market by developing a regional sales model for its storage capacities.

Electricity market

It is important to prevent the loss of flexible capacities and to improve flexibility capabilities by integrating energy storages and new gas-fired power plants (CCGT) into the system, making better use of demand response, efficient operation of aggregators and energy communities, expanding cross-border capacities and strengthening market coupling.

Headline targets:

i) The creation of a**new CCGT capacity of 1 500 MW** partly to meet the increasing electricity demand in the baseload type and partly to support the flexibility needs of the electricity system.

ii) Building electricity storage capacities both in the form of integrated elements at the system operator and network licensees (which have already started) and in order to increase balancing capacity: The Government 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.

iii) Promotion and integration of**demand response:** Demand response is an important instrument for increasing the flexibility of the internal energy market and for enabling optimal use of networks. In the future, we intend to play a much bigger role than is currently the case. .

iv) Enabling aggregators and energy communities: grouping (aggregating) users from different consumer segments also plays a major role in harnessing consumer flexibility.

The electricity grid faces new challenges, in addition to the deployment of renewable capacities with different production profiles and prosumers. At the same time, there are new opportunities to relieve the network for independent consumers and communities, which the government is supporting and planning to support in the future.

Local energy communities are a specific form of organisation based on renewable energy production. They help to ensure that all or part of renewable energy can be used locally (e.g. within a transformer district). The basic legislative framework for aggregators and energy communities was established in 2021, but we plan to prepare the necessary legislative amendments by 2024 to ensure their proper functioning.

v) Increasing**cross-border capacities:** Hungary has connections with all neighbouring countries after the transfer of the Slovenian-Hungarian cross-border line at the end of 2022. In addition, the expansion of Slovak capacity in April 2021 helped imports of cheaper electricity, as prices on the Hungarian electricity exchange decreased, while the spreads vis-à-vis the Slovak and German wholesale prices decreased.

vi) Market coupling: In this respect, one of the key tasks of the period ahead will be to strengthen market integration in both intraday and regulatory markets.

ii. Where applicable, national objectives related to the non-discriminatory participation of renewable energy, demand response and storage, including via aggregation, in all energy markets, including a timeframe for when the objectives are to be met

In order to ensure a cost-effective level of support, support under the technology-neutral METÁR framework can only be obtained on renewable capacity tenders (see section 3.1.2 for details on the METÁR system). The first successful METÁR tender in autumn 2019 showed that the level of aid needed followed the decrease in investment costs.

At the same time, one of the key issues for the effective integration of renewables is the need for renewable producers to make a better contribution to the reliable operation of the system in the future.

Cost-effective integration of renewables will also require encouraging the uptake of innovative technologies (energy storage, increasing the capacity of existing grid elements) and modes of operation (demand response) that help improve the controllability of the electricity system while minimising the need for (cost) investments in grid development and enabling the integration of decentralised renewable energy generation to the extent possible.

(For storage and demand response targets, see this chapter (i) and (iii) (see also point (c) of the judgment under appeal.)

iii. Where relevant, national targets and targets to ensurethat self-generation and new technologies, including smart meters, benefit consumers

Lower costs of renewable energy generation assets, digitalisation and smart metering are leading to a major change of mindset: **the passive consumer approach is increasingly being replaced by an active (partially self-sufficient), prosumer approach.** This requires the development of complex energy policy solutions, differentiated by consumer segment, but also calls for a tailor-made, flexible approach and diversified packages of services.

One of the essential conditions for consumers to play an active role in the market is to create controllability of consumption where it is not yet possible to do so. In this regard, we aim to have at least 1 million smart meters installed by 2030. In the future, this will enable consumers to participate effectively in energy markets through aggregation. In addition, they adapt their own consumption, for example through the possibility of introducing time-based remuneration, in a way that also contributes to the optimal functioning of the system as a whole.

The much wider use of smart meters in the electricity and gas sectors than is currently the case, the proper construction of heat centres for district heating, the controllability of systems and the widespread use of cost allocators, as well as the establishment of the active operational management capacity of distributors, will provide consumers with accurate information on the evolution of their energy consumption and competitive service package offers from their suppliers, while improving the quality of the service.

In addition to enabling the active involvement of consumers in the electricity system and their participation in demand response (DSR), it will also make it easier for consumers to control charges. For households and smaller corporate customers, this also requires the emergence of **independent aggregators** (a specific form of which are energy communities) who combine several customer load or production units for sale or purchase on an organised energy market (exchange, day-ahead market, [40]intraday market, [41]systemic services market, local distribution flexibility market).

iv. National objectives with regard to ensuring electricity system adequacy, as well as for the flexibility of the energy system with regard to renewable energy production, including a timeframe for when the objectives shall be met

The Hungarian electricity system is currently characterised by a high level of security of supply, two of which are a diversified domestic production portfolio and market integration.

Installed PV capacity is growing rapidly, creating challenges. The surge in weather-dependent power generation capacities from the point of view of electricity supply raises three questions that need to be addressed:

1) In periods without weather-dependent renewable generation, will there be sufficient capacity on the supply side of the electricity system to fully satisfy demand during these periods by activating domestic generation capacities and trading through cross-border capacities?
2) Can the development of the domestic electricity grid keep pace with the rapid expansion of weather-dependent production?
3) Will there be sufficient flexible response capacity to address the electricity system problems caused by the rapid expansion of weather-dependent production?

To address the challenges generated by accelerating electrotrification, we aim to **strengthen the electricity system**: increasing classical and renewable generation capacities, network development, introducing electricity market regulation solutions. The grant framework of the National Recovery Plan, adopted in December 2022, foresees support of more than HUF 180 billion for the development of the network and the installation of smart meters. In addition, additional resources are available for the construction of storage capacities.

The Government has therefore launched significant investments to facilitate the transformation of the electricity system on a renewable basis. This is a multi-annual and multi-agency process. **The aim is not to maximise the investment window, but to achieve optimal business functioning.** This also requires regulatory, tariff and demand side investments in addition to classical and digital network development elements. In this respect, the Government is also planning measures that are essential in the short term.

While the international interconnections and transmission capacities of the Hungarian electricity system (see for the internal energy market dimension) allow for sufficient, secure and flexibly diversified commercial transactions, further market integration steps are needed in the context of balancing markets (MARI and PICASSO products).

[40] day-ahead market (DAM)
[41] intraday market (IDM)

Flexibility targets (including those related to energy storage and demand response) are described in point (ii) of this Chapter.

v. Where applicable, national objectives to protect energy consumers and improve the competitiveness of the retail energy sector

Low tariffs, increased energy independence, high freedom of choice: these are essential values for consumers to be served by the solutions proposed by a consumer-centred energy strategy. The focus on consumers can be monitored at several levels of the new Hungarian energy strategic thinking, both in the main programmes and in the objectives. Support for home-grown renewable energy production, thus encouraging consumers to become prosumer, and promoting the uptake of smart meters are both a means of putting consumers at the centre.

From the point of view of service providers and network operators, strengthening competition in the wholesale market, creating a smart network and limiting infrastructure operating costs will help to reduce the cost of overheads in a sustainable manner. From the consumer side, reduced demand through conscious use of energy, exploiting the potential of decentralised backyard energy production and optimising supply modes can contribute to ensuring cost-effective energy supply. The aim may be to compile different service packages, while preserving the result of the reduction in charges. In the case of district heating, the aim is to revise the support scheme, as the current methodology does not incentivise cost-effective implementation of the investments needed to modernise and green the district heating system.

It should foresaw a vision for consumers in which, in addition to increasing prosumerism, flexible suppliers of choice can play an active role. The road leads to the competitiveness of the sector through the development of the fullest possible coverage of customer needs, mainly due to the static nature of pricing and its decoupling from cost-orientation. Our aim is therefore to **improve the service of final energy consumers and to create the necessary regulatory conditions to improve customer experience.** The programme includes the development of digital channels, the introduction of digital signatures and the development of a consumer-friendly billing picture.

Energy service providers should take into account the inter-sectoral dependencies of each critical infrastructure sector when designing and providing the service. To this end, following a mapping of the specificities of the sectors, legal standards ensuring effective protection measures should be developed.

2.4.4. Energy poverty

i. If applicable, national objectives with regard to energy poverty including a timeframe for when the objectives shall be met

Vulnerable customers/households are those who have difficulties in securing the basic energy needs of their homes. The concept thus covers the difficulty of financing meeting energy needs in the same way as the high specific energy consumption of the property.

For the purpose of determining membership of vulnerable consumers, detailed definitions with indicators are defined for each supporting policy measure.

2.5. The dimension of research, innovation and competitiveness.

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

The RDI policy set the objective for Hungary to catch up among the EU's emerging innovators by the end of the decade among the EU's emerging innovators through the value-creating capacity of the RDI ecosystem, by intensively increasing the innovation performance of the enterprise sector and consistently implementing smart specialisation. In order to achieve the target, the Government committed itself in the RDI strategy to increase the R & D expenditure as a share of GDP to 3 % by 2030.

In June 2023, the Hungarian Government adopted the country's new innovation strategy, János Neumann,42which identified the focus areas and the selection methodology on which RDI funds are planned to be concentrated in the next period in order to strengthen the economic impact of RDI spending. One of the 4 areas is to support the green transition of the economy and the development of a circular economy (with priority energy production, agricultural technologies, climate change and water management technologies).

In line with the European Green Deal, the aim is to develop solutions to support the development of a modern, resource-efficient, competitive and sustainable domestic economy that drives climate neutrality, from the challenges of climate change and geographical basis (agricultural innovations and water management), increasing energy savings, accelerating the clean energy transition, exploiting indigenous energy carriers, supporting sustainable and smart mobility, alternative propulsion and mobility solutions, and energy storage and grid innovations, to a sustainable environmental economy and bio-based economy (waste management, cyclical and recycled technologies, new materials).

Hungary is committed to the innovative transformation of the energy sector, with a particular focus on increasing the performance of RDI in this area and exploiting the potential of energy innovation and climate change for economic development. In this dimension, the objectives set out in the NECP remain in force.

15table: Objectives for innovation and competitiveness

[42] https://kormany.hu/hirek/elfogadta-a-parlament-a-neumann-janos-programot

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

We want to encourage the use of innovative solutions that will smooth the transformation of energy markets, characterised by electrotrification, decentralisation and digitalisation, and contribute to the objectives of increasing consumer choice, strengthening security of supply and climate-friendly transformation of the energy sector. Priority Innovation Areas: all stages of the electrotrification process, electricity network operation, nuclear energy use, use of earth heat and biogas, hydrogen ecosystems. Another aspect is that energy innovation contributes as much as possible to the performance of the Hungarian economy; increase domestic RDI capacity and create opportunities for industrial development.

ii. Where applicable, national objectives for 2050 to support the uptake of clean energy technologies and national targets including long-term targets for the deployment of low-carbon technologies, including technologies for decarbonising energy-intensive and carbon-intensive industrial sectors and related carbon transport and storage infrastructure (by 2050)

The strategic frameworks and orientations for energy innovation are set out in the National Energy Strategy on the one hand, and the National Smart Specialisation Strategy (S3) for 2021-2027, on the other hand, under one of its national priorities (Energy and Climate Priority)43. The S3 Strategy sets out the paths of specialisation for the national economy with high development potential, where concentration of resources can contribute to increasing the competitiveness of the economy. In formulating S3 priorities, the megatrends defined by the OECD have been taken into account. Among the priorities of the national economy, the objectives of the Energy and Climate Priority are to combat climate change and to facilitate the transition to a carbon-neutral economy, including energy generation, storage, use-related activities and activities to replace or reduce the use of natural gas and oil-based energy production, and to encourage businesses to operate energy efficiently and environmentally friendly. In addition, the priority should cover R & D activities related to the expansion of nuclear energy capacity and the subsequent nuclear innovations, 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 the reduction of emissions from the largest CO2-emitting industries by reducing energy use and increasing manufacturing efficiency, and research into technologies for the wider deployment of renewable and natural energy sources in energy-intensive sectors and residential use.

[43] https://nkfih.gov.hu/hivatalrol/nemzeti-intelligens/nemzeti-intelligens-szakosodasi-strategia-2021-2027

iii. Where applicable, national objectives with regard to competitiveness

In addition to the quantified targets, it is important to strengthen competitiveness based on green innovations and technologies, leading to more successful and effective businesses, more jobs, greater added value and, as a final result, a higher standard of living and a better quality of life.

The Neumann János Programme focuses on connecting universities and research institutes and the economy. The programme sets out the orientations for developing innovation pillars for a knowledge-based, high-value-added economy and putting Hungarian research on an international path. The Government aims to make Hungary one of the 25 best innovators in the world by 2030.

Strengthening competitiveness requires the retention and strengthening of a skilled workforce and the training of replacements. The manufacturing and R & D capacity of companies established and operating in Hungary has a significant impact on the professional's demand, which imposes additional requirements for higher education training, so we aim to increase the number of suitably qualified professionals and R & D staff.

In addition to the above, it is crucial that related training activities are carried out in close proximity to industry companies, thus ensuring more effective practical training and maintaining a skilled workforce. In addition, cooperation between higher education places and companies, strengthening innovation attitudes and strengthening the innovation ecosystem and smoothing knowledge flows can be organised more effectively.

3. POLICIES AND MEASURES

Detailed information on policies and measures can be found in Annex 1 and only a summary overview is provided in this chapter.

3.1. Decarbonisation dimension

This section describes the policies and measures envisaged for each CO2-emitting sector, including the options that are already being applied, decided or examined.

3.1.1. GHG emissions and removals

i. Policies and measures to achieve the target set under Regulation (EU) 2018/842 as referred in point 2.1.1 and policies and measures to comply with Regulation (EU) 2018/841, covering all key emitting sectors and sectors for the enhancement of removals, with an outlook to the long-term vision and goal to become a low emission economy and achieving a balance between emissions and removals in accordance with the Paris Agreement

GHG emissions from the use of energy sources are determined by the amount of energy consumed in the processes and by the specific emission factor of the energy sources. A significant reduction in GHG emissions is due to a reduction in the amount of energy used, an increase in the use of renewable energy sources and the replacement of fossil energy sources with a higher emission factor with other carbon-free (nuclear) and low-carbon energy sources. Measures specifically targeting the use of renewable energy and increasing energy efficiency are described in chapters 3.1.2 and 3.2 respectively, while measures related to the decarbonisation of transport are described in chapter 3.1.3.

In addition to programmes supporting energy efficiency and renewable energy, **maintaining nuclear capacities in the long term** has a significant impact on reducing greenhouse gas emissions. In December 2022, Parliament adopted Decree 56/2022 on the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant. (XII. In the OGY Decision, it took note, by a large majority, of the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant, which serves the country's energy sovereignty, climate protection and security of supply objectives. On this basis, preparatory activities are carried out which are necessary for the administrative authorisation procedure for the further extension of service.

In addition, Paks II is already operational in the next decade with two units (with a capacity of 1 200 MW per block), so that together, the six blocks (if all four blocks of Paks I. are technically suitable for an extension of service) would already have a power of 4400 megawatts and a huge decarbonisation potential for Hungary. We will also explore the potential for the deployment of small modular reactors (SMRs).[44] However, in Europe, including Hungary, there is currently no permitting framework for these plants. Hungary expects that if new capacities were to be needed, the purchase of these capacities could be put on the agenda at the earliest 5 years.

Most of the planned policies **and measures to reduce greenhouse gas emissions in the residential and service sectors** concern improvements in the energy efficiency of buildings (Chapter 3.2) and the use of renewable energies (Chapter 3.1.2). Several instruments can support GHG emissions in these sectors by improving their energy efficiency and increasing the use of renewable energy. (details in sections 3.2 and 3.2.1).

Industry can also systematically reduce GHG emissions by **investing in energy efficiency and switching to cleaner fuels, including cleaner technology**. The latter's main instrument is switching to electricity. Where this is not possible for technical or economic reasons, it may be justified to **use carbon capture** or **hydrogen-based technologies**.

Appropriate solutions also need to be found in the hard-to-carbon sectors of industry and in large emitting facilities, which may require closer cooperation between government and industry. This can be facilitated by the conclusion of climate agreements between the parties.

In the production of hydrogen, natural gas production, which is still dominating today, will be phased out. Instead, the aim is to use renewable and nuclear power in water dismantlement. (As shown by the European Commission's Joint Research Center study, the production of nuclear-based electricity has the same low GHG emissions and carbon footprint as solar or wind power plants.) In addition to water dismantling technology, alternative processes such as bio-based hydrogen production methods are expected to play an increasing role in hydrogen production over a 5-8 year horizon. This is why they are also intended to be researched.

Hydrogen will need to be used in hard-to-kritible, typically energy-intensive **industries**, so in particular chemical, steel, cement, glass and ceramics can be a solution to decarbonise it.

The measures envisaged for increasing energy efficiency and switching to cleaner fuels (electrification, hydrogen, other) are set out in chapters 3.1.2 and 3.2.

In the future, Hungary **envisages an increased role in the use of CO2$_{\text{capture}}$ technologies**, which we intend to achieve through dedicated regulatory and financial instruments. These technologies cannot be used on their own, since it is necessary to ensure the use of captured carbon dioxide or its long-term reliable storage. In view of this, it is essential to develop complex solutions. However, this instrument can only be used economically for industrial installations with higher capacity. The RePowerEU chapter of Hungary's Recovery and Resilience Plan, which is currently planned, includes an investment specifically aimed at

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44All nuclear power plants in operation today are unique products, but the production technology for much smaller SMRs will be standardised. This should allow these series products to be produced at a much lower cost and are expected to be allowed, built and expanded more quickly.

reducing emissions in GHG intensive industries, which would, inter alia, offer support sources for the use of carbon capture technology.

Measures concerning **transport** are presented in point 3.1.3 (iii).

In order toenhance CO_2 sink capacities, we will significantly increase the share of forest and other wood stands in **line with the National** Forest Strategy and improve forest resilience to environmental factors in order to preserve the carbon sequestration capacity of forests. We are actively participating in theCouncil negotiations on establishing an EU certification framework for carbon dioxide removals (COM(2022) 672 final).

Hungary also offers[45] support options in the CAP Strategic Plan 2023-2027 to reduce GHG emissions in the agricultural sector and increase carbon sequestration in the LULUCF sector. The main areas of intervention of the Plan relevant for GHG emissions and climate change applications are:

- Reducing GHG and ammonia emissions in the livestock sector.
- Reduction of GHG and/or atmospheric load emissions through forestry tools
- Support for investments contributing to the production of renewable energy.
- Increase climate change mitigation and adaptation.
- Improving the carbon sequestration capacity of soils and ecosystems (grasslands, non-productive landscape features and areas, fallow land, wetlands, ecological boundary strips, erosion control strips, maintenance, ecological improvement of agro-technological practices, changing the way manure is applied, etc.).

In addition to the above, a **programme for an energy- and climate-smart society** will contribute to achieving our goals, including energy and climate awareness campaigns targeting different age groups, as well as awareness-raising measures focusing on young generations.

In the context of **adaptation** to the adverse impacts of climate change, the National Adaptation Strategy (NAS), already referred to in *Chapter* 2.1.1(i), aims to integrate climate change into the following policies and areas of action for the period up to 2030, taking into account nature conservation and landscape conservation aspects:

- human health,
- water management
- disaster management and security policy;
- agriculture and rural development,
- landscape and nature conservation;
- forestry,

[45] https://kormany.hu/dokumentumtar/magyarorszag-kap-strategiai-terve-2023-2027

- built environment (land and settlement development, spatial and urban planning, municipal infrastructure),
- energy management;
- tourism.

ii. Where relevant, regional cooperation in this area

Support for the implementation of Hungary's National Climate Change Strategy

The project consists of two parts, both of which aim to implement the National Climate Change Strategy of Hungary. The first element is planned to focus on the national monitoring, evaluation and reporting framework for energy and climate policy. The second component, which has already been implemented, addressed aspects of environmental impact assessment.

Western Balkans Green Fund

The Western Balkans Green Fund (hereinafter: Project 2) gives Hungary the opportunity to play a leading role in the development of projects linked to the 46 Nationally Determined Commitments and Climate Adaptation Objectives of the Western Balkan countries and allows Hungarian companies to have access to more tendering opportunities in the region than is currently the case. Despite positive trends, some of the challenges and risks continue to stem from climate extremes and environmental pollution. However, this risk is also an opportunity to introduce new, efficient technologies and methods to ensure a greener and more sustainable future for the Western Balkans region. One of the supporters of this transformation process is a project involving domestic companies, which, in addition to boosting the circulation of high value-added services and goods, can help the Western Balkan countries fulfil their EU accession obligations.

iii. If applicable, without prejudice to the applicability of State aid rules, financing measures, including EU support and the use of EU funds, in this area at national level

Decarbonisation efforts will be greatly supported by the relevant pillars of operational programmes implemented with EU funds, as well as green investments planned to be financed by the Recovery and Resilience Facility (RRF) and Common Agricultural Policy (CAP) funds, with GHG reduction impacts.

Among the relevant OPs for the 2021-2027 development period, the Environment and Energy Efficiency OP Plus (KEHOP Plus) and the Territorial and Settlement Development OP Plus (TOP Plus), but the Integrated Transport Development Operational Programme Plus (IKOP Plus), Digital Renewal Plus (DIMOP Plus) and Human Resources Development OP Plus

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[46] Republic of Albania, Bosnia and Herzegovina, Republic of Kosovo, former Yugoslav Republic of Macedonia, Montenegro, Republic of Serbia

(EFOP Plus) may also be relevant.[47] The programmes aim at increasing the use of renewable energy, improving energy efficiency, supporting sustainable mobility, improving waste management and waste water treatment, and supporting the protection of forest resources and afforestation.

Common Agricultural Policy sources may also be relevant for reducing GHG emissions and improving adaptation. (More details can be found in the CAP Strategic Plan.[48])

Although non-reimbursable RRF funds have not yet been made available to Hungary, the Government has already provided funds from the national budget for investments[49] presented in the already adopted Recovery and Resilience Plan. The investment in network development directly reduces GHG emissions, while investment in the installation of residential solar panels and the electro-electrification of heating systems directly reduces GHG emissions. In addition to grants, Hungary intends to use part of the RRF loan pillar. These funds are planned to be used to strengthen the energy transition and increase energy security. Details will be included in the REPowerEU chapter of the Recovery and Resilience Plan still to be prepared.

During the fourth trading period of the EU Emissions Trading System (2021-2030), a certain proportion of the proceeds from the sale of allowances will be used under the Energy **and Climate Policy Modernisation System (ECMR)** allocation.

The government is also taking steps towards modernising Hungary's energy system and increasing energy efficiency, thereby reducing GHG emissions, using resources from the Modernisation Fund established for the period 2021-2030, financed by the auctioning of allowances. Since its inception in 2021, we have launched the following development programmes financed by the Modernisation Fund:

The METÁR system for supporting electricity produced from renewable energy sources and thus reducing GHG emissions plays a key role in the Hungarian energy market, as described in point 3.1.2.

3.1.2. Renewable energy

i. Policies and measures to achieve the national contribution to the binding 2030 Union target for renewable energy and trajectories as referred to in point (a)(2) Article 4, and, where applicable or available, the elements referred to in point 2.1.2, including sector- and technology-specific measures 50

[47] https://www.palyazat.gov.hu/fejlesztesi_programok_2021_2027

[48] https://cdn.kormany.hu/uploads/document/0/0e/0ec/0ec4a4b0ea4a1f5a0c98ef633503faab726809e0.pdf

[49] https://www.palyazat.gov.hu/helyreallitasi-es-ellenallokepessegi-eszkoz-rrf

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

The following policies and measures shall support the achievement of renewable energy targets:

Electricity

The increase in **electricity generation on the** grid is facilitated by the granting of operating aid under the **Renewable Energy Support Scheme** (METÁR). In addition supporting the construction of new units, the RESS also supports the use of renewable energy (so-called brown bonus).

In order to ensure a cost-effective level of support, support under METÁR should only be granted on technology neutral renewable capacity tenders. We want to provide electricity producers using weather-dependent renewable sources with credit products available to foreign producers with competitive sources.

METÁR support, with the exception of the brown premium, may be granted to renewable electricity production linked to a new investment and construction of the investment has not started at the time the aid is requested. Multi-fired and waste-incinerating power plants may receive aid only for the part that is renewable (inproportion to heat).

Under the METÁR system, aid for the construction of capacity above or equal to 1 MW is allocated only in the context of artificially created competition. Under the METÁR tender green premium, in addition to power plant units linked to the new investment, existing power plant units which are subject to substantial renovation or development costs exceeding 50 % of the initial initial investment cost may also be eligible for aid. The aid available under the METÁR system depends on the production capacity of the power plant concerned. In the METÁR feed-in support category (METÁR-KÁT), power plants with a capacity of less than 0.5 MW (except wind) and demonstration projects were eligible until 26 April 2018. In the case of these power plants, MAVIR ZRt. takes over the energy produced from the generators (mandatory takeover) and sells it on the organised electricity market operated by HUPX Zrt. With the closure of the green premium categories without METÁR-KÁT and without tenders, with the exception of the brown premium, it is only possible to obtain METÁR support from 1 May 2019 onwards. Until 2026, the maximum annual new grant amount that can be allocated under METÁR is HUF 45 billion according to the legislation in force at the time of the preparation of the NECP.

As part of the Recovery and Resilience Plan, the investment “Supporting of residential solar panel systems and equating heating systems in combination with solar panel systems” was launched.[51] By 2026, the aid could result in around 140-175 MW installed solar cell capacity and 50 MW installed electric heating system capacity.

In Hungary, the installation of **household-scale small solar power systems** (HMKE) producing partial replacement for own electricity consumption is rapidly increasing (Chapter 4.2.2). The **‘near-zero’ building energy level applicable to new properties after 2024 requires an average renewable energy share of 25 %**, so that generation units currently

[51] https://www.palyazat.gov.hu/helyreallitasi-es-ellenallokepessegi-eszkoz-rrf

defined as small household-sized power plants are expected to grow further. The very dynamic roll-out of small household power plants in recent years confirms that the target of having at least 200 thousand households with an average of 4 kW rooftop solar panels will be significantly overachieved by 2030. To maintain this trend, we want to introduce a complex regulatory and financial solution that is sustainable in the longer term, both for the owners of small power plants and for the electricity grid as a whole.

The new priority target group for the deployment of renewable capacities with installed capacity below 50 kW is enterprises, which are able to generate part of the energy they consume. This reduces the network load.

We **also** plan to increase installed wind capacity in order to diversify the domestic electricity mix. To this end, domestic regulatory barriers are being eased. The aim is to find the best possible between societal and investor interests.

In order to increase electricity generation from renewable sources, it is necessary to promote the **cost-effectiveness of the integration of renewable investments,** to maintain security of supply and system regulation, and to prepare the electricity grid to accommodate decentralised capacities in a cost-effective manner. (3. (Heading 4)

Energy communitiesmay be able to cushion the load on the electricity grid and to make renewable energy production available to a wider range of consumers, so that the aim is to create legislation to support the establishment and functioning of energy communities, in particular to enable the establishment of renewable-based heat communities and district heating systems of the 5th generation. We have also encouraged and encouraged their spread through legal and financial support.

Heating and cooling, domestic hot water

As a result of last year's energy crisis in the field of heating and cooling, the share of biomass in renewable energy sources increased most in view of the fact that the residential sector used heating with either fully switched or complementary solutions for heating. In order to achieve and maintain domestic emission targets, efficient biomass heating solutions and incentives for production should be maintained according to the criterion of sustainable forest management. In addition, the deployment of other renewable fuels is a priority.

In the area of individual heating, the main intervention direction is the **expansion of heat pumps while reducing the heat** demand of buildings. Before the rapid ramp-up phase, it is appropriate to consider the urban landscape and noise exposure of outdoor units of heat pumps in order to be considered as a favourable solution after mass penetration. Similarly to the charging of electric cars, it is also appropriate to define the role of these devices in the electricity system as a whole.

A heat pump should be supported in the case of or at the same time as a building that has already been thermally upgraded, i.e. where the apartment has already been thermally insulated and windows replaced.

As mentioned above, we also intend to create the legal conditions for the establishment of energy communities producing heat.

In district heating, the target is to **reduce the share of natural gas to 50 % by 2030 with renewable and municipal solid waste-based technologies and waste heat technologies**.

Ageing and greening district heating (greening the district heating sector by increasing the use of geothermal, biomass, biogas, residual heat and possibly waste for heating/cooling) as well as increased use from wastewater treatment, depolnia gas and the use of agricultural biogas can play a key role in replacing natural gas and increasing our use of renewable energy in the heat market. The promotion of the use of these resources will be established on the basis of an in-depth analysis, taking into account local conditions, on a case-by-case basis for larger districts.

As regards industrial and district heating, the **practical exploitation** of the earth heat potential in Hungary is one of the main objectives in those parts of the country where it is economically viable (i.e. there is a suitable heat transfer medium). The aim is **to double existing geothermal energy by 2030**. We can achieve this by combining several regulatory, support and recovery measures. Drilling activities should be supported depending on the degree of success (in the case of successful drilling, a higher aid intensity may be granted in the case of successful drilling.) However, sustainable management of Earth heat is of paramount importance in order for our natural wealth to be exploited across generations.

In addition, the potential of solar collector systems should be better exploited. The technology can also be used for domestic-hot water production and heating assistance.

Overall, **the use of weather-decoupled renewable energy sources, municipal solid waste and waste heat for heat generation is more important than in the past,** without limiting the growth of renewable energy in the production of electricity.

Transport

In the **transport sector**, the primary aim is to reduce the increase in GHG emissions by increasing the incorporation rate of biofuels, by increasing the uptake of vehicles with alternative propulsion and by shifting traffic towards low-emission modes of transport, in particular by increasing the competitiveness of rail transport.

In addition, in order to reduce the growth rate of energy use in **transport, it is of utmost importance to develop and increase the use of public** transport; furthermore, freight transport by rail should be a realistic option.

Section 3.1.3 (iii) provides information on rail developments and further measures applied and planned in the context of other alternative mobility.

Horizontal interventions

An action programme for the utilisation of biogas and biomethane will be prepared, helping to reduce natural gas imports. The guarantee of origin scheme should be extended to include biogas.

The support schemes and instruments referred to in Chapter 3.1.1 also offer funding for a larger share of renewable energy. In addition,[52] it is worth mentioning the Swiss Fund, which can contribute to a higher utilisation of Hungary's good geothermal potential and the development of current geothermal energy generation opportunities.

ii. Where relevant, specific measures for regional cooperation, as well as, as an option, the estimated excess production of energy from renewable sources which could be transferred to other Member States in order to achieve the national contribution and trajectories referred to in point 2.1.2

Five EU countries are around our countries, so we are looking particularly at the possibility of joint projects under the CEF53 programme, and we are open to cooperation with neighbouring countries.

iii. Specific measures on financial support, where applicable including EU support and the use of EU funds, for the promotion of the production and use of energy from renewable sources in electricity, heating and cooling, and transport

The **METÁR system for the promotion of electricity produced from renewable energy sources plays a key 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 increasing the production and consumption of renewable energy. Among these instruments, the following should also be highlighted:

1) **the KEHOP Plus programme**[54], of which priority axes 4 and 5 will also provide funding for renewable energy production and exploitation.

   4.pyrority: Renewable energy economy

In promoting renewable energies, the focus is on putting electricity generation at community and power plant level and community heating and cooling on a renewable energy base. Under the OP we also aim to make more effective use of the potential of non-weather-dependent renewable energy sources.

We also plan to improve the conditions for renewable energy production and deployment in the context of the development of smart energy systems, grids and storage. To

[52] https://svajcialap.hu/programok/energiahatekonysag-es-megujulo-energiaforrasok
[53] Connecting Europe Facility
[5454] https://www.palyazat.gov.hu/kornyezeti_es_energiahatekonysagi_operativ_program_plusz

this end, improvements to the flexibility of transmission and distribution networks, smart energy systems and energy storage should be encouraged, as well as promoting the widespread use of hydrogen as an energy carrier and storage.

5.pyrority: Just Transition Fund

Towards a just transition plan for Baranya, Heves and Borsod-Abaúj-Zemplén counties (eligible areas: development of micro, small and medium-sized enterprises, business start-ups, research, development and innovation, digitalisation, rehabilitation of contaminated sites, use of energy efficiency and renewable energies, support for the circular economy and waste management, employment improvement activities, etc.).

2) Priority axes 1 and[55] 2 of the**TOP Plus programme**:

We focus on priority 2 of the OP, which aims to create a climate-friendly county. In this context, interventions focus on energy developments in the local government (energy efficiency modernisation of municipal buildings and spa and increasing the use of renewable energy).

In addition, priority axis 1 – Eligible County – provides funding for green development. The framework shall support the following activities:

- integrated urban development: local transport infrastructure and services, municipal green and blue infrastructure;
- climate adaptation, brownfield rehabilitation, local community and cultural, sports and leisure spaces and services,
- ICT and smart settlement development and social urban regeneration

3) DINOP Plus[56] Priority Axis 2

In the context of the Hight-tech and green transition priority, the developments also aim at developing digital sensor systems to support the digitalisation of building energy, IT services to energy communities, and climate tracking.

4) IKOP Plus [57] Priority Axis 1 and 2

Under priority 1, Strengthening clean urban-suburban transport, it is possible to support:

- Suburban railway (e.g. Budapest HÉV) and tramway developments in metropolitan cities
- Zero-emission public transport vehicles (e.g. urban electric buses,

  trolleybuses, trams) and development of related electric chargers and sites

[55] https://www.palyazat.gov.hu/terulet_es_telepulesfejlesztesi_operativ_program_plusz
[56] https://www.palyazat.gov.hu/digitalis_megujulas_operativ_program_plusz
[57] https://www.palyazat.gov.hu/integralt_kozlekedesfejlesztesi_operativ_program_plusz

- P+R, B+R, Intermodal Node Investments
- Project preparation

Under priority 2 'Development of TEN-T rail and regional intermodal transport', the following activities are eligible:

- Ten-T (international) railway infrastructure development (stations, track and interlocking equipment), electrification
- Procurement of multiple units
- Investments in TEN-T ports
- Project preparation

5) Recovery and resilience plan:

The following energy investments are planned from RRF grants. (Partially these investments have started). (See also section 3.1.1)

16table 1 – Planned investments and support framework, HUF mrd

	Aid intensity (net)	RRF grant need, net (HUF billion)
Classic and smart network developments of transmission system operator and distribution networks	50 %	163,7
Support for residential solar systems and electrophication of heating systems in combination with solar systems	100 %	185,9
Installation of grid storage at Mavir and distributors	100 %	58
Installation of grid storages at energy market participants	50 %	62
Installation of smart meters	100 %	22,3
Total	50 %	492

As already mentioned in chapter 3.1.1, Hungary intends to use part of the RRF loan pillar in addition to non-repayable funds. We plan to support the greening of the economy by increasing renewable-based self-generation (including earth heat and renewable hydrogen). Specific details on this will be included in the REPowerEU chapter of the Recovery and Resilience Plan still to be prepared. (See also section 3.1.1)

6) Swiss Fund

Funds from the Swiss Fund contribute to the implementation of the National Energy and Climate Plan, one of the objectives of which is to significantly reduce the share of natural gas use for heating purposes through renewable energy production. To this end, the Renewable Energy Programme aims to make greater use of the country's good geothermal potential and to develop the current geothermal energy generation potential.

7) Modernisation Fund

The Modernisation Fund can also provide the necessary resources to finance investments related to the expansion of renewable energy. We estimate that more than HUF 750 billion could be available from this fork between 2023 and 2030.

iv. Where applicable, the assessment of the support for electricity from renewable sources that Member States are to carry out pursuant to Article 6(4) of Directive (EU) 2018/2001 v. Specific measures to introduce one or more contact points, streamline administrative procedures, provide information and training, and facilitate the uptake of power purchase agreements

The METÁR system described in the previous point is assessed on a continuous basis and new tenders will be published on that basis. The successful METÁR tender also showed that the level of support needed follows the decrease in investment costs.

v. Specific 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 to promote and facilitate self-generation and the development of renewable energy communities pursuant to Articles 21(6) and 22(5) of Directive (EU) 2018/2001

Hungary will encourage initiatives to ensure that electricity and heat are used locally by consumers. In this area, the main task is to promote the development of energy communities through legislative means and support sources (details under point (i) of this chapter).

There is also a need to make better use of the possibilities offered by long-term renewable energy supply contracts (PPA) by assessing its regulatory options.

Another regulatory objective is to simplify the permit-granting process for renewable energy investments.

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

As a first step, rationalisation of the existing district heating system should be achieved by creating optimisation of production capacities. In that regard, the parts are set out in point (i) of this Chapter.

vii. Where applicable, specific measures on the promotion of the use of energy from biomass, especially for new biomass mobilisation taking into account:

biomass availability, including sustainable biomass: both domestic potential and imports from third countries

other biomass uses in other sectors (agriculture, forestry-based sectors); as well as measures for the sustainability of biomass production and use

The Forest **Act** ensures and obliges the forest owner by law to replace the harvested forest, with the required quality and time limit, thereby guaranteeing the sustainability of forests and the continuous provision of their various services at national level.

In principle, the criteria58 laid down in the REDII Directive under review are met by domestic forestry. In addition to the obligation to renovate forests, the legality of timber harvesting is based on a system of forest planning and forest supervision. Most protected sites of national importance were designated as protected decades ago. In accordance with the statutory provision in force since 1997, their conservation management plans must be published in legislation. The conservation management requirements for forests in the ministerial decrees containing the 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 authorities (forestry, nature conservation). As one of the basis for tree species selection is the production site, the regeneration of forests will lead to the creation of wood stands that are suitable for the site of production (which can adapt to its future change) and make the best use of it wherever possible, ensuring that forests are maintained in the long term and their productive capacity is preserved and improved.

3.1.3. Other elements of the dimension

i. Where relevant, an assessment of national policies and measures affecting the EU ETS and their complementarity and impact on the EU ETS

Among the optional elements of the European scheme, we use the mechanisms under Articles 10c (2013 and 2021-2030) and 27a(3) of Directive 2003/87/EC (from 2021 onwards). Hungary is also entitled to use the Modernisation Fund. Hungary does not currently apply a national emissions trading policy complementing the EU Emissions Trading Scheme.

ii. Policies and measures to achieve other national targets, where applicable

The National Hydrogen Strategy sets out specific targets for the production and use of hydrogen (Chapter 2.1.2(v)), with a particular focus on hydrogen production that can support

[58] 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)

decarbonisation, as well as on the use of hydrogen for transport and even more industrial purposes.

In order to scale up green hydrogen production, the Strategy envisages the installation of at least 240 MW electrolysis capacity by 2030, or overachieved depending on demand and domestic renewable energy production. It 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 basic infrastructure investments adapted to the location and extent of the intended use.

Other policies to achieve the transport targets are described under point (iii) of this chapter. In terms of industrial production processes, renewable and low carbon hydrogen can emerge in the already significant volumes of hydrogen in petrochemistry and chemical industries (mainly ammonia production), gradually replacing carbon intensive 'grey' hydrogen. We also want to create opportunities for renewable hydrogen to support emission reductions in industries that are difficult to decarbonise. Increasing industrial use in other areas will take into account the needs.

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

We want to reduce the increase in GHG emissions in the transport sector by increasing the incorporation rate of biofuels, supporting the uptake of electric and hydrogen fuel cell vehicles and shifting traffic towards low-emission modes of transport.

59As a result of legislation already adopted by the government, the **share of biocomponents** in fuels increased to 8.2 % (including 6.1 % in petrol) from 2020. In the future, we want to encourage both the use and domestic production of so-called advanced or second-generation biofuels.

DECISION NO 397/2022 On the basis of Directive 2009/33/EC, the Government Decree requires the procurement of **energy-efficient and environmentally friendly vehicles** in the public and municipal sectors. The Regulation requires a minimum procurement rate for low or zero local cars and urban and suburban buses, and one in two newly procured urban buses should be clean vehicles in line with EU standards. The proportions for clean vehicles vary depending on the type of vehicle and location, with separate regulations for buses in big cities. Trucks and city buses above 3.5 tonnes covered by the Regulation fall under the clean road vehicle category, which includes gas, battery electric, hydrogen fuel cell and hybrid vehicles using these technologies, and zero-emission heavy-duty vehicles are a subset of clean vehicles that do not have an internal combustion engine or with an internal combustion engine that emits less than 1 g CO^2/kWh.

[59] 186/2019. (VII. Government Decree No 487/2015

The amendment to the Road Transport Act of July 2019 aims at **encouraging the uptake of this GHG zero-emission mobility mode** by regulating electromobility services. All-electric or partially electric cars and zero-emission cars are exempt from vehicle tax, company car tax and registration tax. In addition, the level of vehicle tax on buses, lorries and lorries also depends on the environmental classification of the vehicle. Additional tax relief is granted to trucks when combined transport is used. The level of company car tax and registration tax are also determined by the environmental classification of the vehicle. As stated in the Jedlik Ányos Plan 2.0, we will continue to promote the uptake of electric vehicles and the necessary infrastructure through regulatory, tax policy and financial support instruments.

Developing **public transport, increasing its utilisation and increasing the competitiveness of rail freight transport** is another way to keep the energy use of transport within transport.

Under **the Green Bus Programme**, some 300 green, electric and hydrogen-powered local buses are expected to be operational by 2025.

Measures for the deployment of alternative fuels infrastructure are included in Hungary's **Alternative Fuel Infrastructure Development Policy Framework**.

The **National Hydrogen Strategy** also sets as an objective the deployment of hydrogen propulsion in transport sectors where it is technically and financially competitive for the transition to clean modes of transport. The objectives set out in Chapter 2.1.2 will be supported by several programmes named in the Strategy:

1) Green Bus Programme Plus (Purpose to encourage the emergence of fuel cell buses in local public transport by extending the Green Bus Programme)
2) Green Road Programme (Purpose to facilitate the decarbonisation of motor vehicle traffic for freight transport.)

KEHOP Plus and RRF funds can also support the implementation of the planned investments. Support may be provided for the production of hydrogen, the purchase of hydrogen-powered vehicles and the deployment of hydrogen refuelling infrastructure. For the latter, it is appropriate to focus geographically on two types of areas:

1) according to the place of use for transport purposes (e.g. bus transport),
2) and along the major European transport corridors.

In accordance with Decree No 1414/2020 (VII. Government Resolution 16) establishes a targeted State aid scheme to maintain and stimulate domestic rail freight transport, with a view to connecting small and medium-sized enterprises and large strategic companies to international trade. The essence of the **carriage of individual railway wagons** is that the transport of small quantities of freight, even if sufficient for only one wagon, is carried by rail, but is therefore characterised by significant live work ("wagon layout") and a high proportion of costs. However, it can carry out freight transport operations with much lower GHG emissions compared to road.

The **Budapest Agglomeration Railway Strategy** (BAVS) was adopted by Government Decision 1994/2021 of 28 December 2021 and contains an indicative action plan to implement the strategy in the period 2021-2040

Define a long-term rail development strategy that meets the objectives of the capital city and the country:

- promoting a sustainable transport system, maximising the use and efficiency of the rail system for both freight and passenger transport;
- improving the environmental performance of the transport sector at national and urban level;
- reducing the impact of climate change by reducing greenhouse gas emissions from transport;
- improving the quality of life of urban populations through efficient and comprehensive transport planning, spatial planning and urban planning.

The development of the rail network can have large-scale urban development, social, economic, environmental, transport management and operational and organisational effects and can lead to significant positive changes in the life of the city and agglomeration. The strategy identifies and evaluates, in a complex way, realistic solutions that effectively combine different functions and ensure future interoperability of the transport system, taking into account technical, economic, social, environmental impacts and opportunities. Another objective is to identify optimal operational, operational concepts and options that improve and further enhance the attractiveness of the local transport system.

The **National Cyclist Strategy** sets outthe objectives, direction and financial background for the development of cyclists for the period 2023-2030. The vision of the strategy is as follows: In Hungary in 2030, cycling is a fast, safe, accessible and economical alternative to everyday transport, and thus an attractive alternative to it, and is also the most popular leisure tool, contributing to the greening of transport, the achievement of energy efficiency and climate protection goals, making Hungary the main pro-Cyclist country in Eastern Central Europe.

The strategy identifies four main intervention areas:

- development of modal shift schemes for everyday transport (good transfer links – bicycle-public transport, bicycle storage facilities and financial incentives for cycling);
- in the field of tourism, doubling the number of foreign tourists and regular cycling for domestic recreational purposes, increasing the backbone network of cyclists to 15 000 km, quality services and comprehensive promotion;
- improving transport safety: the number of road fatalities during cycling is reduced from 70 to 35 by 2030, the need to make school environments more cycling and to introduce two-stage transport exams in primary education;

- Horizontal measures: strengthening monitoring, innovation and research activities, promotion, integration of cycling aspects into territorial planning, development resources.

The support schemes and instruments referred to in Chapter 3.1.1 also offer funds for the use of renewable energy for transport.

iv. Where appropriate, planned national policy knives, roadmaps and measures to phase out energy subsidies, andin particular fossil fuel subsidies

3.2. Dimension energy efficiency

Planned policies, measures and programmes to achieve national energy efficiency contributions without commitment for 2030 and other objectives referred to in point 2.2, including planned measures and instruments (including those of a financial nature) to promote the energy performance of buildings, in particular as regards:

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

In accordance with Article 7 of the Energy Efficiency Directive 2012/27/EU (EED), which requires them to achieve annual final energy savings of 0.8 % between 2021 and 2030, an**Energy Efficiency Obligation Scheme (ESR) was introduced as of 1 January** 2021, which directly obliges energy traders to make energy efficiency improvement investments leading to proven energy savings on the end-user side.

The obligated parties implement energy efficiency measures resulting in final energy savings, which take place on the end-user's side or make use of the option to buy out and pay an energy efficiency contribution, The 701 PJ savings obligation for 2021 and 2022 has been overachieved by the majority of the 833 obligated parties, only 1.5 % of the obligations have not been met. In particular, low-cost savings were achieved in the transport and industrial sectors.

The contribution of the EPS to the national energy savings target is 26 %. 74 % of the target should be achieved by alternative energy efficiency policies, the results of which are monitored and validated by the Hungarian Energy and Public Utility Regulatory Authority. **Therefore, we consider it of utmost importance to continue and renew alternative policy measures to improve energy efficiency**.

The Long-Term Renovation Strategy provides the basis for achieving a sustainable, energy- and cost-effective domestic building stock by 2050. The main measures of the strategy include the Otthon Renovation Facility, energy inspection, the Industrial Sector Production Programme, the Modern Cities Programme, the Catching-up Municipalities Programme, the

Hungarian Falu Programme, the dissemination of smart cost-sharing, the radiator exchange programme, the Family Otthon Generation Facility (CSOK) and the Falusi CSOK.

The **Otthon Renovation Aid Scheme** is 1 January 2021. — Open from 31 December 2022. It covered 50 % of the renovation costs, with a maximum available amount of HUF 6 million. In this context, the Government supported the renovation of the homes of some 300 thousand families with children, worth more than HUF 620 billion. According to the data, half of the investments were for energy efficiency purposes.

The **Family Otthon Creation Allowance (CSOK)** is a non-refundable State grant of up to HUF 10 million, which can be claimed for an existing orborn child and which can be used for the purchase, construction or extension of a new or second-hand dwelling or housing. **Falusi CSOK** is available in the 2631 preferred small municipalities of Hungary. The Government has extended the scheme and is therefore open until 31 December 2024. The village CSOK grant may be used for the purchase of real estate and at the same time for the extension, modernisation and upgrading of existing real estate. Importantly, half of the amount that can be claimed can be spent on purchase, the other half should be used for modernisation or extension. In the case of an extension or modernisation with the purchase of a dwelling in the preferred small settlement, a maximum of 50 % of the maximum amount of the aid may be used for the purchase of dwellings.

The **obligation to carry out an energy review** was introduced as of 1 January 2022 under Act LVII of 2015 on energy efficiency. This included regular energy inspections (inspections) for heating and air-conditioning systems with a rated capacity above 70 kW, to be carried out every 8 years. The aim of the inspection is to encourage consumers, without making investments in energy efficiency, and by proposing to optimise the systems, towards better energy use. Apartment blocks and housing cooperatives are required to inform the residents of the results of the review and its recommendations by a general meeting, and the State will assume the fee for the review of larger residential building systems by 2025.

The **Production Programme** provides grants to large companies for energy efficiency and energy production investments. With a maximum aid intensity of 30 % in Budapest and 45 % in rural areas, a total of EUR 15 million (approx. HUF 6.2 billion) per company. The Government allocated a budget of HUF 150 billion for implementation in 2022.

The programme announced in **2015 under the Modern Cities Programme** is aimed at 23 towns with county rights, with resources of HUF 4200 billion, with which agreements were signed in 2017. The aim of the programme is to support the implementation of large, regionally important and complex investments. Cities were able to set their own development goals according to their own needs. 133 for the 270 development targets have been fully implemented and a high share of investments is planned to be completed by 2025. The total budget of the scheme exceeds HUF 4.000 billion; more than half of the amount has already been paid to the project promoters. Two thirds of the grants are domestic budgetary resources.

The **Catching-up Municipalities Programme** was launched in July 2019 and is ongoing under the coordination of the Hungarian Charity Service of Malta. It provides targeted interventions to help the 300 most disadvantaged settlements in the country. The overall objective of the interventions is to improve the social and infrastructural supply of lagging settlements and to bring about positive, forward-looking changes in the lives of their people and communities, and to provide the necessary expertise, support and services. The 300 municipalities were selected using a complex indicator, taking into account as many indicators as possible, in cooperation with the Central Statistical Office.

The Government **published the Hungarian Falu Programme** in 2018. The aim of the programme is to strengthen and develop small settlements below 5000 inhabitants, improve local quality of life and stop population exodus.

The '**Exploitation of cost sharing, radiator replacement programme**' was a grant in 2021, with a maximum rate of 50 % of the eligible gross heating modernisation costs of a given co-ownership building. HUF 3 billion was available for the entire tender. The minimum amount to be won per co-ownership was HUF 150 thousand, but up to HUF 75 million.

In addition, a new **tax advantage** was introduced in 2017 for **businesses on energy efficiency-enhancing investments**. Up to 70 % of the **Company Tax Allowance (TAO)** can be spent on energy efficiency investments in the form of tax relief. The tax relief is available in the form of tax retention. The tax reduction that may be used by the taxpayer shall be 50 % of the total investment cost in the case of small enterprises, 40 % of the total investment cost in the case of medium-sized enterprises, and 30 % of the total investment cost in the case of large enterprises.

We also put a strong emphasis on education. Our most important measures include the mandatory use of an energy policy officer in large companies, the obligation to install smart sub-metering, the National Energy Network providing free energy advice to public institutions, and the free energy advice of the Hungarian Chamber of Engineers to the general public and small and medium-sized enterprises.

The **National Energy Network**, established in 2017, is responsible for promoting the energy efficiency of public bodies, in which the NEH:

- provide free energy advice;
- assist the management of public bodies in drawing up energy saving action plans and implementation reports;
- encourages public institutions to launch awareness-raising programmes and helps to set up an energy management system, including energy audits, at regional and local level;
- it provides technical assistance for the preparation of the energy saving action plan, the reporting of building energy and energy consumption data and its notification to the Hungarian Energy and Public Utility Regulatory Authority responsible for the operation

of the network, the development of energy efficiency awareness among building users and the development of the county's regional development programme.

- technical support for the development of the county regional development programme, consultancy on the conclusion of energy procurement contracts, verification of energy bills and energy procurement.

The **Hungarian Chamber of Engineers provides free energy advice to the general public and small businesses, monitors the energy** savings achieved as a result of the advice, encourages small and medium-sized enterprises to conduct energy audits and implement the recommendations contained in audits, provides information on available energy efficiency tenders and energy performance certificates pursuant to the Government Decree on the certification of the energy characteristics of buildings, their purpose and purpose, cost-effective measures, financial instruments to improve the energy performance of the building in the framework of renovation advice, and the replacement of fossil fuel boilers with a more sustainable alternative.

The **business organisation referred to in Section 1(16) of Act LVII of 2015 on energy efficiency shall use the energy desk officer**, whose average annual final energy use in the 3 years preceding the reference year exceeds 400 000 kWh of electricity or 100 000 m³ of natural gas or 3 400 GJ of heat. The task of the energy officer is to promote the establishment of energy efficiency approaches and energy-efficient behaviours in the operation and decision-making of the economic organisation required to use it. As**a further policy measure, we are planning to launch programmes to increase energy efficiency for the general public. From an**energy efficiency point of view, it is crucial that the building stock undergoes deep renovations, i.e. the replacement of windows, insulation and heating modernisation. Among the building categories considered, including public buildings, multi-apartment buildings and single-family houses, detached houses offer the greatest energy savings potential.

In 2021, buildings accounted for 50 % of final electricity consumption and 65 % of district heating. Almost three quarters of households' final energy consumption is used for heating in Hungary. The average energy performance of the domestic housing stock falls into the category 'FF'.

At the same time, we encourage the use of ESCO-type financing solutions that simplify and expand access to financial resources in both the residential and corporate sectors (development of energy generation capacities to support product production). In addition, the services provided by ESCO can increase the share and volume of economically sustainable investments, standardise the quality of the works and contribute to a price level acceptable to the demand side.

ESCO models are based on the service modules "preparation, planning – financing – construction – operation" and are used systematically. Nevertheless, the content of each module can be flexible and adapted to the possibilities and needs of the respective project promoters (spondents). For ESCO-funded energy efficiency investments, the purchased assets and equipment are included in ESCO's balance sheet, i.e. the costs and risks of the investment are not borne by the principal.

The source of the project's return is the excess of resources generated by the energy savings or the flat-rate service fee paid by the principal. In one case, we refer to the Energy Performance Contracting (EPC)60 model and the Shared Savings Contracting (SSC)61 model in the other. Both models have the potential to meet energy savings needs in addition to carrying out modernisation and to guarantee the design and delivery of economically sustainable investments. In addition to the above, the EPC model also commits to realising the savings ratio previously assessed and then specifically set out in the savings contract.

In the case of central budget and local government investments in building energy and energy efficiency, ESCO-based services can reduce the use of budgetary resources and EU grants, thus contributing to the reduction of public debt and a more rational use of subsidies that will decrease in the 2021-27 programming period.

The combined funding that can be used by ESCO firms allows not only a stronger use of financial products, thereby increasing the sources of financing for energy efficiency upgrades, but also for higher-risk investments. Financial products have a strong multiplier effect and re-use them.

Energy efficiency targets are also served by programmes and instruments already described in points 3.1.1 and 3.1.3 respectively.

ii. Long-term renovation strategies to support the renovation of the national stock of residential and non-residential buildings, both public and private,62including policies and measures to incentivise cost-effective deep renovations towards the worst performing segments of the national building stock in accordance with Article 2a of Directive 2010/31/EU

The Long-Term Renovation Strategy (HTFS) is in line with our EU obligations and strategic objectives, which underpins the achievement of a sustainable, energy and cost-effective domestic building stock by 2050, with energy efficiency, value, comfort and health promotion measures, renewable energy use and the use of smart technologies that reduce national primary energy use and CO2 emissions. (For the purposes, see chapter 2.2)

Some 2.6 million **dwellings require some kind of energy upgrade**.

(The list of measures taken in this area can be found under the previous point.)

iii. Description of policies and measures promoting energy efficiency services in the public sector and measures to remove regulatory and non-regulatory barriers

[60] Energy performance contracting

[61] Profit participation agreement

[62] In accordance with Article 2a of Directive 2010/31/EU.

that hamper the use of energy performance contracting and other energy efficiency service models63

Energy **consumption in public buildings** accounts for almost 10 % of the energy use of the domestic building stock.

Energy-saving potential is significant in improving the energy efficiency of the building stock of some 12550 public institutions in Hungary. On the basis of experience abroad, energy consumption can be reduced by around 15 % to 30 % in public bodies over 5 years. The combination of energy efficiency improvements and efficient use of buildings can lead to a significant reduction in operating costs, thereby reducing energy imports and budget expenditure.

The revised Energy Efficiency Directive requires an annual saving obligation of 1.9 % in the public sector and at least 3 % of the total floor area of heated and/or cooled buildings owned by public bodies to be renovated annually by transforming them into nearly zero-energy or zero-emission buildings. Deep renovation projects and the widespread deployment of renewable energy sources can contribute to harnessing the energy saving potential of public buildings.

Energy efficiency measures in public bodies are also supported by the National Energy Network detailed in point 3.2.i.

We have imposed a legal obligation on the managers of public institutions to fulfil the obligations and to exploit the energy saving potential of the operation of public buildings. We will set up a system of personal interests for operators of public institutions. We clarify the rules for the use of proposals from energy auditors and policy officers.

The ministerial decree defining the energy characteristics of buildings, as amended from 1 November 2023, and the Government Decree on the certification of the energy characteristics of buildings, which will result in a modern system and more detailed renovation proposals than in the previous ones, could assist in the design and evaluation of renovations.

The transparent certificate model shows graphically the energy use of the whole building (or stand-alone part of the building) and of each mechanical system with classifications. The certificate sets out detailed proposals for renovation and upgrading with a section, timetable and cost plan. The recommendations can also be beneficial for a better use of energy by the public building stock.

The regulation, which will enter into force on 1 November 2023, will alleviate the complex and outdated requirements for buildingers and for major renovations. Among other things, we will introduce a flexible carbon-based set of requirements, meaning that the renewable share will not be mandatory and that energy requirements can be met with a much wider range of technologies, relaxing the requirements for major renovations, and introducing

[63] In accordance with Article 18 of Directive 2012/27/EU.

more flexible technical building rules for building extensions. Simpler, more flexible conditions may even make improvements leading to a reduction in energy consumption cheaper, investments driven by clearer requirements reduce household overheads, while also promoting the achievement of energy independence targets.

iv. Other planned policies, measures and programmes to achieve national energy efficiency contributions without commitment for 2030 and other objectives referred to in point 2.2 (e.g. measures promoting the exemplary role of public bodies, energy-efficient public procurement, measures to promote energy audits and energy management systems,64consumer information and training measures 65 and other measures to promote energy efficiency66)

Sustainable and climate-friendly energy management is a priority for the economic sector, while preserving industrial performance and further expanding it. The competitiveness of energy- and GHG-intensive industrial activities depends on their ability to produce up to the level of specific energy use and GHG emissions of European industrial competitors. This aspect can be partially monitored through the functioning of the EU Emissions Trading System, through GHG intensity and allowance availability data for domestic sectors and European competitors. **The objective is to achieve at least the EU average for domestic sectors.** As a key tool, the Innovation Fund, managed by the European Commission, needs to be used as much as possible by domestic industrial producers.

While retaining existing energy-intensive industrial sectors, from an energy strategic point of view, industrial investments in high-tech industries of low GHG intensity are aimed at supporting the development of the Hungarian economy in a sustainable and competitive direction.

v. Where applicable, a description of policies and measures to promote the role of local energy communities in contributing to the implementation of policies and measures in points i, ii, iii and iv

There is no energy community notified to the Hungarian Energy and Public Utility Regulatory Authority in Hungary. At the same time, twenty-one renewable energy communities have been awarded support for photovoltaic electricity generation programmes under two support schemes.

(See also point (v) of Chapter 3.1.2)

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[64] In accordance with Article 8 of Directive 2012/27/EU.

[65] In accordance with Articles 12 and 17 of Directive 2012/27/EU

[66] In accordance with Article 19 of Directive 2012/27/EU.

vi. Description of measures to develop measures to utilise energy efficiency potentials of gas and electricity infrastructure67

The issue of the use of gas pipelines and, in this context, the development of network access charges is also relevant at the level of the distribution network. Our goal – is 1772/2018. (XII. Examine – the removal of distribution lines68 with low utilisation (less than 10 %) from the public-funded system and explore alternative uses of these pipelines, in accordance with Government Decision No 21/2015.

In the electricity sector, we install 1 million smart meters. It is stipulated that, once certain conditions are met, conventional meters can only be replaced by smart meters at the end of their validity, the cost of which should not be borne by consumers. At the same time**, we aim to offer smart meter customers a flexible tariff that encourages them to make better use of the network.**

In addition, the upcoming REPowerEU chapter of the Recovery and Resilience Plan would focus on energy efficiency improvements in natural gas storages that also improve security of supply.

vii. Where relevant, regional cooperation in this area

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

The Recovery and Resilience Plan, including the REPowerEU chapter, KEHOP Plus and TOP Plus, would provide a total of around HUF 800 billion for energy efficiency for businesses, citizens and public buildings.

We also have at our disposal the revenues generated by Member States as part of the EU ETS quotas, the revenues of which, according to the previous rules, must be spent at least 50 % on greening; From 2024 onwards, this share will be 100 %. Greening under the Directive includes 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.

We also count on the new Social Climate Fund 2026-2032, of which Hungary will contribute 4.33 % to around EUR 2.816 billion. In order to draw up the funds, a Social Climate Plan needs to be prepared and we will start preparing it. Eligible measures shall include, inter alia, increasing the energy efficiency of buildings, building renovation, decarbonisation of

[67] In accordance with Article 15(2) of Directive 2012/27/EU.

[68] Government Decree No 1772/2018 (XII. Government Decision of 21 December 2006 on the decisions used as a basis for the new National Energy Strategy

heating and cooling of buildings, facilitating the uptake of zero- and low-emission mobility and transport, and direct income support.

According to Section 15/E(2) of Act LVII of 2015 on energy efficiency, the revenues from the energy efficiency levy must be used primarily to finance alternative policy measures to improve the energy efficiency of the households to be supported.

3.3. **Dimension energy security 69**

i. Policies and measures related to the elements set out in point 2.3 70

Oil and natural gas markets

In the changed geopolitical context, greater emphasis should also be placed on security of oil supply. Our aim is to maintain import exposure at manageable levels and diversify supply. In **addition to increasing domestic production, there could be a tangible means of increasing the capacity of the Adria oil pipeline, while also increasing the flexibility of refinery capacities,** which also requires the cooperation of the Croatian side. It is also essential to **maintain the quality of our security of supply system based on strategic stockpiling**.

The need to reduce import exposure is therefore significant in the case of natural gas. One means of reducing exposure is to increase the volume of domestic natural gas extraction on the basis of further guaranteeing the predictability of the concession system and improving the flexibility of the system. In order to strengthen domestic production, new hydrocarbon concession areas are expected to be announced already in 2023.

In addition, energy efficiency measures and interventions encouraging a better use of renewable energy sources (biogas and biomethane, earth heat, solar and wind energy, hydrogen) will be needed.

According to the National Energy Strategy, the Hungarian biogas and biomethane potential offers a realistic option to replace at least 1 % of Hungary’s natural gas consumption by 2030. In 2023, the Hungarian biogas programme will be completed, outlining measures to facilitate the wider exploitation of the biogas potential.

The production, purification and feeding into the gas grid of biogas obtained from agricultural waste, depionies and sewage plants is considered as an option with medium demand for support with high potential.

As biogas can also provide a cost-effective supply of energy to municipalities without a natural gas network or using the existing network at a very low level, based on local resources,

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[69] Policies and measures shall reflect the energy efficiency first principle.
[70] Bconsistency 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.

and economic activities that increase the population retention power of the countryside on biogas production, we intend to support these innovative investments directly.

In addition to biogas and biomethane, Hungary considers re and derivatives of ‘clean’ **hydrogen**as an alternative. The composition of “classical fossil” natural gas is expected to be gradually modified in the future due to alternative and renewable energy sources fed into the grid (e.g. biomethane, hydrogen, e-methane, etc.). These new items are gradually reducing the share of fossil gas. In 2022, the ENTSO-G Ten-Year Network Development Plan already describes the existing gas transmission system as a ‘methane’ system, thus underlining the expected changing gas composition and decreasing share of natural gas.

In addition to renewable gases, we build on domestic geothermal assets when replacing natural gas.

Gas consumption in industry will depend primarily on the pace of economic growth. Despite economic growth, our aim is to maintain the relatively low level of consumption in 2022 in the longer term. We support the decarbonisation of industrial production by implementing pilot projects encouraging the use of hydrogen from carbon-free sources.

The remaining import needs should be met from the most diversified sources possible, reducing dependence on one source. However, this does not happen overnight, but Hungary, in cooperation with the countries of the region, is actively seeking ways to reduce dependence on the Russian supplier over a foreseeable timeframe. This requires new sources of independent gas imports and the development of infrastructure to achieve them. In order to create a diversified import portfolio, it is necessary to continue a policy of diversification of the gas market in order to reach Azerbaijan, Black Sea and liquefied natural gas sources.

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We also **want to improve the use of gas storage capacities**. The investment planned in the REPowerEU chapter of Hungary’s Recovery and Resilience Plan aims to reduce the energy use and increase the availability of underground gas storages operated in Hungary. The investment is aimed at the efficiency and security of supply of gas storage facilities and does not include capacity extensions.

The combined objective of reducing natural gas consumption and increasing infrastructure use can be achieved primarily through the **use of the high-pressure natural gas transmission system** for transit purposes, which can be effectively supported by significant domestic storage capacities at regional level. **It is therefore necessary to strengthen competition in the gas storage market and the regional role of domestic installations.**

The **strategic vision of Hungary’s natural gas storage facilities needs to be divided into the short and long term.** The short-term objective is to ensure domestic security of supply by using storage facilities. The longer-term objective is to adapt to the shift of former east-west transport routes to the south-north-west direction. An important pillar of Croatian-Hungarian market coupling could be the Hungarian storage capacity. In the event of the construction of the Slovenian-Hungarian pipeline, storage would also be possible for Western European traders on a direct route. In order to achieve the decarbonisation goals, we will also explore the possibility of converting some of the storage capacities into hydrogen storage.

Only hydrogen transport will require investments in major system transformations, new hydrogen-compatible pipelines and underground storage. The connection to the European hydrogen backbone is an important task for the creation of a future hydrogen infrastructure. In this context, cooperation with neighbouring countries and other stakeholders should be strengthened. FGSZ is already part of a pan-European hydrogen network (European Hydrogen Backbone – EHB) initiative, which plans to complete more than 60 % of the planned hydrogen transport network of around 53 thousand km through the transformation of the current natural gas transmission network. In addition, a regional transit function for hydrogen supply will be warranted in the future.

It is also important to test underground gas storage facilities for hydrogen compatibility. The project of Magyar Natural Gas Storage Zrt. is of decisive importance in this respect. Zrt. The Aquamarine pilot project, although it concerns surface technologies, could be an important milestone for the creation of a hydrogen economy. Under the project, the company set up an electrolysis system with a total capacity of 2.5 MW at the Kardoskút underground gas storage facility. The company is also part of an international consortium that examines the possibilities for storing hydrogen in underground porous rock layers.

Electricity market

The main task is to implement the electricity market vision. The main elements of this from a security of supply perspective are:

i) **Measures to achieve objectives related to capacity adequacy and reduction of import dependency**

- **Ensuring reliable, flexible and diversified domestic production capacities**

In a context of increasing power demand, sufficient availability **of power generation capacities** shall be ensured.

i. In the longer term, weather-dependent and independent renewable technologies are the backbone of the system, as well as modern nuclear technology that can be safely applied in the electricity sector (Paks II investment and extension of the additional period of operation of the Paks Nuclear Power Plant)[71].

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[71] . 1335/2022on taking certain necessary measures related to the energy emergency. (VII. Point 5 of the Government Decision called on the Minister for Energy to take the necessary measures to extend the period of operation of the Paks Nuclear Power Plant. In December 2022, Parliament adopted Decree 56/2022 on the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant. (XII. In the OGY Decision, it took note, by a large majority, of the further extension of the operating hours of the existing units of the Paks Nuclear Power Plant, which served 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 a further extension of service can start. Preparatory activities will take between 9 and 10 years based on the experience of the previous extension.

ii. During the transition, the use of natural gas-based technologies is essential to ensure a continuous and predictable supply of energy, for which a decision was taken to **deploy 1 500 MW CCGT capacity**.

iii. Ensuring security of **supply by maintaining spare capacities** in a period of technological change in our country and in the region as a whole. In order to ensure domestic security of supply, it is appropriate to maintain overcapacity that can contribute to domestic electricity production in critical situations, e.g. during winter days with peak demand, or where the availability of imports is limited due to technical reasons.[72]

- **Exit of lignite-based electricity generation capacity from the electricity market:** building a conventional coal-fired power plant in Europe is no longer profitable in a context of tightening pollutant emission standards and rising GHG emission allowance prices. The lignite blocks of the Mátra power plant will be phased out, placing the more modern blocks in a strategic reserve.

- **Further improve the flexibility capacity of the system through new regulatory capacities guaranteeing safe operation and balancing**. In addition to generation capacities providing flexibility, this includes new types of flexibility services, DSR solutions, energy storage.

- **Cross-border capacities:** cross-border capacities will be further expanded with the capacity expansion of the Hungarian-Serbian connection.

ii) **Development of infrastructure, regulatory and market environment supporting the integration of renewables**

- Transparency in the **allocation of grid connection capacities should be increased (see the commitment in Hungary's Recovery and Resilience Plan to improve the transparency and predictability of the grid connection** process) in order not to block the connection of renewable generatorsto the grid.

- **The extent to which the uptake of energy storage technologies is hampered by current network charges (hereinafter: RHD)**and what steps could help remove this obstacle, possibly to what extent a favourable RHD regulatory structure could stimulate the uptake of storage technologies.

- **Preparing the grid for decentralised energy production**

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[72] The choice of assets should take into account that the strategic reserve constitutes a capacity mechanism and is thus subject to the strict prior authorisation requirements imposed by Regulation (EU) 2019/943 on the internal market for electricity. Although network reserves have already been maintained by several system operators, the implementation of the Clean Energy Package requires that they be procured in the form of competing frames. The relevant EU regulation is less stringent than strategic reserves and the system operator is able to use such capacities more flexibly. In an arrangement with distributors that are technology-neutral, storage-based and demand-response solutions, a capacity fee could be guaranteed for a longer period of time for assets with such capabilities.

As in the past, renewable production takes place on a decentralised basis, often connected to low or medium-voltage distribution networks. Therefore**, a prerequisite for a rapid increase in renewable penetration is the preparation of the transmission and distribution grids to face the challenges arising from a decentralised and significantly weather-dependent generation structure**. The increase in the share of renewables can only be achieved in parallel with the development and "generisation" of the transmission and **distribution networks, as well as through the development of distribution plant management as a decentralised intervention capability and its transparent market mechanisms** (distribution flexibility market).

Further details can be found in chapter 3.4.3(ii).

iii) With regard to**strengthening the integration of the electricity market in the region and coordinating the functioning of the gas and electricity markets**, Chapter 3.4.3 provides information.

Carbon market

The **implementation of a region-wide decarbonisation strategy and action plan**, with the involvement of stakeholders, is the key to achieving the targets, which has started.

These objectives are linked to the implementation of the **Just Transition Programme**, which covers the counties of Hungary with a carbon-intensive economy, namely Heves, Borsod-Abaúj-Zemplén and Baranya County. The sites of the Mátra power plant are located in Heves and Borsod-Abaúj-Zemplén counties. As described under point (iii) of Chapter 3.2.1, the programme is supported by the Just Transition Fund as part of KEHOP Plus with an envelope of HUF 110 billion.

The sectoral and regional decarbonisation transition shall include:

- 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. On this basis, the revitalisation should pay particular attention to the diversification of the region's economy and labour market and to a just transition, taking advantage of the potential for further use of the site and the plant value chain.
- A significant proportion of households affected by lignite heating in the country live in the Mátra power plant region. During the transition, we aim to provide adequate heating solutions by phasing out lignite and reducing energy consumption.
- The Mátra power plant's large-scale site may be suitable for multi-purpose use beyond energy functions. This includes the expansion and diversification possibilities of the industrial park, the expansion of agricultural or other storage and logistics functions, the conservation and demonstration of mining cultural heritage, habitat reconstruction for tourism and nature conservation purposes or natural water conservation measures.

Mention should be made of the investments made by the **Mátra power plant to fuel** lignite, which the Government has identified as being of major importance for the national economy.

