Innovációs és Technológiai Minisztérium

Ministry of Innovation and Technology

National Energy and Climate Plan

ITM

FELADATUNK A JÖVŐ

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ACER	Agency for the Cooperation of Energy Regulators
AEO	Annual Energy Outlook Published by: US Energy Information Administration / US EIA
aFFR	Automatic Frequency Restoration Reserve
AEA	annual emission allocation
APT	Advanced Persistent Threat
SAO	State Audit Office of Hungary
AT	Austria
BE	Belgium
BG	Bulgaria
BKV	Budapest Public Transport Company
^{o}C	degree Celsius
CACM Regulation	COMMISSION REGULATION (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance)
CAPEX	capital expenditure
CCR	capacity calculation methodology
CCGT	combined cycle gas turbine
CCS	carbon capture and storage
CCU	carbon capture and utilisation
CCUS	carbon, capture, utilisation and storage
CEE	Central 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 for combined heat and power

CNG	compressed natural gas
COST	Cooperation in Science and Technology
CY	Cyprus
CZ	Czech Republic
Core FB MC project	Core Flow Based Market Coupling Project
CNG	compressed natural gas
DAM	day-ahead market
DE	Germany
DK	Denmark
DRL	Dynamic Line Rating
DSO	Distribution System Operator
DSR	demand side responses
DW value	Durbin Wattson value
EE	Estonia
EBB	European Investment Bank
EB GL	European Balancing Guideline
EBRD	European Bank for Reconstruction and Development
ECG	Electricity Coordination Group
EPO	European Patent Office
US EIA	Energy Information Administration
EIF	European Investment Fund
EIT	Energy Innovation Council / European Institute of Innovation and Technology
EL	Greece
ENTSO-E	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
ESCO	energy saving company, energy service company
ESCO programme	third party financing without own contribution

ESD	Effort Sharing Decision
ESFRI	European Strategy Forum on Research Infrastructures
ESR	Effort Sharing Regulation
EU	European Union
EUA III allowance	emission allowance issued to facilities for the ETS III trading period (2013-2020) (European Emission Allowances)
EUAA allowance	European Aviation Allowances
EU ETS	European Union Emissions Trading System
EUREKA	European Research Coordinating Agency
EURELECTRIC	Union of the Electric Industry
EV	electric vehicle
CCAP	Climate Change Action Plan
ÉMI	Építésügyi Minőségellenőrző Innovációs Nonprofit Kft.
ÉTTT	Advisory Panel on Climate Change
FGSZ Zrt.	FGSZ Földgázszállító Zrt.
FI	Finland
FOM cost	Fixed O&M costs / fixed operation and maintenance costs
FR	France
FRL	Forest Reference Level
GCG	Gas Coordination Group
GDP	gross domestic product
GIE	Gas Infrastructure Europe
EDIOP	Economic Development and Innovation Operational Programme
Hg	Mercury
HHI	Herfindhal-Hirschman index
HIPA	Hungarian Investment Promotion Agency
AFLC	Audio Frequency Load Control
HSPP	maximum 50 kW household-scale power plant
HR	Croatia
HU	Hungary
HUPX	Hungarian Power Exchange

ICIS	International Conference on Information Systems
ICS	industrial control system
IDM	intraday market
IEA	International Energy Agency
IGCC	International Grid Control Cooperation
IE	Ireland
ITDOP	Integrated Transport Development Operational Programme
INEA	Innovation and Networks Executive Agency
IT	Italy
IT technology	information technology
ITER	International Thermonuclear Experimental Reactor
MIT	Ministry of Innovation and Technology
IT technology	tools of information technology
SMP	significant market power
FIS	electricity feed-in system
TEEIAP	Transport Energy Efficiency Improvement Action Plan
EEEOP	Environmental Energy Efficiency Operational Programme
RDI	research and development, innovation
LV grids	low voltage grids
SME	small and medium-sized enterprise
MV grids	medium voltage grids
LOLH	loss of load hours
LNG	liquefied natural gas
LOLE	loss of load expectation
LOLH	loss of load hours for one year
LOLP	loss of load probability
LPG	liquefied petroleum gas
LU	Luxembourg
LT	Lithuania
LV	Latvia
MARI	Manually Activated Reserves Initiative
MAVIR ZRt.	MAVIR Magyar Villamosenergia-ipari Átviteli

	Rendszerirányító ZRt.
MÁV	Magyar Államvasutak Zrt.
MCO	Market Coupling Operator
HEEI	Hungarian Energy Efficiency Institute
HEA	Hungarian Energy and Public Utility Regulatory Authority
REAS	Renewable Energy Aid Scheme (feed-in support scheme relating to heat and electricity produced from renewable and alternative energy sources)
mFRR	manual frequency restoration reserve
MGT	Magyar Gáztranzit Zrt.
MOL Nyrt.	Magyar Olaj- és Gázipari Nyilvánosan Működő Részvénytársaság
MRC	Multi-Regional Coupling
MT	Malta
MTA	Hungarian Academy of Sciences
HV grid	high-voltage grid
NAS	National Adaptation Strategy
NATÉR	National Adaptation Geographic Information System
NECP	National Energy and Climate Plan
NEMO	Nominated Electricity Market Operator
NBEPS	National Building Energy Performance Strategy
NES	National Energy Strategy
NCCS	National Climate Change Strategy
NCCS 2	Second National Climate Change Strategy
NF_3	Nitrogen trifluoride
NIS	network and information systems
NRDI Fund	National Research, Development and Innovation Fund
NRDIO	National Research, Development and Innovation Office
NKI	Hungarian Demographic Research Institute
NTS	National Transport Strategy
NL	Netherlands
NO_2	Nitrogen dioxide (and nitrogen monoxide) is mainly produced and emitted into the atmosphere by the burning of materials (fuel wood, biomass,

	coal, lignite, hydrocarbons, plastics) with nitrogen content. It is considered to be an air pollutant, an element of acid rain, which may be toxic in higher concentrations and has a moderate greenhouse effect. Nitrogen oxides are collectively referred to as NOx.
N_2O	Dinitrogen oxide is emitted into the atmosphere mainly through the activity of soil bacteria utilising the nitrogen content of organic substances in the soil. The quantity of dinitrogen oxide entering the atmosphere increases moderately after soil manuring (extended in time) and at a higher rate upon use of fertiliser. In terms of climate protection it is classified among strong greenhouse gases; it accounts for a clearly identifiable quantity of agricultural GHG emissions.
NRA	National Regulatory Authority
NTC	Net Transfer Capacity / Network Transfer Capacity
HAEA	Hungarian Atomic Energy Authority
OCG	Oil Coordination Group
OECD	Organization for Economic Cooperation and Development
NEC	National Environmental Council
OMSZ	Hungarian Meteorological Service
OPEX	operational expenditure
OTC market	over-the-counter market
power-to-gas technology	electricity storage technology, where hydrogen is produced with electricity or, subsequently methane is produced, which may be converted back 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
PRIMES model	Price-Induced Market Equilibrium System
PT	Portugal
PV	photovoltaic
RDF	Secondary fuel produced from the selective collection of mixed municipal waste and residual

	waste from selective waste collection. It is utilised in power plants and cement plants. (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 (text with EEA relevance)
REKK	Regional Centre for Energy Policy Research
RES	renewable energy sources
RES-E	renewable energy sources for electricity
RES-H&C	renewable energy sources for heating and cooling
RES-T	renewable energy sources in transport
NAF	network access fee
RFLC	radio frequency load control
RO	Romania
RSI	Residual Supply Index
R^2	coefficient of determination
SDAC	single day-ahead coupling
SE	Sweden
SEE	South-East Europe
SCADA	Supervisory Control and Data Acquisition
SEPS	Slovenská elektrizačná prenosová sústava, a. s. (the Slovenian system operator)
SEQ	Standing Group on Emergency Questions (at the International Energy Agency)
SET Plan	Strategic Energy Technology Plan
script-kiddies	'Cybercriminals' with average computer skills. Often they cause damage by using support programs (scripts) or software developed by others. They are often also commonly called hackers.
SI	Slovenia
SK	Slovakia
SO_2	sulphur dioxide
corporation tax	corporation tax

tCO_{2e}	unit of GHG emissions calculated in tonnes CO_2 equivalent
TERRE	Trans-European Replacement Reserves Exchange
SaT cooperation	Cooperation in Science and Technology
TIMES model	The Integrated MARKAL-EFOM System: The TIMES model adapted to Hungary covers the entire Hungarian energy sector, including the transformation sectors, the energy consumption of the industrial and transport sectors, and the energy consumption of buildings.
TOTEX	total expenditure
TSC	TSO Security Coordination
TSO	transmission system operator
TWG	Technical Working Group
TYDP	Ten-year Network Development Plan
UK	United Kingdom
GHG	greenhouse gas(es)
CCHOP	Competitive Central Hungary Operational Programme
Electricity Act	Act LXXXVI of 2007 on electricity
V4	Visegrád Group (Czechia, Hungary, Slovakia, Poland)
RDOP	Rural Development Operational Programme
VOLL	value of lost load
VOM costs	Variable O&M costs / variable operation and maintenance costs
WAM	with additional measures
WEM	with existing measures
XBID	cross-border intraday
4M MC	4 Markets Market Coupling

List of units of measurement and their conversion

Quantity of energy:

koe	*kilogram of oil equivalent*
toe	*tonne of oil equivalent*
ktoe	*thousand tonnes of oil equivalent*
mtoe	*million tonnes of oil equivalent*
1 mtoe = 1 000 ktoe = 1000 000 toe = 1000 000 000 koe	

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

kWh	*kilowatt-hour*
MWh	*megawatt-hour*
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	

Conversion of different units of measurement:

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

1 TWh = 85 984.52 toe = 3 600 TJ = 102 359 965.88 m^3

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

1 TJ = 277 777.78 KWh = 23.88459 toe = 28 433.32 m^3

1 billion m^3 (1 bcm) = 9.76944 TWh = 35 170 TJ = 840 021 toe <u>Capacity:</u>

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

1. REVIEW AND DRAWING-UP PROCESS OF THE PLAN

1.1. Summary

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

The main objective of the new Energy Strategy and the National Energy and Climate Plan ('NECP') is to strengthen **energy sovereignty** and **energy security**, to **maintain the results of reduced overhead costs**, and to achieve the **decarbonisation of energy production, which is possible only through the combined use of nuclear energy and renewable energy**. For countries with scarce conventional energy sources, such as Hungary, energy sovereignty is a **question of welfare, economy and national security**.

It is clearly in the interest of Hungary to reduce its demand for energy imports and to simultaneously ensure its connection to the regional electricity grids and natural gas networks, which guarantees the security of supply and effective import competition.

The cleanest sources of energy are unused fossil fuels. The reduction of the use of fossil fuels may be achieved through the use of **heating/cooling solutions based on renewable resources**, implementation of the Green District Heating Programme, and the reduction of **energy consumption in public institutions, industry and transport**.

Owing to the high useful efficiency of electric motors, the **spread of electromobility** clearly leads to energy savings for final customers. With the implementation of the Green Bus Programme – aimed at greening local transport – environmentally friendly electric buses will be used in larger cities.

The **energy independence of families** can be facilitated by supporting **household-scale energy production for private purposes** and the spread of **smart meters**.

The Government aims to ensure that most of the power generated in Hungary originates from two sources: **nuclear energy and renewable energy** – the latter produced mainly by solar power stations. These technologies do not replace or exclude each other, but are mutually supportive, and both are considered to be clean sources of energy.

Carbon neutral nuclear energy provides roughly half of power generation in Hungary. This ratio can be maintained in the long term with the Paks2 investment. Carbon neutral energy production is inconceivable and unfeasible without nuclear energy.

The Government of Hungary is committed to protecting our natural heritage and the natural environment of the way of life that we, Hungarians, jointly created in Hungary. Therefore the Government believes it is important to protect the world and the environment, and to provide protection against the adverse effects of climate change.

The Government needs to pursue **realistic and responsible climate protection policies.** Firstly, it needs to be realistic in assessing global political trends, the expected results of feasible measures afforded by current technologies and their cost.

Hungary's position within the continent's interior and the special micro-climate of the Carpathian Basin renders the country particularly exposed to the undesirable effects of climate change compared to other European countries, although on a global scale the consequences of warming are expected to be less severe than in countries of mainly developing regions, **thus Hungary will not become a source of climate migration, but be a safe target country**. Thus, climate change and international migration are correlated issues that are inseparable. When the Government addresses climate policy it also **safeguards the sovereignty of Hungary, ensures the livelihood of the nation and families,** and **the preservation of Christian culture**.

The European Union expects Member States to operate overall climate neutral economies by 2050. Hungary **would need approximately HUF 50 000 billion** to implement carbon neutral power generation, fully phase out the use of natural gas and to fully electrify transport. The Government of Hungary holds the view that Hungary can meet this target, but not without substantial financial contribution from the European Union. **Hungary assigns a priority to the enforcement of the polluter pays principle:** the cost of decarbonisation should mainly be borne by countries and companies mostly held responsible for the current situation. Hungary can make specific commitments only after **careful consideration of the means and costs.** The Government of Hungary is therefore adopting a realistic and feasible strategy.

Economic growth and the objectives of climate protection are not incompatible. Hungary is among 21 countries in the world where since 1990 the GDP increased with a 32 % decline in carbon dioxide emissions and a 15 % drop in energy consumption. Thus, Hungary is not only ranked high in Europe in terms of economic growth, surpassing the average rate of GDP growth in the euro zone by 2-3 percentage points, but also leads by example in relation to climate protection.

To secure our future, protect the world and our environmental heritage, the realistic and responsible policies should be pursued further, ensuring **energy sovereignty** and **energy security, maintaining the results of reduced overhead costs**, with the clear understanding that the **carbon neutral economy can only be established with nuclear energy**.

The European Commission published the 'Clean Energy for All Europeans' package of proposals ('Clean Energy Package') at the end of November 2016, which, in addition to setting out several new regulatory proposals concerning climate and energy policy, called on Member States to draw up National Energy and Climate Plans (NECP) based on a single methodology, with uniform content. In the opinion of the Commission, the NECP may rely on the climate and energy strategies, and action plans of Member States in effect, if these are compatible with the EU climate and energy policy objectives to be met by 2030, and with greenhouse gas emission reduction obligations arising from the Paris Agreement.

In the course of drawing up the NECP, Hungary conducted wide-ranging professional, CSO and social consultations to ensure that the plan is implemented with public support. Integrated planning spans the dimension of decarbonisation, energy efficiency, energy security, the internal energy market, research, innovation and competitiveness.

In the course of drawing up the NECP, Hungary has taken into account current national plans, measures and policies. The drawing up of the NECP is closely related to the contents and development process of the new National Energy Strategy, which is drawn up concurrently with the NECP. The plan is also in harmony with policy measures set out in the Second National Climate Change Strategy (NCCS 2), adopted by Parliament in the autumn of 2018, and in the related First Climate Change Action Plan (CCAP), and with the National Development and Spatial Development Concept defining the development and spatial development objectives of Hungary up to 2030.

As regards the plan, to ensure fulfilment of the objectives of the Energy Union and compliance with the Paris Agreement, the Government of Hungary has authorised the Ministry of Innovation and Technology (hereinafter 'MIT') to draw up the appropriate policy programmes and vision, requiring political decision-making, determining the future of the energy sector and of other sectors involved in decarbonisation; to determine national objectives and Hungarian commitments relating to energy and climate change, with particular regard to reducing emissions, 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 (NECP) are summarised below, grouped according to the dimensions of decarbonisation, energy efficiency, security of supply, internal market and innovation-competitiveness. **The quantified objectives are supported by results of the Hungarian TIMES model, specifically developed for drawing up the NECP**, which also lay the groundwork for selecting the most cost-effective policy instruments serving fulfilment of the objectives.

Dimension of decarbonisation

GHG emissions and removals[2]

The EU climate and energy framework approved by the European Council in October 2014 provides for a minimum 40 % GHG emissions reduction at EU level by 2030, compared to the figure for 1990. Hungary **aims to reduce GHG emissions by at least 40 % by 2030 over the year 1990**, i.e. in 2030 gross emissions may not exceed gross 56.19 million t CO_{2eq}, thus the value for 2017 should be reduced by 7.6 million t CO_{2eq}.

[2] Consistency to be ensured with long-term strategies under Article 15.

Decarbonisation of lignite based energy production

One of the key decarbonisation tasks is the conversion of the lignite-fired Mátra Power Plant based on low carbon technologies, thereby the phasing out of coal and lignite from national power generation by 2030. The Mátra Power Plant is a strategic general power plant of the national electricity system, but is also the largest CO_2 emitter in Hungary, accounting for approximately 50 % of CO_2 emissions in the entire energy production sector and 14 % of total national GHG emissions. The reorganisation of the Mátra Power Plant, however, goes beyond technological aspects of the power plant, as it should also take into account the social-economic and environmental effects of the plant's operation in the North Hungarian region. This regional and economic decarbonisation transition is composed of the following elements:

Reorganisation of lignite based power generation at the Mátra Power Plant based on low carbon technologies, benefiting from the characteristics of the site. Construction of a new gas turbine power plant at the site of the Mátra Power Plant, with particular relevance for ensuring the security of supply in the eastern area of the country; construction of a new PV power plant and industrial energy storage unit, and the energy recovery of refuse derived fuel (RDF). The site of the Mátra Power Plant and/or the North Hungarian region in which it is located offers a good opportunity for implementing low carbon intensity energy production and energy storage projects that could provide relief for other territories.

- The Mátra Power Plant had a substantial social-economic impact within the immediate region, including the creation and retention of jobs, the indirect creation of jobs by related undertakings, and local tax revenues. Based on the above, in the course of revitalisation particular attention should be paid to diversifying the region's economy and labour market and to a just transition by making use of the future utility of the site and the power plant's role within the value-added chain.
- Most of the 100 000 households supplied with household lignite based heating are located in the region of the Mátra Power Plant. In the course of revitalisation and the transition we aim to replace household heating energy with clean energy and to reduce energy consumption. Similarly to the whole of Hungary, in the Mátra Power Plant's region we also plan to install power generating PV panel systems to partially supply local electricity consumption.
- The large site of the Mátra Power Plant may also be suitable for multi-purpose utilisation going beyond energy functionalities. Such use includes industrial park expansion and diversification opportunities, the expansion of agricultural or other storage and logistics functions, conservation and presentation of the cultural heritage of mining, habitat reconstruction serving tourism and nature conservation purposes, and natural water conservation measures.

The **Effort Sharing Regulation (ESR)** was adopted in May 2018. It sets national emission reduction targets for Member States for the 2021–2030 period, relative to the base year of 2005. Pursuant to the Regulation, Hungary's reduction target is 7 % between 2021 and 2030, i.e. during the ESR period.

GHG emissions may be reduced by decreasing the quantity of consumed energy, more efficient energy consumption, increasing the use of renewable energy sources and by maintaining nuclear capacities.

Two new nuclear power plant units will be built in Hungary by 2030, each with a capacity of 1 200 MW (Paks2). As a result **the share of carbon-free power generation in Hungary could further increase.** In terms of both climate protection and local air quality, it is important to substitute predominantly fossil fuel based **retail** heating with clean energy to the extent possible. We are planning a **transport greening programme.** The reduction of **agricultural** emissions is primarily served by the prescription of correct agricultural practices and various aid schemes. The currently prepared new waste management strategy will define **waste management** targets and measures for the post-2020 period. To increase our CO_2 sink capacities we will significantly increase the share of areas covered by forest and other tree stock consistently with the **National Forest Strategy.** In addition a **key project serving the creation of an energy and climate literate society** will also serve fulfilment of the above objectives.

Renewable energy

Hungary plans to increase the share of renewable energy sources to at least 21 % within gross final energy consumption.

Within the heating and cooling sector the share of renewable energy – with additional measures – may approximate 30 % in 2030. The efficient use of biomass in both individual heating equipment and in district heating, and options for using ambient heat through heat pumps have great potential. Implementation of the **Green District Heating Programme** plays a key role in the replacement of natural gas, the increase of using renewable energy sources on the heat market, and the supply of as many individually heated buildings as possible with renewable energy sources.

Hungary has set the target of a minimum 14 % share of renewable energy in **transport** by 2030. To meet this target Hungary will increase the share of first generation biofuels produced from food crops and fodder plants to roughly 7 %, and the share of second generation (or advanced) biofuels produced from waste and biogas to 3.5 % in the final energy consumption of transport.[3] The remaining share of the target will be met through the significant increase of electricity in transport.

Hungary plans to increase the share of renewable resources within gross final electricity consumption to at least 20 % by 2030. The increase of PV capacities is at the core of 'greening' the electricity sector, which will increase from just under 680 MW in 2016 to ~6 500 MW by 2030. In 2030 wind power station

[3] The shares should be interpreted in consideration of the multipliers used in the Renewable Energy Directive.

capacities will approximate the current level (~330 MW). In addition to maintaining existing hydroelectric power plants, the increase of small-scale hydroelectric power plant capacities is justified.

The transformation of the electricity sector requires the promotion of using innovative and smart solutions ensuring greater flexibility, which generates substantial market organisation, distribution and transmission network development, human capacity and competence development, and regulatory tasks. Implementation of the above should be preceded by a further major increase in the system integration of weather-dependent renewable energy producers to ensure the sustainability of system security and cost control. To this end, after the system integration of the 2 000 MW PV capacity, it is necessary to examine the funds and time frame of financial and infrastructure conditions of additional growth on a realistic basis.

The new Hungarian aid scheme for incentivising electricity generated from renewable energy sources (REAS) was launched in January 2017. The first REAS tender was launched on 2 September 2019. To ensure cost-effective levels of aid, in the future aid within the REAS framework will only be available through technology-neutral renewable capacity tenders; production aid will be available within the conventional feed-in system only for experimental technologies and model projects.

We also plan to install power generating PV panel systems to partially supply own electricity consumption. We aim to have at least 200 000 households with roof-mounted PV panels with an average capacity of 4 kW by 2030.

Dimension of energy efficiency

Hungary's energy efficiency target is to ensure that the country's final energy consumption does not exceed the value of 2005 in 2030 (785 PJ), either. If final energy consumption exceeds the level for 2005, such increase should exclusively derive from carbon neutral energy resources. The reduction of energy consumption is obviously a priority, but energy consumption in either the industry or in transport should not be limited to this end in case of economic growth. We aim to ensure that GDP growth exceeds the rate of the increase in energy consumption at a growing rate.

We are planning the introduction of an obligation scheme ensuring the cost-effective fulfilment of energy efficiency targets, which may drive investment to areas with the highest energy consumption and energy efficiency potential on a market basis. The improvement of energy efficiency in the economy is a key project of the new Energy Strategy.

Dimension of energy security

The energy supply of Hungary – on both the electricity and gas markets – is characterised by a high share of imports. Significant dependence on energy imports may carry serious risks related to the security of supply and prices. Since Hungary defines the security of supply as an element of national sovereignty, the

Government of Hungary assigns a priority to **strengthening energy independence.** In the course of reducing dependence on energy imports and strengthening geopolitical independence, Hungary places emphasis on **improving energy efficiency, maximising the sustainable exploitation of** (conventional and unconventional) national hydrocarbon reserves and **renewable resources**, and on **maintaining the level of nuclear capacities**. Exposure, however, will still remain high; Hungary plans to mitigate the inherent risks by **reducing import dependency, strengthening market integration** and **developing a diversified supply portfolio**.

The security of supply can be further enhanced by developing a **consumer and climate-friendly electricity sector** that encourages the introduction of new, flexible products on the market and can continuously integrate innovative solutions. To guarantee the security of supply on the electricity market it is necessary to continue to ensure sufficient capacities for satisfying national peak demand and to manage extreme market conditions resulting from decommissioned and commissioned power plants and growing cross-border capacities, and the Hungarian electricity system (including consumers) should possess flexible capacities guaranteeing secure operation and system balancing, and the transmission and distribution networks should also have a high level of availability. **By maintaining and increasing national production capacities it will be possible to reduce the share of electricity imports – currently higher than 30 % – to under 20 % by 2040.** Since energy based on renewable energy sources was produced by decentralised means in the past, a **prerequisite for rapid growth in the penetration of renewables is the preparation of the transmission and distribution network for managing challenges attributable to the decentralised and partly weather-dependent production structure.** This effort necessitates appropriate regulatory incentives. The increase of the share of renewables can only be achieved in parallel with the development and 'enhanced intelligence' of transmission and distribution networks, and the development of **distribution network operation, as a decentralised intervention capability, and its transparent market mechanisms.** Weather-dependent, primarily PV capacities are playing a growing role within renewable energy production.

Short-term fluctuations in weather-dependent production can currently be balanced mainly by gas-fired power plants, but the spread of new, innovative solutions – such as energy storage and demand side responses – should also be enabled.

The benefit of reduced import dependency for the security of supply is most obvious in relation to **natural gas**, as it accounts for the largest share of final energy consumption in Hungary (32-33 %), also in consideration of the consumed quantity of electricity and heat generated with natural gas. In recent years national production covered approximately 20 % of consumption, therefore ~80 % had to be imported to Hungary. We aim **to reduce Hungary's share of gas imports to roughly 70 % by 2030 based on a decline in consumption and growing domestic production.** The decline in consumption can mainly be achieved with energy efficiency investments induced by introduction of the obligation scheme and by reducing the share of natural gas consumption in district heat generation. The **use of domestic resources at a higher rate** also contributes to strengthening energy independence. The increase of **domestic natural gas production** is guaranteed by continuing efforts to ensure the predictability of the concession scheme. By enhancing the flexibility of the system and improving the efficiency of non-standard gas extraction we can offset the exhaustion of production inventories with the encouragement of new extraction projects, thus under an ideal scenario **we can expect to increase domestic conventional natural gas production up to even 2.4 billion m^3 by 2030.** In addition to domestic natural gas, **the use of alternative gas resources** (biogas, biomethane, hydrogen in the longer term) **also has potential.** We estimate that the domestic biogas potential can realistically substitute 1 % of national gas consumption in Hungary by 2030.

As an additional strategic objective, the remaining annual import requirement of around 6.2 billion m^3 can be met with sources as diverse as possible in 2030. To this end **we aim to implement an infrastructure ensuring access to four independent gas import sources** (gas traded on the Russian, LNG, Romanian and Western European markets). Hungary's security of supply can be further enhanced by strengthening market integration.