Already in December 2020, MVM, as owner, approved the long-term development programme of the Mátra power plant. The aim of modernisation is to ensure that all new production units are operational during this decade. During the process and future operation, MVM will pay particular attention to the upskilling and employment of workers in the company.

Planned investment elements[73]:

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 lignite mines,

— and preparing for the construction of a small multi-fired power plant.

The transformation of the capacity of the Matra power plant based on sustainable systems is a matter of strategic importance and technology change is a major step forward in improving air quality and reducing CO2 emissions.

At the same time, we want to ensure that, given the substantial domestic lignite wealth, lignite-based production remains available as a strategic reserve.

Coal is an important resource for the country, which we intend to use in the future (e.g. construction materials) and the impact of the use of clean coal technology.

Nuclear safety

According to Act CXVI of 1996 on atomic energy, the use of nuclear energy may be carried out only in possession of the authorisations specified in the legislation and under continuous official supervision. Hungary has also committed itself in international conventions to use nuclear energy only for peaceful purposes, in a safe and secure manner. Nuclear and other radioactive materials are used under strict licensing procedures, control and record keeping to prevent non-proliferation, i.e. nuclear and radiological weapons. Safe operation is ensured by a multifaceted set of regulations and multi-stage, complex, substituted, complementary systems and operating mechanisms to ensure that the use of nuclear energy does not adversely affect the general public. Security is guaranteed by safety solutions, technologies and regulations for the physical protection of nuclear facilities, radioactive waste repositories, nuclear and other radioactive materials.

The establishment of new nuclear units is also possible under strict conditions. A complex, multidisciplinary facility such as a nuclear power plant is not licensed and supervised

[73] https://mert.mvm.hu/hu-HU/Media/Hirek/Zold%20jelzest%20kapott%20a%20matrai%20eromu%20atalakitasa

by a single authority. Each authority issues the necessary authorisations in its own licensing procedures and, as a specialised authority, enforces its own specialised aspects in the procedures of other authorities. The licensing of nuclear safety, security and safeguards for the construction and operation of a nuclear power plant is the responsibility of the Hungarian Atomic Energy Authority (HAEA). Installation-level procedures follow the life cycle of a nuclear installation. Accordingly, the adequacy of the site must be assessed before the substantial part of the project starts, the technical plans and safety analyses of the nuclear power plant must be fully developed, which the authority shall review and, if appropriate, issue the installation permit. The installed installation shall be put into operation, consisting of testing the functionality of the installed systems and subsequently carrying out a series of measurements by installing fuel assemblies containing nuclear fuel. If all the reactor units operate in accordance with the nuclear safety requirements and in accordance with the safety analyses and plans, a longer-term operating licence may be granted to that reactor unit. The HAEA verifies the operation in accordance with the nuclear safety requirements and the licences issued. If a discrepancy is detected, it enforces the standards through a validation process.

The fact that Hungary is 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 details are provided on the HAEA74's website.

It is also important to mention the **strategy to ensure the long-term supply of nuclear materials and fuels**, in particular the expansion of nuclear capacity.

Government Decree 44/2002 on the minimum level of energy carrier stocks for power plants of 50 MW and more and the order of stockpiling (XII. Section 1(1) of the 75 Decree of the Minister for Economy and Transport provides that a producer operating licensee for a power plant with a nominal capacity of 50 MW and above must constitute a normative and safety energy carrier stock per power plant.

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

Act II of 2014 promulgated the Agreement for Cooperation in the Peaceful Uses of Nuclear Energy between the Government of Hungary and the Government of the Russian Federation, which includes obligations relating to the maintenance of the performance of the

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

Paks Nuclear Power Plant and the expansion of capacity, i.e. the construction of new units. The Act is accompanied by several implementing agreements, including the fuel contract, in which the Euratom Supply Agency is co-signed.

The Russian-Ukrainian war has accelerated efforts to diversify nuclear fuel, and the legislation in force in Hungary provides for the theoretical possibility of using different fuel elements in the nuclear power plant.

Digitalisation and cybersecurity

Already today, the operation of the electricity system is deeply pervasive by various digital solutions and applications. Our aim is to raise the level of digitalisation in all sub-sectors of the electricity system and to promote data-based operation and make public network data available to other energy actors.

Cybersecurity has become one of the most important elements of national security, so that one of the conditions for maintaining our sovereignty is to maximise the overall level of cybersecurity. The EU NIS Directive also highlights76 the energy sector in order to ensure a high common level of security of network and information systems.

The Hungarian energy sector should also be ready to address the challenges, threats and risks in cyberspace, ensure an adequate level of cybersecurity, carry out cyber defence tasks, develop cyber resilience and 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.

Sectoral cybersecurity requirements

At present, major organisations involved in the Hungarian electricity system do not fall within the77 scope of Act CLXVI of 2012 on the identification, designation and protection of vital systems and installations, i.e. they have not been designated as vital system elements. Since operators of essential services are designated as operators of designated national critical constituents during the designation process of national critical constituents, the 78 requirements of the NIS Directive on security of network and information systems do not apply to major entities either.

In view of the above, the legislative environment for the protection of vital systems and installations in the domestic energy sector should be adapted in such a way that the thresholds allow major entities to be designated as essential constituents. Furthermore, the designation of operators of essential services should be based on a separate procedure from the procedure for

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[76] 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

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

[78] 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 (https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:32016L1148&from=EN)

the designation of national critical constituents. With the involvement of the relevant professional organisations, it is necessary to draw up a set of sectoral cybersecurity requirements specifically designed for entities operating in the electricity industry, in accordance with Act L of 2013 and Decree No 41/2015. The requirements laid[79] down in Decree No 41/2015 of the Minister for the Interior (also taking into account the fact that Decree No 41/2015 of the Minister for the Interior) Certain provisions of the Decree of the Minister for the Interior in the case of ICS and SCADA systems used in the electricity industry cannot be interpreted or applied due to the operational/use characteristics of these systems). The strategic objective is to continuously improve the ability to prevent, detect and respond by setting standards, organising targeted exercises and creating support tools.

Sectoral cybersecurity information sharing

Information sharing between major organisations involved in the energy sector should be made more effective at both domestic and international level. We intend to launch regular information sharing between the main actors involved in the Hungarian energy sector (energy producers, suppliers, system operators) through government coordination, in order to ensure the safe and secure operation of the energy systems. In this context, possibilities for automated sharing of relevant electricity-related cybersecurity information should be developed.

Setting up a rapid response unit for incident management

The unit shall provide on-site support to individual actors in the event of cybersecurity incidents. (trace recording, threat analysis, network security monitoring, incident management, analysis of various attackers' tools and methods)

Human resources issues

Settings in accordance with the minimum safety requirements laid down in the legal requirements are of primary importance. The continued supply of qualified and experienced professionals to cybersecurity operational activities is the most important measure to improve the cybersecurity landscape.

Improving the labour market situation in the energy sector

In order to improve the labour market situation in the energy sector**, it is necessary to improve the quality of specialised education and to make better use of the potential of the dual training system.** Following the assessment of educational needs and the identification of shortages, the number of students in the field of energy engineering needs to be increased by means of guidance programmes. Corporate wage developments and the development of a solid vision can play a major role in mitigating the drainage effects of other industries.

Economic structural changes towards lower carbon-intensity energy production and use can also bring about significant changes in employment needs and opportunities

outside the energy sector. It is therefore necessary to develop a programme to meet the human needs of the green economy, providing an opportunity to monitor labour market processes associated with the energy transition; it helps to improve the employment opportunities of the workforce in green economic sectors and provides support for upskilling and reskilling of the vulnerable workforce.

ii. Regional cooperation in this area

CESEC

Hungary is a member of the Visegrad Cooperation and the Central and South-Eastern Europe High Level Group on Energy Connectivity (CESEC)[80], where energy and climate policy issues relevant to the NECP are regularly discussed. The High Level Group on Energy Connectivity in Central and South-Eastern Europe, set up in 2015, bringing together 9 Member States of the European Union and 8 other countries, aims to accelerate the integration of electricity and gas markets in the region.

Visegrad Cooperation

Visegrad Cooperation is a regional organisation of Czechia, Hungary, Poland and Slovakia. The purpose of cooperation shall be to jointly represent the economic, diplomatic and political interests of these Central European countries and to coordinate their possible actions.

Consultations between the Visegrad States ("Visegrád Four" or "V4s") shall take place on the following issues:

- establishing a common position within the European Union on the development paths of the energy sector,
- scientific research and development cooperation (including discussions to develop a dedicated cooperation platform for energy RDI),
- exchange experience on the development of the energy sector, including in the field of cooperation with individual technology suppliers, in particular suppliers of nuclear technologies.

Other forums

The **Hungarian Government and the Hungarian energy companies**, including system operators, and **the Hungarian regulatory authority** (MEKH) **participate in a number of organisations and working groups,** thereby strengthening security of supply in Hungary.

<u>Gas market</u>

- Gas Coordination Task Force (European Commission)

[80] Central and South East Eruope Energy Connectivity

As a result of the Security of Gas Supply Regulation (994/2010), the Gas Coordination Group (GCG) has met regularly since 2012 to coordinate security of gas supply measures between EU countries. Hungarian participation in the meetings is also 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 is actively involved in ENTSO-G projects that have a direct impact on its activities, such as the development of the single European network codes and the preparation 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 system, storage and LNG terminal operators, vis-à- 81vis individual institutions of the European Union (European Commission, Parliament, Council of the European Union) and European Regulatory Authorities Organisations (ACER, CEER). Hungary is also a member of MMBF Hungarian Natural Gas Storage Zrt. The chairmanship of the Gas Infrastructure Europe (GIE) storage organisation is held by the Hungarian Natural Gas Storage Company, so that Hungarian participation is very active in the implementation of EU decarbonisation efforts in the storage market, bearing in mind the benefits of the current natural gas infrastructure.

Oil market

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

Other

- Participation of a regulatory authority in ACER's activities.
- Regional coordination during the planning of the NECP. More details can be found in Chapter 1.4.

Electricity market

- Task Force for Electricity Coordination (ECG)
- Participation of its system managers (MAVIR ZRt.) in various organisations and forums:

On the basis of the Electricity Energy 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 management organisations, to continuously coordinate cooperation, to

[81] Council of European Energy Regulators

pursue Hungarian interests and to participate in the work of the management bodies and working groups of each organisation.

MAVIR ZRt. participates in a number of international organisations and fora. The most important ones are:

- European Network of Transmission System Operators for Electricity (ENTSO-E),
- Cooperation between 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).

Cooperation on nuclear matters82:

On the basis of 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 field of 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 in relation to the safe use of nuclear energy in relation to nuclear safety, safe management of radioactive waste and spent fuel, nuclear accident response, nuclear security, non-proliferation and liability for nuclear damage,
- prepare national reports under international and European Union obligations on nuclear safety and safe management and shipment of radioactive waste and spent fuel.

As a result of the HAEA's international activities in the field of multilateral relations, Hungary is actively party to all relevant multilateral international treaties relating to the peaceful use of nuclear energy and the full implementation of their provisions. Representatives of the HAEA continue to play an active role in universal and regional international organisations established on the basis of international treaties on the safety and security of

[82] https://www.haea.gov.hu/web/v3/OAHPortal.nsf/web?openagent&menu=02&submenu=2_7

nuclear energy use, in organisations 83 and fora set up for the implementation of84certain multilateral international treaties and in other fora forms of international cooperation85. In addition, the HAEA has developed bilateral international relations.

iii. Where applicable, financing measures in this area at national level, including Union support and the use of Union funds

Information on PCI projects is provided in chapter 3.4.2 (iii).

3.4. Dimension internal energy market 86

A number of measures enhancing security of supply and strengthening the internal energy market are described in Chapter 3.3. Measures that are more closely linked to the issue are presented here.

A high level of compliance with the obligations laid down in European and domestic legislation to strengthen the internal energy market is necessary in order to achieve the objectives.

3.4.1. Electricity infrastructure

i. Policies and measures to achieve the targeted level of interconnectivity as set out in point (d) of Article 4

Hungary is significantly above the EU's target of 15 %. Nevertheless, we are planning to further increase cross-border capacities, where the Serbian-Hungarian cross-border capacity expansion will play a crucial role.

Further information can be found in the Security of Supply chapter (Chapter 3.4(ii)).

ii. Regional cooperation in this area 87

There is continuous communication between system operators and, typically,88good cooperation has been established during the implementation of projects, in particular in the case

[83] Nuclear Suppliers Group, Zangger Committee

[84] International Atomic Energy Agency, Organisation for Economic Cooperation and Development, European Atomic Energy Community, Comprehensive Nuclear-Test-Ban Treaty

[85] Western European Nuclear Regulators Association, European Safeguards Research and Development Association, Association of Competent Authorities in the European Nuclear Protection Area, Meeting of Leaders of European Radiation Protection Authorities, WWER Authority Forum, Association of Competent Authorities in the area of Safe and Sustainable Transport of Radioactive Materials

[86]Policies and measures shall reflect the energy efficiency first principle.

[87] Other than the PCI Regional Groups established under Regulation (EU) No 347/2013.

[88]Slovenská elektrizačná prenosová sústava, a.s. (Slovene system operator)

of the operators of the Slovak-Hungarian electricity system (MAVIR ZRt. and SEPS). Further information can be found in the security of supply chapter (Chapter 3.4(ii)).

iii. Where applicable, financing measures in this area at national level, including Union support and the use of Union funds

3.4.2. Energy transmission infrastructure

i. Policies and measures related to the elements set out in point 2.4.2, including, where applicable, specific measures to enable the delivery of Projects of Common Interest (PCIs) and other key infrastructure projects

Natural gas projects

Further significant expansion of the domestic pipeline system is necessary only in the context of the development of cross-border capacities, linked to the diversification of supply routes. This leads to an increase and deepening of the liquidity of the domestic natural gas market, which overall benefits the consumer.

The FGSZ's 'Ten Annual Network Development Plan'[89] includes the pipeline projects planned over the next 10 years. The main task is to make better use of and rationalise existing infrastructure. The aim is to phase out distribution pipelines with low load (below 10 %) from the publicly funded system by offering low carbon intensity heating alternatives.

As an alternative to the phasing-out of low-use distribution lines and the achievement of climate protection objectives, enabling the grid to feed hydrogen can play a key role. The production and supply of hydrogen (and synthetic gases) to the distribution system also reduces dependence on natural gas and provides cheap, flexible energy storage options. Therefore, our aim is to create the conditions and incentives for the introduction of hydrogen and other "natural gas" gases into the system.

Electricity projects

- **Further increase cross-border capacities by increasing** Serbian-Hungarian cross-border capacity (see security of supply chapter).
- In order to integrate renewable energy producers, **significant cost-effective grid development** is justified, which has already started at transmission and distribution grid level. In this context, we will prepare the electricity grid, in particular the distribution network, for the increasing spread of decentralised capacities.

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

ii. *Regional cooperation in this area90*

There is continuous communication between system operators and, typically, good cooperation has been established during the implementation of projects, particularly in the case of Slovak-Hungarian electricity system operators (MAVIR and SEPS). The security of supply chapter is also relevant to this topic. (Chapter 3.4(ii))

iii. *Where applicable, financing measures in this area at national level, including Union support and the use of Union funds*

In order to ensure a cost-effective level of support, operational type support for renewable energy plants can only be obtained in a competitive procedure within the framework of the METÁR scheme.91

As mentioned above, in the coming years, the development and digitalisation of the electricity grid and the installation of energy storages are planned, partly from public sources, as energy transition efforts require modern and flexible electricity grid operation. Until 2030, the following resources are available in Hungary for these purposes:

- In Hungary's Recovery and Resilience Plan, a total of HUF 306 billion was planned for the following elements:
    - Classical electricity grid development
    - Network energy storage for market participants and network operators
    - Installation of smart meters
- The REPowerEU chapter to complement the Recovery and Resilience Plan, for which Hungary plans to borrow a significant amount of loans from Member States in addition to RRF financial resources, is currently planned – **a total of HUF 534,35 billion** is planned for the following elements:
    - Classical electricity grid development
    - Digital developments on the network
    - Installation of smart meters
    - Improving the accuracy of weather forecasts to promote renewable-based production
- The Environment and Energy Efficiency Operational Programme Plus includes a **total of HUF 173 billion** for the development of flexibility of transmission and distribution networks and systems, the promotion of smart energy systems and energy storage.

[90] Other than the PCI Regional Groups established under Regulation (EU) No 347/2013.
[91] During the first half of 2019, the existing provisions reducing aid effectiveness in the KÁT and METÁR schemes were amended in two stages.

- In addition to national funds, the Modernisation Fund provides support for the installation of energy storage facilities in the domestic system management companies for a**total amount of HUF 33 billion**. Investments are already in the process of being implemented.

In total, the Hungarian State and the European Union are contributing to the development and development of flexible modern electricity distribution and transmission networks with a total of HUF 1046 billion.

3.4.3. Market integration

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

Gas market

Further expansion of cross-border capacities is also planned for security of supply and market integration purposes:

i. construction**of a Hungarian-Slovenian cross-border gas pipeline**that would allow bi-directional transport between countries.

ii. increase**of Romanian-Hungarian cross-border** capacity. The possibility of 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 Azeri origin to Hungary via Romania, linking it to the planned Solidarity Artic route (Bulgaria – Romania – Hungary – Slovakia).

   It is possible to increase the capacity of the Romanian-Hungarian cross-border point in the RO>HU direction with a minimum extension from the current 300.000 m^3/h to up to 365.000 m^3/h, which can be additional gas from Azerbaijan or from Turkish and Greek LNG terminals on the Türkiye-Bulgaria-Romania-Hungary route.

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

Petroleum

Our primary objective is to achieve greater diversification of imports, which can be achieved through two parallel investments:

i. **Increase the capacity of the Adria oil pipeline,** if implemented by the Croatian side.

ii. **Increasing the flexibility of the Danube Refinery (refinery reconfiguration),** aiming at 100 % processing of crude oil from non-Russian origin.

Electricity market

Creatinginfrastructure elements to support the integration of **renewable energy producers (energy storages, fast start-up natural gas power plants), regulatory and market environments, and in line with this, making the integration of renewable investments more cost-effective is important.** It is very important that the level of possible aid should follow the reduction of investment costs for all technologies, thus avoiding over-subsidisation.

i) **Ensuring the availability of flexible capacities guaranteeing safe operation and balancing:**

The need for resources to provide flexibility and regulatory capabilities has increased significantly in recent years. One of the main factors in achieving cost-effectiveness was the modification of the reserve size methodology in 2023. The new reserve size is based on the likelihood of imbalances occurring over the last two years, complemented by the estimated impact of other factors such as weather conditions. The new methodology takes into account the IGCC for the amount of aFRR to be booked, which is the netting of simultaneous counter-balancing in the international region formed by system operators, without activating regulatory energy. In addition, the sizing of mFRR reserves takes into account the virtually continuous availability (in operation) of rotating units. The new methodology met preliminary expectations for the first month, with the decrease in the volume of reserves acquired (with the exception of positive mFRR) reducing the average FRR capacity tariffs, resulting in a significant reduction in the cost of capacity booking for FRR.

ii) **Creation of a new CCGT capacity of 1 500 MW to support the flexibility needs of the electricity system**

There are 1500 megawatts of modern power generation capacity at Tiszai power plant in Tiszaújváros and Mátra in Viseonta to cater for increasing electricity demand. The MVM Group launched open conditional tendering procedures for the construction of combined cycle gas turbine power units in Borsod and Heves County. The developments will strengthen Hungary's energy sovereignty by increasing domestic electricity production. Modern facilities enable more efficient use of natural gas and hydrogen, with a higher share of renewable energy.

iii) **Installation of electricity storage capacities in the form of integrated elements at the system operator and network licensees:**

The energy storage market is practically non-existent today (currently around 20-25 MW installed battery capacity is in place). We want to boost it through a combination of legislative and financial incentives.

Regulatory incentives:

It is necessary to develop and develop a transparent, specific regulatory framework, including grid connection and operating authorisation procedures, in[92] order to facilitate the rapid integration of storage capacities into the grid and to increase the supply side of the balancing market.

Financial incentives:

- With the joint use of the **Modernisation Fund** and Member State funding, a call for tenders was launched in 2022 for companies holding a network operator licence to support the implementation of energy storage as a fully integrated network element. As a result of the tender, a capacity of at least 66 MWh is expected to be deployed by the first semester of 2025.
- The **Recovery and Resilience Plan**also includes investments for the installation of network storages in the transmission system operator and distribution companies to increase network security, and for market participants already present or wishing to enter the balancing market (e.g. aggregators, electricity producers and large industrial consumers) to purchase and operate storage assets. In addition to investment aid, the aid scheme to promote the deployment of energy storages, which is to be announced to market participants, provides long-term support (10 years) in the form of income compensation with lower investment aid.

Facilitating the functioning of energy communities

The aim is to review and, if necessary, amend existing legislation on energy communities in order to simplify the functioning of the energy community.

iv) **Supporting independent aggregators**

In order to encourage the participation of aggregate demand responses, Hungary continuously seeks to improve market regulation with the aim of reducing barriers for decentralised market participants.

v) **Increase the digitalisation of the electricity system**

- The electricity grid and the system as a whole have reached a level of complexity that can only be monitored and controlled by continuous measurement and analysis of measured data supported by IT processing and artificial intelligence. The necessary improvements should be made to all relevant actors.
- Data should be stored in well-structured, protected and built into decision-making databases. Building databases that are still missing (e.g. for managing data from smart meters) is a top priority.

[92] Specifying the specific market services that may be provided by storage system operators.

- There is also a need for continuous improvement of the operational applications of major energy actors.
- It is necessary to ensure that the data generated is made available to other energy actors.

vi) **Encourage the uptake of smart metering**

National legislation requires the installation of smart meters for certain consumers at their point of consumption. Government Decree 273/2007 implementing certain provisions of Act LXXXVI of 2007 on electricity A smart meter will be installed for low-voltage users on the basis of Government Decree (X. 19.) in the case of annual use equal to or above 5 000 kWh; 3x32 A for new connections with a power demand not exceeding 3x80 A; and for users who already have a small household power plant or will install such a system in the future.

An investment in the Recovery and Resilience Plan aims at facilitating the fulfilment of this requirement. The planned investment contributes to the fulfilment of the legal obligation described, covering about half of it. The use of smart meters will play an important role as a tool to accurately define customer profiles and optimise electricity demand, and their data collection and communication functions can be used in a wide range of applications. Smart meters shall be remotely operated and may switch on and off the nominal power of the meter when measured directly, provide controllability and include a communication module. The introduction of smart meters and flexible tariffs based on them is the basis for demand response options, which will help build the flexibility of the electricity system in the long term. The beneficiaries of the investment are the distribution companies selected on the basis of a tender. The aid scheme is allocated in proportion to the consumption sites involved in the smart metering in the geographical area in which each distribution company operates.

With regard to encouraging the uptake of smart metering, Hungary plans to require that traditional clocks can only be replaced by smart meters when they expire, provided that certain conditions are met.

vii) **Promotion and integration of demand response**

There should also be scope for the spread of new innovative solutions, such as energy storage and demand response (DSR) solutions, to stimulate the integration of renewable energy production in the electricity grid**.**

System-wide regulation requires the inclusion of significant consumption side control options, HVV (voice-frequency central control) and RVV (radio-frequency control)systems associated with controlled connection points. The main regulatory task is to create incentives, the most obvious instrument being to create a flexible tariff structure.

In order to further integrate the potential of DSR, the **introduction of a separate product for flexible consumption in the market for system-level services may also be justified.**

The creation of a legislative environment for the creation of independent aggregators is also key to unlocking the potential of DSR.

Opportunities can be exploited through digital and smart tools. Active participation of consumers in the energy market gives them the opportunity to keep their overheads under control, while also helping to maintain system balance by providing flexibility services.

viii) **Introducing innovative market organisation practices and enhancing consumer services**

An example of such a novel solution could be the expansion and targeted use of heat storage in the population as a contribution to balancing the electricity system. This solution is beneficial in several respects: it generates lower investment than storage solutions for electricity, lower balancing costs and better use of ambient heat when combined with a heat pump.

ix) **Networking measures**

The electricity grid, in particular the distribution network, should be prepared for the increasing spread of decentralised capacities. Distributors should also be prepared for active system operation. Market mechanisms for the active operation of the distribution network should be put in place, distributors should develop locally based voltage control and congestion management flexibility markets.

For this, see also points 2.4.2 and 2.4.3 below.

x) **Market coupling:** In addition to increasing cross-border capacity, the interconnection of markets and the efficiency of the functioning of interconnected markets should be increased. It is therefore also a task to further strengthen the interconnection of intraday and day-ahead markets and to operate them efficiently.

1. The introduction of cross-border auctions in intraday markets is expected to start in 2024, instead of current continuous trading, and flow-based capacity allocation is expected to be introduced in the course of 2025.
2. In the context of the integration of balancing markets, timely implementation of the93 connection to PICASSO (Platform for the International Coordination of Automated Frequency Restoration94 and Stable System Operation) and MARI (Manually Activated Reserves Initiative) is warranted, for which the necessary IT developments are already underway.

ii. Measures to increase the flexibility of energy systems for renewable energy generation, such as smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, redispatching and

[93] Mari is an early implementation project concerning the European platform for exchanging balancing energy from EB GL manually activated frequency restoration reserves, which aims to fulfil EB GL requirements as soon as possible.

[94] PICASSO aims to design and further develop an operational platform that collects tenders from all relevant TSOs (TSOs) and allows for the optimal distribution of the market product (energy settlement from frequency restoration reserve with automatic activation, energy balancing from aFRR) to adequately meet the needs of the participating TSOs.

curtailment and real-time price signals, including the introduction of intraday market coupling and cross-border balancing markets

Preparing a distribution network for the development of decentralised energy production

Establish the market mechanisms necessary for the active operation of the distribution network and develop a flexibility market for voltage regulation and congestion management distribution distributors providing in-situ price indicators taking into account regional specificities.

Close cooperation between the transmission system operator responsible for the balancing energy market and the distributors is necessary in order to ensure that the functioning of the two markets is mutually beneficial and that demand at different voltage levels does not cause cross-effects and thus generate additional costs.

<u>Making the integration of renewable investments cost-effective.</u>

- Efficient scheduling as required by Article 5 of Regulation (EU) 2019/943 on the internal market for electricity requires high resolution and reliable meteorological forecasts to enable the OMSZ to provide a more accurate weather forecast. .

  (Given that the OMSZ has an inevitable role and task in supporting energy neutrality efforts and the integration of renewable energies inhis district, the organisation's activitiesinthe future will bescientific and climate researchtasks.)

- Develop**a compensation scheme, i.e. equalisation aid scheme**, to increase the regulatory capacity of the generators of the feed-in system and of the METÁR-KÁT system below 0.5 MW. If the increase in the cost of generating balancing energy is due to poor scheduling, it reduces the level of compensation, including the burden on cost bearers;

- **Encouraging the development of a diversified renewable portfolio**: exploiting domestic bioenergy potentials and small hydropower generation capacities in addition to solar energy;

- **Encouraging the connection of renewable electricity production to the market balance group instead of the mandatory participation of renewable electricity production in the KÁT balance group** led by the system operator as the balance group manager, while maintaining the conditions for support, in order to facilitate market integration.

Investments in energy storage and micro-grid solutions (facilitating single-site operation of renewables and energy storage through regulatory tools) should be encouraged.

See also point (ii) of this Chapter and Chapter 3.3.

iii. Where applicable, measures to ensure the non-discriminatory participation of renewable energy, demand response and storage, including via aggregation, in all energy markets

Transparency and economic efficiency in the allocation of grid connection capacities should be increased in order to ensure that the connection of renewable generators to the grid is not hampered by 'low quality' or 'low-end' power plant projects. For example, non-discriminatory capacity auctions announced at regular intervals are good tools.

- Generators with a connection power above 0.4 MW shall be included in voltage regulation.
- **Encouraging the connection of renewable electricity production to the market balance group instead of the mandatory participation of renewable electricity production in the KÁT balance group** led by the system operator as the balance group manager, while maintaining the conditions for support, in order to facilitate market integration.

iv. Policies and measures to protect consumers, especially vulnerable and, where applicable, energy poor consumers, and to improve the competitiveness and contestability of the retail energy market

In addition to energy efficiency measures, encouraging more active consumer participation can contribute to increasing the level of consumer protection. Enabling consumers to play an active role in the market is essential if consumption can be regulated where it is not yet possible to do so. The use of smart meters in the electricity and gas sectors is needed much wider than is currently the case.

The development of **'Smart Regulation'** seeks to provide positive incentives for distributors to introduce new products and innovative technologies, as well as increased opportunities for suppliers to prioritise digital administration. (More details can be found under point 5(iii) of Chapter 3.3)

The most important technological task is the **introduction of smart meters**, which are also capable of managing time-based tariffs. Due to the large number of installation of smart metering devices, consideration should also be given to the possibility of producing them domestically.

Encouraging more active consumer participation can contribute to increasing the level of consumer protection. Enabling consumers to play an active role in the market is essential if consumption can be regulated where it is not yet possible to do so. The use of smart meters in the electricity and gas sectors is needed much wider than is currently the case.

v. Description of measures to enable and develop demand response, including those addressing tariffs to support dynamic pricing 95

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

The answer to this question under (i) of this Chapter and under point (i) of Chapter 3.3 is relevant.

3.4.4. Energy poverty

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

The aim is to reduce the number of vulnerable consumers that we intend to achieve through integrated support in the relevant programmes, for example in the area of energy efficiency.

3.5. Dimension research, innovation and competitiveness

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

The implementation of the measures identified in the existing NECP remains essential, with new areas such as carbon capture technology and hydrogen being highlighted.

The most concrete challenges for energy innovation are:

i. **To ensure system balance**, we want to encourage the uptake of innovative technologies and modes of operation that help to improve the controllability of the electricity system while minimising the need for network development investments and allowing the integration of renewable, decentralised generation to the greatest extent possible. The proposed programme focuses on promoting energy storage, strengthening the possibilities/obligations of weather-dependent producers to support balancing, stimulating demand-side adaptation of consumers and rethinking the competences of the Transmission System Operator (TSO) and Distributors (DSOs).

ii. Incentivising **innovative seasonal electricity and heat storage solutions**, the aim is to facilitate the development of technologies that can store large amounts of energy over a longer period (even months). In addition to electricity storage, the programme may be extended to heat and cold storage.

iii. **The aim of promoting innovative modes of energy** supply is to ensure that electricity produced from renewable sources is consumed locally. This should reduce the cost of grid losses and simplify the integration of renewable energy sources. On the regulatory side, the energy community as a separate consumer-producer concept and accounting entity should be made more comprehensible. The most important technological task is the introduction of smart metering devices, which can also manage time zone-specific tariffs. Although the barriers to the introduction of the scheme are mainly legislative and technological in nature, reducing the administrative burden associated with the installation and connection of renewable energy producers can bring about substantial cost reductions.

iv. **The development of 'Smart Regulation'** seeks to provide positive incentives for distributors to introduce new products and innovative technologies, as well as increased opportunities for suppliers to prioritise digital administration. Innovative solutions can be used to better stimulate the reduction of electricity consumption, the development of energy communities and investments in energy efficiency and self-generation. In order to facilitate innovation, it is also proposed to develop a "regulatory sander" in which the HEPCA may grant a temporary exemption from meeting certain service parameters in order to test novel solutions.

v. **By supporting nuclear innovation**, innovative services can be developed in Hungary that improve the competitiveness of nuclear power generation and contribute to the maintenance and expansion of domestic nuclear experience.

vi. **The aim of the transport greening programme** is to reduce the growth rate of GHG emissions in the sector by encouraging the uptake of electric vehicles and car use in the Community, as well as the increased use of biofuels. It is also intended to promote the domestic production of electric and hydrogen powered vehicles and to support domestic research on the secondary (energy) use of used car batteries. Particular support is proposed for the use of second-generation biofuels; the related pilot project would serve to test such fuel production technologies (and to empirically assess their domestic cost and competitiveness).

vii. **Carbon capture, storage and valorisation technologies (CCS and** CCU) have an important role to play in the future of industrial processes that are difficult to decarbonise. There are limited possibilities for storing CO2 captured at home, so we focus on using the captured CO2 in the first place. The change in the regulatory environment in the EU and the consequent strong rise in quota prices under the emissions trading system and the changes have confirmed the relevance of **carbon capture technologies**, so we also intend to assess the possibilities for their deployment and subsequent deployment in practice.

The use of technology will reduce the proportional financial burden for businesses resulting from ETS quotas, thereby increasing the competitiveness of industry and reducing the country's emissions. It would be possible to support the deployment of technology from the REPower EU chapter of the Recovery Plan.

viii. The National Hydrogen Strategy aims to stimulate the domestic deployment of hydrogen and hydrogen technologies and the creation of a back-up base for the hydrogen industry. Therefore, research and development of the hydrogen ecosystem as a whole is important. The use of green hydrogen is also facilitated by the production of hydrogen by other means than electrolysis, e.g. by biological means. Such research is therefore important for decarbonising industry and transport.

In order for the energy investments described in the NECP to be feasible, it is essential to produce some of the green technologies domestically and to expand the related domestic contractor capacity. 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.

In[96] line with the Commission Communication "An SME Strategy for a sustainable and digital Europe", the focus of the supported activities is to be achieved through the development of technological renewal of SMEs, the deployment of green and digital solutions, innovation-building and the development of entrepreneurship. The Economic Development and Innovation Operational Programme (GINOP) Plus and the REPower EU chapter of the Recovery Plan would be in the first place, but KEHOP Plus Priority Axis 5 (Just Transition Fund) would also provide funding for the implementation of the just transition plan for the Baranya, Heves and Borsod-Abaúj-Zemplén counties. (Details under Chapter 3.2.1 (iii))

It is linked to the above that, in addition to technologies, it is important to develop and train human resources, labour market entrants and professionals already present in the labour market. We need to make the specific knowledge and skills necessary for the functioning of the green economy, be it in building energy, the safe management of hydrogen or the purification of biogas.

As a result of strengthening competitiveness, we want to increase the skills base needed for the energy transition, by increasing training (both vocational and higher education) and by developing teaching materials by making knowledge production more efficient. The development and training of human resources, labour market entrants and professionals already present in the labour market is an important task. We need to make the specific knowledge and skills necessary for the functioning of the green economy, be it in building energy, the safe management of hydrogen or the purification of biogas. In addition, cooperation in R & D within industry and with universities needs to be further strengthened and made more effective. The development of human resources would be partly financed under the EU heading of the Recovery Plan REPower. However, priority axis 5 of KEHOP Plus mentioned above is also relevant.

In order to make better use of the opportunities offered by the Innovation Fund, dissemination of current information about the Fund among domestic stakeholders can further strengthen the innovation capacity and competitiveness of domestic enterprises.

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

V4 cooperation in R & D and innovation

Regular meetings will be held to raise the profile of economic and scientific diplomacy in the region. Regional cooperation between the V4 countries allows members to participate in joint international programmes more effectively, to better make use of their resources and to enhance their appeal to foreign partners to establish long-term cooperation.

[96] https://eur-lex.europa.eu/legal-content/HU/TXT/?uri=COM%3A2020%3A103%3AFIN

In the context of the V4 cooperation, the Think.BDPST conference, which has been held annually since 2016 by the József Antall Knowledge Centre with the contribution of the Ministry of Foreign Affairs and Trade and the International Visegrad Fund. The strategic conference will focus on strengthening cooperation between V4 countries in research, innovation and technologies for the future.

The Ministry of Economy of the Slovak Republic organised a V4 Energy Task Force, which took place in Bratislava on 27 April 2023. The aim of the Task Force was to present Member States' commitments and achievements in relation to the NECP and to discuss issues and problems related to the achievement of the targets. The Working Party placed particular emphasis on energy efficiency and renewable energy sources.

In 2010, the ALLEGRO project was set up by the V4 countries' nuclear research institutes to build a fourth generation gas-cooled rapid reactor and demonstrate the incineration of high-activity waste in spent fuel. The French CEA Institute is another scientific contributor to the V4 cooperation. The scientific work under the ALLEGRO project is also supported by EURATOM.

Energy Technology Strategy Plan (SET Plan)

The European Commission aims to promote the Energy Union in R & D and to take the lead in renewable energy technologies through the implementation of the revised SET Plan, which the European Commission set up in 2008 in order to provide a technology-based stimulus for climate and energy policies in 2020. Hungary is currently represented in five out of 10 working groups (TWG):

- SET-Plan High Voltage DC and DC TWG (SET Plan – HVDC & DC TWG)
- Set-Plan Battery (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 cooperations

- Participation in international relations, in particular the European Union's EURATOM programme and the work of the International Atomic Energy Agency (IAEA), is an important element in the training of professionals.

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

97Hungary joined the European Organisation for Nuclear Research (CERN) in Geneva in 1992. Over the past years, Hungary's involvement in the construction and operation of experiments in CERN, in the evaluation of the data obtained and in the understanding of the physical results has increased significantly. According to the Wigner Physics Research Centre,

[97] World's largest particulate physics laboratory

“based on the level of the Hungarian contribution, we can also consider that 1 % of CERN is a Hungarian research institute, and the Hungarian high energy physical research site.” 98

- **Thermonuclear plasma physics research and development under EURATOM**

Thermonuclear plasma physics research and development are carried out in the framework of EURATOM in international cooperation, mainly on and in connection with large European equipment. As measured by international standards, our Hungarian researchers have made significant progress in researching the turbulent state of plasma and in testing the plasma behaviour of macroscopic fragments of material introduced into plasma. 99

- **Participation of the Hungarian Atomic Energy Authority (OAH) in the European Safeguards Research and Development Association**

Founded in 1969, the European Safeguards Research and Development Association brings together European organisations active in the field of nuclear safeguards. The main objective of the organisation is to coordinate and facilitate research and development activities in the field of nuclear safeguards.

- **Participation in the OECD Nuclear Energy Agency (NEA)**

Hungarian experts actively participate in the OECD NEA working groups and research projects on safe, environmentally friendly and economic use of nuclear energy. These working groups and projects carry out world-class activities, the results of which feed into domestic nuclear developments. In the development of new generations of nuclear reactors, the international coordination role of the OECD NEA is of paramount importance.

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

In the framework of IAEA research projects, Hungarian experts have been successfully involved in the development of 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 the extension of the lifetime of nuclear power plants. The IAEA has selected the Budapest-based Energy Research Centre as a cooperative partner in the field of nuclear forensic analysis.

International partnerships under Horizon Europe

Horizon Europe European Partnerships are research and innovation initiatives and programmes linked to major societal challenges, in collaboration and mostly co-funding between the European Commission and public and private actors. By encouraging cooperation between the Commission, Member States’ research funding organisations and relevant industry

[98] http://www.rmki.kfki.hu/kutatas/CERN.html
[99] http://www.rmki.kfki.hu/plasma/rolunk.html

actors, the Partnerships will contribute to strengthening the coordination of research and innovation programmes across Europe and to making investment in research and development more effective, and thus constitute one of the main tools for achieving the European Research Area. They also aim to contribute to the Union's policy objectives. Partnerships are built closely on the different types of partnership initiatives launched under Horizon 2020 (ERA-Net Cofund, European Joint Programme Cofund, Joint Programmes, Joint Technology Initiatives, contractual public-private partnerships, EIT KICs, etc.), but the set of instruments was significantly renewed at the start of the new Framework Programme. Partnerships can be divided into three categories: co-programmed, co-financed or institutionalised partnerships.

Under the Climate, Energy and Mobility cluster, we were linked to the following partnerships:

- Driving Urban Transitions (DUT) – Partnership for Sustainable Urban Development
- Clean Energy Transition Partnership (CETP)
- Built4People | People-centric sustainable built environment
- BATT4EU|Towards a competitive European industrial battery value chain for stationary applications and emobility | Partnership**for**a competitive European industrial battery value chain
- Clean Hydrogen Partnership
- Towards zero-emission road transport partnership (2Zero)
- Connected, Cooperative and Automated Mobility (CCAM) Partnership
- European Partnership for Zero-Emission Waterbone Transport (ZEWT)

Participation in Quant-ERA, FLAG-ERA and M-ERA-NET programmes

The main objectives of ERA -NET[100]programmes are to improve the coordination of publicly funded research programmes implemented at national and regional level, to network national and regional research activities and to mutually open up research programmes at national and regional level.

- ***Participation in M-ERA-NET:*** The M-ERA-NET programme aims to strengthen the coordination of European research programmes in the field of materials science and engineering through joint calls.
- ***Participation in FLAG-ERA II*:** The European Union provides long-term support for promoting research aimed to pursue grand interdisciplinary scientific and technological challenges through FET (Future and Emerging Technologies) and flagship initiatives.

[100] European Research Area

- ***Participation in QuantERA*****:** 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 implemented with projects supported with EU, national and own funds, enabling cooperation in international research with a yearly budget of 100 million EUR for 10 years. The annually launched calls for proposals of the QuantERA Consortium provide support for international research projects relating to the flagship initiatives.

European Institute of Innovation and Technology

The European Institute of Innovation and Technology (EIT) is the EU's educational (higher education), research and innovation institution that coordinates education, industry, business and research in one field to promote a knowledge-based economy in Europe, with a view to increasing competitiveness. In accordance with Decision 2008/634/EC, the EIT shall have its seat in Budapest. The Institute works primarily by developing knowledge and innovation communities across the continent. The cooperation will be based on Science and Innovation Associations (KICs) bringing together higher education institutions, research organisations and businesses, as well as partners working with them. Itthon institutions are not involved as core partners but indirectly in all KICs:

- EIT Climate-KIC: BME
- EIT Raw Materials: University of Miskolc, Bay Zoltán Non-profit Research Centre
- EIT InnoEnergy: Green Brother

Intergovernmental science and technology (S & T) cooperation101

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

One of the priority objectives of bilateral TAT relations is to support RDI cooperation between the two participating countries through tender. International TAT relations are also facilitated by the external TéT Attachés, whose task is to gather information on the host country's R & D and innovation policies, to promote the results of domestic science and technology and to help build bridges between research and innovation communities in both countries, and to support the launch of collaborations. It currently comprises 15 stations (Berlin, Brussels, Vienna, London, Moscow, New York, San Francisco, Paris, Beijing, Seoul, Sao Paulo, Stuttgart, Tel-Aviv, Tokyo and New Delhi). NKFIH, together with the Ministry of

[101] https://nkfih.gov.hu/hivatalrol/nemzetkozi-kapcsolatok

Foreign Affairs and Trade, operates the TéT Attaché network, which carries out scientific and technological diplomacy.

In addition, the NKFIH participates and represents Hungary's interests (EUREKA) and[102]ensures participation in the work of ESFRI and its working groups coordinating European Research Infrastructures, as well as in the EURATOM programme. It shall also coordinate the technical tasks, representation and coordination of expertise 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 domestic policy-making.

In order for Hungary to have a successful innovative energy industry on international markets, it is necessary to step up international cooperation on energy technologies and energy RDI activities and to develop new links. Accordingly, international cooperation on RDI activities that are successful at international level and relevant to domestic priorities should be prioritised, while exploring new opportunities.

iii. Where applicable, financing measures in this area at national level, including Union support and the use of Union funds

The National Fund for Research, Development and Innovation (NKFI Fund) plays an important role in the financing of domestic RDI, which is a dedicated public fund exclusively dedicated to providing state support for R & D and innovation from domestic sources. The NKFI Fund promotes discovery research, targeted development and innovative businesses in a balanced way.

There is no dedicated fund for projects in the field of energy, which is published every year. The national R & D and innovation calls financed by the NKFI 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 through specific thematic calls for proposals on energy topics.

The timing and financial envelopes of the **EU-funded operational programme (GINOP Plus)** for non-reimbursable RDI applications were decided by the Government at the time of the adoption of the Annual Development Framework (AEDF) on the basis of a proposal from the NKFIH as the policy manager at the time. The FSD contains the basic data of a development programme to be published in a given year and of the calls already launched. Decree No 1300/2021 laying down the annual development framework for EDIOP Plus Government Decision (V. 21.) contains the GINOP Plus framework.

We will also launch further pilot projects to promote energy innovation, financed from quota revenues. The extension of innovative solutions will be decided on the basis of the

[102] European market-oriented R & D cooperation

experience of pilot projects, with funding being planned using the resources of the 2021-27 operational programmes and the Modernisation Fund.

The Government intends to play an active role in promoting direct EU proposals among domestic operators, universities and research institutes, e.g. through the CEF, Horizon Europe, InvestEU, EUROSTAR and EURATOM programmes, promoting their participation in international consortia.

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

The aim is also to maximise the opportunities offered by the Innovation Fund. In the case of projects focusing on highly innovative technologies and major projects with European added value and leading to significant emission reductions, the Fund could create opportunities to share risks, thus helping to realise highly innovative ideas.

In addition, an even more intensive involvement of foreign private capital is warranted. The National Investment Agency (HIPA), established to support working capital investment, can play an important role here.

4. STATE OF PLAY AND PROJECTIONS WITH EXISTING POLICIES

4.1. Projected evolution of main exogenous factors influencing energy system and GHG emission developments

i. Macroeconomic projections (GDP and population growth)

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

For the most important input factors, the values recommended by the Commission were used. These include population size and GDP growth, while exchange rates have been considered constant throughout the period.

17. Table: Key input data used

	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 exch. rate	325	400	400	400	400	400	400
Population, e	9772.7	9697.2	9619	9532.8	9441.1	9350.8	9270.4
Average annual growth rate of real GDP	—	2.27 %	2.60 %	2.10 %	1.60 %	1.40 %	1.60 %

ii. Sectoral changes expected to impact the energy system and GHG emissions

In the following, the key factors that determine the performance of a given sector, and thus partly its energy consumption and GHG emissions, are summarised by sector.

Factors affecting residential energy use

The energy consumption of households can be divided into two broad groups: on the one hand, the energy needed to produce cooling, heating and hot water associated with the building and, on the other hand, energy use related to the use of household appliances, lighting and cooking. Different factors determine the evolution of energy demand in the two areas.

Factors affecting the energy use associated with the production of residential heating, cooling and hot water

The energy use of residential buildings is essentially determined by three factors: the floor area of the entire built-up stock; the energy efficiency of buildings and (iii) the fuel composition of the energy used. While the first factor (development 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 is based on the most commonly used residential building typology, which includes 23 building types, 12 of which are family and 11 co-ownership buildings. For building types, the construction method, the construction time and the size of the building are decisive. On the[103] basis of a number of studies, questionnaires and other data sources, we identified the typical technical parameters and fuel consumption of these 23 building types. The table below summarises the building typology we base and their main characteristics.

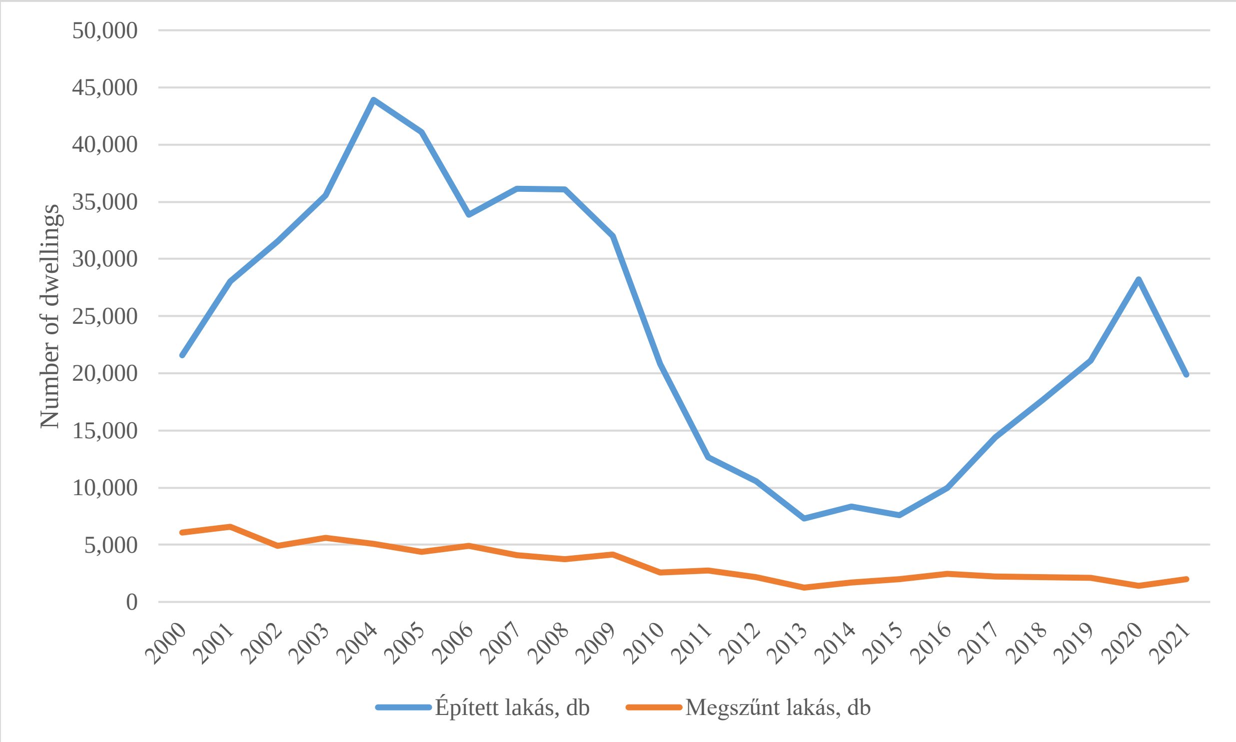
18table -: Building typology

Type of building	Building Characteristic	Built	Greatness	Number of dwellings inhabited	Average housing size, nm
1	Love without foundation		—	150 023	66
2	Loam with 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	apartment building, 4-9 dwellings	—1945	—	**72** 027	55
14	apartment building, 4-9 dwellings	1945-1989	—	100 247	57
15	apartment building, 4-9 dwellings	1990-2005	—	41 607	65
16	apartment building, 4-9 dwellings	2006-2020	—	24 150	64
17	large apartment building (10+ apartments)	—1944	—	179 424	58
18	large apartment building (10+ apartments)	1945-1989	—	241 509	50
19	large apartment building (10+ apartments)	Block	—	163 771	50
20	Panel	—1979	—	290 941	50
21	Panel	1980—	—	163 780	50
22	large apartment building (10+ apartments)	1990-2005	—	68 772	53
23	large apartment building (10+ apartments)	2006-2020	—	47 484	54

The evolution of the number of dwellings is influenced by the number of new and disappearing dwellings. The development of new constructions has been very hectic over the last two decades: it reached its highest level in the mid-2000s (40-45 thousand houses/year), with a trough in the mid-2010s (less than 10 thousand apartments) and then picked up again to close to 30 thousand by 2020. By contrast, the number of dwellings lost has been on a stagnating trend since the mid-2010s, with around 2500 dwellings closing a year. For both values, we assumed that the national building stock is characterised by an average level of 20 years over

[103]Sources: REKK (2023): The 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 Tipology Study, Project KEOP-7.9.0/12-2013-0019, Budapest, 2015

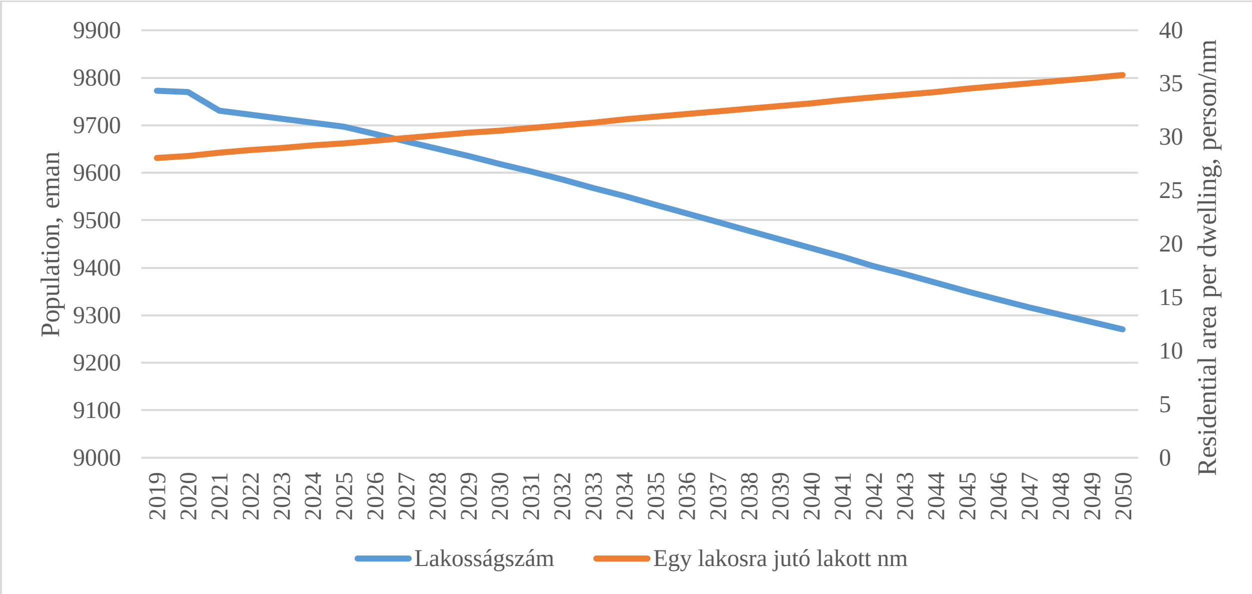
the next three decades, i.e. 23.5 thousand dwellings per year and 3.3 thousand apartments being lost.



2figure. Developments in housing constructions and disappearances 2000-2021, p.m.

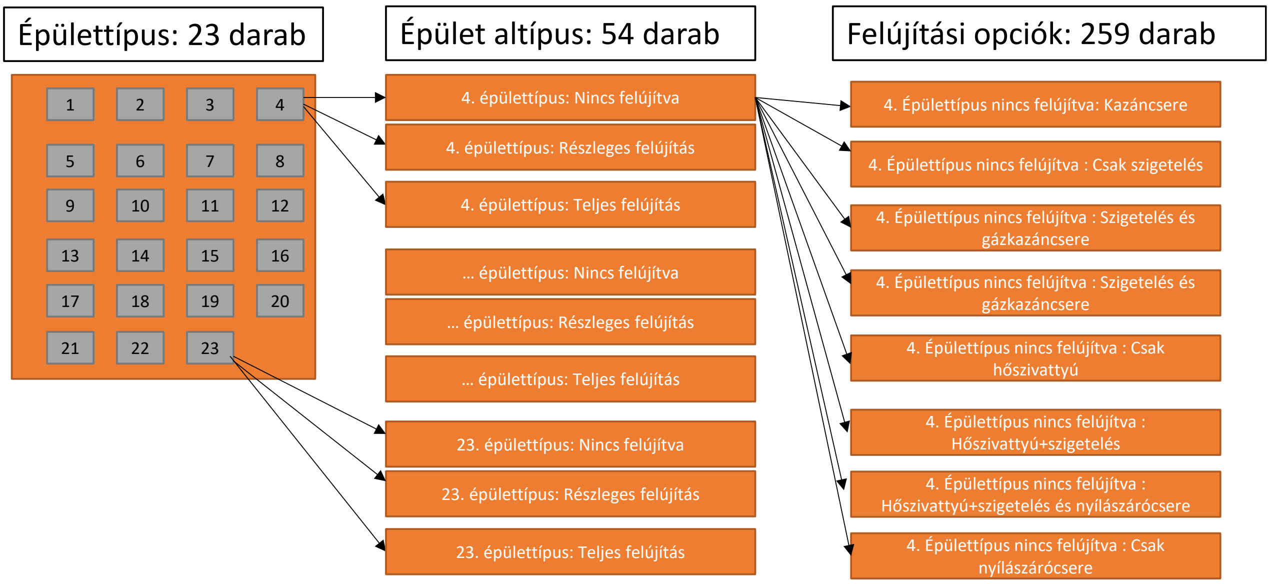
Source: HCSO

Although a downward trend can be observed in terms of population, the number of new dwellings built exceeds the number of disappearances, so that overall, as seen from past trends, the size of the residential area per inhabitant is increasing. In the case of new dwellings, it was assumed that the number of dwellings would be equally distributed among small single-family houses, large-scale single-family houses, small apartment blocks and multi-dwelling blocks. They have different average floor areas, which correspond to the average floor area according to the category.



3figure. Population and projections of population and population area per inhabitant, 2019-2050

The 23 categories have been further subdivided into 54 categories according to the level of renovation of a given building type. For each of them, we defined which renovation options exist. Typically, 5-8 renovation options have been assigned to a building type: gas boiler exchange, conversion to heat pumps, insulation and window replacement, or a combination of these. This may vary for individual building types and subtypes and therefore needs to determine the costs of 259 renovation options overall.



4figure. Buildings and renovation options

The renovation costs were determined on the basis of the 2022 construction costing aid, but we also considered specific contractors' offers. For each renovation option, the costs of the main materials and equipment, as well as the cost of the labour, have been taken into account in determining the costs. The costs have been calculated for the floor area of each apartment, so the cost per floor area of each renovation option differs from one type to another.

19table -: Unit cost per floor area of each renovation element, HUF/nm

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

Factors affecting the energy use of household appliances

Household appliances have been divided into six different types:

- Refrigerators
- Freezers
- Washing machines
- Lighting
- Cooking
- Other electrical appliances.

For each subtype, we have identified their future demand separately. This is the population size, the current penetration rate and its assumed evolution. As a result, the demand for refrigerators and freezers increases by 42 % between 2019 and 2050, the demand for lighting by 57 % and 112 % for other devices. For cooking and washing machines, due to the shrinking population, we calculate a minimum reduction of 2-4 %.

Within each sub-category, we identify 5-6 new technology options (a type of new technology for other assets) whose investment costs and energy needs are included in the model. Replacement is possible at any time and at the latest at the end of the life of the asset in question. The model 'may decide' to replace a given asset, as the transition to new technology will yield returns and/or help achieve the objectives set.

Public and commercial buildings

For public and commercial buildings, detailed data on the type and area of buildings that can be used directly for modelling is not available. Unlike residential buildings, no representative survey has been carried out for this sector. Although there are many databases, they have very different structures, cannot be homogenised and controversial. In many cases, specific energy consumption is unrealistically low and sometimes too high. For each source, the total floor area of the total unoccupied building stock varies between 52 and 125 million square metres. Most information can be found on state-owned buildings (public buildings), but not from surveys based on a representative sample.

Given the limited availability of energy data on buildings other than public buildings, our estimations have been based on the building types included in the Long-Term Renovation Strategy, supplemented by a 'other' building type, the specific consumption of which was determined by the consumption of the typology used, weighted by the national floor area. The total floor area of the 'other' type has been determined in such a way that the metered aggregated energy consumption resulting from the energy balance is precisely taken into account. The value obtained is 70 million m². This gives a total floor area of 126 million m² for the total stock, which is close to the official EU statistics on the service sector's building stock, i.e. 125 million m². As we have very little information on these buildings, we have taken as a starting point the investment options for residential buildings to determine renovation options and their costs.

For public and commercial buildings, a total of 15 subcategories are distinguished, as shown in the table below.

20table -: Typing of public and commercial buildings

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 residential buildings, renovation options were distinguished for all types of buildings, a total of 71.

The following assumptions have been made for the future increase in floor area. In the case of non-insulated buildings, we assumed a cessation rate of 2 % per year, while within one category (e.g. hospitals, educational buildings, etc.), the increase in the floor area of new buildings increases by 30 % of GDP growth. Thus, under the current GDP trajectory, total public and commercial buildings will grow by 19.7 % between 2019 and 2050.

Transport

In order to compare the transport emissions modelling results with domestic greenhouse gas emission trends, transport demand had to be determined on the basis of data consistent with the national emission inventory, therefore the transport statistics established[104] by Eurostat and DG MOVE on the105 basis of the so-called 'Territoriality principle' were used. However, the available time series for transport performances is incomplete for several categories and only a few years ago, making 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 on the basis of the territoriality principle), which was corrected by estimation.[106]

Passenger-kilometres (ukm) for passenger transport and tonne-kilometres for freight transport (tkm). For modelling, separate projections have been made for each mode of transport.

[104]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

[105]Territoriality principle, regardless of the nationality of the operator of the transport vehicle. These statistics serve as the basis for e.g. the definition of the modal split (Eurostat).

[106]HCSO, State of the Transport Sector, 2020, https://www.ksh.hu/docs/hun/xftp/idoszaki/jelszall/2020/index.html

The values ofukm and tkm were predicted by the econometric method Cochrane-Orcutt.[107] On the basis of these projections, the baseline scenario without mode change is modelled. By incorporating modal shift, the demand defined by mode of transport may vary to a certain extent, so modelling may result in a more efficient modal split. The data and assumptions used to forecast demand are presented below.

Passenger transport

The evolution of the public transport segment of local passenger transport was projected through regressions. For the future demand of each mode of transport, for the basic scenario without modal shift, we assumed that their share in public transport is similar to the baseline year.

Among the individual modes of transport, the passenger-kilometres associated with the use of passenger cars were forecasted by a regression, and the part of it relating to local transport was determined as a proportion of the vehicle-kilometres for 'built-in areas' in Eurostat's 'transport traffic' tables. In the case of motorcycles, we proceeded in a similar way with regard to the share of local transport, but basic statistical data were not available to determine future demand, i.e. we had to estimate passenger-kilometres for the starting year. Three sources have been used to do so. For motorcycles, only stock data are available in the HCSO database and, on the basis of our investigations, these data do not include vehicles with a cylinder capacity of less than 50 cm^3 and an engine power of less than 4 kW (auxiliary bicycles). The national GHG inventory provides annual energy consumption data for two-wheeled motor vehicles.[108] Unfortunately, neither the HCSO nor the Eurostat database has access to statistics on mopeds, so we estimated the number of mopeds on the[109]basis of the latest data from TRACCS (2013) for 2010, which are closest to the current estimates110. [111]Based on the National Transport Strategy (NKT) Transport Energy Efficiency Action Plan (KEHCsT, 2013)[112] and EC (2022b), the average consumption of motorcycles was considered to be around 3 l/100 km and the average number of persons transported was 1.1 (2022b). We assume that the trend of future trends in demand (ukm) is mainly determined by the evolution of the number of two and three-wheel motor vehicles, so we estimated the evolution of the vehicle fleet on the basis of the post-crisis trend of 16 years after 2010. The annual average run-off was reduced from the energy consumption in the GHG inventory to 2 102 km. The values obtained in this way have been used to predict future passenger-kilometre values for motorised two-wheeled vehicles.

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

[108]UNFCCC (2021): National Inventory Report for Hungary, 2019 https://unfccc.int/ghg-inventories-annex-i-parties/2021?gclid=Cj0KCQiA6fafBhC1ARIsAIJjL8lYU52ZBhjCdmZ8k4-r8-l4WgD4bDAtfdbNPP96u76l8u48fHfQ6iAaAq8-EALw_wcB

[109]TRACCS (2013): Transport data collection supporting the quantitative analysis of measures relating to transport and climate change, https://traccs.emisia.com/index.php

[110]https://hvg.hu/cegauto/20190416_robogo_biztositas_baleset_karesemeny

[111]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

[112]KEHCsT (2013): National Transport Strategy, Transport Energy Efficiency Action Plan 2013-2020 (2050)

Consolidated statistics on local bus, HÉV, metro, tram and trolleybus traffic were available for a few years. As we did not see any significant changes in the trend over time (except for the one-off increase caused by the entry of the new metro line), we assumed that, by default, their future share of local transport is the same as in the initial year.[113]

In forecasting long-distance, *i.e. interurban passenger transport*, we have acted in a similar way to local transport. We subtracted local bus performance data from EC (2022a) territorial bus transport statistics and calculated the future demand for interurban bus transport on the basis of similar ratios. In the case of rail transport, statistics follow the territorial principle. Passenger-kilometres of passenger car and motorcycle demand are defined in traffic statistics as a proportion of extra-urban vehicle-kilometres, as is the case for local transport.

Among other sectors, the forecasting of demand for passenger air transport is complicated by the fact that historical passenger-kilometres are only available in domestic statistics on the performance of local economic organisations, and the data reported by Eurostat are also incompatible with energy consumption and GHG emissions data114. Therefore, an estimate of the EU 2020 Reference Scenario (EC, 2021) has been accepted.

Goods transport

Unfortunately, in the case of freight transport, it is not possible to obtain data on the activity of freight vehicles on the national territory, but only on the total (foreign and domestic) performance of transport companies, broken down by vehicle size required. Therefore, based on Eurostat statistics and EC (2022a), we estimated the distribution of tonne-kilometre data into size classes based on maximum load capacity. Another problem is that in the case of small commercial vehicles only information on the number of vehicles is available, and the statistical survey on freight transport performance ignores this category. Therefore, as in the case of motorcycles, we estimated small commercial vehicles tonne-kilometres based on the energy consumption data of the National GHG inventory, assuming an average annual mileage of 22 000 km, an average capacity utilisation rate of 70 % and a 50 % empty distance ratio. Short- and long-term transport performance is determined on the basis of Eurostat traffic data as a proportion of vehicle kilometres measured in built-up areas and other roads.[115]

The transport performance of larger vehicles on domestic roads was determined on the basis of estimated tonne-kilometre ratios based on HCSO and Eurostat data, Eurostat traffic data and average utilisation (EU, 2022b). The data on tonne-kilometres for short-distance and long-distance transport are determined on the basis of Eurostat transport statistics broken down by distance, taking into account transport performances below 50 km for short distances.[116]

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[113]KSH STADAT, local passenger transport data KSH STADAT, https://www.ksh.hu/stadat_files/sza/hu/sza0021.html
[114]Eurostat, https://ec.europa.eu/eurostat/cache/metadata/en/avia_tp_esms.htm
[115]Eurostat, https://ec.europa.eu/eurostat/databrowser/view/ROAD_TF_ROAD/default/table?lang=en
[116]Eurostat, https://ec.europa.eu/eurostat/databrowser/view/ROAD_GO_TA_DC/default/table?lang=en

Future demand for waterborne and pipeline transport was estimated by regression, the trend of which was mainly driven by developments in activity (GDP change).[117]

The following table shows projections for transport demand over 10 years. The 2019 and 2020 values are based on actual values and reflect the impact of the pandemic on transport performances, which has been taken into account in the forecast. (It should be noted that the current figures show a faster increase than rail passenger transport than we base the estimate.)

21table 1 – Transport demand forecast

	2019	2020	2030	2040	2050
Passenger transport, local (million ukm)					
Bus (local)	4574	3116	4517	4612	4695
Tram	1284	844	1268	1295	1318
Trolleybus	206	140	203	208	211
Metro	1523	1001	1504	1536	1563
HÉV	474	316	468	478	487
Motorcycle (local)	594	601	670	746	822
Car (local)	15176	14 651	18527	21988	25198
Passenger transport, interurban (million ukm)					
Bus (interurban)	14147	9309	10140	9573	9028
Car (interurban)	51857	50066	63310	75138	86106
Passenger train	7752	4854	5563	5251	4952
Motorcycle (interurban)	1135	1147	1279	1425	1570
Freight transport, short distance (million tkm)					
Small commercial vehicle (max 3.5 t)	1114	1055	1589	1899	2215
Truck (max. 12 t)	206	195	294	351	410
Truck (over 12 t)	1595	1510	2275	2719	3171
Freight, long distance (million tkm)					
Small commercial vehicle (max 3.5 t)	4808	4551	6857	8196	9560
Truck (max. 12 t)	655	629	948	1134	1322
Truck (over 12 t)	25230	23883	35983	43007	50164
Freight train	10625	11595	13935	16299	18493
Other demand					
Waterborne transport, million tkm	2120	1998	3049	3823	4507
Pipeline transport, million tkm	8901	6739	8400	9802	11141
Air transport, millions of ukms	3285	2193	6104	7500	8802

Source: Eurostat, KS

[117]HCSO STADAT: ksh.hu/stadat_files/sza/hu/sza0002.html

Agriculture, forestry and fishing

In the case of the agricultural sector, the volume index of agricultural production was forecast using the randomised minimum squares (Cochrane-Orcutt regression method) mentioned above, taking into account changes in population and oil prices as explanatory variables.

On the basis of these calculations, we projected an increasing energy consumption trajectory. While energy consumption in the agricultural sector amounted to 28.31 PJ in 2019, by 2030 this figure is projected to rise to 28.41 PJ, to 30.93 PJ by 2050.

Industry

The industrial energy use sectors have been broken down into a total of 31 sub-sectors, which provide a more detailed breakdown than the energy balance sheet. For each sub-sector, we estimated volume indices for each sector up to 2050 using an econometric method (using the Cochrane-Orcutt or the Prais-Winsten algorithm based on similar principles), using the explanatory variables defined by the European Commission: GDP, population and oil prices. While some sectors can see strong growth (e.g. construction), some sub-sectors are calculated with stagnation (e.g. textile production) or a smaller decrease (e.g. machinery).

The following table summarises the dependent variables of regression estimates and their unit of measurement, the explanatory variables and their parameters (variables for the cells with parameter estimates), the correction parameters defined 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 predict the trend of estimates for the period 2020-2050 under consideration.

22. Table 1 – Parameter estimates and characteristics of models fitted

Dependent Variable	R^2	Constant	GDP volume index	Population in thousands of persons	Oil price dollar/barrel	Delaying	Correct-up para-meter	DW	Dur-bin H
Agricultural production volume index 1995=100	54,6	576,856		—0,045689	—0,230205		0,002	1,75	
Volume index of construction output 1995=100	90,8	—4140,33	4,15	0,37294			0,106	1,78	
Car fleet at year-end	97,9	126231	19936,8		—177,915		0,024	1,9	
Total production output (tonnes of goods M)	97,5	—14233,7	262,782		56,5807	0,39198	0,087		2,347
Rail transport performance (tonnes of freight M)	83,3	2482,82	49,0334		—4,3949		0,05	1,88	
Road transport performance (tonnes of goods M)	96,8	—1287,85	206,55		46,8		0,54	0,91	
Waterborne transport performance (tonnes of goods M)	58,1	—169,479	5,657			0,626	0,051		0,449

Pipeline transport performance (tonnes of goods M)	63,4	1440,32	28,8242				0,264	1,29	
Interurban passenger transport (passenger-km)	29,1	—45276,4		7,02873			0,085	1,8	
Local passenger transport (passenger-km)	86,3	—145693	56,6511	14,552			0,45	1,096	
Passenger-kilometre by car (passenger-km M)		5309,99	201,675			0,3476	—0.16		—1.44
Mining and quarrying volume index 1995=100	45,5	—1740,8	1,34729	0,161873			0	1,88	
Food, drink and tobacco production volume index 1995=100	83,8	142,621		—0,0136095		0,92811	0,12		0,9
Volume index for manufacturing of textiles, clothing, leather and leather products 1995=100	80	—1260,21	0,524149	0,127556			0,47	1,05	
Wood processing, manufacture of paper products, printing volume index 1995=100	97,1	—77,5294	1,98393			—0,155561	0,088		0,718
Volume Index of Coke Manufacture, Petroleum Processing 1995=100	75,3	—1147,54	0,5547	0,115	0,111		0,01	1,975	
Volume Index 1995=100 for the manufacture of chemicals and products	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, plastics and non-metallic mineral products 1995=100	98	—276,788	3,61595				0,15	1,67	
Volume index for manufacturing of basic metals and fabricated metal products 1995=100	86,7	—1971,37	2,28898	0,179108			0,124	1,744	
Production of computer, electronic and optical products volume index 1995=100	89,5	—2131,43	2,19964	0,189409		0,667942	—0,135		—0,749
Electrical equipment production volume index 1995=100	84,4	—1561,64	19,2646				0,47	1,05	
Volume Index 1995=100 for the manufacture of machinery and equipment	96,6	10244,5	—3,84133	—0,954288	1,21699	0,426724	—0,2		—4,77
Vehicle production volume index 1995=100	97,3	—630,919	12,0555		—1,30935		0,386	1,2	
Other manufacturing and processing industries; 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
Volume index for manufacturing 1995=100	98,6	—216,65	3,8544				0,0666	1,8	
Electricity, gas, steam and air conditioning volume index 1995=100	72,9	—680,016	0,44322	0,0682883		0,425674	—0,026		—0,358

Volume index for industry without water and waste management 1995=100	98,7	—162,289	3,12173			0,057	1,83

On the basis of the above parameter estimates and forecasted oil prices, population and GDP growth, we have the possibility to sectorally determine the production of each sub-sector or the amount of energy used for production. The table below summarises the projected factor for each sub-sector, the initial value used and the evolution of the sector's emissions in 2030 and 2050.

23. Table 1 – Production or energy use by industrial sub-sectors in 2019, 2030 and 2050

Industrial sector	Subsector	Unit	2019	2030	2050
Iron and steel	**Iron and steel production – blast furnace**	MT	1,15	1,72	2,60
	Manufacture of iron and steel – electric arc furnace (EAF)	MT	0,35	0,53	0,79
	Other	PJ	5,37	8,03	12,13
Chemical and pharmaceutical industries	**Ammonia production**	MT	12,96	16,36	22,19
	Olefin production	MT	12,63	15,94	21,62
	Chlorine cycle	MT	4,08	5,15	6,99
	Other	PJ	27,51	34,71	47,08
Manufacture of basic non-ferrous metals		PJ	4,88	4,81	6,94
Manufacture of non-metallic mineral products	**Cement/clinker**	MT	2,43	3,69	5,82
	Glass – Flat glass	MT	0,30	0,46	0,72
	Glass – Glasses	MT	0,14	0,21	0,32
	Glass – Light source	MT	0,08	0,12	0,19
	Glass – insulating material	MT	0,05	0,07	0,12
	Ceramics – bricks	MT	0,67	1,02	1,61
	Ceramics – tiles	MT	0,02	0,03	0,05
	Ceramics – sanitary	MT	0,02	0,03	0,05
	Ceramics – Fire resistant	MT	0,01	0,02	0,03
	Other	PJ	10,85	9,47	31,15
Transport Equipment		PJ	9,70	14,00	21,22
Machinery		PJ	18,71	16,57	16,16
Mining and quarrying		PJ	1,57	2,62	3,94
Manufacture of food, beverages and tobacco products		PJ	27,81	37,30	54,61
Paper production, printing industry	**Paper ETS**	MT	0,71	0,97	1,42
	Paper pulp, cellulose ETS	MT	0,02	0,03	0,04
	Paper and pulp NETS, printing	MT	2,91	3,99	5,85
Wood processing (excluding furniture)		PJ	5,05	7,24	10,62
Construction		PJ	12,24	23,72	37,71
Textiles and leather		PJ	1,69	1,79	1,90
Other industrial sector		PJ	12,79	14,90	21,48
Material use		PJ	41,81	52,75	71,54

MT: million tonnes, PJ: eggs

Primary solid biomass

In the case of primary solid biomass, a natural resource that is renewable on the one hand, but on the other hand is not available indefinitely, had to be included in the modelling process. In other words, when modelling the use of energy carriers, it was necessary to set a biomass capacity limit.

The biomass capacity limit was set as a result of the next steps. We modelled the supply of forest firewood under the specified regulatory parameters, then recorded the historical share of primary solid biomass of non-forestry origin in Hungary's energy balance, and finally, by summing up these two sources, we established the biomass capacity limit.

We have modelled the supply of forest firewood using the bio-economic model developed separately by REKK.[118] This was done on the basis of the National Forest Data Repository and the Sopp increment tables and forest management statistics (harvest, wood selections, choice prices, operational costs) provided by the National Land Centre.

We also assumed that the forest sector, as part of the LULUCF sector, should play a significant part in meeting the EU's carbon sink target set in April 2023. According to the Regulation setting targets for greenhouse gas emissions and removals from land use, land use change and forestry by 2030, Hungary's LULUCF sector needs to significantly increase its net carbon sequestration by almost 20 %.[119] For the reference period (2016-2018), the$_{average}$ value of – 4 791 kt CO 2eq reported in the emission inventory shall be increased by almost one million tonnes. The Hungarian LULUCF sector will have to meet -5 724 kt CO_{2eq} by 2030. Therefore, in the modelling we assumed climate policy legislation that ensures that the Hungarian forest sector approaches this target by 2030.

On the basis of the above, we modelled the supply limit for forest firewood for 2030, 2040 and 2050. This capacity limit has been significantly increased by the supply rates of non-forestry primary solid biomass sources observed in statistics and considered typical for the modelled period. From this market segment, we used official official data on recyclable cutting room scrap (NFK), herbaceous primary solid biomass (MEKH specific data submission) and net imports of wood selections suitable for energy recovery (EUROSTAT). We used additional data sources (KSH, NAV) for woody biomass that can be extracted from agricultural land classified as non-forest, the total estimated amount of which was included in the biomass capacity limit available for energy purposes.

The capacity limit for the supply of primary solid biomass, as estimated above, is summarised in the table below.

24. Table 1 – Estimated capacity limit values for primary solid biomass in the considered corner years

[118]The FOX (Forest Carbon SINK Optimisation) model is a quantitative model that optimises the carbon sequestration of forests taking into account economic parameters. A dynamic linear mathematical optimisation model that defines optimal forest harvesting cycles at national level based on exogenous wood harvesting functions, forest management costs, timber market prices and optional carbon prices. For a more detailed description of the FOX model, see: https://rekk.hu/modellezes/karbon-megkotes-modellezese/?mobile_view=0

[119]In consolidated form: Regulation (EU) 2018/841 OF THE EUROPEANPARLIAMENT AND OF THE COUNCIL of 30 May2018

	Estimated capacity limit for primary solid biomass (PJ)		
	2030	**2040**	**2050**
Forest firewood capacity limit (modelled)	39	35	32
Other primary solid biomass capacity limit (not modelled)	65	58	52
Total estimated primary solid biomass capacity limit	**104**	**94**	**84**

Source: REKK

Taking into account the period 2010-2020, on average, only 38 % of primary solid biomass used for energy purposes is covered by domestic firewood production data, 9 % is assumed to be recovered from extractive biomass waste (cutting-room scrap), only 1 % net imports of non-EU firewood and other energy wood ranges, 3 % reported for agricultural primary biomass of herbaceous origin (straw, seed peel, etc.) and 6-8 % estimated for woody biomass that can be harvested from non-forest agricultural areas each year.

iii. Global energy trends, international fossil fuel prices, EU ETS carbon price

Independent variables used for key modelling include oil prices, natural gas prices, coal prices, biomass prices and carbon quota prices, which have a significant impact on modelling values, such as total energy use or GHG emissions. For these values, the values recommended by the Commission are taken as a basis. No such recommendation was made for biomass, so the current price level was applied for the future.

25table -: Factor price projections

	2019	2025	2030	2035	2040	2045	2050
Oil price, $/barrel	64.3	96.8	96.8	96.8	102.3	111.1	123.2
Natural gas price, EUR/MWh	16	47.5	40.7	40.7	40.7	40.7	40.7
Carbon price, EUR/GJ	2.1	3.1	3.1	3.1	3.3	3.5	3.7
CO2 quota price (ETS1), EUR/t	25	80	80	82	85	130	160
CO2 quota price (ETS2), EUR/t	0	0	50	82	85	130	160
Biomass price, HUF/GJ	1 940	2 200	2 200	2 200	2 200	2 200	2 200

Source: EB (2023) and REKK assumption

In addition to wholesale prices, other retail price components – taxes, network charges, wholesale and retail margins – have a significant impact on the results of modelling. They are defined individually for each fuel and for each sector. It was assumed that the extent of these would not change over the time horizon examined. An exception is made for excise duties. Here, we assumed that the new EU minimum taxation would be applied if it exceeded the current excise duty level.

iv. Technology cost developments

As technologies evolve, there are three types of impact: on the one hand, the unit cost of the same technology may decrease, (ii) increase the efficiency of the same technology or (iii) introduce a completely new technology with a different cost structure (investment and operating costs). These changes are presented below, focusing on the sectors analysed in detail. The energy use of agriculture has not been analysed at the technological level, but only in an aggregated way, so that the development of technology cannot be demonstrated. 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. These are presented below.

For the electricity and heat production and transport sectors, we describe in detail the future technological costs and their evolution over the time horizon examined (renovation costs have already been presented for the building sector).

Electricity and heat production

In total, 24 different technologies were distinguished for the electricity and heat sectors. Of these, 16 technologies concern electricity generation only, 5 combined heat and power plants, while three are heat-only producers. With the exception of six technologies, they are already available and can be used in modelling in the first year. The renovation of wind turbines can only be achieved at the end of the lifetime of the current 330 MW wind power plant capacity, while plants with carbon sequestration (CCS) have only been made available from 2030 onwards.

26. Table 1 – Presumed lifetime and changes in efficiency of electricity and heat generation installations between 2020 and 2050

	Technology	Lifetime	Efficiency, %			
			2020	2030	2040	2050
Renewable electricity producers	Geothermal	30	36 %	36 %	36 %	36 %
	Wind power plant – new	25	—*	—*	—*	—*
	Wind power plant – restoration	25	—*	—*	—*	—*
	Solid biomass	40	47 %	49 %	51 %	53 %
	PV – household size	25	—*	—*	—*	—*
	PV – medium size	25	—*	—*	—*	—*
	PV – large size	25	—*	—*	—*	—*
Conventional power plants	Coal power plant without CCS	55	42 %	44 %	46 %	48 %
	Coal power plant with CCS	55	42 %	44 %	46 %	48 %
	OCGT without CCS	40	47 %	49 %	51 %	53 %
	OCGT with CCS	40	47 %	49 %	51 %	53 %
	CCGT without CCS	30	56 %	58 %	60 %	62 %
	CCGT with CCS	30	56 %	58 %	60 %	62 %
	Nuclear	50	33 %	33 %	33 %	33 %
Cogeneration plants (electricity efficiency)	Natural gas	15	32 %	33 %	34 %	35 %
	Solid biomass	15	20 %	20 %	20 %	20 %
	Biogas – Depotnia	25	57 %	57 %	57 %	57 %
	Biogas – waste water	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 %

*: Not relevant as there is no transformation loss or fuel cost in the energy balance

27. Table 1 – Characteristic cost data for electricity and heat installations

	Technology	Investment cost, EUR/kW				Annual fixed cost, EUR/kW	Annual variable cost, EUR/GJ
		2020	2030	2040	2050	Unchanged during the period	
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 – restoration	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 size	717	581	479	404	5,0	0,0
Conventional power plants	**Coal power plant without CCS**	2 586	2 460	2 339	2 225	28,3	1,3
	Coal power plant with CCS	5 726	5 726	5 726	5 726	66,2	1,3
	OCGT without CCS *	879	877	876	874	6,7	0,7
	OCGT with CCS *	1 700	1 700	1 700	1 700	13,8	0,7
	CCGT without CCS *	922	918	913	909	14,0	1,3
	CCGT with CCS *	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 – Depotnia	1 750	1 750	1 750	1 750	262,5	0,0
	Biogas – waste water	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

**: For OCGT, only variable costs other than fuel costs are included in the table. As OCGT is a significantly simpler technology than CCGTs, it has a lower operating cost.

Source: REKK data collection

Transport

In determining transport technologies and costs, it was assumed in the case of motorcycles that, in the case of powered two-wheel vehicles (three-wheels), the current and expected future role of diesel power will be very low. Although there is also a hybrid vehicle, its spread is currently very slow (mainly concentrated in Asia) and its future role is questionable. This is because in the case of vehicles of relatively smaller size, a doubling drive system can mean extra weight and complexity (as reflected in service costs). In addition, some models are expected to emerge mainly in the higher power segment, as the range of electric propulsion for shorter-haul vehicles involved in local transport tends to meet demand and the range is likely to increase further in the future. As a result, only petrol and electric technologies have now been considered as an option in the model. Technological developments are reflected in the increase in the efficiency of motorcycles and in the cost reduction potential of electric vehicles (in line with the expected reduction in battery cost of 25 % of the value of the vehicle).

As a new technology for passenger cars, hydrogen fuel cell passenger cars will be included in the model and will be available from 2025. In addition, current technologies are constantly evolving until 2030, resulting in lower consumption and changing purchase costs. In line with the literature, the cost of electric and hydrogen fuel cell vehicles is slightly decreasing and the cost of internal combustion engine-powered vehicles is increasing due to the need to use increasingly complex technological solutions to meet ever-increasing emission requirements.

For buses, in addition to modern diesel, hybrid, CNG and electric vehicles, the model has been calculated with the appearance of hydrogen fuel cell vehicles, and in addition to new diesel buses for long-distance transport, hybrid and fuel cell vehicles. Of hybrid technologies, only conventional hybrid propulsion was considered. This is because the distance travelled in long-distance transport may be low due to the loss of time caused by charging time, while in local transport the expansion of the range and new charging solutions (e.g. fast chargers at stops) may over time make the installation of the two types of propulsion systems superfluous.

Based on information from transport operators (BKK, MÁV-Start), no alternative fuel technology (e.g. hydrogen) is expected for rolling stock by 2030, and no significant reduction in consumption is expected for advanced electric technologies compared to current young vehicles (0-5 years old). As a result, there is no new tram and metro technology in the model, but it is expected that assets equivalent to those currently on the market (CAF, Alstom) will be deployed. In the case of HÉVs, a new notional technology will be available, which will be more efficient than old HÉV technology to the extent seen for other rolling stock. The new technology is available in the model as of 2025, as no new vehicles have been procured yet in 2023. For new rolling stock, the consumption of rolling stock will not change until 2030, and the improvement observed for other rolling stock is expected for LEVs.

Analogous technology with KISS multiple units will be available in the model from 2020. As passenger diesel trains aged 0 to 5 are not on the market, it was necessary to define a new technology that consumes less energy in line with the efficiency gains observed for rolling stock.

The new vehicles that can be entered by the model may be petrol, diesel, electric, plug-in hybrid, hydrogen fuel cell and CNG for short journeys and petrol, diesel, electric and hydrogen powered for long distance transport. For the higher load categories, the chargeable hybrid variant (diesel) is not included in the options for the reasons mentioned for buses, only conventional hybrid technology is calculated. With regard to natural gas propulsion, we considered CNG in the category below 12 tonnes and LNG for vehicles above 12 tonnes. With the new models in the HDV category, we assumed that electric and hydrogen propulsion could also be a possible alternative in the future for vehicles above 3.5 tonnes.

Building sector

In the case of the building sector, neither changes in renovation costs nor efficiency gains were taken into account, so no change in technology costs is reflected in this sector.

Industrial sectors

28. Table 1 – Number of new technology options for industrial sectors analysed in detail

		Standard technology	Advanced technology
Iron and steel	**Blast furnace**	1	5
	Electric arc furnace	1	2
Chemical and pharmaceutical industries	**Ammonia**	2	3
	Olefins	2	2
	Chlorine	2	1
Manufacture of non-metallic mineral products	**Cement**	1	1
	Glass – Flat glass	1	4
	Glass – Glasses	1	4
	Glass – Light source	1	3
	Glass – insulating material	1	2
	Ceramics – bricks	1	5
	Ceramics – tiles	1	5
	Ceramics – sanitary	1	2
	Ceramics – Fire resistant	1	4
Manufacture of food, beverages and tobacco products		1	0
Paper production, printing industry	**Paper ETS**	2	5
	Paper pulp, cellulose ETS	1	3
	Paper and pulp NETS, printing	1	1

4.2. Decarbonisation dimension

4.2.1. Greenhouse gas emissions and removals

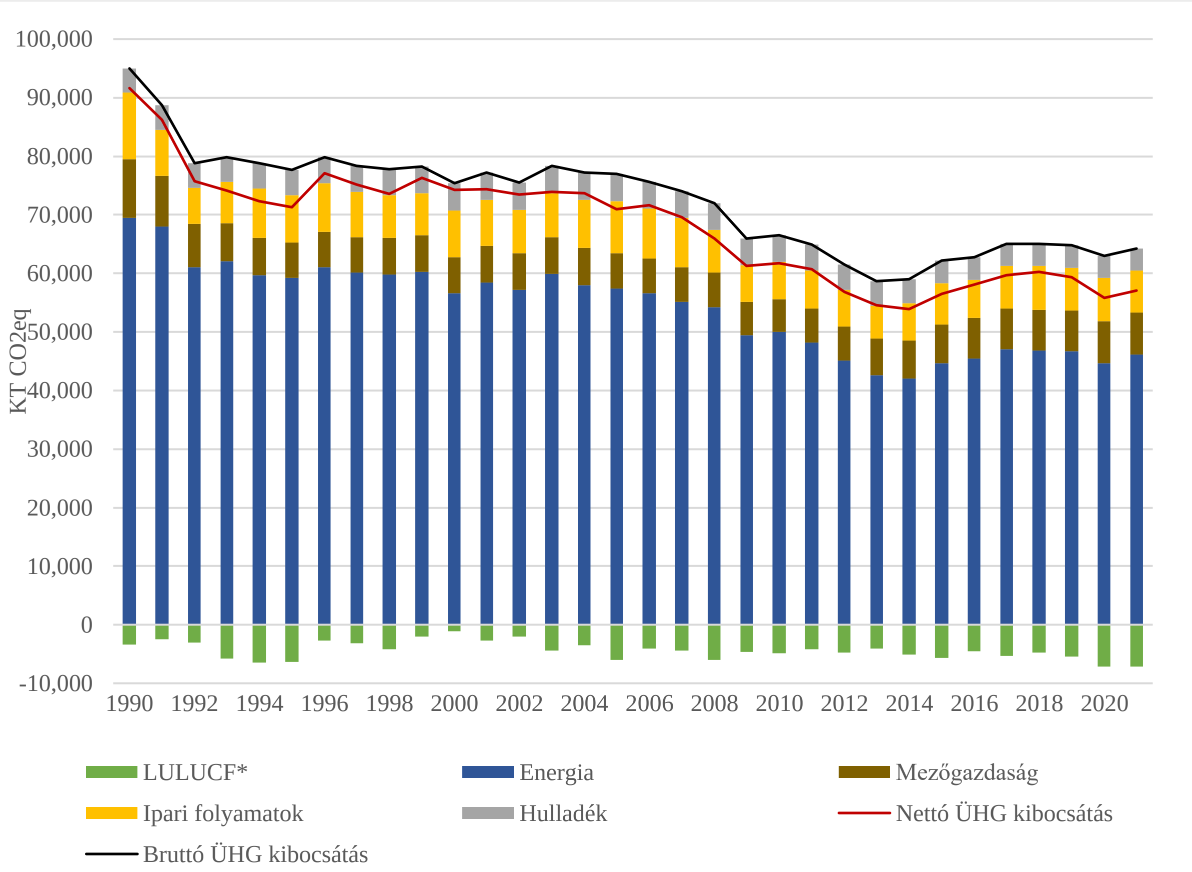
i. Current trends in greenhouse gas emissions and removals in the EU ETS, Effort Sharing Regulation and LULUCF sectors and different energy sectors

Detailed information on the history of GHG emissions can be [120] found in Hungary's 2023 National Inventory Report, a brief summary is provided in this chapter.

The most pronounced anthropogenic greenhouse gas is carbon dioxide (CO_2), which accounts for 76 per cent of total emissions. Most of the CO2 is generated in the energy sector through the combustion of fossil fuels.

[120] Hungary's National Inventory Report 2023, UNFCCC, https://unfccc.int/documents/627849

According to the calculations provided in the Inventory for[121] 2021, Hungary's GHG emissions excluding land use, land-use change and forestry (gross)$_{were}$64.2 million tonnes of CO2 equivalent in 2021, 32.4 % lower than 94.99 million tonnes of CO_2in 1990. Including the land use, land-use change and forestry sector, GHG emissions (net) amounted to 57 million tonnes of CO_2equivalent, a reduction of 37.8 % compared to 91.6 tonnes of CO_2in 1990. Gross emissions per capita were 6.6 tonnes in 2021, below the Union average (7.8 tonnes per capita).[122]

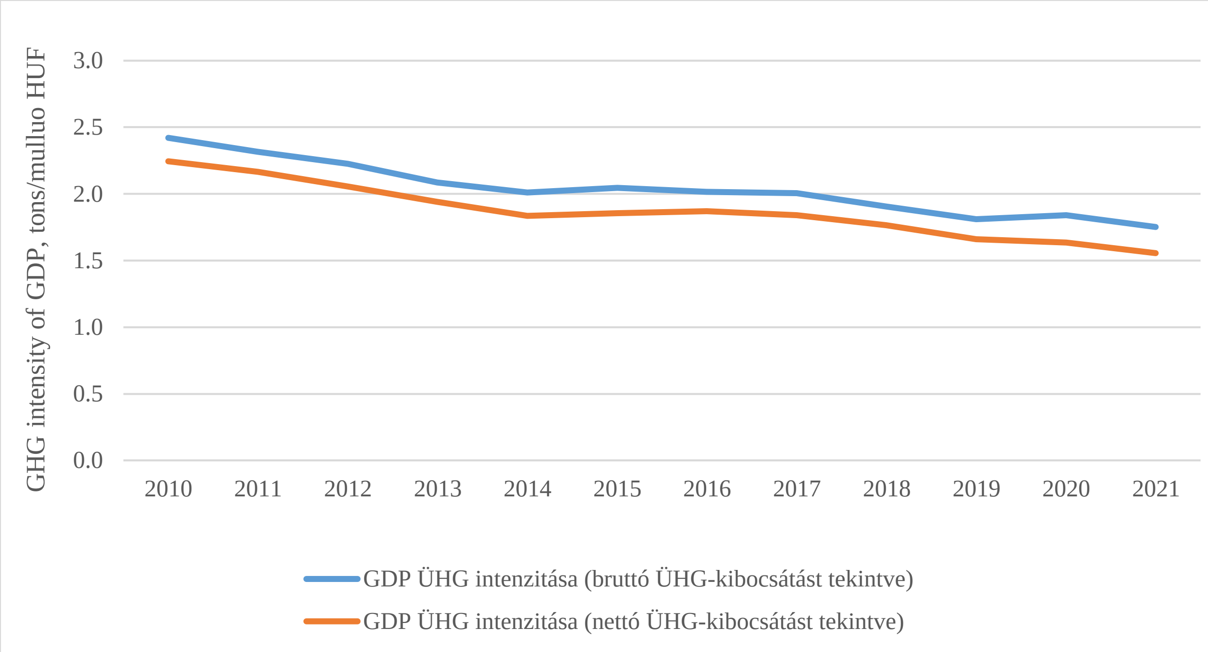


5figure – Evolution of greenhouse gas emissions by sector, 1990-2021 (kt CO_2eq)

Source: National Inventory Report 2023

Although emissions have tended to stagnate in recent years, it is positive that the GHG intensity of the Hungarian economy, i.e. GHG emissions per unit of GDP, has improved by 27.6 % since 2010, indicating that **climate protection can boost economic growth**.

[121] The value does not include 'memo items' (e.g. bunker fuels, biomass emissions, etc.)



6figure – GHG intensity of GDP

Source: Eurostat

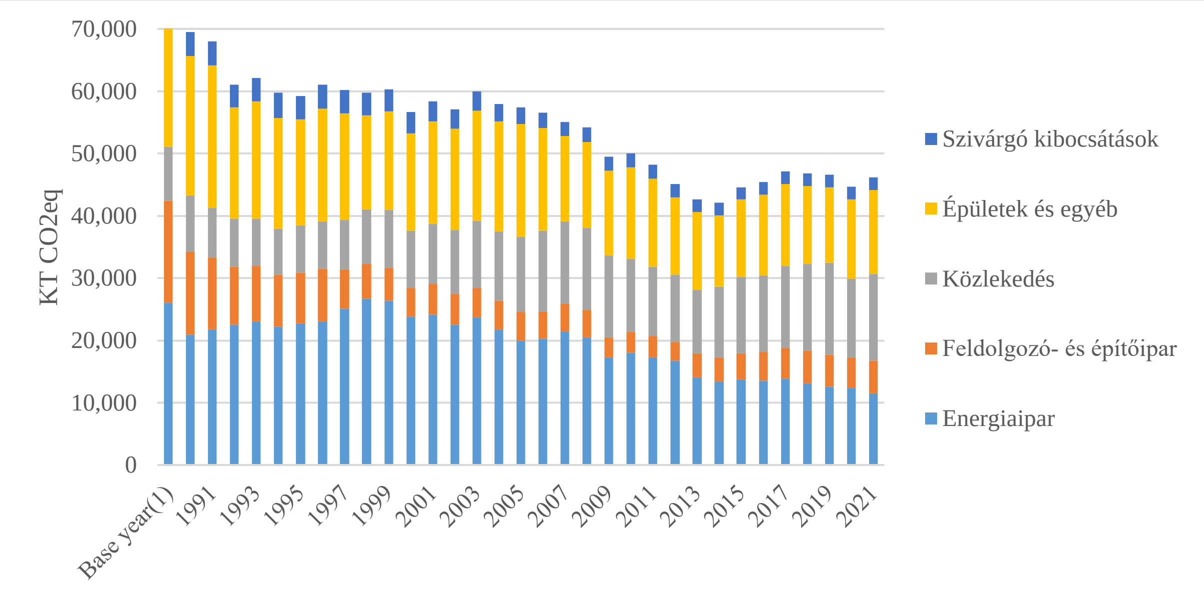
Energy sector

The largest share of total emissions, 72 %, comes from the energy sector. In the energy sector, CO2 from the combustion of fossil fuels is the largest item, accounting for 94.1 % of greenhouse gas emissions. Fossil gases contributed 47 %, liquid fuels 40 %, solid fuels (coal and lignite) 11 % in 2021.

The most prominent sector in the energy sector is transport, with a share of 31 %, followed by the group ‘other sectors’ and other emissions with 29 % (combustion of fuels for residential and commercial buildings, agriculture, forestry, fishing). The energy sector, comprising power and heat generation, oil refining and solid fuel production, was the segment with the largest share until 2018, but in 2021 it was already third in the energy sector, emitting 25 % of GHG. Own-account energy production in the manufacturing sector contributed 11 % to emissions in the energy sector. Leaking emissions related to the extraction, processing, transformation and distribution of oil and natural gas represented 5 %.

GHG emissions from the energy sub-sectors have decreased by 42 % to 68 % since 1990, except for transport, which has increased more than one and a half times over the same period. The transport sector reached the highest emissions in 2019, the year before the COVID-19 outbreak and started to grow again after a temporary downturn in 2020.

In view of the trend over the past 5 years, the energy industry is experiencing a reduction in emissions despite the 13 % increase in gross electricity production between 2016 and 2021 and the volume of district heating is about the same as in 2015. This is due to an increase in the share of natural gas 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 electricity production increased from 20 % to 27 %, the share of coal generation decreased from 18 % to 8 % during the same period. There is also a fuel shift in heat production, the share of natural gas-based heat production increased from 69 % to 74 %, and coal heat production decreased from 5 % to 2 %.



7figure – Energy sector emissions sources between 1990 and 2021, kt CO_2eq

Source: National Inventory Report 2023

In the so-called 'other sectors', comprising the residential, commercial and public sectors, as well as agriculture, forestry and fisheries, GHG emissions have decreased by 40 % since 1990, but the trend over the past 5 years shows an increase of 4 %. It is driven by a 15 % increase in emissions from households and agriculture, forestry and fisheries, which is somewhat compensated by a 12 % reduction in emissions in the commercial and public sectors.

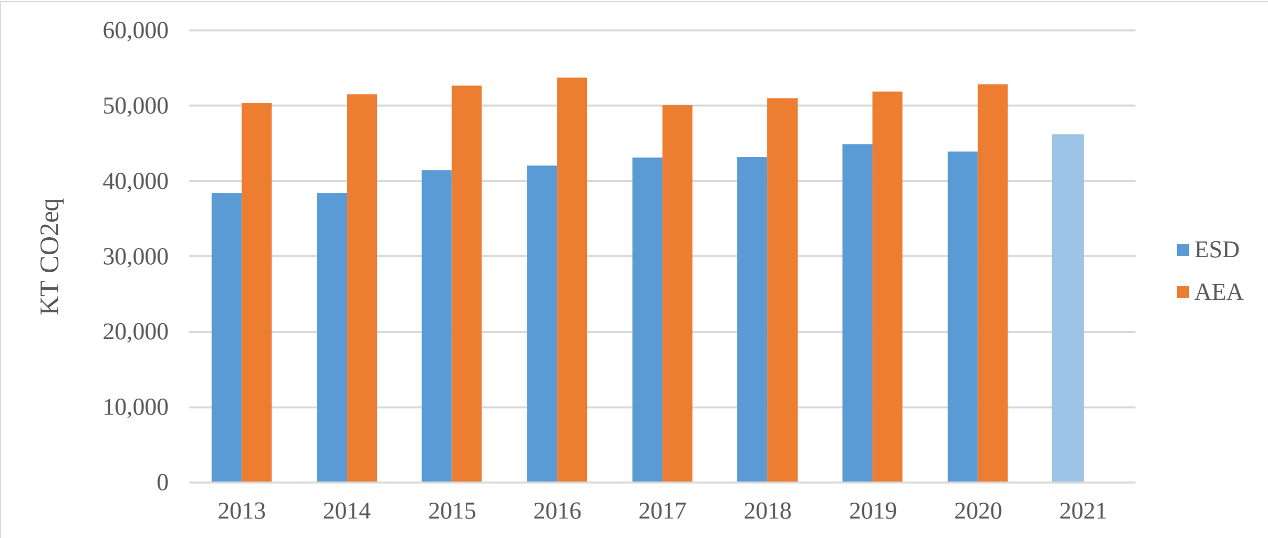
Effort Sharing Decision and Regulation (ESD and ESS)

Emissions from sectors not covered by the ETS were regulated by the EU Effort Sharing Decision for the period 2013-2020, the role of which will be taken over from 2021 onwards (ESR).[123] The two regulations provide for the emission reductions required by Member States for the sectors they cover by establishing annual emission allocations. Currently, detailed emission data are available for the period of application of the ESD 2013-2020. Transport, buildings, agriculture and waste management accounted for the largest share of ESD emissions, but also industrial energy use and F-gas emissions.

According to EEA calculations, the ESD/ESR sector emitted a total of 46.1 Mt CO_2eq GHG in 2021. The graph below shows the total emissions of the sector and the evolution of emission allocations (AEAs) since the introduction of the legislation in 2013. It can be seen that Hungary complied with the legislation in the relevant years, i.e. emissions did not reach the

[123]Effort Sharing Decision, 406/2009/EC and Effort Sharing Regulation, Regulation (EU) 2018/842, as amended by Regulation (EU) 2023/857.

level of allocated entitlements. However, total emissions in the ESD/ESR sector, apart from the temporary downturn caused by the COVID-19 outbreak in 2020, have steadily increased and so far have not been put on a declining path. The 2021 emission value shown in the figure is already covered by the Regulation (ESR), which entered into force from 2020, for which the level of emission allowances will change in line with the above-mentioned amendment of the 2023 legislation.[124]



8figure – Evolution of annual emission allocations (AEA) and GHG emissions (ESD) allocated under the Effort Sharing Decision (2013-2021, kt CO_2eq)

Source: EUTL and EEA125

The largest contributors to ESD emissions in 2020 were the household, commercial and institutional (building) sectors, as well as the transport sector, with 29 % and 28 per cent respectively. Transport GHG emissions in 2020 were only 4.2 % higher than in 2005 due to reduced transport activity due to the COVID-19 outbreak. On the other hand, 41 per cent less GHG emissions were released from buildings in 2020 than in 2005, partly due to energy efficiency measures and partly due to the use of cleaner energy carriers.

Agriculture emissions increased by 18 % compared to 2005 and contributed 17 % to total ESD emissions in 2020. Agricultural activities generate emissions of CH_4 and N_2O, the largest share of our N_2O emissions (83 % including LULUCF) comes from this sector. Since 2011, GHG emissions from agriculture have been increasing almost continuously, mainly due to fertiliser use and increased cattle.

The waste sector contributes 8 % to total ESD emissions. Landfilling of solid waste generates the bulk of emissions (86 %), while waste water treatment accounts for 9 %,

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[124] With the 2023 review, the initial 7 % reduction target for Hungary for 2020-2030 has been raised to 18.7 %.

[125] 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

composting 4 % and non-energy waste incineration of 1 %. The increase in emissions came to a halt in the previous decade, with a decrease of 23 % between 2005 and 2017.

According to EEA data, emissions from energy installations covered by[126] ESD increased by 40 % between 2005 and 2020, while this segment of industrial installations emitted 45 % more GHG in 2020 than in 2005.

F-gas emissions accounted for 8 % of total emissions in 2020. After reaching the highest level of F-gas emissions in 2015, it started to increase again in 2017 after a significant reduction. It was 80 % higher in 2021 compared to 2005.[127]

Overall, emissions increased under the ESD, with the exception of the buildings and waste sector.

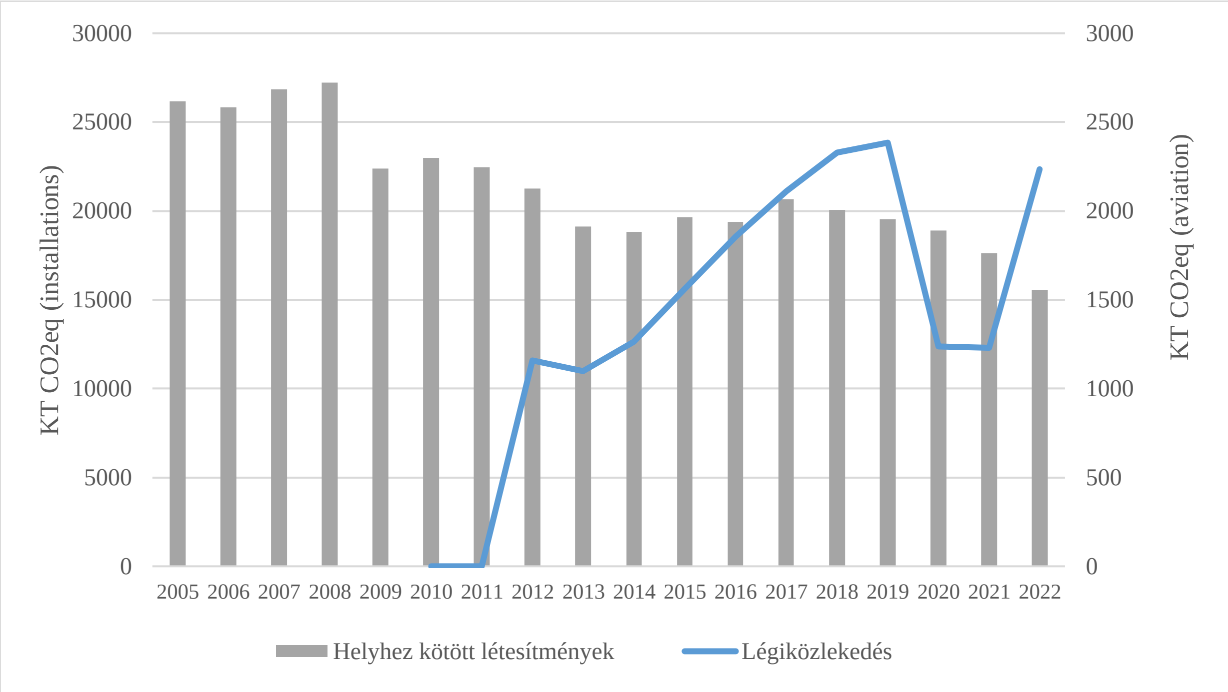
EU ETS

Hungary's ETS GHG emissions (excluding aviation) amounted to 15.6 Mt $CO2_{equivalent}$ in 2022, 41 % lower than in 2005.

The country's GHG emissions under the EU ETS continued to decrease between 2009 and 2014, with the exception of a minor correction in 2010. After 2014, the trend reversed and overall emissions increased by almost 10 % until 2017. However, after 2018, total emissions were again on a declining path.

However, aviation emissions almost doubled between 2012 and 2022, from 1.2 million tonnes to 2.2_{Mt} CO2eq. Continual growth was only curbed by the COVID-19 pandemic in 2020 and 2021, but the trend reversed rapidly and GHG emissions in 2022 were again close to pre-pandemic levels.

[126] Source: EEA, https://www.eea.europa.eu/data-and-maps/data/data-viewers/eea-greenhouse-gas-projections-data-viewer
[127] Source: EEA, https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

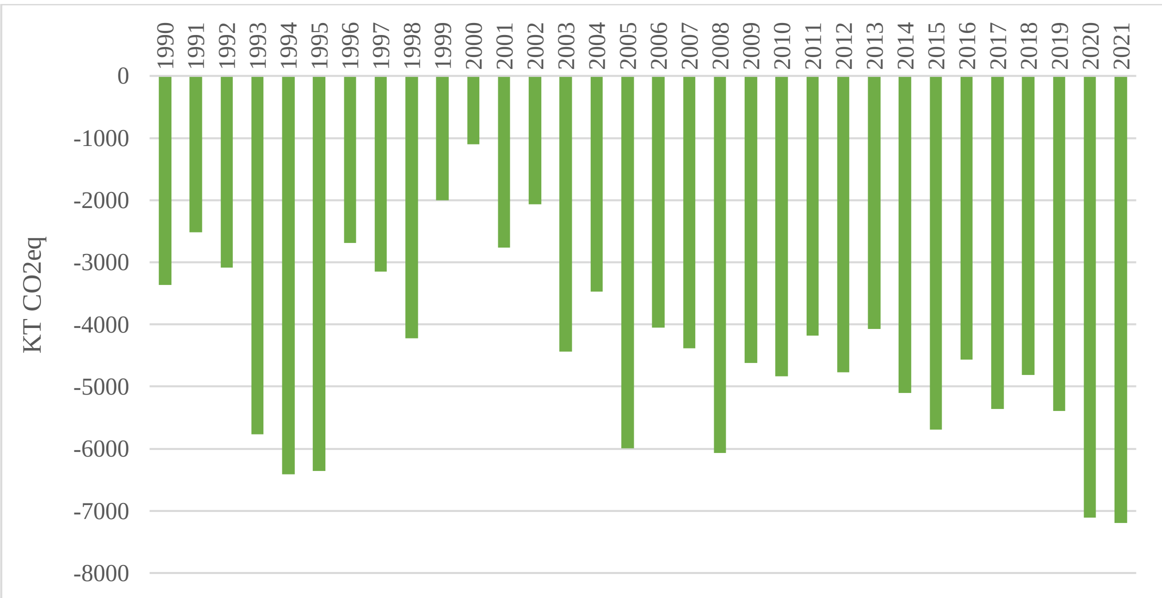


9figure – Evolution of emissions under the EU ETS, 2008-2022 (kt CO_2eq)

Source: EEA[128]

Land use, land-use change and forestry sector (LULUCF)

Overall, the land use, land-use change and forestry sector is considered sinking due to the CO2 sequestration of forests due to afforestation and sustainable forest management in recent decades. There is an increasing trend after 2000 in terms of net absorbance of the sector, from 1.1 million tonnes in 2000 to 7.2 million tonnes of CO 2eq emissions by sinks in 2022.



[128] Source: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

10figure – Evolution of carbon sequestration in the LULUCF sector, 2008-2022 (kt CO_2eq)

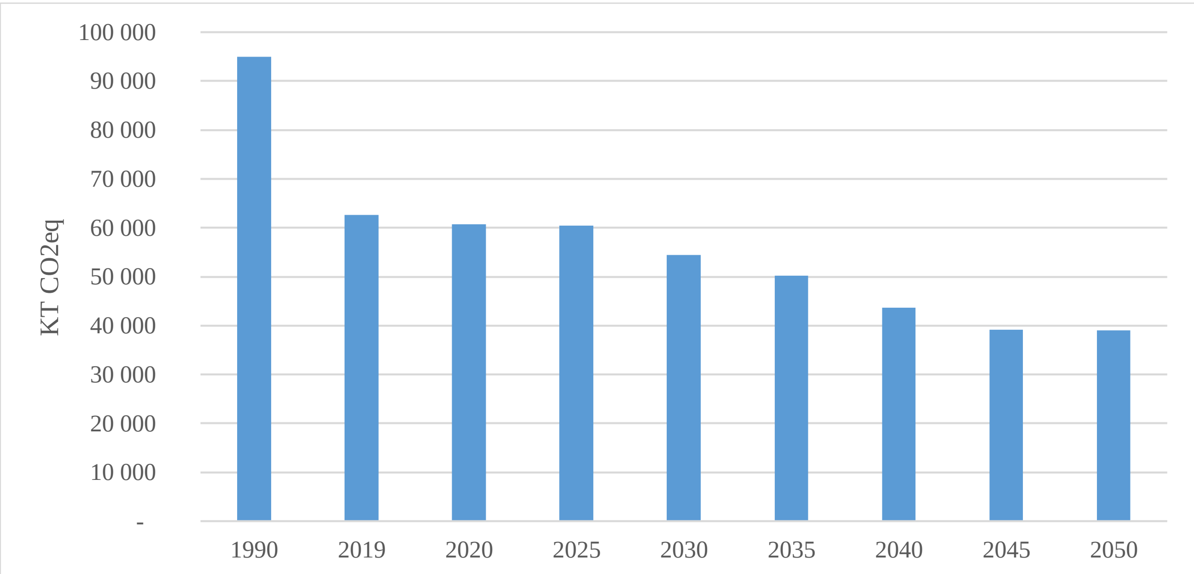
Source: National Inventory Report 2023

ii. Projections of sectoral developments with existing national and Union policies and measures at least until 2040 (including for the year 2030)

Detailed results of GHG projections can be found in Annex 4. For the energy and agriculture categories, a scenario (WEM) taking into account the effects of existing measures and taking into account the effects of complementary measures (WAM) has been prepared.

For industrial processes and product use and waste sectors, only a WEM scenario was prepared for the draft NECP, while no projections were made for the land use and land-use change sectors. The final version of the NECP will include a WEM and a WAM scenario for each sector.

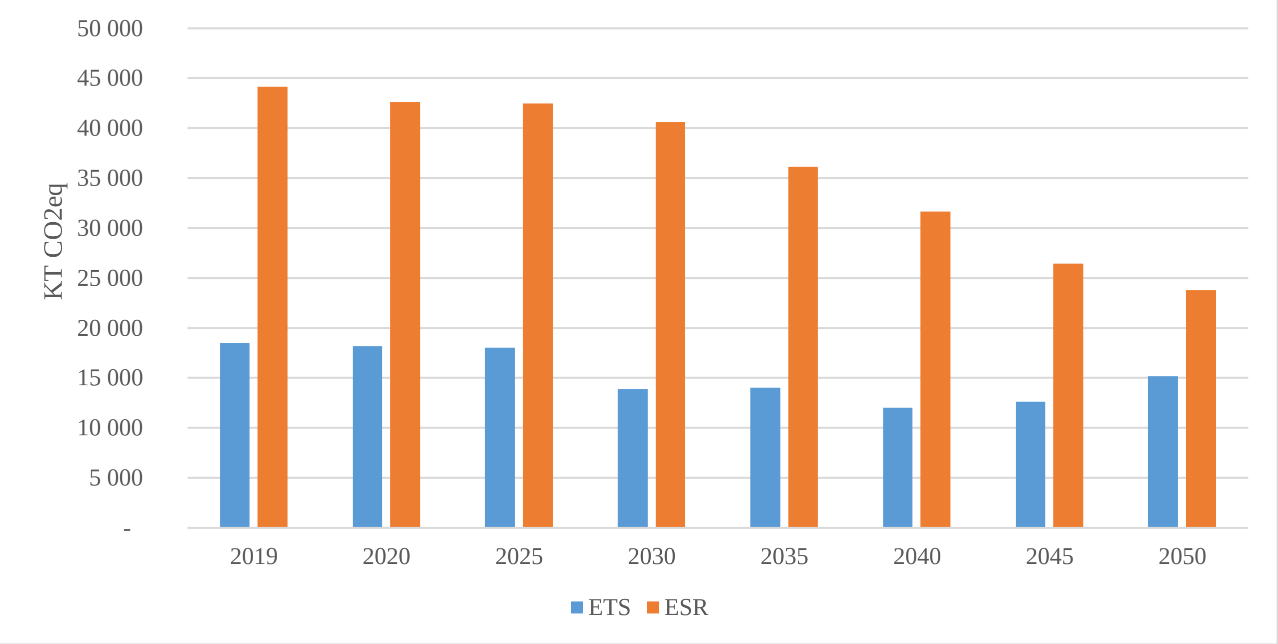
Hungary's total gross GHG emissions excluding the land use, land use change and forestry sector are expected to decrease to 54.5 thousand kt CO 2eq in the WEM scenario by 2030, a decrease of 5.8 % compared to 2021 and **42.6 % compared to 1990.**



11figure – GHG emissions with existing policies and measures, 2016-2050 (kt CO_2eq)

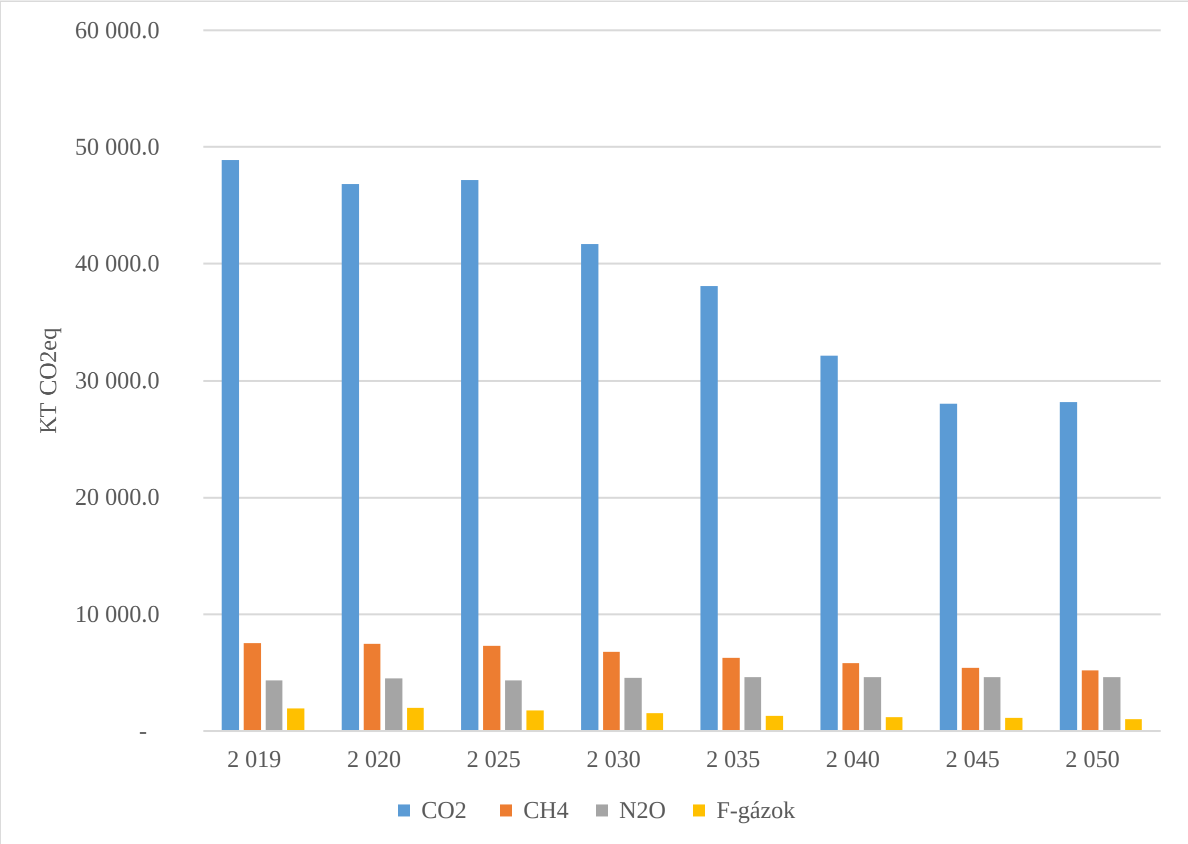
Source of factual data: National Inventory Report 2019

Emissions under the EU ETS will decrease by 24.9 % by 2030 compared to 2019, while emissions under ESD/ESR will decrease by 8 % (see Figure 1 in chapter 2.1.1).



12figure – ETS and ESR emissions with existing policies and measures, 2019-2050 (kt CO_{2eq})

In the WEM scenario, CO_2 remains the most significant GHG. Its emissions are down by 14.8 % by 2030 compared to 2019, while CH4 emissions will decrease by 9.5 % for F-gases by 20.8 %. Meanwhile, N_2O emissions increase by 5.2 %. We do not expect NF_3 to appear in the Hungarian inventory.

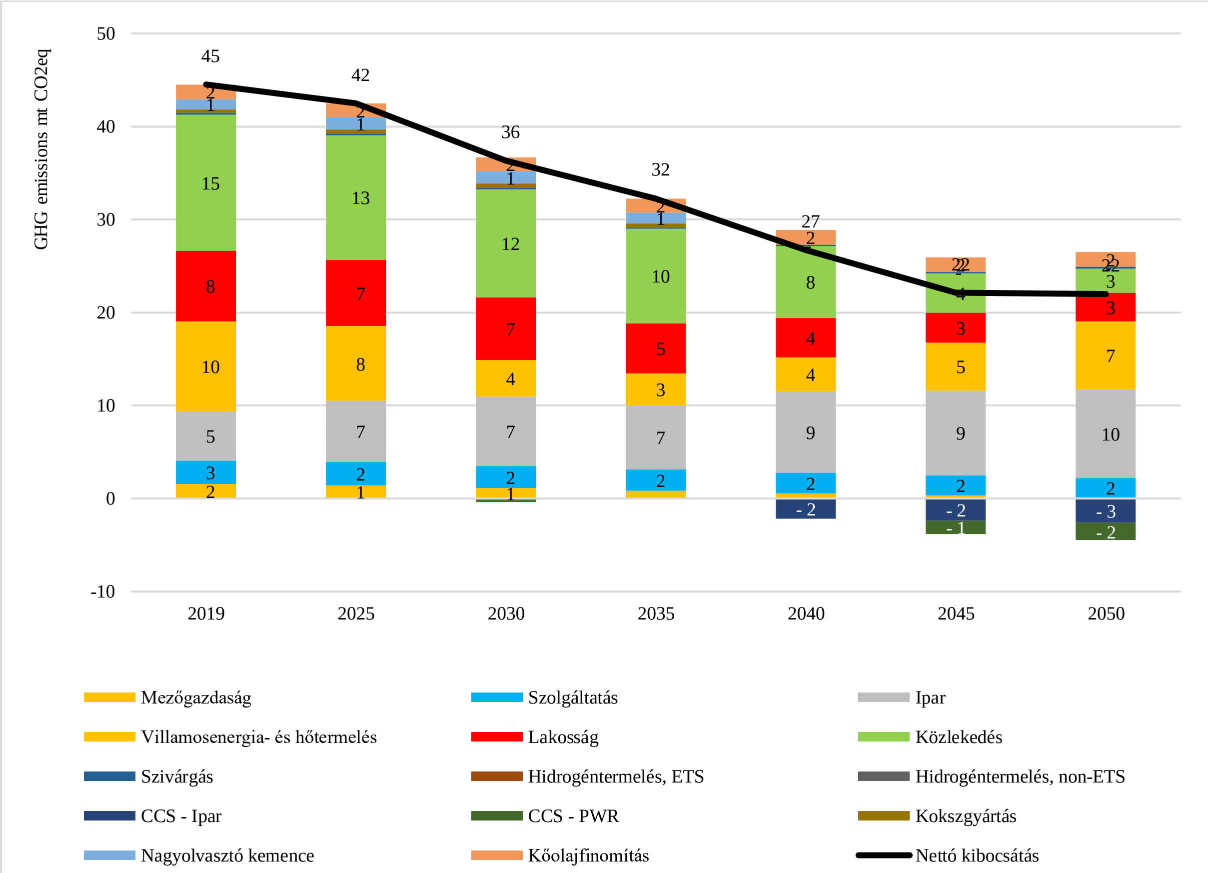


13figure – Evolution of greenhouse gas emissions in the WEM bulletin by gas 2019-2050

Energy

Greenhouse gas emissions will change significantly until 2050 under the current measures scenario. Compared to 2019, the decrease will reach 18 % by 2030 and close to 51 % by 2050.

Transport (one third), energy (22 %), the population (17 %) and industry (12 %) contributed mainly to energy-related emissions. By 2050, the contribution of each sector to total emissions will change significantly. By 2030, transport will keep its weight (32 %), while the energy industry will be responsible for only 11 % of energy-related emissions. The highest GHG emissions increase in industry by 2030 and 2050, with industry accounting for 43 % of energy emissions by the end of the period under review. While emissions from the industrial sector increase by 41 % by 2030 compared to 2019, this increase is 80 % in 2050. This is due to increased demand forecasts. Emissions from the residential sector will be reduced by almost 60 % by 2050, with a share of 12 % of total energy emissions. By contrast, services sector emissions will be reduced by almost 20 % by 2050 compared to 2019.



14figure – Sectoral composition of greenhouse gas emissions in the energy sector, WEM scenario, mt CO2e

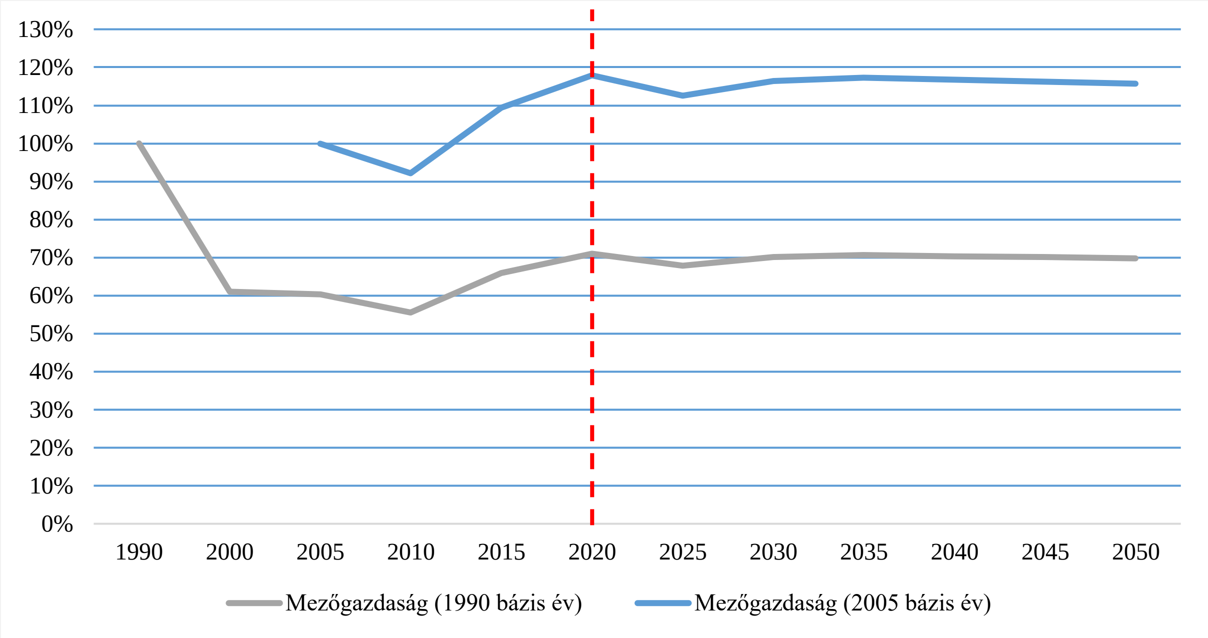
Industrial Processes and Product Use

Total GHG emissions from industrial processes and product use sector would increase by 8 % between 2019 and 2030 and by 9 % between 2019 and 2050. Between 2035 and 2040, there will be a decline in energy use in the mineral, metal and chemical sectors and again an increasing trend, so that growth between 2030 and 2050 would slow down and increase by only 1 per cent.

While total GHG emissions in the 2D (non-energy products from fuel and solvent use) and 2G (product use substitutes for ODS) sectors are expected to halve by 2050, this decrease is offset by the expected increase in non-metallic mineral, metal and chemical industry needs.

Agriculture

According to the WEM scenario, agricultural GHG emissions are expected to be 7 067 kt CO2eq in 2050. Emissions increase slightly between 2005 and 2030 (+ 17.2 per cent) and decrease by 29.3 per cent and 30 per cent over the period 1990-2030 and 1990-2050. The significant decrease in emissions is due to the digestion of farm animals and manure management categories, with a decline of 45.1 % and 49.9 % in these two categories over the period 1990-2050.



15figure – GHG emissions from the agricultural sector compared to 1990 and 2005 levels in the WEM scenario between 2000 and 2050

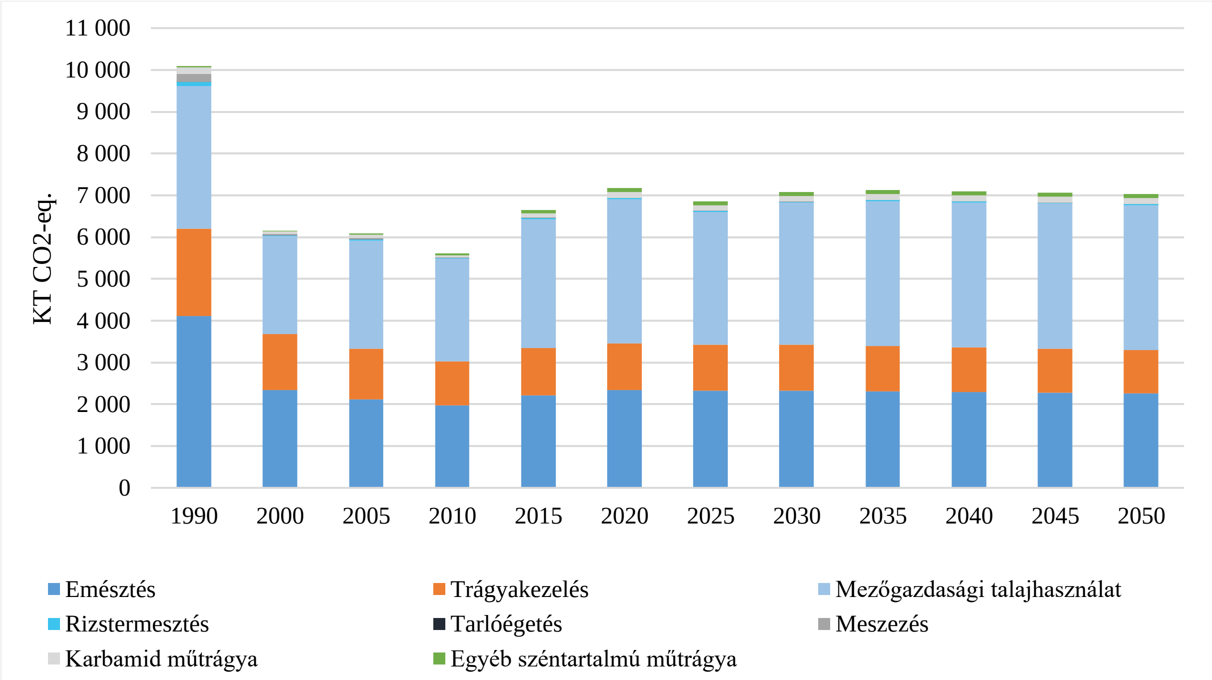
Source: done at the Climate and Environment Research Department of the AKI

Emissions **from** land use account for around 50 per cent (3 500 kt CO 2 equivalent)of total GHG emissions in the agricultural sector in 2050. Under the WEM scenario, tillage emissions in 2050 are slightly above 1990 levels, due to increasing fertiliser use, which is compensated by reduced livestock and livestock manure use. These emissions are 0.8 per cent lower in 2030 than in 1990, while an increase of 32.5 per cent is expected in the period 2005-2030 due to increasing fertiliser use.

Emissions from digestion in 2050 represent a significant share of GHG emissions **from** the whole sector (32 per cent), with an estimated 2 255 kt CO $2_{equivalent}$. The emissions of the category are significantly reduced (-45.1 per cent) over the period 1990-2050. Emissions in 2030 are 43.2 per cent below 1990 levels, while they are increasing slightly between 2005 and 2030 (+ 10.5 per cent).

GHG **emissions from manure management** in 2050 are only 1 048 kt CO $2_{equivalent}$, close to 50 per cent less than in 1990. This is expected to decrease by 47.4 per cent between 1990 and 2030 and by 9.2 per cent between 2005 and 2030. The significant decrease is due to changes in the dairy cow and pig population.

GHG emissions from the use of **urea** -based fertilisers will decrease by 24.2 per cent to 130 kt_{CO2}equivalent by 2050 compared to 1990. Emissions are expected to increase by 1.5 times between 2005 and 2030.



16figure – GHG emissions from the agricultural sector in the WEM scenario between 1990 and 2050

Source: done at the Climate and Environment Research Department of the AKI

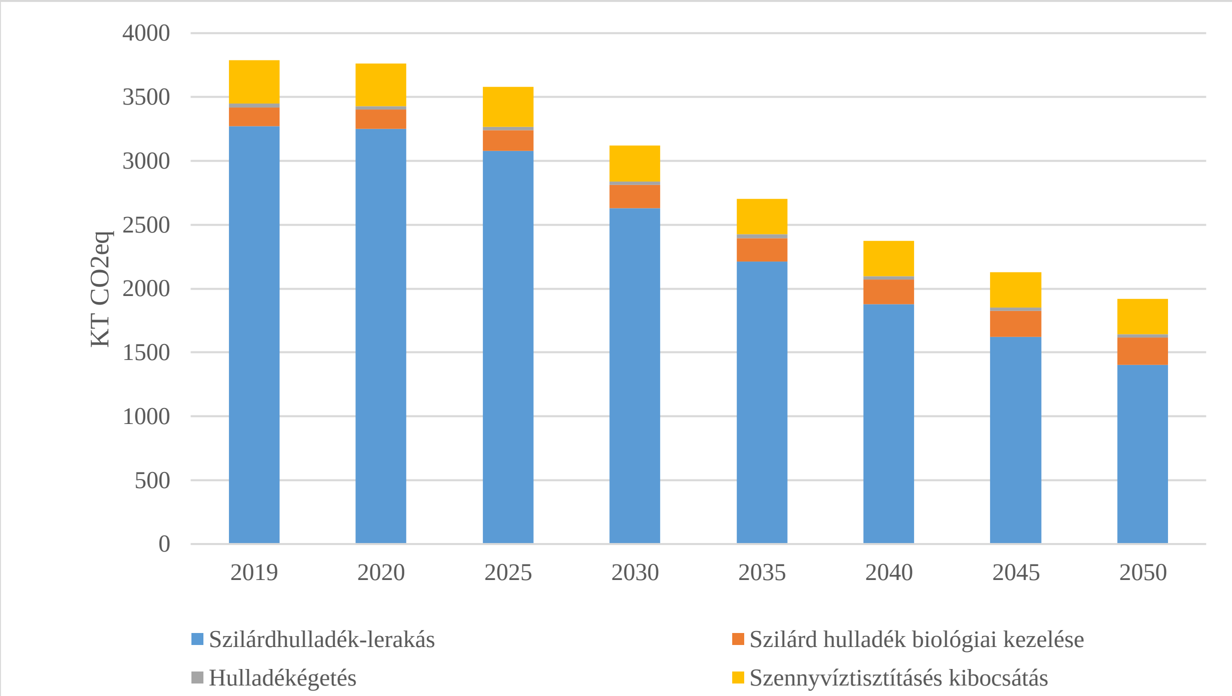
Total **emissions of CH_4** in agriculture in the WEM scenario, 2 971 kt of CO_2 equivalent in 2050, which is 46.3 per cent less than in 1990. CH_4 emissions increase slightly between 2005 and 2030 (+ 5.6 per cent). Emissions **from** digestion represent more than 75 per cent of the sector's total CH4 emissions, 2 255 kt CO_2eq. in 2050. Despite decreasing by 45.1 per cent between 1990 and 2050, emissions from animal digestion are expected to slightly increase between 2005 and 2030 and 2005-2050 (+ 10.5 per cent and + 6.8 per cent). A significant proportion of CH4 emissions **from manure treatment** is accounted for by a decrease in the pig population in the period 1990-2050, despite rising emission levels from poultry, by 48.0 per cent over the period 1990-2050, which represents a decrease of only 7.8 % and 11.8 % between 2005 and 2030 and 2005-2050.

In the WEM scenario, the agriculture sector's **N_2O** emissions are expected to decrease by 7.6 per cent between 1990 and 2050 to 3 855 kt of CO 2 equivalent, and to increase by 27.6 per cent between 2005 and 2050. Emissions by 2030 are 8.6 per cent lower than in 1990 and 26.2 per cent higher than in 2005. Despite the decrease in livestock numbers, the slight decrease can be explained by a marginal reduction due to tillage. Soil **use** accounts for more than 90 per cent of N_2O emissions, 3 500 kt CO_2eq. in 2050.

According to the WEM scenario, CO2 **emissions** from the agriculture sector are expected to decrease by 37.5 per cent to 240 kt between 1990 and 2050. However, due **to an increase in the use of urea and other carbon fertilisers**, emissions increase by 65.8 % between 2005 and 2030. However, emissions from the use of urea fertilisers are still 23.5 percent lower in 2030 than in 1990.

Waste

the GHG emissions of the sector will halve by 2050 and are expected to decrease by 18 % by 2030.



17figure – GHG emissions in waste sequential (2019-2050)

Although methane emissions from solid waste landfill are expected to decrease by the highest rate (57 % by 2050), this source category remains the most important in the waste sector. 86 %, 84 % and 73 % in 2019, 2030 and 2050.

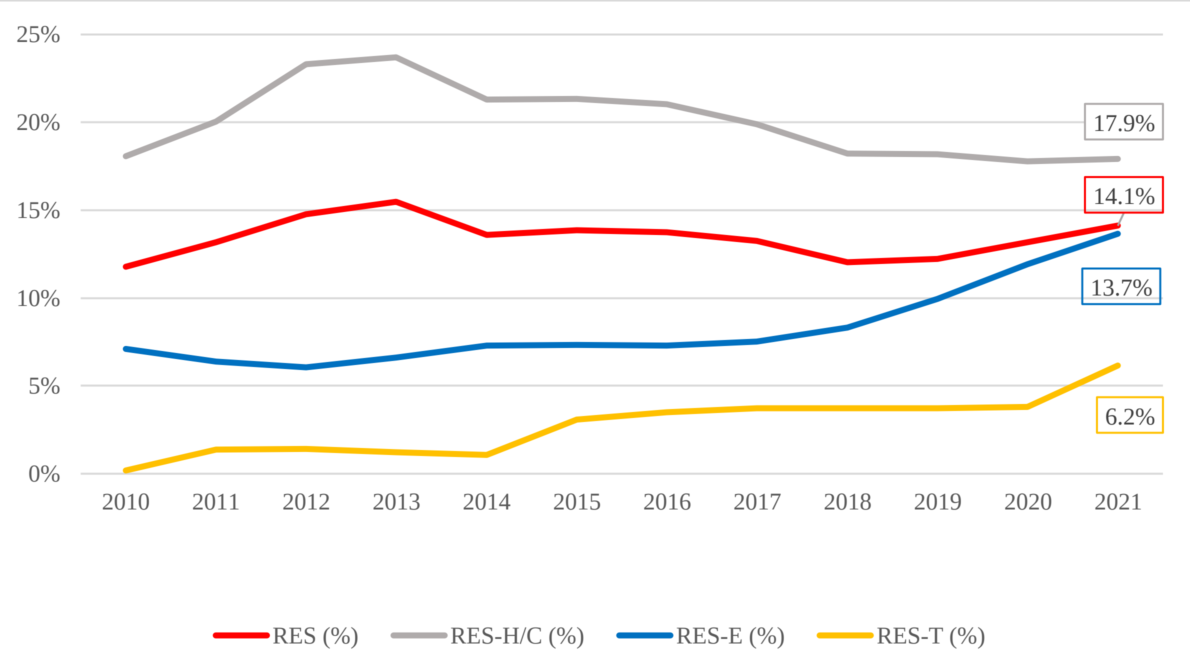
The expected increase in both composting and biogas production will lead to increased emissions in the source category of biological treatment of solid waste. Under the current WEM scenario, emissions will increase by 43 % by 2050 and 21 % by 2030 compared to 2019.

As regards waste water treatment, we expect a steady increase in the use of sewage sludge for energy purposes, which is likely to increase methane leakage. On the other hand, higher connection speeds to centralised tertiary treatment plants would result in higher nitrogen removal and thus lower N2O emissions. As a result, total greenhouse gas emissions would be reduced by 18 % between 2019 and 2050. However, most of the expected reduction (i.e. 17 %) would be achieved by 2030.

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, the129 share of renewables in gross final energy consumption in Hungary was 14.11 %. In electricity consumption, the share of renewable energy in gross final energy consumption[130] increased from 7.1 % to 13.66 % in 2010 and 2021 and from 0.19 % to 6.16 % in transport. The share of renewable energy in heating and cooling decreased slightly from 18.08 % to 17.93 %. Statistics show that the heating sector in Hungary uses most renewable energy (mainly through the combustion of solid biomass (firewood) in households), but in contrast to the electricity and transport sectors, renewable energy use in the heating sector has not increased in the recent period. 69.2 % of renewable energy consumption in2021 was for heating and cooling, 20.2 % for electricity production and 10.6 % for transport.



18figure – Evolution of the renewable energy share by sector (RES – aggregated renewable energy share, RES-H/C – renewable energy share in heating/cooling, RES-E – renewable energy share in electricity use, 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. For many years, there has been a strong substitution effect in domestic use of natural gas and solid biomass. Until 2021, the consumption of natural gas by the population was increasing, while household

[129]The indicator, the share of renewable energy sources in gross final consumption of energy, 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.
[130] As of 2021, the use of new multipliers in line with RED 2 rules has also increased the share of renewable energy in the transport sector.

solid biomass consumption showed a declining trend. Although domestic consumption of both natural gas and biomass decreased in 2022 in the global and economic situation of war, the substitution effect remains, based on preliminary data, with a renewed increase in demand for firewood due to increased natural gas prices.

29table – Share of renewable energy in gross final consumption of energy by sector, 2021

	Total renewable energy use in gross final energy consumption	**Share of renewable energy in gross final energy consumption**
	PJ	**%**
Total renewable energy consumption in gross final energy (2021)	**116,6**	**14,1**
Electricity	23,57	13,7
Heating and cooling	80,73	17,9
Transport	12,31	6,2

Source: Eurostat

Solar power generation, biomass and geothermal district heating and heat pump systems, as well as biofuels with mandatory blending rates, have increased dynamically in recent years.