Dimension of the internal energy market

The appropriate operation of the internal energy market primarily depends on three main components: level of interconnection and necessity of its increase, the level of market coupling, and its reduction of prices and price volatility, and the liquidity of the Budapest electricity and gas exchange.

Hungary is already significantly surpassing the EU target relating to electricity interconnection. We nevertheless plan to increase the share of interconnection to ~60 % by 2030, as the increase of existing cross-border capacities and the establishment of interconnection with Slovenia remains justified because an adequately interconnected energy network operated with neighbouring countries improves the national security of supply; in the event of any disruption within the national system, namely, the risk of disruptions in service in large areas is reduced. The expansion of the interconnection of energy networks also contributes to strengthening competition on the wholesale market, reducing the competitive disadvantage of Hungarian energy consumers compared to their Western European counterparts.

Hungary's supply can be further enhanced by **strengthening market integration**. In other words, beyond the increase of cross-border capacities, it is also necessary to increase market coupling and to improve the efficiency of operating interconnected markets. In relation to the above, it is necessary to draw up regulations enhancing the efficiency of wholesale and balancing markets; the framework of the above is provided by the implementation of European operational and operating regulations. Further strengthening of the coupling of both intra-day and day-ahead markets on the electricity market is justified, with the efficient operation of these markets. To strengthen integration on the gas market consultations are under way between Hungary and

Croatia concerning the integration of the two countries' gas markets, which in practice would lead to the elimination of cross-border tariffs. We are also exploring other options for integration.

Beyond the foregoing it is also necessary to **promote projects enhancing the regional role and liquidity of Hungary's regulated electricity and gas markets.**

Dimension of research, innovation and competitiveness

Hungary aims to maximise the ability of the Hungarian energy and RDI sectors to fulfil the energy and climate policy objectives of Hungary and the European Union. To this end Hungary assigns a priority to the objective of improving innovation, maximising the economic development opportunities underlying energy innovation and climate change.

Within the framework of the new energy innovation strategy we plan to encourage use of innovative solutions ensuring smooth transformation of the electricity markets noted above, on the one hand, and contribute to fulfilling objectives relating to the increase of consumer choices, the strengthening of the security of supply and the climate-friendly transformation of the energy sector, on the other. Innovation in the energy sector should also support the performance of the Hungarian economy, increase national RDI capacities and create industrial development opportunities to the extent possible. To support the drawing up of an energy innovation strategy in conformity with the above criteria, in October 2018 the Ministry of Innovation and Technology set up the Energy Innovation Council (EIC)[4] with the participation of Hungarian energy and industrial companies, universities, research establishments, professional organisations, the Hungarian Energy and Public Utility Regulatory Authority (HEA), the MIT, the minister without portfolio in charge of managing national assets and specialists of the state secretariats of the minister without portfolio in charge of the two new units of the Paks Nuclear Power Plant. The Council identified possibilities of intervention in the following areas:

1. Innovative system balancing (flexible storage and demand management);
2. Encouragement of the market launch of innovative energy supply solutions;
3. Energy efficiency innovation programme;
4. Facilitation of the use of Hungarian natural gas reserves;

[4] The EIC, composed of Hungarian energy and industrial companies, universities, research establishments, professional organisations, the Hungarian Energy and Public Utility Regulatory Authority (HEA), the MIT, the minister without portfolio in charge of managing national assets and specialists of the state secretariats of the minister without portfolio in charge of the two new units of the Paks Nuclear Power Plant, aims to assess energy innovation opportunities in Hungary, improve the effectiveness of exploiting Hungarian energy innovation potential and to lay the strategy-oriented professional groundwork for the government's effective energy innovation policy framework. The report prepared on the basis of the EIC's work, presenting the directions of energy innovation, serves as a basis for Hungarian energy innovation strategy.

5. ‘Smart regulation’ to secure the interest of distributors and suppliers in innovation;

6. Transport greening;

7. Encouraging use of renewable energy sources;

8. Support of nuclear innovation;

9. Encouraging innovative seasonal electricity and heat storage solutions.

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

The table below summarises Hungary’s key, quantified objectives.

Dimensions of the Energy Union	**Indicators**	**Overview (2017)**	**Targets for 2030**
Decarbonisation	Reduction of GHG emissions compared to 1990	-31.9 %	min. -40 %
	GHG intensity of the GDP	1.98 t CO_2e/HUF million	steady reduction of GHG intensity
	Reduction of non-ETS emissions compared to 2005	-9.3 %	min. -7 %
	Share of renewable energy within gross final energy consumption	13.33 %	min. 21 %
Energy efficiency	Final energy consumption	775 PJ	max. 785 PJ The source of final energy consumption above the target may only be carbon neutral energy resources between 2030 and 2040
	Final energy intensity of the GDP	0.579 toe/HUF million	0.429 toe/HUF million
Energy security	Net import dependency – natural gas	~96 %[5]	~70 %
	Net import dependency – oil	~86 %	max. 85 %
	Net import dependency – electricity	32-33 %	max. 20 %
	N-1 rule for the natural gas infrastructure	143 %	min. 120 %
Internal energy market	Share of interconnected electricity systems	~50 %	min. 60 % *(the EU mandatory target is min. 15 %)*

[5] The level of import dependency may change from year to year. The share of net imports in 2017 is an exceptional value. Net imports are around 80 % based on the average of multiple years.

Research, innovation, competitiveness	Number of implemented innovation pilot projects	0 pcs	min. 20 pcs
	Number of international patents registered during the implementation of pilot projects	0 pcs	min. 10 pcs

Table 1 – Main objectives of Hungary

1.2. Overview of current policies

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

The European Council approved the **climate and energy framework for the 2021–2030 period** in October 2014; based on the framework, the adoption of sectoral legislation determining the climate and energy policy of the EU between 2021 and 2030 – considered to be primary legislation – was concluded in 2019 with the adoption of legislation of the Clean Energy package, which was debated last.

In the case of Hungary, the new National Energy Strategy – prepared in parallel with the NECP – and the Second National Climate Change Strategy (NCCS 2)[6] are the key national documents in conformity with the climate and energy policy objectives and directions of the EU for the year 2030.

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

Pursuant to the Second National Climate Change Strategy, adopted by Parliament by way of Decision No 23/2018 of 31 October 2018 of Parliament, relating to the 2018–2030 period, and providing a projection of the period up to 2050, a gross GHG emission reduction of 52–85 % should be achieved by 2050 over the figure for 1990. In addition to the National Decarbonisation Road Map, this strategy also contains the National Adaptation Strategy (NAS) and the 'Climate Partnership' Awareness Raising Plan. Climate Change Action Plans - relating to three-year periods - are drawn up to fulfil objectives of the Second National Climate Change Strategy. The First Climate Change Action Plan – in effect up to 2020 – aims to precisely define tasks determined by the short-term directions of action of the NCCS 2, and to prepare long-term measures. The Climate Change Action Plan determines the main areas of intervention by relying on the three pillars of mitigation, adaptation and awareness raising. The first plan will be followed by new ones every three years.

Pursuant to the RED[7], the mandatory share of **renewable energy sources** should reach 13 % in gross final

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

[7] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of

energy consumption in 2020, but Hungary has voluntarily increased this value to 14.65 % in the Renewable Energy Recovery Action Plan[8]. During the current budgetary period of the EU, several operational programmes were launched in Hungary to support environmental and climate protection tasks, and renewable energy sources, with a development budget of HUF 760 billion. The new Hungarian aid scheme for electricity generated from renewable energy sources (REAS) was launched in January 2017. The first REAS tender was launched on 2 September 2019. The REAS is in conformity with national needs and with EU guidelines concerning State aid for the environment and energy in the 2014–2020 period.

A number of measures have been introduced to support the improvement of energy efficiency:

- energy installations of households were modernised within the framework of the Warm Home Programme,
- launch of implementing the network of energy engineers,
- mandatory employment of energy engineers prescribed for large companies,
- introduction of tax advantages for corporate energy investments,
- improvement of energy efficiency at public institutions (renovation).

The Government of Hungary assigns a priority to guaranteeing the **security of energy supply.** Hungary operates an adequate gas infrastructure to satisfy the stagnant, moderately declining rate of natural gas consumption.

As a result of regulatory changes and infrastructure investments implemented in the past decade, a diversified supply model has evolved on the basis of multiple sources of supply. As indication of the success of implemented gas market diversification efforts (including construction of the Slovakian-Hungarian, Hungarian-Croatian and Hungarian-Romanian interconnected pipelines), strengthened import diversification and establishment of competition on the wholesale market has eliminated the competitive disadvantage of Hungarian gas consumers compared to Western European consumers since early 2014.

iii. Key issues of cross-border relevance

Although Hungary has substantial lignite reserves, it is grouped among countries with limited fossil fuel reserves and is therefore reliant on significant – mainly hydrocarbon – imports. Approximately 90 % of oil is

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energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (text with EEA relevance)

8 https://20102014.kormany.hu/download/2/b9/30000/Meg%C3%BAjul%C3%B3%20Energia_Magyarorsz%C3%A1g%20Meg%C3%BAjul%C3%B3%20Energia%20Hasznos%C3%ADt%C3%A1si%20Cselekv%C3%A9si%20terve%202010_202 0%20kiadv%C3%A1ny.pdf

imported, although import sources are adequately diversified. Hungary imports approximately 80 % of its natural gas, most of which originates from Russia, therefore the issue of natural gas deliveries from Russia is of paramount importance for Hungary. The Russian-Ukrainian conflict, the expected decline in transiting through Ukraine, in particular, projects possible long-term changes to traditional transit routes in the 2020s. These developments may also modify transits to Serbia and Bosnia, which are currently realised exclusively through Hungary.

Beyond Russian gas, access to alternative gas sources is important. However, the establishment of interconnectivity on the natural gas market – ensuring new source of supply – is not possible without international cooperation.

As regards the electricity market, due to the integration level of electricity systems in Central Europe, fluctuating production in German power plants based on renewable energy sources has a direct, pronounced effect on the electricity systems of other States in the region. The interconnection of European electricity markets aims to resolve this problem by increasing and optimising, and improving the efficiency of electricity trade between countries. In 2018 the German, Austrian and Polish energy authorities approved the launch of the project serving the connection of the Hungarian-Czech-Slovakian-Romanian markets (4M MC) to the already interconnected Western European markets.

A large share of demand is satisfied with imports, in addition to domestic production capacities. It is necessary to monitor current and expected capacity changes in countries serving as import sources, and Hungary needs to be aware that it is critically exposed to adverse regional events.

iv. Administrative structure of implementing national energy and climate policies

The Ministry of Innovation and Technology (MIT) – called as such since May 2018[9] – is competent to carry out most tasks relating to the plan's implementation. The functions and authority of the minister responsible for innovation and technology cover, *inter alia*, the following fields: State infrastructure investments, mining, energy and climate policy, use of European Union funds, construction economy, economic development, sustainable development, waste management, industry, trade, transport, regional development, and coordination of innovation and science policy. Within the scope of his responsibility for energy policy, the minister establishes strategic conditions for sustainable economic development, energy efficiency and energy management, and drafts climate policy legislation. Within the scope of his responsibility for industry, the minister, *inter alia*, draws up decisions supporting the spread of electromobility in Hungary, carries out tasks

[9] The Ministry of Innovation and Technology, within the meaning of Act V of 2018 on the listing of the ministries of Hungary and amending certain related acts, shall continue to operate by renaming of the Ministry of National Development under Act XX of 2014 on the listing of the ministries of Hungary.

concerning the allocation and settlement of European GHG emission allowances in relation to the emissions trading scheme of the European Union, the operation of the emissions trading scheme (ETS), and arranges for their execution.

Additional institutions and actors involved in the implementation and monitoring of the plan:

- Research Institute of Agricultural Economics,
- Ministry of Agriculture,
- Ministry of Foreign Affairs and Foreign Trade,
- Építésügyi Minőségellenőrzési Nonprofit Kft.,
- Hungarian Mining and Geological Service,
- Hungarian Energy and Public Utility Regulatory Authority,
- Hungarian Hydrocarbon Stockpiling Association,
- Centre for Energy Research of the Hungarian Academy of Sciences,
- Hungarian Chamber of Engineers,
- Prime Minister's Office (government offices),
- National Research, Development and Innovation Office,
- Minister without portfolio in charge of national assets,
- Hungarian Atomic Energy Authority,
- Hungarian Meteorological Service,
- Minister without portfolio in charge of the design, construction and commissioning of the two new units of the Paks Nuclear Power Plant,
- Ministry of Finance.

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

i. Involvement of the national parliament

The Hungarian Parliament has not debated the NECP.

ii. Involvement of local and regional authorities

Local and regional authorities were involved in the drafting of the plan, and had the opportunity to present their opinions in the course of social consultations serving the plan's finalisation.

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

In April 2016, a working group managed by the department coordinating technical work (formerly called the Department of Strategic and Energy Policy), with the involvement of several partner departments and external collaborators responsible for modelling, was set up by the former Ministry of National Development to ensure more efficient cooperation. The main stakeholder groups were defined as part of planning the national consultation processes.

Within the framework of the one-month sectoral consultations, the request of the ministry for proposals concerning the national targets, and the policies and measures considered necessary for their fulfilment was forwarded to 134 stakeholders in the summer of 2018. The partners requested to cooperate include industrial associations, industrial/sectoral operators, civil society organisations, higher education institutions, research institutes, consulting firms and individual experts. The national objectives and targets defined in the draft NECP, and the policies and measures serving their fulfilment were defined in consideration of the professional processing and evaluation of the roughly 50 proposals received as part of the sectoral consultations.

The draft was presented at a number of forums in 2019. These forums were attended by representatives of public authorities, civil society organisations, industrial operators and researchers. The draft has been accessible on the website of the Government since May 2019.

Members of two permanent forums, the Advisory Panel on Climate Change (APCC) and the National Environmental Council (NEC), discussed the NECP. The NEC is the advisory, proposing, reviewing body of the Government involved in decision-making concerning environmental policies with national or regional impact. The APCC is a body established for providing scientific support for strategic documents concerning climate change. It is headed by the Minister of State for Energy and Climate Policy.

In November 2019 wide ranging professional consultations were held with the participation of scientific bodies, industrial operators, universities, research establishments, CSOs and stakeholders in public administration.

iv. Consultations with other Member States

Hungary is member of the Visegrád Group cooperation and the High Level Group on Central and South Eastern Europe Energy Connectivity (CESEC), which regularly discusses energy and climate policy matters with relevance for the NECP.[10]

The High Level Group on Central and South Eastern Europe Energy Connectivity (CESEC) – established in 2015, with 9 EU Member States and 8 additional countries as members – serves to accelerate the integration of electricity and gas markets in the region.

The Visegrád Group cooperation is a regional organisation of Czechia, Poland, Hungary and Slovakia. It aims to provide joint representation of the economic, diplomatic and political interests of Central European countries and to coordinate their possible steps.

In the course of 2018 and 2019 Hungary held targeted consultations with several Member States on the National Energy and Climate Plan. As a first step of consultations, in November 2018, Hungary participated in the NECP consultations[11] organised by the V4 countries and Austria in Bratislava. The meeting offered an opportunity to discuss - on a regional level - the progress of Member States in drawing up the NECP. In addition to practical aspects of preparing the NECP, the following topics were also discussed: renewable energy sources, climate change, energy efficiency, internal energy market and energy security.

In July 2019 Slovenia organised a new round of targeted consultations in Ljubljana relating to the NECP. In addition to the host country and Hungary, the event was attended by Austria, Croatia and Italy.

Within the framework of the Central Eastern European Energy Conference held in Bratislava, in November 2019 the V4 countries and neighbouring countries discussed the NECPs of Member States, options for boosting ambitions and regional effects.

v. Iterative process with the Commission

In April 2017, the delegation of the European Commission visited Hungary to obtain information and to clarify certain technical matters. In the course of successful bilateral consultations, the ministry reported on progress relating to the NECP.

The Commission published its recommendations concerning the NECPs of Member States in June 2019.[12] These state, *inter alia*, that the target for the use of renewable energy should be raised to 23 %, it is necessary to significantly increase the targets for 2030 regarding the reduction of both final and primary energy consumption, and measures relating to the above and to market integration, energy security, and research and innovation should be elaborated in greater detail. It is also necessary to further detail analyses relating to the investment requirements and effects of measures.

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[10] CESEC = Central and South Eastern Europe Energy Connectivity

[11] Pentalateral consultations between Austria (AT), Czechia (CZ), Poland (PL), Slovakia (SK) and Hungary (HU).

[12] https://ec.europa.eu/energy/sites/ener/files/documents/hu_rec_hu.pdf

Hungary held personal consultations on the recommendations with the Commission in May 2019.

1.4. Regional cooperation in preparing the plan

i. Elements subject to joint or coordinated planning with other Member States[13]

NECP consultations were held as described in point 1.3(iv).

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

[13] For details see relevant points of Chapter 3 in relation to specific dimensions.

2. TARGETS AND OBJECTIVES

2.1. Dimension of decarbonisation

2.1.1. GHG emissions and removals[14]

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

The emissions of non-ETS sectors (buildings, waste sector, transport, agriculture, small industrial emitters and F-gases) are regulated by the **Effort Sharing Decision** (ESD) up to 2020. Pursuant to the Decision, between 2013 and 2020, i.e. during the ESD period, Hungary may increase its emissions by 10 % compared to the emission levels of 2005.

The **Effort Sharing Regulation (ESR)** was adopted in May 2018, which sets national emission reduction targets for Member States for the 2021–2030 period, relative to the base year of 2005. To this end, GDP/capita-proportionate targets were set for Member States in the range of 0–40 %. Pursuant to the Regulation, Hungary's reduction target is 7 % between 2021 and 2030, i.e. during the ESR period. At the current stage, mandatory national targets[15] in the 2021–2030 period may not yet be provided because pursuant to Regulation (EU) 2018/842, their calculation also requires 2018 emission values, which are not yet available in the professional process. (Annual values are published in a Union act.)

ii. Where applicable, other national objectives and targets consistent with the Paris Agreement and existing long-term strategies; Where applicable, contribution to the EU commitment aimed at reducing greenhouse gas emissions, other objectives and targets, including sectoral targets and adaptation targets, if available.

Based on the 'Roadmap for moving to a competitive low-carbon economy in 2050' drawn up by the European Commission in 2011, by 2050 GHG emissions in the entire economy of the EU should decrease by 80 % over the level measured in 1990. The EU emission reduction target is determined by the 2030 climate and energy framework approved by the European Council in October 2014. The document declares that the EU will reduce GHG emissions by at least 40 % by 2030 compared to 1990. The Long-term Strategy sets out the decarbonisation targets of Hungary up to 2050.

To meet the long-term decarbonisation target, in addition to the targets referred to in point 2.1.1 i., this document sets out the following national targets up to 2030:

GHG emissions should be reduced by at least 40 % by 2030 over the year 1990, i.e. in 2030 gross emissions may not exceed gross 56.19 million t CO_{2eq}, thus the value for 2017 should be reduced by

[14] Consistency to be ensured with long-term strategies under Article 15.

[15] I.e. emission allowances under Article 4 of Regulation (EU) 2018/842.

7.6 million t CO_{2eq}.

The GHG intensity – i.e. GHG emissions per unit of GDP – **of the Hungarian economy improved by 22 % since 2010**, suggesting that climate protection does not impede economic growth, but can actually boost it. The positive trend is also confirmed by preliminary emissions data for 2018: GHG emissions declined by roughly 0.6 %, with 4.9 % GDP growth. **It is our strategic objective to strengthen this trend, i.e. to further reduce the energy and GHG intensity of Hungary's generated national income in parallel with maintaining high-quality economic growth.**

Beyond reducing GHG emissions and improving the GHG intensity, Hungary also assigns a priority to **promoting adaptation to the effects of climate change.** At an international level the Paris Agreement defines the global adaptation objectives[16] and the need to balance mitigation and adaptation measures. At the level of the EU, the **'EU strategy on adaptation to climate change *(EU Adaptation Strategy)*'**, adopted in April 2013 by the European Commission, is the principal normative document for adaptation policies of Member States. To ensure climate change-proof investments, the objectives of the strategy mainly focus on the establishment of Member State adaptation strategies, support of adaptation capacity development, development of voluntary urban adaptation strategies, identification of insufficiently understood fields and the remedying of such deficiency, further development of the CLIMATE-ADAPT information platform[17], integration of the field of adaptation in the Common Agricultural Policy and Cohesion Policy, enhancement of the resilience of infrastructures and development of related guidance, and the promotion of new insurance schemes and other financial services.

As part of the Second National Climate Change Strategy (NCCS 2), **Hungary adopted the National Adaptation Strategy (NAS)[18]**. The NAS – in harmony with Union objectives and national needs – defines the following specific objectives for the period up to 2030:

- Conservation of natural and semi-natural **ecosystems**;
- Conservation of the reserves and quality, long-term use of **natural resources**;
- Identification of the adaptation options of **vulnerable regions**, drawing up of region-specific adaptation strategies supported by the NATÉR[19] system;

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[16] Paris Agreement, Article 2(1)(b).

[17] https://climate-adapt.eea.europa.eu/

[18] Decision No 23/2018 of 31 October 2018 of Parliament on the Second National Climate Change Strategy relating to the 2018–2030 period, and providing a projection of the period up to 2050.

[19] The NAS presents the results of the vulnerability assessment drawn up within the framework of the National Adaptation Geographic Information System (NATÉR, https://nater.mbfsz.gov.hu/). The NATÉR provides reliable and objective information on Hungary's climate, the effects of climate change and strategic risks relating to other long-term management of natural resources, and on possibilities affecting and influencing adaptation to these. The system also functions as a means of raising public awareness of climate literacy and a database serving climate change related

- Implementation of the flexible and innovative adaptation of **vulnerable sectors** (*inter alia* agriculture and forest management, tourism, energy, transport, buildings, telecommunications and communications systems);
- Risk management and adaptation in **horizontal areas of with key national strategic relevance** (*inter alia* disaster management, critical infrastructure in water resources management and rural development);
- **Mitigation of the social impact** of climate change, **awareness raising**, improvement of social adaptability;
- Support of **research and innovation** relating to adaptation, publication of scientific research results.

2.1.2. Renewable energy

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

We will increase the share of renewable energy sources to at least 21 % within gross final energy consumption by 2030.[20]

Electricity

Hungary plans to increase the share of energy production based on renewable energy sources within electricity consumption to at least 20 % by 2030.[21] The increase of PV capacities is at the core of 'greening' the electricity sector, which will increase from just under 680 MW in 2016 to approximately 6 500 MW by 2030, and significantly exceed 10 000 MW by 2040. The NECP projects wind power station capacities to approximate the current level (~330 MW) in 2030. In addition to maintaining existing hydroelectric power plants, the increase of small-scale hydroelectric power plant capacities is justified.

Heating and cooling

In the heating and cooling sector we see major potential for the efficient use of biomass in both individual heating equipment and in district heating, and options for using ambient heat through heat pumps. Currently only 10-15 % of Hungary's geothermal potential is exploited, even though the use of geothermal energy can offer a competitive alternative to other energy resources with the introduction of appropriate incentives. **Considering Hungary's geological characteristics, we plan to exploit the geothermal energy potential** in both district heat generation and in the agro-industry (e.g. heating of

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research.

[20] The implementation of additional renewable energy capacities is possible at a growing cost. According to our current estimates, above a 20 % share of renewable energy, the unit funding requirement of domestic renewable energy recovery significantly increases. (Source: REKK (2018): Cost estimate of achieving the share of renewable energy by 2030 https://rekk.hu/downloads/projects/2019_REKK_NEKT_megujulo_final.pdf)

[21] The value projected by modelling exceeds 21 % based on the WAM scenario.

greenhouses). The integration of the recovery of biodegradable municipal waste in useful heat generation is also a viable option.

Transport

Pursuant to the Renewable Energy Directive, fuel distributors are required to ensure that renewable energy accounts for at least 14 % of total energy consumption in the transport sector by 2030. To meet this target Hungary will increase the share of first generation biofuels produced from food crops and fodder plants to roughly 7 %, and the share of second generation (or advanced) biofuels produced from waste and biogas to 3.5 % in the final energy consumption of transport.[22] The remaining share required to meet the 14 % target will be provided through the significant increase of electricity in transport.

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;

(%)	2017	2020	2025	2030
Share of renewable energy within gross final energy consumption - total	13.3	13.2	16.4	21
Shares by sector				
Electricity	7.5	10.8	16.4	21.3
Heating and cooling	19.6	18.2	20.7	28.7
Transport	6.8	6.6	16.8	16.9

Table 2 – Estimated trajectory for the sectoral share of renewable energy in gross final energy consumption

iii. Estimated trajectories by renewable energy technology that the Member State projects to use to achieve the overall and sectoral trajectories for renewable energy from 2021 to 2030, including expected total gross final energy consumption per technology and sector in Mtoe / ktoe and total planned installed capacity (divided by new capacity and repowering) per technology and sector in MW

The tables below provide information relating to the topic.

(ktoe)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RES-E	402	459	515	572	628	684	741	799	856	913	971
RES-H	1 946	1 966	1 986	2 005	2 025	2 045	2 181	2 316	2 451	2 586	2 722
RES-T	194	243	291	340	389	438	421	405	389	374	358

[22] The shares should be interpreted in consideration of the multipliers used in the Renewable Energy Directive.