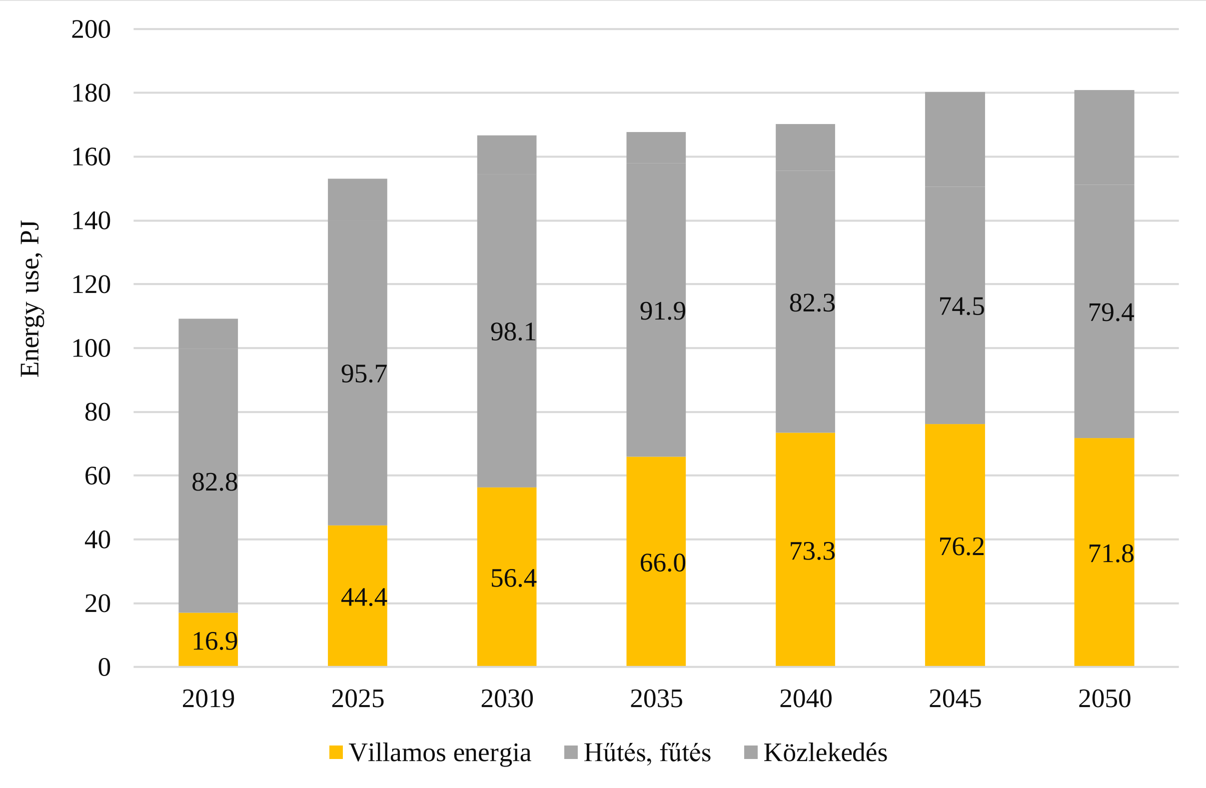
30table 1 – Renewable energy use in gross final consumption of energy by sector and technology, 2010-2021

	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
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 renewable	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**
Cooling heating (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**

Source: Eurostat

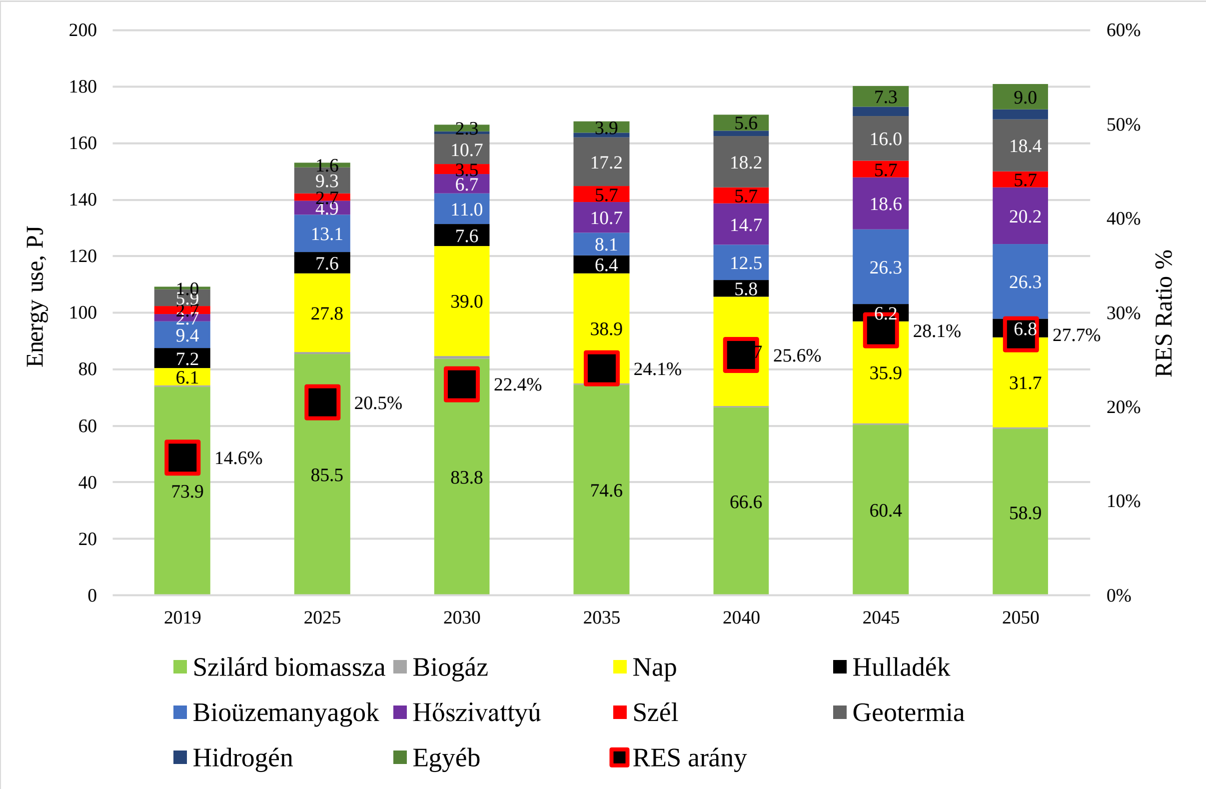
ii. Uncommitted development forecast based on existing policies by 2030 (with a perspective to 2040)

While the heat sector (including biomass) currently accounts for the vast majority of renewable energy use, we see a significant shift in the time horizon under consideration. The electricity sector is accounting for an increasing share of total renewable energy use, accounting for more than a third by 2050, thanks to PV and biomass 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 the renewable energy use decreases from the initial 76 % to 44 %.



19figure – Sectoral composition of renewable energy use, WEM scenario, 2019-2050, PJ

In the WEM scenario, total renewable energy use will be around 180 PJ in 2050, which alone is already significant compared to the current 110 PJ. As final energy consumption decreases slightly, this also contributes to increasing the share of renewable energy use. The renewable share will increase from the current level of 14 % to 22.4 % in 2030 and 27.7 % by 2050 without additional measures. The composition of renewable energy use in 2050 shows a very diverse picture compared to the current biomass focus. Solid biomass use falls to 33 % and the share of biofuels in renewable energy is increasing to 15 %. The energy produced by solar power plants is also significant, with a share of almost 18 %.



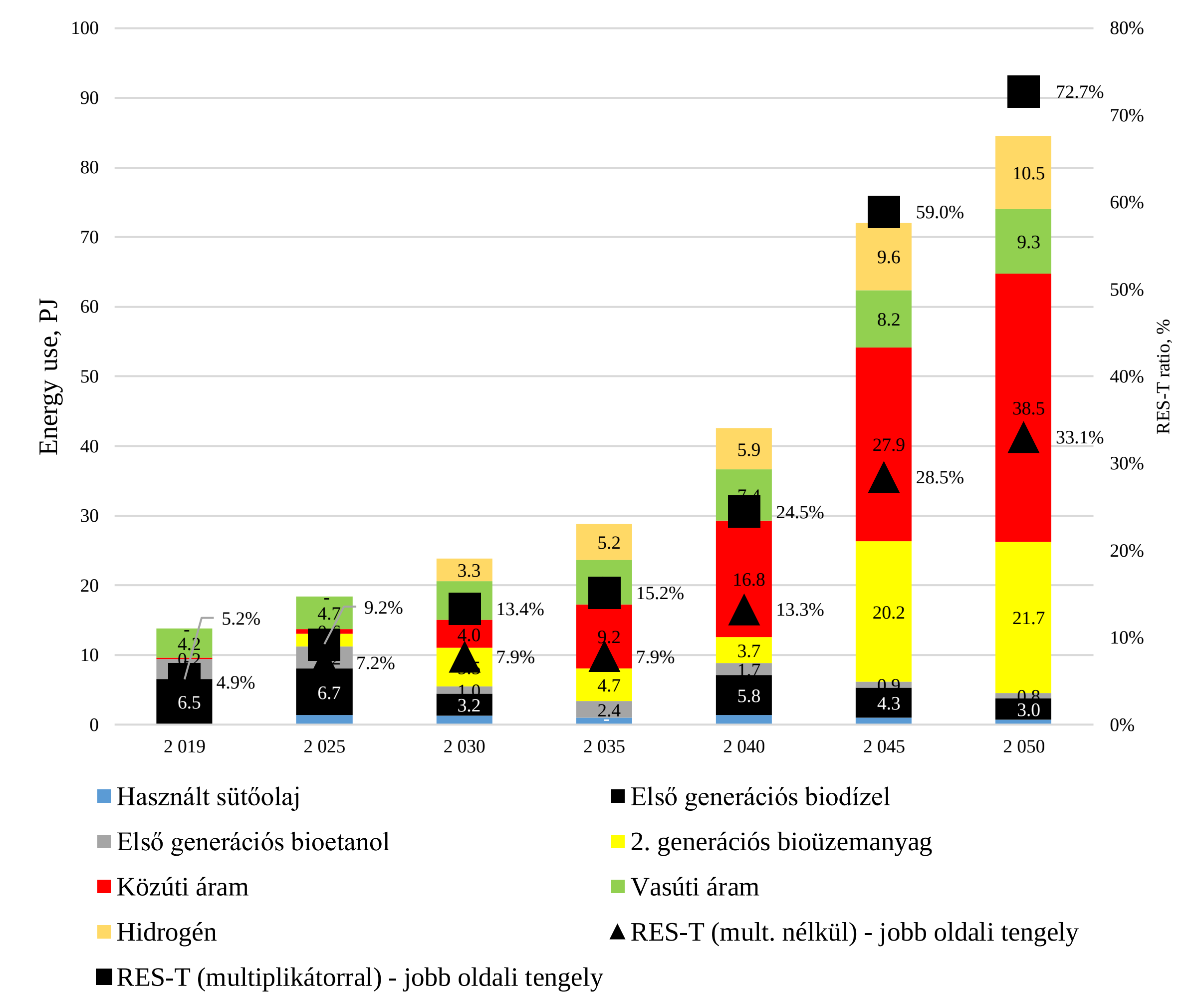
20figure – Resource mix of renewable energy use, WEM scenario, 2019-2050, PJ

Renewable energy use in the transport sector

In the transport sector, the share of renewable energy is increasing significantly, mainly due to biofuels and electric cars. By 2030, the renewable share of around 6 % today will increase to 13.4 %. The primary source of this is second-generation biofuels, as well as a small presence of hydrogen and an increase in the electricity use of road vehicles with an equal market deficit.

By 2050, the two main sources of renewable energy are second-generation biofuels and electricity. The increase in the former is driven by the introduction of ETS2 at the end of the 2020s with ever increasing quota prices, making biofuels competitive over time. This effect is reinforced by calculating a higher level of excise duty from 2026 onwards, in line with the EU minimum tax levels[131]. Although hydrogen use in this sector is steadily increasing, the transport sector's share of renewable energy use is only around 12 % in 2050. The partial shift of freight to rail also increases the electricity used by rail.

[131] In line with the 2023 amendment of the Directive on taxation of energy products and electricity (2003/96/EC).

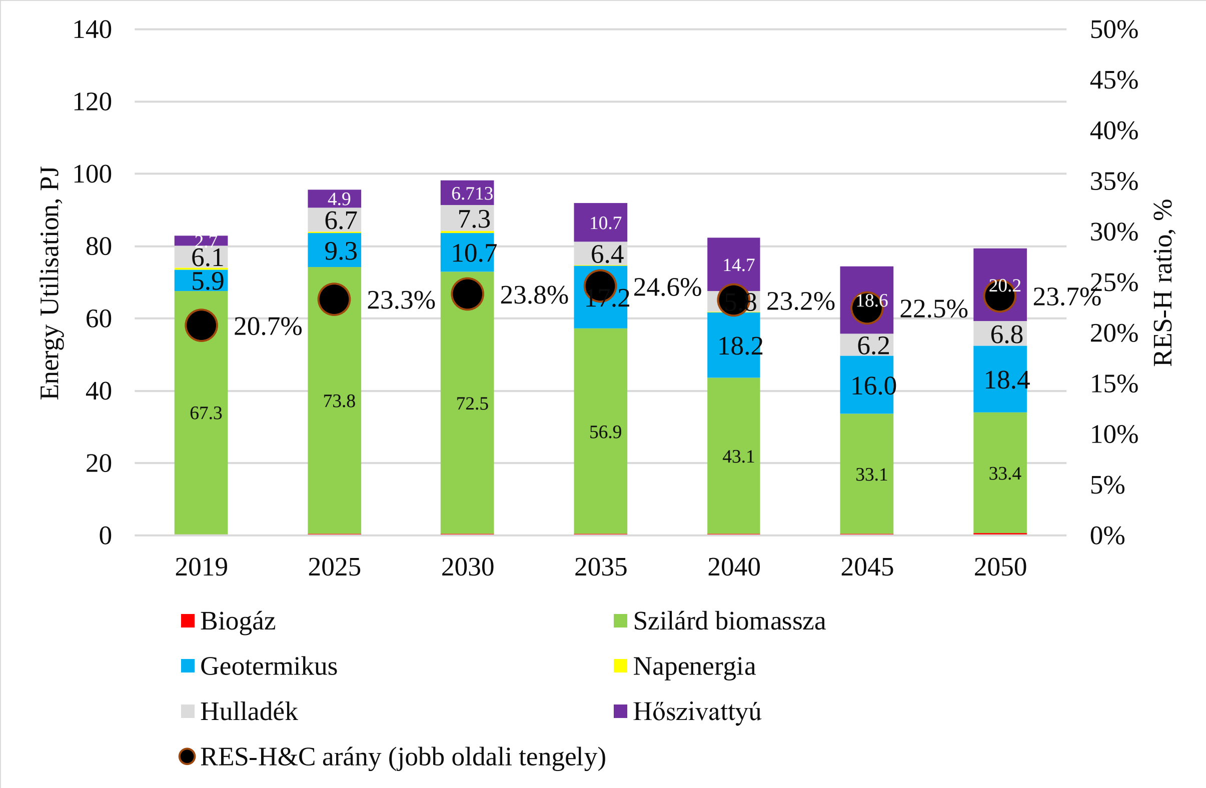


21figure – Resource mix of renewable energy use in the transport sector, WEM scenario 2019-2050, PJ

Renewable energy use in the cooling/heating sector

Solid biomass in the heating/cooling sector currently accounts for more than 80 % of renewable energy use. Although solid biomass use will be reduced slightly by 2030 (by 5 %) for the population, significant solid biomass use in the industrial segment is expected to increase. The use of this fuel in district heating production is also increasing by around 5 PJ by 2030. However, as the uptake of heat pump technologies and the increased use of geothermal energy is taking place in parallel, the share of solid biomass use among renewable sources will be reduced to 74 % by 2030. However, after 2030, biomass use will decrease drastically, mainly due to residential energy efficiency measures and fuel switching, and halve today’s use value by 2050. Although the role of heat pumps and geothermal energy continues to grow between 2030 and 2050, renewable energy use in the heating/cooling sector is still slightly lower than today’s levels in 2050.

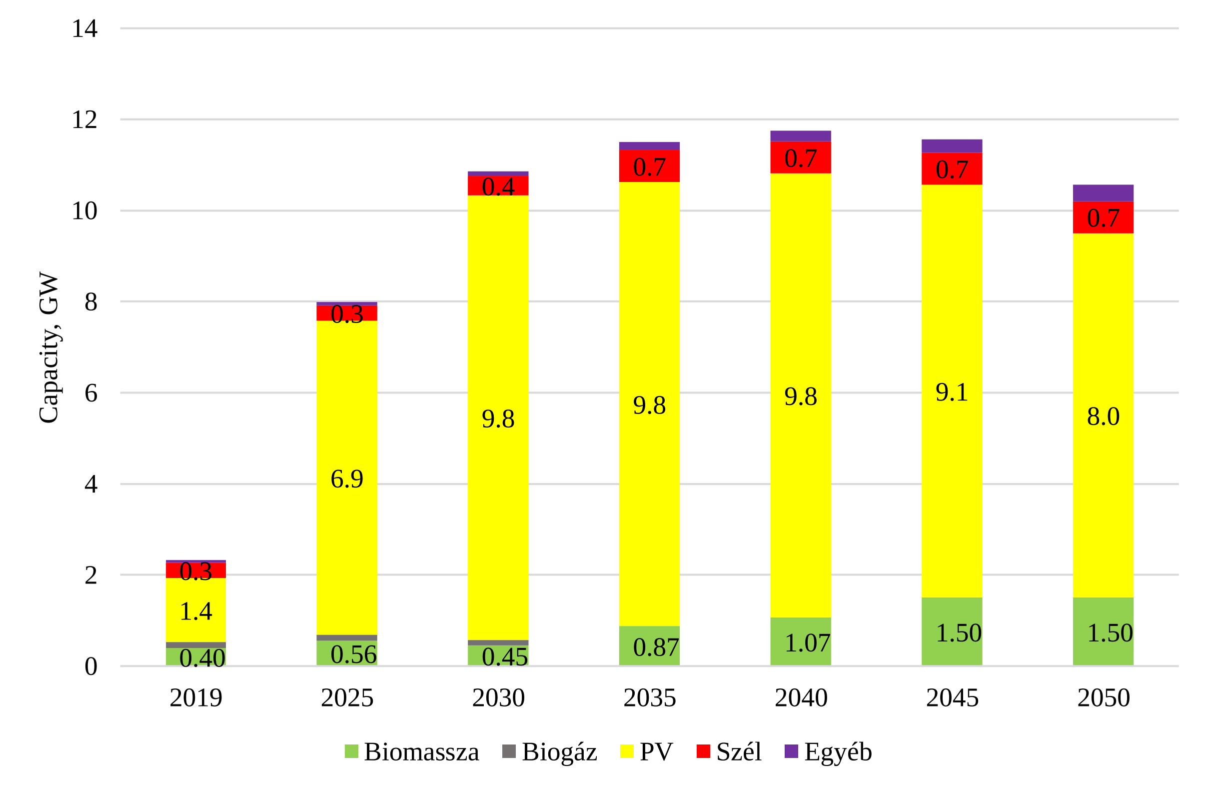
The renewable share will increase from 20.7 % in 2019 to 23.8 % in 2030 and will remain close to the same value until 2050. The significant reduction of final energy consumption by 2050 plays a major role in maintaining the share of renewable energy use.



22figure – Resource mix of renewable energy use in the cooling/heating sector, WEM scenario 2019-2050, PJ

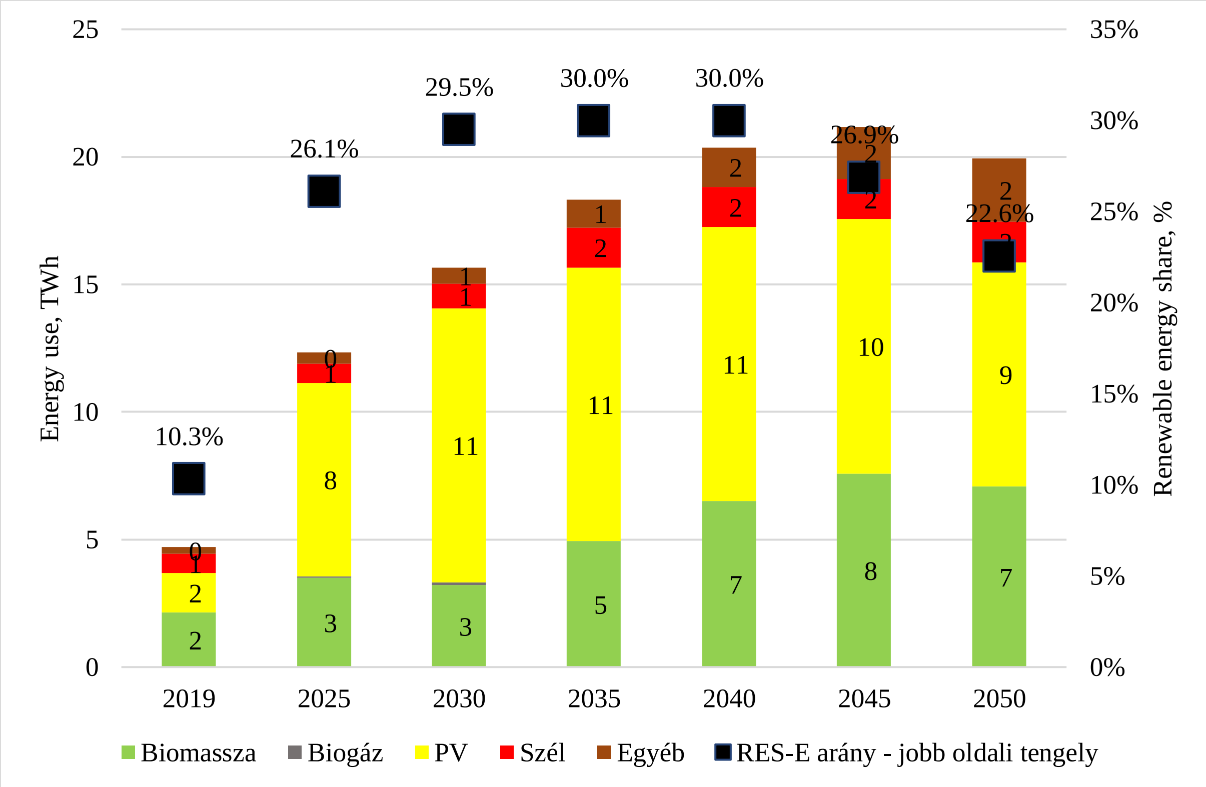
Renewable energy use in the electricity sector

In the electricity sector, the biggest change in the penetration of PV can be observed. Although a maximum limit of 13 GW was set for PV capacities in the modelling exercise by 2030, penetration remains significantly below this level. In addition, capacities will stagnate from 2030 onwards and then decrease slightly. By contrast, solid biomass use will increase slightly after 2030, although it is below 2 GW in 2050.



23figure – Evolution of renewable power generation capacities, WEM scenario, 2019-2050, GW

As a consequence of capacities, solar and biomass play a crucial role in renewable-based production. In 2050, total renewable electricity generation will be around 20 TWh, representing 27 % of total electricity consumption. In previous years, higher levels of renewable energy use have been observed due to a steady increase in the use of electricity, while renewable electricity production only slightly increases between 2035 and 2050.



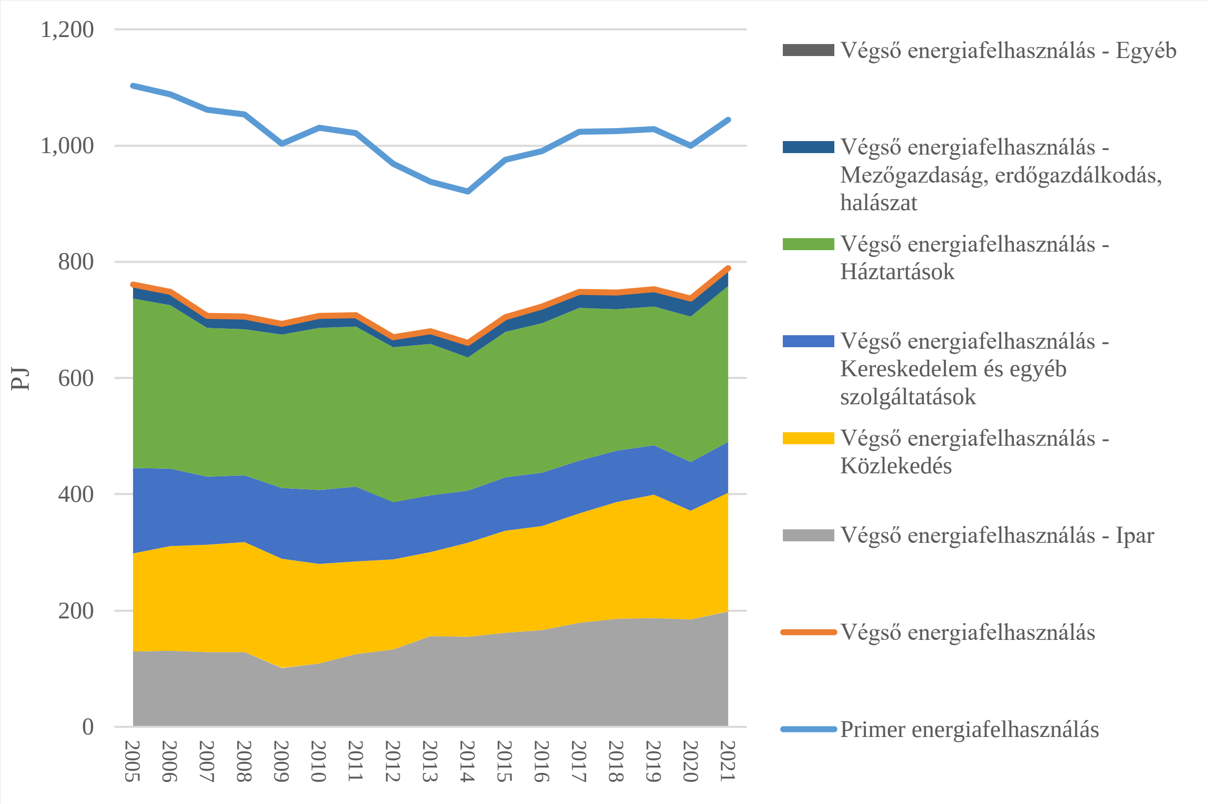
24figure 1 – Resource mix of renewable energy use in the electricity sector, WEM scenario 2019-2050, TWh

4.3. Dimension energy efficiency

i. Current primary and final energy consumption in the economy and per sector (including industry, residential, service and transport)

Hungary's primary energy consumption (2020-2030) in 2021 was 1 044 PJ, 6 % (around 60 PJ) lower than in 2005. The country's primary energy consumption decreased gradually over the period 2005-2014, reaching only 921 PJ in 2014, but again slightly increasing from 2014 onwards, which was somewhat reduced by the COVID-19 outbreak in 2020. A broadly similar pattern can be observed for final energy consumption, but for this indicator the figure for 2021 (789 PJ) is already higher than 761 PJ in 2005, i.e. overall, a higher share of primary energy consumption reaches consumers than in 2005. The increase in final energy consumption of 28 PJ cannot be considered significant, especially in view of the average annual increase in GDP during this period of 3.5 %. Compared to 2005 and 2021, final energy consumption increased by 4 %, while GDP increased by 69 %.

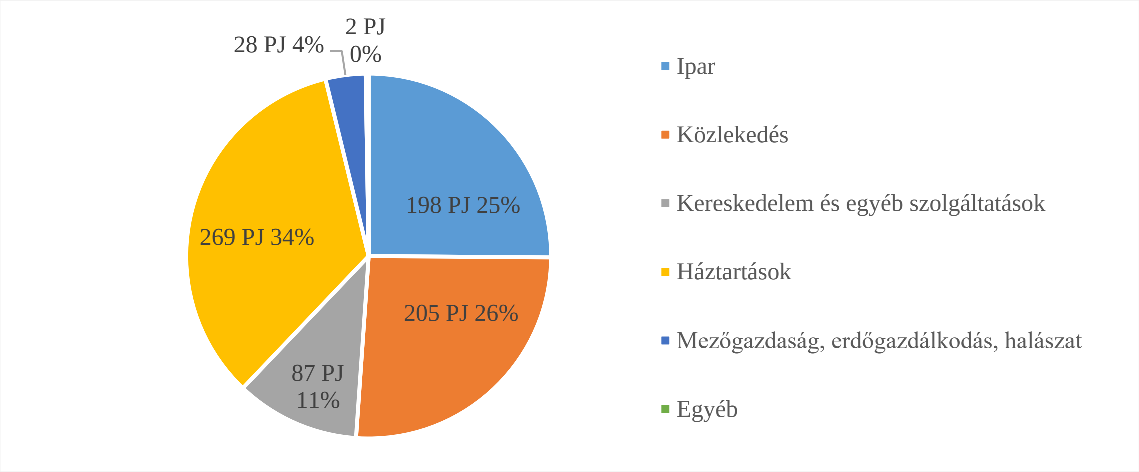
According to the methodology to be used to assess compliance with the targets set under the EED, final energy consumption was 802 PJ in 2021 compared to 785 PJ in 2005.



25figure – Primary energy and final energy consumption 2005-2021

Source of factual data: Eurostat

Looking at the sectoral distribution of final energy consumption, it can be concluded that the most significant amount of energy consumed remains in the residential sector (in 2 021.269 PJ excluding private transport, which is present in the transport sector). 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 consumption related to trade and other services has been declining since 2005 (2021: 87 PJ). The energy use associated with agriculture, forestry and fisheries is not significant (2021: 28 PJ). Industry accounted for 25 % of final energy consumption, 26 % for transport, 34 % for the population and 11 % for trade and services in 2021.



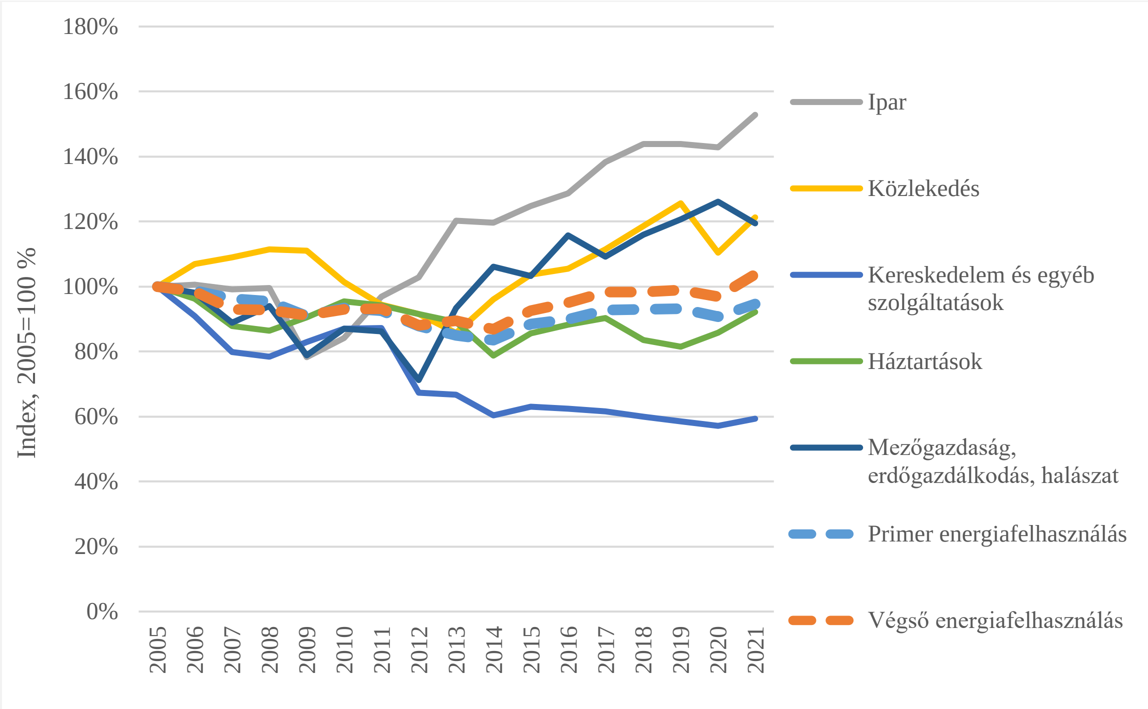
26figure - 132 Distribution of final energy use by sector, 2021

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, which is also outlier than in all other sectors. Energy use in transport and agriculture increased by around 20 % compared to 2005. Household energy consumption decreased by 5 %, while energy consumption related to trade and other services reached 60 % of 2005 levels.

It is worth noting that, in official statistics, consumption in trade and services and other sectors decreased significantly from 2011 to 2012, while industrial consumption increased. The main reason for this was the change in statistical methodology, which also gives some nuance to the picture in the energy intensity indicators to be presented later.

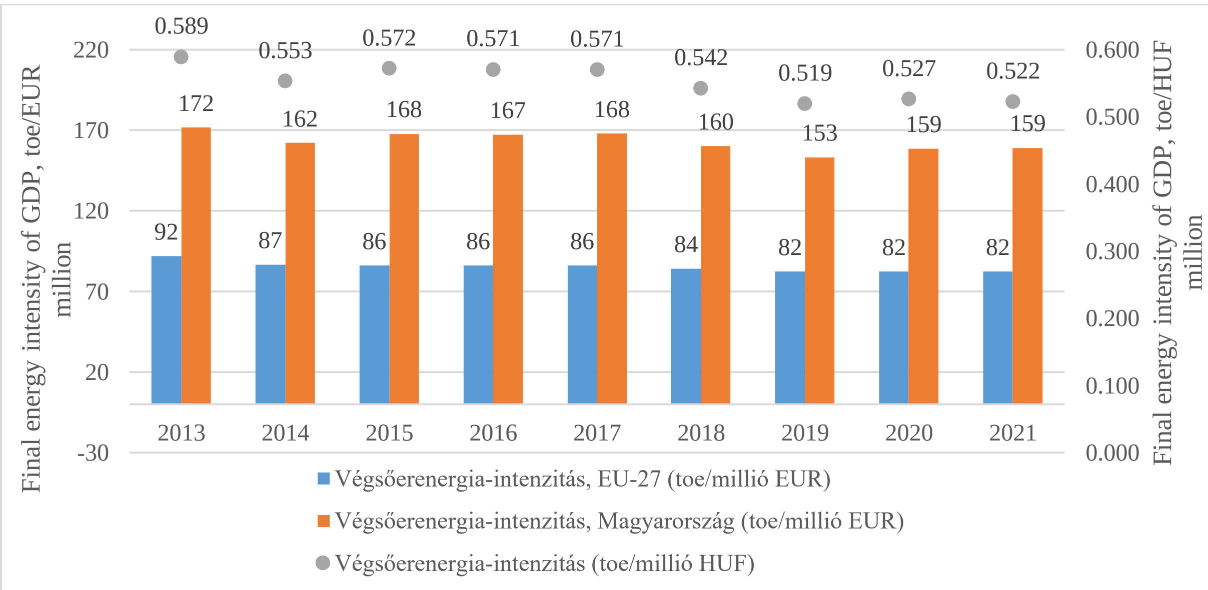
[132] The breakdown according to the old methodology is not yet available in the Eurosat database, given that, according to the new methodology, data broken down by sector is not yet available in the Eurosat database.



27figure – Evolution of final energy consumption by sector, 2005-2021

Source: Eurostat

The energy intensity of the Hungarian economy (final energy intensity of GDP) remains high compared to the overall performance of the European Union, but is constantly declining. Although the European Union's energy intensity indicator is also decreasing at a faster pace, the difference decreased in absolute terms (the difference was 80 toe/EUR million in 2013 and 77 toe/EUR million in 2021).

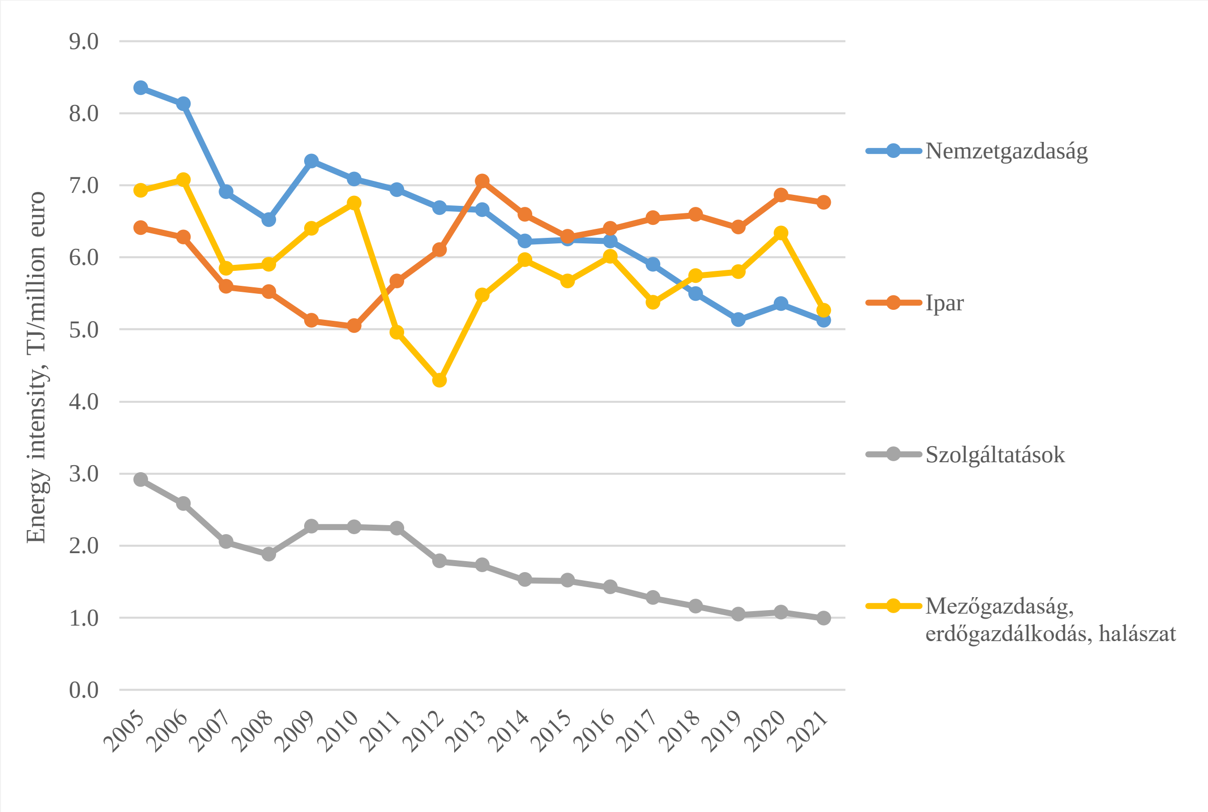


GDP in 2010 prices, final energy consumption calculated according to the new methodology

28figure – Evolution of the final energy intensity of Hungary and the EU27

Source: Eurostat

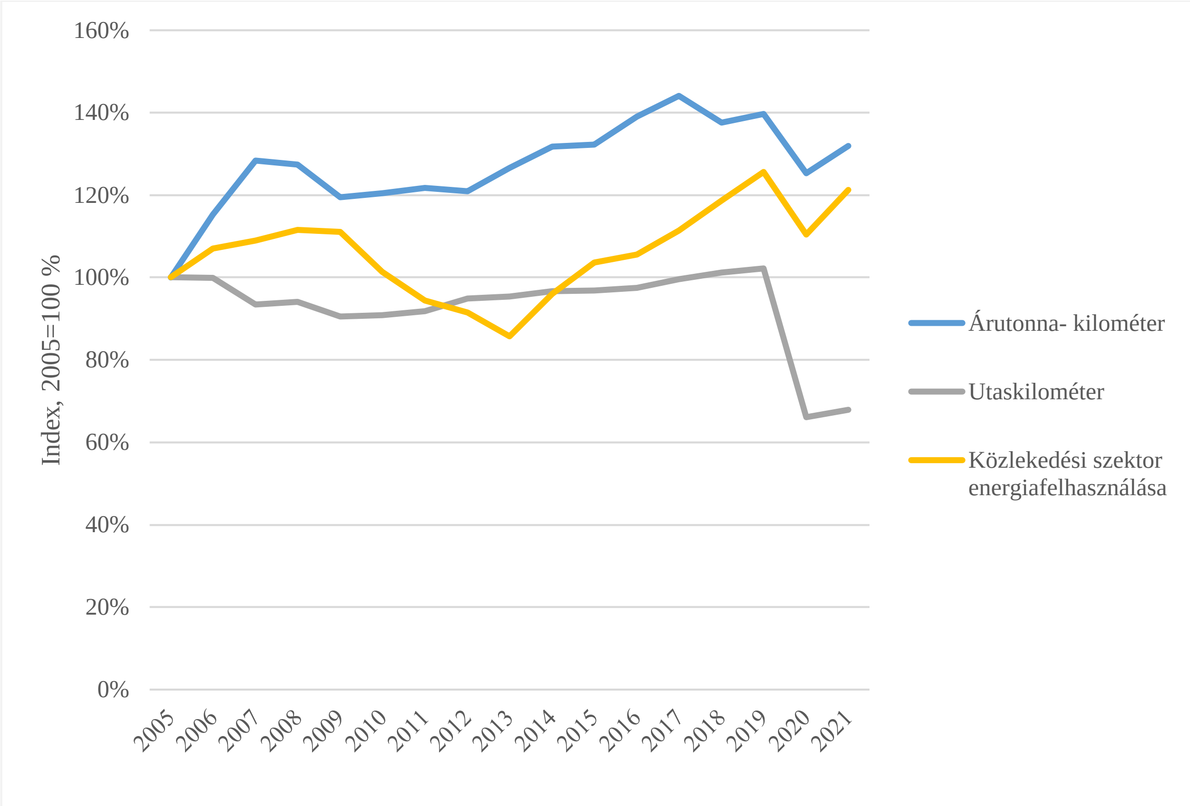
Looking at energy efficiency developments at sectoral level, mixed trends emerge. For the services sector, the improving trend is clear and can be considered practically continuous between 2005 and 2021, this trend was not observed in the more energy-intensive industrial sector and even increased by around 6 % in 2021 compared to 2005. The energy intensity of the industrial sector increased sharply after the 2008 crisis and then stagnated in the last decade.



29figure 1 – Evolutions in energy intensity of the national economy, industry, agricultural sector and services between 2005 and 2021

Source: Eurostat

In the case of the transport sector, a positive trend started after the economic crisis in 2008, as energy consumption in the sector decreased significantly, with passenger-kilometres and tonne-kilometres unchanged, up to 2013. However, from 2014 onwards, energy consumption in the sector started to rise again, while passenger and freight volumes increased slightly at the same time. The sector’s performance and energy consumption were significantly reduced by COVID-19 lockdowns in 2020, but it can be seen that this decline was only temporary and does not substantially change the increasing trend in previous years. Despite this decline, in 2021 the sector’s energy consumption was 21 % higher than in 2005, while the tonne-kilometre indicator increased by 32 %, while in the passenger transport sector the figure for 2021 is not relevant due to the aforementioned lockdowns.

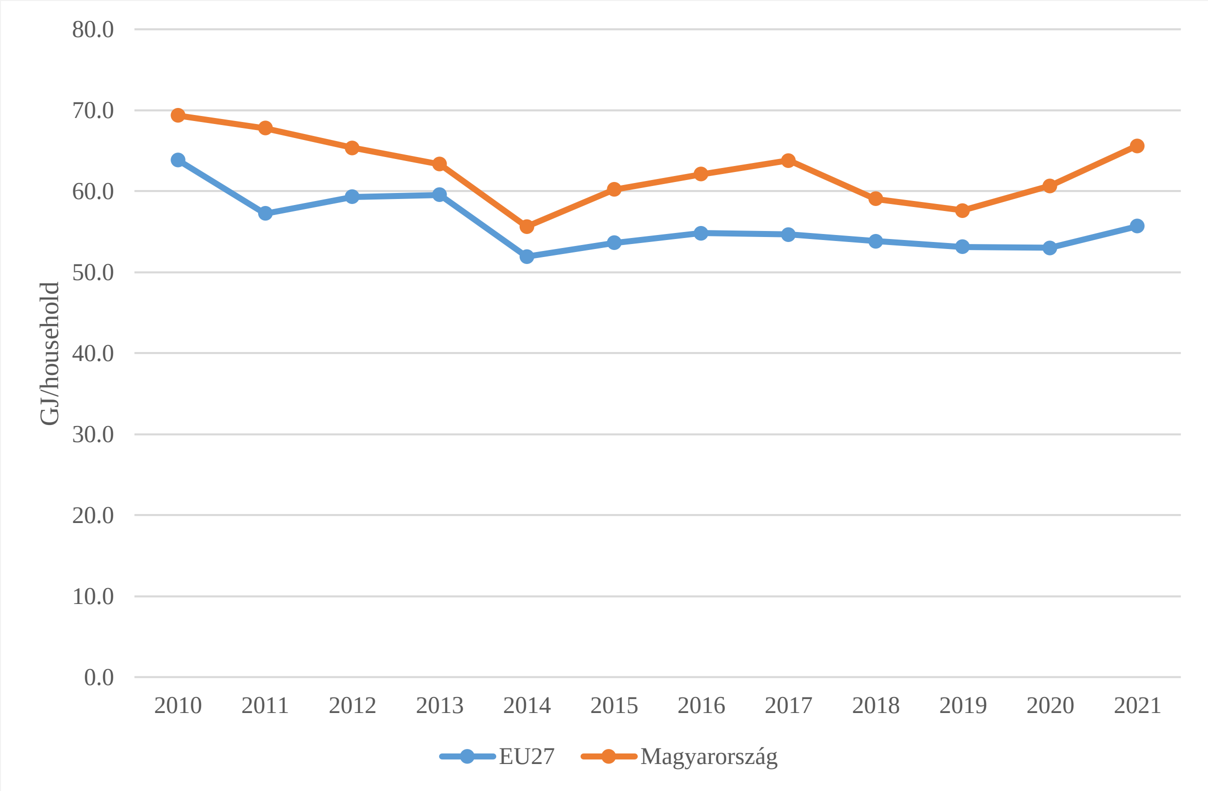


30figure – Changes in passenger and 133freight transport and final energy consumption for transport between 2005 and 2021

Source: Passenger and freight data: HCSO, data on transport energy use: 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 fell only marginally in 2021 (65.6 GJ) compared to 2010 (69.3 GJ) and increased again in recent years. Over the last decade, the energy consumption of households in Hungary has always been higher than the EU average, and the gap between the two has widened since 2019.

[133] Without air transport.



31figure – Average energy consumption by households in Hungary and the European Union between 2010 and 2021

Source: Eurostat

In 2021, a new Energy Efficiency Obligation Scheme (EEOS) was introduced to significantly reduce energy use in the period 2021-2030. Under the system in place, obligated energy traders must achieve end-use energy savings measures and programmes that result in savings calculated on the basis of a given calculation system and subsequently certified savings for end-users.

In Hungary, the obligated entities include electricity traders, universal electricity suppliers, natural gas traders, natural gas universal service providers and suppliers of transport fuel to final customers. For the scheme put in place, each year has a savings target for the period 2021-2030, which is always determined on the basis of a percentage of final energy use in the year 'referential year-2'. The savings rate will gradually increase until 2024, with the highest values (0.5 % savings per year) corresponding to the 2024-2027 period. Under the established system, certified energy savings can be freely sold among obligated parties on an organised market.[134]

ii. Current potential for the application of high-efficiency cogeneration and efficient district heating and cooling135

134 https://www.enhat.mekh.hu/ekr

135 In accordance with Article 14(1) of Directive 2012/27/EU.

The survey pursuant to Article 14(1) of Directive 2012/27/EU was carried out in 2015 and updated in 2020.[136] The report shall address the identification of district cooling and district heating potentials as a specific theme. The report outlines a total of three scenarios, different from the extent to which the demand for district heating will change in the future. The balanced table shows that the needs and the energy mix will save the district heating sector financers HUF 14124 million in 2020 compared to 2015, which will increase significantly by 2040 (HUF 35776 million). This means that even if scenario 2 materialises, the base value of the district heating aid cannot be eliminated in 2040, even if scenario 2 materialises. The total need for the development of geothermal capacity by 2019 is 150 MW (HUF 45 billion) and a further 274 MW up to 2039 (HUF 82.3 billion). The necessary biomass-based resources require the construction of 215 MW capacity (HUF 25.8 billion) before 2020, which will increase by about 265 MW (HUF 31.8 billion) by 2040.

If the funding savings were fully used to reduce the cost of district heating for the population (continuing reduction in charges), this would make it possible to reduce the initial cost of HUF 3900 per GJ by HUF 651 per GJ in 2020 (by 16.7 %) and by 1 924 HUF/GJ (49.3 %) in 2040.

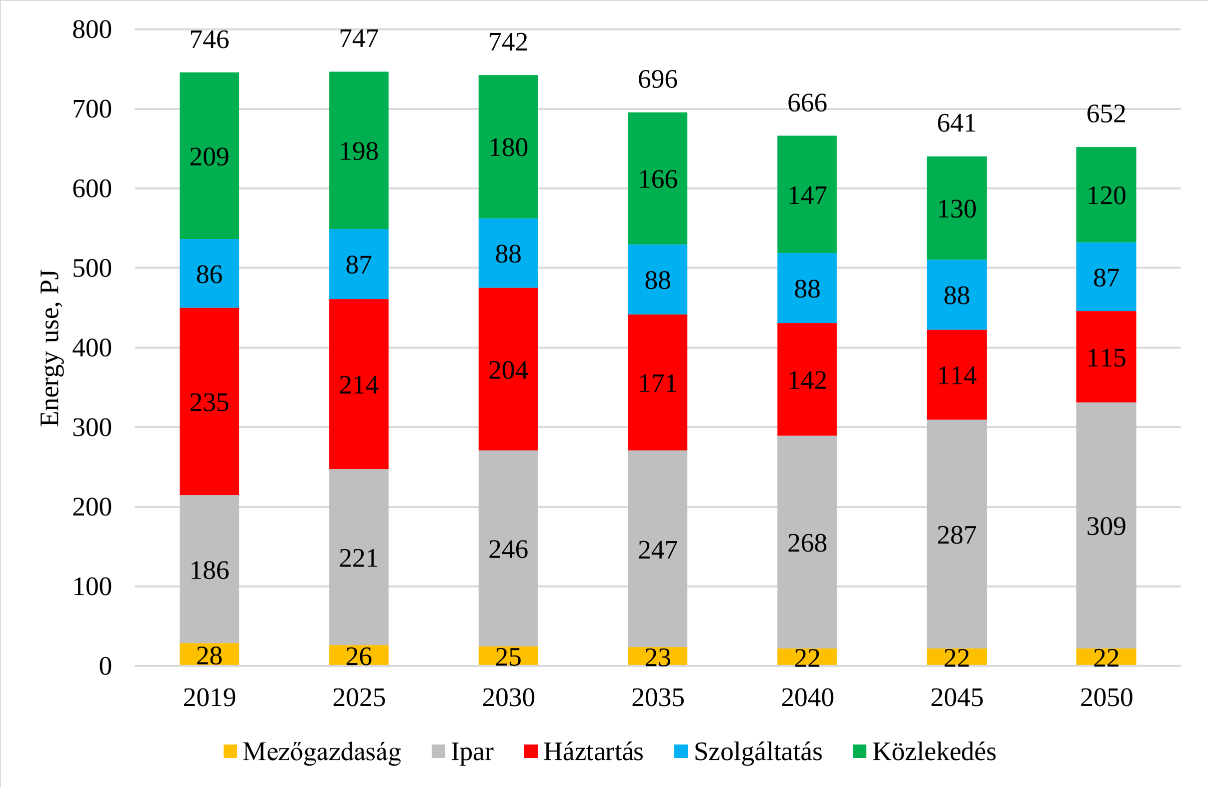
iii. Projections considering existing energy efficiency policies, measures and programmes as described in point 1.2.(ii) for primary and final energy consumption for each sector at least until 2040 (including for the year 2030) 137

Final energy consumption

In the current measures (WEM) scenario, the domestic gross final consumption of energy will decrease by 0.5 % by 2030 to 742 PJ compared to 2019.

[136] https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en

[137] This reference business as usual projection shall be the basis for the 2030 final and primary energy consumption target which is described in 2.3 and for conversion factors.

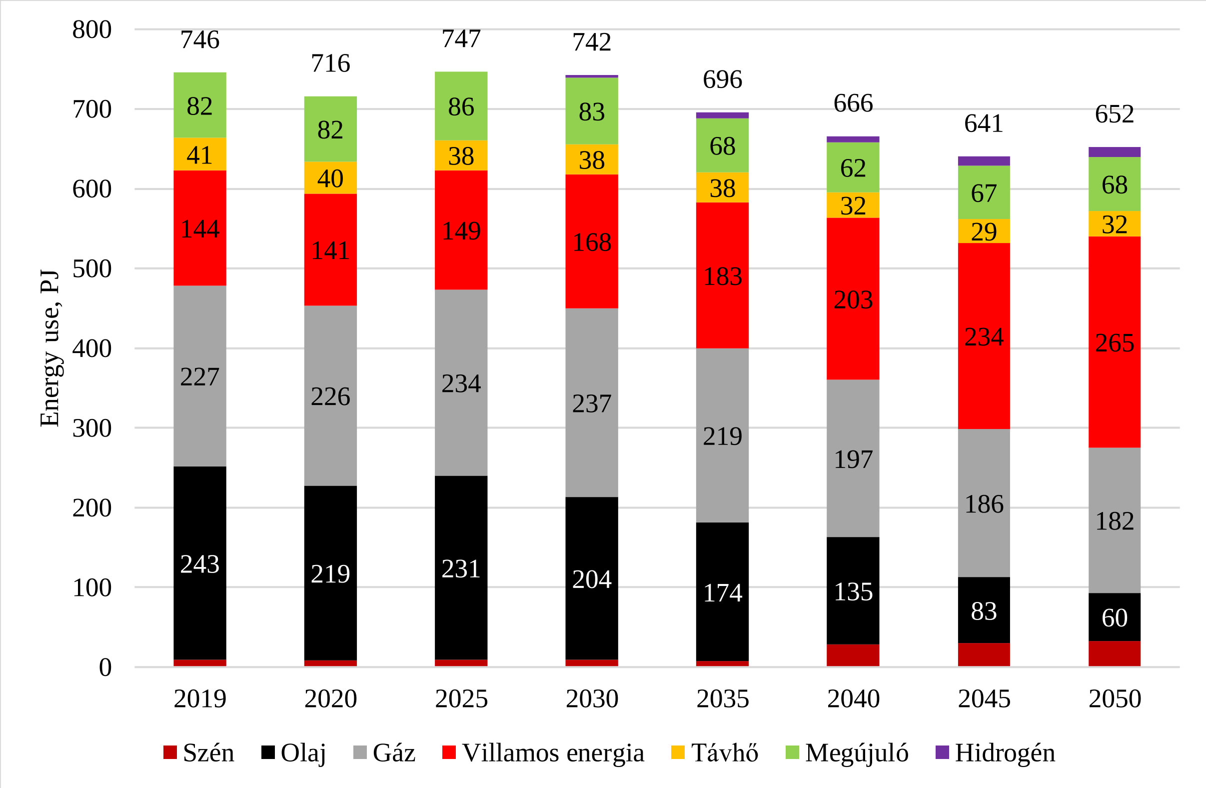


32figure – Evolution of gross final energy consumption by sector, WEM scenario 2019-2050, PJ

The largest increase during this period is observed in industry, with an increase in energy use of almost 32 %. Despite the increasing efficiency of industrial and technical building equipment, this impact cannot fully offset the large increase in demand. Lower growth (1.6 %) can be observed in the services sector. In the residential sector, on the other hand, the scenario without additional measures is also seeing a decrease in energy use by around 13 % by 2030, and the rate of decreasing trend is even more visible during the 2030s and 2040s.

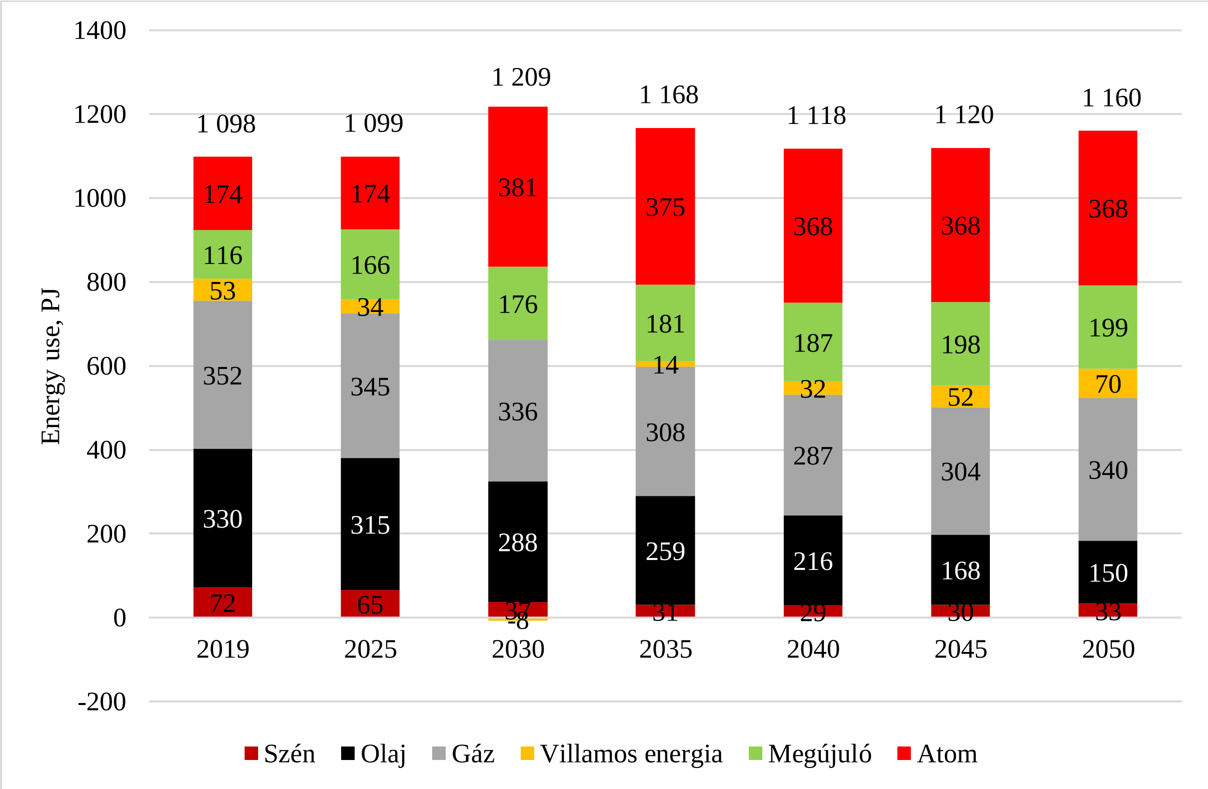
For the transport sector, we see the same decrease of 14 % as residential buildings between 2019 and 2030, followed by a further decrease in consumption and drop to 58 % in 2019 by 2050.

Looking at the type of energy used, there is a significant increase in electricity consumption (16 %) between 2019 and 2030. To a lesser extent (6 %), the use of coal-based products is also growing mainly due to an increase in the use of coal in the industrial and transformation sector (coke manufacturing), but the share of coal is still below 1.3 % in 2030. Natural gas consumption will also increase by 4.5 % over the period 2019-2030, increasing its share to 32 %, and by 2030 the consumption of petroleum products will decrease by 16 % compared to 2019, thus reducing its share of total final energy consumption to 27 %. The use of district heating will be 6 % lower by 2030. The role of hydrogen – 0.4 % of total final energy consumption – is still negligible. The consumption of renewable energy carriers is almost unchanged – 1.5 % higher than in 2019 – the share of renewable energy carriers is higher than 11 % by 2030.



33figure – Evolution of the composition of gross final energy consumption by energy carrier, WEM scenario, 2019-2050, PJ

Looking at the fuel mix, it can be seen that coal loses its relevance due to its marginalisation in electricity generation, so that its use will be almost half by 2030 and its overall share of primary energy consumption could be around 3 %. There is a significant increase in nuclear energy in 2030, when new and old Paks units are assumed to operate in parallel. Nuclear energy consumption will increase by 118 % by 2030 compared to 2019, with a share of over 31 %. There is also a significant increase in the use of renewable energy: By 2030, consumption will increase by around 51 % compared to 2019, thus accounting for almost 15 % of total primary energy consumption. Electricity imports are falling sharply in 2030, with Hungary becoming fully self-sufficient on an annual basis when the Paks blocks coexist, and with the increase in domestic electricity consumption, imports will increase again in the 2030s and 2040s.



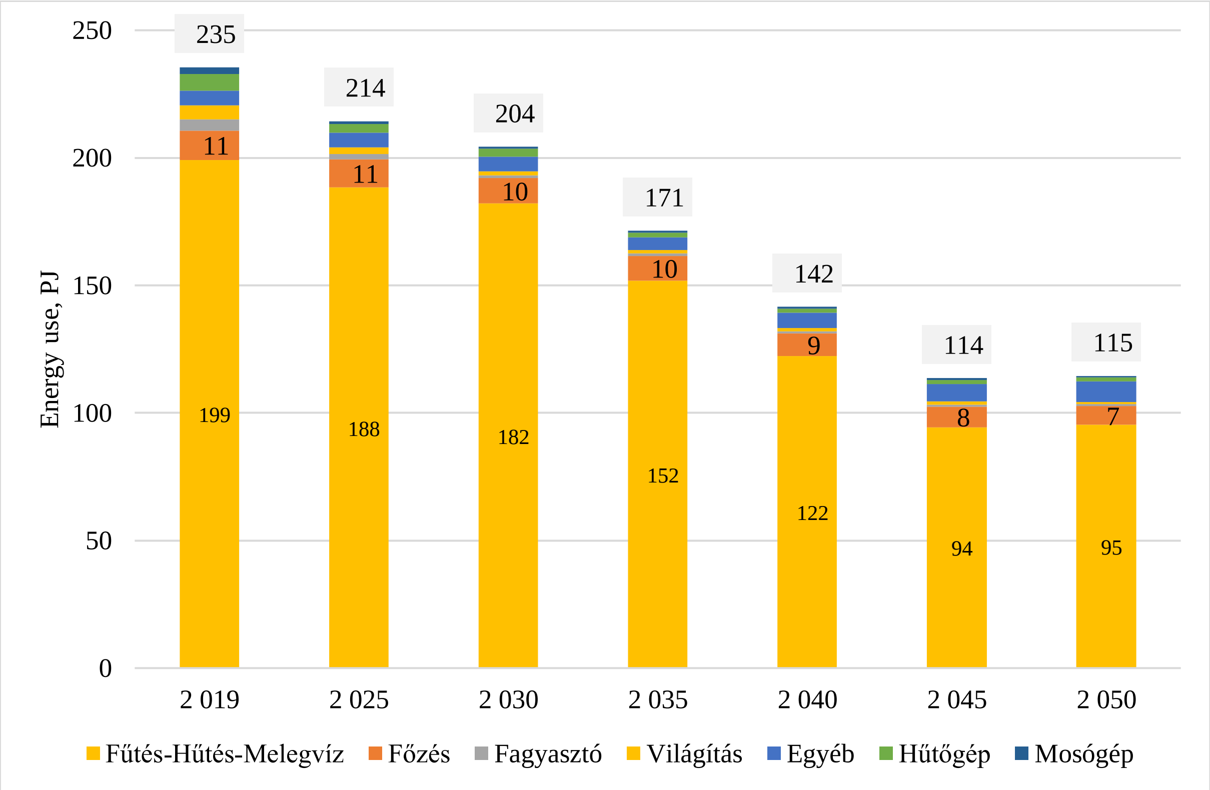
34figure – Evolution of the primary energy consumption mix by energy carrier, WEM scenario, 2019-2050, PJ

The fuel mix in each gross end-user segment and the significant consumer sub-segments within a given sector are described in detail below.

Population

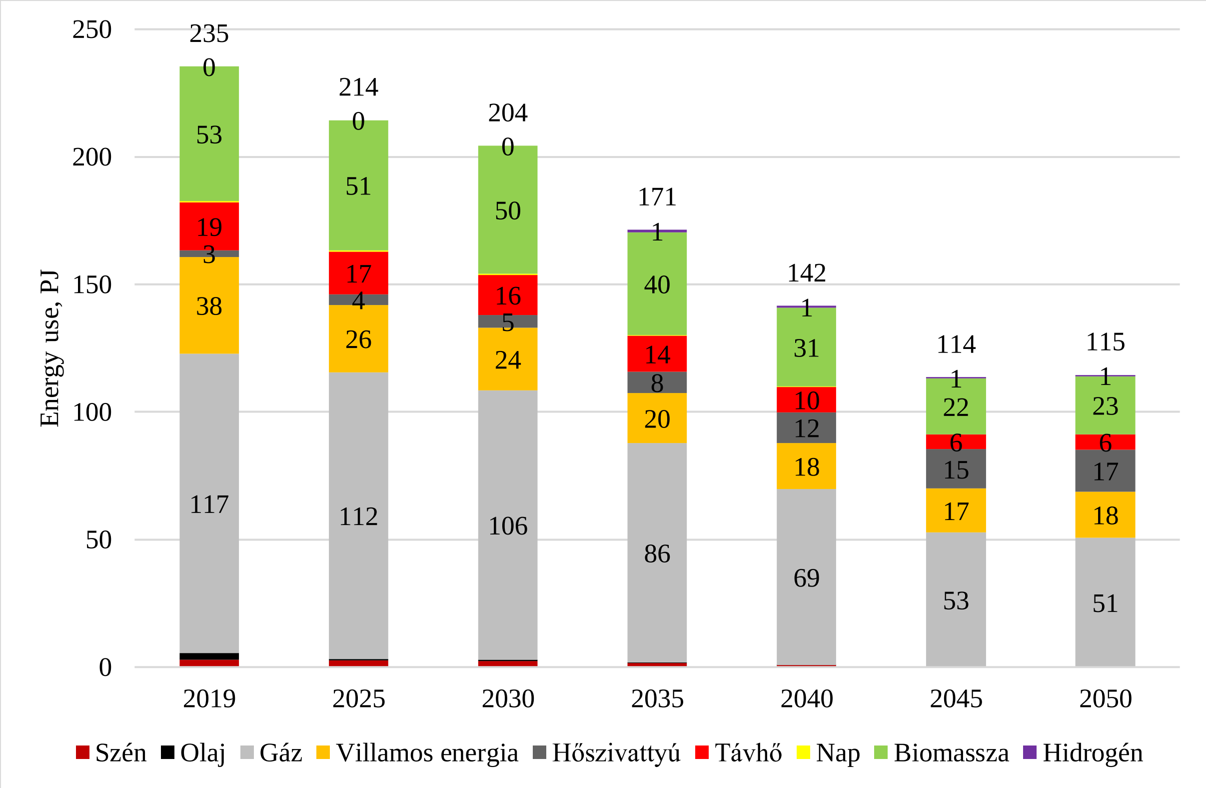
Energy efficiency investments are becoming increasingly competitive thanks to rising energy prices due to the energy crisis, leading to a significant reduction in the overall use of energy for heating. Energy consumption for heating, cooling and hot water production will fall by almost 9 % by 2030 compared to 2019. Total household final energy consumption will decrease by around 13 % to 204 PJ by 2030. The reduction in household energy consumption will continue beyond 2030, halving the 2019 consumption by 2050 under current measures. In addition to increased market energy prices, the introduction of ETS2 will further increase demand for energy efficiency investments.

In addition to a reduction in energy use for heating, cooling and hot water, there is also a significant drop in the energy use of household appliances. The energy use of refrigeration, freezing and washing machines is significantly reduced, as these devices have relatively high rotational speeds and new devices are significantly more energy efficient than previous ones. A similar trend can be expected for lighting. The energy use of other assets is increasing in line with economic development, but the magnitude of this increase is not significant.



35figure – Evolution of the household energy mix by use, WEM scenario, 2019-2050, PJ

Natural gas and biomass are the most important fuels for household energy consumption. Consumption will decrease for both fuels by 2030, more significantly for natural gas (10 %) and lower for biomass (5 %). Electricity consumption will also be significantly reduced by around 36 % by 2030, thanks to improved energy efficiency of new devices. By 2050, electricity consumption will decrease by half, with a significant increase in the take-up of new energy-efficient household appliances. District heating consumption is also expected to decrease significantly, with consumption falling by almost 16 % by 2030. Coal and oil use will be completely phased out by 2050, with only a few PJs already being used in 2030. By contrast, energy-efficient heat pumps can see increasing energy use already in 2030, with electricity consumption doubling compared to 2019. The energy consumption of heat pumps in 2050 is six times higher than in 2019, with a share of 14 % of total household final energy consumption.

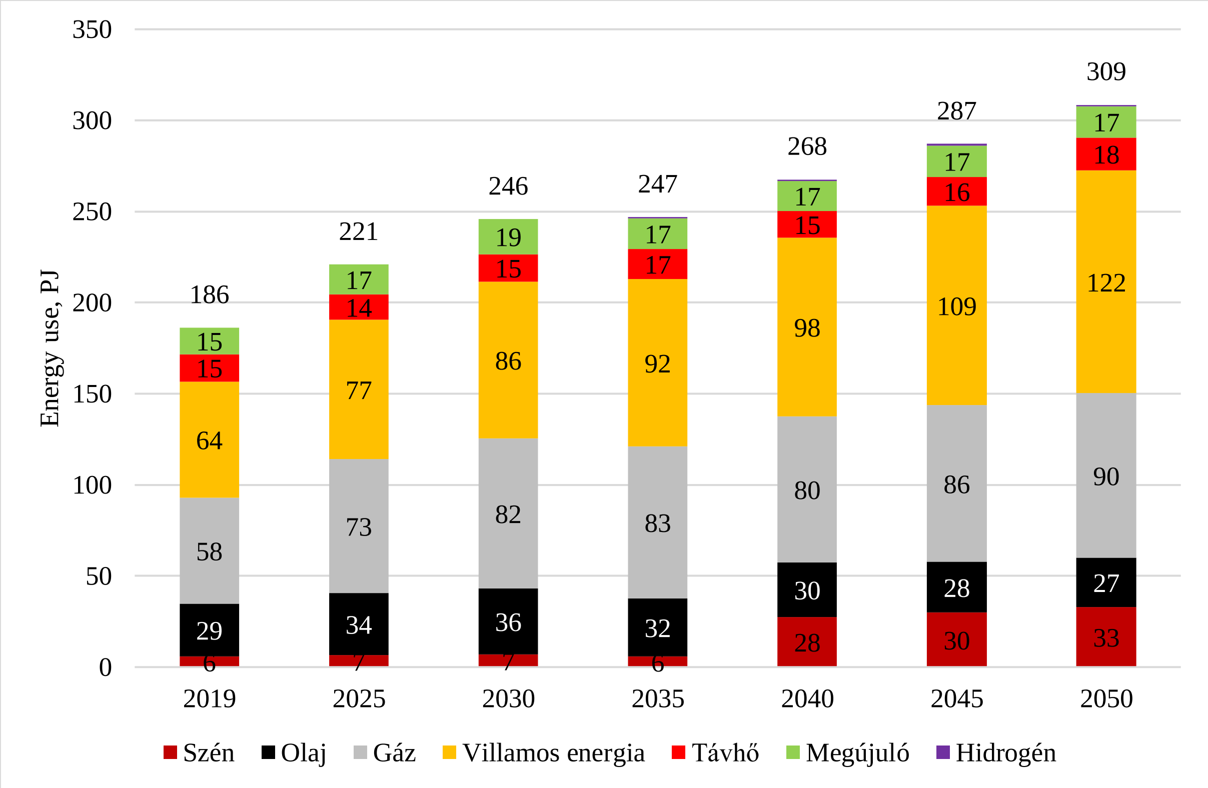


36figure – Evolution of the household energy mix by fuel, WEM scenario, 2019-2050, PJ

<u>Industry</u>

Despite investments in energy efficiency, industry's energy use is increasing significantly, reaching 246 PJ by 2030, an increase of 31 % compared to 2019. Growth is slowing down slightly in the 2030s and 2040s, but total industrial final energy consumption in 2050 is more than 65 % higher than in 2019.

Thanks to increased industrial production and new investments, oil, gas and electricity consumption will also increase significantly, by 25 %, 42 % and 35 % respectively by 2030 compared to 2019. By 2050, these increases will already reach 59 %, 57 % and 50 %. Coal consumption will increase to a lesser extent by 2030, due to increased demand for pig iron. A significant use of coal will be achieved by 2050, thanks to the uptake of CCUS technology for pig iron production. The use of renewable energy, in particular primary solid biomass, is increasing significantly by 2030, 32 % higher than in 2019. At the same time, the use of this energy source will decrease after 2030 due to the scarcity of primary solid biomass.



37figure – Evolution of the energy consumption mix of the industrial sector by fuel, WEM scenario, 2019-2050, PJ

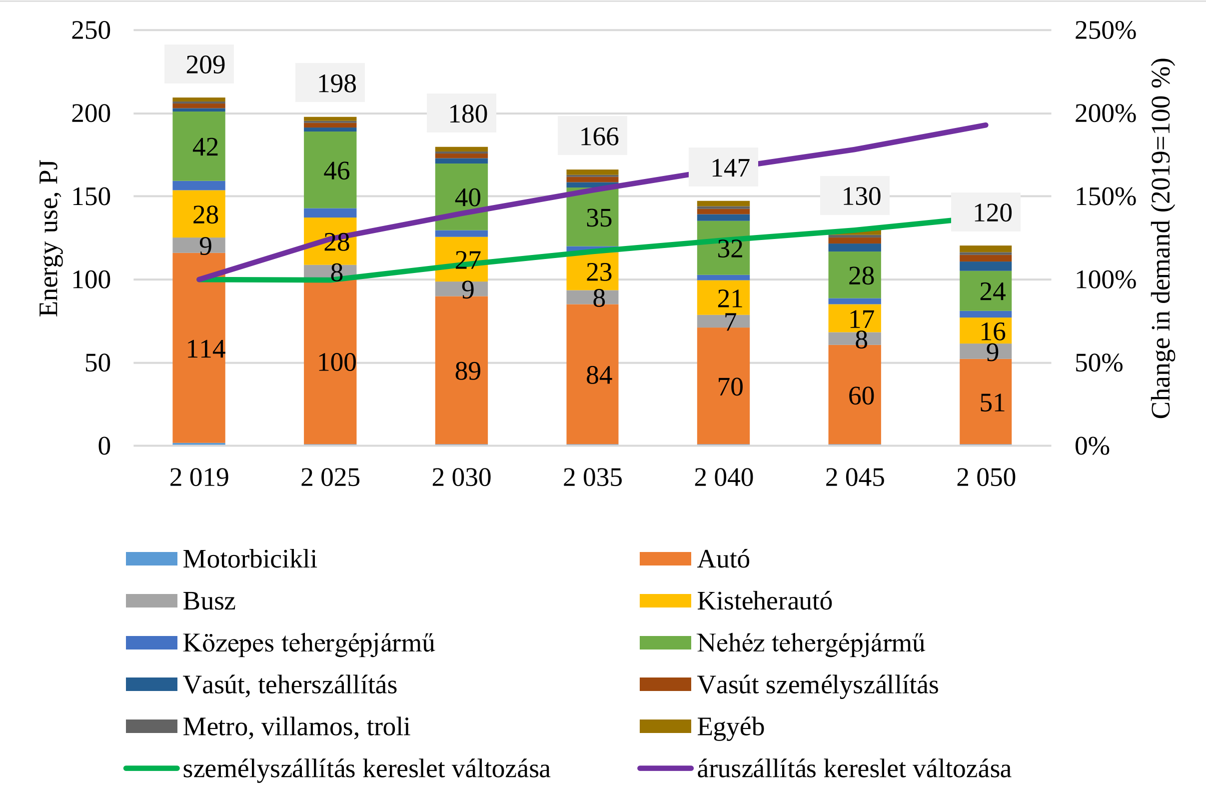
Transport

For passenger transport, the estimated passenger-kilometres increase by 9 % by 2030 compared to 2019 and by 38 % by 2050. At the same time, the estimated freight transport performance is significantly higher than in 2019 by around 40 % and 98 % by 2030 and 2050.

In a context of increasing demand, energy consumption is due to the combination of several factors. In part, there will be a change of mode whereby individual motorised transport will be partly shifted to public transport by 2030. The share of energy use in passenger cars will decrease from 55 % in 2019 to 50 % in 2030 and 43 % by 2050. At the same time, the share of buses, rail and rail-based public transport modes will increase to 7 % by 2030 and 12.4 % by 2050, from 6.5 % today. With regard to freight transport, there is also a minor shift from road to track-based transport. The share of the latter increases from 0.9 % in 2019 to 1.6 % in 2030 and 4.5 % in 2050.

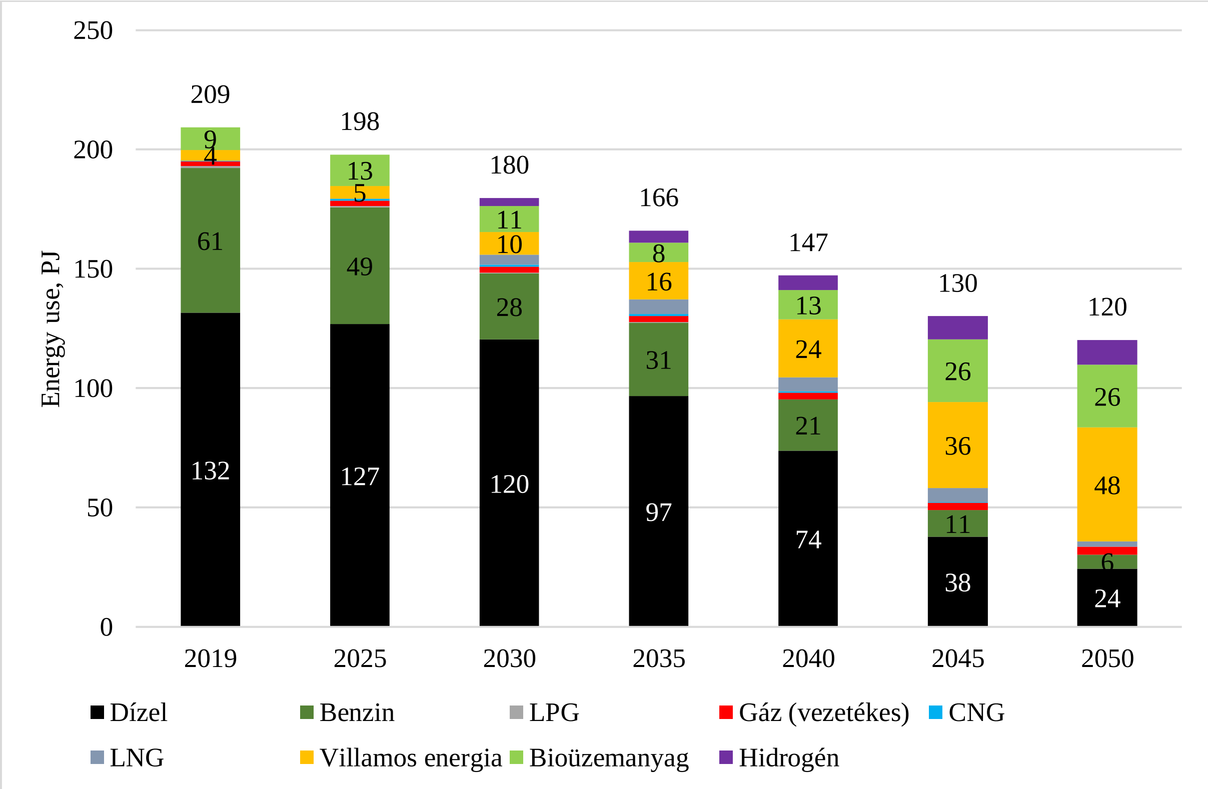
In addition to modal shift, a reduction in energy intensity is also contributing to a reduction in energy use. For passenger cars, energy intensity will be almost 23 % lower by 2030 on average, and close to 52 % by 2050 than in 2019. This is mainly due to the uptake of more advanced internal combustion and electric vehicles. On average, the energy intensity of trucks is 30 % and will decrease by 60 % by 2030 and 2050. For rail and urban tramway transport, energy intensity will increase by 20 % by 2030.

There is also a significant drop in the energy use of buses, which is also due to a decrease in energy intensity.



38figure 1 – Evolution of the energy mix of the transport sector by main modes (PJ) and changes in estimated passenger and freight demand (%), WEM scenario, 2019-2050

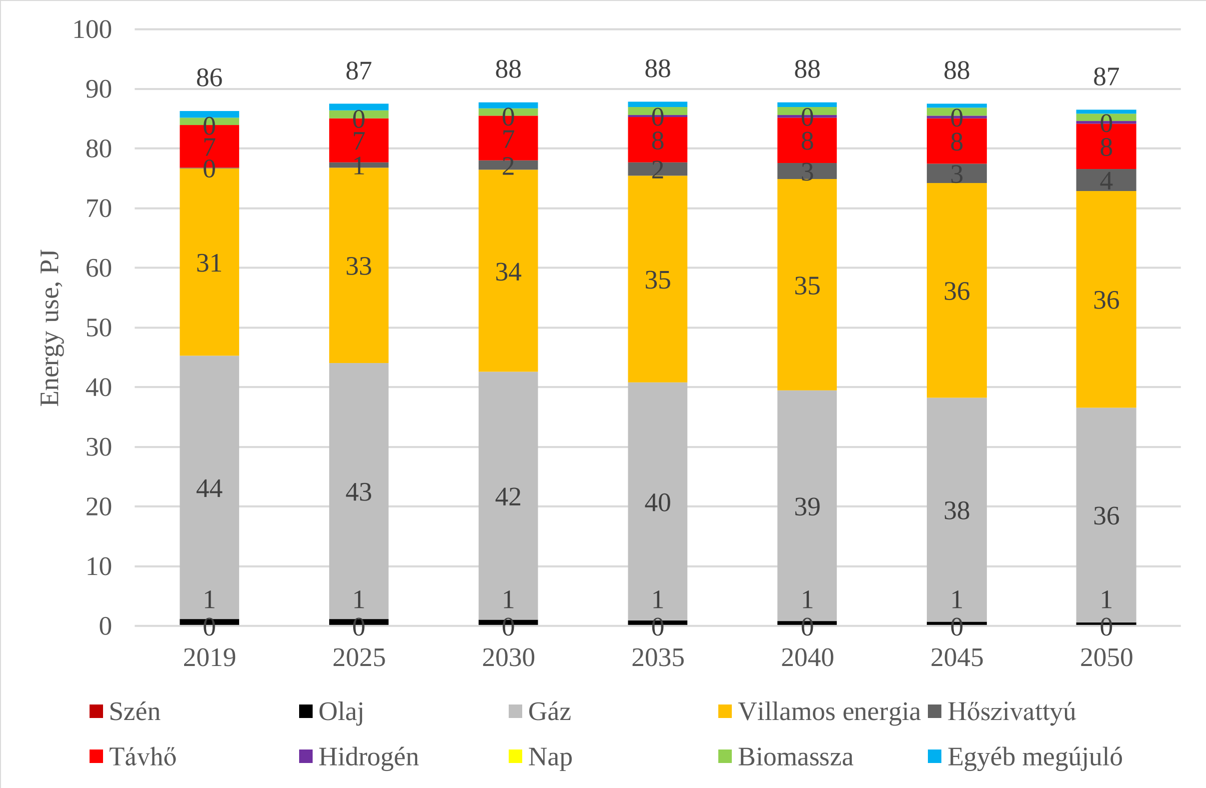
In the transport sector, petrol consumption will fall significantly by almost 54 % by 2030 and diesel consumption will decrease by around 9 %. The use of biofuels will increase by 17 % and electricity consumption by around 116 % by 2030. Based on modelling results, final energy consumption in the transport sector will decrease by 14 % by 2030 and 43 % by 2050 compared to 2019. The transition to more efficient and less greenhouse gas emission technologies will be made more competitive by the introduction of the ETS2 system.



39figure – Evolution of the energy consumption mix of the transport sector by fuel used, WEM scenario, 2019-2050, PJ

Services sector

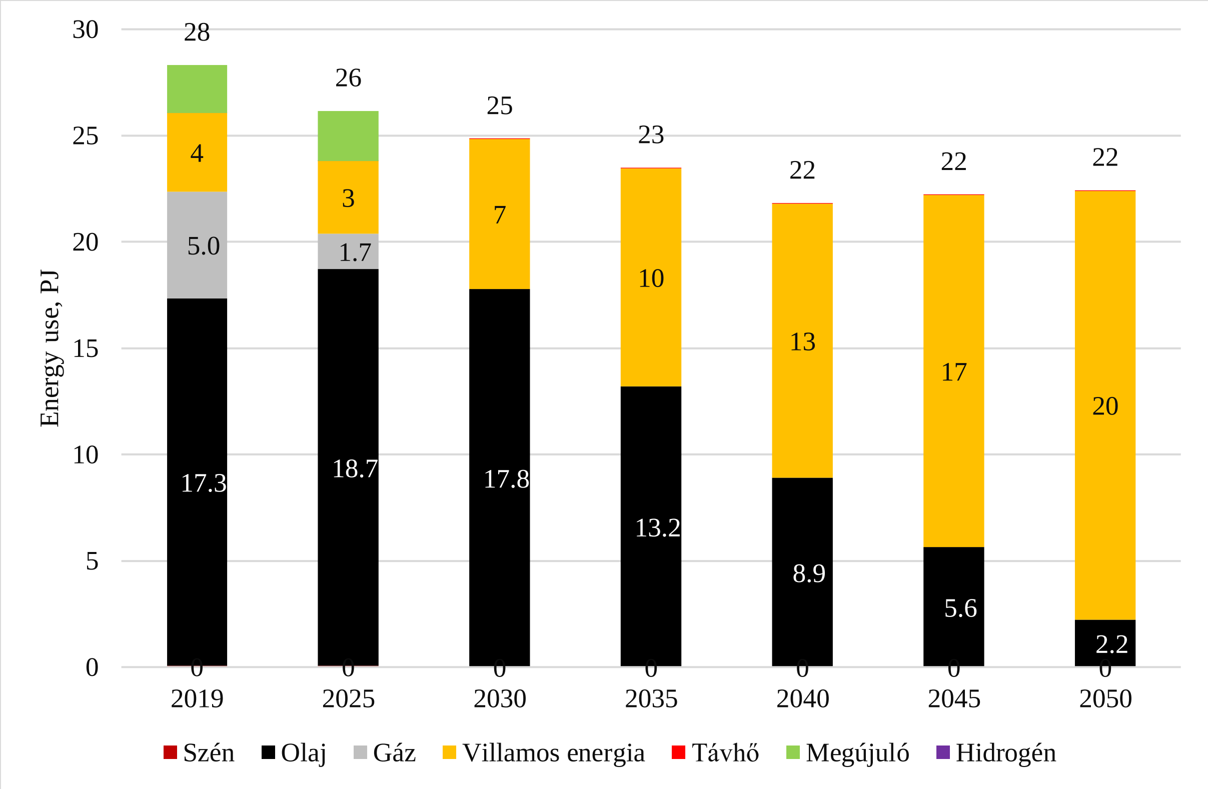
In the services sector, energy consumption in the "current measures" scenario is stagnating. In a context of increasing demand, real energy use will increase by 1-2 PJ by 2030 and 2050 compared to 2019 levels, with significant energy efficiency investments and the use of less energy intensive technologies. In terms of fuel mix, the use of natural gas and a more significant increase in the use of electricity and the use of heat pump technology is on the rise.



40figure – Evolution of the fuel mix of energy use in the services sector, WEM scenario, 2019-2050, PJ

Agriculture, forestry and fishing

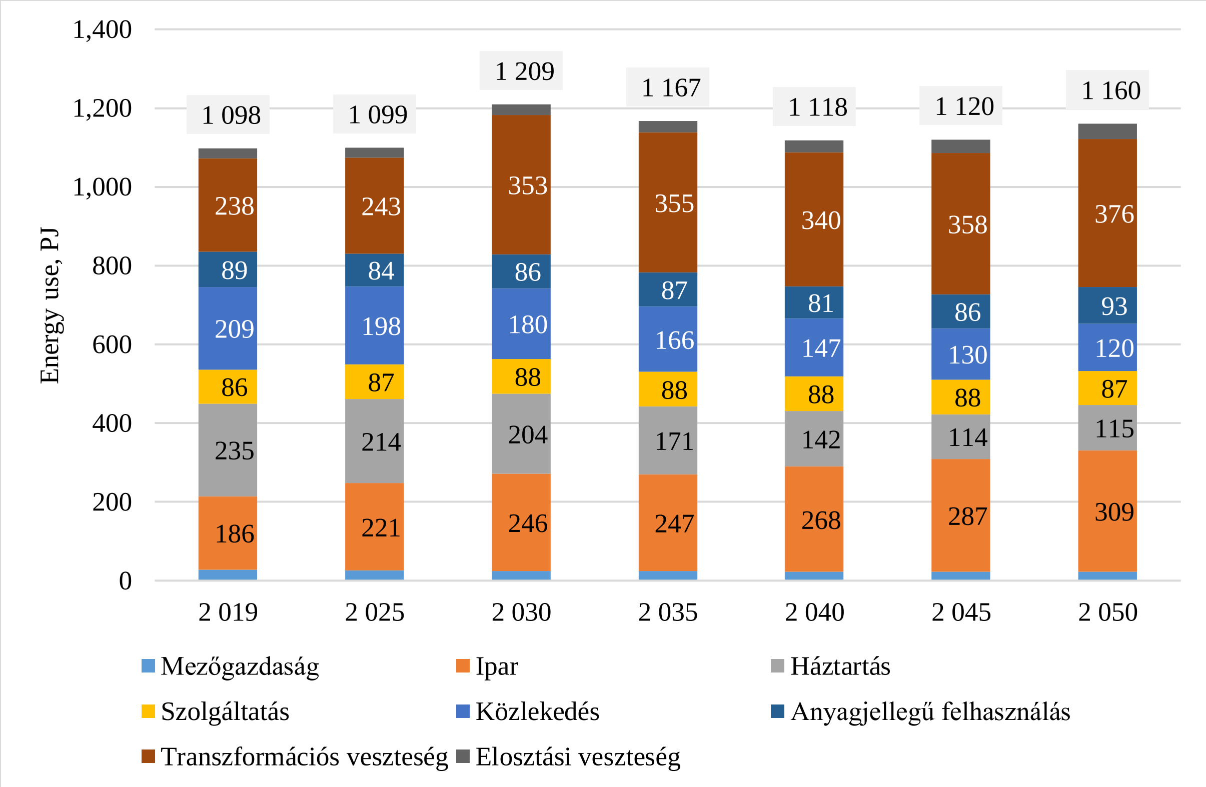
Compared to 2019, energy use in the agriculture, forestry and fisheries sectors will decrease by 12 % by 2030 and by almost 21 % by 2050. The share of electricity in the current predominant sectoral energy mix of oil is increasing, reaching 90 % by 2050.



41figure – Evolution of the fuel mix of energy use in the agricultural sector, WEM scenario, 2019-2050, PJ

Primary energy consumption

There is a significant increase in primary energy consumption in 2030, largely due to the entry of new Paks blocks increasing the transformational loss, and then, due to a decrease in final energy consumption, the value of this indicator will decrease somewhat by 2050. In addition to an increase in transformational losses, growth in distribution losses and industrial final energy consumption can be offset over the longer term by decreasing final energy demand in transport, residential and agricultural sectors with stagnating material consumption.



42. Figure 2: Evolution of the composition of primary energy consumption by sector, WEM scenario 2019-2050, PJ

4.4. Dimension energy security

i. Current energy mix, domestic energy resources, import dependency, including relevant risks

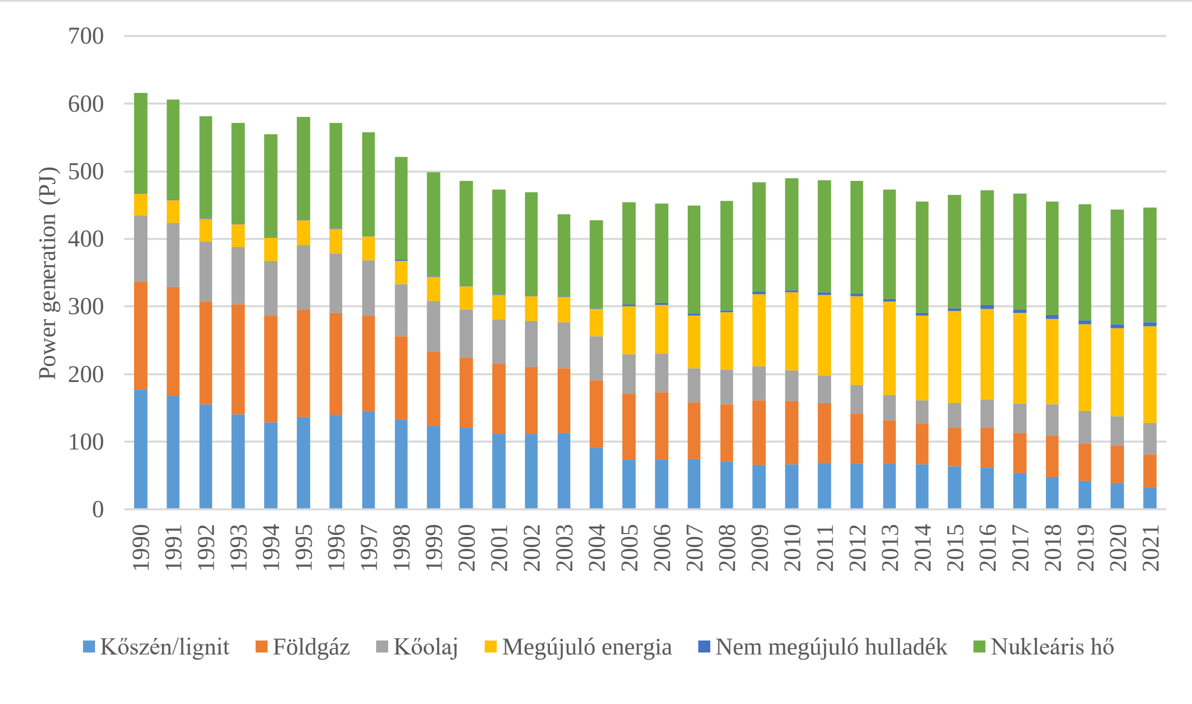
The overall trend of fossil fuel extraction in Hungary is decreasing.

Coal mining (black coal, brown coal, lignite) was dominant in the country's energy supply until the 1960s, but from there has been a drastic reduction in the amount of coal mined. The decline in coal mining was initially caused by the deindustrialisation of heavy industries. In the future, the impact of the tightening of pollutant emission standards has become increasingly effective. As a result, in 2021 only 32.4 PJ of coal/lignite were produced in the country (representing 56 % of domestic demand), far below the volume of 176.8 PJ extracted in 1990.

The extraction of hydrocarbons in Hungary reached its peak in the 1980s, with smaller or larger fluctuations since then declining. However, as a result of successful concession tenders, the decline in domestic hydrocarbon extraction has stopped in recent years and has even increased in recent years. Natural gas production amounted to 49.3 PJ in 2021 (1.18 mtoe). Oil production in 2021 ranged from 43 to 45 PJ.

The growth of nuclear heat production and even more renewable energy production facilitates the climate-friendly transformation of the Hungarian energy system. Biogenic energy production (solar energy, biomass from forestry and agriculture, biogas, agrofuels), geothermal and thermal energy are the most important in the context of renewable energy sources in Hungary.

All these processes have led to a significant change in the composition of Hungarian energy production. While in 1990, the share of lignite in energy generation was still 29 % (176.8 PJ) and 16 % (73.2 PJ) in 2005, the share of this fuel has now fallen below 7.3 % (32.4 PJ). A similar trend has been observed in recent years for the share of hydrocarbons: with a share of 26 % in 1990 (159.6 PJ), the weight of natural gas fell to 21 % (97.6 PJ) in 2005, to 11 % (49.3 PJ) in 2021, from 16 % (97.9 PJ) in 1990 to 13 % (t58.9 PJ) in 2005 and 7.7 % (35 PJ) in 2014, but remained at around 10 % (46 PJ) in the years 2017-18. At the same time, the weight of nuclear and renewable energy production has increased significantly: their combined share already reached 70 % in 2021 (37.9 % nuclear, 32 % renewable energy, combined 312 PJ).

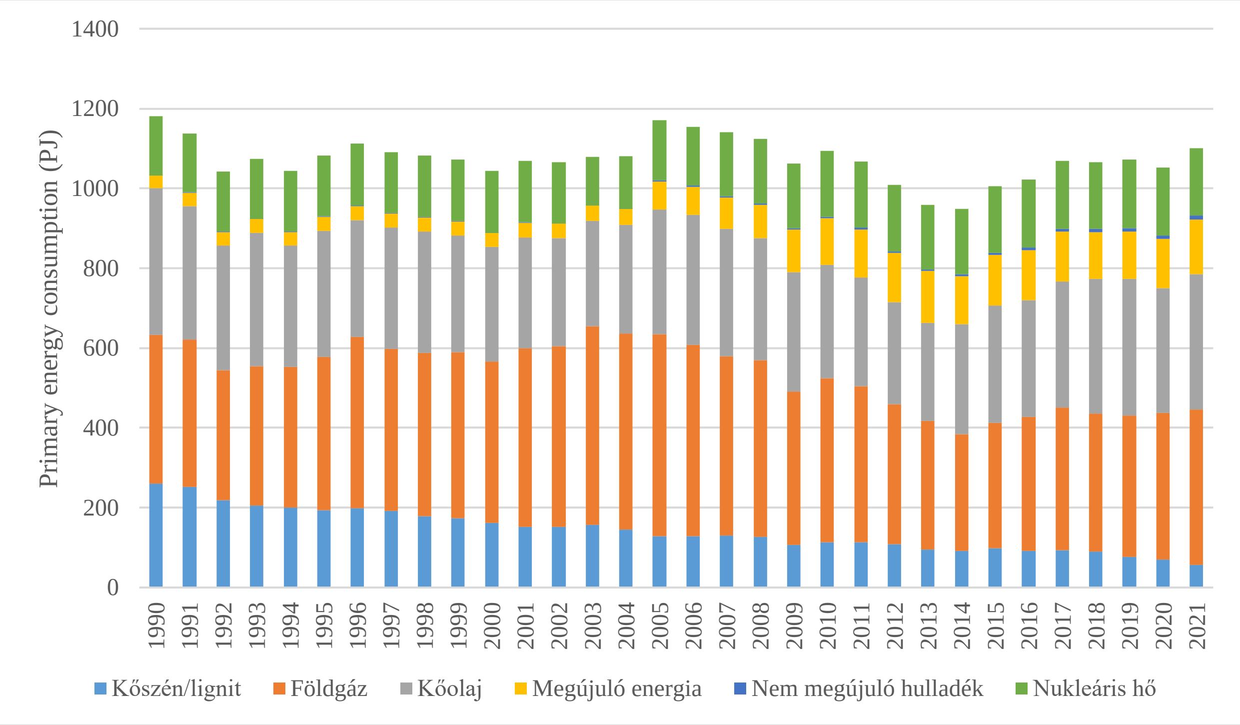


43figure 1 – Composition of Hungarian primary energy production between 1990 and 2021

Source: Eurostat

Gross inland energy consumption

By type of fuel, fossil fuels continue to predominate in gross domestic energy consumption. The share of hydrocarbons is predominant, with natural gas accounting for 34 % of our most important energy source in 2021 (which is far from 45 % in 2003) and oil accounted for 30 % of gross inland energy consumption. However, the share of coal/lignit (the domestic structure of coal use is mainly based on lignite) fell significantly from 21 % to 5 % between 1990 and 2021, with the decoupling of domestic deep-mining coal extraction, with minor fluctuations. Meanwhile, renewable energy sources play an increasingly important role in Hungary's energy use: The share of renewable energy increased between 1990 and 2007, and 2007-2013 (1990 =2.6 %, 2007 = 6.8 %, 2013 =13 %), but has slightly decreased since 2013 and ranges between 10.5 % and 12 %, with a value of 11.8 % in 2021. In addition to renewables, nuclear energy is another source of energy involved in the decarbonisation transition, with a share of around 15 % for years.



44figure – Gross inland energy consumption (PJ)

Source: Eurostat

Import Exposure

Hungary is able to supply only 46.3 % of Hungary's primary energy demand on its own (38.7 % in 2005), so that Hungary's energy supply continues to have a high share of imports.

The composition of primary energy use in Hungary significantly increases the risks to the country's energy security. Dependence on foreign markets is mostly characterised by the sourcing of hydrocarbon energy sources, with import dependency exceeding 80 %.

Our stocks of Lignite and our lignite mining are significant in relation to their own use, yet on average we import a third of our coal/lignite consumption.

Hungary's energy supply continues to be characterised by high exposure to imports. In all cases, the energy supply exposure was measured by the share of non-domestically produced energy. 74 % of our primary energy supply comes from external sources (including nuclear fuel elements). This ratio is lower than the values of recent years, driven by a decrease in natural gas exposure.

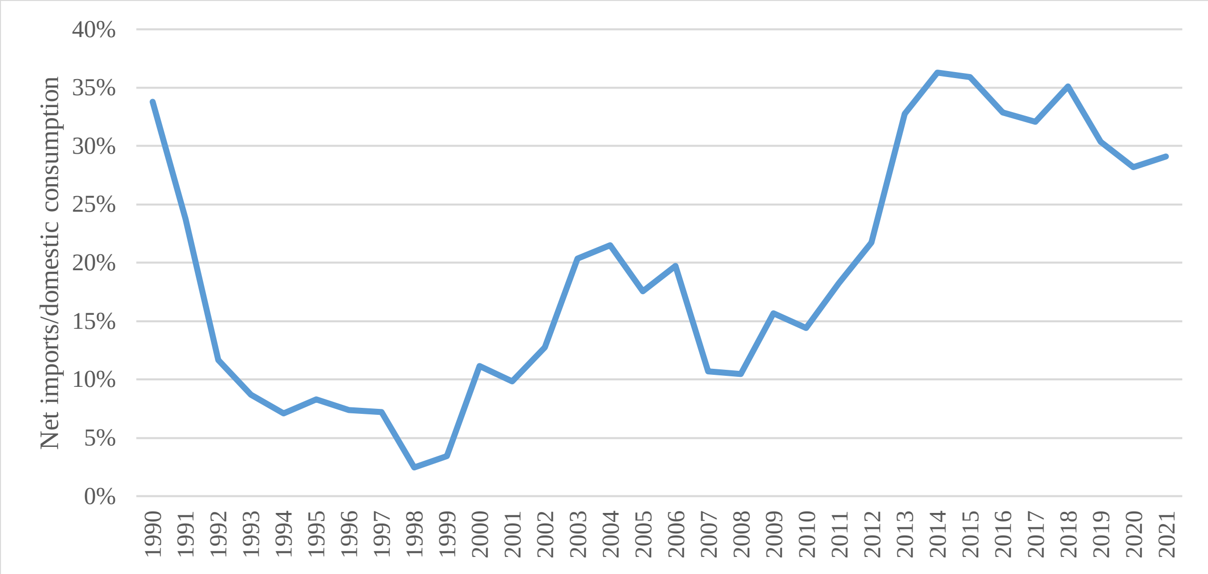
Our import exposure is mostly related to the supply of hydrocarbons, but exposure is also significant in the electricity market. The country's dependence on high energy imports may pose a security of supply and price risk.

Dependence on foreign markets is mostly characterised by the sourcing of hydrocarbon energy sources, with import dependency exceeding 80 %.

45figure – Hungary's import dependency 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 captive use (without self-consumption of domestic power plants and network losses) decreased from 36 % to 28 % between 2014 and 2022. However, given that seasonal electricity storage has not yet been solved, this rate can still be considered high. However, domestic demand for electricity is expected to grow in the next 6-10 years, beyond previous expectations. This is partly counterbalanced by the planned expansion of electricity generation capacity, both renewable and gas-based. However, a relatively high share of imports has to be taken into account in certain periods.



46figure – Net import ratio to electricity consumption (%)

Source: HCSO

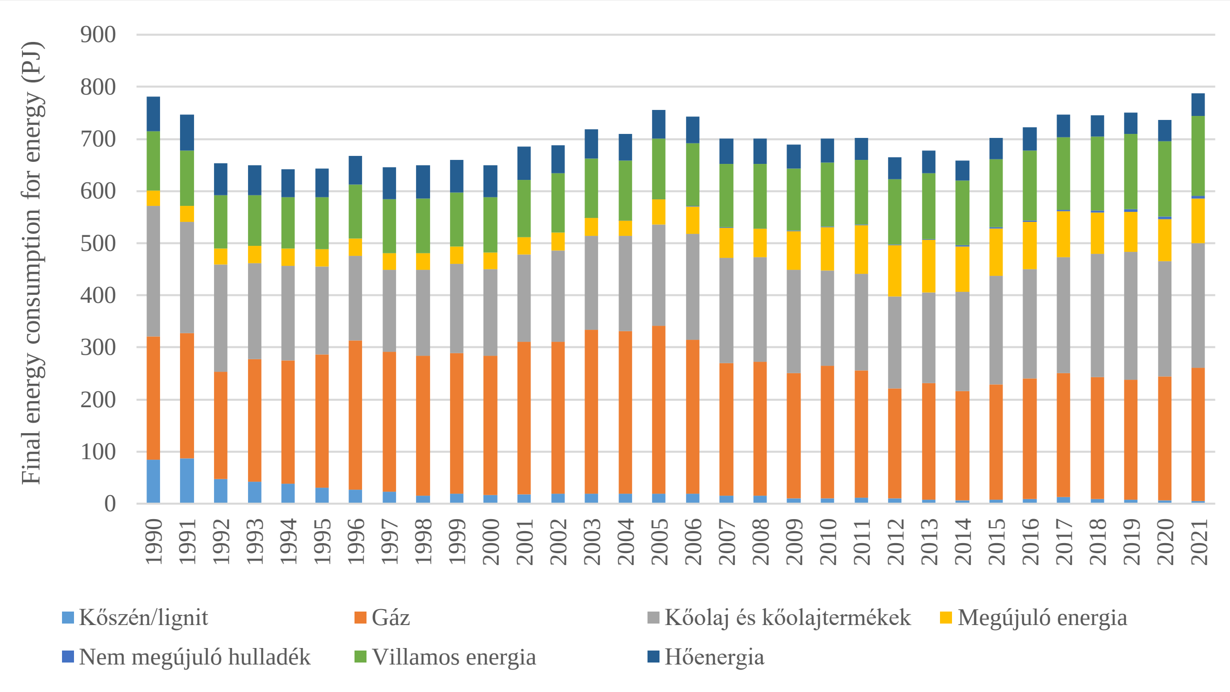
Final energy consumption for energy

After the drastic decline following the change of system, the Hungarian economy's energy use was on a declining path from 2005 to 2014. However, a new upward trend has emerged in recent years. In 1990, domestic final energy consumption was 793.9 PJ and, although it decreased to 660 PJ in 2014 (similar to the low of 650 PJ in the second half of the 1990s), it has been increasing almost steadily since 2015 and absorbed 789 PJ in 2021 almost equal to '90' (68 % of primary energy consumption).

The largest increases occurred in the period 2014-2021 for crude oil (49 PJ) and natural gas (46 PJ) and electricity consumption increased by 27 PJ. District heating consumption has also increased since 2014: Our heat consumption increased from 38 PJ to 44 PJ.

The composition of final energy consumption, even the composition of primary energy production, has evolved significantly over the past two decades. While in 1990 Hungary still covered 11 % of its final energy use from coal, today, the share of coal/lignite has gone down to a few percent. With the reduction in coal use, natural gas use has gained considerable potential. Natural gas reached the highest share of the energy mix in 2004 (with a share of 44.2 % of gas at that time), before decreasing fluctuating, the share of gas in final energy consumption decreased to 32 % in 2021. The share of oil in the energy mix typically ranged between 25 % and 30 % during the reference period, but in recent years (since 2017) this energy carrier has been recorded in our final energy consumption at around 30-33 %. The contribution of electricity increased from 14.3 % to 19 % between 1990 and 2021, while the share of renewable energy consumption in final energy consumption increased from 3.7 % to 11 %

during the same period[138]. (It peaked at 14.9 % in 2013) The country's thermal energy consumption represented 5-6 % of final energy consumption in recent years.



47figure -Final energy consumption by fuel type

Source: Eurostat

The sectors with the three largest shares in the energy mix are the household sector (residential), transport and industry. The household sector's share of final[139] energy consumption is the highest, accounting for 34.1 % of total final energy consumption in 2021 (268.9 PJ), 4.3 percentage points lower than in 2005 (38.4 %, 291.8 PJ). Transport is the second most important area (with a share of 26 % in 2021), followed closely by the industrial sector (25.1 % in 2021). The services sector (including commercial activities) accounts for 11 % of energy use, while the other sectors contributed only 2.6 % in 2021.

Natural gas (51.8 %), renewable energy sources (21.1 %) – mainly 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 %) with values of around 1 % for coal and petroleum products (the latter practically LPG consumption, with a contribution of 1.2 %). According to

[138] The share of renewable energy in relation to final energy consumption should not be confused with the share of renewable energy sources in gross final energy consumption, which is the official indicator for monitoring the 2020 target set out in Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Eurostat defines gross final energy consumption as the country's total energy demand, energy consumption, including final energy consumption, power plant self-consumption, grid loss and so-called statistical discrepancy. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Gross_inland_energy_consumption

[139] This does not include private transport, as private consumers are counted towards transport.

the data140 of the HCSO, it is also apparent that almost three quarters of the energy consumption of Hungarian households (72.7 % in 2021) were used for heating. Another typical area of energy use is the production of domestic hot water (11.8 %). Lighting and electrical devices account for 10.2 % of energy consumption. Cooking accounts for 4.8 % and cooling only 0.3 %. The latter is expected to grow significantly, 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 petroleum and petroleum products in final energy consumption at 91.3 % in 2021. In 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 predominant in industrial energy use. Oil accounted for 15.3 %, district heating 8 %, renewable energy sources 6.6 %, non-renewable waste 2.9 % and coal accounted for 1.6 % of final energy consumption in 2021. The services sector is characterised by natural gas dominance (53.6 %), but also a significant share of electricity (33.8 %) and district heating (8.1 %). The share of renewable energy was only 2.7 % and the combined share of oil and non-renewable waste was below 1 % in 2021.

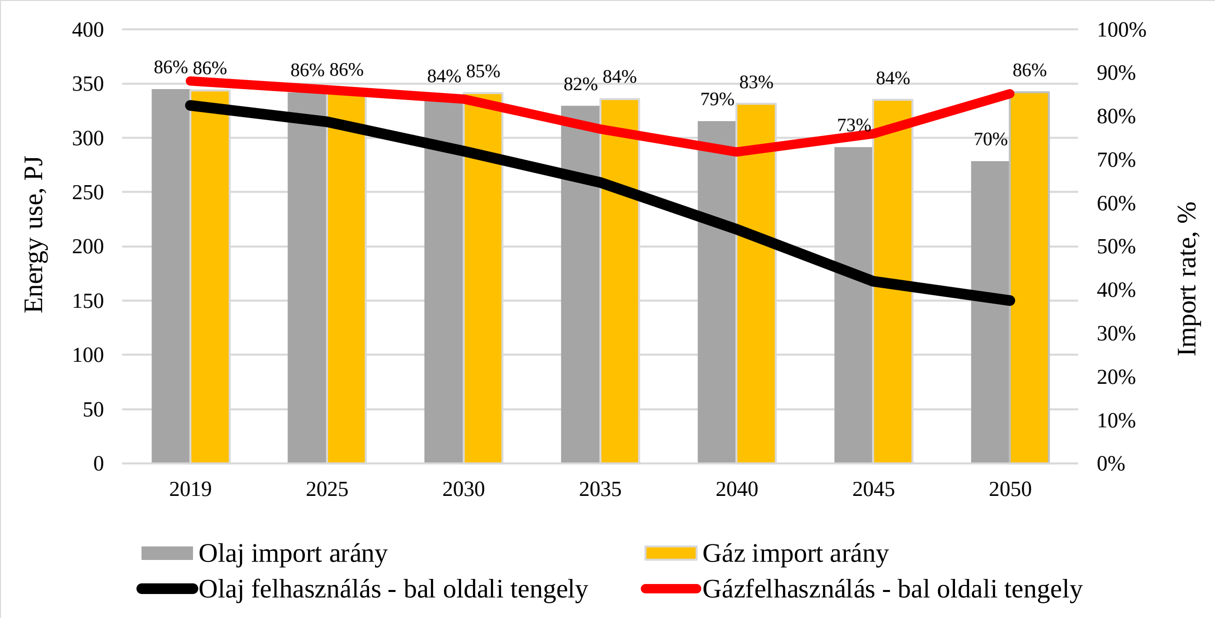
ii. Projections of development with existing policies and measures at least until 2040 (including for the year 2030)

Import dependency is mainly based on three energy sources: to be analysed for oil, natural gas or electricity.

In the modelling, we quantified the evolution of the consumption of oil and natural gas in Hungary in the WEM scenario. Assuming that domestic extraction for both raw materials develops at 2021 levels up to 2050, we can determine the net imports of the two energy sources.

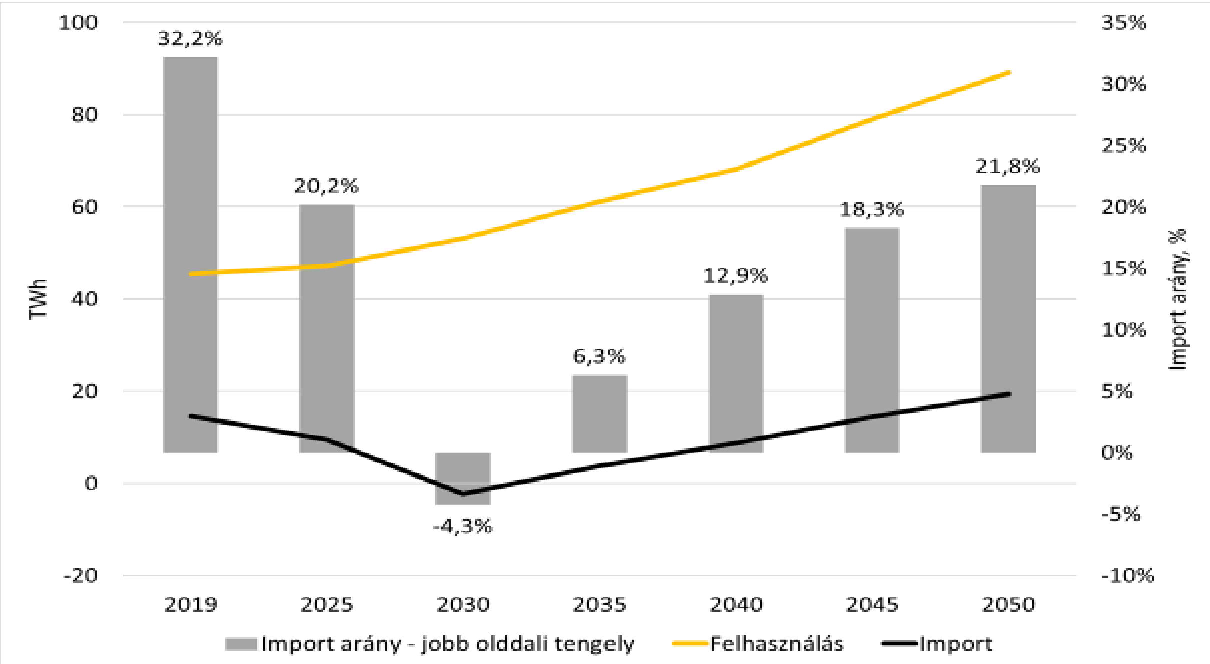
Oil consumption is drastically decreasing from the current level of 330 PJ to 150 PJ during the period under review, which also improves the net import position, bringing the current import share above 86 % down to 70 %. There is no such sharp decline in the use of natural gas: the consumption of 350 PJ will decrease to 340 PJ by 2050, so the share of net imports can only slightly decrease (assuming that the absolute level of domestic production does not change).

[140] https://www.ksh.hu/stadat_files/ene/hu/ene0007.html



48figure -Evolution and net imports (%) of natural gas and oil consumption (PJ), WEM scenario, 2019-2050

In the electricity sector, the current net import ratio of 32 % could already decrease significantly by 2025, mainly due to the emergence of solar power plants, while Hungary will become a net exporter with the entry into operation of the Paks2 units. Although we calculate the extension of Paks1, the net exporter position will be replaced by net imports after 2035 due to the significant increase in electricity consumption, but it does not exceed 22 % in 2050.



49figure. Evolution of electricity consumption and net imports (TWh) and net import ratio (%), WEM scenario, 2019-2050

4.5. Dimension internal energy market

4.5.1. Electricity interconnectivity

i. Current interconnection level and main interconnectors141

The Hungarian electricity system has a direct connection to all neighbouring countries. (See map showing the network in Chapter 4.5.2.)

The evolution of the annual physical turnover is summarised in the following tables.

31table 1 – Annual physical turnover 2022

Border chair	**Annual turnover, GWh**		
	Imports	Export	**Salvage**
Ukraine	3 590,92	881,14	**2 709,77**
Slovakia	10 722,79	109,57	**10 613,23**
Romania	527,65	1 628,36	**—1 100,71**
Serbia	1 096,30	561,94	**534,36**
Croatia	774,34	3 316,87	**—2 542,52**
Austria	3 255,02	714,59	**2 540,43**
Total	**19 967,02**	**7 212,45**	**12 754,57**

Currently available transmission capacities allow for flexible commercial transactions that can be diversified.

ii. Projections of interconnector expansion requirements (including for the year 2030)142

Although Hungary is significantly above the EU interconnection target, the extension of the interconnection is justified, as **the scarcity of cross-border capacity limits imports of cheaper electricity from Austria and Slovakia**. At the other cut-off points, the positive and negative price differences occur alternately. Due to the scarcity of cross-border capacities, the low share of cheaper hydropower and other reasons, the annual average Hungarian wholesale electricity price level (day-ahead markets, hourly averages) has been higher for years than in neighbouring countries. Looking more broadly in the region, Hungarian wholesale prices are relatively high. It is therefore planned to extend the Serbian-Hungarian border.

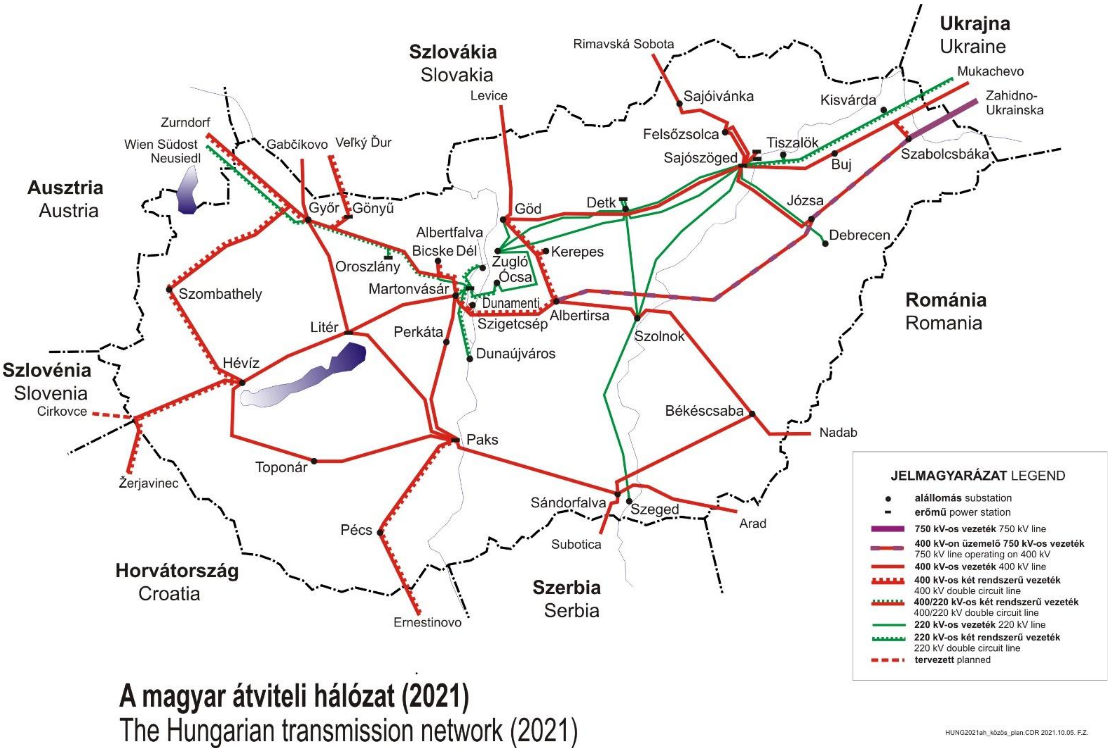
4.5.2. Energy transmission infrastructure

i. Key characteristics of the existing transmission infrastructure for electricity and gas 143

[141]With reference to overviews of existing transmission infrastructure by Transmission System Operators (TSOs).
[142] With reference to national network development plans and regional investment plans of TSOs.
[143]With reference to overviews of existing transmission infrastructure by TSOs.

Electricity market

The transmission network of the Hungarian electricity system is shown in the map and table below.



50figure – The Hungarian electricity transmission network

Source: MAVIR ZRt.

The length of the route of the transmission network is shown in the table below.

32table 1 – Track length of transmission networks

	2017	2018	2019	2020	2021
	km	km	km	km	km
Total high voltage open line and cable line	**3813,00**	**3813,00**	**3821,75**	**3821,65**	**3846,79**
Total high voltage open line	3797,00	3797,00	3805,11	3805,01	3830,15
of which:	268,00	268,00	266,16	266,16	266,16
750 kV open line	2287,00	2287,00	2297,59	2297,59	2322,72
400 kV open line	1099,00	1099,00	1099,32	1099,32	1099,32
220 kV open line	142,00	142,00	142,04	141,95	141,95
132 kV open line	17,00	16,64	16,64	16,64	16,64

Source: MAVIR ZRt. (2022): 2021 data of the Hungarian electricity system (VER)

Further details can be found in the '*Hungarian Electricity System (VER) 2021 data'*[144] *and the*related statistical tables, prepared by MAVIR ZRt., as well as in VER leporello. 145

Gas market

Hungary has a natural gas distribution network in good condition with a length of more than 85 thousand km and a significant capacity.

The capacity data of the Hungarian natural gas transmission system and the daily peak capacity data of the Hungarian natural gas transmission system are summarised in the tables below.

33table – Capacity data of the natural gas transmission system, 2021

Capacity data	Annual firm capacity (billion m^3)	Daily firm capacity (million m^3)	Annual interruptible capacity (billion m^3)	Daily interruptible capacity (million m^3)	Daily peak capacity (million m^3)	Of which interruptible (million m^3)
Entry points						
Ukraine/Hungary interconnector entry point (Beregdaróc)	17,5	48,0	8,5	23,3	71,3	23,3
Austria/Hungary interconnector entry point (Mosonmagyaróvár)	5,3	14,4	0,0	0,0	14,4	0,0
Hungary/Romania interconnector entry point (Csanádpalota)	1,75	4,8	0,0	0,0	4,8	0,0
Hungary/Croatia interconnector entry point (Drávaszerdahely)	1,75	4,8	5,3	14,4	19,2	14,4
Hungary/Slovakia interconnector entry point (Balassagyarmat)	4,4	12,0			12,0	0,0
Domestic net production	8,4	22,9			22,9	0,0
Commercial underground gas storage facilities	1,56	4,9			4,9	0,0
Strategic underground gas storage facility	4,87	48,3		6,5	54,8	6,5
Total entry points excluding strategic storage	1,46	20,0			20,0	0,0
Exit points	45,5	160,1	13,8	44,2	204,3	44,2
Hungary/Serbia interconnector exit point (Kiskundorozsma)						
Hungary/Romania interconnector exit point (Csanádpalota)	4,8	13,2			13,2	0,0
Hungary/Ukraine interconnector exit point (Beregdaróc)	2,6	7,2			7,2	0,0
Hungary/Croatia interconnector exit point (Drávaszerdahely)	0,0	0,0	7,0	19,2	19,2	19,2
Hungary/Slovakia interconnector exit point (Balassagyarmat)	2,6	7,2	4,4	12	19,2	12,0
Gas transmission 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

Exit points do not include mixing circuit expenses, storage points and cross-border exit points.

Source: FGSZ (2022): 2021 data on the Hungarian natural gas system

[144] https://www.mavir.hu/documents/10258/45985073/VER_%C3%B6sszegoglal%C3%B3_2022_MAVIR.pdf
[145] https://www.mavir.hu/web/mavir/mavir-ver-leporello

34table -Total peak capacity of the natural gas transmission system per day, 2021

total (at 15 °C and Nm 3 in^{Nm}3)	**204,3**
Of which interruptible	44,2
Imports	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

Source: FGSZ (2022): 2021 data on the Hungarian natural gas system

Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010 requires transmission system operators to establish permanent physical capacity for bi-directional natural gas transmission on all interconnections between Member States.

Hungary has interconnection points with bi-directional capacity among the EU Member States with Romania, Croatia and Slovakia.

Hungary has an unlimited exemption for the Hungarian-Austrian cross-border point. 146

As regards security of supply, the Decree also refers to the 'N-1' principle (explanation under point (i) of Chapter 2.3). The results of the calculation carried out for the year 2022 are 147 summarised in the following two tables:

[146] https://ec.europa.eu/energy/sites/ener/files/table_reverse_flows_-for_publication.pdf
[147]Main details of the calculations:
– 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: according to the statistical probability used in the calculation, the calculation of the total daily gas demand occurring once every 20 years was based on two assessments:
- As a first step, the correlation between Hungary's natural gas consumption and the temperature was examined with linear regression using data for gas years from 2011/2012 to 2017/2018. (The examination ignored former years as – due to the changes of market structure and consumption patterns and targets – those represent a natural gas consumption structure which greatly differs from the current one.)
- As a second step, the consumption values for extreme cold days were estimated with the methodology of generalised extreme value (GEV) distribution.

35table – Results of the N-1 calculation forHungary, including UA 2022

2022, including UA/HU			
EPm1	Oozak-Hungarian border entry (Mosonmagyaróvár)	Mm³/day	14,4
EPm2	Serbian-Hungarian	Mm³/day	22,9
	Ukraine/Hungary cross-border entry (Beregdaróc)	Mm³/day	48
EPm3	Slovakia/Hungary cross-border entry (Balassagyarmat)	Mm³/day	12
EPm4	Romania/Hungary cross-border entry (Csanádpalota)	Mm³/day	6,72
EPm5	Croatian/Hungarian cross-border capacity (Drávaszerdahely)	Mm³/day	4,8
EPm6	Other (unplanned entry)	Mm³/day	0
EPM summa	Total delivery capacity	Mm³/day	108,82
IM	Maximum technical production capability	Mm³/day	4,4
SM	Maximum technical withdrawal capacity (100 %)	Mm³/day	74,8
LNGm	Maximum technical LNG facility capacity	Mm³/day	0
IM	Maximum feed capacity (EPm2-Beregdaróc)	Mm³/day	48
Dmax	Total daily gas demand (1/20)	Mm³/day	79,7
N-1			175,7
N-1 (%)			**176 %**

36table – Results of the N-1 calculation for Hungary without point UA 2022

2022, UA/HU without point			
EPm1	Oozak-Hungarian border entry (Mosonmagyaróvár)	Mm³/day	14,4
EPm2	Serbian-Hungarian	Mm³/day	22,9
EPm3	Slovakia/Hungary cross-border entry (Balassagyarmat)	Mm³/day	12
EPm4	Romania/Hungary cross-border entry (Csanádpalota)	Mm³/day	6,72
EPm5	Croatian/Hungarian cross-border capacity (Drávaszerdahely)	Mm³/day	4,8
EPm6	Other (unplanned entry)	Mm³/day	0
EPM summa	Total delivery capacity	Mm³/day	60,82
IM	Maximum technical production capability	Mm³/day	4,4
SM	Maximum technical withdrawal capacity (100 %)	Mm³/day	74,8
LNGm	Maximum technical LNG facility capacity	Mm³/day	0
IM	Maximum entry capacity (EPm2-Serb-Hungarian)	Mm³/day	22,9
Dmax	Total daily gas demand (1/20)	Mm³/day	79,7
N-1			146,95
N-1 (%)			**147 %**

On the basis of the calculation carried out, Hungary's N-1 value exceeds 140 % for both calculations, thus meeting the EU's requirements on infrastructure requirements as set out in the SoS Decree.

ii. Projections of network expansion requirements at least until 2040 (including for the year 2030)148

The forecast until 2040 entails a multitude of uncertainties, meaning that network expansion requirements cannot be formulated in a concrete and reliable manner. The electricity and gas projects planned by the system operators (MAVIR, FGSZ) over the next ten years are dealt with in chapter 2.4.2.

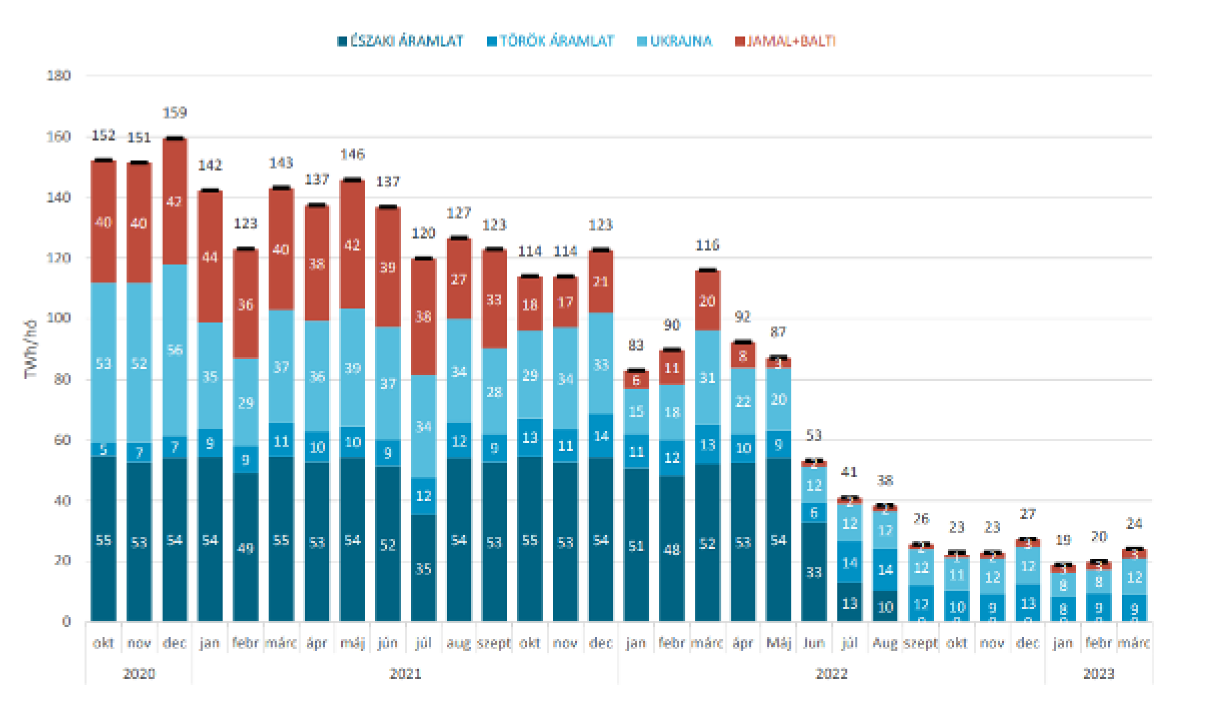
Electricity and gas markets, energy prices

iii. Current situation of electricity and gas markets, including energy prices

Gas market

International summary

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. Hungarian transport was continuous through the Turkish Stream pipeline. European prices have risen to unprecedented heights. At the same time, due to an adequate sourcing policy and a fall in consumption, no supply disruption occurred during the winter of 2022.



51figure 1 – Russian deliveries on different pipelines to Europe from October 2020 to March 2023 (TWh/month)

Source: MEKH Monitoring Report March 2023

148With reference to national network development plans and regional investment plans of TSOs.

The European Union has responded to the challenge with the adoption of the REPowerEU Strategy Paper, which aims to significantly reduce Russian gas dependence already in the short term by diversifying sources, reducing consumption and fast-tracking renewable energy sources[149]. For the first time in its history, the European Union has imposed a storage obligation on Member States and has proposed to make savings of 15 % in winter 2022/23 compared to their average winter consumption over the previous five years[150].

Hungary has fulfilled its obligation as a storage facility and has continuously examined the security of supply situation. Consumption decreased by 20 % between August 2022 and March 2023, with wholesale gas prices on European markets returning to the range of EUR 25/MWh by May 2023. It is important for Hungarian security of supply that all neighbouring countries except Slovenia have gas pipeline connections. However, the limited cross-border capacity in certain routes and the insufficient capacity in some places in neighbouring countries is limited to making full use of this potential.

Supply mix and gas consumption in Hungary

In 2021, the share of natural gas in total energy use in Hungary was 34 %. 84 % of this volume was imported. While the share of natural gas in total energy consumption decreased (by 43 %) compared to 2005, imports, i.e. exposure, increased slightly (2005: 81 %), mainly due to the fact that domestic production fell by half compared to 2005 (108 PJ) in 2021 (55 PJ), but the country's natural gas consumption did not decrease to that extent.

Total gas consumption in Hungary, including electricity and district heating, was 424 PJ in 2021, a decrease of 21 % compared to 2005.

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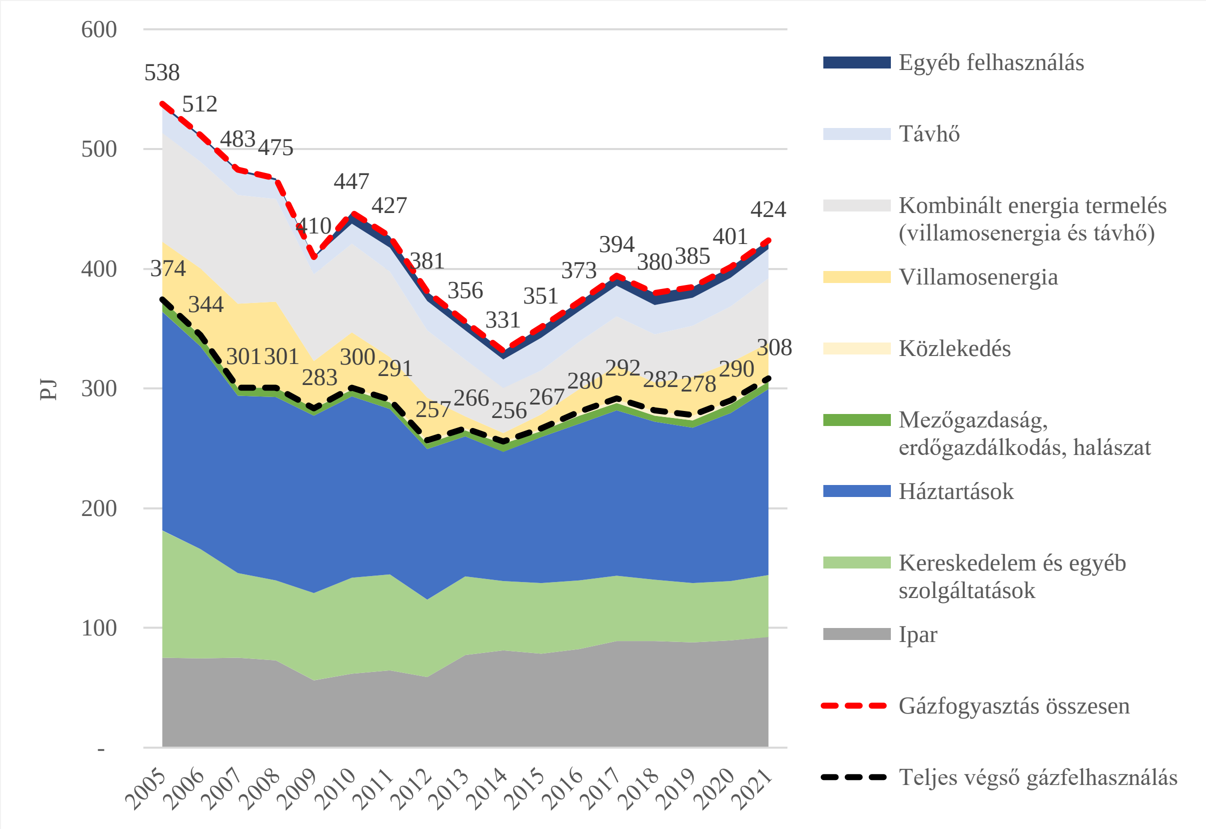
[149] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, REPowerEU Plan Brussels, 18.5.2022. COM(2022) 230 final https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0016.02/DOC_1&format=PDFand 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

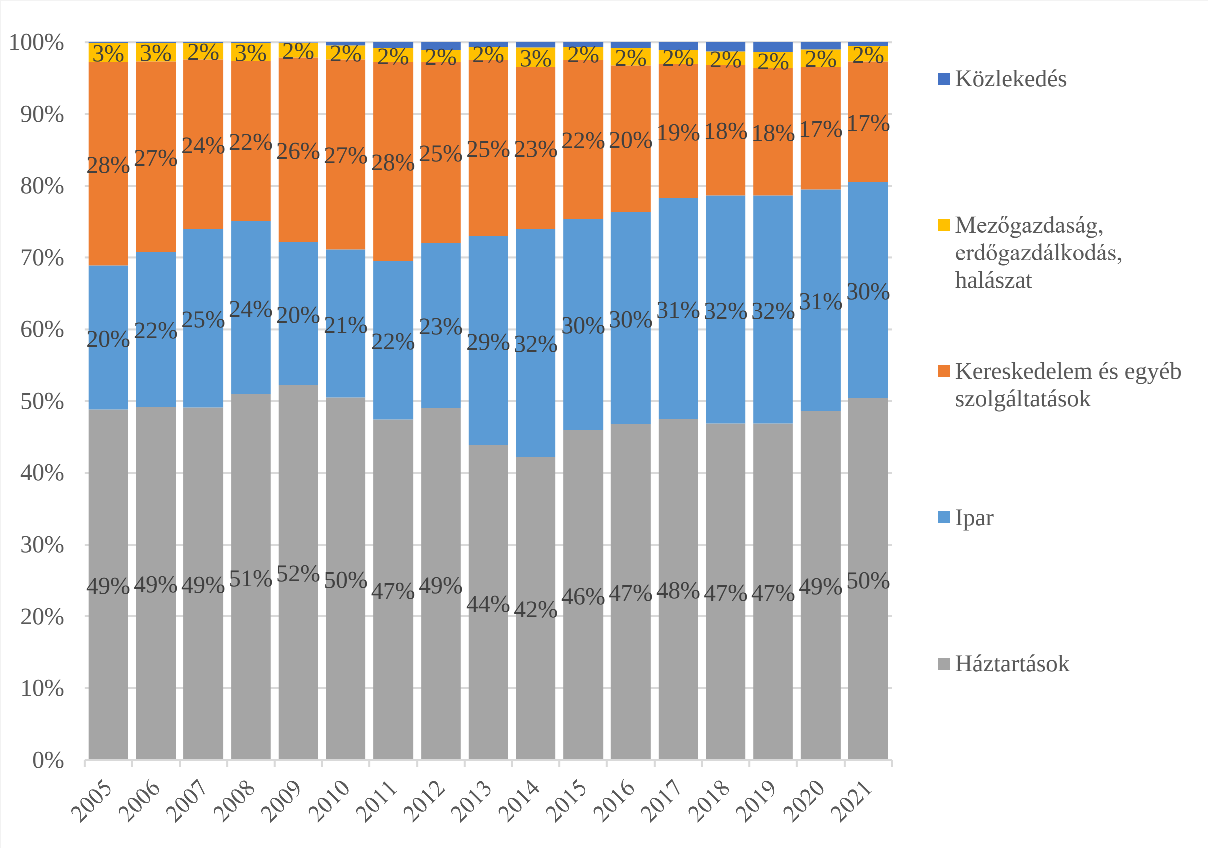
[150] Council REGULATION on coordinated demand reduction measures for gas, Brussels, 20.7.2022 COM(2022) 361 final 2022/0225 (NLE) – Article 3 on voluntary demand reduction Source: https://eur-lex.europa.eu/legal-content/HU/TXT/PDF/?uri=CELEX:52022PC0361



52figure 1 – Evolution of total gas consumption by sector in Hungary 2005-2021

Source: Eurostat

The combined use of natural gas by plants producing electricity and electricity and heat in the period 2005-2021 was highly volatile, with a combined consumption of 85 PJ, while district heating-only units were 24 PJ in 2021. The amount of natural gas used to produce electricity only has gradually increased since 2014 (2014: 7 PJ, 2021: 31 PJ), it is clear that consumption did not decrease in 2021, despite the higher price environment. At present, the role of gas power plants in the backup market and in the provision of positive and negative regulatory energy is also significant and cannot be absent in the short term in the backup market, but their role can be reduced by the take-up of alternative technologies (renewables, storage, DSM).

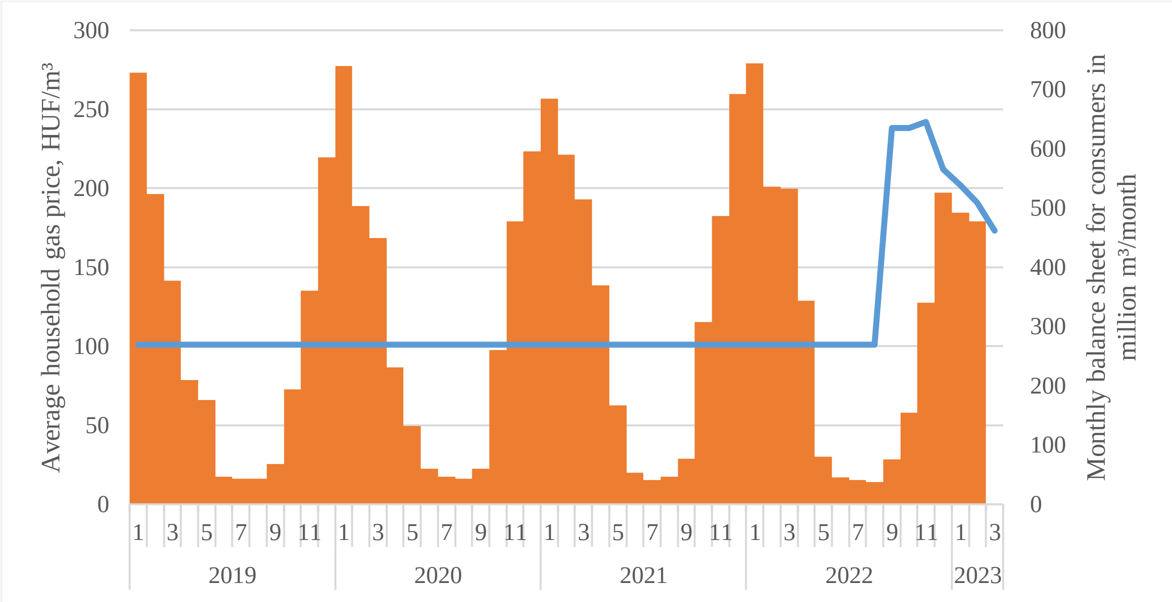


53figure 1 – Sectoral distribution of final gas consumption, 2005-2021 in Hungary

Source: Eurostat

Looking at the use of gas in each sector, the most significant consumption is attributable to households. The share of natural gas consumption by households in domestic final gas consumption has gradually increased from 44 % to 50 % since 2013, which is around the same rate observed in 2005.

The household price protection system changed in 2022 due to a significant increase in wholesale natural gas prices: As of August 2022, a double tariff system for household consumers was introduced, under which the amount consumed above a given consumption threshold (currently 1 729 m 3/year) has to be paid almost 7.5 times the basic price. The tariff system introduced in 2022 thus provides a strong price signal for households whose gas consumption is higher than the average. 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 increase in prices resulting from the regulatory change, Hungary’s consumption of natural gas has been significantly reduced. The households concerned reacted practically immediately to the price increase they are now seeing.