Table 3 – Use of renewable energy sources in specific sectors, 2020-2030 (ktoe)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity consumption (GWh)											
Water	244	244	244	244	244	244	244	244	244	244	244
Solar	1 335	1 853	2 371	2 890	3 408	3 926	4 457	4 988	5 518	6 049	6 579
Wind	693	693	693	693	693	693	693	693	693	693	693
Biomass and renewable waste	2 332	2 431	2 531	2 631	2 731	2 831	2 930	3 029	3 129	3 228	3 328
Other renewables	78	114	151	188	225	261	298	335	371	408	445
Capacity (MW)											
Water	57	57	57	57	57	57	57	57	57	57	57
Solar	1 170	1 691	2 212	2 733	3 255	3 777	4 310	4 845	5 380	5 915	6 454
Wind	329	329	329	329	329	329	329	329	329	329	329
Biomass and renewable waste	519	583	647	710	774	838	796	754	712	670	796
Other renewables	11	16	21	26	31	35	60	85	109	134	60

Table 4 – Technological breakdown of electricity consumption based on renewable energy sources and electricity generation capacities installed for the use of renewable energy sources (electricity consumption: ktoe; installed capacity, MW)

(ktoe)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Heat pump	2.4	4.6	6.4	7.9	9.0	13.6	13.6	13.6	13.6	13.6	13.6
Geothermal energy	84.6	106.9	128.8	150.3	171.5	114.0	134.6	155.2	175.8	196.4	116.6
Biomass and renewable waste	1 785.0	2 155.1	2 524.8	2 894.1	3 263.1	1 853.0	2 351.1	2 849.2	3 347.2	3 845.3	2 504.0
Solar	11.1	12.8	14.1	15.1	15.7	11.1	17.8	24.4	31.1	37.7	46.9

Table 5 – Use of renewable energy sources in heating and cooling (ktoe)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Bioethanol	47	90	133	176	219	262	253	244	235	226	217
- Annex IX, part ‘A’	0	42	84	126	168	210	207	204	201	198	195
- Annex IX, part ‘B’	0	0	0	0	0	0	0	0	0	0	0
Biodiesel	220	272.8	325.6	378.4	431.2	484	456.6	429.2	401.8	374.4	347
- Annex IX, part ‘A’	0	42	84	126	168	210	207	204	201	198	195
- Annex IX, part ‘B’	147	157.2	167.4	177.6	187.8	198	183.8	169.6	155.4	141.2	127
Renewable electricity	37	48.4	59.8	71.2	82.6	94	127	160	193	226	259
- Road	20	29	38	47	56	65	96	127	158	189	220
- Rail	17	19.2	21.4	23.6	25.8	28	30	32	34	36	38
Hydrogen from renewables	0	0	0	0	0	0	10.2	20.4	30.6	40.8	51

Table 6 – Consumption of renewable energy in transport by fuels, with multipliers (ktoe)

iv. Estimated trajectories on bioenergy demand, disaggregated between heat, electricity and transport, and on biomass supply by feedstocks and origin (distinguishing between domestic production and imports). For forest biomass, an assessment of its source and impact on the LULUCF sink

Demand

In 2016 total bioenergy consumption amounted to 2 361 ktoe, most of which (73 %) was consumed by households. According to our estimates, the use of bioenergy will increase by approximately 30 % with additional measures. Most of this growth will be driven by electricity and district heat generation, the industrial and services sectors. In contrast, retail biomass consumption will significantly decline by 46 % by 2030. The use of bioenergy will peak in the 2030s, followed by a moderate decline.

Bioenergy consumption (ktoe)	2020	2025	2030
Electricity	200	243	286
Cooling and heating	1 911	1 959	2 584
Transport	194	227	111

Table 7 – Bioenergy consumption (ktoe)

Supply

Options for using Hungarian forests are determined within the framework of district forest planning, also in consideration of sustainability requirements (with the exception of freely used forests). Most State forests are managed by State-owned forestry companies limited by shares under the shareholder control of the Ministry of Agriculture. Determination of the annual logging volume of State forestry holdings is an ecological question. Logging in conformity with the maintenance and cultivation of forests, providing for the necessary funds and ensuring the sustainability of forest management is planned in several stages. Ten-year forestry plans comprise the basis for three-year strategic plans and annual plans.

Based on more than ten years of experience relating to the National Forest Programme, the main problem associated with private forest management remains the management of small-scale areas. Such management decreases the effectiveness of forest management and conservation, on the one hand, and significantly increases administrative burdens, on the other. Based on the National Forest Strategy, the appropriate integration of the fragmented forest holding structure and its improvement to the extent possible should be achieved by modification of the regulatory framework and with other State measures. The appropriate regulation of forest management partnerships can contribute to these efforts.[23]

Climate change has already caused unprecedented damage to forests, disrupting the planned course of forest management. Although domestic deciduous species, and measures already introduced in forest management and by forest holdings contribute to preventing larger scale damage to forests, such damage may be impossible to rule out, which (due to the necessary logging of dead trees) will lead to the temporary sharp increase in the availability of wood biomass, followed by its expected decline.

	WEM scenario (ha)					
Species	**2017**	**2021**	**2022**	**2025**	**2027**	**2030**
Oak	133	600	600	600	600	600
Turkey oak and other hard deciduous	53	300	300	300	300	300
Beech	0					
Acacia	464	1 000	1 000	1 000	1 000	1 000
Canadian poplars és white willow	95	100	100	100	100	100
Domestic poplar and other soft deciduous	106	500	500	500	500	500
Scotch pine	4					
Black pine	1					

[23] 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)

Spruce and other pine	0					
Total	855	2 500	2 500	2 500	2 500	2 500
	WAM scenario (ha)					
Oak	133	600	600	800	900	900
Turkey oak and other hard deciduous	53	300	300	300	300	400
Beech	0					
Acacia	464	1 000	1 000	1 400	1 400	1 400
Canadian poplars és white willow	95	100	100	300	300	300
Domestic poplar and other soft deciduous	106	500	500	800	800	800
Scotch pine	4					
Black pine	1					
Spruce and other pine	0					
Total	855	2 500	2 500	3 600	3 700	3 800

Table 8 – **Expected annual forestation rate based on species (hectares)**

Scenario		**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 rate **	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
Logging kept at a low level ***	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: assumed logging at Forest Reference Level prescribed under the LULUCF Regulation.

**: Increased logging: scenario assuming increased logging compared to current level.

***: Logging kept at a low level: logging kept at approximately current level.

Table 9 – Projection of the future net carbon balance of existing forests

	2021	2022	2025	2027	2030
Wood species	**WEM scenario**				
Acacia	500	500	500	500	500
Canadian 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
Canadian poplar	750	750	750	750	750
Total	1 500	1 500	1 500	1 500	1 500

Table 10 – Expected changes to industrial log plantations (hectares)

v. Where applicable, other national trajectories and objectives, including those that are long term or sectoral (e.g. share of renewable energy in district heating, renewable energy use in buildings, renewable energy produced by cities, energy communities and renewables self-consumers, energy recovered from the sludge acquired through the treatment of wastewater);

With the spread of household-sized PV panels, a growing number of consumers can generate their own energy, which not only offers the option of a more active presence on the market beyond the conscious regulation of consumption, but also strengthens energy independence on a household scale. **We wish to continue encouraging energy production for private purposes, based on renewable resources, strengthening the energy independence of consumers and consumer communities.** In addition to the production of electricity with PV panels to satisfy consumer electricity demand (possibly including the energy demand of electric vehicles), this also involves the substitution of piped gas consumption or inefficient district heating with the use of geothermal heat, ambient heat, electric heating or biomass. We will promote initiatives aimed at satisfying municipal heat demand with local energy. **In parallel with growth in decentralised production based on locally available renewable resources it is necessary to support initiatives ensuring the local consumption of electricity.** This effort could reduce costs associated with energy supply and simplify the integration of renewable sources of energy. **In relation to the above, encouragement and support of energy communities is the most important task.** With regard to **district heating**, we aim to ensure that in the longer term the entire Hungarian district heating service, in the medium term the district heating systems of municipalities where the quantity of district heat supplied to the network reaches 100 000 GJ, fall within the category of ‘efficient district heating/district cooling’ within the meaning of the relevant directive[24], which can significantly increase the amount of national and EU funds serving development, and reduce the energy consumption of buildings and GHG emissions. Pursuant to the directive, district heating/district cooling is deemed to be efficient if operating with at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat, or 50 % of a combination of such energy resources.

2.2. Dimension of energy efficiency

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

Hungary's energy efficiency target is to ensure that the country's final energy consumption does not exceed the value of 2005 in 2030 (785 PJ), either. If final energy consumption exceeds the level for 2005, such increase should exclusively derive from carbon neutral energy resources. The reduction of energy consumption is obviously a priority, but energy consumption in either the industry or in transport should not be limited to this end in case of economic growth. We aim to ensure that GDP growth exceeds the rate of the increase in energy consumption at a growing rate.

Based on the method presented in the National Energy Efficiency Action Plan, the cumulative end-use energy saving obligation for the 2014–2020 period amounts to 167.5 PJ. Eurostat introduced the 2020-2030 final energy indicator to calculate the energy efficiency targets of Member States based on a single methodology and to allow comparison with the previous programming period. Based on the above method, the cumulative final energy consumption savings obligation relating to the 2021–2030 period, not including reduction options, equals 331.23 PJ, which can be achieved with steady annual savings of 7 PJ, assuming steady 0.8 % annual savings and policy measures spanning the entire period, compared to the trajectory calculated without these.

Fulfilment of the energy saving target prescribed in the Energy Efficiency Directive[25] is a serious challenge in all areas. The energy efficiency programmes and measures introduced in the 2014-2020 period result in approximately 3-4 PJ final energy savings annually for final customers, thus it is necessary to roughly double current savings in the next period.

ii. Milestones relating to 2030, 2040 and 2050, not involving commitments; measurable result indicators drawn up on a national level and their contribution to the EU energy efficiency objectives, once these are included in the trajectories determined in long-term strategies aimed at the renovation of privately and publicly owned residential and non-residential buildings, in harmony with Article 2(a) of Directive 2010/31/EU

[24] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

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

The drawing up of the long-term energy efficiency roadmap relating to Hungary's building stock is in progress. The drawing up of the roadmap may commence after the approval and processing of Commission guidelines concerning Article 2(a), enacted after the amendment of Directive 2010/31/EU in 2018. The renewed survey of the national building stock, based on the building certification method modified in consideration of new international standards, is expected to be carried out in 2020.

In accordance with our Union obligations[26], we are **drawing up and implementing a long-term renovation strategy.**

According to data of the National Building Energy Performance Strategy (NBEPS) in effect, approximately 40 % of primary energy is consumed in buildings, with residential buildings accounting for the largest share of about 60 %.[27] According to Eurostat[28] data, the household sector's share of final energy consumption is some 35%, primarily from the energy use of buildings.

According to data of the HEA relating to household energy consumption[29], much (three fourths) of the energy consumption of Hungarian households is related to heating, most of which is supplied with natural gas (retail consumption accounts for about half of national gas consumption). The production of domestic hot water, lighting and use of electronic devices (with a share of one tenth, respectively) are two other areas with high energy consumption. Thus, in relation to residential buildings the biggest potential for energy savings lies in the modernisation of buildings and heating systems. **We estimate that the modernisation of the residential building stock aimed at improved energy efficiency and a growing transition to alternative heating methods can replace up to one quarter of natural gas imports (annual natural gas consumption of ~2 billion m^3).** Retail modernisation projects will be implemented on a market basis, within the framework of the planned energy efficiency obligation scheme, thus most of the costs thereof will not be borne by households or the State budget.

The **deep renovation of 3 % of the floor area of the central government building stock annually** is also a strategic objective.

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[26] Directive 2010/31/EU on the energy performance of buildings and Directive (EU) 2018/844 amending Directive 2012/27/EU on energy efficiency; Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

[27] National Building Energy Performance Strategy (2015), p. 24; https://www.kormany.hu/download/d/85/40000/Nemzeti%20E%CC%81pu%CC%88letenergetikai%20Strate%CC%81gia%20150225.pdf

[28] https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

[29] http://mekh.hu/download/5/13/90000/8_1_Haztartasok_felhasznalasa_eves.xlsx

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

A key objective is sustainable and climate-friendly energy management even by maintaining and further increasing industrial output. The competitiveness of energy and GHG intensive industrial activities is guaranteed by their ability to not exceed the unit energy consumption and GHG emissions of their European industrial competitors. In parallel with maintaining the existing energy intensive industrial sectors, from an energy strategic point of view future industrial investments should be made in low energy and GHG intensive, high-tech industrial sectors that support the sustainable and competitive development of the Hungarian economic structure.

To reduce increasing energy consumption in transport, it is essential to develop and increase the use of public transportation, and to offer the carriage of goods by rail as a realistic option for freighting. Owing to the high useful efficiency of electric motors, the spread of electromobility clearly leads to energy savings for final customers. With the implementation of the Green Bus Programme – aimed at the greening of local transport – by 2030 only environmentally friendly electric buses will be used in long distance public transport.

Point v. of Chapter 2.1.2 presents the district heating targets.

2.3. Dimension of energy security

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

The high share of imports is a determining factor in the energy supply of Hungary (Chapter 4.4), which carries serious risks for the security of supply and prices. Since Hungary defines the security of supply as part of national sovereignty, the Government of Hungary assigns a priority to **strengthening energy independence and reducing import dependency.** In the course of reducing dependence on energy imports and strengthening geopolitical independence, Hungary places emphasis on **improving energy efficiency** (detailed in Chapter 2.2 on energy efficiency)**, maximising the sustainable exploitation of** (conventional and unconventional) national hydrocarbon reserves and **renewable resources** (information provided in Chapter 2.1.2), and on **maintaining the level of nuclear capacities**. Hungary's security of supply can be further improved by **strengthening market integration** and **developing a diversified supply portfolio**.

Electricity market

Hungary aims to establish an electricity sector that can simultaneously guarantee the security of supply, is consumer and climate-friendly, encourages the introduction of new, flexible products on the market and can continuously integrate innovative solutions. **The consumer-oriented electricity sector should offer sustainable, affordable energy costs and a large degree of freedom of choice to Hungarian consumers.**

Main electricity market objectives:

(i) Objectives relating to capacity compliance and the reduction of import dependency:

- ***Ensuring reliable, flexible and diversified national capacities:***

- To maintain the current high level of the security of supply it is necessary to ensure that **sufficient capacities remain available to satisfy domestic peak demand** in consideration of decommissioned and commissioned power plants, and growing cross-border capacities.

- It is essential to ensure that the Hungarian electricity system (including consumers) **possess dispatchable capacities guaranteeing secure operation and system balancing** (e.g. production capacities ensuring flexibility, new types of flexibility services, DSR solutions, energy storage). It is important to **ensure sufficient domestic reserve production capacities** to manage extreme market conditions.

- As a general principle, **import capacities ensuring flexibility and manoeuvering room for the Hungarian electricity system should also be available** (preferably from as many directions as possible).

- In relation to capacity compliance it is also necessary to **further decarbonise the electricity mix.**

- ***Import capacities and import dependency:***

- Maintaining and increasing national production capacities is essential for the security of supply; if these are successfully managed, **it will be possible to reduce the share of electricity imports – higher than 30 % – to under 20 % by 2040.**

- Beyond the reduction of import dependency **we also aim to further diversify import opportunities by increasing cross-border capacities.** Although Hungary is significantly exceeding the 15 % Union target, it would be justified to increase the cross-border capacities of its electricity grid to 60 % by 2030.

(ii) The establishment of an infrastructure, a regulatory and market environment supporting the integration of renewables, and ensuring the cost-effectiveness of integrating renewable investments in line with the above, is also a priority. It is very important for the amount of aid to match the decline in investment costs in the future, because if aid levels commonly applied at the end of 2018 are ‘frozen’, the aid requirement would double by 2030 in comparison to cost-effective funding as a combined consequence of excessive unit funding and substantial new capacities.[30]

To ensure cost-effective levels of aid, in the future aid within the REAS framework will only be available through renewable capacity tenders; production aid will be available within the conventional

[30] REKK (2018): Cost estimate of achieving the share of renewable energy by 2030. (https://rekk.hu/downloads/projects/2019_REKK_NEKT_megujulo_final.pdf)

feed-in system only for experimental technologies and model projects.[31]

(iii) **The electricity grid should be prepared for the growing spread of decentralised capacities.** Beyond large power plants and energy systems under centralised control, the number of distributed, household-scale power plants (HSPP) is rapidly increasing (potentially replacing the former plants). This trend poses challenges for the energy networks as well, as these need to be adequately managed.

(iv) **Hungary aims at effectively exploiting innovation opportunities.**

(v) **Strengthening integration of electricity and gas markets and coordinating the operation of gas and electricity markets further bolsters Hungary's security of supply.**

Gas market

The benefit of reduced import dependency and import diversification for the security of supply is most obvious in relation to natural gas, as it accounts for the largest share of final energy consumption in Hungary (32.5 % share in 2017), also in consideration of the consumed quantity of electricity and heat generated with natural gas. In recent years national production covered approximately 20 % of consumption, therefore around 80 % had to be imported to Hungary. For this reason it is essential to establish a sustainable economic and regulatory environment on the gas market that preserves the results of the reduction of overhead costs and guarantees the security of supply in the long term. **Continuous compliance with the N-1 rule** can guarantee Hungary's energy security. (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.) The **N-1 value should in each case reach 120 %.**

Main gas market objectives:

(i) **Reduction of import dependency:** As a result of a decline in gas consumption and growing domestic production, Hungary's share of gas imports will decline to around 70 % by 2030 and is expected to decrease further below 70 % after 2040.

- ***Consumption reduction milestones:***

- As a result of energy efficiency investments and growing use of renewable technologies, by 2030 gas consumption for heating may be 2 billion m^3 less than the current consumption level.
- Consumption of natural gas for district heat generation may fall by 50 %.

- ***Milestones relating to the increased use of domestic resources:***

- **Increased production of natural gas:** by continuing to guarantee the predictability of the concession

[31] In the first half of 2019, the existing provisions of the FIS and the REAS, reducing aid effectiveness, were modified in two stages.

scheme, enhancing the flexibility of the system and improving the efficiency of non-standard (unconventional) gas production we can offset the exhaustion of production inventories with the encouragement of new extraction projects, thus under an ideal scenario we can expect to increase domestic conventional natural gas production up to even 2.4 billion m^3 by 2030.

- **Use of alternative gas resources:** according to estimates, by 2030 the Hungarian **biogas potential** could offer a realistic possibility for substituting 1 % of Hungarian natural gas consumption, amounting to around 85 million m^3 annually. An additional increase is expected by 2040, raising the Hungarian biogas potential to 100 million m^3. In addition to biogas, Hungary also considers 'clean' **hydrogen** to be an alternative; we also aim to examine means of feeding hydrogen into the natural gas network.

(ii) The biggest challenge in the short term is to manage the one-sided dependence on Russian sources and the route related risk caused by the developments in Ukraine. As a key objective**, the remaining annual import requirement of approximately 6.2 billion m^3 should be met with sources as diverse as possible and through diversified routes in 2030.** To this end Hungary **aims to implement an infrastructure ensuring access to four independent gas import sources** (gas traded on the Russian, LNG, Romanian and Western European markets).

(iii) **It is also necessary to establish access to LNG sources to further enhance flexibility.** This would not only enhance the flexibility of the Hungarian gas sector **but also strengthen the security of supply by creating a more favourable bargaining position on international gas markets, resulting in more affordable gas prices for Hungary and Hungarian consumers.** (Details in point i. of Chapter 2.4.3.)

(iv) The security of supply can be further enhanced by strengthening **market integration**.

(v) **Hungary aims to maintain the largest possible transit quantity within the national natural gas transmission system[32],** as strengthening transit flows in recent years have continuously supported the decline of domestic transmission tariffs.

(vi) Upon a sharp decline in natural gas consumption or in the volume of natural gas distributed within the network it may be necessary to also **rationalise the infrastructure** (point ii. of Chapter 2.4.2).

Oil market

Despite the high share of imports, the **efficiently operating global and regional oil market**, the availability of transmission alternatives (pipelines or rail/road), alternatives to pipeline supply (Friendship and Adria pipelines) and the emergency oil stockpiling system **guarantee efficient pricing and a high level of a**

[32] The possible significant decrease in transits would entail the risk of rising gas prices including higher network access fees.

security of supply on the Hungarian market. The security of supply is further strengthened by the dominant regional market position of Magyar Olaj- és Gázipari Nyilvánosan Működő Részvénytársaság ('MOL Nyrt.') in which the State has a minority shareholding.

Maintaining import dependency on a manageable level remains justified. Although an increase in domestic petroleum concessions is expected in the medium term (which may reduce the volume of Hungarian oil imports by up to 10 percentage points), their number is expected to stay constant due to the gradual exhaustion of the fields in the long term. Therefore the key to managing Hungarian import dependency is to reduce the rise in consumption, which is also essential for meeting decarbonisation targets. On the oil market a **key goal is therefore to maximise the increase of the use of petroleum products in transport at 10 % by 2030.**

Coal market

The share of coal in Hungarian power generation has significantly declined. At the present time only one coal-fired large power plant – the Mátra Power Plant – operates in Hungary, extracting lignite in Visonta and Bükkábrány. As the second largest power plant of Hungary, it accounts for 15 % of total Hungarian power generation.

The **Mátra Power Plant plays an important role not only in energy production but also on the labour market:** it is the only dispatchable large power plant in the eastern half of Hungary and is also a major employer, considering that most of the inhabitants of the districts concerned (Gyöngyös and Mezőkövesd) directly or indirectly work in the industry or at related undertakings (10 000 jobs are directly or indirectly related to the power plant, with 27 000 affected family members). However, the power plant is also the largest CO_2 emitter of Hungary, **accounting for approximately 50 % of** CO_2 **emissions in the energy production sector and 14 % of total national** CO_2 **emissions.** The power plant and the roughly 100 000 households in the region heating with lignite also significantly contribute to concentrations of other air pollutants in Hungary: 36.2 % of SO_2, 13.71 % of Hg and 4.48 % of NO 2.[33]

Based on the power plant's role in Hungarian electricity supply it is necessary to prepare for changes in the operation of the electricity system, the replacement of some capacities with other technologies, the retraining of workers in the affected region and for maintaining various industrial activities relying on the power plant's technological systems. **In addition, taking into account the substantial Hungarian lignite reserves, we plan to ensure the availability of lignite production as a strategic reserve.**

Achievement of the goals can be guaranteed **by drawing up a regional decarbonisation strategy and action plan** involving stakeholders. EU funds are also available for implementing the decarbonisation programme. This sectoral and regional decarbonisation transition is composed of the following elements:

[33] Emissions data for 2017.

- The Mátra Power Plant had a substantial social-economic impact within the immediate region, including the creation and retention of jobs, the indirect creation of jobs by related undertakings, and local tax revenues. Based on the above, in the course of revitalisation particular attention should be paid to diversifying the region's economy and labour market and to a just transition by making use of the future utility of the site and the power plant's role within the value-added chain.
- Most of the 100 000 households supplied with retail lignite based heating are located in the region of the Mátra Power Plant. In the course of revitalisation and the transition we aim to replace household heating energy with clean energy and to reduce energy consumption. Similarly to the whole of Hungary, in the Mátra Power Plant's region we also plan to install power generating PV panel systems to partially supply local electricity consumption.
- The large site of the Mátra Power Plant may also be suitable for multi-purpose utilisation going beyond energy functionalities. Such use includes industrial park expansion and diversification opportunities, expansion of agricultural or other storage and logistics functions, conservation and presentation of the cultural heritage of mining, habitat reconstruction serving tourism and nature conservation purposes, and natural water conservation measures.

Nuclear safety

A key objective is to maintain the high level of safety in the peaceful use of nuclear energy.

Improving cybersecurity

With the spread of IT solutions and digitalisation, and the growing application of artificial intelligence the number of cyber-attacks and risk factors arising from the interdependence of information systems is expected to increase in all economic segments. The activities of attackers (script-kiddies[34], cybercriminals, State-organised attacker groups, APT[35] groups) with diverse backgrounds and motivation are increasingly reaching the energy sector as well. The combined use of new, modern and legacy technological solutions is also a challenge. Cybersecurity should therefore become a key element of national security. The combined use of new, modern and legacy technological solutions is also a challenge to be managed.[36]

Improvement of the labour market in the energy sector

Based on feedback from the industry, the shortage of specialists and competence observed in the energy sector is a growing problem, *inter alia*, in satisfying increasing network development and connection demand arising in relation to real estate development and renewable energy production investments. Hungary may face

[34] Script-kiddies: 'cybercriminals' with average computer skills. Often they cause damage by using support programs (scripts) or software developed by others. They are often also commonly called hackers.

[35] Advanced Persistent Threat

[36] Commission Recommendation (EU) 2019/553 on cybersecurity in the energy sector.

similar problems during the future operation of the new units of the Paks Nuclear Power Plant, therefore it is necessary to mitigate the problem of lacking specialists and competence.

ii. National objectives for achieving improvement in the following fields: increased diversification of energy sources and of energy supply originating from third countries for the purpose of increasing the resilience of regional and national energy systems

Taking into account that Article 4(c) of the Governance Regulation also covers this field, the reply is included in the reply under point (i).

iii. Where applicable, national objectives aimed at reducing dependency on energy imports from third countries to increase the resilience of regional and national energy systems

Taking into account that Article 4(c) of the Governance Regulation also covers this field, the reply is included in the reply under point (i).

iv. National objectives aimed at increasing the flexibility of the national energy system, in particular by means of deploying domestic energy sources, demand response and energy storage

Hungary aims to increase the share of renewable resources within final energy consumption. Chapter 2.1.2. presents goals defined in relation to the use of Hungarian renewable sources of energy.

Electricity market

The penetration of renewables can only be achieved in parallel with the development and 'enhanced intelligence' of transmission and distribution networks suitable for the integration of new, more efficient technological solutions, and the development of distribution network operation, as a decentralised intervention capability, and its transparent market mechanisms (flexible distribution market) network.

The availability and use of dispatchable capacities necessary for reliable power supply in the system operation of the transmission and distribution networks is a key strategic task requiring close cooperation between all market participants, licence holders and regulators.

Since **short-term fluctuations in weather-dependent production are currently mainly balanced with gas-fired power plants**, it is necessary to prevent a decline in the necessary amount of dispatchable power plant capacities. The **spread of new, innovative solutions – such as energy storage and demand side responses (DSR solutions) – should also be enabled.** The active participation of consumers on the energy market allows them to control their overhead expenses and to potentially contribute to maintaining system balance through the availability of flexibility services. Opportunities can be exploited with digital and smart devices. As regards energy storage, Hungary plans to encourage use of energy storage systems to integrate renewable energy production.

Development of regulated energy markets (operating mainly within a short time frame, supporting system flexibility) and **of additional means of electricity interconnection, and enhancement of market integration** is also justified to improve the national energy system's operation and flexibility.