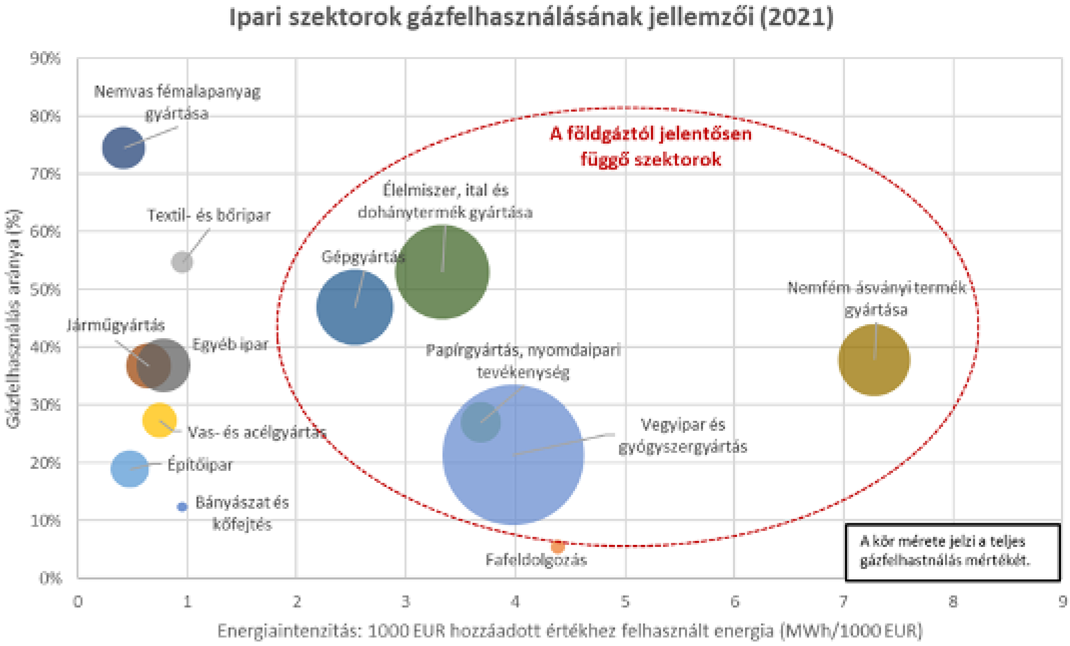


54figure – Evolution of pipeline natural gas prices for residential customers (HUF/m³) and changes in the volume of natural gas consumption in the public sector, million m³/month

Source: HCSO, MEKH

Consumption in the industrial sector has increased both in absolute terms and in terms of its share of final gas consumption since 2005: In 2005, consumption related to the sector was 75 PJ, compared to 93 PJ in 2021, its share of final consumption increased from 20 % to 30 %.

The most important sub-sectors in terms of gas consumption and exposure to natural gas are chemicals and pharmaceuticals, food, drink and tobacco products, non-metallic mineral products and machinery. The consumption of natural gas in these four sectors represented 77 % of the total industrial sector consumption 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 input (manufacturing of fertilisers, hydrogen), with natural gas used as feedstock accounting for almost a quarter (23 %) of total consumption in the sub-sector. In the field of machinery, further growth is expected in the future due to the construction of new battery factories and associated plants, as their energy use and natural gas consumption are significant. Gas demand in the industrial sector reacted flexibly to high prices, with partial and temporary interruptions of production (e.g. fertiliser production), technology transformation, accelerating investments in renewable and energy efficiency and saving.



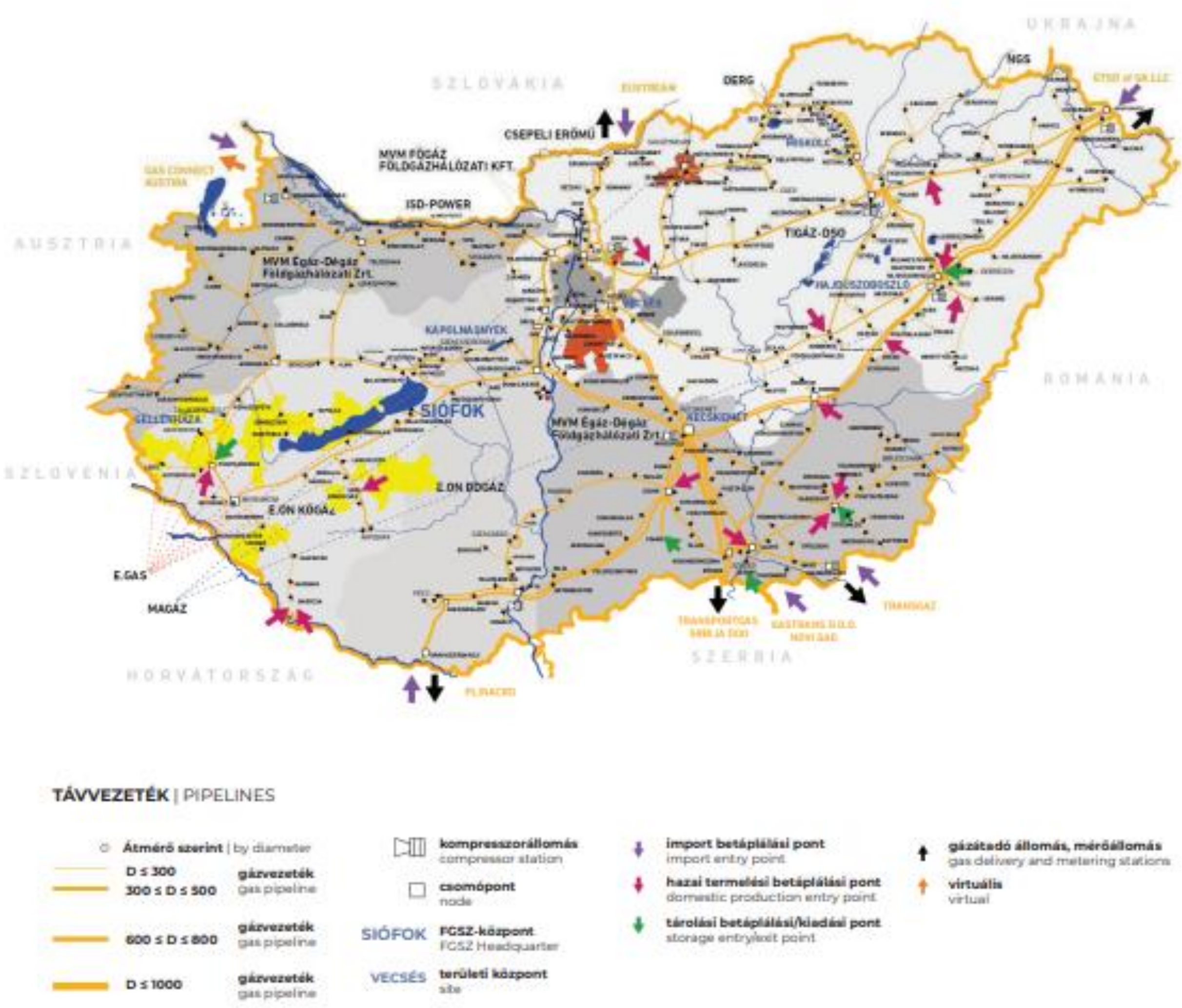
55figure – Gas consumption characteristics of industrial sub-sectors[151] (2021)

Source: HCSO, MEKH

Security of supply and storage obligation

Gas security of supply is a priority in Hungary in view of the high import dependency and the key role of gas in the heat and electricity markets. Security of supply is ensured by the fact that the Hungarian gas system has a high degree of interconnection with the gas markets of neighbouring countries. While in the past the main feed-in direction was a feed-in from Ukraine and Austria, as of October 2021 this role was taken over by the new two-way pipeline, which transports Russian gas from Serbia via the Turkish Stream pipeline to our country.

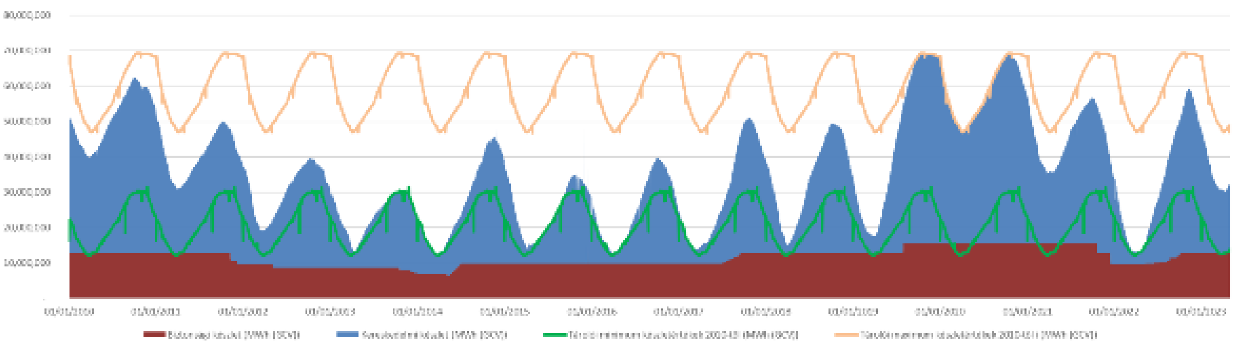
[151] In the use, including the use of natural gas of a material nature.



56figure 1 – FGSZ High-pressure Gas Transmission Pipeline System

Source: MEKH 2021

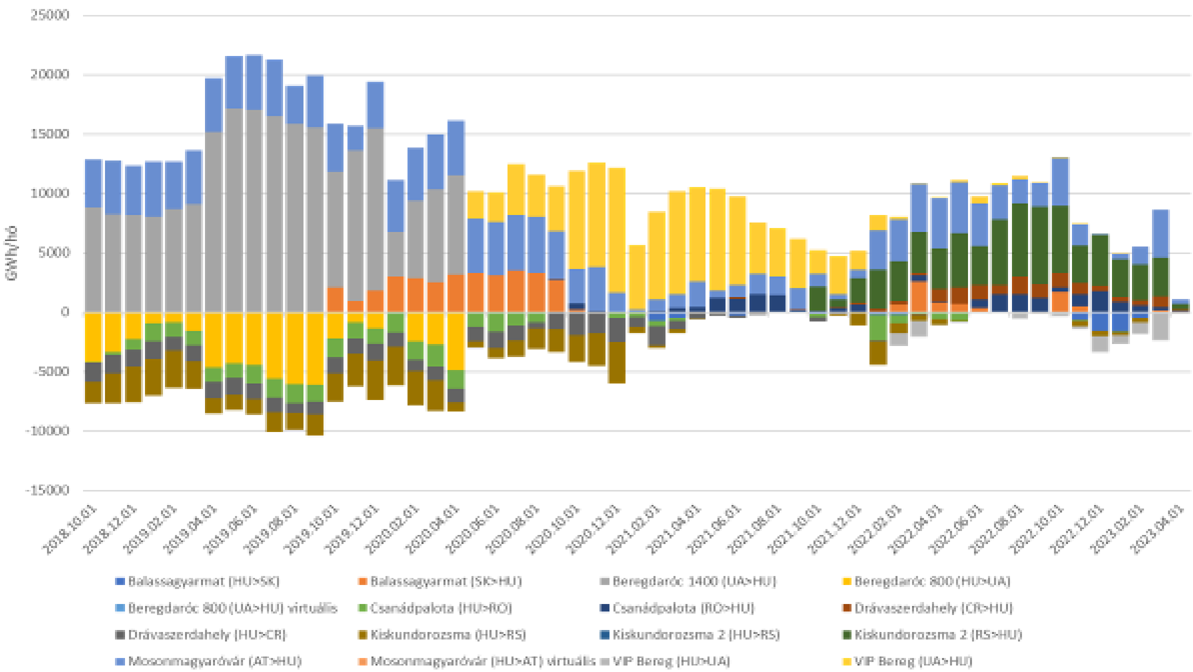
The most important pillar of the security of gas supply in the winter is the stock that is immediately available in the storage facility. The Hungarian (commercial and strategic) storage capacities (6.3 bcm/year) are very significant compared to the level of domestic consumption (which ranges from 9 to 11 billion per year). As shown in the graph below, storage capacities were typically underused until 2019. The Ukrainian-Russia transit contract expired at the end of 2019, therefore a larger volume of Russian long-term contract volumes was delivered bilaterally for two years to mitigate risks. Following the outbreak of the war on 24 February 2022, the European Union also imposed a storage obligation, which also resulted in a higher than usual state of charge. Due to the mild winter 2022/23, storage stocks remained at a high level at the end of winter, but the EU storage obligation remains in place and requires 90 % filling by 1 November 2023.



57figure – 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. As of the end of 2021, the previously dominant imports via Ukraine are transported partly through Serbia and partly from the Austrian direction, under the new Hungarian long-term contract concluded for 15 years in 2021. Hungarian traders booked at the Croatian terminal Krk are able to supply gas via the Croatian-Hungarian pipeline (Drávaszerdahely). Azeri gas has now arrived in smaller quantities at the Romanian entry point, but the possibility to import the production of Neptun fields in Romania remains possible if the necessary investments are made. In order to ensure security of supply, Hungary has seized every opportunity to diversify its gas supply over the past year, as evidenced by the fact that natural gas from Azeri and LNG sources already entered the Hungarian system in 2023.

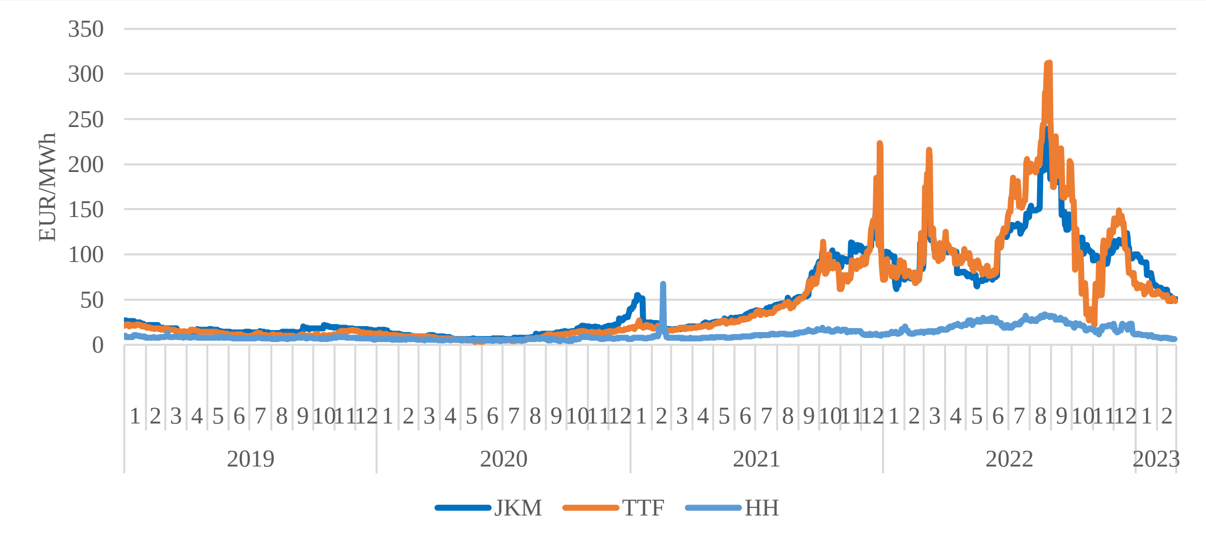


58figure – Evolution of monthly gas flows at each cross-border exit and entry point

Source: FGSZ

Natural gas prices and trade

In 2021, European wholesale natural gas prices left the range of EUR 20-25/MWh, which has been customary for years in a market characterised by scarcity of resources, and then reached a height of EUR 300/MWh in August 2022, reflecting the geopolitical situation and huge security of supply uncertainty. The Dutch Gas Price Index (TTF), which predominates in Europe, also surpassed the Japanese Korea marker (JKM) as a price signal in Asia during the energy crisis, both being far removed from the North American gas price (HH). After reaching the target level of filling of storage facilities, prices have gradually decreased. At the same time, the situation remains fragile and depends on the maintenance of a balance between supply and demand.



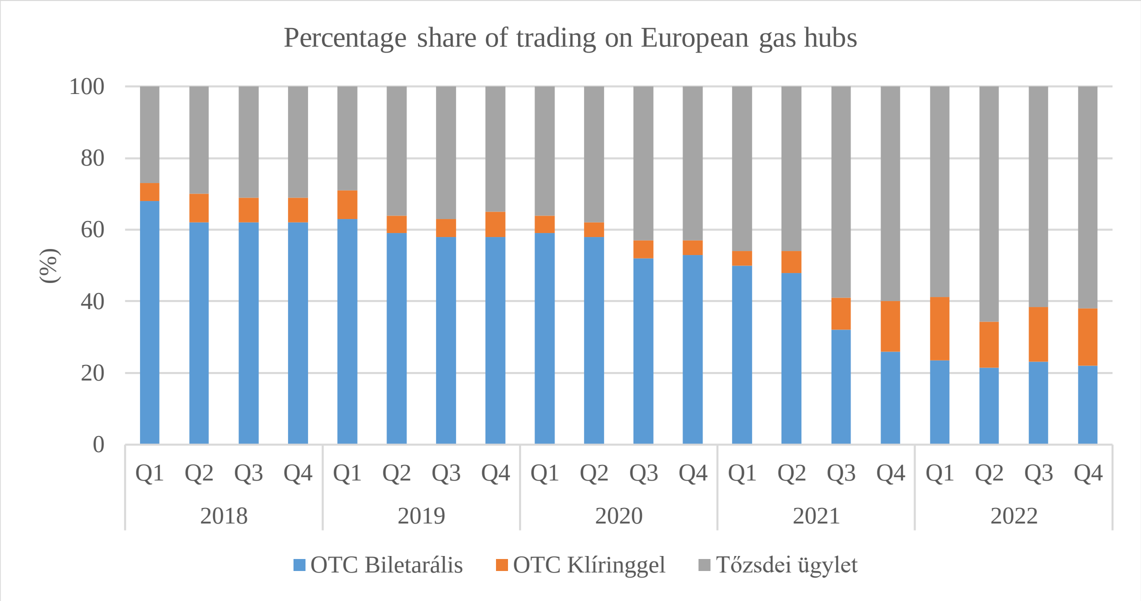
59figure – Wholesale natural gas prices in Europe, the USA and the Far East

Source: EEX, EIA, Investing.com

CEEGEX is the Hungarian gas exchange, which contributes to improving Hungary's energy and energy position in the medium and long term. The previously defined objective of the Hungarian wholesale gas market is to become a dwell (commercial hub), for which several necessary conditions are met (e.g. cross-border infrastructure, storage capacities), but further sufficient conditions are in the process of being met, such as stock exchange trading, regional competition, gas market integration and partnerships. As a result of the energy crisis, facilitating the trading of renewable gases, improving clearing house and settlement conditions and changing the pricing of domestic final consumer contracts were also on the agenda in Hungary.

Increase in stock exchange trading

The energy crisis has served as a catalyst for a shift in energy trade, with an increasing number of bilateral trade shifts to exchanges. During the turbulent period, market participants have turned to safer forms of trade, despite higher collateral needs, in order to avoid increasing counterparty and default risks.



60figure. Percentage share of trade in liquid and advanced European gas hobs

Source: European Commission

In addition to the steady increase in liquidity in spot spot markets, it is crucial to scale up futures markets. For the time being, transactions have moved even further towards closer maturities and spot markets, but the aim is to shift a major part of domestic bilateral trade to the exchange platform. In addition to the already liquid domestic spot gas market, the aim is to create a stable and widely used price signal from the next monthly delivery period until the end of the next gas year, based on actual trading. Good cooperation is also crucial, as international examples show that liquid futures markets can only be realised through the establishment of appropriate international cooperation.

Market concentration and competition

There is currently no meaningful competition in retail end-user sales, with the number of companies ranging from 2 to 3 in 2017-2021, and 99.8 % of the market in 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). In addition to the larger number of market participants, it is worth pointing out, however, that the share of the three largest players in 2021 represented around 50 % of the market, the highest in the period 2017-2021.

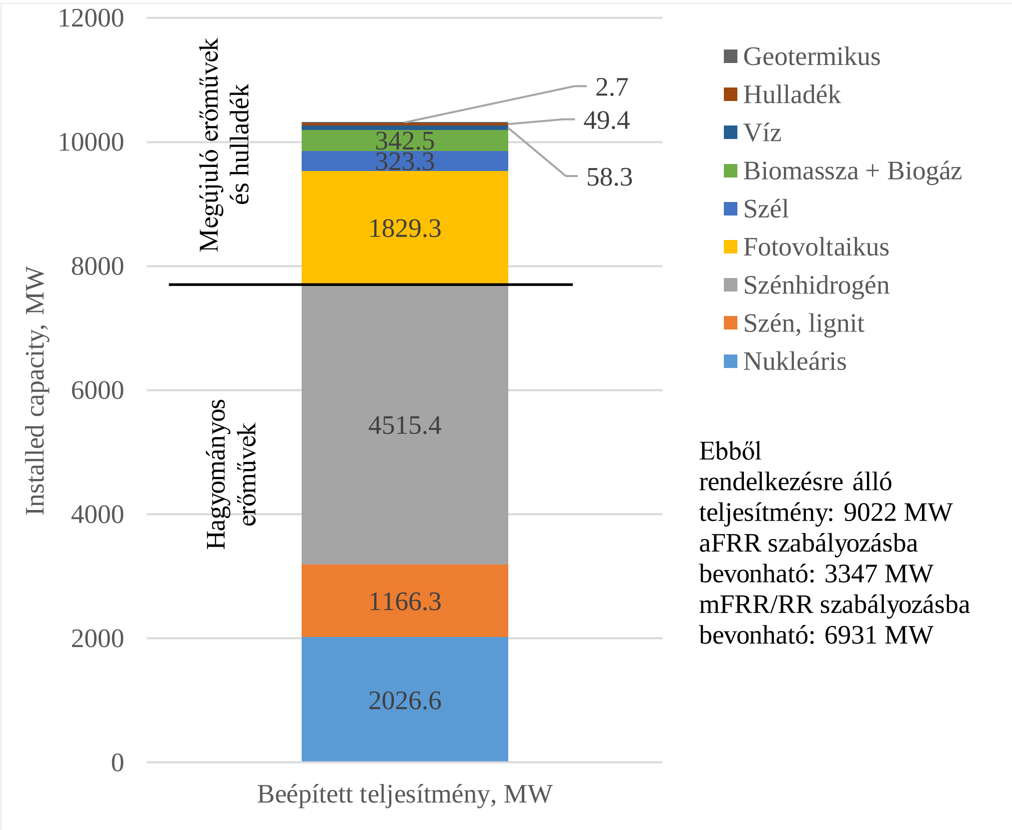
The number of companies selling on the wholesale market has decreased in recent years, from 40 in 2021. In 2021, four out of 40 companies had a market share of more than 5 %, the share of the three largest market players was 65 %, unchanged from 2019 and 2020.

Electricity market

The Hungarian electricity system is currently characterised by a high level of security of supply, two of which are a diversified domestic production portfolio and market integration.

Production and consumption

As of 31 December 2021, the plants had a gross installed capacity of 10 314 MW, of which 9 022 MW was available. The detailed evolution of installed and available capacities in 2021 is summarised in the graph below.



61figure 1 – Breakdown of installed capacity of all domestic power plants by primary source

Data source: MAVIR ZRt. (2022): 2021 data of the Hungarian electricity system (VER)

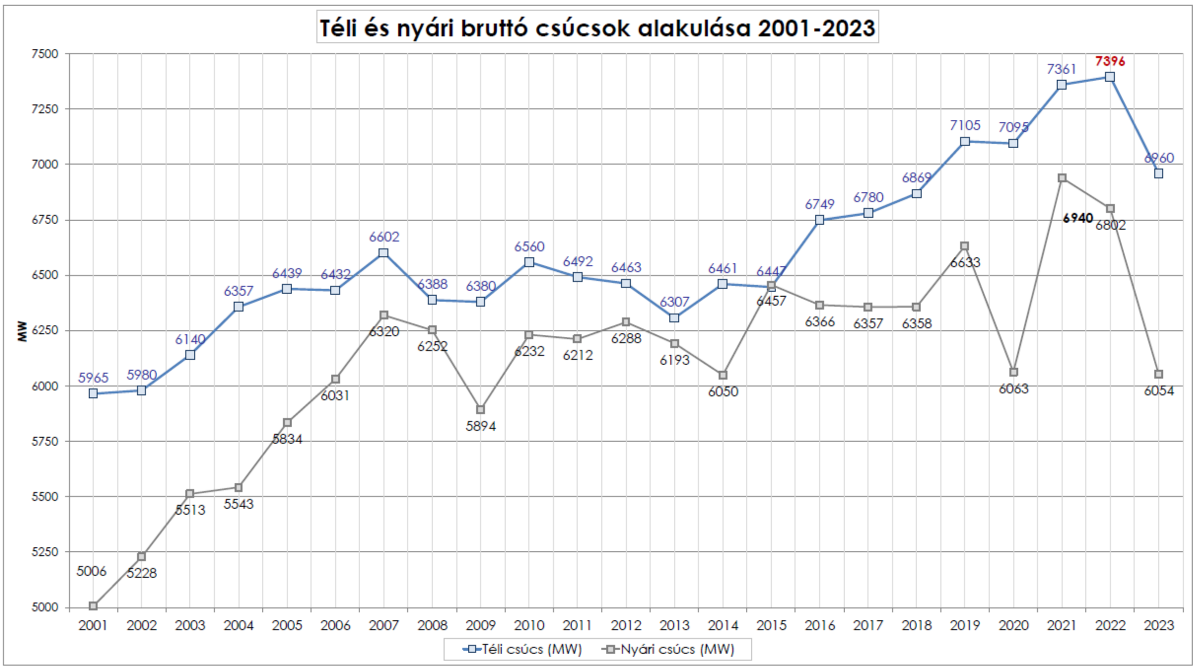
The largest player on the domestic electricity market – the MVM Group – plays a decisive role mainly through the Paks Nuclear Power Plant and the Mátra Power Plant. In addition, MVM owns MAVIR, which operates the transmission network and performs the functions of system operator, two of the six distribution network companies and a share of more than 40 % in the retail market.

The combined market share of the four groups with the largest shares in domestic electricity production (MES, Veolia, Uniper and Alpiq) after MVM was 25 %[152].

Installed PV capacity is growing rapidly, currently exceeding 5 GW. An additional PV capacity of around 4.5 GW has some level of commitment (accession contract or binding techno-economic plan – MGT), in addition to which 3 800 MW of MGT has recently been emitted, bringing the total PV capacity to 12 GW by 2030.[153]

[152] MEKH National Assembly Report 2021
[153] Source: MAVIR

This capacity is particularly high in the light of the scale of system load. The peak in 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 peak daily summer load in 2022 was 6 802 MW, 14 % higher than in the previous year.154 The peak system load in summer 2021 was 6 940 MW, the highest number of system loads recorded in summer. This year there is a marked decline in both system load data and total gross electricity consumption.)



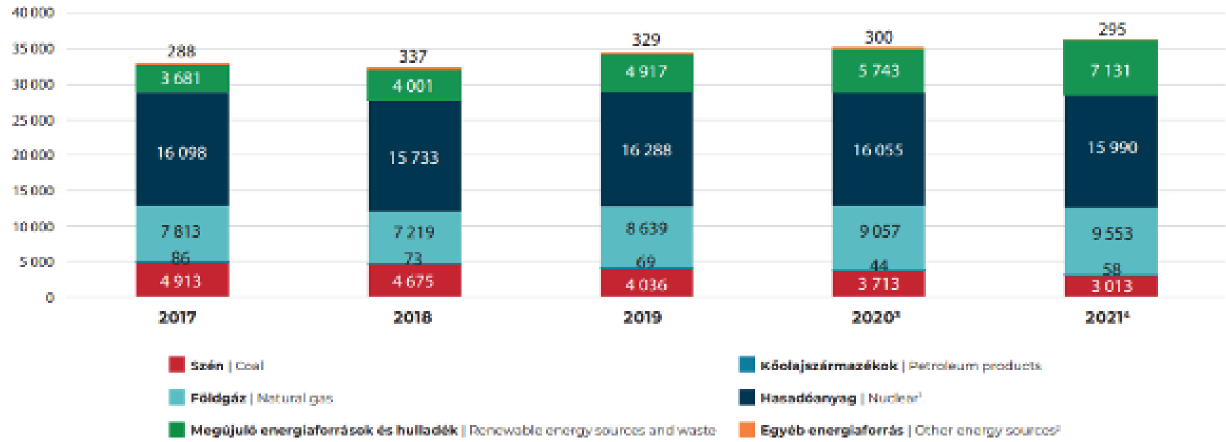
62figure – Winter and summer peaks

Source: MAVIR ZRt

In terms of production, the breakdown of the composition of resources is shown in the graph below.

In terms of production, the breakdown of the composition of resources is shown in the graph below.

154 MAVIR ZRt. (2022): 2021 data of the Hungarian electricity system (VER)



63figure – Resource distribution of domestic electricity generation 2017-2021, GWh

Source: MAVIR ZRt. 155

In 2022, 44 % of domestic electricity production came from the Paks Nuclear Power Plant, while the share of renewable electricity production was almost 20 %, and PV capacities are expected to grow further. Overall, 64 % of domestic electricity production already comes from GHG-neutral sources in 2021, above the EU average.

Gas-fired power plants with relatively high marginal costs also account for a significant share of domestic capacity, which also play a significant role in the regulatory markets. As a result of the evolution of fuel prices and the GHG emission allowance (EUA) price at the end of the 2010s, the production cost of European gas power plants fell permanently below the production cost of coal power plants, but this was reversed in 2022 due to a surge in gas prices, so that the production of gas-fired power plants was partly taken over by coal-fired power plants: within the EU-27 production, the weight of coal and lignite combustion increased from 12.3 % to 14.2 %, again exceeding the 13.9 % contribution of gas-fired power plants.156

In Hungary, these shifting trends in gas-to-charitable production have been poorly observed: the production of the lignite-fired Mátra power plant has been steadily decreasing since 2017, and although this decline stopped last year, no significant fuel switch has taken place in the Hungarian electricity system. This decrease in gas-based production across Europe was not only marginally observed in Hungary in 2022, but in the first half of 2023, the utilisation rate of Hungarian gas power plants was already significantly lower than in previous years. In an increasing number of times, gas power plants do not produce on the product market, but only on the regulatory markets.

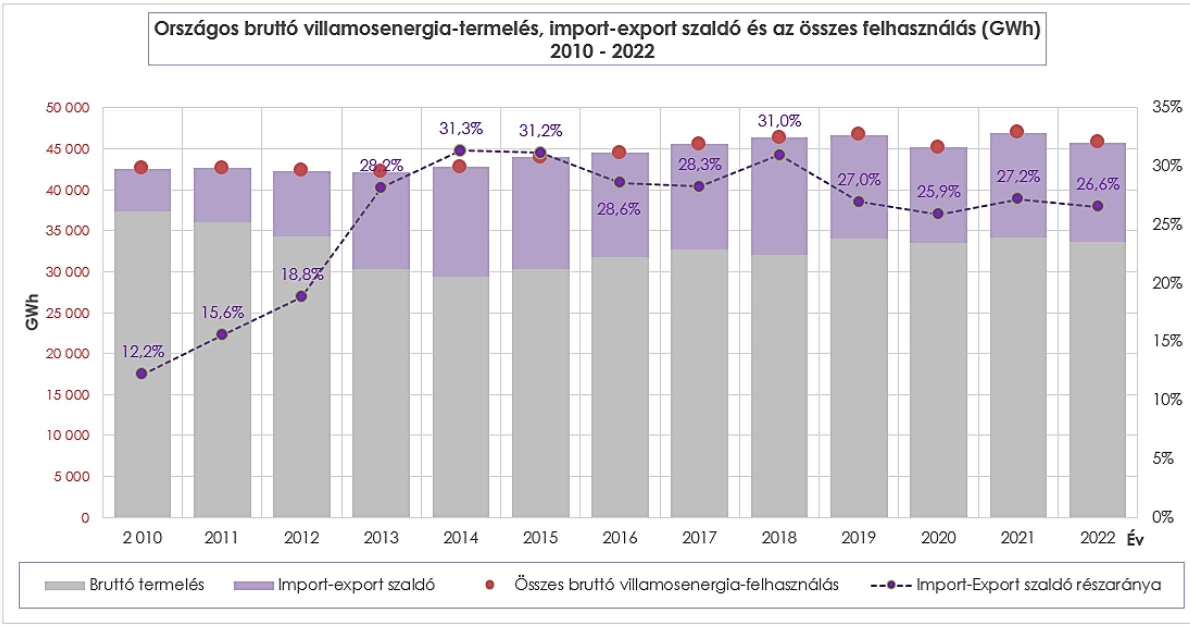
Electricity demand growth in 2016-2019, slightly above 1 % per year, was interrupted in 2020 due to the lockdown measures taken in response to the pandemic. Subsequently,

155 MAVIR ZRt. (2022): 2021 data of the Hungarian electricity system (VER)

156 Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf

electricity consumption increased by 4.9 % in 2021, an increase of 4.3 % compared to 2019.[157] Gross electricity consumption, excluding the production data of household-scale producers, was 46.9 TWh in 2021, of which domestic production accounted for 73 % and 27 % came from imports, while in 2022 it decreased to 45.8 TWh, of which 26.6 % was the import-energy share.

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 7.88 % between 1 January 2022 and 30 June 2023 compared to the first half of last year.



64figure – National gross electricity production, import-export balance and total consumption (excluding HFCUs)

Source: MAVIR ZRt.158

The domestic electricity system typically operates with high net imports: over the last 5 years, the net import ratio has fluctuated between 26 % and 32 % on an annual basis. The high import demand does not currently pose a significant security of supply risk as cross-border capacities are also strong at international level. 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. At the same time, according to the reference scenario of ENTSOE's 2022 resource adequacy analysis, the number of unserved hours (LOLE) in Hungary is expected to be 6.3 hours in 2025, which can also be described as high in European comparison. There is no capacity mechanism for security of supply purposes in Hungary, but the State's ownership role means that it has a direct influence on important power plant investment decisions (e.g. the planned extension of the operating

[157] Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf

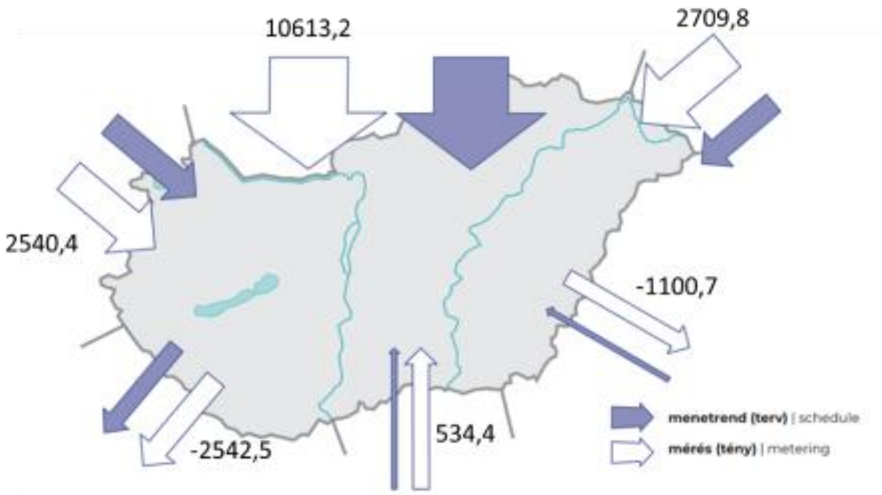
[158] https://www.mavir.hu/web/mavir/a-teljes-brutto-villamosenergia-felhasznalas-megoszlasa

hours of the existing units of the Paks Nuclear Power Plant or the construction of new nuclear power plant units).

Retail and wholesale trade, market integration

In 2021, there was a significant increase in cross-border capacities, 800 MW at the Slovak cross-border, around 140 MW in the import direction at the Romanian border and around 250 MW in the export direction. Despite the significant capacity increase, the frequent scarcity of cross-border capacity has become a feature not only on the Slovak and Austrian pipelines, but also from Romanian imports.[159]

The following graph shows the evolution of international electricity sales and actual flows in 2021 on each cross-border line.



65figure. Actual electricity flow, import GWh-2021

Source: MAVIR ZRt. (2022): 2021 data of the Hungarian electricity system (VER)

The most valuable import capacities are typically Slovak and Austrian cross-border pipelines, while the largest exports traditionally shift to Croatia (and, more recently, Slovenia). However, the structure of external trade flows has changed somewhat in recent years. While import volumes increased further with the expansion of Slovak-Hungarian import capacity (in 5 years, Slovak imports virtually doubled), imports from Austria almost halved in 2021 compared to previous years. In 2022, with the transfer of the Slovenian pipeline and the strong increase in turnover in the Croatian relationship, very significant export growth occurred in the South-West connections.

As part of the EU's third energy package adopted in 2009, Regulation (EC) No 714/2009 required the creation of interconnected electricity markets. Accordingly, there have been significant market integration developments affecting the Hungarian market in recent years. In

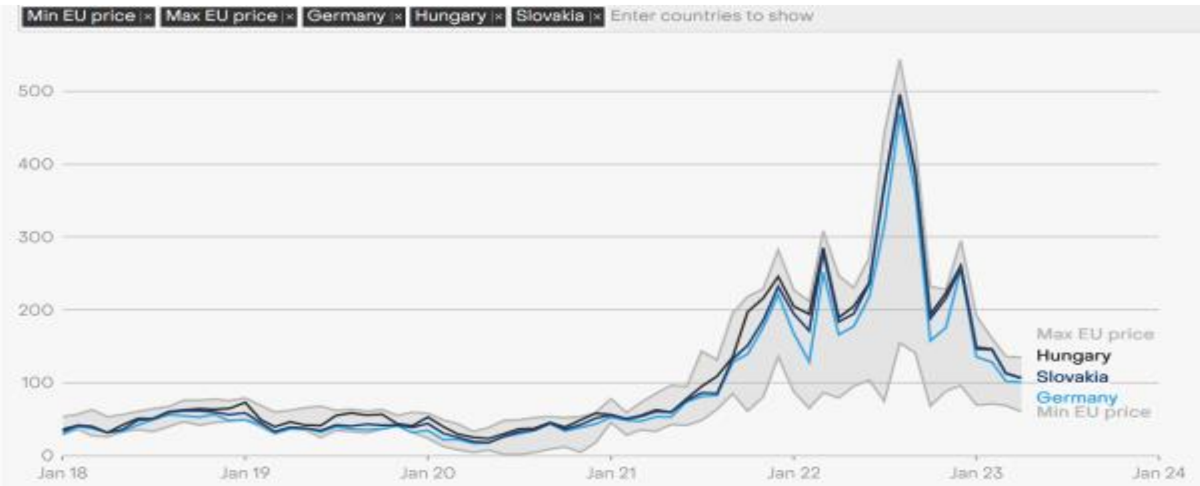
[159] Source: MEKH, Electricity Market Annual Report 2021, https://www.mekh.hu/download/d/ca/11000/vill_eves_2021.pdf

our region, there was initially only Czech-Slovak day-ahead coupling, to which Hungary joined in September 2012 as a result of the Czech-Slovak-Hungarian market coupling project, triggering the day-ahead implicit allocation based on net transfer capacity (NTC) at the Hungarian-Slovak border. Subsequently, the so-called 4M MC market coupling started with Romania's accession on 19 November 2014. As a next major step, the so-called Interim Coupling project was launched in December 2018, leading to the completion of a pan-European integrated market on the day-ahead horizon.160

Finally, the Core Flow-based market coupling project was launched in June 2022, during which capacity allocation changed from NTC-based to flow-based, allowing more efficient use of network elements. The experience with the introduction of flow-based capacity calculation is positive, the frequency of particularly high price differences decreased, while the frequency of overall price convergence slightly increased.

After the start of the flow-based project, HUPX traffic appears to stabilise at around 2 TWh of monthly turnover, but market liquidity in forward trading remains very low.

Electricity prices increased significantly as of the second half of 2021, mainly driven by the increase in the price of natural gas and GHG allowances, and the Russian-Ukrainian war that broke up in 2022. As a result of the strong price increase, the Hungarian electricity market has also increased its mark-up compared to the surrounding markets. Hungarian day-ahead prices tend to vary between Italian and German prices, with countries with higher prices in the region: compared to Austrian and Slovak wholesale prices, the Hungarian market typically traded a mark-up of EUR 5-10 per MWh. In the second half of 2021, these spreads did not rarely jump to EUR 60/MWh, while the liquidity of the Hungarian OTC markets (which has already declined sharply since 2018) fell sharply in 2022.



66figure – Wholesale prices of domestic and regional electricity, EUR/MWh, distribution of sources of electricity generation

Source: MAN

[160] Source: https://www.mavir.hu/web/mavir/masnapi-piac-osszekapcsolas

There are increasing intraday price fluctuations on stock exchanges, with new business strategy opportunities for traders.

As regards intraday markets, the XBID project was implemented in[161] Hungary in November 2019. As a result, the Hungarian intraday market also became an international market, with all Hungary's EU borders participating in market coupling (both day-ahead and intraday horizons). Thereafter, volumes traded on the intraday market show a steady increase, apart from the stagnation after the start of the day-ahead flow-based project, currently accounting for a quarter of the day-ahead market.[162] This shows that there is still potential in this market. This is an important development in light of the fact that the integration of large volumes of renewable capacity can be effectively supported by the intraday market.

It is important to note that the market integration steps already taken have yielded a number of positive results: they improve security of supply, increase market efficiency and liquidity, while also leading to price convergence and more stable electricity prices in the energy market in the region. Further positive developments in the Hungarian electricity markets could be expected in the near future developments in intraday markets, as well as the expected integration of the regulatory energy markets next year.

The retail market has a dual structure: while users entitled to universal service (mainly residential and small customers) are able to obtain electricity at a maximum regulated price, the market in the free market segment drives prices. One third of the total end-user consumption is covered by the universal service (official price) and two thirds in the free market segment (market price). In 2 021.13199 GWh of electricity was sold to consumers under the universal service. 54 % of these consumers were supplied by MVM Next, 46 % by the electricity supplier E.ON. In 2 021.27172 GWh of electricity was sold to consumers supplied from the free market. Although several traders are active in this market segment, there is also a high concentration: MVM alone accounts for 54 % of competitive consumers and 97 % together with E.ON.[163]

In the universal service segment, the Hungarian government implemented a step-by-step price reduction in 2013 and until the summer of 2022, these so-called 'reduced' prices were in force. As a result, the electricity tariffs paid by domestic household consumers are still the lowest in the European Union. As a result of unprecedented price increases on European electricity markets, the regulator has made some changes to the universal service: while sales are made at constant prices to the extent of the so-called 'average' private consumption, 'market prices' above this level were set by the authorities. In addition, the government has reduced the range of non-residential consumers eligible for universal service: consumers who are excluded from the official price will be supplied at free market prices by a temporary last resort and

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[161] Cross-Border Intraday Project

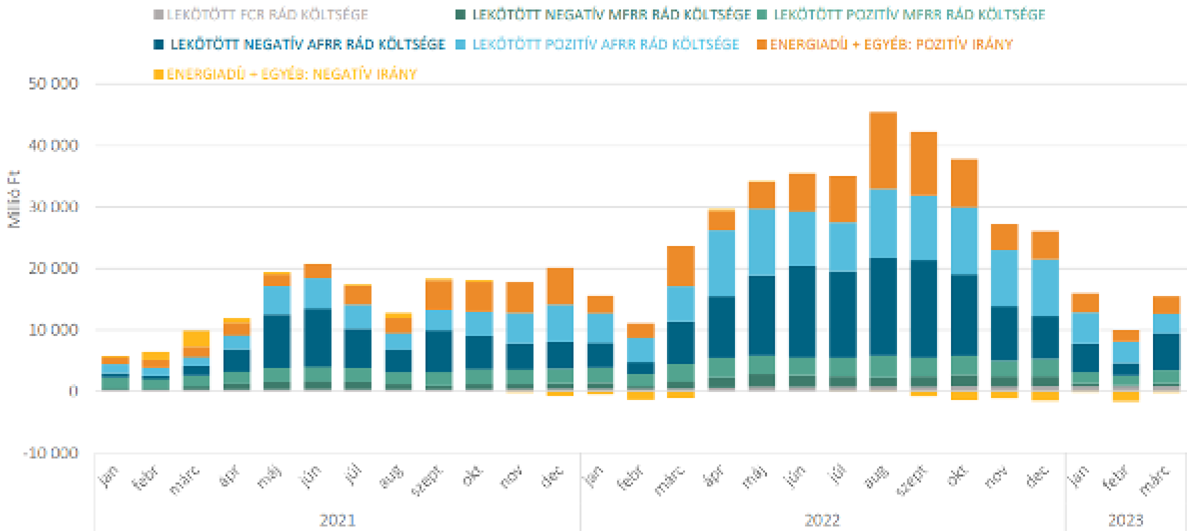
[162]Source: HUPX, https://hupx.hu/uploads/Piaci%20adatok/DAM/havi/2023/HUPX_Spot_April_Report_2023.pdf

[163] Source: MAVIR ZRt. (2022): 2021 dataof the Hungarian electricity system (VER) and MEKH National Assembly Report, 2021

subsequently by a free-market trader. (Non-residential consumers who have left the universal service and have been granted the status of last resort, have moved from the status of last resort, which ceased at the end of 2022 to the so-called 'bill-fix' status, to support their transition to the free market. This status is also granted for a limited period of time – the end of the 2023 gas year for gas and the end of 2023 for electricity – as it is also intended to support the transition).

<u>Regulatory capacity and energy market</u>

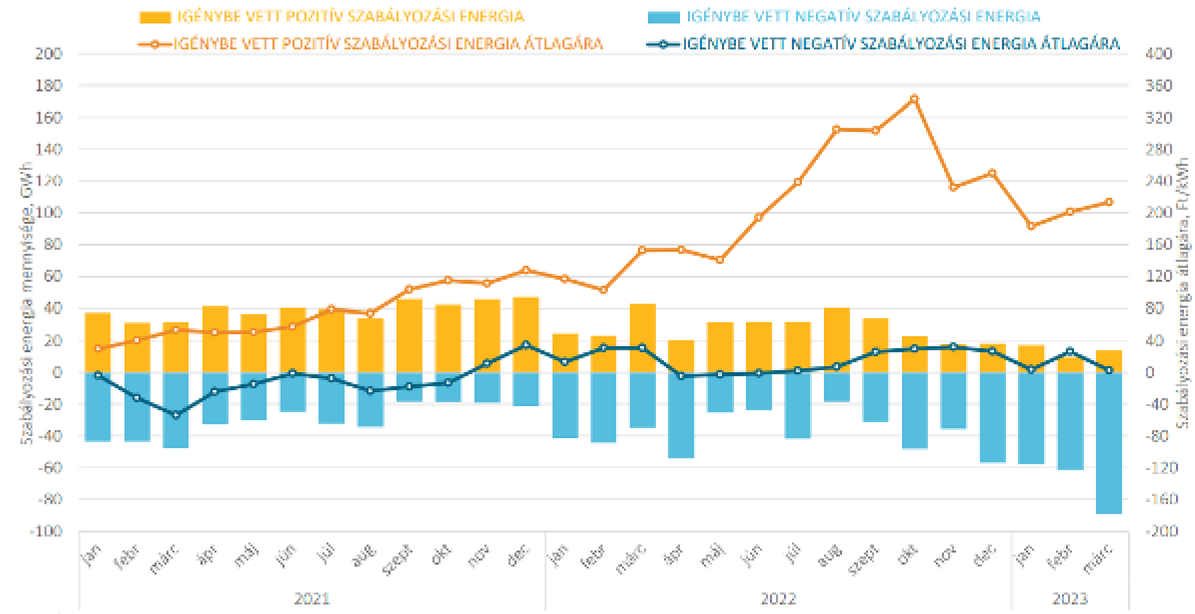
The total cost of the regulation used by the system operator doubled from 2020 to 2021 and from 2021 to 2022. There may be a number of cumulative reasons for this. On the one hand, capacity charges for committed reserves and regulatory energy prices were also strongly affected by very high market prices and, on the other hand, the volume of 'downstream' reserves increased significantly in 2022.



67figure – Total cost of control used by the system operator

Source – MEKH monthly report 164

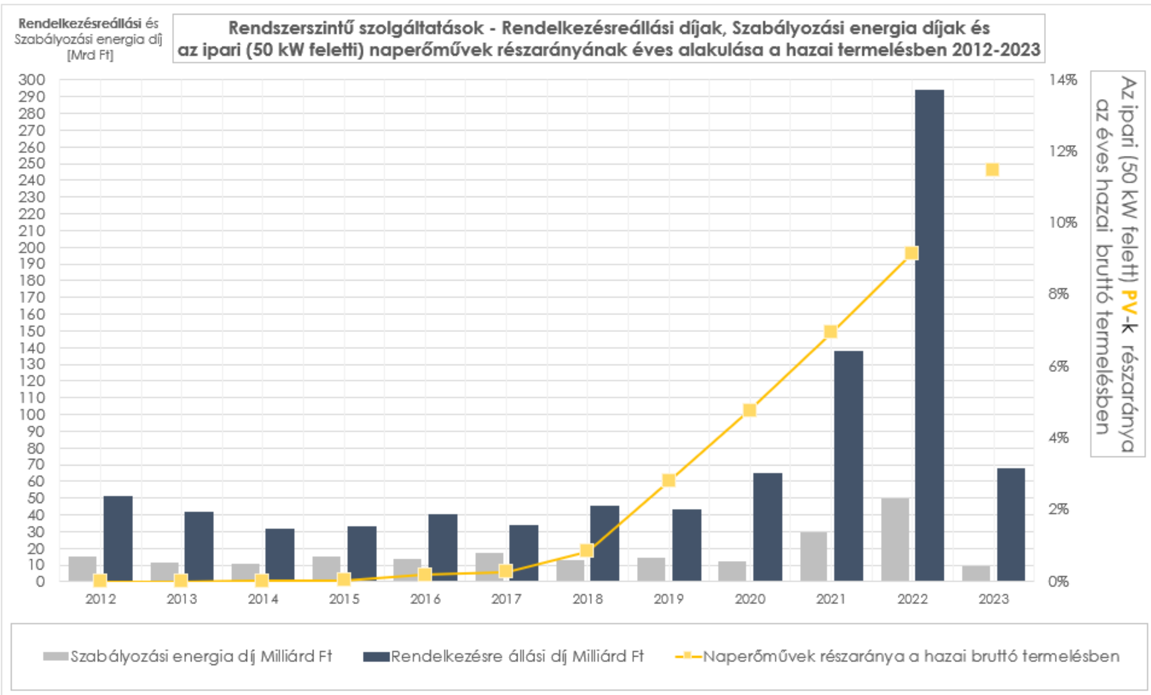
[164] https://www.mekh.hu/download/6/14/41000/HaviRiport_villamosenergia-piacok_2023_3_vegso.pdf



68figure – Monthly volume and average price of regulatory energy consumed

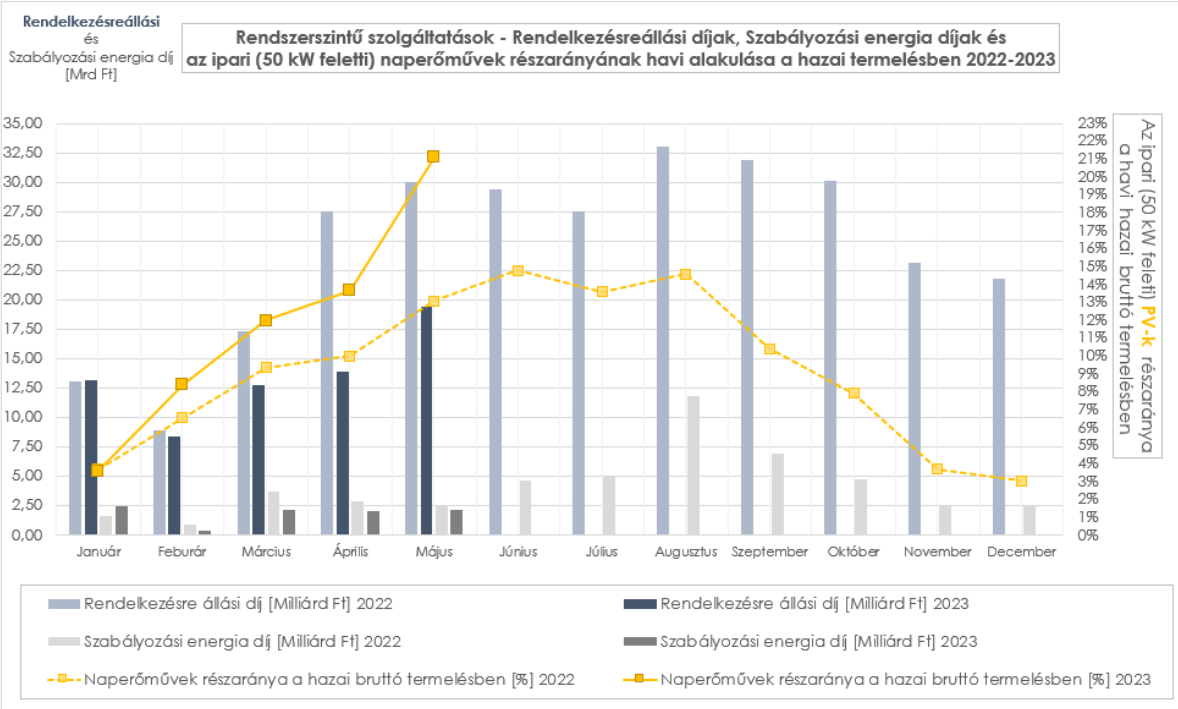
Source: MEKH monthly report

In summary, there have been exponentially increasing annual costs for availability and regulatory energy tariffs in the area of system-level services in recent years. However, according to 2023 data, costs appear to moderate compared to last year's figures. In addition to costs, the production share of solar power plants plays an important role, as well as the fact that a growing number of solar generators are included in the market for system services.



69figure – System-wide services, regulatory energy charge, availability fee, share of solar power plants in gross production

Source: MEKH monthly report



70figure – Monthly volume and average price of regulatory energy consumed

Source: MEKH monthly report

iv. Projections of development with existing policies and measures at least until 2040 (including for the year 2030)

Gas market

Regional competition

A strong stock exchange and market integration processes may result in lower prices for domestic consumers, as the market size and the number of suppliers increase, thus increasing competition between them.

Hungary has an active trade relationship with a number of non-EU countries. This is why it is important not only for EU operators to enter the domestic market, but also outside the EU, such as Serbian, British, Swiss or Ukrainian operators. This process is supported by the fact that many countries have started to harmonise their regulatory environments on the basis of EU rules.

Gas market integration and partnerships

The utilisation rate of 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), with Hungary in geographical and gas trading terms. An important element of market coupling projects is to capitalise on the experience accumulated in the electricity markets and the Baltic gas markets. In practice, this is the creation of a shared order book, which can be achieved with a non-zero tariff, mainly on the day-ahead and intraday product horizons.

The primary condition for market integration is the physical connection of gas supply systems. It is recommended to connect neighbouring markets with two-way cross-border capacities and similar market sizes, thus increasing competition between players in the interconnected market. The physical conditions for Croatian-Hungarian market coupling are met, as two-way trading is available at the cross-border point.

Improving house and settlement conditions

The record high natural gas prices seen in 2022 resulted in record high financial expectations for traders in the form of collaterals. This had a direct impact on the financing of natural gas traders across Europe, but overall there was an over-insured system where the European settlement system would be prepared for more than 100 % defaults without risk aggregation.

In the recent period, a number of minor progress have been made to address the problem and further significant improvements can be achieved through appropriate partnerships. One of the trends examined is a decentralised netting of buying and selling positions, which would significantly help traders and ultimately reduce consumer prices. The improvement of the clearing house conditions for domestic gas trading can be done through the expansion of eligible assets, be it through a bank guarantee or the use of underlying contracts (e.g. end-consumers) in the case of financial custody.

Facilitating trade in renewable gases

With a view to further diversifying gas sources, it has also become necessary to expand tools and accelerate processes to support the achievement of previous targets for domestic biomethane potential.

On the basis of international examples, one of the most effective ways of doing so is the domestic establishment and integration of the GO registry in the international environment for networked biomethane. Based on the experience of GO in the electricity market, where Hungary has become one of Europe's liquid marketplaces by 2023, a gas market system for the corresponding certificates can be established. An important feature of the trading of these GOs, certificates and renewable gases is that trade is decoupled from physical delivery. Therefore, with a prudent regulatory environment, Hungary can facilitate the trade in European biogas beyond its domestic biogas potential.

Change in domestic final consumer contracts

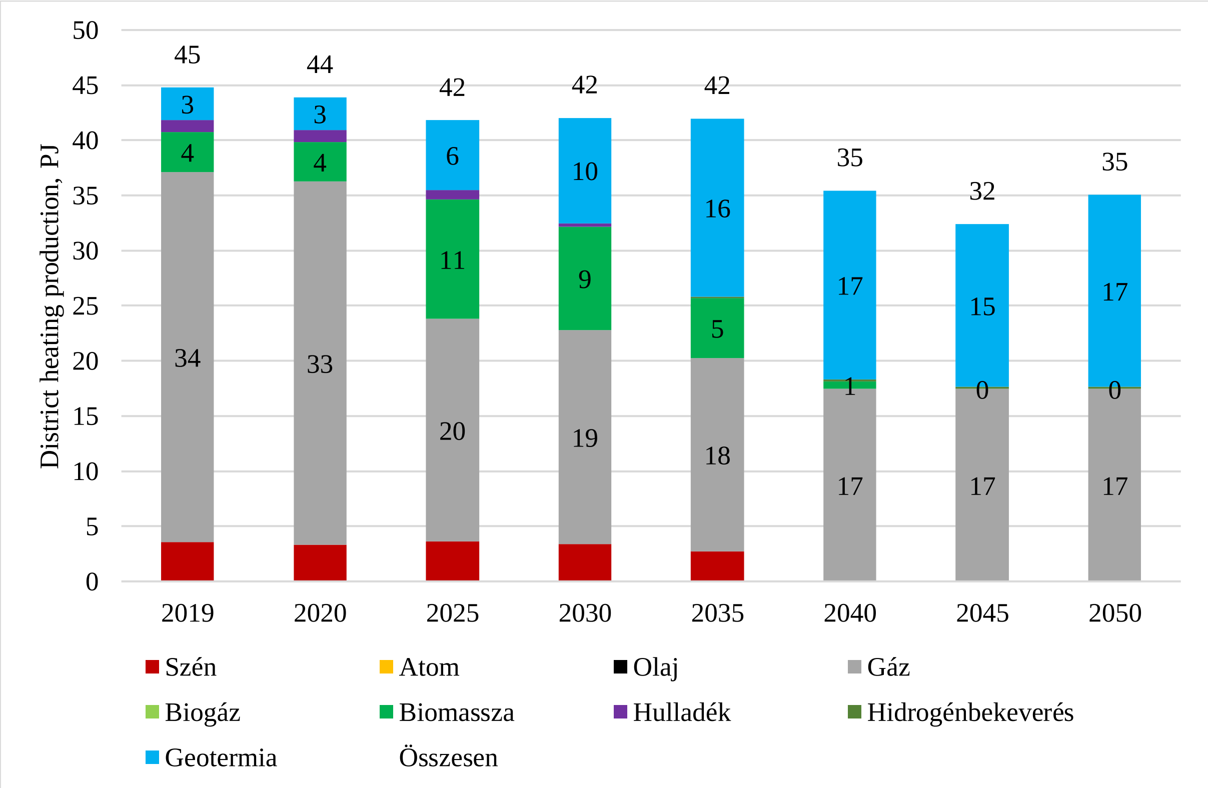
The year 2022 also changed traders' pricing and risk management practices. Since the 2010s, TTF indexation in commercial contracts has spread across Europe in addition to fixed prices, and this practice was also established in Hungary, as reflected in a number of legislative references. When these laws came into existence, the domestic gas stock exchange did not yet have sufficient liquidity, but this situation has now been reversed.

As a result of the energy crisis, fixed-price schemes have typically been phased out of end-consumer contracts on the market, and merchants have made available indexed pricing with lower price risk, in particular spot-indexed schemes. Previously unknown concepts for consumers have become the new norm and CEEGEX indexed consumer contracts have also emerged. The latter arrangement is more advantageous for both the consumer and the trader, as it allows for pricing reflecting domestic supply and demand.

As a next step in CEEGEX indexation, domestic forward prices may appear alongside the TTF in the case of hedging transactions, which would create the possibility of pre-fixing prices for domestic natural gas market participants.

Role of natural gas in district heating and energy mix

In the case of district heating, due to the substitution of natural gas with renewable alternatives, we are already expected to reduce the use of natural gas as a result of existing measures.

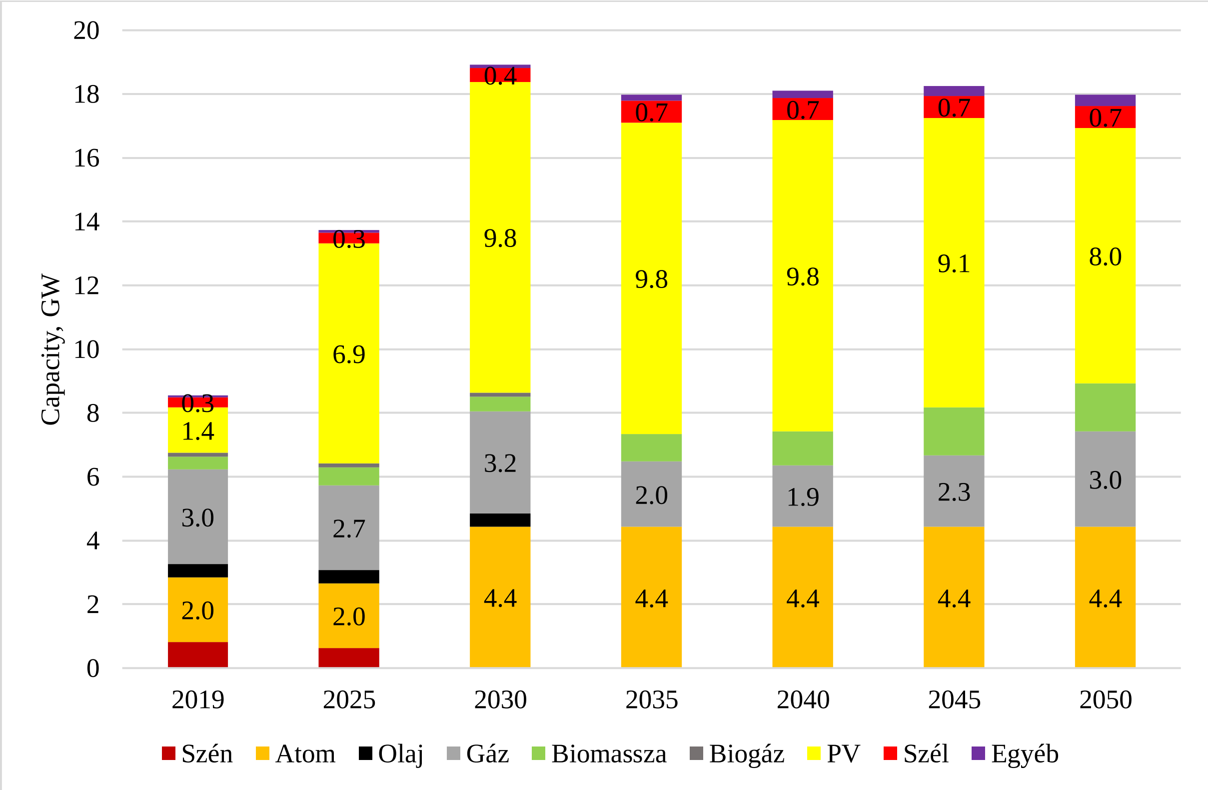


71figure – Expected evolution of district heating production by fuel mix along existing policies and measures (WEM scenario)

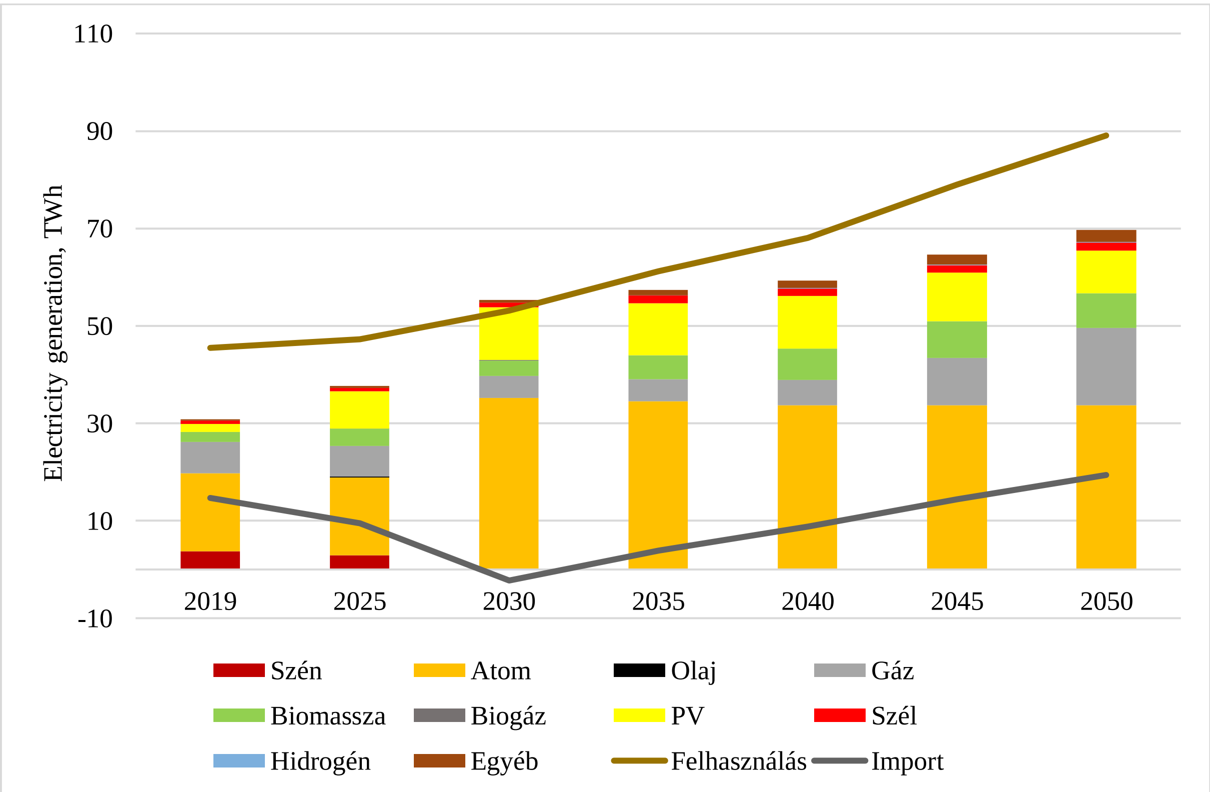
Graphs showing the expected future evolution of the role of gases in the energy mix, taking into account the impact of the current measures, are presented in chapter 4.2.)

Electricity market

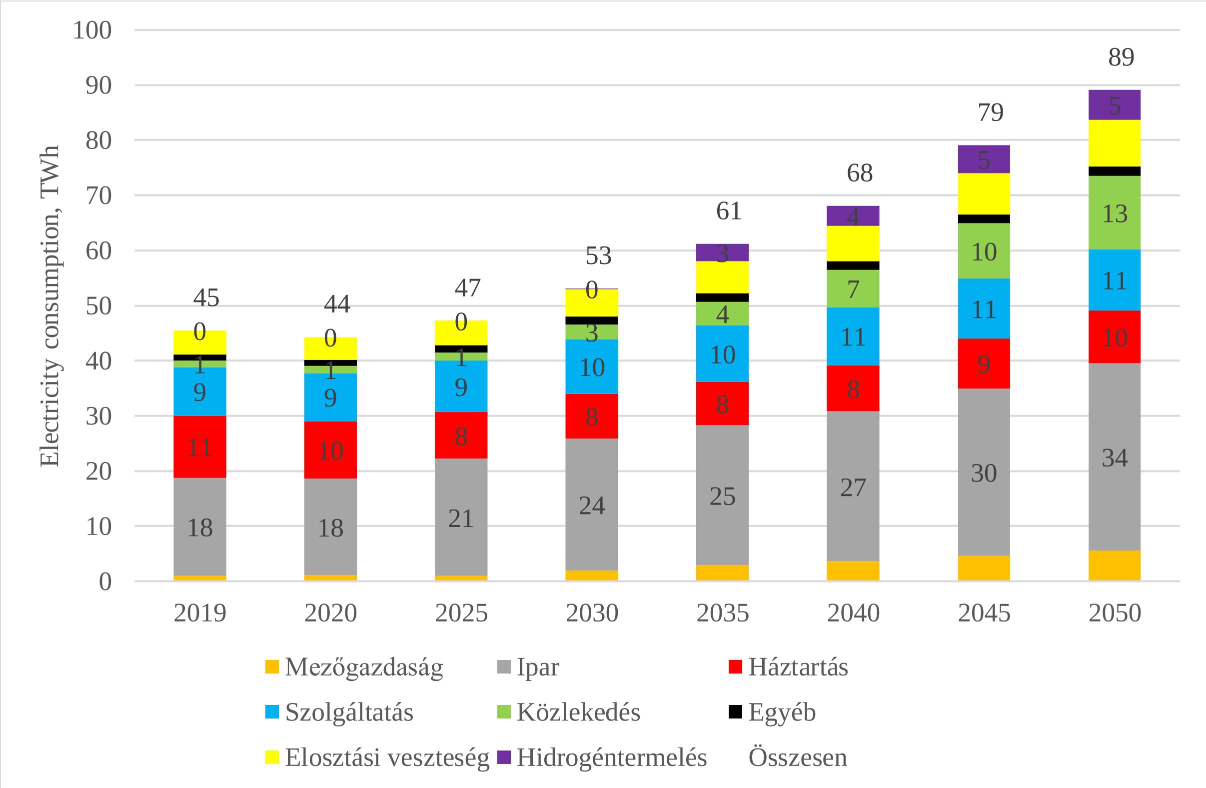
The impact of existing policies and measures is expected to be a butt electricity capacity mix and/or production mix in the graphs below.



72figure – projected evolution of electricity capacity along existing policies and measures (WEM scenario)



73figure – projected evolution of electricity generation and consumption along existing policies and measures (WEM scenario)



74figure – Evolution of electricity recovery by sector in the WEM scenario taking into account the current measures, GWh

Charts showing the expected future evolution of the role of electricity in the energy mix, taking into account the impact of the current measures, are presented in chapter 4.2.

Joining platforms that facilitate the exchange of regulatory energy (PICASSO[165] and MARI[166] platforms) can bring about a significant change in regulatory energy prices, creating an integrated European market in the regulatory energy market. Platforms can lead to price reductions for several 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 those of operators from other European countries.

However, regulatory reserve markets will remain typically national markets, i.e. the supply side of reserve capacities needs to be expanded with the participation of domestic actors. In the recent period, positive changes have started in this direction. Renewable producers are increasingly involved in the regulation (although their role is still negligible) and industry reflection has started on maximising consumer involvement. Thanks to the storage support programme, significant volumes of storage are expected to enter the regulatory markets in the future. In order to support the market participation of new types of players, the product structure

[165] Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
[166] Manually Activated Reserves Initiative

of the reserve market has also been restructured: As of Q2 2023, in addition to baseload purchased in monthly tenders and peakload products purchased in weekly tenders, day-to-day tenders will also be procured and intraday capacity tenders will be introduced shortly.

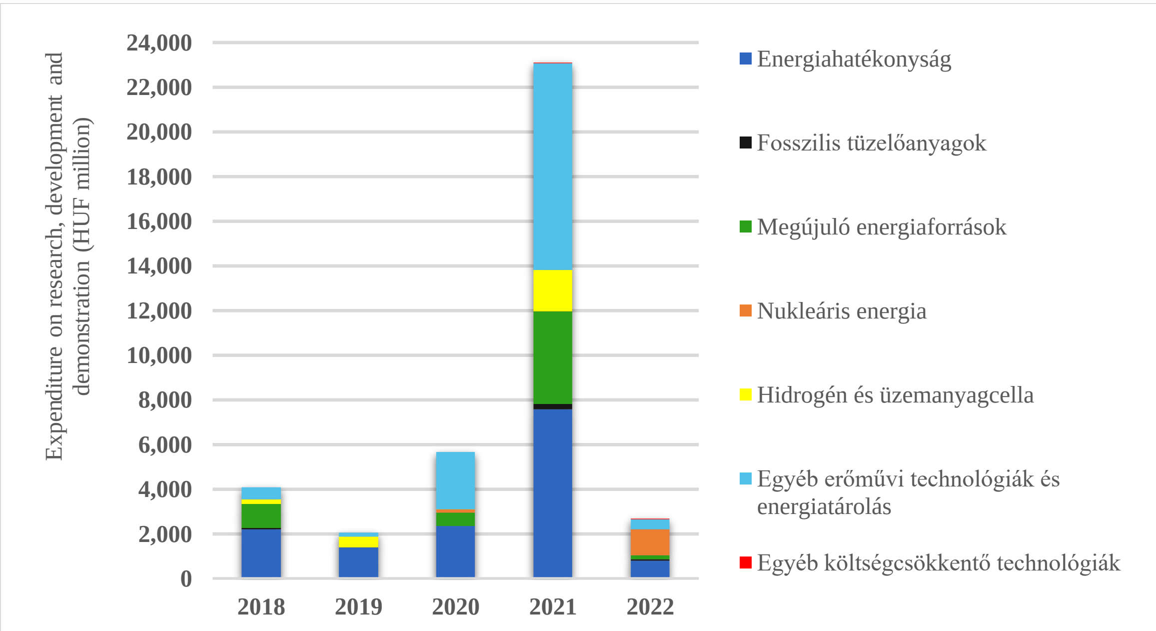
2021 marked an important step towards meeting the Clean Energy Package's objective of enabling consumers to become active players in the electricity market. To this end, new market participants and activities such as active customers, aggregators or energy communities, flexibility services or electricity sharing have been defined in domestic legislation. Market integration of new types of players requires a rethink of the market's operating model, which could be an important challenge for the coming years.

4.6. **Dimension Research, innovation and competitiveness**

i. Current situation of the low-carbon-technologies sector and, to the extent possible, its position on the global market (that analysis is to be carried out at Union or global level)

The main directions for the development of energy RDI were based on the distribution of public R & D and development expenditure, which was reviewed from the data provided to the International Energy Agency (IEA).

We do not have accurate information on support from private investment. Hungary's energy R & D priorities in 2021 remain energy efficiency; alternative propulsion in transport; renewable energy, including solar energy; and energy production, transport and storage. For the time being, we have only estimated data on 2022 expenditure, but it can be seen that nuclear development expenditure has been catching up in addition to the above priorities.



75figure – Breakdown of public R & D and development expenditure by technology, 2018-2022 [167] [168]

Source: IEA [169]

Between 2018 and 2022, the Hungarian State spent on average HUF 7.5 billion per year on energy R & D expenditure from domestic sources. Energy efficiency development paths remain decisive, but other power plant technologies and storage developments were also dominated in 2021, thanks to support for demonstration projects.

In 2021, energy innovation pilot projects were launched with financial resources from a green economy financing scheme to use revenues from the sale of CO2 quotas for climate protection. The main objective of the calls for tenders was to encourage the development and massive deployment of innovative solutions that promote the increased use of indigenous renewable energy sources in electricity generation and in locally available renewable energy sources. 6 energy innovation applications have been launched from the source, projects are still in progress and are expected to be completed in 2023.

When evaluating Hungary’s energy R & D activities, reference should be made to the seven-year Framework **Programmes for Research and Innovation of the European Union, Horizon 2020 (2014-2020) and Horizon Europe (2021-2027) as an integral follow-up.** In the context of the clean energy transition, for Horizon 2020, Pillar III ‘Societal challenges’ provides support. Among the activities of the Pillar, the following thematic areas are relevant:

- Secure, clean and efficient energy
- Smart, green and integrated transport
- Climate change, environment, resource efficiency and raw materials

For Horizon Europe, Pillar II ‘Global Challenges and European Industrial Competitiveness’, Climate, Energy and Mobility cluster. The promotion of the green and digital transitions has been highlighted, and 35 % of its budget is expected to be spent in relation to climate change objectives.

The Euratom Research and Training Programme is a complementary funding programme to the above Framework Programmes, covering nuclear research and innovation. Three training programmes have been launched in the past period (2014-2018, 2019-2020 and 2021-2025).

The table below provides information on the European comparison.

37table – Grants from Horizon 2020 and Horizon Europe for energy and climate projects (data not available for the Euratom Training Programme 2021-2025)

Horizon 2020										
	EN	**AT**	**CZ**	**BUT**	**PL**	**SK**	**SI**	**RO**	**Other EU**	**EU total**
Secure, 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

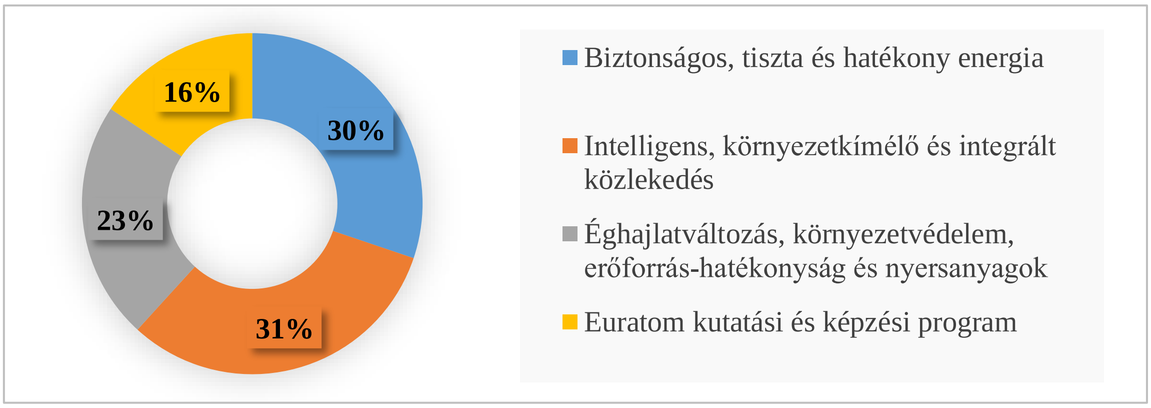
[167] There is no reliable detailed breakdown available for energy efficiency.
[168] Other cost-reducing technologies: Energy system analysis, fundamental research and other activities not elsewhere classified
[169] http://wds.iea.org/WDS/TableViewer/tableView.aspx

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
Share of energy and climate aid in the total H2020 grants awarded by the respective country's applicants (%)	19,9	22,5	27,2	24,1	19,0	20,3	32,2	28,6	21,9	22,7
Horizon Europe										
	EN	**AT**	**CZ**	**BUT**	**PL**	**SK**	**SI**	**RO**	**Other EU**	**EU total**
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	11568,4	15 786,9
Share of energy and climate funding in Horizon Europe grants awarded in total by the respective country's applicants (%)	13,6	21,1	19,7	19,8	16,1	15,0	22,8	22,3	19,9	19,9

Source: Horizon Dashboard [170]

Under Horizon 2020, the number of Hungarian participations supported in the 3 areas mentioned above and in the Euratom research and training programme (2014-2018 and 2019-2020 training periods) was 377. Hungary's project members received a total EU grant of EUR 73.5 million. The chart below gives an overview of the distribution between areas.

76figure – Share of grants received by Hungarian participants in the clean transition categories of the H2020 programme, %



Source: Horizon Dashboard

The experience of the **National Investment Agency** (HIPA) can also help determine the position of clean energy technologies. **HIPA highlights that Hungary has a unique position not only in the region but across Europe in the field of electromobility as a technology of the near**future. Significant R & D capacities related to electric propulsion (AVL, Bosch, Thyssenkrupp) were built in Hungary. In order to strengthen domestic cooperation, the NKFIH, with the policy support of the predecessor of the Ministry of Energy, established the

[170]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

National Laboratory Programme[171], the objectives of which are: (1) concentration of national workshops in a specific thematic area, (2) development of competences capable of responding to major global challenges at international level, (3) knowledge transfer. The National Laboratories aim to create a new, collaborative and institutionalised platform for exploration and experimental research for the social, economic and environmental exploitation of research results. Of these, 5 thematic areas are relevant for energy or climate. The related National Laboratories and their research areas are:

- **Climate change Multidisciplinary National Laboratory**

They focus on mapping the climate impacts of soot particles, the effects of planktonic organisms related to climate change, solutions to preserve biodiversity, and the design and deployment of bio-battery.

- **National Laboratory for Renewable Energies**

In their R & D orientations, the decarbonisation targets undertaken by Hungary are highlighted. In order for the country to be the winner of the Green Economy, it is necessary to create a pool of knowledge and competence that will enable domestic economic operators to be competitive in the various decarbonisation technologies. To this end, the National Laboratory is involved in building a scientific and technological, legal, economic and industrial property base for low-footprint energy technologies, in particular H2 production/transport/storage/use and CO2 utilisation (in particular H2 development and CO2 conversion electrolysers and catalytic technologies; disruptive H2 production/storage and CCU processes and in the research of test stations comparing the lifespan of the two technologies). On the other hand, the recycling and production technology aspects of fuel cells and next generation Li-ion batteries; and the design of a pilot plant is interested in the production of syngas.

- **Nanoplasmonic Lézeres Fusion Research Laboratory**

The laboratory will explore new pathways for nanotechnological preparation and laser irradiation of the fusion target to increase the efficiency of energy absorption and avoid the development of instability during ultra-short pulses. The expected results of research can contribute to the development of efficient and clean fusion power generation, which will also be applicable to transportable power plant sizes.

- **National Lézeres Transmutation Laboratory**

The main objective of the project is to create fusion neutrons generated by ultra-short laser pulses and to carry out further experiments to increase neutron yields, as well as pilot and simulation studies to facilitate nuclear waste transmutation (spent fuel) of laser-derived

[171] https://nkfih.gov.hu/nemzeti-laboratoriumok-program

neutrons. The expected benefits of research would include the addition of control units used in road and rail freight transport to monitor licensed nuclear material.

- **National Laboratory for Water Sciences and Water Safety**

Taking into account the location and management of Hungary and its water resources, the National Laboratory aims to implement new water sciences and water safety that contribute to the protection of water quality. The Laboratory assesses in detail the status of the various surface and groundwater bodies using laboratory measurements, computer simulations and taking into account the complexity and central importance 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 waste water treatment.

ii. Current level of public and, where available, private research and innovation spending on low-carbon-technologies, current number of patents, and current number of researchers

Funding of R & D

In 2021, an average of 2.27 % of GDP was spent on R & D in the European Union (EU27_2020). In Hungary, the figure was 1.64 %, putting it 13rd in the EU Member States.

The amount spent on R & D in 2021 exceeded HUF 900 billion at national level. 76 % of R & D expenditure was spent in business research organisations, almost HUF 685 billion, a further 14 % (HUF 125 billion) in higher education and 10 % (HUF 93 billion) in general government R & D institutes and other budgetary research organisations.

In recent years, the amount of R & D spending in the field of engineering has increased most dynamically. The funds used represented 63 % of the total R & D expenditure. Most of engineering was devoted to R & D in pharmaceuticals and electrical, electronics and IT engineering[172]. These two disciplines exceeded one third of the total R & D expenditure in 2021.

In most cases, in Hungary, R & D funds are allocated to different projects rather than to a specific field of science; thus, energy-related obligations may vary from year to year.

The HCSO provides data on the R & D transmissions of undertakings, but these data are not available for the entire energy sector. However, within the energy sector, the HCSO publishes data on the electricity, gas, steam and air conditioning sectors. These are set out in the table below.

38table 1 – R & D expenditure of entrepreneurial research and development sites in the electricity, gas, steam and air conditioning sectors, 2021

Indicators	2021
Total R & D expenditure of the enterprise sector (inside walls) (HUF million)	3687
Total R & D costs for the enterprise sector (HUF million)	2128

[172] No further breakdown is available.

Foreign resources for R & D expenditure of the enterprise sector (HUF million)	257
Non-profit resources for R & D expenditure of the enterprise sector (HUF million)	
Higher education resources for R & D expenditure in the enterprise sector (HUF million)	
State budgetary resources for R & D expenditure in the enterprise sector (HUF million)	1019
Total enterprise resources for R & D expenditure of the enterprise sector (HUF million)	2412
Total investment in R & D by the enterprise sector (HUF million)	1559

Source: HCSO (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)

Expenditure in the field of energy RDI activity may be significant, but not exclusively, in the technical and natural science fields. Such expenditure for the total economy is shown in the table below.

39table – Main data on R & D spending in entrepreneurial research and development sites by discipline, 2021

Indicators	Grand-total discipline “07”	Of which natural sciences	Of which engineering	Of which other
Total R & D expenditure of the enterprise sector (inside walls) (HUF million)	684723	108445	534604	41674
Total R & D costs for the enterprise sector (HUF million)	521758	96535	391300	33923
Total investment in R & D by the enterprise sector (HUF million)	162965	11910	143303	7752
Total enterprise resources for R & D expenditure of the enterprise sector (HUF million)	452641	73665	358764	20212
State budgetary resources for R & D expenditure in the enterprise sector (HUF million)	119734	21817	82576	15341
Higher education resources for R & D expenditure in the enterprise sector (HUF million)	283	26	123	134
Non-profit resources for R & D expenditure of the enterprise sector (HUF million)	689	98	45	546
Foreign resources for R & D expenditure of the enterprise sector (HUF million)	111376	12839	93096	5441

Source: HCSO (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)

R & D headcount

No database is available for the number of researchers and developers focusing only on energy developments. The HCSO aggregates only the number of researchers of companies falling under the categories of electricity, gas, steam and air conditioning. Data for this sector are summarised in the table below.

40table – Main data of entrepreneurial research and development sites are electricity, gas, steam, air conditioning, 2021

Indicators	2021
Number of research and development sites in the enterprise sector	8
Total actual R & D personnel in the enterprise sector (persons)	234
Total actual staff of researchers in the enterprise sector (persons)	173

Total calculated R & D population of enterprise sector (persons)	137
Total staff of researchers in the enterprise sector (persons)	97

Source: HCSO (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)

In the context of the energy RDI activity, the background base is mainly, but not limited to, researchers in the technical and natural science fields. In 2021, the registered number of technical researchers was 19838, while the number of natural sciences was 7820.

41table 1 – Key data on entrepreneurial research and development sites are scientific disciplines, 2021

Indicators	Grand-total discipline "07"	Of which natural sciences	Of which engineering	Of which other
Number of research and development sites in the enterprise sector	2305	680	1238	387
Total actual R & D personnel in the enterprise sector (persons)	42692	10180	28629	3883
Actual R & D staff in the enterprise sector, women (persons)	9649	2060	6113	1476
Total actual staff of researchers in the enterprise sector (persons)	29771	7820	19838	2113
Actual staff of researchers in the enterprise sector, women	5470	1253	3511	706
Total calculated R & D population of enterprise sector (persons)	34991	8766	23117	3108
Calculated number of R & D in the enterprise sector, women (persons)	8254	1824	5180	1250
Total staff of researchers in the enterprise sector (persons)	24811	6802	16271	1738
Calculated number of researchers in the enterprise sector, women (persons)	4677	1117	2954	606

Source: HCSO (https://statinfo.ksh.hu/Statinfo/haViewer.jsp)

Patent data

The following table summarises the patent data registered in Hungary on low-carbon energy technologies.

42table 1 – Patent data registered in Hungary on low-carbon energy technologies, 2020-2022.[173]

Technical domains, technologies	Number of notifications in Hungary			European patents in force in Hungary			Applications with final protection as at 31.12.2022
	2020	2021	2022	2020	2021	2022	
Wind	1	3	7	1	0	0	3
Solar and geothermal energy	8	9	14	8	2	0	9
Marine 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

[173] The table can only be interpreted horizontally, as an invention may belong to several technical fields at the same time.

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 climate-relevant technologies (methane sequestration, nuclear energy)	1	1	0	0	0	0	10

Source: Hungarian Intellectual Property Office

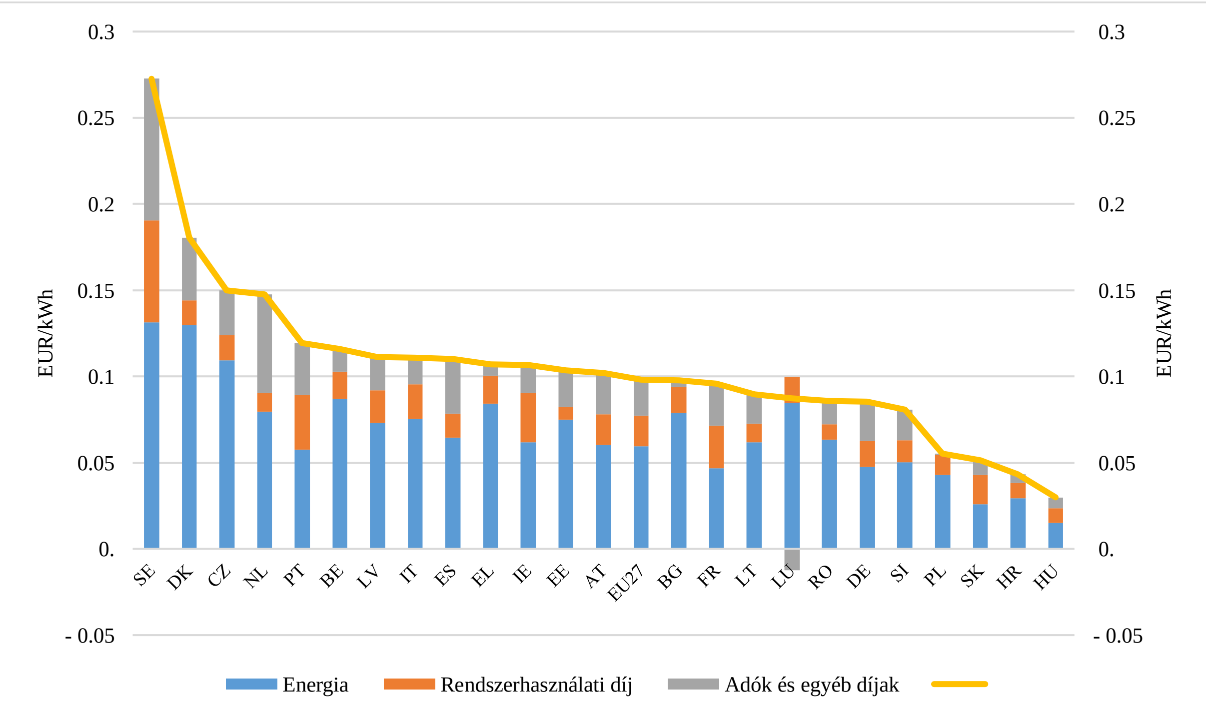
The international comparison is based on the number of applications received by the European Patent Office. The source of data is the OECD, which aggregates environmental and clean energy patents.

iii. Expand the three most important elements of prices today (energy, grid, taxes/levies)

Natural gas price

While electricity prices are partly set as a result of fossil fuel prices (with other, more national or regional factors also shaping price), natural gas prices are based on global fossil fuel – including oil – prices.

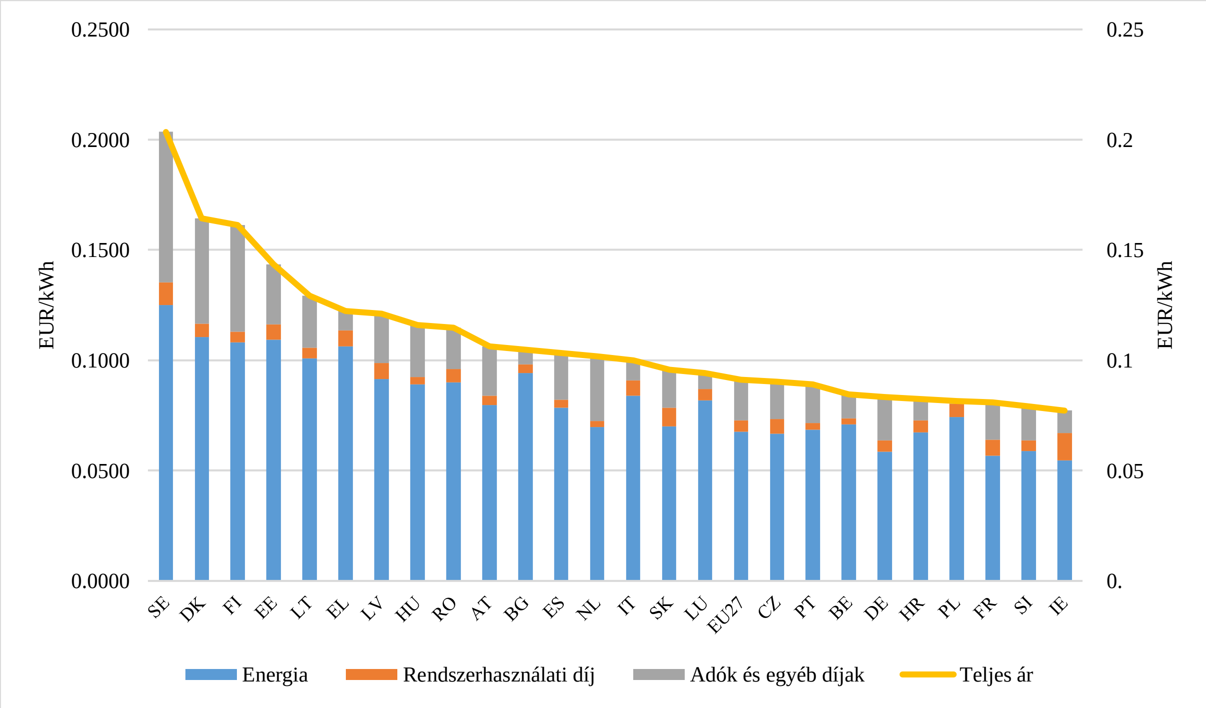
Thanks to price regulation**, household gas prices in Hungary are also the lowest in Europe**. Information on the elements of the (regulated) natural gas price to the public is provided in the graph below.



77figure – Retail gas prices in 2022 (all consumption bands)

Source: Eurostat

Natural gas prices on the market are shown in the graph below.

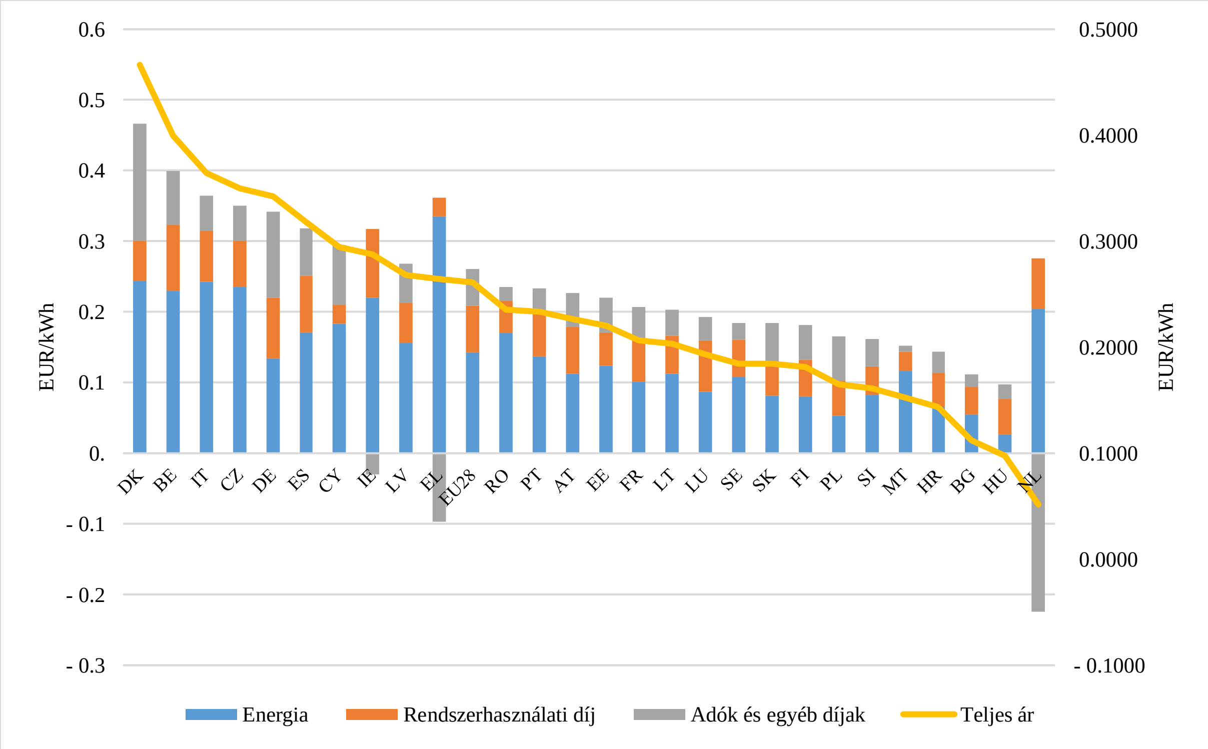


78figure – Market (non-household) gas prices in 2022 (all consumption bands)

Source: Eurostat

Electricity prices

Due **to price regulation, the Hungarian retail electricity price is the lowest in Europe**. In December 2022, the 2nd price was the lowest in Hungary, with only Serbia having lower household electricity prices.



79figure – Retail electricity prices in 2022 (all consumption bands)

Source: Eurostat

iv. Description of energy subsidies, including for fossil fuels

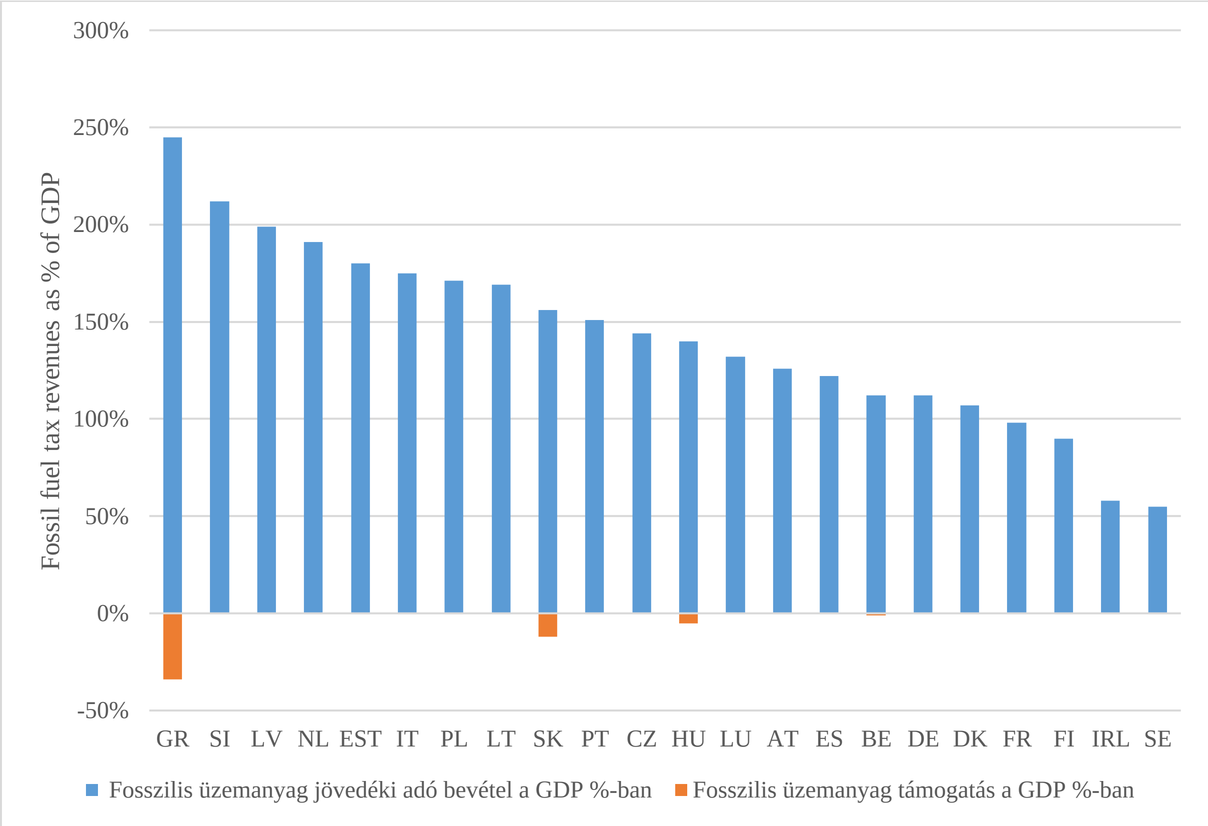
Efficient renewable subsidies available for alternative technologies

As of 1 January 2017, the METÁR scheme174 for the promotion of electricity from renewable sources entered into force. Information on METÁR is provided in Chapter 3.2.1.

EU-funded renewable energy funding programmes as well as the domestically funded NEDFI Fund also indirectly support investments in the sector (details under point (i) of this chapter).

There are no direct subsidies for fossil fuels in Hungary. Indirectly, products and services on the market will be supported. 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. The level of indirect fossil fuel consumption subsidies in Hungary (subsidisation as a percentage of tax revenues) is broadly in line with the OECD average.

[174] 13/2017. (XI. MEKH Decree 8) on the level of operating support for electricity produced from renewable energy sources



80figure -Fossil subsidies 2021

Source: OECD175

175 https://stats.oecd.org/

5. IMPACT ASSESSMENTOF PLANNED POLICIES AND MEASURES

5.1. Impact of planned policies and measures described in Chapter 3 on other Member States and on regional cooperation until at least the last year of the period covered by the plan, including comparison with projections based on existing policies and measures

i. Impacts on the energy system in neighbouring and other Member States in the region to the extent possible

A strategic environmental impact assessment is being finalised in relation to the objectives and measures of the NECP. The preliminary findings of the SEA, which have not yet been the subject of the social consultation, concerning the effects on other Member States, are as follows:

Natural units located in Hungary, such as our river waters, aunts and mountains, tend to extend beyond its administrative boundaries. As a result, resources taken out of the natural environment in 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, resulting in the environmental burden in Hungary and the benefit of fossil fuel substitution in the importing country.

In transport, waterborne freight and passenger transport can suffer transboundary pollution of our watercourses during catastrophic cases.

One of the strategic objectives of the NECP is to connect the **electricity and gas markets** in the region, which has a significant impact on energy trade with neighbouring countries and enhance security of supply. Investments will deepen Hungary’s integration into the European energy system (electricity and gas supply), thus changing domestic consumption can increase or reduce environmental pressures beyond national borders.

The **extraction of raw materials and energy sources** linked to domestic energy production and use (e.g. transport) **and the environmental burden of the production of imported electricity** is extra-boundary but relevant. NECP measures to reduce import dependency (both energy carrier and electricity) also reduce these external effects. The equipment needed to use solar energy is typically imported products, and the mining of raw materials for rare earths also takes place outside national borders.

ii. Impacts on energy prices, utilities and energy market integration

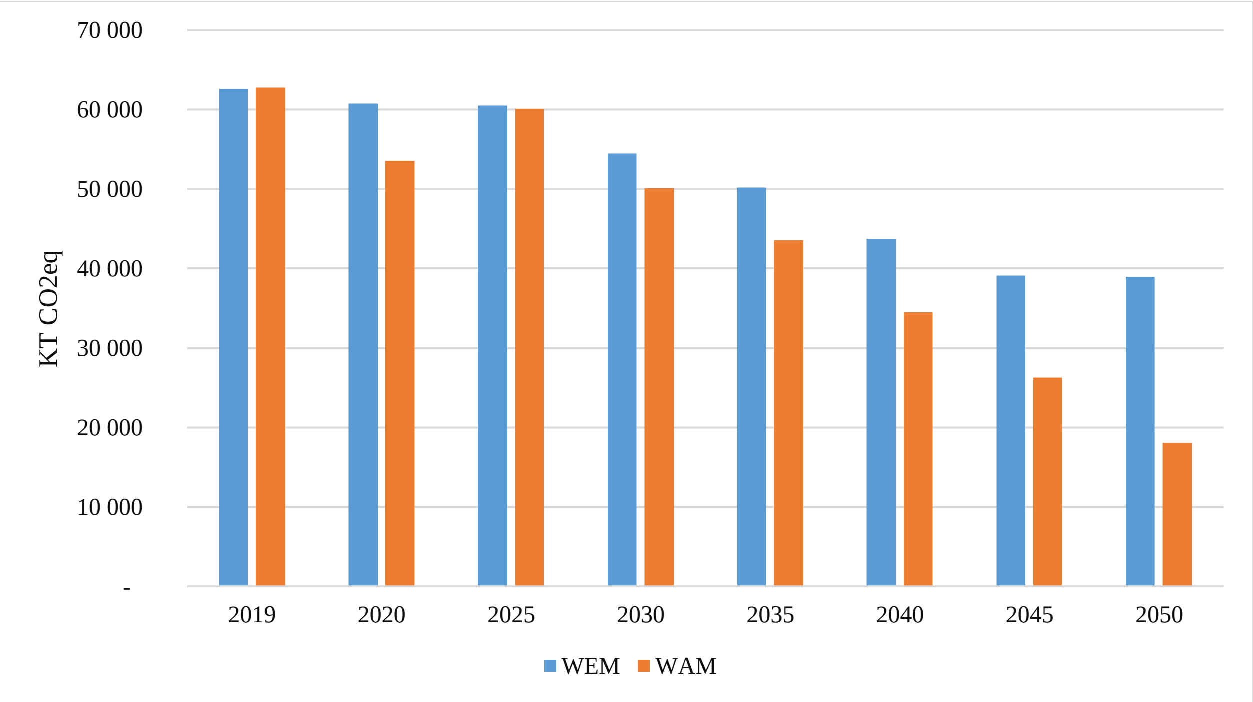
iii. Impact on regional cooperation, where relevant

5.2. Impacts of planned policies and measures described in section 3 on energy system and GHG emissions and removals, including comparison to projections with existing policies and measures (as described in section 4).

i. Projections of the development of the energy system and GHG emissions and removals as well as, where relevant of emissions of air pollutants in accordance with Directive (EU) 2016/2284 under the planned policies and measures at least until ten years after the period covered by the plan (including for the last year of the period covered by the plan), including relevant Union policies and measures.

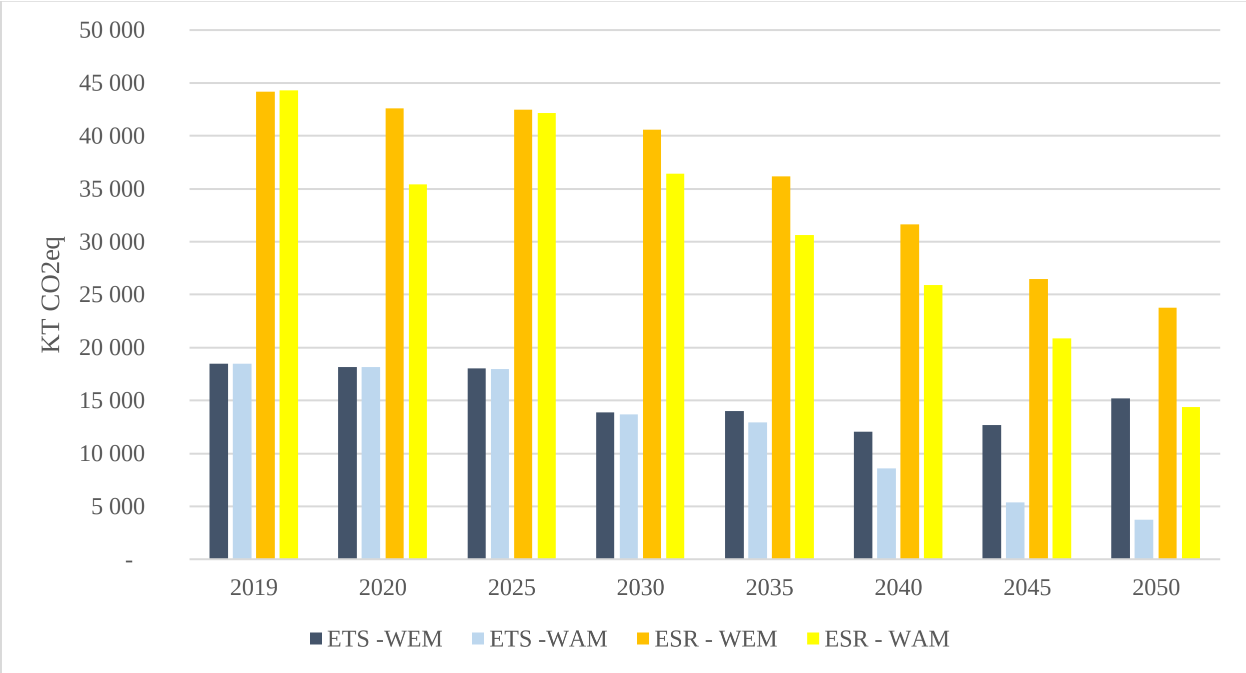
Greenhouse gas emissions

In the WAM scenario, greenhouse gas emissions will fall by 47.2 % by 2030 compared to 1990. This falls short of the target of 50 %, so new measures are identified until the NECP is finalised. The total deficit is 2.6 million kt CO2eq.



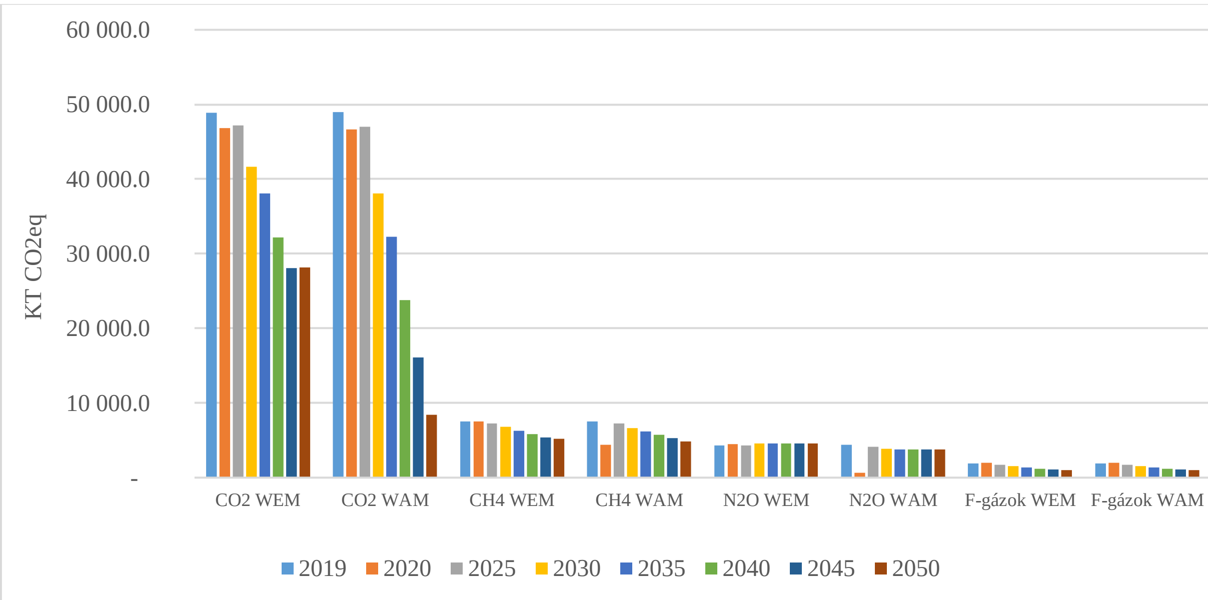
81figure - Evolution of gross greenhouse gas emissions 2019-2050

In the WAM scenario, ETS emissions are expected to decrease by 25.9 % and emissions under the ESR by 17.8 % by 2030. 79.9 % and 67.6 % respectively by 2050.



82figure - EST and ESR emissions 2019-2050

For individual greenhouse gas emissions, all gases except F-gases have lower emissions in the WAM scenario than in the WEM in both 2030 and 2050. Proportionally, the difference in N2O is the most significant in 2030, 15.7 %. Emissions of CO2 are 22.2 % lower in 2030 compared to 2019, while emissions of CH4 are 11.5 % lower and N2O 12.8 % lower.



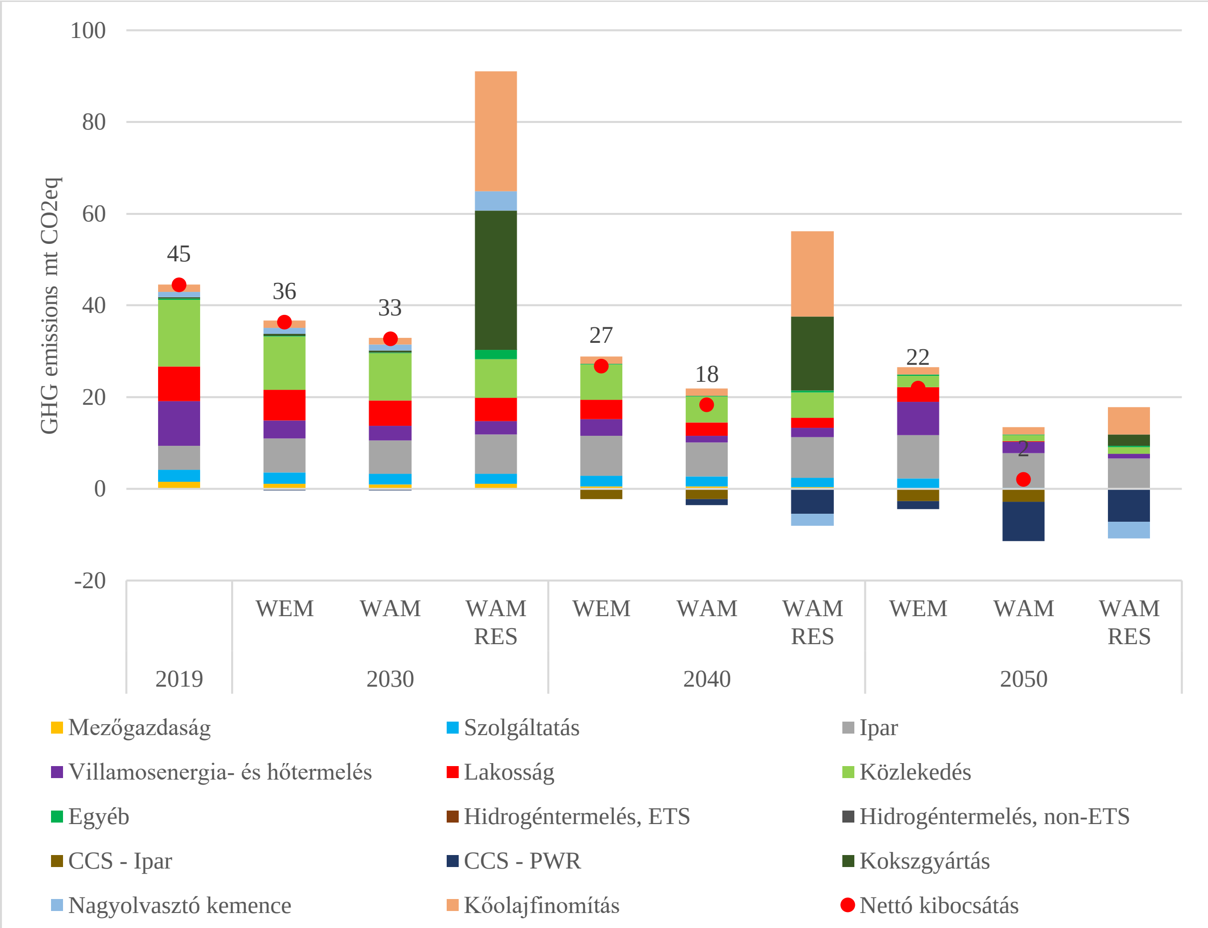
83figure - Breakdown of greenhouse gas emissions by gas 2019-2050

Energy

The greenhouse gas (GHG) emissions scenario (WAM) assumes a cap of 2 million tonnes of CO 2eq applied to the energy sector in the National Clean Development Strategy (NTFS) Early Action scenario by 2050. It also builds on two assumptions for maximum GHG emissions in the 2030 energy sector. Partly, the 50 % emission reduction for the entire Hungarian national economy was taken into account – compared to 1990, which results in 47.2 mt CO 2eq by 2030. The share of this value for the energy sector tested in the HU-TIMES model was taken into account in the NTFS Early Action scenario in 2030 as the share of the energy sector, which represents 73.1 % of total national output. Thus, with a maximum emissions of 2mt CO 2eq in 2050, a value of 34.5 mtCO 2eq was set for 2030, while a linearly decreasing limit was assumed in the interim period. On the other hand, for non-ETS sectors, a limit of 30.8 mt CO 2eq is set for 2030, representing a decrease of 18.7 % compared to 2005.

The following graph shows the evolution of greenhouse gas emissions by sector in the WEM and WAM scenarios.

In a scenario taking into account the effects of additional measures (WAM scenario), net emissions of energy-sourced greenhouse gases will be significantly reduced by 2050, based on pre-defined limits. By 2030, GHG emissions will be reduced by almost 28 % compared to 2019 and an overall reduction of almost 96 % is already expected by 2050.



84figure – Evolution of greenhouse gas emissions by sector, WEM and WAM scenarios, 2019-2050, mt CO_{2eq}

Transport will remain the largest emitter of priority sectors (31.8 %) by 2030, maintaining its high share. Emissions from the transport sector are gradually decreasing to 21.4 mt CO_{2eq} by 2050. The highest GHG emissions are expected to occur in industry in 2050, close to 4.8 mt$_{CO}$ 2eq. While emissions increase by 27 % by 2030 compared to 2019, they will fall below 2019 levels by 2050, thanks to energy efficiency measures and less greenhouse gas intensive technological solutions. This can be achieved in a context of increased demand based on the forecast, provided that the energy demand to meet increasing demand will be covered to a greater extent by electricity and natural gas by the industrial sector. At the same time, significant reductions in GHG emissions are expected for electricity and heat production: Emissions can be reduced by almost 62 % by 2030 thanks to the simultaneous operation of existing and new nuclear power plants and the generation of electricity from renewable sources. However, in 2050, net GHG emissions from this sector are$_{-6}$ mt CO 2eq, which can be achieved through the carbon capture, storage and recovery (CCUS) technology for biomass-based electricity generation. In addition to the technologies currently known and available, decarbonisation targets can only be achieved with the operation of biomass-based CCUS power generators. Until GHG emissions in the residential, service and agricultural sectors reach 5.4

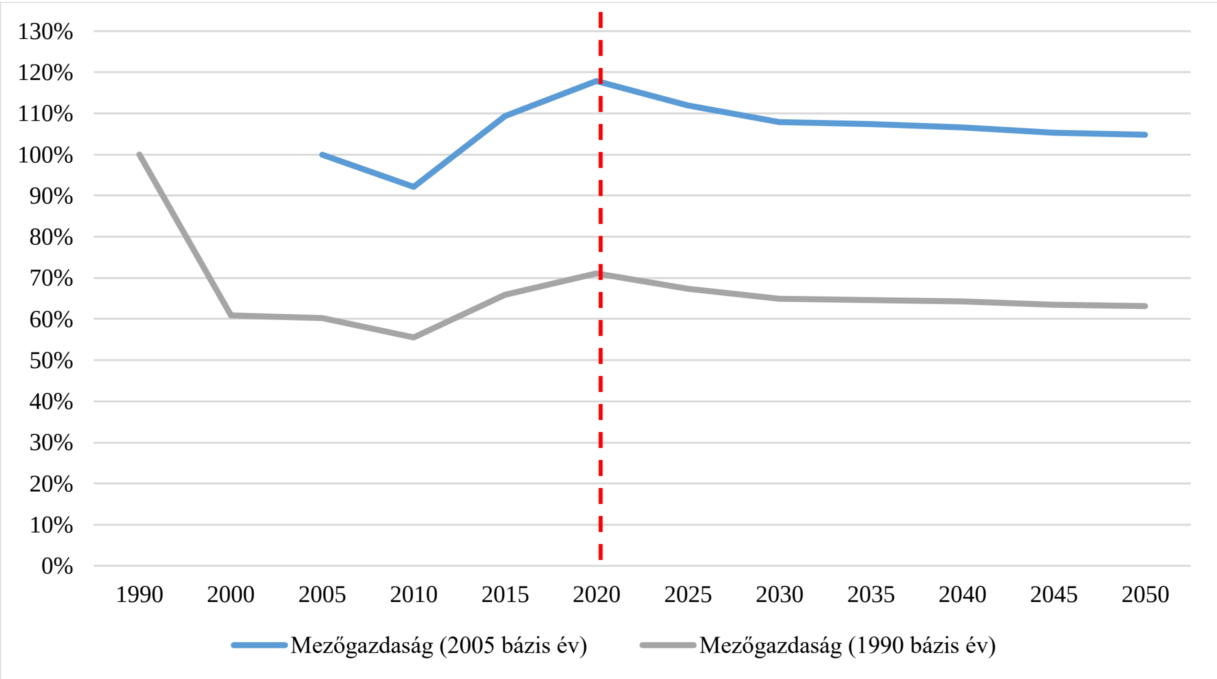
mt CO 2eq, 2.3 mt CO 2eq and 1 mt CO 2eq in 2030, aggregate emissions of these sectors will not exceed 0.2 mt CO 2eq in 2050.

Industrial Processes and Product Use

A WAM scenario will be prepared for this area at a later stage.

Agriculture

In the case of agricultural GHG emissions, the WAM-OLP scenario anticipates the effects of the planned measures to reduce emissions of certain air pollutants set out in the NEC Directive, which we are planning to implement in the framework of the National Air Load Reduction Programme (OLP), currently under review. According to the WAM-OLP projection, 6 379 kt of CO 2 equivalent in 2050 is expected. Emissions increase slightly between 2005 and 2030 (+ 7.8 per cent), still representing a decrease of 35.0 per cent and 36.8 % between 1990-2030 and 1990-2050. As in the WEM scenario, the significant emission reductions occur in the categories of digestion of farmed animals and manure management due to the loss of livestock.



85figure – Change in agricultural GHG emissions compared to 1990 and 2005 levels in the WAM-OLP scenario between 2000 and 2050

Source: done at the Climate and Environment Research Department of the AKI

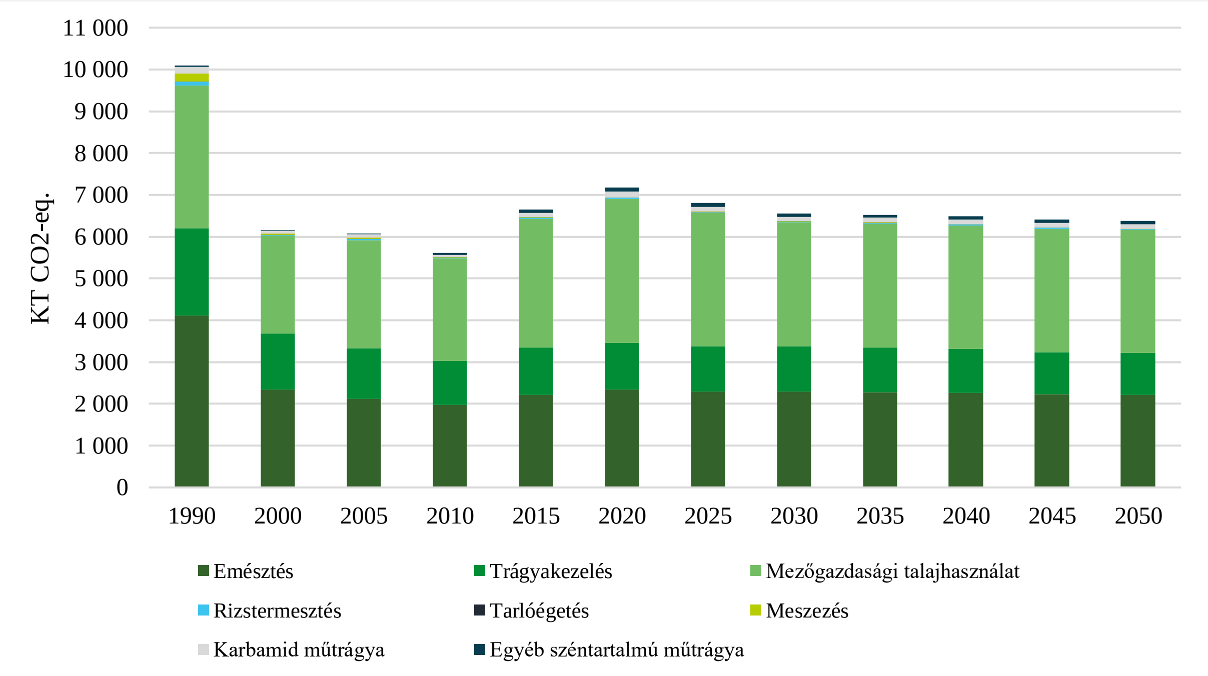
Emissions **from** land use account for almost 50 per cent (2 949 kt CO 2 equivalent) of total GHG emissions in the agricultural sector in 2050. Under the WAM-OLP scenario, tillage emissions in 2050 – more than 450 kt CO_2 equivalent – are lower than the 1990 emission value due to a decrease in livestock and livestock manure use. This emission is 13.0 per cent lower in

2030 than in 1990, but represents an increase of 14.4 per cent in relation to the period 2005-2030.

Emissions from digestion represent a significant share (35 per cent) of GHG emissions from **the** entire agricultural sector in 2050, which is expected to be 2 218 kt$_{CO2}$equivalent. The emissions of the category are significantly reduced (-46.0 per cent) over the period 1990-2050. Emissions in this category are 44.0 per cent lower than 1990 levels in 2030, but a slight increase (+ 9.0 per cent) can be observed between 2005 and 2030.

GHG **emissions from manure management** in 2050 are only 997 kt of CO_2equivalent, more than 50 per cent less than in 1990. A decrease of 11.7 % is expected over the period 2005-2030. The significant decrease is due to changes in the dairy cow and pig population.

GHG emissions from the use of **urea** -based fertilisers will decrease by 36.2 per cent by 2050 to 109 kt CO_2equivalent compared to 1990, while emissions increase by 24.9 per cent between 2005 and 2030.



86figure – GHG emissions from the agricultural sector in the WAM-OLP scenario between 1990 and 2050

Source: done at the Climate and Environment Research Department of the AKI

Total **emissions of** CH_4**in** agriculture in the WAM-OLP scenario are 2 897 kt CO_2equivalent in 2050, which is 47.7 per cent lower than in 1990. $CH_{4\ emissions}$increase slightly between 2005 and 2030 (+ 3.8 per cent) and remain almost unchanged in the period 2005 to 2050 (-0.7 per cent). Emissions **from** digestion represent more than 76 per cent$_{of}$the sector's total CH4 emissions, 2 218 kt CO_2eq. in 2050. Despite decreasing by 46.0 per cent$_{between}$1990 and 2050, emissions from animal digestion are expected to slightly increase between 2005 and

2030 and 2005-2050 (+ 9.0 per cent and + 5.1 per cent). There is also a significant proportion of CH4 emissions **from manure treatment**. Despite increasing emission levels from poultry farming, the pig population declines by 50.9 % over the period 1990-2050, representing a negative change of 10.6 % and 16.7 % between 2005 and 2030 and 2005-2050.

Under the WAM-OLP scenario, all sectoral **N_2O** emissions are expected to decrease by 21.1 per cent between 1990 and 2050 to 3 290 kt of CO 2 equivalent, and to increase by 8.9 per cent between 2005 and 2050. Emissions by 2030 are 20.0 per cent less than in 1990 and 10.4 per cent more than in 2005. In addition to the decline in livestock, the decrease can be explained by a reduction in emissions from manure storage. Soil **use** accounts for nearly 90 per cent of N_2O emissions, which is expected to be 2949 CO 2 equivalent in 2050.

CO_2 emissions are expected to decrease by almost 50 per cent to 193 kt between 1990 and 2050 under the WAM-OLP scenario. Thanks to an increase **in the use of urea and other carbon fertilisers**, emissions increase by 35.4 % between 2005 and 2030. Emissions from the use of urea fertilisers are 36.2 per cent lower in 2030 than in 1990.

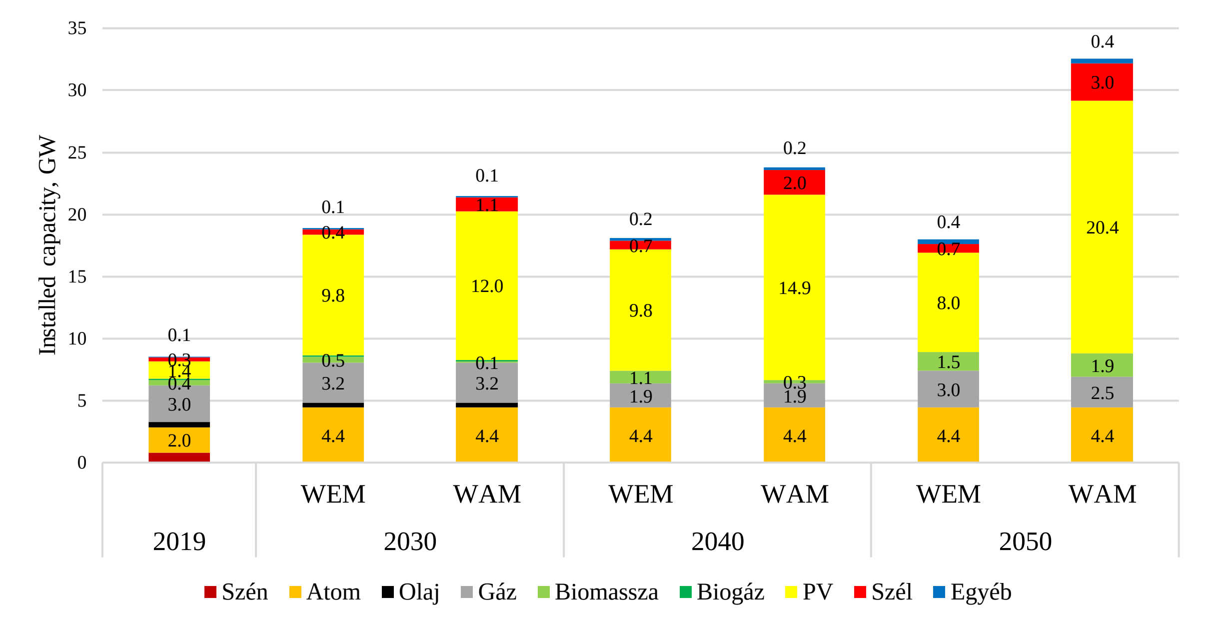
Waste

A WAM scenario will be prepared for this sector at a later stage.

Electricity generation and use

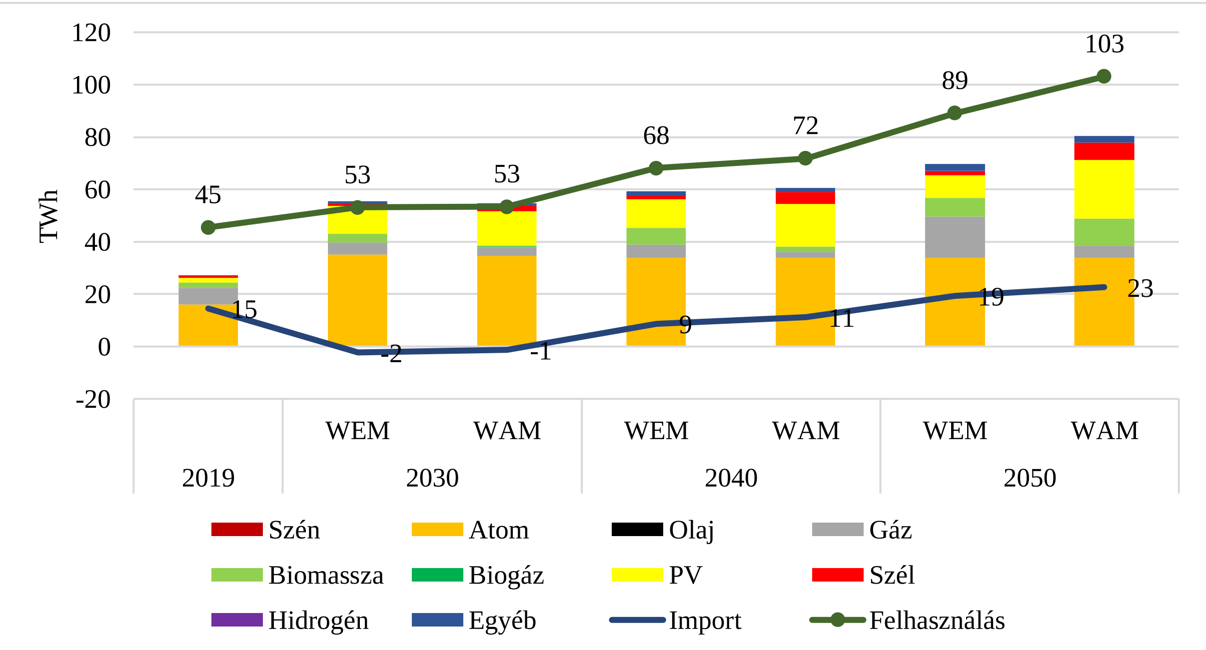
As a result of additional measures, solar energy is expected to grow the most in the electricity sector. Solar capacities will account for around half (12 MW) of the total installed capacity in 2030. A further fifth (4.4 MW-to) of capacity will come from nuclear (as a result of the construction of the new units and the extension of Paks I) and 15 % by gas (3.2 MW). The capacity of solar power plants (20.4 MW) and their share in total capacity (63 %) will continue to increase by 2050, while the share of nuclear capacity (4.4 MW remains) reduced to 14 %. At the same time, the share of biomass capacities equipped with CCS is estimated at 6 %, gas capacity is 7 % and wind capacity 9 %.

Nuclear capacity generates about two thirds of the electricity produced in 2030. Solar panel capacities contribute an additional quarter to domestic electricity generation. Electricity demand will rise to 55-60 TWh over this time horizon, while production will be at 54.7 TWh. By 2050, the share of electricity generated on a nuclear basis will decrease to 42 %. At the same time, the share of electricity produced by PV is expected to be 28 %. The share of biomass and gas-based electricity in total production is 8 % and 6 % respectively. In the meantime, total consumption is rising to 103 TWh due to an intensification of electrotrification. Nearly four-fifths of this can be ensured by domestic power plant production.



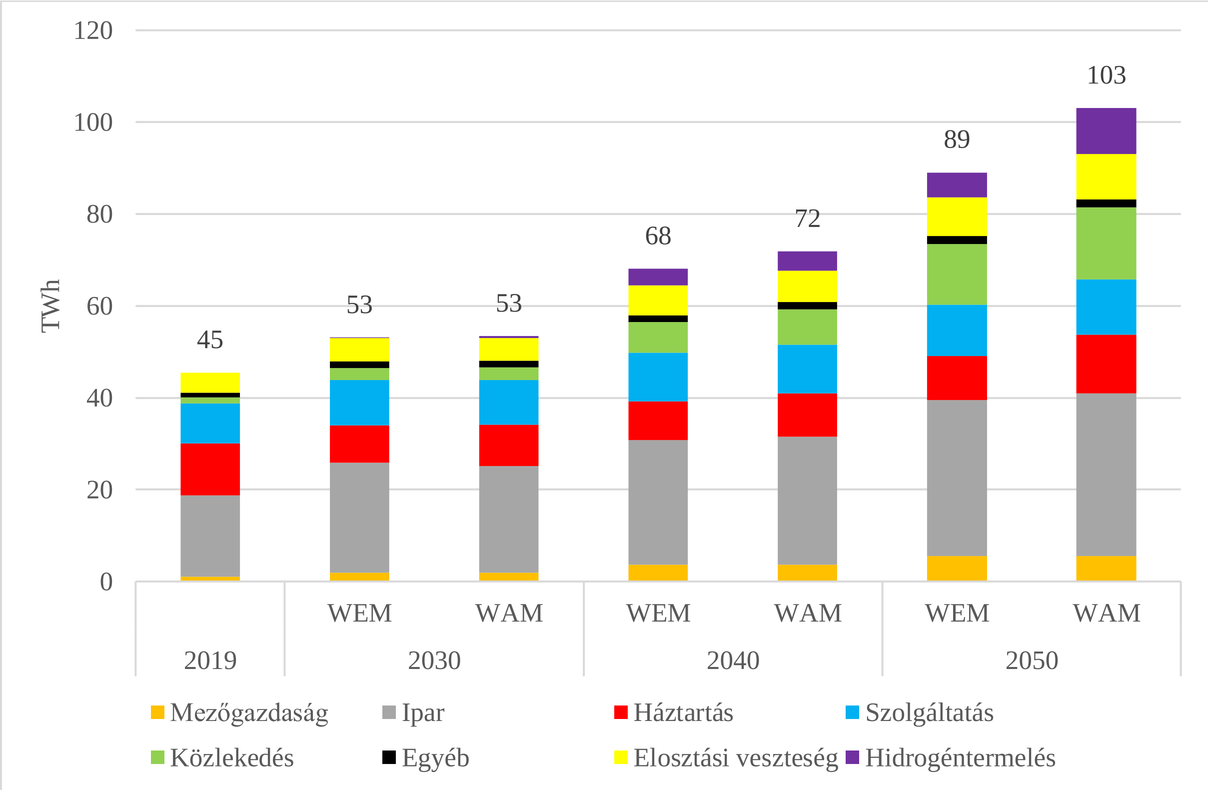
87figure – Evolution of installed electricity generation capacity in the WEM scenario taking into account the current measures and in the WAM scenario included in the additional measures, GW

Source of factual data: Eurostat



88figure – Evolution of electricity generation, utilisation and imports in the WEM scenario taking into account the current measures and the WAM scenario included in the additional measures, GW

Source of factual data: Eurostat

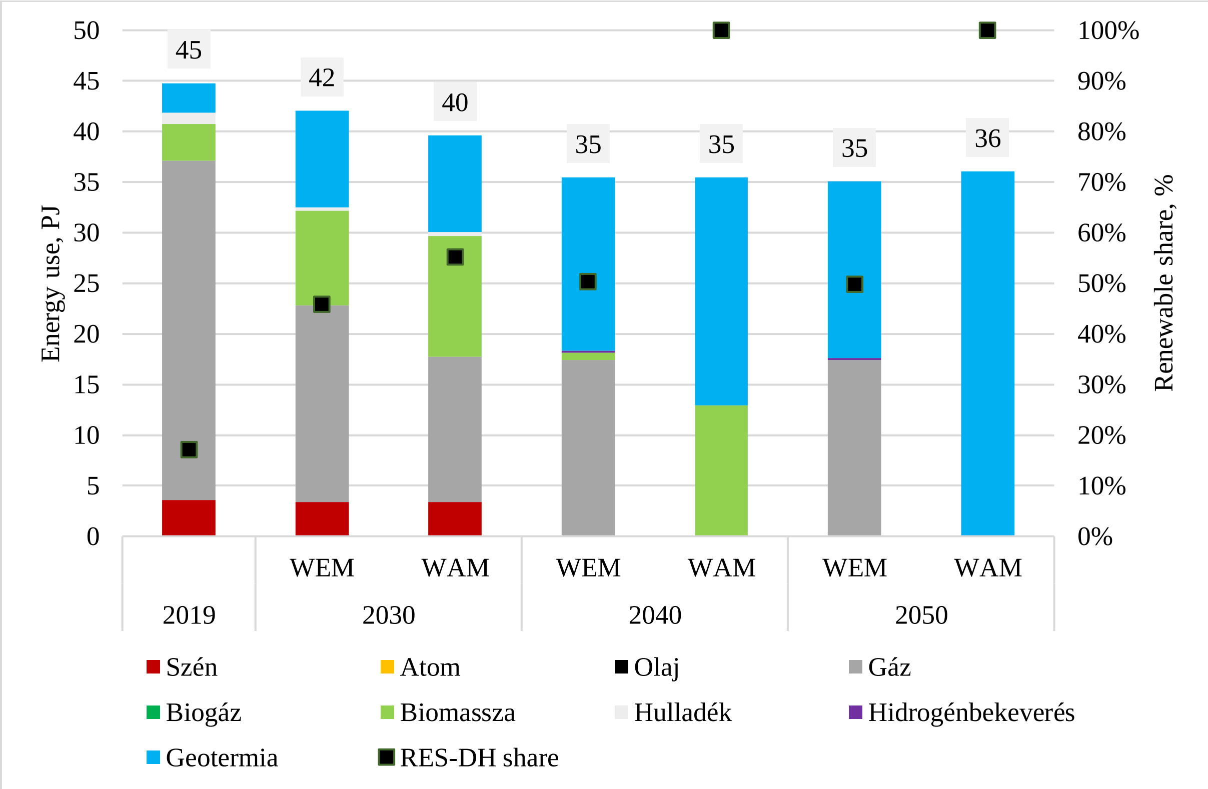


89figure – Evolution of electricity recovery by sector in the WEM scenario taking into account the current measures and the WAM scenario in which additional measures are taken into account, GW

Source of factual data: Eurostat

District heating production

While district heating production is decreasing by 2030 (energy efficiency measures will reduce demand), the heating sector will become more efficient and greener, as the share of fossil fuels will fall below 50 %. By 2050, district heating production will become highly renewable.



90figure – Evolution of district heating production in the WEM scenario taking into account the current measures and the WAM scenario included in the additional measures, GW

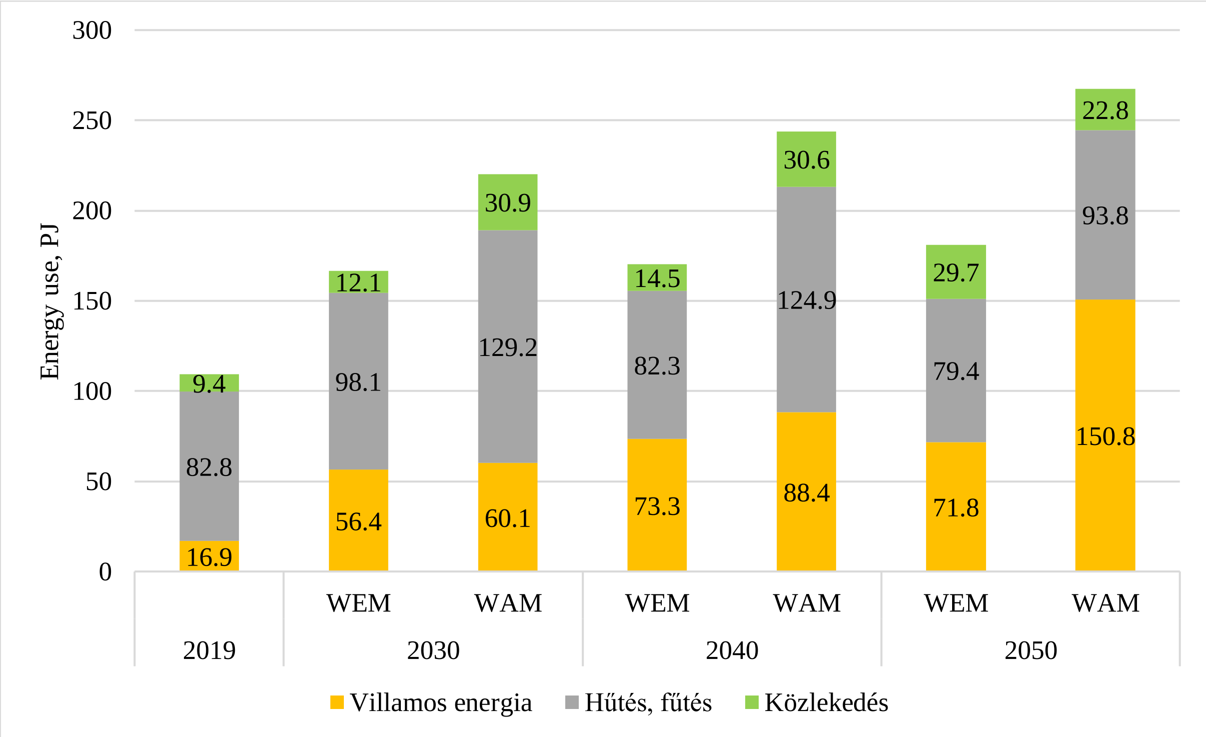
Source of factual data: Eurostat

Renewable energy

For the future, in the WAM scenario, which also takes into account additional (additional) measures, sectoral and aggregated targets for the renewable energy use ratio have been set for 2030. The share of renewable energy in final energy consumption shall be 27 %, district heating shall be at least 37.8 % and natural gas shall not exceed 50 % of total district heating production. A renewable energy use rate of 27.2 % in the heat production sector and a minimum of 29 % for transport should be achieved.