Gas market

Based on domestic consumption and gas market trends, the amount of emergency natural gas stockpiles is prescribed by decree by the minister in charge of energy affairs, under authority granted by Act XXVI of 2006 on the emergency stockpiling of natural gas. In case of a supply crisis, the minister orders the sale of natural gas reserves to buyers and at the price determined in his decree. As regards natural gas, Hungary's method of preparation for possible supply problems remains unique in Europe to this day. Additional goals are not justified in this regard. In relation to natural gas storage, **our aim is rather to strengthen competition on the gas storage market and the regional role of Hungarian facilities.** Maintaining natural gas transit flows is a key issue in relation to storage capacities as well.

In addition to ensuring storage, flexibility may also be enhanced with increased use of biogas/biomethane and alternative natural gas sources, and access to LNG sources, in particular. Ensuring a reverse-flow Croatian-Hungarian cross-border pipeline is also key in relation to the latter. Access to the LNG terminal planned on the island of Krk, namely, would also allow Hungary to import gas from Croatia.

Oil market

Requirements relating to minimum emergency petroleum stocks are based on Council Directive 2009/119/EC and the Agreement on an International Energy Programme drawn up within the framework of the International Energy Agency (IEA). Based on the above, the emergency stockpiling of imported oil and petroleum products is regulated by Act XXIII of 2013. The system is functioning normally, therefore Hungary considers it unnecessary to define additional goals.

2.4. Dimension of the internal energy market

2.4.1. Electricity interconnectivity

With the exception of Slovenia, cross-border capacities are available from all neighbouring countries (see details in Chapter 4.5). The transfer capacity of cross-border high-voltage lines reaches around 50 % of Hungarian gross installed capacities, which is significantly higher than the 15 % target targeted by the EU. Hungary nevertheless plans to increase the share of electricity interconnections to approximately 60 % by 2030, as the increase of existing cross-border capacities and the establishment of interconnection directed toward Slovenia (PCIs presented under point i. of Chapter 3.4.2) remains justified because an adequately interconnected energy network operated with neighbouring countries improves the national security of supply; in the event of any disruption within the national system, namely, the risk of disruptions in service in large areas is reduced. The establishment of market interconnections may also reduce the cost of system operation through the more efficient use of balancing capacities in cooperation with neighbouring countries.

(i) *The level of electricity interconnectivity the Member State aims for in 2030 in consideration of the electricity interconnection target of at least 15 % by 2030, together with a strategy that determines the rate applicable from 2021 in close cooperation with the Member States concerned, taking into account the 2020 interconnection target of 10 % and the following indicators of the urgency of action:*

(1) *Price disparities between Member States, regions or bidding zones on the wholesale market, exceeding the limit exclusive of the 2 EUR/MWh commitment;*

Based on the report submitted by the Commission Expert Group in November 2017 on the 2030 electricity interconnection targets mandated by the Electricity Coordination Group, it is necessary to check whether a margin of at least 2 EUR/MWh exists between the Hungarian and neighbouring bidding zones; if such margin exists, based on the report it is necessary to assess the need for potential development. Based on the analyses carried out by MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság (MAVIR Zrt.) – responsible for operating the Hungarian electricity system – in the course of drafting the 2018 Ten-Year Network Development Plan (TYNDP-2018), with an outlook to 2030, a margin exceeding 2 EUR/MWh exists with Austria, Romania, Slovakia and Serbia.

(2) *Nominal transfer capacity of interconnectors below 30 % of peak load;*

(3) *Nominal transfer capacity of interconnectors below 30 % of installed renewable energy generation.*

Each new interconnector shall be subject to a socio-economic and environmental cost-benefit analysis and implemented only if the potential benefits outweigh the costs.

In relation to above points 2 and 3, the calculation methodology defined in above point (1) is based on the following pillars:

(1) nominal transfer capacity / peak load, 2030, and

(2) nominal transfer capacity / installed renewable production capacity, 2030.

According to the recommendation of the expert group, if any of the above indicators do not reach 60 % in a given country, the establishment of additional cross-border lines should be considered.

In the case of Hungary, depending on the scenarios provided in the Ten-Year Network Development Plan for the year 2016 (TYNDP-2016)[37] of MAVIR Zrt., the value of the first indicator is between 197 % and 218 %, that of the second indicator is between 157 % and 852 %.

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[37] https://www.mavir.hu/web/mavir/halozattervezes

Based on market simulation tests, a dual-system 400 kV connection (with one installed system) between Debrecen and Oradea is a potentially recoverable capacity increasing investment. This transmission line has been included in the network development plans prepared by MAVIR Zrt. for years as an investment proposed for implementation.

2.4.2. Energy transmission infrastructure

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

The energy transmission infrastructure must at all times meet security requirements of energy supply, it is therefore necessary to prioritise development projects ensuring the secure operation of energy networks and establish a balance between energy supply and demand.

Electricity market

Hungary assigns a priority to implementing electricity projects included on the (fourth) list of PCIs[38] currently in effect, also affecting Hungary.

These projects are as follows:

(i) Establishment of new 400 kV cross-border transmission line between Gabčikovo (SK) and Gönyű (HU) and Veľký Ďur (SK), upgrade of Gönyű substation and implementation of necessary cross-connections;

(ii) Establishment of 400 kV cross-border transmission line between Sajóvánka (HU) and Rimavská Sobota (SK), upgrade of Sajóvánka substation;

(iii) Interconnection of Žerjavenec (HR)/Hévíz (HU) and Cirkovce (SI);

All three projects are part of the following: Priority corridor North-South electricity interconnections in Central Eastern and South Eastern Europe ('NSI East Electricity').

The 2019 report[39] of the Agency for the Cooperation of Energy Regulators (hereinafter 'ACER') provides information on the above electricity projects of common interest and on their progress.

(iv) The **'Intelligent grids: Danube InGrid'** Hungarian-Slovakian project is also worth noting, which is part of the 'Deployment of smart grids' thematic priority axis.

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[38] List of European projects of common interest: (https://ec.europa.eu/energy/sites/ener/files/c_2019_7772_1_annex.pdf)

[39] ACER (2019): Consolidated Report on the progress of electricity and gas projects of common interest. 2019. Ljubljana. 27.06.2019. (https://acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/CONSOLIDATED%20REPORT%20ON%20THE%20PROGRESS%20OF%20ELECTRICITY%20AND%20GAS%20%20PROJECTS%20OF%20COMMON%20INTER EST%20-%202019.pdf

Natural gas market

Hungary assigns a priority to implementing the natural gas projects – with Hungarian relevance – included on the (fourth) list of PCIs[40] in effect at the time of drawing up the NECP. These projects are as follows:

(i) Phased capacity increase of the cluster along the (Bulgaria) – Romania – Hungary – Austria reverse flow corridor.

It is currently called the '**ROHUAT / BRUA'** project.

The project is aimed at enabling the transmission of 1.75 billion m^3/year and 4.4 billion m^3/year of natural gas in phase 1 and phase 2, respectively, and the exploitation of new resources in the Black Sea. Phases:

(a) **ROHU (AT) / BRUA – Phase 1:**

Development of the transfer capacity in Romania between Podișor and Recas, including the establishment of a new pipeline, metering installation and three new compressor stations in Podișor, Bibesti and Jupa.

(b) **ROHU (AT) / BRUA – Phase 2:**

- Városföld compressor station (HU);
- The project involves the increase of transfer capacity to 4.4 billion m^3/year from Recas, Horia in Romania to Hungary, and upgrade of the compressor stations in Podișor, Bibesti and Jupa;
- On the Black Sea coast: Construction of the Podișor (RO) pipeline for transmission of gas from the Black Sea;
- Implementation of reverse flow in the Hungarian section of the Romanian-Hungarian cross-border natural gas transmission pipeline. Upgrade of the compressor station located in the municipality of Csanádpalota (HU).

(ii) **Hungary-Slovenia-Italy reverse flow gas corridor project** that offers substantial regional potential for participating countries. (Interconnection of Hungary – Slovenia – Italy (interconnection of Nagykanizsa (HU) – Tornyiszentmiklós (HU) – Lendava (SI) – Kidričevo (SI) – Ajdovščina (SI) – Šempeter (SI) – Gorizia (IT))

(iii) Interconnection between Poland, Slovakia and Hungary with related internal enhancements, including the following PCI projects:

(a) Interconnection of Poland and Slovakia;

(b) North-South Gas Corridor in Eastern Poland.

(iv) **Development and upgrade of Slovakian-Hungarian interconnecting transfer capacities**, expansion of

[40] List of European projects of common interest: (https://ec.europa.eu/energy/sites/ener/files/c_2019_7772_1_annex.pdf)

Szada compressor station.

(v) Construction of LNG terminal planned on the Croatian island of Krk and the related evacuation pipeline toward Hungary and beyond. Related PCI projects:

(a) Development of LNG terminal on Krk (HR) (phase 1: capacity: 2.6 billion m^3 / year), and implementation of Omišalj – Zlobin (HR) connecting pipeline;

(b) **Compressor station (1) for the Croatian gas transmission system.** (Project promoter: Plinacro Ltd).

(vi) Implementation of the LNG terminal in Gdansk, Poland

These projects are part of the following: Priority corridor for north-south gas interconnectors in Central-Eastern and South-Eastern Europe ('NSI East Gas').

The 2019 ACER report[41] provides information on the projects and their progress.

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

Electricity projects

The document 'Network Development Plan of the Hungarian Electricity System, 2017' sets out other envisaged investments, not included on the list of PCIs. The plan – published in English and Hungarian – can be accessed by the public on the website[42] of MAVIR Zrt.

Natural gas projects

(i) Projects covered by the 'Ten-year Network Development Plan' of FGSZ:

On 4 October 2019, FGSZ Földgázszállító Zrt. (hereinafter 'FGSZ') took over the operation of the 92 km natural gas transmission pipeline connecting Hungary and Slovakia from Magyar Gáztranzit Zrt. (hereinafter 'MGT'); FGSZ is now operating the entire high-pressure, roughly 6 000 km long natural gas transmission pipeline system. Firstly, the single transmission system operator (TSO) model was implemented in relation to the control and operation of the Hungarian high-pressure natural gas transmission pipeline system. Secondly, FGSZ continues to carry out its TSO tasks relating to the interconnected natural gas system.

Upon conclusion of the transaction the shares of MGT were also acquired by FGSZ. Government Decision

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[41] ACER (2019): Consolidated Report on the progress of electricity and gas projects of common interest – 2019. Ljubljana. 27.06.2019. (https://acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/CONSOLIDATED%20REPORT%20ON%20THE%20PROGRESS%20OF%20ELECTRICITY%20AND%20GAS%20%20PROJECTS%20OF%20COMMON%20INTER EST%20-%202019.pdf

[42] https://www.mavir.hu/documents/10258/15454/HFT_2017.pdf/8826edb7-d17a-463e-8983-29b616337f76

No 1366/2019 of 25 of June 2019 regulates the terms of purchasing the business unit of MGT, including, *inter alia*, the transfer of employees and equipment, and the purchase price.

FGSZ, as TSO, has drawn up its Ten-year Development Plan for the year 2018 relating to the Hungarian interconnected natural gas system based on proposals received from system operators involved in operating the high-pressure natural gas transmission system, and on other relevant information.

Projects planned for implementation between 2019 and 2022:

- Projects proposed for unconditional implementation during the next three years[43] – irrespective of the outcome of the HU-SK-AT[44] and RO-HU[45] projects – to ensure the security of supply:
- Development aimed at implementing automatic reversal in Balassagyarmat, Szada,
- Upgrade of Balassagyarmat metering installation to 800 em^3/h,
- Reconnection in Gödöllő for 800 em^3/h capacity metering,
- Security of supply in North-Eastern Hungary: Conversion of hubs at Városföld, Hajdúszoboszló, Nemesbikk, Beregdaróc.
- Projects proposed for conditional implementation in the plan during the next three years:

- Phase II of Romanian-Hungarian (RO-HU) transmission corridor, depending on success of the Open Season procedure
    - Upgrade of Csanádpalota compressor station with a 4.5 MW machine unit + metering installation upgrade,
    - Upgrade of Városföld compressor station with a 5.7 MW unit + hub conversion,
    - Upgrade of Mosonmagyaróvár compressor station (5.4 MW),
    - Establishment of Dorog compressor station – 3 x 5.7 MW,
    - Construction of new line between Kozármisleny and Kaposvár in DN400 or DN600 size, depending on the outcome of the Hungarian-Slovenian (HU-SI) capacity increase procedure;
    - Phase II of Transdanubian odorisation conversion.
- HU-SK-AT transmission corridor depending on the success of the capacity increase procedure under Commission Regulation (EU) 2017/4592
    - Establishment of Szada compressor station – 2 x 7.5 MW.

[43] Initial year is the plan's year of approval.

[44] Hungary – Slovakia – Austria

[45] Romania – Hungary

- Investments necessary for meeting the reverse flow obligation prescribed in Regulation (EU) 2017/19383 and implementation of reverse flow with Member States of the Energy Community as well.
    - o Unconditional projects: Implementation of reverse flow transmission between Serbia and Hungary along the existing lines, with unchanged capacity (Kiskundorozsma metering installation + hub connections);
    - o Conditional implementation, depending on the success of the long-term capacity reservation procedure:
        - ▪ Upgrading of the Serbian-Hungarian (reverse flow) transmission route with increased capacity. (The drawing up of the auction terms of the line is under way.)
        - ▪ Conversion of the capacity from Hungary to Ukraine into non-interruptible capacity.
- Establishment of new cross-border capacity depending on the success of the capacity increase procedures under Commission Regulation (EU) 2017/459:
    - o Establishment of new Hungarian-Slovenian reverse flow cross-border capacity in two phases
        - ▪ with a capacity of 50 em^3/h (0.44 billion m^3/year),
        - ▪ with a capacity of 230/300 em^3/h (2.0/2.6 billion m^3/year)
        - ▪ in the procedure under Commission Regulation (EU) 2017/459.

- **Project proposed for conditional implementation in the 4-10th year:** Establishment of uninterruptible capacity in the Hungary > Austria direction depending on the success of the procedure under Regulation (EU) 1938/2017.

(ii) Goals planned in relation to the utilisation rate of Hungarian gas pipelines:

To **increase the utilisation rate of energy infrastructures, reduce systemic costs and implement the climate-friendly transformation of the energy system, Hungary assigns a priority to implementing the most favourable heating and infrastructure solutions with the phasing out of energy infrastructures built in parallel,** as regulated by Government Decision No 1772/2018 of 21 December 2018. (Further information is provided in point vi. of Chapter 3.2.)

2.4.3. Market integration

i. National objectives related to other aspects of the internal energy market such as increasing system flexibility, in particular related to the promotion of competitively determined electricity prices in line with relevant sectoral law, market integration and coupling, aimed at increasing the tradeable capacity of existing interconnectors, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-

dispatching and curtailment, and real-time price signals, including a timeframe for when the objectives shall be met

Regional market integration facilitates the implementation of efficient trade flows, the balancing of demand and supply volatility between countries and improves the security of supply. The **increase of cross-border capacities** and the **establishment of harmonised rules allowing efficient flows of electricity and natural gas between countries** are the two prioritised objectives of energy market integration in the region. The drawing up of regulations enhancing the efficiency of wholesale and balancing markets should be continued; the framework of the above is provided by the implementation of European operational and operating regulations. Beyond the foregoing it is also necessary to **promote projects enhancing the regional role and liquidity of Hungary's regulated electricity and gas markets.**

Electricity market

(i) **It is important to prevent outages in flexible capacities and to improve the capacity for flexibility.** (Taking into account that flexibility is also justified for ensuring the security of supply, Chapter 2.3 also discusses this topic, and point ii. of this chapter is relevant in relation to energy storage and demand side responses.)

(ii) **Facilitating establishment of independent aggregators:** the aggregation of consumers belonging to various consumer segments also plays an important role in exploiting consumer-side flexibility. **Local energy communities** represent a special form of aggregation based on renewable energy production. They contribute to ensuring the local consumption (e.g. within a transformer zone) of produced energy and that production fluctuations do not load the distribution network.

(iii) **Preparation of the electricity network for the growing spread of decentralised capacities.** (This is also a relevant goal in relation to the security of supply. Further information is provided in Chapter 2.3.)

(iv) **Increase of cross-border capacities:** Although the capacity of high-voltage cross-border lines reaches 50 % of Hungarian gross installed capacities, and Hungary can import electricity from all neighbouring countries, with the exception of Slovenia, the relatively limited capacities with Austria and Slovakia still limit imports of cheaper electricity. Due to limited cross-border capacities, the price of Hungarian wholesale electricity remains higher than in neighbouring countries. Based on a broad comparison in Hungary's region, Hungarian wholesale prices are relatively high (details relating to price trends are provided in Chapter 4.5.3). Further strengthening of regional market integration is therefore justified in this regard as well.

(v) **Market coupling**: beyond the increase of cross-border capacities, it is also necessary to increase market coupling and to improve the efficiency of operating coupled markets. To this end, we aim to further enhance the coupling of both intra-day and day-ahead markets on the electricity market, and to efficiently operate these markets. This, however, requires the coordinated determination of transfer capacities and their availability for trading.

(vi) **Encouragement of the market launch of innovative energy supply solutions.**

Gas market

As a result of regulatory changes and infrastructure investments implemented in the past decade, a diversified supply model has evolved on the basis of multiple sources of supply. With the exception of Slovenia, Hungary has established gas network connections with all neighbouring countries. The expansion of import opportunities and the availability of alternative trade routes significantly contributed to the decline in domestic gas prices (see Chapter 4.5.3. for details on price trends).

In the future Hungary aims to facilitate the operation of an integrated gas market, enabling the sustainable reduction of consumer energy costs, in accordance with relevant EU directives and regulations. The increase and optimisation of Hungary's natural gas purchase options offers is the biggest guarantee for achieving the above goal, and also guarantees the security of supply. The above is also crucial for the implementation of infrastructure development.

In the short term, Hungary's key objective is the management of risks that threaten these favourable conditions due to the uncertainty of the route of Russian deliveries to Europe.

The efforts aimed at ensuring the security of supply - presented in point i. of Chapter 3.3 - also advance regional gas market integration through the diversification of sources and routes. Although only a minimal quantity of gas can currently be imported from Croatia, Romania and Serbia due to lagging development in the partner countries, a real reverse flow interconnection from Romania[46] and Croatia is already under implementation, and there are negotiations under way for ensuring access to Russian sources from Serbia expected to become available from 2021.

Access to the LNG terminal planned on the island of Krk renders the establishment of potential gas imports from Croatia particularly important for Hungary. The above option, namely, would provide access to potentially competitively priced gas sources (with global prices similar to those of oil) for traders involved in supply in Hungary. This would also bolster Hungary's bargaining position vis-à-vis Russia in negotiations on import contracts after 2021. Integration of the two countries' gas markets would significantly contribute to improving the competitiveness of Croatian LNG, which in practice would lead to the elimination of cross-border tariffs. Negotiations on market integration – which may also contribute to the improved use of Hungarian storage capacities[47] – commenced in July 2019. To ensure implementation of the Croatian LNG

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[46] In the first phase of upgrading the Romanian-Hungarian interconnection – expected in the second half of 2020 – an uninterruptible transfer capacity of 896 678 kWh/h, i.e. 1.75 billion m^3 annually, will become available from Romania to Hungary as well.

[47] Storage capacity could become an important pillar of Croatian-Hungarian market coupling.

project, consultations are also held on acquisition of a Hungarian stake.

The promotion of gas market integration in the region is a strategic goal going beyond the LNG project; a market free of cross-border tariffs, operating with single wholesale price signals can lead to more effective competition, lower prices and greater security of supply. We are therefore also exploring market coupling options with Slovakia, Slovenia, Austria and Romania.

In parallel with the promotion of market integration, Hungary also aims to further strengthen the liquidity and regional price indicator function of CEEGEX, the Hungarian gas exchange. It is additionally aiming to support natural gas market integration by devising a regional sales model for its storage capacities.

Sector coupling

As regards integration, Hungary also aims to promote the interconnection of the production processes of various forms of energy (electricity and heat, and fuels). The gas and electricity markets are already connected at a number of points, therefore mainly the coordination of the two markets' operating cycles and regulatory framework is a priority.

(Additional information on sector coupling is provided in point i. of Chapter 4.5.3.)

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 time-frame for when the objectives are to be met

To ensure cost-effective levels of aid, in the future, aid within the REAS framework will only be available through technology-neutral renewable capacity tenders (details on the REAS scheme are provided in Chapter 3.1.2); production aid will be available within the conventional feed-in system only for experimental technologies and model projects. The first successful REAS tender launched in the autumn of 2019 demonstrated that the amount of necessary aid is adjusted to declining investment costs. The tender launched in the autumn of 2019 can ensure the adjustment of the amount of aid to decreasing investment costs.

As regards the effective integration of renewables, a greater contribution of renewables producers to the reliable operation of the system is a key factor in the future.

To **ensure the cost-effective integration of renewables** it is **necessary to encourage the use of innovative technologies (energy storage, increased capacities of existing network elements) and operating modes (demand side responses)** that support improvement of the dispatchability of the electricity system by also minimising the necessity of network development investments (and their costs) and allow the integration of decentralised energy production based on renewable energy sources to the extent possible.

(Chapter 2.3 on the security of supply is also relevant in relation to storage and demand side responses.)

iii. Where applicable, national objectives with regard to ensuring that consumers participate in the energy system and benefit from self-generation and new technologies, including smart meters

The falling cost of renewable energy production, digitalisation and the growing affordability of smart metering are leading to a major paradigm shift: **the notion of the 'passive consumer' is increasingly replaced with that of the active (partially self-sufficient) prosumer.** This necessitates complex, differentiated energy policy solutions for consumer segments and at the same time a tailored and flexible approach, with the development of diversified service packages.

A fundamental prerequisite for active consumer participation on the market is the regulation of consumption in cases where this is not yet possible. The more extensive use of smart meters in the electricity and natural gas sectors, appropriate implementation of heating centres serving homes with district heating, controllability of the systems and the wide ranging use of cost allocators, establishment of the active system operation capacity of distributors will allow consumers to receive accurate information on their energy consumption, competitive service plan offers from their suppliers with the maintained or improved quality of service. (Further information on goals relating to smart metering is provided in point vi. of Chapter 3.2.) Ensuring regulation of consumption not only enables active consumer participation in the electricity system, and thereby their participation in demand-side responses (DSR), but also facilitates consumer control of overhead costs. To this end, in relation to households and small corporate consumers, **independent aggregators** (a special form of energy communities) are needed, which combine several consumer load or production units for buying and selling on a regulated energy market (exchange, day-ahead market (DAM), intraday market (IDM), system level services market, local distribution flexibility market).

With the spread of household-sized PV panels, a growing number of consumers can generate their own energy, which not only offers the option of a more active presence on the market beyond the conscious regulation of consumption, but also strengthens energy independence on a household scale. (Point v. of Chapter 2.1.2 provides additional details on enhancing energy production for private purposes, and the establishment and support of energy communities.)

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 time-frame for when the objectives shall be met

The priority of improving flexibility should be ensured within the entire value-added chain, from the provision of resources to production and energy transmission, distribution and energy consumption (demand side).

The reserve requirements of the electricity system and the determination of technical reserve requirements is in each case adjusted to the characteristics of the current system, in accordance with

Regulation (EU) 2017/1485, including the share of renewable energy. Such determination takes into account the maximum expected contingency and the expected balancing demand, together with the related probability distribution. At least 50 % of reserve capacity requirements - determined according to the methodology of the Regulation - must be provided from national sources.

Points (i) and (ii) of this chapter and Chapter 2.3 present other flexibility objectives (including those related to energy storage and demand side responses).

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

Low overhead costs, strengthening energy independence, broad freedom of choice: these values are relevant for consumers, which build on solutions proposed by the consumer-oriented energy strategy. The focus on consumers is expressed on multiple levels of the new Hungarian energy strategy, in the main programmes and objectives. Support of household energy production for private purposes – thereby encouragement of consumers to become energy producers (prosumers) – and facilitation of the use of smart meters are all means of shifting focus on consumers.

On the side of suppliers and network operators, the sustainable reduction of overhead costs is supported by strengthening wholesale market competition, establishment of the smart grid and limits to infrastructure operating costs. On the side of consumers, a decline in demand through conscious energy consumption, use of opportunities offered by decentralised household energy production and optimisation of supply methods can contribute to cost-effective energy supply. In relation to point iii. of this chapter it may be necessary to **carry out the conceptual reform of administrative price control of electricity, natural gas and district heat.** In relation to electricity and natural gas, one option is the review of eligibility for universal service – in accordance with Directive (EU) 2019/944 of the European Parliament and of the Council[48] and in relation to requirements set out in Government Decision No 1772/2018 of 21 December 2018[49] – and the offer of different service packages within the framework supply, maintaining the results of the reduction of overhead costs. In relation to district heat, the option is to review the aid scheme, as the currently applied methodology does not encourage the cost-effective implementation of investments necessary for the modernisation and greening of the district heating system.

Customers (consumers) should be projected a vision that not only reinforces the prosumer concept, but in which suppliers – offering flexible choices – can also play an active role. Due mainly to the fixed and cost-

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[48] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast).

[49] Government Decision No 1772/2018 of 21 December 2018 on decisions laying the groundwork for a new National Energy Strategy.

based nature of pricing, competitiveness of the sector can be ensured through the emergence of customer side needs to the extent possible and the development of satisfying such needs. For this reason we aim to **enhance services provided to energy final customers** (mainly those eligible for universal services) **and establish regulatory conditions necessary for improving the customer experience.** The programme covers the development of digital administration channels, introduction of digital signatures and the design of a consumer-friendly invoice template.

Participants of the energy supply market assign a priority to vital systems and system components when repairing disruptions in energy supply. A sectoral regulatory framework – covering aspects of both procedural law and technology – should be drawn up that ensures the definition of exceptions and priorities necessary for the continuity of supply for organisations, service providers and operators involved in remedial and restoration measures.

When planning and providing services, participants of the energy supply market should take into account dependencies between individual critical infrastructure sectors. To this end, legal standards ensuring effective protection measures should be drawn up after assessing the particular sectoral characteristics.

2.4.4. Energy poverty

(i) Where applicable, national objectives with regard to energy poverty, including a time-frame for when the objectives are to be met

The Government measures launched in January 2013, concerning consumers falling within the scope of universal services, have been guaranteeing affordable energy supply and financial foreseeability to consumers of universal services through fixed universal service tariffs for more than half a decade. **As a result of reduced energy overhead costs, district heating, natural gas and electricity[50] became extremely cheaper compared to the year 2013, thus the household energy costs of Hungarian consumers are one of the lowest in Europe.** Hungary will measure the success of policies aimed at further easing heating related difficulties by monitoring the share of households spending at least 25 % of their income on energy costs (9.8 % in 2016). **Hungary needs to assist, in particular, vulnerable consumer groups.** In this regard we will mainly focus on two clearly distinct social groups: large families living in single-family houses in small municipalities and single pensioners living in apartment blocks (or to a lesser extent in single-family houses).[51]

The lignite-fired **Mátra Power Plant** plays an important role not only in energy production but also on the labour market, therefore **the structural reform of the power plant's region is of crucial social significance** (for further details see point of Chapter 2.3).

[50] http://mekh.hu/download/8/22/c0000/nemzetkozi_arosszehasonlitas_2019_december.pdf

[51] Századvég (2019): Strategic study – Survey of Hungarian energy poverty, drafting of policy proposals aimed at its mitigation, in consideration of the separation of energy and social policies to the maximum extent possible.

2.5. 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 time-frame for when the objectives are to be met

The Government of Hungary is committed to the innovative reform of the energy sector. **A key objective is to increase energy RDI output and to maximise economic development opportunities offered by energy innovation and climate change.**

The Government has initiated broad sectoral dialogue to survey the innovation potential. Based on the new National Energy Strategy – drawn up within the framework of and in parallel with the NECP, and adopted by the Government simultaneously with the NECP – Hungary assigns a priority to determining the directions of energy innovation, the implementation of supporting regulatory changes and in the creation of financing opportunities for innovative projects.

Within the framework of the new energy innovation strategy Hungary plans to encourage use of innovative solutions that ensure the smooth transformation of the electricity markets based on electrification, decentralisation and digitalisation, on the one hand, and contribute to fulfilling objectives relating to the expansion of consumer choices, the strengthening of the security of supply and the climate-friendly transformation of the energy sector, on the other. Innovation in the energy sector should also support the performance of the Hungarian economy, increase national RDI capacities and create industrial development opportunities to the extent possible.

ii. Where applicable, national objectives relating to the year 2050, supporting the spread of clean energy technologies, and national objectives - including long-term targets (for 2050) - relating to the introduction of low CO_2 *emissions technologies, including decarbonising technologies for energy-intensive and carbon-intensive industrial sectors, and to the related* CO_2 *transport and storage infrastructure*

iii. Where applicable, national objectives relating to competitiveness

Hungary assigns a priority to strengthening the framework of qualitative growth and to further enhancing Hungary's innovation-driven competitiveness; these efforts will result in more successful enterprises, more jobs, greater added value, and ultimately in a higher standard of living and a better quality of life.

Hungary's characteristics offer a favourable background for establishing innovation-driven competitiveness. By building on the Hungarian undertakings playing a leading role in the manufacture of electrical machinery, the automotive industry and in IT solutions, Hungary will not only be a user of new technology, but could become an active player on the innovative energy market.

3. POLICIES AND MEASURES

Annex 1 includes detailed information relating to the policies and measures; this chapter only provides a summarised overview.

3.1. Dimension of decarbonisation

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 in the energy industry (generation of electricity and heat, petroleum processing, production of solid energy resources) are determined by the quantity of energy used in processes and the unit emission factor of energy sources. GHG emissions can be reduced by decreasing the quantity of consumed energy, increasing the use of renewable energy sources, and by replacing fossil energy sources - with a higher emission factor - with nuclear energy or with other energy sources with lower emission factors. Chapters 3.1.2 and 3.2 present measures aimed specifically at increasing use of renewable energy and improving energy efficiency, while Chapter 3.1.3 describes measures relating to the decarbonisation of transport.

Among the instruments financed with the Economic Development and Innovation Operational Programme (EDIOP) and the Competitive Central Hungary Operational Programme (CCHOP), the **credit scheme of the Hungarian Development Bank**, in the exclusive ownership of the Hungarian State, is worth noting, which aims to provide funds necessary for building energy performance investments serving the improved energy performance of buildings in the retail sector. The credit is offered to private persons, apartment blocks and housing co-operatives, subject to a minimum 10 % own contribution, serving, *inter alia*, the upgrading, insulation of heating systems, the replacement of doors/windows, and the installation of renewable sources of energy, i.e. PV panels, solar thermal collectors, heat pumps and modern wood gasification equipment. The repayable amount of credit is minimised at HUF 500 000 and maximised at HUF 10 million for private persons, and HUF 7 million for apartment blocks and housing co-operatives, per dwelling. The credit has a maturity of maximum 20 years, with 0 % interest.

In addition to programmes supporting energy efficiency and renewable energy, the **maintaining of nuclear capacities** plays an important role in reducing greenhouse gas emissions. Pursuant to the intergovernmental agreement between Hungary and the Russian Federation, two new nuclear power plant units will be built in Hungary by 2030, each with a capacity of 1 200 MW (Paks 2 project).

Point iii. of Chapter 3.1.3 covers **transport** measures.

We currently plan to reduce **agricultural** emissions by prescribing correct agricultural practices and with various aid schemes.

Act CLXXXV of 2012 on waste sets out general rules of **waste management**. The currently prepared new waste management strategy will define waste management targets and measures for the post-2020 period.

To increase CO_2 sink capacities we will significantly increase the share of areas covered by forest and other tree stock consistently with the **National Forest Strategy**; to maintain the CO_2 sequestration capacity of forests we will improve the resilience of forests against environmental factors.

Beyond the foregoing, fulfilment of our objectives will also be served by the **programme aimed at establishing an energy and climate literate society**, based on energy and climate literacy enhancing campaigns targeting different age groups and educational awareness raising measures focussing on younger generations.

Within the framework of **adaptation** to the adverse effects of climate change, the National Adaptation Strategy (NAS) – referred to in above Chapter *2.1.1.i.* – plans to integrate climate change, as an absolute boundary condition, in the following policy and action areas up to 2030, taking into account aspects of nature conservation and landscape protection:

- human health,
- water resources management,
- disaster management and security policy,
- agriculture and rural development,
- landscape protection and nature conservation,
- forest management,
- built environment (spatial and urban development, spatial and urban planning, municipal infrastructure),
- energy management,
- tourism.

ii. Regional cooperation in this field, if applicable

Supporting the implementation of Hungary's National Climate Change Strategy

The project under preparation consists of two elements, both of which serve implementation of the National Climate Change Strategy of Hungary. The first element focusses on the national monitoring, evaluation and reporting framework related to energy and climate policy, while the second one deals with aspects of environmental impact assessment. The Swedish Environmental Protection Agency is participating in the project in cooperation with the Mining and Geological Survey of Hungary and the MIT.

Western Balkans Green Fund Project

The Western Balkans Green Fund Project (hereinafter 'Project') offers an opportunity for Hungary to play a leading role in the development of projects of Western Balkan countries[52] related to their Nationally Determined Commitments and climate adaptation objectives, and allows Hungarian undertakings to access more tender opportunities within the region. The Western Balkans is an emerging region of Europe where economic growth exceeded the average EU rate in 2017. Notwithstanding the positive trends, some of the challenges and risks are still rooted in extreme climatic events and environmental pollution. Such risks, however, may also encourage the introduction of new, efficient technologies and methods to ensure a greener and more sustainable future in the Western Balkan region. The project supports the transformation process, aims at the inclusion of Hungarian companies, and may provide assistance in meeting the EU accession obligations of countries in the Western Balkan region, in addition to enhancing the provision of services with high added value and the trade in goods.

The Project approved by way of Government Decision No 1770/2018 of 21 December 2018 consists of two phases. The Hungarian-financed Nyugat-Balkáni Zöld Központ Nonprofit Kft. was established in the first phase in 2019, which aims to finance preparation of low-budget projects and create tender opportunities for Hungarian companies in areas where Hungarian companies are traditionally strong (e.g. preparation of large-volume projects, technical design, engineering works, drafting of business plans etc.). In the second phase of the project, in 2021, a fund (hereinafter 'Multidonor Fund') would be set up with involvement of international donors, operating with a significantly larger budget, offering financial instruments considerably more refined than the non-refundable aids. Upon the Hungarian initiative, beyond the offers of other governments involved, the Multidonor Fund will also mobilise market capital to finance green technology transfers and low-emission, climate-friendly investments that support adaptation. The Multidonor Fund can operate effectively mainly in fields and in medium-scale investments that fall outside of the focus of major international – e.g. EBRD, Green Climate Fund, World Bank, European Investment Bank – and national funds active in the region, by seeking synergies with them.

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

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

Decarbonisation efforts are currently significantly supported by operational programmes implemented with EU funds, including the Environmental and Energy Efficiency Operational Programme (EEEOP), Economic Development and Innovation Operational Programme (EDIOP), Competitive Central Hungary Operational Programme (CCHOP), Integrated Transport Development Operational Programme (ITDOP) and the Rural Development Operational Programme (RDOP). The goals of the programmes include increased use of renewable energy, improvement of energy efficiency, support of sustainable mobility, development of waste management and waste water treatment, and supporting protection of forest resources and forestation.

In the third trading period (2013-2020) of the EU emissions trading scheme, a specific share of revenue from the sale of emission allowances (50 % of EUA III allowance sales, 100 % of EUAA aviation allowance sales) is used for budget appropriation managed under the **Green Economy Financing Scheme** chapter.

The **REAS scheme** – described under point 3.1.2 – plays a key role on the Hungarian energy market by supporting electricity produced from renewable energy sources.

3.1.2. Renewable energy

i. In relation to renewable energy, policies and measures necessary for implementing the national contribution to the mandatory EU target set for 2030, the trajectories referred to in subpoint (2) of Article 4(a), and - if applicable or available - elements referred to in point 2.1.2, including sector and technology specific measures[53]

Beyond information provided in point 3.1.1, the following policies and measures support fulfilment of the renewable energy objectives.

The increase in **electricity generation** for the grid in Hungary was primarily boosted by the feed-in system (FIS) until the end of 2016, which provides operational support (guaranteed feed-in tariff higher than the market price). This system was replaced by the **Renewable Energy Aid Scheme** (REAS) in 2017, which also provides operational support and supports the market integration of renewable energy generation as well. In addition supporting the construction of new units, the REAS also supports the use of renewable energy (so-called brown bonus).

To ensure cost-effective levels of aid, in the future aid within the REAS framework will only be available through technology-neutral renewable capacity tenders; production aid will be available within the conventional feed-in system only for experimental technologies and model projects. The funds we plan to offer to electricity producers using weather-dependent renewable resources are competitive with credit products available to foreign producers.

[53] When planning these measures, Member States must take into account the end of the life-cycles of existing installations and the potential for repowering.

REAS aid is provided for the generation of renewable electricity, except for the brown bonus, which is related to new investment, and implementation is not commenced before application for the aid. Multi-fuel firing power plants and waste incinerator power plants are eligible for aid only for the share of electricity generated from renewable energy sources (in proportion to fuel heat).

Under the REAS scheme, aid aimed at the installation of capacities of at least 1 MW is awarded only under artificially established competition. Within the framework of the REAS green bonus tender, aid is available not only to newly invested power plant units, but also to existing power plant units undergoing major overhaul or an upgrade in excess of 50 % of the original initial investment cost. The amount of aid available under the REAS scheme depends on the production capacities of the given power plant. Within the REAS category of feed-in aid (REAS-FIS), power plants with a capacity of less than 0.5 MW are eligible (except for wind). In relation to these power plants, produced energy is received by MAVIR Zrt. from producers (feed-in) and sold on the regulated electricity market operated by HUPX Zrt. Pursuant to legislation in force on the date of the NECP, a maximum annual amount of HUF 45 billion in new aid may be allocated within the framework of the REAS up to 2026.

To increase electricity generation based on renewable energy sources, it is necessary to ensure the cost-effectiveness of integrating renewable investment, to maintain the security of supply and system dispatchability, and to prepare the electricity grid for the cost-effective integration of decentralised capacities.

The nearly zero energy building performance level applicable after 2020 to newly built immovable property prescribes an average 25 % share of renewable energy, thus production facilities currently defined as a household-scale power plant are expected to further grow at an exponential rate. As regards individual heating, the concept of ‘household’ (decentralised) energy production focusses on encouraging heating solutions using heat pumps and efficient biomass.

Hungary encourages the installation of PV systems to partially supply private electricity consumption. We aim to have at least 200 000 households with roof-mounted PV panels with an average capacity of 4 kW by 2030.

As noted in the policy document entitled ‘Cost-benefit analysis of high-efficiency district heat generation’, sent to the European Commission on 24 October 2017, the replacement of existing natural gas based district heat generation **with renewable heat generation** is justified. The above project cannot be implemented in Hungary on a market basis – it can only be supported with substantial investment aid.

In the 2014–2020 period, the construction of heat generating facilities based on renewable energy sources receives investment aid in Hungary, which contributes to the significant increase in biomass based and geothermal generation of district heat. In the future the construction of new biomass and geothermal district heat generation capacities will be encouraged in this field with high-intensity non-refundable aid after the 2014–2020 programming period as well. Hungary also aims to facilitate the use of energy from non-recyclable waste for district heat generation.

Implementation of the **Green District Heating Programme** and increased consumption of energy recovered from waste water treatment, landfill gas and agricultural biogas play a key role in replacing natural gas and increasing use of renewable energy on the Hungarian heat market (greening of the district heating sector by increasing recovery of geothermal energy, biomass and waste for heating/cooling). Encouraging use of these resources will be developed for each larger district heating zone, based on a detailed analysis, in consideration of local characteristics. To implement the programme it is necessary to review current district heating price controls. The review of price controls will be followed by the establishment of conditions of competition on the district heat market.

Hungary will encourage use of heat pumps and the burning of biomass in efficient individual heating equipment to satisfy the heating and cooling needs of modern buildings.

We encourage the establishment of biogas plants processing agricultural waste to both satisfy local heat demand and to feed in purified biomethane to the natural gas network.

Point iii. of Chapter 3.1.3 covers **transport** measures.

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

Within the framework of the EU budget for the period between 2021 and 2027, the CEF[54] programme supports investment in European infrastructure networks in the transport, energy and telecommunications sectors. Synergies between the three sectors and growing cross-border competition in the field of renewable energy are key areas of the CEF after 2020 that aim to speed up digitalisation and decarbonisation in the EU economy.

Five EU Member States neighbour Hungary, therefore we are focussing on exploring the potential for joint projects implemented within the framework of the CEF and are open to cooperation with neighbouring countries.

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

The **REAS scheme** – taking effect 1 January 2017 – plays a key role on the Hungarian energy market by supporting electricity produced from renewable energy sources.[55] (Point i. of Chapter 3.1.2 provides details on

[54] Connecting Europe Facility

[55] HEA (2017): Information on the new Renewable Energy Support Scheme (REAS). Hungarian Energy and Public Utility Regulatory Authority (HEA). November 2017

the REAS scheme.)

Support of the installation of PV panels aimed at **replacing electricity consumption for private purposes and at community level** is planned jointly with refundable aids of operational programmes in the 2021-2027 programming period.

In relation to **local cooling and heating**, encouraging the use of heat pumps, burning of biomass in efficient individual heating equipment, and the establishment of decentralised community heating plants producing renewable energy is implemented with non-refundable aids.

The supply of **district heating** based on renewable energy and its energy efficient upgrade can be encouraged with non-refundable aid of operational programmes in the 2021–2027 period, carbon credit revenues and revenues of the Modernisation Fund launched in 2021. We are also planning to introduce heat storage aid (and possibly FIS-type aid during the heating period) for efficient co-generated district heating.

The establishment of **biogas plants processing agricultural waste** should be encouraged with refundable aids in the 2021-2027 period.

The further spread of **solar power stations and biomass power plants** is supported by the operating aids of the REAS scheme, while the spread of **geothermal power plants** may also be encouraged by the pilot project relating to the Geothermal Guarantee Fund to be launched in 2020 during the period of the Swiss-Hungarian Cooperation Programme II. In case of positive experience relating to the pilot project, investment aid may also be considered with non-reimbursable funds of the relevant operational programmes in the 2021-2027 programming period.

From 2021 the Modernisation Fund could provide some of the funds not covered by network access fees, necessary for the **system integration of weather-dependent renewables**; carbon credit revenues will finance the implementation of a reliable meteorological forecasting system – covering a large area – for efficient scheduling of weather-dependent renewables producers.

From 2021 the non-refundable funds of the operational programmes and the Modernisation Fund will support the spread of **seasonal electricity storage and battery energy storage**, network upgrades and implementation of smart networks. Demand-side regulation and related funding of **smart metering** promoting network flexibility will be implemented with non-refundable aids under the relevant operational programmes of the 2021-2027 period. The **energy development** – based on renewable energy, aimed at reducing natural gas consumption – **of power-to-gas production (biomethane, hydrogen), municipalities, parts of municipalities,** pilot projects planned for testing **complex consumer DSR solutions, independent aggregators and renewable communities**, and for promoting **the flexibility of the distribution network and integration of renewable producers** can be implemented with carbon credit funds.

(mekh.hu/download/e/fc/40000/mekh_metar_tajekoztato_2017_nov.pdf)

In the transport sector, **implementation of the necessary electric charging infrastructure, development of second generation biofuels and promotion of carriage of goods on road with alternative propulsion, and the replacement of the light commercial vehicle fleet of the postal service or other (public) services with clean vehicles** is possible with non-refundable aids of relevant operational programmes in the 2021-2027 programming period. Transport electrification and implementation of the infrastructure necessary for development could also be financed with credit offered on the market and by the European Investment Bank. The funding of **public transportation by road with alternative propulsion** could be implemented with carbon credit revenues, while the **government electric fleet** could be expanded with national budgetary funds. Funds of the European Clean Mobility Fund (as part of the CEF) are also available to fund **sustainable and innovative transport.**

iv. Where applicable, assessment of the support of electricity from renewable energy sources which Member States are to provide pursuant to Article 6(4) of Directive (EU) 2018/2001

The REAS scheme supporting production of renewable electricity – presented in the above point – is continuously evaluated; new tenders are launched on the basis of such evaluation. The first invitation to tender was published in September 2019. The successful REAS tender demonstrated that the amount of necessary aid is adjusted to declining investment costs.

v. Specific measures to introduce one or more contact points, rationalise administrative procedures, provide information and training, and to facilitate energy purchase agreements

Summary of policies and measures within the support framework to be established by Member States to promote and facilitate the development of autoproduction and renewable energy communities pursuant to Article 21(6) and Article 22(5) of Directive (EU) 2018/2001

Hungary will encourage initiatives that ensure the local consumption of electricity. In this regard the support of developing energy communities is a priority; the energy community – as a separate consumer-producer unit and settled entity – should be clearly defined in regulation. In relation to the above it is also necessary to define in regulation a community metering point in addition to the metering point of production-consumption. It is a priority to extend net metering (or an equivalent incentive programme) to apartment blocks, as the means of the distribution of produced energy beyond the sole connection point is irrelevant in terms of the distribution network. The programme also contributes to reducing network losses. Laying the groundwork for establishing communities within the transformer zones is a second-level goal. The option of managing 'village heating plants' as energy communities is a third-level goal.

As regards the establishment of renewable energy communities, the question of vulnerable consumers and the security of supply is assigned a priority; the legal environment should allow even a miniature-scale district heating zone to fulfil these two criteria.

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

The role of economical and environmentally friendly district heating should be enhanced. As a first step, it is necessary to rationalise the existing district heating system by optimising production capacities. Hungary aims to establish the infrastructural conditions necessary for increasing the utilisation rate and heat output of district heating generating facilities based on renewable energy sources. It is also important to complete the modernisation of the consumer side. The transition of energy production to biomass or geothermal heat sources can be achieved with the introduction of incentives after professional consultations. In parallel with existing district heating systems typically operating in large cities, with favourable legal and economic conditions it is necessary to promote the implementation new, small-scale, local systems based on self-supply. It would be appropriate to implement the regulatory support of renewables based 'village heating plants' within the framework of energy communities. In addition to enhancing self-supply and energy independence, it is also important to guarantee economy and energy security to connecting entities (institutions, private persons, undertakings) when developing local district heating zones.

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 use by other sectors (agriculture and forestry-based sectors); and measures aimed at the sustainability of biomass production and use*

The **Forest Act** ensures by law and requires that the forest owner replace its cleared forest in the quality and by the deadline prescribed for such forest, thereby guaranteeing the sustainability of forests and the continuous provision of their services at national level.

Hungarian forest management is essentially compliant with criteria prescribed in the RED II Directive[56]. Beyond the obligation of forest regeneration, the legality of logging is grounded in forest planning and the forest supervision system. Most protected natural areas of national priority were declared protected decades ago. Pursuant to the statutory provision in force from 1997, their nature conservation management plans must be promulgated by law. The nature conservation management requirements of ministerial decrees setting out the nature conservation management plan must be included in the district forest plans comprising the basis for forest management. Competent (forestry, nature conservation) authorities verify enforcement of the forest plan

[56] 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).

(including measures aimed at preventing damage to soil). Since the place of production serves as a basis for choosing tree species, in the course of regenerating forests, tree stocks suitable for and preferably most effectively utilising the place of production (capable of adaptation to future changes) are used to ensure the long-term maintenance of forests, and the conservation and repair of their productivity.

3.1.3. Other elements of the dimension

i. Where applicable, national policies and measures affecting the EU ETS sector and assessment of the complementarity and impacts on the EU ETS

Currently Hungary is not applying additional policies complementing the EU ETS.

Among the system's optional elements, it is applying the mechanisms under Article 10c. (in 2013 and between 2021 and 2030) and Article 27(a)(3) (from 2021) of Directive 2003/87/EC. Hungary is also eligible for funds of the Modernisation Fund.

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

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

We plan to reduce GHG emissions in the transport sector by increasing the blending ratio of biofuel, supporting the spread of electric motor vehicles and by encouraging the use of low-emission transport solutions.

The **Electromobility Act** enacted in 2019 aims to regulate electromobility services. The act defines electromobility services, related licensing, and reporting obligations and rules. Hungary is currently also supporting the spread of electric vehicles with financial instruments. Private persons and undertakings are offered aid for purchasing electric cars and goods vehicles under 3.5 tonnes. Aid is maximised at 21 % of the price or HUF 1.5 million. Additionally, funds of the Green Economy Financing Scheme are used to implement other programmes promoting the use of electromobility. The substance of programmes and form of financing instruments changes year to year. In addition, fully electric cars, cars partially rechargeable in electrical networks, and zero-emission cars are exempt from motor vehicle tax, company car tax and registration tax. The rate of motor vehicle tax levied on buses, trucks and goods vehicles is also determined by the environmental classification of the vehicle. Goods vehicles are eligible for additional tax advantages when carrying out combined goods transport. The environmental classification of motor vehicles also determines the rate of the company car tax and registration tax. In conformity with the Jedlik Ányos Plan 2.0, in the future we also plan to promote the spread of electric vehicles and implementation of the necessary infrastructure by means of regulatory, tax policy and financial aid instruments.

The new regulation[57] adopted by the Government ensures that by 2020 the **share of biocomponents** in fuels will increase to 8.2 % (to 6.1 % in petrol). In the future we plan to encourage both the use and domestic production of advanced, second generation biofuels.

To reduce increasing energy consumption in transport, it is also essential to **develop and increase the use of public transportation**, and to offer the carriage of goods by rail as a realistic option for freighting.

Within the framework of the **Green Bus Programme** adopted by the Government, around 1 300 environmentally friendly local buses are expected to enter service by 2029. In the initial years the programme will also allow the procurement of compressed natural gas (hereinafter 'CNG') and EURO-6 modern diesel buses, and will subsequently focus on electric vehicles. Beyond public transportation, natural gas and biogas could play a greater role in the carriage of goods.

The **Policy Framework for Alternative Fuel Infrastructure Development** of Hungary defines measures concerning the development of infrastructure for alternative fuels.

iv. Where applicable, national policies, timelines and measures planned to phase out energy subsidies, in particular for fossil fuels

3.2. Dimension of energy efficiency

Planned policies, measures and programmes to achieve the indicative national energy efficiency contributions for 2030 as well as other objectives referred to in point 2.2, including planned measures and instruments (also of a financial nature) to promote the energy performance of buildings, in particular with regard to the following:

i. Energy efficiency obligation schemes and alternative policy measures referred to in Articles 7(a) and 7(b) of Directive 2012/27/EU, to be drawn up in accordance with Annex II of this Directive

Energy efficiency targets are currently served mainly by programmes referred to in above points 3.1.1 and 3.1.3. It is also worth noting that a new **tax advantage** was introduced in 2017, **offered to undertakings in relation to efficiency-improving investments**. The tax advantage scheme – serving enhanced stability of operation – is being fine-tuned with solutions in conformity with EU regulations and universally adopted by national regulations to also ensure the implementation of projects requiring larger investment and offering a greater energy saving potential.

The **National Network of Energy Engineers** was set up in 2017 as an advisory network operating at government offices and district offices. The advisers are responsible for supporting the energy efficient operation of public bodies – including local authorities – and undertakings, and the reduction of retail energy

[57] Government Decree No 186/2019 of 26 July 2019.

consumption with professional consulting. By enhancing the National Network of Energy Engineers it is necessary to ensure the provision of free online and personal consulting services to the public with the involvement of energy and engineering specialists, economic specialists and architects. In the future, indication of the contact information of the closest network consulting point will become mandatory for building performance certificates.

As two new instruments of the energy efficiency policy, we have introduced the obligation scheme referred to in the EED and encourage use of ESCO-type financing solutions. Within the **obligation** scheme, Hungary requires energy distributors and/or retail energy trade undertakings to introduce programmes and implement measures resulting in evidenced energy savings for final customers.