In the WAM scenario, the renewable energy use rate is 29 % by 2030 and above 51 % by 2050. Apart from the 2030s, the development of renewable energy is linear. Overall renewable energy use growth is above 100 % between 2019 and 2030 and will grow almost two and a half times by 2050.

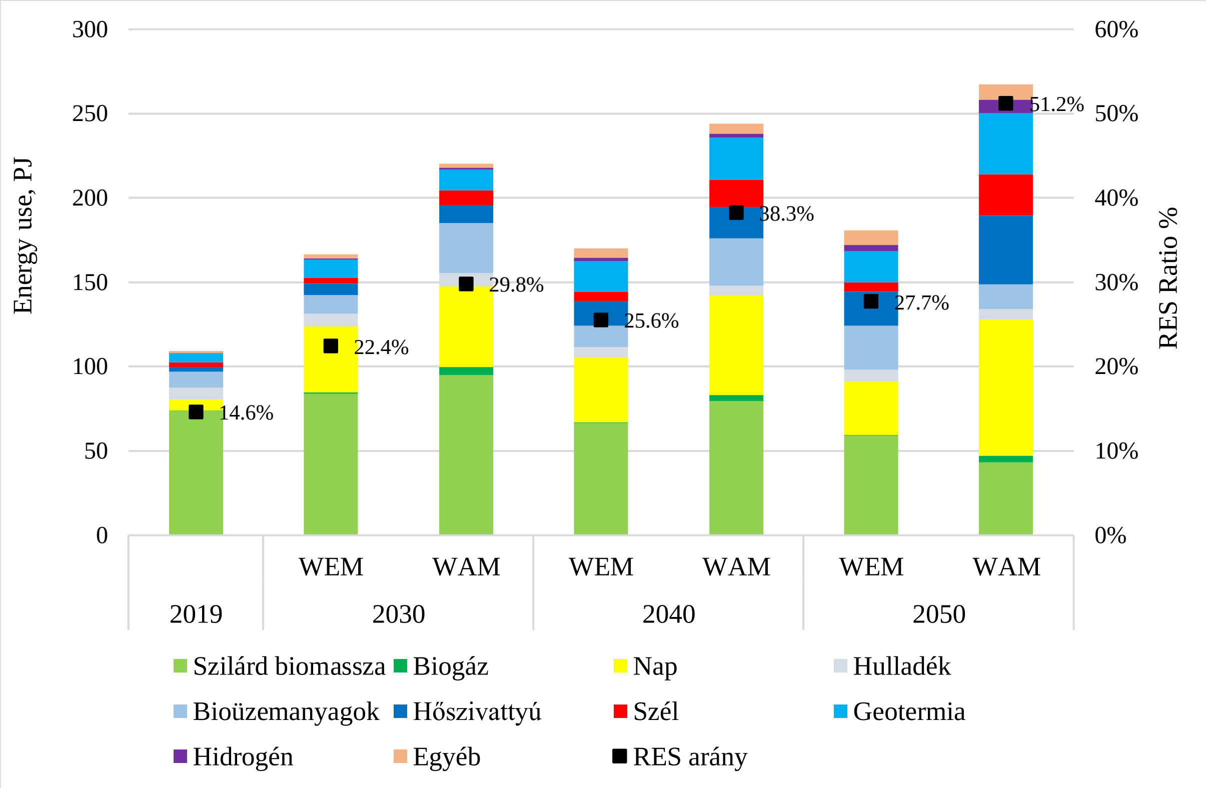
The electricity sector is the main driver of the expansion of renewable energy use. While in 2019 the sector's renewable-based energy production amounted to 16.9 PJ, it will increase almost fourfold to 60.1 PJ in 2030. In 2050, with 151 PJ renewable energy, the electricity sector accounts for more than half of renewable energy use. At the same time, heating and cooling will continue to account for more than 59 % of renewable energy consumption in 2030. In the transport sector, there is a significant increase in the use of first- and second-generation biofuels and in the use of renewable electricity on the road, but the latter does not appear in the transport sector but in the electricity sector when looking at the overall target.



91figure – Renewable energy use in each sector (PJ), WEM and WAM scenarios, 2019-2050

Source of factual data: Eurostat

As four-fifths of the total renewable energy use in 2019 originated from biomass, Hungary has set the target of diversifying the composition of renewable energy use. By 2030, solar energy, biofuels and the uptake of heat pumps will reduce biomass dominance. In addition to increasing solar energy consumption, the use of both geothermal energy and other renewable energy sources is increasing under the WAM scenario. Nevertheless, biomass use still accounts for more than 43 % of total renewable energy use in 2030. Renewable energy produced in 2050 comes mainly from solar (30 %), solid biomass and heat pump use (16 % and 15 % respectively), wind energy and biofuels (5 % respectively).



92figure – Renewable energy use by source, WEM and WAM scenarios, 2019-2050, PJ

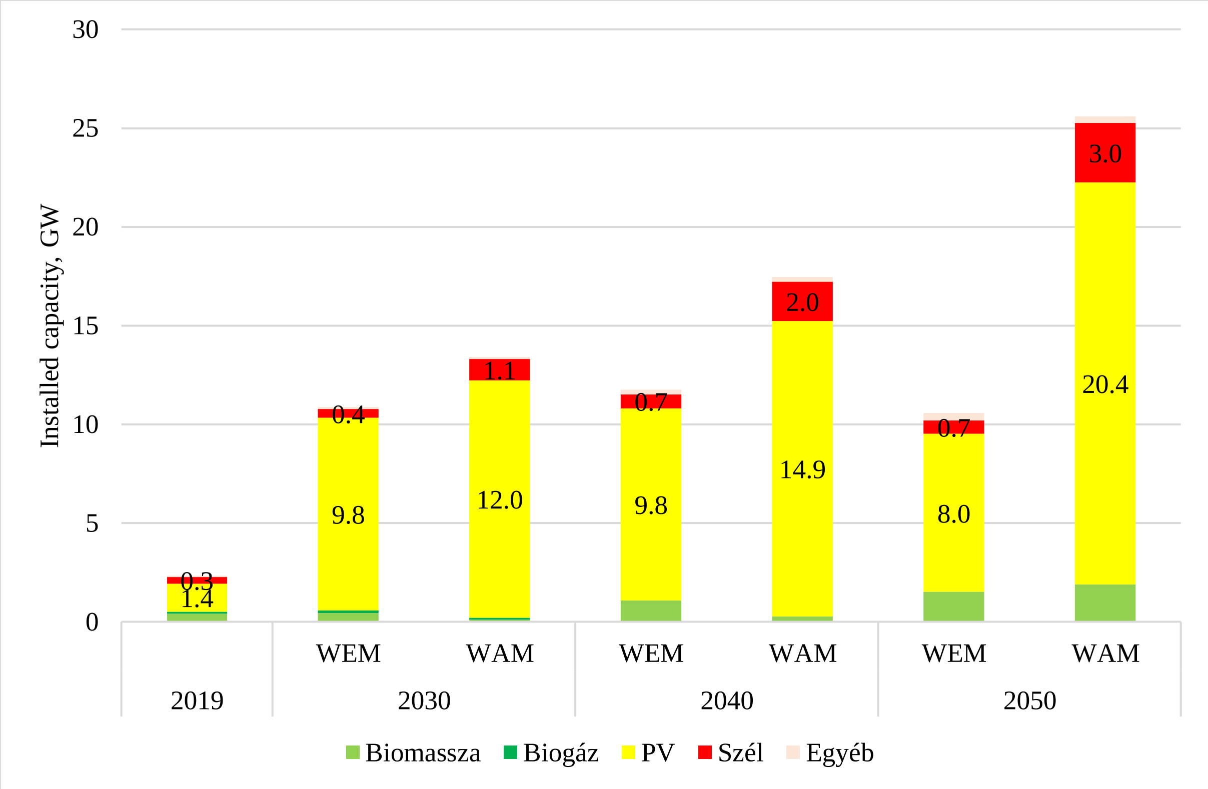
Source of factual data: Eurostat

<u>Renewable energy use in the electricity sector</u>

Solar energy is expected to grow the most from renewable energy sources in the electricity sector thanks to additional measures. Looking at the expected evolution of total installed photovoltaic (PV) capacity, the value above 1 GW in 2019 will increase to 6.9 GW in 2025 and 12 GW by 2030, while it will also exceed 20 GW by 2050. The additional measures could therefore increase the installed photovoltaic (PV) capacity in the system by around 2 200 MW in 2030 and by more than 12 000 MW in 2050 compared to the WEM scenario, which only takes into account existing measures.

Geothermal capacity is expected to grow gradually, but their role is also marginal in 2050 (1 % of total domestic capacity). Biomass capacity is on a declining trend until 2030, due to the phasing out of existing capacities. The modelling results show that by 2050 around 6 per cent of domestic capacity could be biomass-based electricity capacity using CCUS technology.

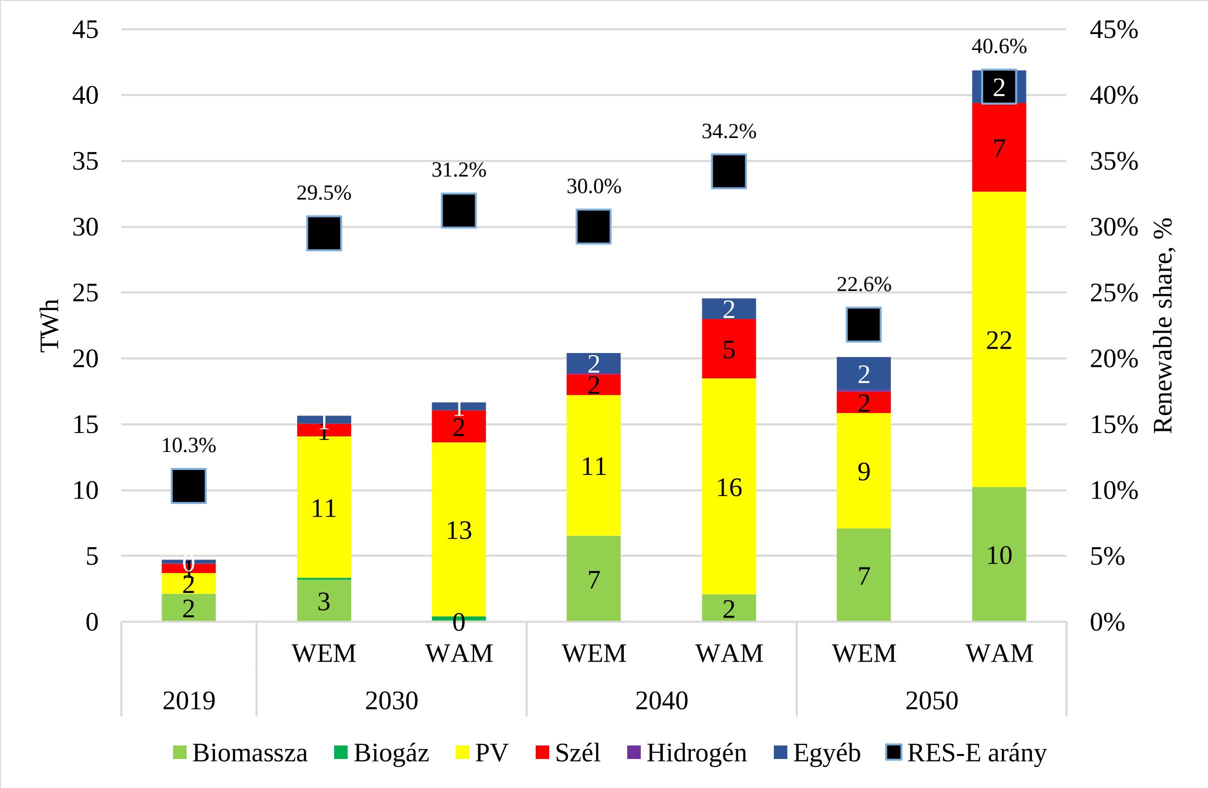
In the WEM scenario with existing measures, we envisage a doubling of the current wind power capacity level (about 330 MW) by upgrading existing capacities, and a slightly increased wind capacity under the additional measures scenario is estimated.



93figure – Evolution of installed renewable capacity in the WEM scenario taking into account the current measures and the WAM scenario included in the additional measures, GW

In 2019, electricity production from renewable energy sources was close to 5 TWh. In the WAM scenario, including additional measures, this could increase to over 16 TWh by 2030 and close to 42 TWh in 2050. In 2030, domestic power plants are thus able to produce about 6.5 % (1.0 TWh) renewable electricity in the WAM scenario and twice (22 TWh) in 2050 than in the WEM scenario.

The planned additional measures will increase the share of renewable energy in total electricity consumption from 10.3 % in 2019 to 31.2 % in the WAM scenario between 2019 and 2030 and already above 40 % in 2050. This represents a surplus of 1.8 percentage points in 2030 and 18 percentage points in 2050 for the WEM scenario.



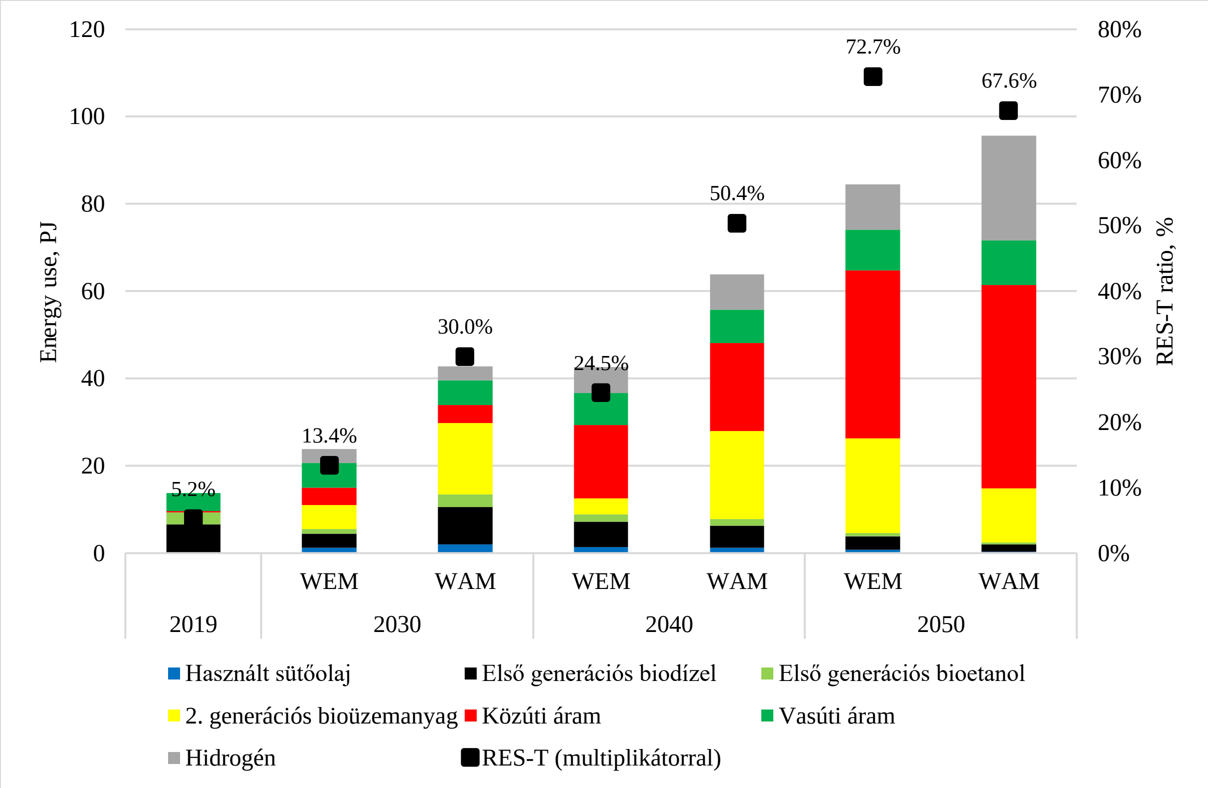
94figure – Renewable electricity generation and share of renewable electricity in consumption (RES-E, %), WEM and WAM scenarios, TWh and %

Taking into account the additional measures, the amount of electricity produced by solar energy will increase. In 2030, 79 % of the electricity produced from renewable sources is already generated by photovoltaic (PV) power plants, with this share falling to 54 % in 2050 due to biomass and wind generation (in 2019, the share of solar energy was only 33 %). The share of biomass will decrease from 45 % to 1 % between 2019 and 2030 and increase to 25 % in 2050.

Renewable energy use in the transport sector

Biofuels currently account for the vast majority of renewable energy use in the transport sector, and to a lesser extent electricity consumption by rail. Although the number of electric vehicles has recently increased, their role in 'clean' transport is still small.

In the WAM scenario, the gross final consumption of energy from renewable sources in transport increases significantly.



95figure – Renewable energy use in the transport sector and renewable share in transport (RES-T, %) excluding multipliers, WEM and WAM scenarios, PJ and %

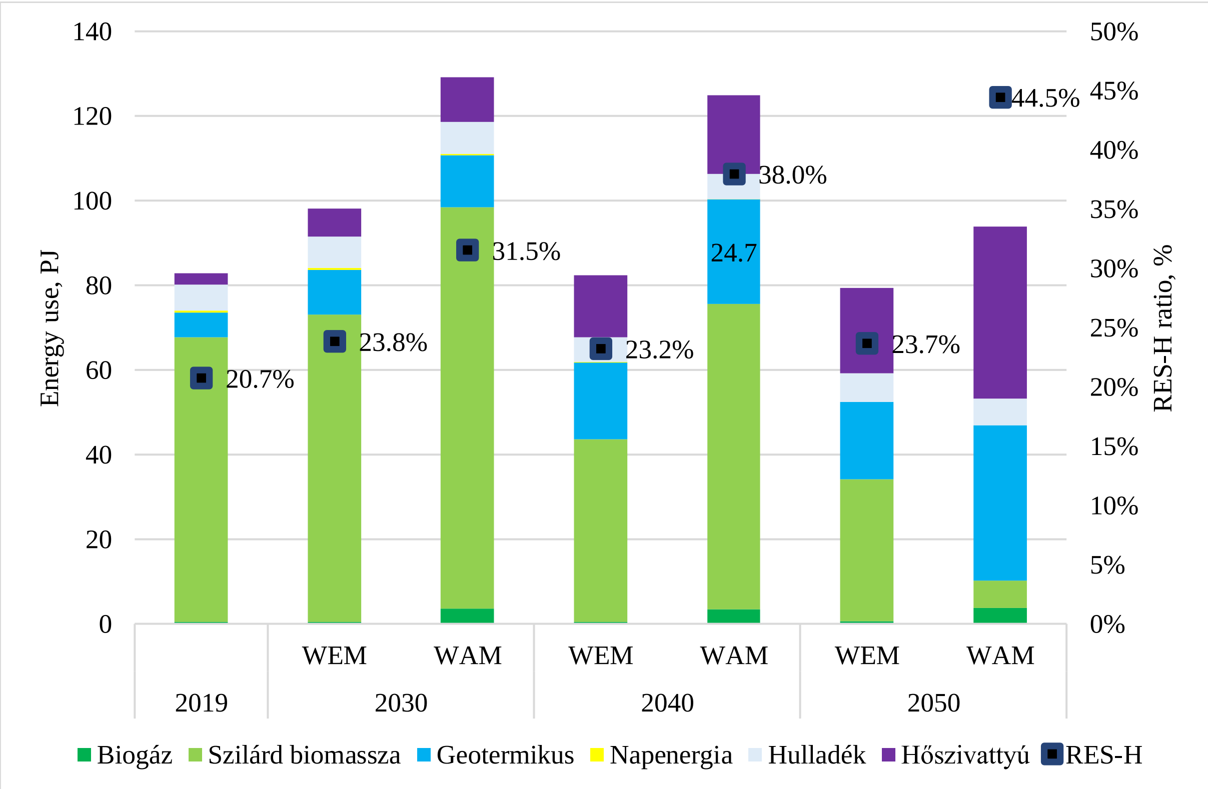
In 2019, there was a renewable share of 5.2 % in transport, including multipliers, increasing to 30.0 % by 2030 due to additional measures, exceeding the minimum of 29 % taken into account in modelling. Furthermore, the WAM scenario is almost 17 percentage points higher than that indicated in the WEM scenario. In the context of the higher growth compared to the WEM scenario, the significant uptake of first- and second-generation biofuels – where second-generation biofuels are given a double weight due to the methodology. The increasing use of renewable electricity on the road is due to the increase in the number of electric vehicles in absolute terms and to a significant increase in the share of renewable electricity in the coming decades. This factor is also behind the increase in the use of renewable energy by rail. The eligible renewable energy use of this sub-segment is nearly 1.5 times higher. Advanced biofuels will account for 38 % and first generation biofuels (including used cooking oil consumption) 26.7 % of the sector's renewable energy use in 2030, but will not exceed the 7 % limit in gross final energy consumption. The role of hydrogen is growing, accounting for a quarter of total consumption in the WAM scenario by 2050.

<u>Renewable energy use in the heating and cooling sector</u>

The share of biomass in renewable energy use in the cooling and heating sector is currently very high. Diversification will mainly be possible from the 2030s onwards, both in the WEM and WAM scenarios.

Biomass-based thermal energy production will increase by 41 % between 2019 and 2030, but there will be a decline after 2030, driven by investments in energy efficiency, mainly in the residential sector, and the use of limited solid biomass resources in biomass-based CCUS production. The use of geothermal energy will double by 2030. There is a significant increase in the use of heat pumps in the cooling and heating sector, with an 8 % share of renewable energy use already in 2030, reaching 44 % by 2050. There is also a significant increase in the use of biogas, but it does not exceed 4 PJ even in 2050, representing only 4 % of total renewable energy use in the heat sector.

As a result, the share of renewable energy use in the cooling and heating sector will increase from the current 20.7 % to 24 % in WEM scenarios and 32 % in the WAM scenarios by 2030. Assuming no further action, this ratio will remain unchanged until 2050. However, in the WAM scenario, due to unchanged production intensity but decreasing final energy consumption, it will increase significantly to 45 % by 2050.



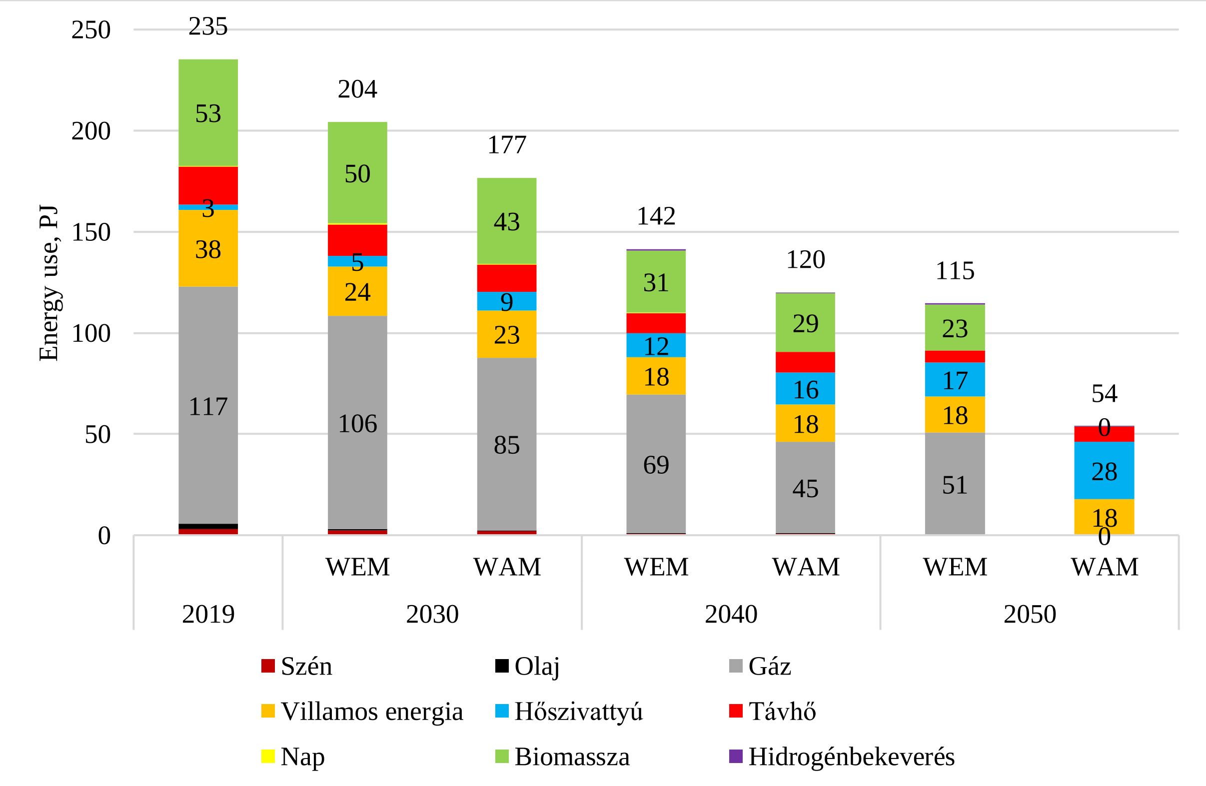
96figure – Renewable energy consumption in the cooling and heating sector (PJ) and renewable share (RES – H, %), WEM and WAM scenarios, PJ and % respectively

Energy efficiency dimension

Final energy consumption

The combined implementation of the new policy measures described in Chapter 3 will achieve significantly higher energy savings in the residential sector than is induced by the current policy framework. The final energy consumption in the WAM scenario in 2030 is 14 % 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 will be reduced by 25 % in 2030.



97figure – Comparison of household final energy consumption and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

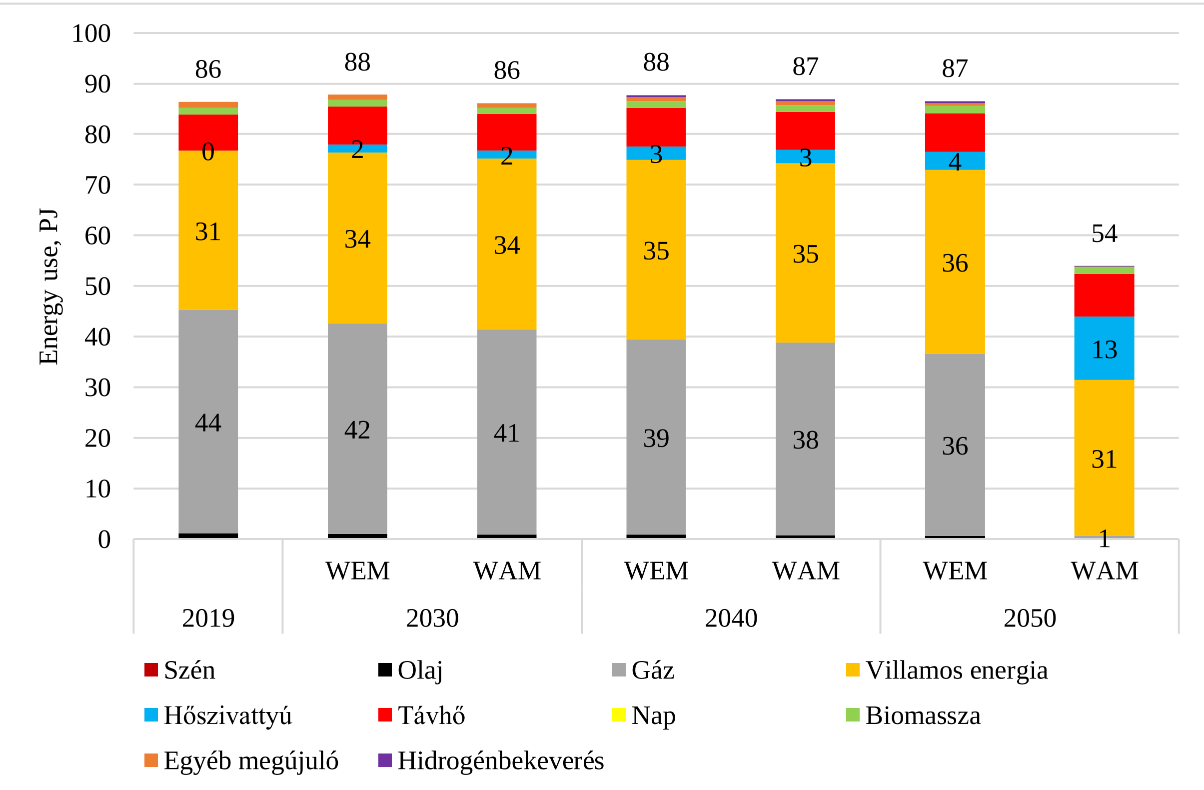
Source of factual data: Eurostat

In general, the introduction of the ETS2 scheme and the increase in the level of minimum taxation for fossil fuels already under the WEM scenario will trigger a high level of energy investment measures. In addition, the gradual uptake of new efficient technologies, in particular heat pumps, will lead to lower energy use.

In terms of proportion, the reduction in final household energy consumption will be the most significant for natural gas consumption, with planned measures leading to a decrease of around 27 % in household gas consumption between 2019 and 2030, and to be fully phased out by 2050.

Between 2019 and 2030 there will be a significant change in consumption patterns. Thanks to investments in energy efficiency, the use of electricity and biomass is also significantly reduced, the amount of energy used by heat pumps will double (WEM) or triple (WAM) by 2030, compared to 2019.

In both the WEM and WAM scenarios, a slight increase in final energy consumption in the tertiary/service sector can be projected up to 2030. In a context of increasing demand, this implies a strong incentive for energy efficiency investment. By 2030, natural gas consumption will be reduced to a lesser extent, while electricity consumption is increasing. Taking into account the projection of the two scenarios, a substantial difference can only be expected by 2050. In the additional measures scenario, energy use will be reduced by 38 % compared to 2019 through much stronger investments in energy efficiency compared to the WEM scenario. This result shows that achieving net GHG emissions of up to 2 mtCO 2eq$_{\text{for}}$ the energy sector requires almost full decarbonisation of the tertiary sector, which can be achieved mainly through energy efficiency interventions and technological change.



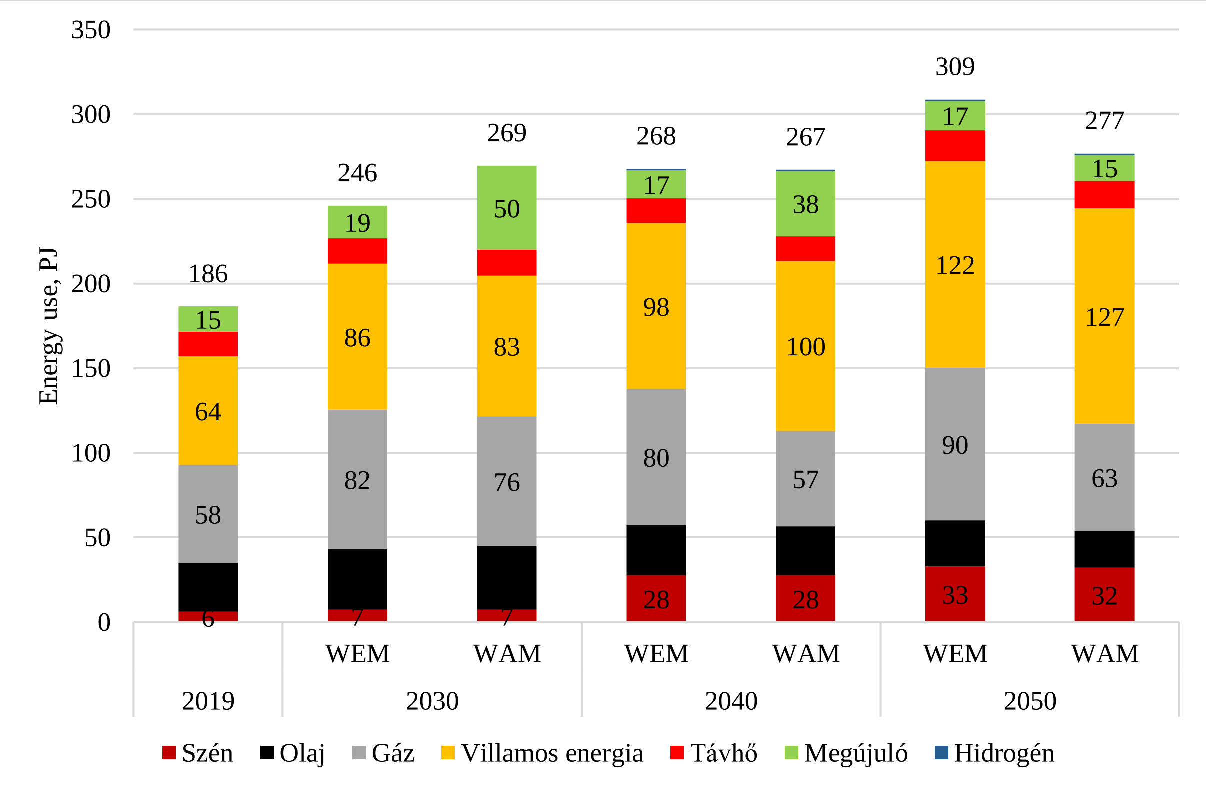
98figure 1 – Comparison of final energy consumption in the tertiary sector and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

For the services sector, it is also important to highlight the role of heat pumps in the longer term, which will increase from 0.1 % in 2019 to 2 % in 2030 and 23 % in 2050. In addition, electricity consumption is gradually increasing, with the exception of the WAM scenario by 2050, where high energy efficiency investments reduce electricity consumption.

For the industrial sector, final energy consumption in both WEM and WAM scenarios projects a significant increase in energy use, by 32 % and 45 % by 2030 compared to 2019 levels, and by 65 % and 48 % by 2050.

In the new policy measures scenario, the increase in energy use compared to the WEM is the result of a shift to technologies with a higher energy intensity, with lower emissions, i.e. cleaner energy.

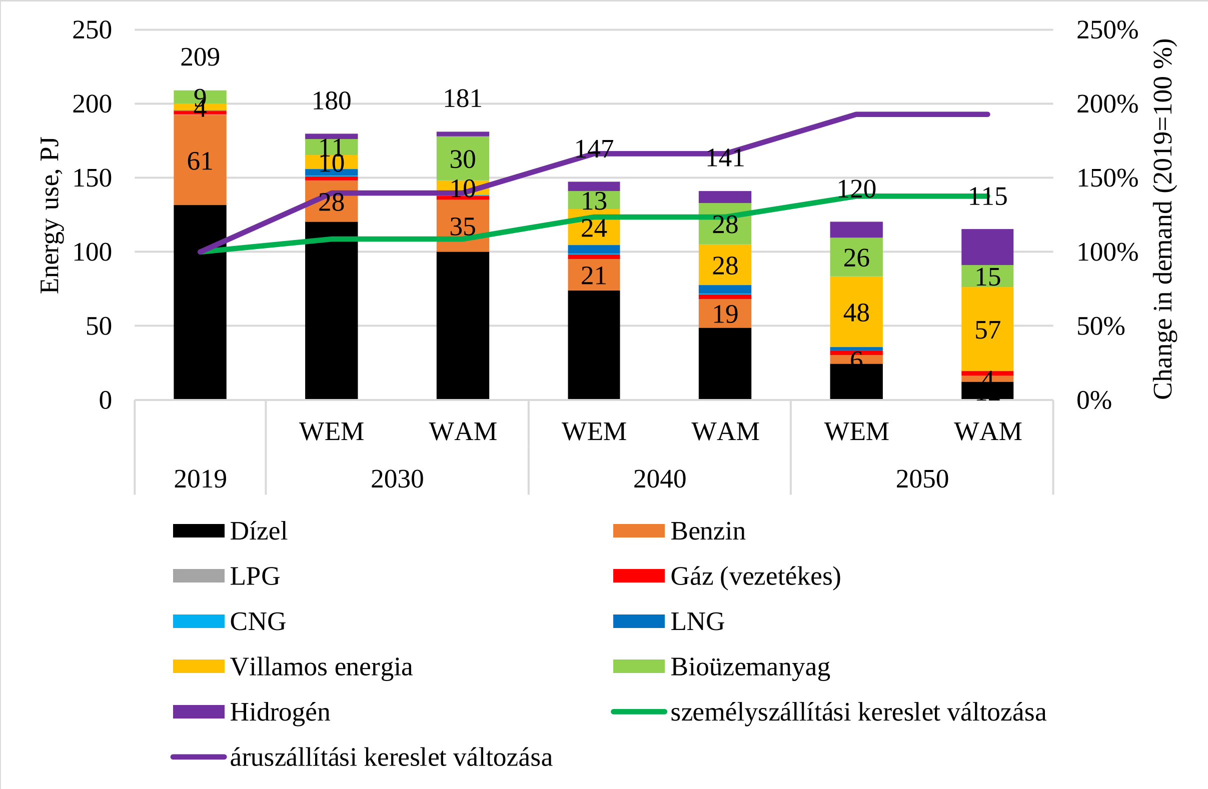


99figure – Comparison and change in the composition of final energy consumption in the industry sector in the WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

Looking at the increase in industrial energy consumption by composition, it can be concluded that between 2019 and 2030 the largest increase in renewable energy use (3,5-fold) and a relatively high increase in coal, electricity and oil use (by 30 % in all three cases) is expected. Comparing the results of the two scenarios over the longer term, we see that the role of natural gas is significantly reduced thanks to new policy measures.

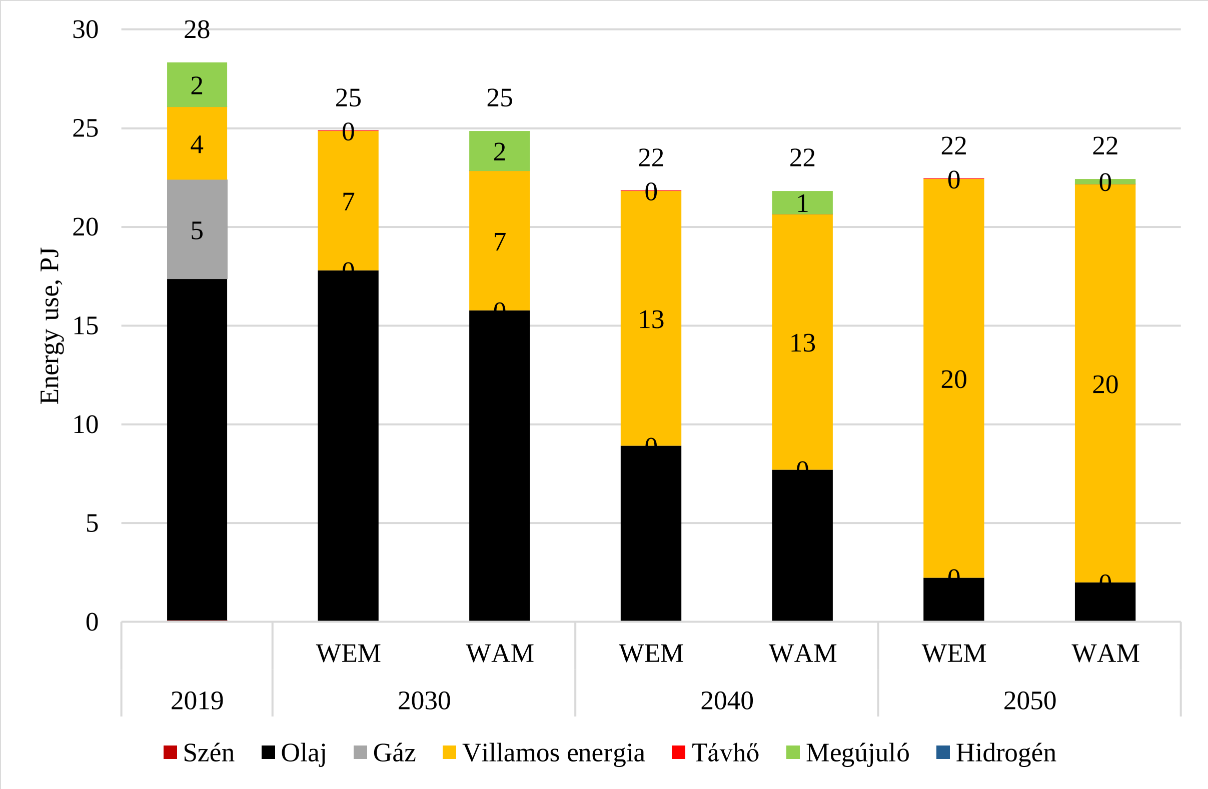
For the transport sector, the introduction of the ETS2 and the additional excise duty on fossil fuels will lead to a significant drop in energy consumption, despite a significant increase in demand. By 2030 compared to 2019, energy consumption in the WEM and WAM scenarios will decrease by 15 %, decreasing to 43 % and 45 % by 2050. In addition to a minor shift to public transport for passenger transport and rail transport for freight transport, the replacement of the existing old vehicle fleet with new and more efficient technology is desirable in order to achieve a high level of decarbonisation of the sector. New policy measures will replace petrol and diesel vehicles by 2030. This goes hand in hand with greater incorporation of biofuels and the uptake of electric technologies. By 2050, the combined share of diesel and petrol will decrease to 14 % in the WAM scenario, while the share of electricity, biofuels and hydrogen uses is 49 %, 13 % and 21 %.



100figure 1 – Comparison of transport final energy consumption and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

For the agriculture, forestry and fisheries sectors, there is no substantive difference between the WEM and WAM scenarios forecast. Both scenarios project a decrease of 12 % between 2019 and 2030, which will decrease to 21 % by 2050. Achieving short- and long-term decarbonisation targets also requires investments in energy efficiency and electro-electrification to gradually replace fossil fuels.



101figure – Comparison of final energy consumption in the agriculture, forestry and fisheries sectors and changes in composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

<u>Final energy consumption</u>

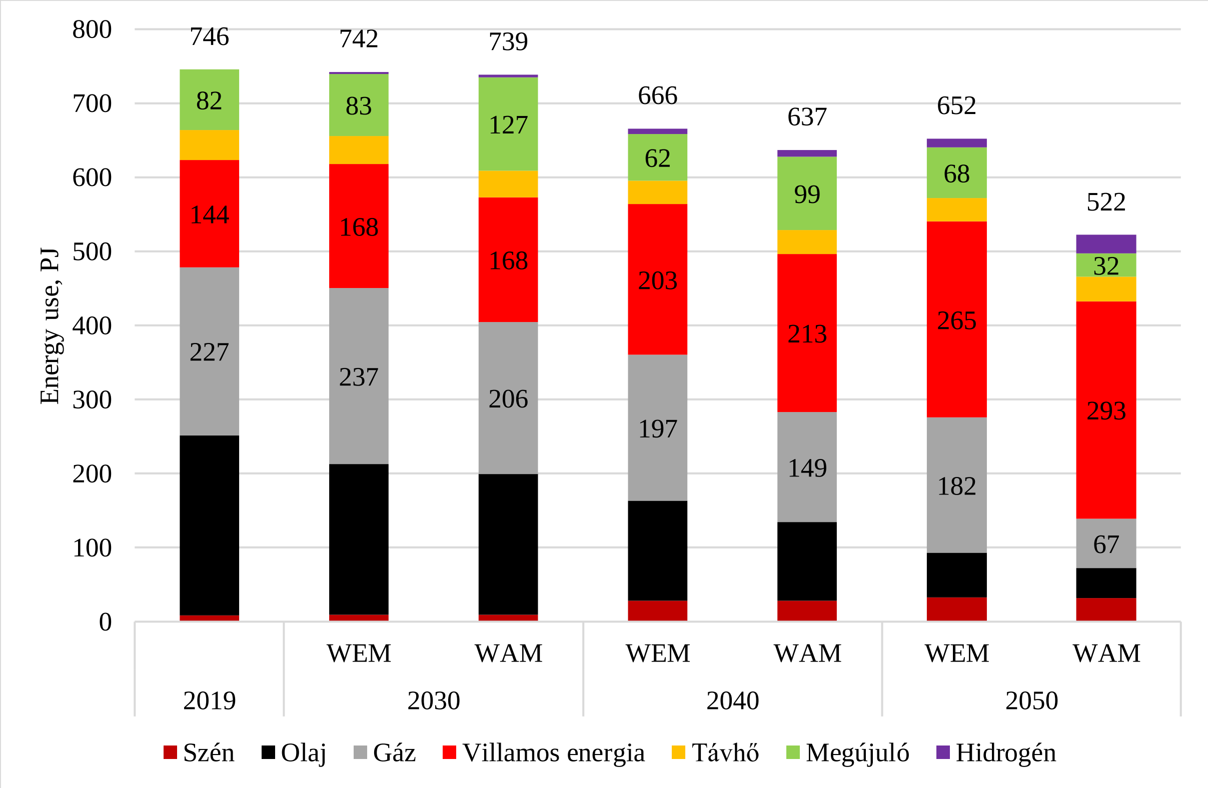
The total final energy consumption in the WAM scenario in 2030 is slightly lower, 4 PJ lower than projected in the WEM scenario, due to the decreasing GHG emission limit and targets for individual renewable energy shares.

In the longer term, in addition to additional measures, total final energy consumption will decrease by 30 % between 2019 and 2050, compared to 13 % in the WEM bulletin over the same period. There is also a significant difference in the composition of final energy consumption between the two scenarios, given that in the WAM scenario the consumption of oil and natural gas will decrease more by 2050 and electricity consumption will increase by 104 % compared to 2019, while in the WEM scenario there is an increase in electricity use of 83 % and a slight decrease in the use of fossil fuels.

Overall, the following cumulative conditions are needed to achieve the 2030 and 2050 maximum GHG emission targets:

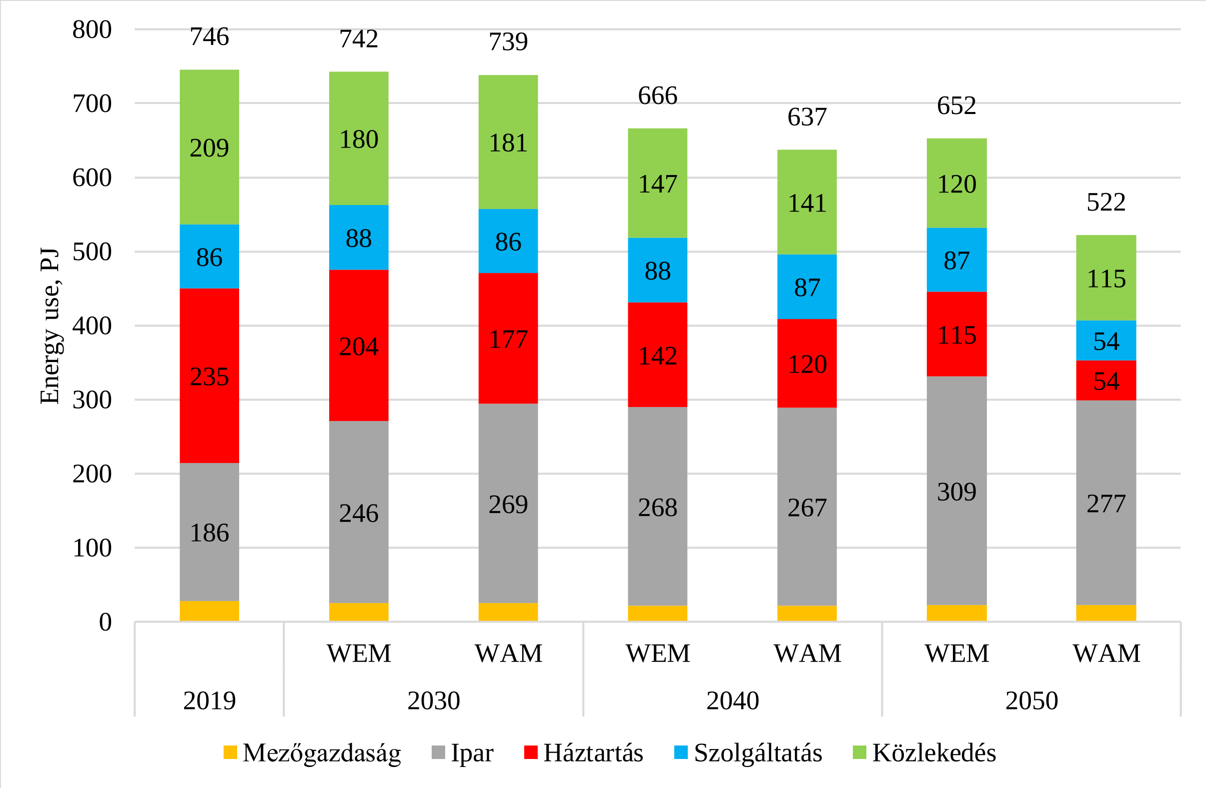
- Encouraging investment in energy efficiency in all final energy use sectors.
- Electrotrification in all sectors of final energy use and decarbonisation of electricity and heat production.
- Operation of ‘net GHG sink’ electricity generation based on biomass, including CCUS technology.

- Reduced uptake of hydrogen.



102figure – Fuel comparison of final energy consumption and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

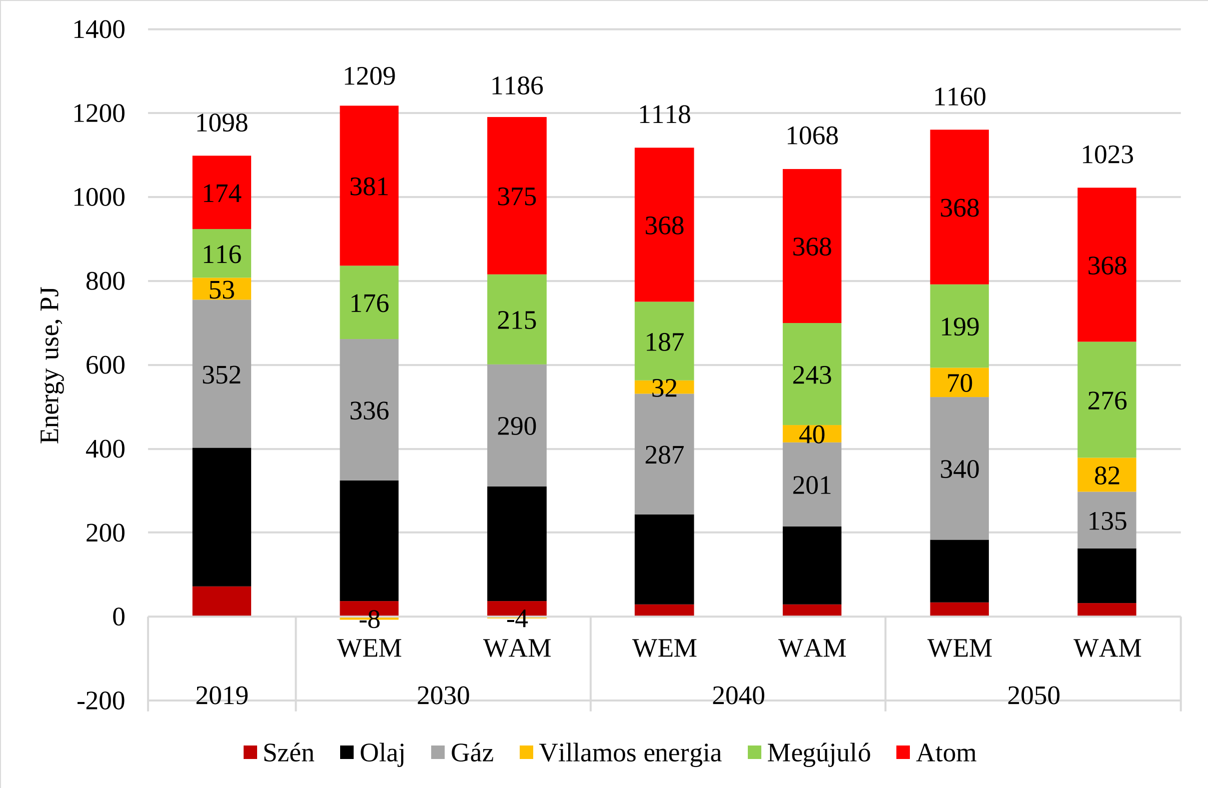


103figure – Sectoral comparison of final energy consumption and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

Primary energy consumption

There is a significant surge in primary energy use in 2030, both in the WEM and WAM scenarios. This is mainly the result of the entry of new units of Paks, which increase the generation of nuclear energy and the resulting transformational losses. In the longer term, this increase is partly counterbalanced by energy efficiency in final energy consumption, with WAM scenarios decreasing by 7 % in primary energy consumption by 2050 compared to 2019, while WEM shows a slight increase of 6 %.



104figure. Fuel comparison of primary energy consumption and change of composition for WEM and WAM scenarios – impact of new policy measures, PJ

Source of factual data: Eurostat

ii. *Assessment of policy interactions (between existing policies and measures and planned policies and measures within a policy dimension and between existing policies and measures and planned policies and measures of different dimensions) at least until the last year of the period covered by the plan, in particular to establish a robust understanding of the impact of energy efficiency/energy savings policies on the sizing of the energy system and to reduce the risk of stranded investment in energy supply*

iii. *Assessment of interactions between existing policies and measures and planned policies and measures, and between those policies and measures and Union climate and energy policy measures*

5.3. Macroeconomic and, to the extent feasible, the 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 and cost-effectiveness), at least until the last year of the period covered by the plan, including comparison with projections based on existing policies and measures

The modelling of macroeconomic impacts has been prepared for the draft NECP in the context of energy modelling. Until the NECP is finalised, the impact analysis will be extended to the entire plan. Results for the most important of all variables of the model used are presented:

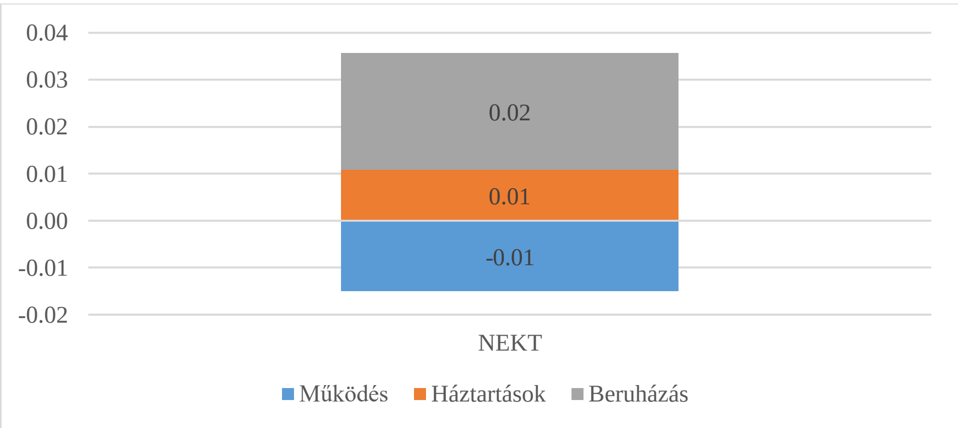
- The percentage effect on GDP, which is the impact on GDP of the appearance of changes in demand;
- The change in the number of persons employed, mainly representing the need for labour to produce additional production needed for changes in demand;
- The evolution of government tax revenues, where direct tax revenues in the model are derived from the taxation of capital and labour income, and indirect tax receipts are taxes on the consumption of products.

43table - Macroeconomic effects of the NECP

	GDP (%)	Employment (persons)	Tax receipts (HUF)
NECP	0,02	3426	172,3

Source: Own VAT computation

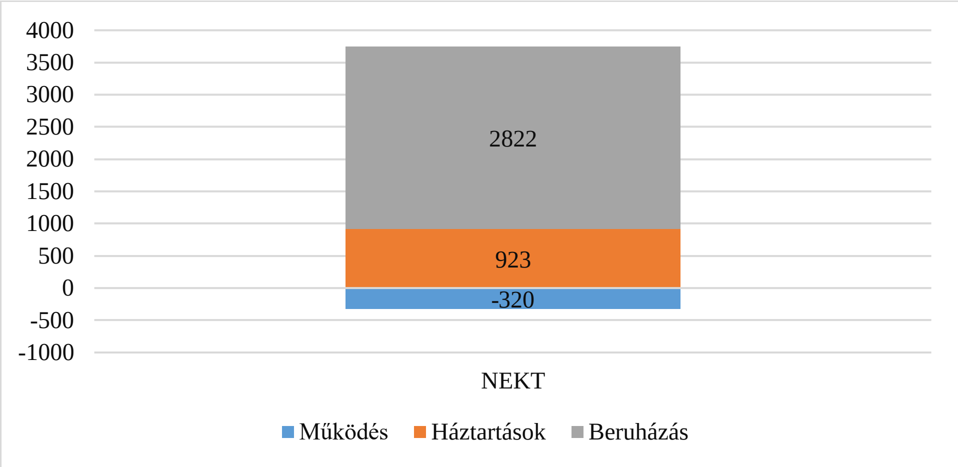
As the effects mainly affect demand in the sector, they do not have long-term supply effects, so GDP impacts are relatively low. Overall, operating costs at macro-economic level are decreasing, with no significant cost increases expected in any sector, contrary to previous modelling. The decline in operating demand has a negative impact on GDP, but is offset by an increase in investment demand, with an overall positive impact of 0.02 % on the GDP path.



105figure 1 – The annual average GDP impact of the NECP (%)

Source: Own VAT computation

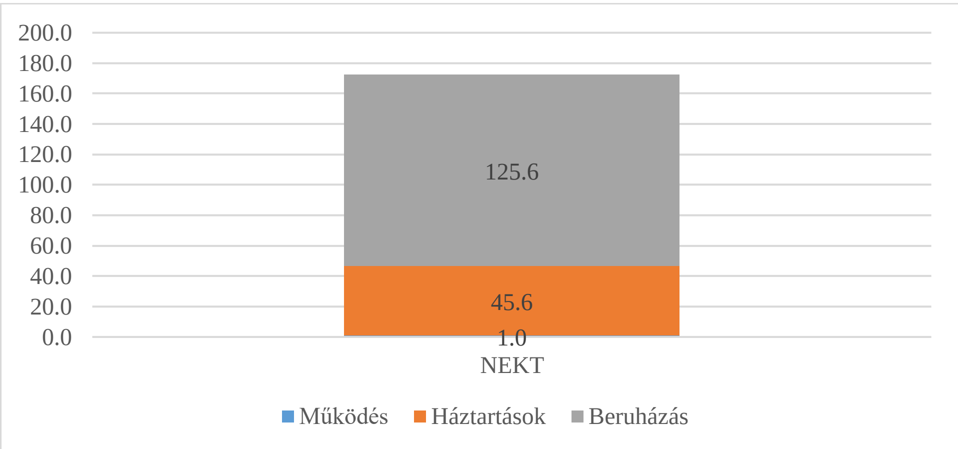
In addition to positive GDP effects, the total employment impact is positive, with an average of 3426 people higher than without the programme. The main result is an increase in staffing needs in the labour-intensive construction sector.



106figure 1 – Annual average employment impact of NECP (persons)

It **would also have a significant impact on government revenues, i.e. the amount of indirect and direct tax revenues.** As a result, revenues would increase by more than HUF 172.3 billion on average in 2022 prices, or **0.82 % of the revenues of the 2022 central budget, according to the State Treasury data.**

Part of the increased tax revenue stems from the fact that employment growth directly provides government revenue through labour taxes, and on the other hand, a higher flow of goods (surplus production) also leads to an increase in tax revenues through indirect taxes.



107figure 1 – Average impact of the NECP on government revenue (HUF billion, 2022 values)

5.4. **Overview of investment needs**

i. Existing investment flows and forward investment assumptions with regards to the planned policies and measures

The TIMES model used for the preparation of the NECP takes into account not only investment costs but also changes in operating costs in the energy sector. The model calculates the additional cost of implementing the measures to ensure the achievement of the objectives of the Energy Strategy as outlined in this document, i.e. the difference between the cost of WAM (with additional measures) and the reference WEM (with existing measures) scenarios.

The model includes the energy transformation sectors, energy use in the household and tertiary sectors, the transport sector and the industrial and agricultural sectors. According to its operating logic, it seeks the most cost-effective way to meet specific end-user demand (e.g. million passenger-kilometres, cement produced, lighting needs, etc.) – which can be seen 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 limit for the model and uses them to find the cost-optimal. The discounted value of the estimated cost over the whole period, the so-called total system cost in the WAM scenario, is higher due to the need to use more expensive technologies, e.g. to achieve higher emission reduction targets.

Modelling results

In the period under review between 2019 and 2050, the additional overall additional costs of the WAM scenario are HUF 2266 billion discounted for the initial year 2019, with an additional cost of HUF 155 billion when annualised and spread over years[176].

Costs can be divided into three broad categories: investment costs, operating costs and quota costs, and their sum determines the total additional cost. The evolution of these additional costs in the first half of the period under review (until 2035[177]) and the second half (2036-2050) is presented below.

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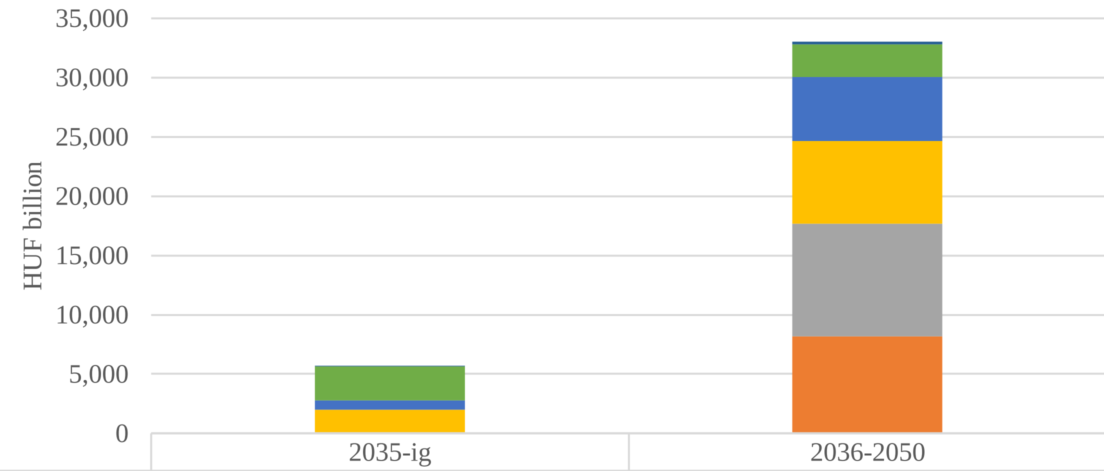
[176] In the additional cost calculation, we have also calculated the difference between residual values. Thus, if an investment takes place in 2040 and has a life content of 20 years, a residual value is accounted for in proportion to part of the total investment cost, which reduces the investment cost.

[177] Breaking down the investment costs into more than two periods, we can draw very misleading and erroneous conclusions. There may be cases where in the WEM scenario the investment costs in a given sector exceed the WAM scenario over a given year/period, while it occurs only as a result of a slightly different investment cycle. To eliminate this, we took two parts of the time period examined.



	2035-ig	2036-2050
Egyéb	4	187
Közlekedés	2,903	2,795
Háztartás	748	5,374
Áram és távő	1,939	6,978
Ipar	34	9,514
Szolgáltatás	44	8,162
Mezőgazdaság	0	0
Összesen	5,670	33,009

For the time being, additional costs are not reflected in the agricultural sector.

108figure. Additional investment cost of the WAM scenario by sector[178], present value, HUF billion

The investment costs for the first period up to 2035 amount to HUF 5670 billion, which represents an extra investment requirement of HUF 500 billion per year in the WAM scenario compared to the WEM. The vast majority of this is made up of three main sectors: transport (approximately HUF 3000 billion), electricity and district heating (nearly 2000 billion) and households (HUF 750 billion). It is important to underline that these show the difference between the two scenarios and not the total investment cost.

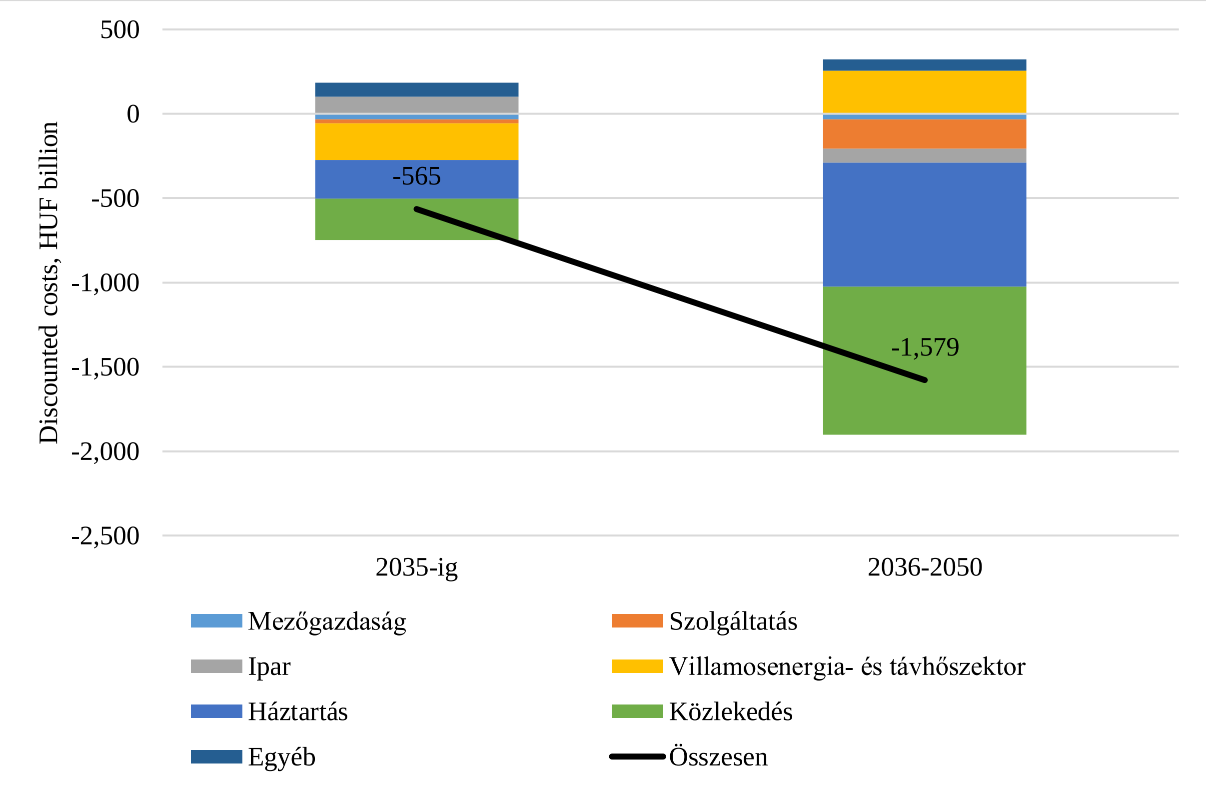
After 2035, investment costs increase significantly and additional investment needs of HUF 33000 billion will be generated between 2036-2050, of which almost 30 % in industry, 25 % in the services sector and 21 % in the electricity and district heating sectors.

The results show that, although new investments are capital intensive, and the optimal operation of existing technologies, variable operating and maintenance costs can be significantly reduced.

In both periods, the operating and maintenance costs in the WAM scenario are below the values obtained in the WEM scenario. It is important to stress that the electricity cost used in each sector is not accounted for in that sector, but in the electricity sector. For example, if

[178] The figures in the figure are calculated with the total investment costs incurred, but not the residual value.

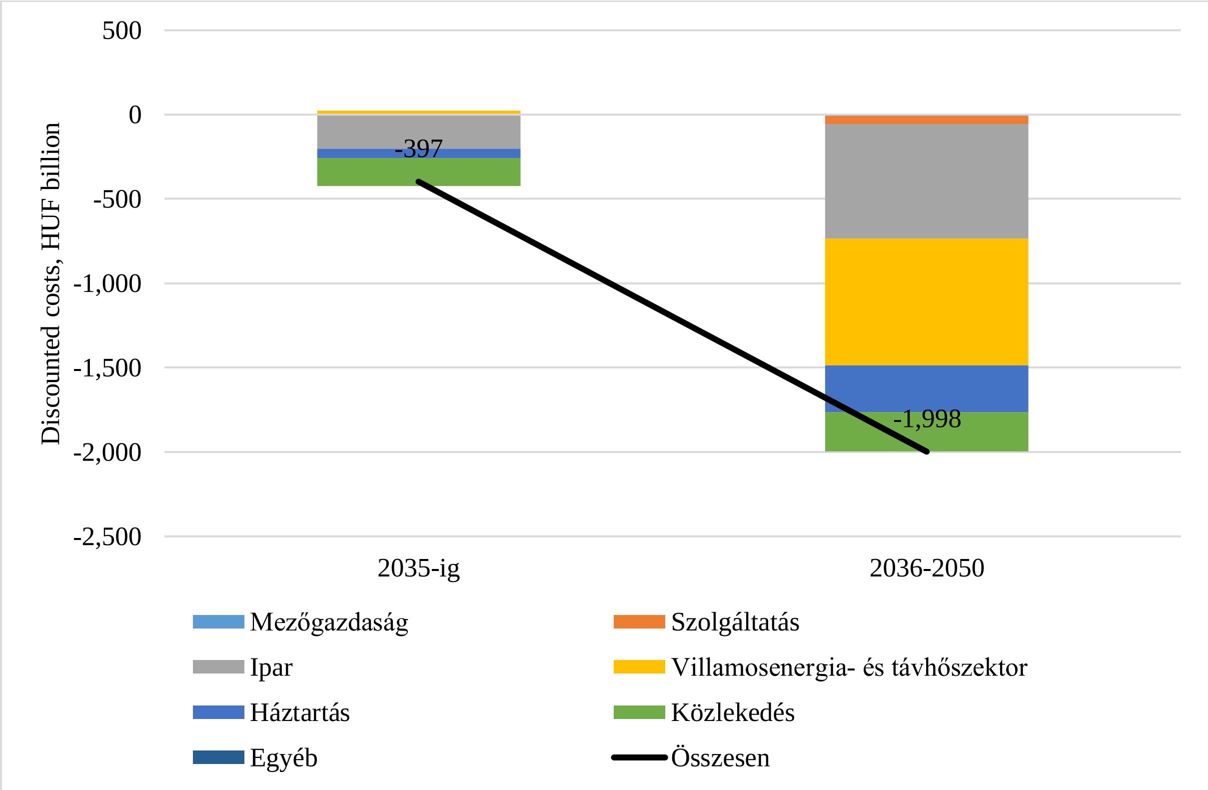
there is an increase in electricity consumption in the industrial sector, the modelling logic means that this cost increase will be attributed to the electricity sector and not to industry.



109figure. Additional operating cost change of the WAM scenario by sector, present value, HUF billion

Already in the first period, the present values of additional operating costs decreased by HUF 565 billion. This value increases to HUF 1600 billion in the second period. Transport (52 %) and households (45 %) have the highest overall savings.

Quota costs will decrease by HUF 400 billion in the first period, but thereafter the total cost decreases drastically as a result of the significant reduction of GHG, and in the second period it amounts to HUF 2000 billion in present value, most of which come from the electricity, transport and industrial sectors, with a smaller proportion coming from household emissions.



110figure. Additional quota cost change in the WAM scenario by sector, present value, HUF billion

ii. Sector or market risk factors or barriers in the national or regional context

iii. Analysis of additional public funding support or resources to address identified deficiencies as defined in point (iii)

5.5. *The 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*

Hungary will become climate neutral by 2050.