The companies concerned are responsible for finding the most cost-effective means of such solutions, thus the introduction of the scheme is expected to achieve the economically optimal fulfilment of energy efficiency objectives. **The obligation scheme also allows suppliers and/or distributors to choose the group of customers – industry, households, public bodies or the services sector – for the given investment.**

The cost-effectiveness of the **obligation** scheme can be further enhanced with ESCO-type financing solutions that simplify and extend access to funds in both the retail and corporate sectors (to increase energy production capacities supporting product manufacturing). The ESCO services can additionally increase the share and volume of economically sustainable investments, ensure uniform quality of implementation, and contribute to establishing acceptable price levels on the demand side.

The ESCO models are based on the ‘preparation, planning – financing – implementation - operation’ service modules and are operated at system level. The substance of individual modules, however, can be flexibly modified, and adjusted to the options and needs of the given project promoters (customers). In the course of energy efficiency investments implemented with ESCO financing, purchased facilities and equipment are stated in the balance sheet of the ESCO company, i.e. the costs and risks of the investment are borne by the customer (off-balance sheet financing).

The project is recovered with surplus funds generated with energy savings or the flat-rate service fee paid by the customer. The Energy Performance Contracting (EPC) model is applied in the first case, while the Shared Savings Contracting (SSC) model is applied in the latter case. Both models are suitable to also satisfy energy saving needs in parallel with implemented modernisation, and to guarantee the development and implementation of economically sustainable investments. The EPC model is also committed to realising the savings ratio measured in advance and subsequently specifically set out in the energy savings contract.

In relation to building energy performance, energy efficiency investments of the central budget and local authorities, the ESCO based services minimise or render unnecessary the use of budgetary resources and EU non-refundable aids, thereby contributing to reducing general government debt and the more rational use of diminishing funds in the 2021-2027 programming period.

Combined financing available to ESCO companies enables not only the more enhanced use of financial products, and thereby the use of financing sources available for energy efficiency upgrades, but also the implementation of more risky investments. Financial products have a strong multiplier effect and owing to their reusability, they can multiply limited available funds.

ii. Long-term renovation strategies to support the renovation of the national stock of residential and non-residential buildings in private and public ownership[58], including policies and measures promoting cost-effective deep renovations aimed at the worst performing segments of the national building stock, in accordance with Article 2a of Directive 2010/31/EU

Hungary will **draw up a Long-term Renovation Strategy** by March 2020.

(Measures implemented in this field are presented under the above point.)

iii. Policies and measures promoting energy efficiency services in the public sector, and description of measures aimed at eliminating regulatory and non-regulatory barriers impeding the uptake of energy performance contracting and other energy efficiency service models[59]

Energy efficiency improvements in the roughly 960 000 public buildings of 12 000–15 000 Hungarian public bodies offer a substantial energy saving potential. Based on experience in other countries, public bodies can reduce energy consumption by 15-30 % in 5 years. The combined improvement of energy efficiency and the efficient use of buildings can significantly reduce operating costs, also enabling cuts in the relevant budgetary expenditures.

We are prescribing more stringent legal obligations to exploit the energy saving potential in the operation of public buildings and are developing a personal incentive scheme for operators of public bodies. We are clarifying rules for implementing the proposals of energy auditors and consultants. We are clarifying legal regulations relating to the construction of nearly zero energy buildings and the decree on certifying building energy performance. (For additional information see point 3.2.i.)

iv. Other planned policies, measures and programmes to achieve the indicative national energy efficiency contributions for 2030, and other objectives referred to in point 2.2 (e.g. measures to promote the exemplary role of public bodies, energy-efficient public procurement, measures promoting energy audits and energy management systems[60], measures to inform

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

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

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

consumers and to provide training[61], and other measures promoting energy efficiency[62])

In the economic sector, a key objective is sustainable and climate-friendly energy management even by maintaining and further increasing industrial output. The competitiveness of energy and GHG intensive industrial activities is guaranteed by their ability to not exceed the unit energy consumption and GHG emissions of their European industrial competitors. Enforcement of this criterion can be monitored partly through the operation of the EU ETS, and the GHG intensity and emission allowance data of Hungarian sectors and European competitors. **The goal is for emission allowances of Hungarian sectors to at least reach the EU average.** As a central instrument of this goal, it is necessary to use funds of the Innovation Fund – managed by the European Commission – by Hungarian industrial producers to the extent possible.

In parallel with maintaining the existing energy intensive industrial sectors, from an energy strategic point of view **future industrial investments should be made in low energy and GHG intensive, high-tech industrial sectors that support the sustainable and competitive development of the Hungarian economic structure**.

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

Details are provided under point v. of Chapter 3.1.2.

vi. Description of measures aimed at exploiting the energy efficiency potential of the natural gas and electricity infrastructure[63]

The use of gas pipelines and, within this context, changes in network access fees are also relevant in relation to the distribution network. We aim to **assess** – in accordance with Government Decision No 1772/2018 of 21 December 2018[64] – the **potential phasing out of distribution pipelines with a low utilisation rate (below 10 %) and their possible phasing out with the offer of heating alternatives with low carbon intensity.**

We are installing 1 million smart consumption meters in the electricity sector. We will prescribe the replacement of conventional consumption meters – upon their expiry – exclusively with smart metering

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

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

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

[64] Government Decision No 1772/2018 of 21 December 2018 on decisions laying the groundwork for a new National Energy Strategy.

equipment upon fulfilment of certain conditions, the cost of which may not be charged to consumers. In parallel **we will require universal service providers and authorised traders to offer flexible tariff packages encouraging the more effective use of the network to consumers with smart meters.**

vii. Regional cooperation in this field, if applicable

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

Targeted solutions offered by companies within the obligation scheme in all economic sectors, with support provided under ESCO-type financing schemes. Own funds of economic operators, and credit products of the EBRD and money market credit institutions should also be used.

Funds may be supplemented with refundable aid offered under the relevant operational programme in the 2021-2027 programming period, and financing provided from the national budget (e.g. maintained corporation tax advantages serving energy efficiency investments).

Innovation in industrial energy efficiency can be implemented with national innovation funds, operational programmes of the 2021-2027 period and financing opportunities offered by programmes directly managed by the EU.

Credit offered on the market and by the European Investment Bank is also a potential financing instrument.

Support of the smart cost allocation programme of homes with district heating and the installation of smart consumption meters with non-refundable aid provided by operational programmes in the 2021-2027 period. Carbon credit revenues and the non-refundable funds of the Modernisation Fund launched in 2021 are also potential financing instruments for developing the district heating sector.

3.3. Dimension of energy security[65]

i. Policies and measures related to the elements set out in point 2.3[66].

Electricity market:

The main task is to implement the vision of the electricity market. Main elements of the above task in terms of the security of supply:

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

[66] Consistency must be ensured with the preventive action and emergency plans under 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 risk preparedness plans under Regulation (EU) 2018/... [as proposed by COM(2016)0862 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC].

(i) Measures serving objectives relating to capacity compliance and the reduction of import dependency:

- **Ensuring reliable, flexible and diversified national capacities**

As regards the future of Hungarian installed capacities, we are focussing on maintaining nuclear capacities and increasing renewable (mainly PV panel) capacities in parallel with efforts to establish a business environment that ensures the availability of gas-fired capacities in a sufficient quantity for ensuring Hungary's security of supply and system flexibility.

- **Maintaining the level of nuclear production capacities:** The construction and entry into service of Paks 2 play a key role in the planned electricity generation portfolio and the decarbonisation of the electricity sector. The independent energy organisation of the OECD, the International Energy Agency (IEA), also notes that to meet the decarbonisation targets, the use of nuclear energy is also necessary in parallel with significantly increased efficiency and investment in renewable energy.[67]

- **Increase of power generation from renewable sources:** Solar power station investments are thriving as a result of declining investment costs and aid; future investments can be supported by introducing a cost-effective aid scheme and providing network access. Although conditions in Hungary are most favourable for increasing PV capacities, a moderate presence of alternative renewable technologies on the market can have additional benefits (e.g. they are dispatchable, such as biomass). The above would reduce fossil fuel use, demand for imports, and system regulation risks and costs.

- **Availability of sufficient gas capacities within the system:** Gas-fired power plants significantly contribute to the reliable operation (dispatchability) of the electricity system. The risk inherent to the reliable operation of the Hungarian electricity system is that the service life of a number of gas-fired power plants will expire in the 2020s, and substantial investments are needed to extend their service life. Heat market revenues and rising wholesale market revenues support positive investment decisions. Since these capacities are important mainly for ensuring system flexibility enabling the system integration of renewables with variable rates of availability, the market of system level services should essentially provide possibly lacking investment incentives. If these prove to be insufficient, other possibilities should be explored as well.

  Thus, it is necessary to regularly monitor the availability of sufficient flexible capacities and – if necessary – to take regulatory measures to prevent situations deemed to carry risk for the security of supply.

- **Lignite based capacities:** With tightening pollutant emissions requirements and rising GHG emission

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[67] IEA (2019): Nuclear Power in a Clean Energy System. 2019. May (https://webstore.iea.org/download/direct/2779?fileName=Nuclear_Power_in_a_Clean_Energy_System.pdf)

allowances, until CO_2 capture and storage become economical it will probably not be profitable to build conventional coal-fired power plants in Europe. The more modern lignite units of the Mátra Power Plant will serve strategic reserves, while the older units will be gradually shut down.

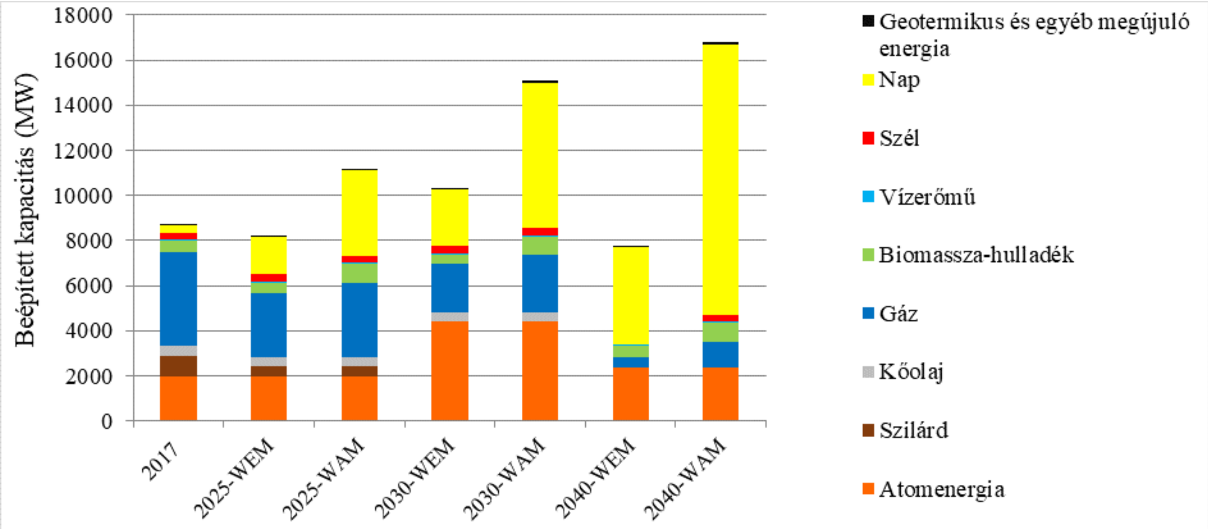

Figure 1 – **Expected composition of power generation capacities under the WEM and WAM scenarios**

Actual data: Eurostat

HU	EN
Beépített kapacitás (MW)	Installed capacity (MW)
Geotermikus és egyéb megújuló energia	Geothermal and other renewable energy
Nap	Solar
Szél	Wind
Vízerőmű	Hydroelectric
Biomassza-hulladék	Biomass waste
Gáz	Gas
Kőolaj	Oil
Szilárd	Solid
Atomenergia	Nuclear energy

- **Further improvement of the system's capacity for flexibility and preventing disruptions in flexible capacities**

Weather-dependent capacities are playing a growing role in renewable production, therefore **the availability and use of dispatchable capacities necessary for reliable power supply in the system operation of the transmission and distribution networks is a key strategic task**.

Short-term fluctuations in weather-dependent production can currently be balanced mainly by gas-fired power plants, but the spread of innovative solutions (e.g. energy storage and DSR) should also be enabled. In addition, the maximised exploitation of opportunities for increasing non-weather-dependent renewable energy production for enhancing flexibility is also justified.

It is essential to promote new types of flexibility services on the market by encouraging energy storage investments **within the REAS scheme (detailed in Chapter 3.1.2)** and mobilising regulation options on the demand side.

It is necessary to encourage energy storage investments and micro-grid solutions (facilitation of operating renewables and energy storage facilities at a single site with regulatory instruments). **It is necessary to simplify the licensing process and the accreditation of balancing markets, develop balancing products more effectively using the technical potential of storage facilities** (e.g. introduction of artificial inertia-type products)**, support innovative solutions in seasonal storage and to promote the heat storage of cogenerators.**

Hungary is also planning a pilot project to enable the support of necessary innovative solutions in the storage of seasonal energy:

- Development of power-to-gas technology based on the already operating domestic prototype;
- Conversion of surplus electricity into heat and its storage in district heating systems also using electric boilers;
- Development of optimal storage and consumption of hydrogen produced with electricity;
- Small-scale testing of the commercial application of cold energy and heat storage solutions under operating conditions.

Several types of technology may be competitive in relation to shorter term storage. **Battery storage facilities may also play an important role in efficiently operating transmission and distribution networks.** The Clean Energy Package, however, does not support direct ownership of balancing energy storage facilities by the TSO and DSO, as this could distort competition between storage facilities maintained with balancing revenues and operated on a market basis. Therefore, in addition to the transmission and distribution pilot projects supporting the gaining of necessary operating experience, the long-term model should be based on encouraging market-based storage investments.

Beyond the increase of storage investment, **it is also essential to mobilise regulation options on the demand side. System-level regulation should cover consumption-side control possibilities already implemented**

to a major degree, AFLC (audio frequency load control) and RFLC (radio frequency load control) systems connecting to the controlled connection points. The **main regulatory task is to establish incentives** that could be the most obvious means of establishing a flexible tariff structure.

To ensure a further increase of the DSR potential, **it may be also justified to introduce separate products for flexible consumption on the market of system level services.**

In terms of exploiting the DSR potential it is essential to also create a legal environment supporting the establishment of independent aggregators. (Further details provided in point i. of Chapter 3.4.3.)

To encourage the spread of smart metering Hungary plans to prescribe the replacement of conventional meters – upon their expiry – exclusively with smart metering equipment upon fulfilment of certain conditions. (Further details are provided in point vi. of Chapter 3.2.)

As regards **innovative system balance (flexibility energy storage and demand management)**, the following pilot projects are planned:

- The launch of pilot projects is recommended for **DSOs and TSOs within energy storage systems;**
- The establishment of a complex, pilot-scaled **research and development centre** is desirable to coordinate and complete currently fragmented research, not covering this entire field, to test the systemic interconnection of various renewable sources of energy and energy storage technologies;
- Testing of **complex DSR solutions** within the framework of a pilot programme, on the level of individual prosumers. Within the framework of the pilot project the testing of solutions is recommended, which offer the DSO a direct option for intervention to optimise the network load of individual consumers.

Since the new types of flexibility services will mainly be used by system operators and distributors, they are expected to develop incentive schemes ensuring a growing offer of such capacities. For preventing limited capacities and ensuring price signals encouraging investment, it is necessary to **introduce marginal cost-based and scarcity pricing, and to eliminate price caps on balancing markets.** It is also necessary to improve the profitability of capacities providing flexible services by reducing operating costs and fiscal burdens. It is necessary to assess means by which cogenerators integrated in the supply of district heating (CHPs) can be integrated in the group of regulators, as their production upturn during the winter period could optimally supplement PV power plants producing at higher levels during the summer period.

To ensure the development and evaluation of adequate regulatory incentives it is appropriate to test certain procedures and technologies with a regulatory sandbox.

To ensure the cost-effective satisfaction of flexibility demand it is necessary to conduct regular exchanges of experience with countries facing similar challenges and with those possessing operational experience, and to collect experience relating to law, regulation, incentives and technological best practices in this process.

Based on the foregoing it is justified to draft a precisely scheduled action plan to improve the flexibility of the electricity system.

It is necessary to regularly monitor the availability of sufficient flexible capacities and – if necessary – to take regulatory measures to prevent situations deemed carry risk for the security of supply.

(Point iii. of this chapter provides information relating to the distribution flexibility market.)

- **Guarantee of the security of supply with reserve capacities**

To guarantee the security of supply in Hungary it is necessary to maintain surplus capacities contributing to domestic power generation under critical circumstances, e.g. on winter days with peak demand or in case of limited access to imports for technical reasons. Such capacities should mainly be secured from sources no longer able to survive on the market, but their technical condition allows their operation to the extent necessary. There are various means of maintaining emergency reserves, e.g. in the form of **strategic reserves**, functioning as a component of the capacity mechanism, **or – as part of system level services –** with regulatory (tariff) sources through **the network (load redistribution)/disruption reserve system** to ensure that such capacities earn sufficient revenue for maintaining an adequate technical condition.

When selecting the means, it is necessary to consider that strategic reserve is deemed to be a capacity mechanism, hence it is subject to strict preliminary licensing requirements prescribed by Regulation (EU) 2019/943 on the internal market for electricity. Although several system operators have maintained network reserves in the past, implementation of the Clean Energy Package prescribes their purchase within a competitive framework. The relevant Union regulation is less stringent than in relation to strategic reserves, and the system operator is able to use such capacities in a more flexible manner. Under the technology-neutral scheme jointly developed by the distributors, also allowing room for solutions building on storage and demand side responses, it could be possible to guarantee a capacity fee in the longer term for capacities with such capabilities.

- **Cross-border capacities (import capacities)**

Cross-border capacities are further increased with new interconnections to Slovakia (and subsequently planned to Slovenia). Upon the increase in Slovakian-Hungarian cross-border capacities, the import capacity of Hungary is expected to rise by a total of 1 450 MW in the early 2020s. In addition to improving access to lower priced wholesale markets, the expansion toward Slovakia also contributes to strengthening the security of supply in regions of Eastern Hungary.

Implementation of the Slovenian line may further increase cross-border capacities by around 1 000 MW.

Pursuant to requirements of Regulation (EU) 2019/943 on the internal market for electricity, a larger volume of capacity should be announced on the market for existing cross-border lines as well, thus trade flows will also become more efficient. (See Chapter 2.4.2 for PCI projects with Hungarian involvement.)

(ii) **Measures planned for determining the level of the security of supply**

Determination of the level of the security of supply in Hungary based on LOLE, LOLP, LOLH indicators, identification of security of supply risks and monitoring of potentially negative economic effects (VOLL), regular review of such risks, determination of target values; coordination of the targeted incentive mechanisms of the Hungarian electricity system based on targets, actual and expected values.

(iii) **The establishment of an infrastructure, regulatory and market environment supporting the integration of renewables**

To ensure that capacity reservations blocked by 'low quality', unimplemented power plant projects do not prevent the network connection of renewable producers, **transparency and economic efficiency should be improved in distributing network connection capacities.** To this end, non-discriminatory capacity auctions could be held, for example, on a regular basis.

If current regulations and technical standards remain in effect, the total **national public and private investment requirement** for conventional network development necessary for satisfying demand **arising on behalf of large consumers and attributable to electrification trends** expected between 2019 and 2030 in the supply areas of Hungarian distributors will **exceed HUF 200 billion.**

Assuming current network connection and network usage practices applicable to PV power plants, the amount of public and private investment necessary for new PV connections expected up to 2030 exceeds HUF 300 billion.

The goal is to develop complex price control encouraging use of innovative, smart solutions and the purchase of flexibility services (e.g. energy storage, demand side response) on the market. In the course of reviewing the distribution price control scheme, the study of British regulatory practice is an option. While Hungarian price cap regulation determines *ex ante* revenue requirements based on costs incurred by licensed distribution network operators earlier, under the British model the regulatory authority determines the opening basic revenue based on the total planned amount of expenditures (hereinafter 'TOTEX') according to the business plans of the licence holders. As an advantage of TOTEX regulation, while regulation separately assessing investment expenditures (hereinafter 'CAPEX') and operating expenditures (hereinafter 'OPEX') encourages asset-intensive investments, in the case of TOTEX regulation the network companies may have an interest in managing problems arising from network congestion with cheaper IT technologies or purchased services (e.g. energy storage facilities).

It is necessary to assess the extent to which current regulation of network access fees (hereinafter 'NAF') impedes the spread of energy storage technologies, the types of measures that may eliminate such impediment, and the extent to which a favourable NAF regulation structure can encourage the spread of storage technologies.

Distributors should be aware that the operation of the network will not be sustainable without active system operation. It is necessary to establish the market mechanisms necessary for active operation of the distribution network, distributors should develop voltage regulating and congestion managing **distribution flexibility markets**, established in consideration of local, regional characteristics, providing price indicators. For the above purpose it is necessary to enhance distributors' capacity to operate their own system. It is necessary to finance the cost of the distribution network's upgrades necessary for system operation, and the costs of developing the regulatory system and related market. Distribution flexibility should be kept within the competence of distributors, as it affects localisation and local network operation. The market of system level services and distribution flexibility capabilities should also be kept separate in the long term, with high-level data exchanges. At the same time, distributors should develop a framework of cooperation with the system operator, amounting to the close coordination of the distribution flexibility market and the market of system level services. On the level of the system operator, the strengthening of international cooperation aimed at the sharing of balancing capacities can significantly contribute to ensuring flexibility necessary for the integration of renewables.

(iv) **Ensuring the cost-effectiveness of integrating renewable investments**

It is very important that the amount of aid is adjusted to the decrease in investment costs. Hungary plans to partially offset new investor burdens arising from introduction of free market sales and dispatching obligations by the following means:

- **Reliable meteorological forecasting – with large area coverage – is necessary** for efficient scheduling required under Article 5 of Regulation (EU) 2019/943 on the internal market for electricity. Since the cost of implementing such a system exceeds the resources of renewables producers, but its implementation also results in substantial external benefits, the **Government shall assume financial support** of the advanced development of a forecasting system developed by the OMSZ;
- Drawing up of a **compensation, i.e. balancing aid scheme,** to enhance the regulatory capacity of FIS producers and REAS-FIS producers with a capacity of less than 0.5 MW. If the rise in the cost of producer balancing energy is caused by poor scheduling, it reduces the amount of compensation, hence the burdens of cost bearers as well;
- **Encouragement of diversified renewable portfolios:** exploitation of national bioenergy potential and small-scale waterpower production capacities, in addition to solar energy;
- Instead of the mandatory participation of renewable electricity generation in the FIS balance group managed by the system operator as balance responsible party, **encouragement of joining a market balance group**, with maintained aid conditions, to promote market

integration.

(v) **Preparation of the electricity grid for the spread of decentralised energy production**

In contrast with earlier practice, renewable energy production is carried out on a decentralised basis, often by connection to low and medium voltage distribution networks. For this reason a **prerequisite for rapid growth in the penetration of renewables is the preparation of the transmission and distribution network for managing challenges attributable to the decentralised and to a significant extent weather-dependent production structure.** This effort necessitates appropriate regulatory incentives. The increase of the share of renewables can only be achieved in parallel with the development and 'enhanced intelligence' of transmission and distribution networks, and the development of **distribution network operation, as a decentralised intervention capability, and its transparent market mechanisms** (distribution flexibility market)**.**

Close cooperation is necessary between the TSO responsible for balancing energy and distributors to ensure that the two markets support each other, use at various voltage levels does not cause cross-effects and thereby rising costs.

The availability and use of dispatchable capacities necessary for reliable supply in the system operation of the transmission and distribution networks is a key strategic task requiring close cooperation between all market participants, licence holders and regulators. Through its balancing role, the existing natural gas infrastructure can cost-effectively and significantly contribute to this process.

Specific measures serving the cost-effective acceptance of decentralised capacities:

- **Increase of the capacities of existing network elements.**
- **More accurate specification of the still available capacities of network elements** by use of innovative technologies (e.g. dynamic line rating (DLR)), under prevailing conditions.
- **Establishment of the active system operator role of DSOs:** assessment of the establishment of a distribution network system operation and voltage regulation centre, the introduction of distribution flexibility products, and establishment of a platform ensuring the joint operational optimisation of TSOs and DSOs.
- **Modification of relevant network connection conditions, obligations for consumers with household-scale power plants (HSPP) in a forward system.** In relation to equipment installed with the final customer's own investment (HSPP, EV charger-inverter) it is justified to define technical requirements in advance and to prescribe conformity with these by the customer.
- The mandatory participation of producers with a connection capacity of more than 0.4 MW should be prescribed in voltage regulation.
- In relation to all consumers connecting to a low voltage (LV), medium voltage (MV) and high-voltage (HV) network, development of **a final customer electricity price scheme** (multiple zone times,

capacity and energy based tariff, yearly basic network access fee) **consistent with the physical properties and cost structure of the electricity distribution network and encouraging consumers to use more balanced network capacities.**

- Modification of the regulation (mainly price and tariff control, network connection regulation) of electricity grid companies.
- **Identification of distribution network congestion and their elimination with market mechanisms (capacity auctions, distribution flexibility market products)** to ensure integration of decentralised production. Establishment of opportunities for distribution network system operation.

(vi) **Establishment of regulatory framework supporting use of innovative solutions on the market**

Main related topics: system balance, innovative energy supply methods, 'smart regulation', nuclear innovation, seasonal electricity and heat storage solutions. Further information relating to the above is provided in Chapter 3.5.

(vii) Point i. of Chapter 3.4.3 provides information on **strengthening regional electricity market integration and coordinating the operation of gas and electricity markets.**

Gas market

(i) **Reduction of import dependency:** decrease in consumption and a higher rate of using own resources also contributes to reducing import dependency.

- **Consumption reduction measures:**

- We plan to reduce gas consumption for heating by encouraging the improvement of building energy efficiency based on the obligation scheme, programmes that also support heating/cooling solutions based on renewable resources, and by implementation of the Green District Heating Programme that encourages use of renewable resources in district heat generation as well. (More information on this topic is provided in the relevant parts of Chapters 3.1.2 and 3.2.)
- Industrial gas consumption will mainly depend on the rate of economic growth; we estimate that it may increase by 0.5 billion m^3 (over 2 billion m^3) over the year 2016. We support the decarbonisation of industrial production by implementing pilot projects encouraging use of 'clean' hydrogen (produced with electricity originating from carbon-free sources).

- **Use of own gas resources:** Hungary's import dependency can also be reduced with the greater use of national resources (natural gas, alternative gas sources, such as biogas/biomethane).

- **We will encourage use of our own natural gas resources.** By guaranteeing the predictability of the concession scheme and enhancing the flexibility of the system we can offset the exhaustion of production inventories with the encouragement of new extraction projects. This **requires the fine-**

tuning of the successful hydrocarbon and geothermal concession scheme.

- It is also justified to **encourage unconventional hydrocarbon exploration and extraction.** Although mining companies are showing interest in unconventional exploration and production, the geological risks remain extremely high. Therefore, to encourage unconventional exploration and production, the State would support the market supply of gas by offering a guaranteed minimum priced feed-in option within the retail supply portfolio.
- **Encouraging use of alternative gas sources (biogas, biomethane and hydrogen) to reduce natural gas consumption:**

The increased use of biogas produced from agricultural waste, landfills and waste water treatment plants may also contribute to reducing natural gas imports and CO_2 emissions of natural gas consumption. We consider the production, purification of biogas and its feeding into the gas network to have major potential, with an average funding requirement, which may also contribute to meeting targets for increasing the use of renewable energy and decarbonisation. **Hungary plans to encourage biogas/biomethane production with the establishment of a feed-in system.** Since biogas may also supply cost-effective energy based on local resources to municipalities lacking a natural gas network or using the existing network at a very low rate, and economic activities enhancing the rural population retention ability can be built on biogas production, we plan to also directly support such innovative investments. Energy from biogas may also be a viable option for municipalities lacking a natural gas network. It may be practical to establish a biogas power plant at these municipalities that would supply electricity to the given municipality either as member of an energy community or as a market participant.

In addition to biogas/biomethane, Hungary also considers hydrogen produced with 'clean' energy as an alternative; the **blending of hydrogen** produced with electricity generated from carbon-free resources **with natural gas** offers an innovative option in the experimental phase, with major potential, but with a high funding requirement, which is also relevant for meeting the renewable energy and decarbonisation targets. **We are planning to launch a pilot project to test this option on the level of natural gas transmission, storage and distribution.**

(ii) **Import diversification and related infrastructure development**

Hungary plans to meet the remaining annual import requirement of approximately 6.2 billion m^3 with sources as diverse as possible in 2030. To this end it is necessary to implement an infrastructure ensuring access to four independent gas import sources (gas traded on the Russian, LNG, Romanian and Western European markets). This infrastructure provides an adequate basis for **further strengthening wholesale competition resulting in the lowest possible prices for consumers by promoting regional market integration** (point i. of Chapter 3.3) **and market development in Hungary.**

It is legitimate to ask why it is necessary to continue upgrading the natural gas infrastructure if we are forecasting a substantial, long-term decline in consumption in both the energy industry and retail sectors. Generally speaking, dependence on purchases from a single supplier and from one direction can be reduced by developing reverse flow cross-border capacities, resulting in a more favourable bargaining position for negotiating purchase conditions. Furthermore, the transmission route of Russian natural gas imports is expected to be supplemented with the alternative southern supply route after 2021, and from 2021 a portion of Russian natural gas is to be imported from the south. Owing to the expected change of the direction of supply, it will be necessary to upgrade the south-west and south-north transit routes and cross-border capacities, and to also enhance the internal network to ensure uninterrupted supply to the region of Eastern Hungary.

Reconsideration of the import portfolio, enhancement of gas market diversification:

As a strategic objective we will retain the Ukrainian-Hungarian connection point to maintain reverse flow deliveries, but we should also prepare for the possibility of the main direction of gas imports shifting to the currently implemented southern gas transmission route. To this end **it is necessary to continue the gas market diversification policy for accessing Black Sea and liquified natural gas resources. We also plan to improve use of natural gas storage capacities.**

The following infrastructure development projects can further enhance diversification and thereby the security of supply:

- **Support of the implementation of planned PCI projects** (details provided in Chapter 2.4.2)
- All barriers had been already eliminated on the Hungarian side at the beginning of the decade before implementing a reverse flow in the Croatian-Hungarian interconnection; **based on the necessary upgrades in Croatia from 2021 we can expect to be able to also import natural gas from our southern neighbour** through the planned LNG terminal.
- Implementation of the reverse flow of the Romanian-Hungarian pipeline from the direction of Romania requires additional upgrades; based on the schedule, the interconnecting capacity of 1.75 billion m^3 annually, allowing the transmission of non-interruptible reverse flows, is expected to be ready by the end of 2020. **The option of Romanian imports is crucial for accessing Black Sea reserves**, because upon the launch of production there Hungary could simultaneously diversify its natural gas purchase sources and routes. The extraction of an annual quantity of 6-8 billion m^3 in natural gas is expected from the Neptun field, the most advanced and most promising off-shore production project. The project is currently awaiting a final investment decision; if such decision is made, we plan to increase the capacity of the Romanian-Hungarian interconnector to 4.4 billion m^3 annually.
- After 2021 most of the supply of Russian gas to Hungary is expected to shift to the southern gas transmission route from the direction of Serbia, the extended second branch of the TurkStream pipeline on the European mainland. With continuing competition on the gas

market, **it is essential for Hungary to have access to Russian gas from Serbia (not only from the west and east) in case supply is terminated from Ukraine.** With the launch of supply from Serbia, demand for natural gas transits to Serbia and Bosnia would cease, although substantial transit flows may be necessary to Austria.

Upon the market-based implementation of the key infrastructure development projects, it will be possible to increase Hungary's cross-border capacities – enabling commercial imports independent from the Russian supplier – from the current annual amount of 9.7 billion m^3 (including Austrian and Slovakian interconnections)[68]

- to 11.45 billion m^3 by 2030, with the implementation of the first phase of Romanian development,
- to 14.1 billion m^3 with the implementation of the second phase of Romanian development (after the final investment decision on Black Sea natural gas production),
- to 12.3 billion m^3 with the Hungarian-Slovenian cross-border pipeline implemented after successful market testing,
- to 12.6 billion m^3 with the reverse flow of the Croatian-Hungarian cross-border point and construction of the LNG terminal,
- to 10.5 billion m^3 with the upgrade of the Hungarian-Slovakian pipeline, and **up to 20.4 billion** m^3 if all of the above development projects are implemented.

The table below shows possible scenarios aimed at satisfying future Hungarian gas demand, comparing the expected security of supply parameters of alternative contract portfolios prepared from them.

billion m^3	Market, without diversification	LNG, but without Romanian supply	Romanian supply distributed in the region	Romanian supply to the Hungarian market	Maximum diversification
Russian	3	3	3	3	3
LNG	0	1	0	0	1
Romanian	0.5	0.5	1.5	3	1.5
market from	4.5	3.5	3.5	2	2.5

[68] The list quantifies the impact of the implementation of individual projects.

Entry capacities in 2019: based on import capacities of Mosonmagyaróvár (AT) 5.3 billion m^3 and Balassagyarmat (SK) 4.4 billion m^3.

other directions					
total	8	8	8	8	8

Table 11 – Possible import scenarios after 2020 (assuming a Hungarian import requirement of 8 billion m^3)
Source: Ministry of Innovation and Technology

Based on the comparison, the 'Maximum diversification' scenario is the optimal one to ensure fulfilment of the security of supply and diversification goals. In the above case Hungary would secure the quantity of base-load consumption necessary for supplying universal services from Russian sources (3 billion m^3/year / 29.31 TWh) in the form of a multi-year contract, and would also assume implementation of the planned Croatian and Romanian projects.

(iii) **Enhancing flexibility**

As regards the management of restrictions or interruptions in energy supply, it is important to improve the adaptability of the national energy system, in relation to which the enhancement of the flexibility factor plays an important role. To this end, ensuring access to LNG sources enabling more flexible purchases is important. Access to the **LNG** terminal planned on the island of Krk renders the establishment of potential gas imports from Croatia particularly important for Hungary. Integration of the two countries' gas markets would significantly contribute to improving the competitiveness of Croatian LNG (see details in point i. of Chapter 3.4.3).

Own resources also enhance the flexibility of supply.

(iv) **Market integration**

The security of supply can be further improved by integration of regional gas markets, the establishment of smooth operating conditions of the internal gas market referred to in Regulation (EU) 2017/1938[69], and by coordinating the operation of gas and electricity markets (sector coupling).

Point i. of Chapter 3.4.3 presents the related measures.

(v) **Maintaining the maximum possible transit quantity within the Hungarian natural gas transmission system, and related storage strategy:**

The joint goal of reducing natural gas consumption and increasing the use of infrastructure can be met with

[69] 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 (https://eur-lex.europa.eu/legal-content/hu/TXT/?uri=CELEX%3A32017R1938)

the **use of the high-pressure natural gas transmission system for transit purposes**, which can be effectively supported with Hungarian natural gas storage capacities that are substantial on a regional scale. **It is therefore necessary to strengthen competition on the gas storage market and the regional role of Hungarian facilities.** Maintaining natural gas transit flows is also key to the use of natural gas storage facilities.

Strategic concepts relating to Hungarian natural gas storage facilities should be divided into short and long-term ones:

- **Short-term concepts:** Taking into account the Russian-Ukrainian geopolitical situation, changes to transmission routes and trends in short-term supply contracts, Hungary prepared for the 2019/2020 gas year with very high storage reserves to ensure the continuous security of supply.
- **Long-term concepts:** The storage strategy should be aligned to the shift of current east-west transmission routes to south-north-west routes. Hungarian storage capacity could become an important pillar of Croatian-Hungarian market coupling. Upon implementation of the Slovenian-Hungarian pipeline, Western European traders could also access storage options along a direct route. To meet decarbonisation goals, we will also assess options for converting some of the natural gas storage capacities for hydrogen storage.

(vi) Upon a sharp decline in natural gas consumption or in the volume of natural gas distributed within the network it will be necessary to also **rationalise the infrastructure** (point ii. of Chapter 2.4.2). Point i. of Chapter 3.4.2 presents the related action plans.

Oil market:

Hungary is planning the following measures to ensure that the use of petroleum products increases by no more than 10 % by 2030 in transport:

- **Encouraging use of public transportation and rail.**
  - Use of motor vehicles with clean (mainly electric) propulsion in public transportation and local services;
- **Fuel switching:**
  - increased biofuel blending ratio,
  - encouraging electric mobility,
  - encouraging CNG/LNG propulsion for heavy goods vehicles,
  - encouraging advanced (second generation) biofuel innovation (detailed in Chapter 3.1.2).
- **Maintaining the Hungarian hydrocarbon concession scheme, encouraging the exploration and extraction of unconventional crude oil.**

- **Maintaining the standard of the security of supply based on strategic stockpiling.**

Coal market

Lignite accounts for 54 % of Hungarian coal reserves; brown coal accounts for 30 % and black coal for only 16 % of geological reserves. Coal production in Hungary consists almost entirely of lignite mining (99.97 %). Based on data of the Hungarian Energy and Public Utility Regulatory Authority, 93.5 % of coal in Hungary is utilised by power plants and 4 % is burned by households. Coal used for household heating is 88 % lignite, 9 % imported hard coal and 3 % brown coal briquettes.

The share of coal in Hungarian power generation has significantly declined. The downturn in coal mining was initially caused by a diminishing heavy industry. The effects of tightening pollutant emissions requirements became more pronounced later on. Today there is only one coal-fired large power plant – Mátra Power Plant – operating in Hungary.

The Mátra Power Plant plays an important role in terms of both the security of supply and the labour market. As the second largest power plant of Hungary, it accounts for 15 % of total Hungarian power generation. It is the only large power plant in the eastern half of Hungary allowing regulation and is also a major employer, considering that most of the inhabitants of the districts concerned (Gyöngyös and Mezőkövesd) directly or indirectly work in the industry (2 100 jobs are directly, 10 000 jobs indirectly related to the power plant, with around 27 000 affected family members). However, the power plant is also the largest CO_2 emitter of Hungary, **accounting for approximately 50 % of** CO_2 **emissions in the energy production sector and 14 % of total national** CO_2 **emissions.** The power plant and the roughly 100 000 households in the region heating with lignite also significantly contribute to concentrations of other air pollutants in Hungary: 36.2 % of SO_2, 13.71 % of Hg and 4.48 % of NO 2.[70]

Based on the power plant's role in Hungarian electricity supply it is necessary to prepare for changes in the operation of the electricity system, the replacement of some capacities with other technologies, the retraining of workers in the affected region and for maintaining various industrial activities relying on the power plant's technological systems. **In addition, taking into account the substantial Hungarian lignite reserves, we plan to ensure the availability of lignite production as a strategic reserve.**

Achievement of these goals can be guaranteed **by drawing up a regional decarbonisation strategy and action plan** involving stakeholders. EU funds are also available for implementing the decarbonisation programme.

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[70] Emissions data for 2017.

Nuclear safety

Pursuant to Act CXVI of 1996 on nuclear energy, nuclear energy may only be used in possession of licenses defined in legislation, under continuous administrative supervision. In international conventions Hungary committed itself to using nuclear energy only for peaceful purposes, under safe and protected conditions. To ensure non-proliferation, i.e. prevention of the proliferation of nuclear and radiological weapons, nuclear and other radioactive materials are used under strict licensing procedures, control and registration. Safe operation is ensured by comprehensive regulation and multi-tiered, complex supporting systems and operating mechanisms substituting each other to ensure that the use of nuclear energy does not produce adverse effects on the population. Security is guaranteed by safety solutions, technologies and regulations serving the physical protection of the nuclear facility, radioactive waste disposal sites, and nuclear and other radioactive materials.

Construction of the new nuclear units is also bound to strict conditions. More than one authority licenses and supervises a complex facility such as a nuclear power plant, involving many fields of expertise. The authorities issue the necessary licenses in their respective licensing procedures and, as regulatory bodies, enforce their own specialised criteria in the procedures of other authorities. The Hungarian Atomic Energy Authority (HAEA) is responsible for authorisation of the establishment and operation of the nuclear power plant in terms of safety, security and safeguards. Installation-level procedures follow the life-cycle of the nuclear facility. Accordingly, it is necessary to assess the suitability of the site before launching the substantial phase of the investment, to fully draw up the technical designs of the nuclear power plant and carry out its safety analyses to be reviewed by the authority, which grants the implementation permit in case of conformity. It is necessary to commission the built facility, which consists of operability testing of installed systems, followed by a series of measurements, including the loading of fuel assemblies containing nuclear fuel. If everything functions in accordance with safety analyses and the plans, in conformity with requirements, the reactor unit may be granted a long-term operating licence. The HAEA verifies operation in conformity with issued permits within the framework of inspections.

The security of nuclear energy is also guaranteed by Hungary's signing of a number of bilateral and multilateral international agreements relating to the safe use of nuclear energy. Details are provided on the website of the HAEA[71].

It is also important to note the **strategy ensuring the long-term supply of nuclear materials and fuels**, with particular regard to increasing nuclear capacities.

Section 1(1) of Decree No 44/2002 of 28 December 2002 of the Minister for Economy and Transport[72] on the minimum quantity of the energy reserves of power plants with a capacity of 50 MW or more, and on the rules

[71] https://www.haea.gov.hu/web/v3/OAHPortal.nsf/web?openagent&menu=04&submenu=4_8

[72] Former Minister for Economy and Transport.

of stockpiling stipulates that the production operation licence holder of a power plant with a nominal capacity of 50 MW or more is required to maintain normative and emergency energy reserves for each power plant.

- Pursuant to paragraph (2)(c), the normative quantity of energy reserve corresponds to the quantity of fuel necessary for at least one year of average electricity and cogenerated heat generation by the nuclear power plant on 1 February of the calendar year.
- Pursuant to paragraph (3)(c), the quantity of safety energy reserve corresponds to the quantity of fuel – jointly with fuel contained in the normative reserve – ensuring at least two years of average electricity and cogenerated heat generation by the nuclear power plant on 1 February of the calendar year.

Act II of 2014 promulgated the convention entered into between the Government of Hungary and the Government of the Russian Federation on cooperation in the field of the peaceful uses of nuclear energy, which sets out obligations relating to the operation of facilities of the Paks Nuclear Power Plant and the increase of capacity, i.e. the establishment of the new units. Several agreements on implementation are related to the act, including the agreement on fuel, which has been also signed by the Euratom Supply Agency.

Improving cybersecurity

Cybersecurity has become a key element of national security, therefore raising cybersecurity to the highest possible level has become a condition for protecting Hungary's sovereignty. The EU NIS Directive[73] also emphasises the energy sector in relation to guaranteeing the uniform high level of security of network and information systems.

The Hungarian energy sector should also be prepared to manage challenges, threats and risks arising in cyberspace, guarantee an adequate level of cybersecurity, carry out cybersecurity tasks, develop cyber-resistant capabilities and to ensure the uninterrupted operation of the national vital information infrastructure. We need to strengthen the protection of electronic IT systems, the national vital information infrastructure, classified information and national data assets.

Proposed measures:

Set of sectoral cybersecurity requirements

At the present time the key organisations involved in the Hungarian electricity system do not fall within the

[73] 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.

scope of Act CLXVI of 2012 on the identification, designation and protection of vital systems and facilities[74], i.e. they have not been designated as vital system components. Since actors providing essential services are designated in the procedure for designating national vital system components from among operators of designated national vital system components, requirements set out in the NIS Directive[75] on the security of network and information systems are not applicable to the key organisations, either. Taking into account the above, the legal framework relating to the protection of vital systems and facilities in the Hungarian energy sector should ensure that based on the thresholds, key organisations can be designated as vital system components. It is also justified to ensure that actors providing essential services are designated in a procedure separately from the procedure for designating national vital system components. With the involvement of the professional organisations concerned it is necessary to draw up a sectoral set of cybersecurity requirements – in the form of a policy strategy[76] – applicable specifically to organisations operating in the electrical industry in accordance with requirements set out in Act L of 2013 and Decree No 41/2015 of the Minister of the Interior (also taking into account that certain provisions of Decree No 41/2015 are not applicable in relation to ICS and SCADA systems used in the electricity industry or due to the operating/usage specifications of such systems). As a strategic objective, the preventive, detection and response capabilities should be continuously improved with the definition of the set of requirements, organisation of targeted exercises and the establishment of funding instruments.

<u>Sharing of sectoral cybersecurity information</u>

The sharing of information between major organisations of the energy sector should be made more effective at both national and international levels. We plan to launch regular sharing of information between major actors of the Hungarian energy sector (energy producers, suppliers, system operators) through government coordination to ensure the secure and uninterrupted operation of energy systems. Within the above framework it is necessary to establish options for the automated sharing of cybersecurity information relevant for the electricity sector.

<u>Set-up of rapid response unit for incident management</u>

In case of cybersecurity incidents the unit will provide on-the-spot assistance to operators (tracing, threat

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

[75] 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).

[76] Pursuant to Section 8(1)(c) and Section 35 of Government Decree No 38/2012 of 12 March 2012 on Government strategic management.

analysis, network security monitoring, incident management, analysis of various attack tools and methods).

<u>Human resources</u>

The application of settings in conformity with minimum security requirements prescribed by legal requirements is a priority. To improve cybersecurity (or to at least prevent the further degradation of cybersecurity risk levels) the most important measure is to ensure the continuous availability of qualified and experienced specialists for operative cybersecurity activities.

Improvement of the labour market in the energy sector

To improve the labour market in the energy sector **it is necessary to raise the standard of specialised education and to better exploit opportunities offered by the dual education system.** Following the survey of educational needs and identification of skills shortages, the number of students pursuing studies in the field of energy should be increased with support from career guidance programmes. Outward migration and the drain effect of other industries (mainly the automotive industry) can mainly be mitigated with corporate wage increases and the offering of a secure vision. Mobility within the country can be encouraged by reducing taxes on (e.g. sublet) aids facilitating mobility.

Economic structural changes resulting in lower carbon intensive energy production and consumption may also bring about significant changes in employment needs and opportunities outside of the energy sector. To ensure a just transition, the strategy aims to:

- enable the monitoring of labour market trends affected by the energy transition and to reverse possibly negative trends;
- facilitate improvement of employment prospects in the green economy sectors, thereby enhancing competitiveness in this field;
- provide support opportunities for the continuing training and retraining of vulnerable workers;
- extend certain development policy based support opportunities to vulnerable social groups and regions;
- facilitate enforcement of equal opportunity for women, and vulnerable social groups and regions, either through separate ‘just transition strategies’ or ‘just transition agreements’.

ii. Regional cooperation in this area

CESEC

Hungary is member of the Visegrád Group cooperation and the High Level Group on Central and South

Eastern Europe Energy Connectivity (CESEC)[77], which regularly discusses energy and climate policy matters with relevance for the NECP. The High Level Group on Central and South Eastern Europe Energy Connectivity (CESEC) – established in 2015, with 9 EU Member States and 8 additional countries as members – serves to accelerate the integration of electricity and gas markets in the region.

Visegrád Group cooperation

The Visegrád Group cooperation is a regional organisation of Czechia, Poland, Hungary and Slovakia. It aims to provide joint representation of the economic, diplomatic and political interests of Central European countries and to coordinate their possible steps.

The Visegrád States (‘Visegrád Group’ or ‘V4 countries’) hold consultations on the following matters:

- achieving a common position within the European Union regarding the directions of developing the energy sector,
- cooperation in scientific research and development (consultations are in progress to establish a platform specifically for RDI energy cooperation),
- sharing of experience on development of the energy sector, with certain technology suppliers as well, including in particular cooperation with suppliers of nuclear technology.

Point ii. of Chapter 3.5 provides further details on V4 RDI cooperation.

Other forums

The **Government of Hungary and Hungarian energy companies** – including system operators – **and the Hungarian regulatory authority** (HEA) **are represented in a number of organisations and working groups**, thereby enhancing the security of supply in Hungary.

<u>Electricity market</u>

- Electricity Coordination Group (ECG)
- Participation of the system operator (MAVIR Zrt.) in various organisations, forums:

Pursuant to the Electricity Act and the operating licence issued by the regulatory authority, MAVIR Zrt. has the right and obligation to represent the position of Hungary in international system operator organisations, continuously coordinate cooperation, carry out technical and diplomatic activity for enforcing Hungarian

[77] Central and South East Europe Energy Connectivity

interests, and to participate in the work of the management bodies and working groups of organisations.

MAVIR Zrt. participates in the work of several international organisations and forums. Key organisations:

- European Network of Transmission System Operators for Electricity (ENTSO-E),
- Cooperation between 8 system operators of Central Eastern Europe,
- Cooperation between the system operators of the South-Eastern European region,
- TSC – TSO System Security Cooperation,
- EURELECTRIC,
- International Council on Large Electric Systems (CIGRE).

Cooperation in the field of nuclear energy[78]:

Pursuant to Government Decree No 112/2011 of 4 July 2011, the Hungarian Atomic Energy Authority (HAEA):

- cooperates with the International Atomic Energy Agency, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, the European Atomic Energy Community, and with other international and regional intergovernmental organisations in the use of nuclear energy for peaceful purposes,
- carries out tasks serving the national implementation of intergovernmental conventions concluded in relation to the safe use of nuclear energy,
- ensures the performance of international obligations within its competence, concerning the safe use of nuclear energy, relating to the safe management of radioactive waste and spent fuel, nuclear accident response, nuclear security, nuclear non-proliferation, and liability for nuclear damage,
- prepares national reports to be made under international obligations relating to nuclear safety, and the safe management of radioactive waste and spent fuel.

As a result of the HAEA's international activities carried out within the framework of international relations, Hungary is an active party to all important multilateral international agreements relating to the use of nuclear energy for peaceful purposes, and fully enforces their provisions. Representatives of the HAEA play an active role in universal and regional international organisations[79] established on the basis of international agreements concerning the safety and security of the use of nuclear energy, in organisations[80] and forums established for

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

[79] International Atomic Energy Agency, Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, European Atomic Energy Community, Comprehensive Nuclear Test-Ban Treaty.

[80] Nuclear Suppliers Group, Zangger Committee.

enforcing certain multilateral international agreements, and in other forums[81] of international cooperation. Firstly, the bilateral international relations of the HAEA are based on certain bilateral international agreements of Hungary, and the HAEA is designated in part or whole for their enforcement. Secondly, the bilateral international relations of the HAEA are based on professional agreements concluded within the scope its own functions and authority. Thirdly, the HAEA also holds meetings, where necessary, within the looser framework of international organisations and forums, with representatives of the partner authorities of States with which neither bilateral international agreements nor professional agreements have been concluded.

Further details are available in Hungarian and English on the HAEA website: (www.oah.hu).

Natural gas market

- Gas Coordination Group (European Commission)

  Pursuant to Regulation (EU) No 994/2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC, the Gas Coordination Group (GCG) regularly holds meetings since 2012 to coordinate measures concerning the security of gas supply in EU Member States. The meetings are regularly attended by Hungary.

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

FGSZ takes part in the work of the ENTSO-G as transmission system operator, representing the interests of Hungary. The company actively participates in ENTSO-G projects directly affecting its activity, such as the drafting of the single European network codes and of the 10-year development plan defined by legal requirements, updated on a yearly basis.

- Gas Infrastructure Europe (GIE)

The GIE is a non-profit organisation based in Brussels representing operators of gas infrastructures in 25 countries – including the operators of the transmission system, storage facilities and LNG terminals – before institutions of the European Union (European Commission, European Parliament, Council of the European Union) and European organisations of regulatory authorities (ACER, CEER[82]). MMBF Magyar Földgáztároló Zrt. also represents Hungary as a member. The board of the storage subdivision of Gas Infrastructure Europe (GIE) is chaired by Magyar Földgáztároló Zrt., thus Hungary plays a very active role in implementing EU decarbonisation efforts affecting the storage market, in consideration of benefits offered by the current natural gas infrastructure.

[81] Western European Nuclear Regulator's Association, European Safeguards Research and Development Association, European Nuclear Security Regulators Association, Meeting of the Heads of the European Radiological Protection Competent Authorities, WWER Regulators' Forum, European Association of Competent Authorities for Safe and Sustainable Transport of Radioactive Material.

[82] European Council of European Energy Regulators.

Oil market

- Participation in the work of the Oil Coordination Group (OCG) of the European Commission.
- Participation in the emergency mechanism of the International Energy Agency and in the work of the Standing Group on Emergency Questions (SEQ).

Miscellaneous

- Participation of the regulatory authority in the activity of ACER.
- Regional coordination in the planning of the NECP. For further details see Chapter 1.4.

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

Point iii. of Chapter 3.4.2 provides information on PCI projects.

3.4. Dimension of the internal energy market[83]

Chapter 3.3 covers a number of measures improving the security of supply and strengthening the internal energy market. This section specifically addresses measures more closely related to the topic.

Performance of obligations prescribed in European and Hungarian legislation, aimed at strengthening the internal energy market, is necessary to achieve the goals.

In relation to the electricity market the 'Clean Energy for All Europeans' energy package is a priority, serving the implementation of the Energy Union. The European Commission proposed and prescribed measures to complete the internal energy market by way of Directive (EU) 2019/944[84], Regulation (EU) 2019/943[85] and Regulation (EU) 2019/941[86].

Regulation (EU) 2017/1938[87] should be noted in relation to the gas market, which serves the establishment of smooth operating conditions on the European gas market.

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

[84] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (https://eur-lex.europa.eu/legal-content/HU/TXT/?uri=CELEX:32019L0944).

[85] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) (https://eur-lex.europa.eu/legal-content/HU/TXT/?uri=CELEX:32019R0943).

[86] Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC (https://eur-lex.europa.eu/legal-content/HU/TXT/HTML/?uri=CELEX:32019R0941&from=EN).

[87] 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 (https://eur-lex.europa.eu/legal-content/hu/TXT/?uri=CELEX%3A32017R1938).

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 surpasses the 15 % target expected by the EU by a large margin. Based on market simulation tests, however, a dual-system 400 kV connection (with one installed system) between Debrecen and Oradea is a potentially recoverable capacity increasing investment. This transmission line has been included in the network development plans prepared by MAVIR Zrt. for years as an investment proposed for implementation.

ii. Regional cooperation in this area[88]

During implementation of the projects, communication is continuous between the system operators, and cooperation is particularly good between operators of the Slovakian and Hungarian electricity systems (MAVIR Zrt. and SEPS[89]).

Additional information is provided in the chapter on the security of supply (point ii. of Chapter 3.4).

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

Point iii. of Chapter 3.4.2 provides information on PCI projects.

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

Electricity market

- Pursuant to Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 (hereinafter

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

[89] Slovenská elektrizačná prenosová sústava, a. s. (the Slovenian system operator)

‘Regulation 347/2013/EU’), by Government Decision No 1577/2019 of 15 October 2019[90], the Government supported the declaration of the projects referred to in point i. of Chapter 2.4.2 as **projects of common interest.**

- The document ‘Network Development Plan of the Hungarian Electricity System, 2017’ provides information on **other electricity market projects**.[91]

Gas market

- Pursuant to Regulation (EU) No 347/2013, by Government Decision No 1577/2019 of 15 October 2019[92], the Government supported the declaration of the projects referred to in point i. of Chapter 2.4.2 as **projects of common interest.**
- Point ii. of Chapter 2.4.2 provides information on **other gas market projects.**
- **Measures planned for rationalising the utilisation rate of Hungarian gas pipelines:**

The **further significant expansion of the Hungarian pipeline system is not justified**; the cross-border capacities should be further expanded only to the extent necessary for allowing the diversification of purchase routes and ensuring the availability of strategic and commercial options. This, too, would only be necessary if development is implemented on a market basis. Development would increase and diversify liquidity on the Hungarian natural gas market, which benefits consumers.

The main task is to make better use of and rationalise the existing infrastructure. **We aim to phase out distribution pipelines with a low utilisation rate (below 10 %) from the publicly funded system by offering heating alternatives with low carbon intensity.** Details are provided in point vi. of Chapter 3.2.

The adaptation of the network enabling the feed-in of hydrogen is an alternative for the phasing out of distribution pipelines with a low utilisation rate and may also play a key role in meeting climate protection targets. The production of hydrogen (and synthetic gases) and its feeding into the distribution system also reduces dependency on natural gas, and offers a cheap, flexible energy storage option. We therefore aim to establish conditions and incentives necessary for supplying hydrogen and other gases of ‘natural gas quality’ in the system.

The **option of free connection** generates development worth billions of forints for distributors at sector level.

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[90] Government Decision No 1577/2019 of 15 October 2019 on measures concerning the declaration of certain investments as projects of common interest relating to the trans-European energy infrastructure. Hungarian Official Journal. Volume 2019, issue No 167 (http://www.kozlonyok.hu/nkonline/MKPDF/hiteles/MK19167.pdf).

[91] *In relation to other electricity market projects, see the document ‘Network Development Plan of the Hungarian Electricity System, 2017’.*

[92] Government Decision No 1577/2019 of 15 October 2019 on measures concerning the declaration of certain investments as projects of common interest relating to the trans-European energy infrastructure. Hungarian Official Journal. Volume 2019, issue No 167 (http://www.kozlonyok.hu/nkonline/MKPDF/hiteles/MK19167.pdf).

To ensure cost-effectiveness, the system should be reconsidered along the following lines:

- Obligation of consumers without actual, constant consumption to pay a fixed fee;
- Binding of free connection to actual consumption as early as the submission of the connection application, subject to financial consequences;
- In relation to pipelines built to satisfy not actual consumption of gas, deadlines for the construction of each new pipeline should not be applicable.

Chapter 3.3 provides additional information relating to the transit role (as a means of improved use of the infrastructure).

ii. Regional cooperation in this area[93]

During implementation of the projects, communication is continuous between the system operators, and cooperation is particularly good between operators of the Slovakian and Hungarian electricity systems (MAVIR and SEPS).

The chapter on the security of supply is also relevant in relation to this topic. (Point ii. of Chapter 3.4)

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

The following Hungarian projects received CEF funding:

Electricity market

For the feasibility study concerning the Hungarian section of the Gönyű-Bős power line and other preparatory activity, in 2014 MAVIR was awarded non-reimbursable financial aid within the framework of the CEF in the amount of 139 034 EUR, with a 50 % co-financing rate, for costs incurred up to 31 September 2017.

Gas market

In relation to the Romanian-Hungarian (RO-HU/BRUA) project, FGSZ Zrt. has so far received financial support within the framework of the CEF[94] for the following activities:

In 2015, in relation to the project concerning the planning application of the Hungarian section of the RO-HU-AT natural gas transmission corridor, 1 377 000 EUR non-refundable aid was awarded within the framework of the CEF, with a 50 % co-financing rate (total estimated project cost: 2 754 000 EUR). FGSZ Zrt. eventually submitted the report closing the project – after multiple modifications – at the end of July 2018 to the INEA[95].

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

[94] Connecting Europe Facility. Energy. Supported actions – update May 2016 (https://ec.europa.eu/inea/sites/inea/files/cef_energy_brochure_-_2_june_final.pdf)

[95] Innovation and Networks Executive Agency.

In 2016, FGSZ Zrt. was awarded 922 500 EUR aid for the environmental impact assessment and environmental licensing of the Hungarian section of the RO-HU-AT natural gas corridor, with a 50 % co-financing rate (total estimated project cost: 1 845 000 EUR). Pursuant to the aid contract, FGSZ Zrt. was required to submit an interim report on activities carried out in 2017, which it submitted to the INEA in June 2018.

3.4.3. Market integration

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

Electricity market

(i) **Measures planned for ensuring the availability of flexible capacities guaranteeing safe operation and system balancing:** With the substantial increase in renewable energy production, to ensure the reliability of the system it is necessary upgrade the capabilities of existing power plants, ensure the entry of new flexibility service providers to the market, and develop demand side responses. Since these services will mainly be used by system operators and distributors, they are expected to develop incentive schemes ensuring a growing offer of such capacities.

Flexibility is also relevant for and is therefore also discussed in relation to the security of supply. Flexibility measures are summarised in point i. of Chapter 3.3.

(ii) **Facilitating and supporting the establishment of independent aggregators:** It is essential **to create a legal framework supporting the establishment of independent aggregators.** It is also necessary to encourage the introduction of simple or combined services/final customer fees on the market, which may result in products based on the consumption flexibility of smaller consumers. These products can be introduced on the market of system level services and on local flexibility markets operated by distributors, with the aim of voltage and congestion regulation. To this end it is necessary to define the (distribution and transmission) roles of aggregators and licensed grid operators, and their cooperation.

Additional information on energy communities is provided in Chapter 3.1.2.

(iii) **Measures aimed at preparing the electricity grid for the growing spread of decentralised capacities:** This is also a relevant topic in relation to the security of supply. The proposed measures are described in point i. of Chapter 3.3.

(iv) **Market coupling**: Beyond the increase of cross-border capacities, it is also necessary to increase market coupling and to improve the efficiency of operating interconnected markets. To this end, it is also necessary to further enhance the coupling of both intra-day and day-ahead markets on the electricity market, and to efficiently operate these markets.

- **Day-ahead market coupling**[96]

- **NTC-based interim coupling project**

The project aimed at the interconnection of the 4M MC and MRC (Multi-Regional Coupling) regions through the HU-AT, CZ-AT, CZ-DE, DE-PL, PL-CZ and PL-SK borders, based on an NTC based capacity calculation methodology, was launched at the end of December 2018 with the approval of the national regulatory authorities concerned. The project would provide a temporary solution before implementation of the Core FB MC, based on the current NTC based capacity calculation methodology and allocation. The target set by the CACM Regulation[97] – implementation of day-ahead market coupling – could thereby be met earlier, and implicit capacity allocation could be applied at these borders before introduction of flow based capacity calculation in the Core region, resulting in the more efficient allocation of cross-border capacities and a higher level of social well-being.

The live launch is expected at the end of the third quarter of 2020.

- **Core Flow-Based Market Coupling Project (Core FB MC project)**

Pursuant to the CACM Regulation, the TSOs and NEMOs are jointly responsible for establishing single day-ahead coupling (SDAC) in the territory of the European Union. After approval of the Market Coupling Operator (MCO) Plan by regulatory authorities (the HEA in Hungary), the PCR solution was also officially declared to be the basis for the joint day-ahead market coupling operator function.

The day-ahead target model is currently implemented within the framework of the Core Flow Based Market Coupling Project (Core FB MC). The project was set up for implementing flow based capacity calculation and allocation based on the target model, with the joint involvement of Core NEMOs and Core TSOs. The prerequisite for implementing the project is implementation of the day-ahead core capacity calculation methodology (Core CCM).

The current target date for launching the live environment is May-September 2021.

- **Intraday markets**

A key task in the coming period will be to **also strengthen market integration on the intraday and balancing markets.** Significant progress is expected in both areas. Hungary joined the XBID[98] (Cross-Border Intraday Market Project) in November 2019; during the next two years European platforms enabling the

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[96] See also Chapter 4.5.3 in relation to the current situation.

[97] Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance).

[98] The XBID project serves implementation of the single intraday market coupling (SIDC) target model referred to in Article 2(27) of the CACM Regulation with participating European States.

The target date for the live launch of the XBID is 19 November 2019.

purchase of balancing energy will also be established. To ensure the financial sustainability of development, renewable electricity generation should be concentrated on the wholesale market to the extent possible. We support that the system operator also be able to enter into international agreements enabling the joint purchase and allocation of balancing capacities. The establishment of the EU institutional framework for these processes is under way; the Hungarian system operator has the additional task of developing options for the effective sharing of resources and short-term trade in the Balkan region as well.

- **Pricing of balancing energy and integration of balancing platforms (balancing markets)**

Article 6(4) of Regulation (EU) 943/2019 on the internal market for electricity ('Regulation'), adopted as part of the Clean Energy Package, stipulates that the 'settlement of balancing energy for standard balancing products and specific balancing products shall be based on marginal pricing (pay-as-cleared) unless all regulatory authorities approve an alternative pricing method on the basis of a joint proposal by all transmission system operators following an analysis demonstrating that alternative pricing method is more efficient.' The Hungarian system operator plans introduction of standard and specific products jointly with the joining of the balancing platforms, which is expected in mid-2022. There are, however, no legal barriers to the earlier introduction of marginal pricing. Upon request by the MIT, the system operator is assessing the effects of introduction, which may result in the earlier implementation of the provision.

The other element of scarcity pricing, the abolition of price limits on the balancing markets – which leads to changes only on the Hungarian mFRR[99] market, considering that price limits have already been abolished on the aFRR[100] market – is prescribed under Article 10(1) of the Regulation by 1 January 2020. The HEA launched an SMP investigation[101] of mFRR market concentration. In Decision No 2606/2019, the HEA required MAVIR Zrt. to apply positive mFRR balancing energy price caps from 1 January 2020, and to draw up and introduce from 1 January 2022 a procedural methodology ensuring identification of essential suppliers.

Integration of balancing markets – balancing platforms:

- **IGCC** (International Grid Control Cooperation)

The IGCC is an early implementation project concerning the European platform for the EB GL imbalance netting process, which aims to fulfil EB GL requirements as soon as possible. Hungary is currently an observer of the IGCC project; its joining as a full member is in progress. The methodology is expected to be finalised in the first quarter of 2020. The implementation deadline is the first quarter of 2021.

- **PICASSO** (Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation)

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[99] Manual Frequency Restoration Reserve.

[100] Automatic Frequency Restoration Reserve.

[101] Investigation of substantial market power.

MAVIR Zrt. joined the project on 12 January 2018. The PICASSO project was initiated by 8 TSOs of five countries, which aims to plan and further develop operating platforms that collect the tenders of all stakeholder TSOs and enables the optimal allocation of market products (energy balancing from automatic frequency restoration reserve, energy balancing with aFRR) to ensure adequate satisfaction of participating TSO needs. The methodology will be finalised and approved by ACER by the deadline in January 2020. The implementation deadline is the third quarter of 2022.

- **MARI** (Manually Activated Reserves Initiative)

Hungary is currently a full member of the MARI project. 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. The methodology will be finalised and approved by ACER. The deadline is January 2020. The project's implementation deadline is the third quarter of 2022.

- **TERRE** (Trans-European Replacement Reserves Exchange)

TERRE is an early implementation project concerning the European platform for exchanging balancing energy from EB GL replacement reserves, which aims to fulfil EB GL requirements as soon as possible. The methodology has been approved. A live environment is expected in the first quarter of 2020.

MAVIR ZRt. is an observer in the project and is currently not planning to join.

(v) **Measures planned for increasing cross-border capacities** – see Chapter 3.3 and Chapter 3.4.2.

(vi) **Encouragement of the market launch of innovative energy supply solutions**

Point i. of Chapter 3.5 provides information on the topic.

ii. Measures to increase the flexibility of the energy system with regard to renewable energy production, e.g. smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment, real-time price signals, including the roll-out of intraday market coupling and cross-border balancing markets

In relation to real-time price signals it is necessary to **adjust market gate closure times to real-time trading.**

In relation to the other topics, the answer is provided under point i. and in Chapter 3.3.

Gas market

To strengthen integration on the gas market consultations are under way between Hungary and Croatia concerning the integration of the two countries' gas markets, which in practice would lead to the elimination of cross-border tariffs. Negotiations on market integration – which may also contribute to the improved use of Hungarian storage capacities – commenced in July 2019.

The promotion of gas market integration in the region is our strategic goal going beyond the LNG project; a market free of cross-border tariffs, operating with single wholesale price signals can lead to more effective competition, lower prices and greater security of supply. We are therefore also **exploring market coupling options with Slovakia, Slovenia, Austria and Romania**.

In parallel with the promotion of market integration, we also aim to further strengthen the liquidity and regional price signalling function of CEEGEX, the Hungarian gas exchange.

Sector coupling

Market integration is understood not only within a regional context, but it **also covers, *inter alia*, coordination of the operation of gas and electricity markets.** The two markets are connected at a number of points, most obviously in relation to gas-fired power plants. Institution-building measures are important in particular, which enable coordination of the two markets' operating cycles and frameworks. In the near future, however, sector coupling may also extend to new areas, such as the replacement of gas based heating and cooling with electricity based on renewable energy sources and heat pumps in regions with infrastructures with a low utilisation rate or which are not connected to the gas network. Use of the natural gas network for energy storage purposes offers a new, innovative alternative, which, *inter alia*, can facilitate integration of electricity generation from weather-dependent renewable resources through the production of 'clean' hydrogen or methane, and its feeding into the gas network.

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

To ensure that capacity reservations blocked by 'low quality', unimplemented power plant projects do not prevent the network connection of renewable producers, transparency and economic efficiency should be improved in allocating network connection capacities. To this end, non-discriminatory capacity auctions could be held, for example, on a regular basis.

- Mandatory participation of producers with a connection capacity of more than 0.4 MW should be prescribed in voltage regulation.
- Instead of the mandatory participation of renewable electricity generation in the FIS balance group managed by the system operator as balance responsible party, **encouragement of joining a market balance group**, with maintained aid conditions, to promote market integration.

Since renewables producers must contribute more to the reliable operation of the system in the future, we will establish the technical and regulatory conditions ensuring the downward regulation of renewables.

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*

Encouraging more active consumer involvement can contribute to enhancing the level of protection for consumers. A fundamental prerequisite for active consumer participation on the market is the regulation of consumption in cases where this is not yet possible. It is necessary to significantly expand use of smart meters in the electricity and natural gas sectors.

The establishment of **'smart regulation'** aims to positively encourage distributors to introduce new products and innovative technologies, and to expand options of suppliers for prioritising digital administration. (Further details are provided in point 5.iii. of Chapter 3.3.)

The key technological task is the **introduction of smart metering equipment** that are also capable of managing time zone dependent tariffs. Installation of a large number of smart metering equipment also comprises part of the programme aimed at establishing innovative system balancing, therefore options for their domestic manufacture should also be considered.

v. Description of measures to enable and develop demand response, including those addressing tariffs to support dynamic pricing[102]

In relation to this topic the answer provided under point i. of this chapter and point i. of Chapter 3.3 are relevant.

3.4.4. Energy poverty

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

The Government of Hungary is firmly committed to maintain sustainable overhead costs for Hungarian households in the future, while also ensuring the earning power of energy companies. The simultaneous fulfilment of the two objectives demands a complex strategy that extends to energy efficiency, an increase in the use of decentralised ('household') heating solutions and in the penetration of power generation, and the optimisation of supply methods. Strengthening competition on the domestic and regional commodity markets, the improved cost-effectiveness of grid operation and development - e.g. based on smart equipment and the elimination of duplication - and the promotion of digital solutions in serving consumers may offset the impact of a possible rise in international energy prices. In the course of the planned reform of eligibility for universal service and the development of various service packages we will ensure that the energy fees of the most deprived persons do not increase.

We are drawing up a programme to improve conditions for vulnerable customers. As part of this process we plan to assess the conditions of vulnerable customers and to draft targeted programmes adjusted to the

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

needs of the social groups concerned.

When planning the energy efficiency obligation scheme, it should support vulnerable consumers. (Points 3.1.2.iii. and 3.2.viiii. provide details on the most expedient financing instruments aimed at supporting the most deprived social groups (upgrades implemented under the obligation scheme, increased use of decentralised heating solutions and electricity production penetration).)

We plan to extend the subscription based electricity connection scheme for households living in buildings that are deteriorated or unsuitable for renovation, which ensures the electric heating of at least one room for families with small children.

We are also planning future awareness raising, information and consulting campaigns. These can also promote low-cost energy efficiency investments that can be implemented by home owners themselves, resulting in substantial savings. The social fuel programme, for example, could be linked to promoting 'out-of-the-box floor insulation'.

3.5. Dimension of research, innovation and competitiveness

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

The Energy Innovation Council (EIC) set up by the Minister for Innovation and Technology in October 2018 has defined possibilities of intervention in the following areas:

1. Innovative system balancing (flexibility storage and demand management, active system operation by distributors);
2. Encouragement of the market launch of innovative energy supply solutions;
3. Energy efficiency innovation programme;
4. Facilitation of the use of Hungarian natural gas reserves;
5. 'Smart regulation' to secure the interest of distributors and suppliers in innovation;
6. Transport greening;
7. Encouraging use of renewable energy sources;
8. Support of nuclear innovation;
9. Encouraging innovative seasonal electricity and heat storage solutions.

To **ensure the system balance** we are planning to encourage the spread of innovative technologies and operating modes that support improvement of the dispatchability of the electricity system by also minimising the necessity of network development investments and allow the integration of decentralised energy production based on renewable energy sources to the extent possible. The proposed programme focusses on encouraging energy storage, enhancing the options/obligations of weather-dependent producers supporting the system balance, encouraging the demand side adaptation of consumers, and on the reconsideration of the competencies of the TSO and DSOs.

Encouraging innovative methods of energy supply aims at the local consumption of electricity produced (from renewable resources). This effort could reduce costs associated with network loss and simplify the integration of renewable sources of energy. In terms of regulation, the energy community – as a separate prosumer unit and settled entity – should be clearly defined in regulation. The key technological task is the introduction of smart metering equipment that are also capable of managing time zone dependent tariffs. Although there are mainly legal and technological barriers to introducing the programme, the reduction of licensing/administrative burdens relating to the establishment and connection of renewable energy producers may result in a substantial decline in costs.

The **energy efficiency innovation programme** aims to reduce the unit energy consumption of the building stock and industrial production. The energy efficiency programme will build on the enhancement of knowledge-sharing, readily comprehensible advice provided by the easily accessible advisory network, and on the priority of investments based on results of Hungarian innovation and pilot projects ensuring expected payback periods. The programme can achieve an increase in the Hungarian industry's participation in building energy investments, producing a positive impact on employment and economic performance. To support retail investments we will establish a testing centre that drafts modern and cost-effective one-size-fits-all solutions for the energetic modernisation of Hungarian building groups defined in the National Building Energy Performance Strategy (NBEPS). Innovation can also target building automation, and the development and promotion of building supervision and control systems.

By facilitating the **use of Hungarian natural gas reserves** we plan to maintain or even increase the level of extracted natural gas quantities in Hungary, thereby improving the security of supply and reducing Hungary's dependence on imported primary energy sources. Intervention is mainly directed at encouraging the production of unconventional natural gas and enabling the use of natural gas not in conformity with current gas standards.

The establishment of **'smart regulation'** aims to positively encourage distributors to introduce new products and innovative technologies, and to expand options of suppliers for prioritising digital administration. Use of innovative solutions enables a more firm encouragement of reducing the quantity of consumed electricity, establishment of energy communities and implementation of energy efficiency and own energy production investments. The reduced quantity of distributed electricity with constant distributor costs, however, entails growing burdens for the tariff community, therefore the complex reform of the tariff scheme is necessary. To promote innovation the development of a 'regulatory sandbox' is recommended for the testing of innovative solutions, with the HEA's temporary exemption from conformity with certain service parameters.

The **transport greening programme** aims to reduce the rise in GHG emissions in the sector by encouraging the spread of electric vehicles and car-sharing, and increased use of biofuels. We also aim to promote the Hungarian manufacture of electric vehicles and to support national research relating to the secondary (industrial) use of used car batteries. Special support is recommended for the use of second generation biofuels; the related pilot project would serve the testing of such fuel production technologies (and empirical determination of the national production cost and competitiveness).

By encouraging **the use of renewable sources of energy** it would be possible to increase non-weather-dependent renewable energy production (geothermal, biomass, biogas, heat pumps) for both electricity and (district) heat supply. With regulation expanding the market for technologies supporting the integrated and local use of produced renewable energy, it is possible to also promote the Hungarian manufacture of heat pumps, biogas technologies and biomass-fired boilers. Within the framework of a State research programme, areas should be identified where geothermal energy production projects can be implemented. The exploitation of adequately researched areas can be encouraged by setting up a guarantee fund aimed at self-financing.

By supporting **nuclear innovation**, innovative services can be developed in Hungary that enhance the competitiveness of nuclear energy production, and contribute to maintaining and expanding Hungarian experience in nuclear energy.

The encouragement of innovative, **seasonal electricity and heat storage solutions** aims at facilitating the development of technologies capable of the extensive storage of large quantities of energy (even for months), with particular regard to enabling use of the natural gas network as a ‘seasonal energy storage facility’ for the feeding in of methane, biogas produced with power-to-gas technology and ‘clean’ hydrogen. Beyond electricity storage, the programme can also be extended to storing thermal energy and cold energy. Use of the particular technologies can be tested within the framework of pilot projects, subject to review of regulation concerning the feed-in of hydrogen, and biomethane and biogas produced with power-to-gas technology.

ROLE OF HYDROGEN IN THE FUTURE ENERGY SYSTEM

Over the period of the strategy, hydrogen can play a major role in integrating the production of renewable electricity, strengthening the security of supply in Hungary and in achieving our decarbonisation targets. With the rising use of renewable sources of energy, namely, the daily, weekly or even seasonal storage of electricity – not possible with battery technology – will become an increasingly critical issue. With electrolysis technology it is possible to store surplus quantities of produced electricity at a given time in the form of hydrogen and to use it later based on a number of options.

Most of the cost of electrolysis (over 90 %) is made up of the price of consumed electricity, thus the production of hydrogen is already one of the cheapest technologies for storing otherwise unusable energy, and with the smallest ecological footprint based on the entire production cycle. Although the high investment cost and low useful efficiency of fuel cells serving the reconversion of hydrogen into electricity remains a barrier to the market-based spread of the technology, based on forecasts a substantial (up to 90 %) cost decrease and significant efficiency improvement is expected. Taking into account the increasing flexibility needs of the electricity system, as an important aspect of energy policy and a factor supporting financial recoverability, both electrolysis and reconversion can be implemented along the lines of rapidly changing load curves, thus both technologies are suitable for frequency regulation. Obviously, fuel cells are also used in transport, therefore hydrogen produced from surplus renewable electricity generation is also environmentally friendly in mobility, although it still remains an uncertain alternative in terms of economy.

Beyond the use of fuel cells, hydrogen can also be used for electricity generation in units based on the model of conventional gas engines. Dozens of turbines are operating around the world that partly recover hydrogen, including those with hydrogen as the primary fuel. New prospects open up in the future efficient use of existing gas-fired power plants with innovations enabling the conversion of the operating turbines of gas power plants for purely hydrogen operating mode.

Beyond its reconversion into electricity, hydrogen can also be used in other forms. When blended with natural gas, it can contribute to satisfying the energy demand of industrial customers and even of households if blended into the gas network. This not only achieves the ‘greening’ of natural gas, but also improves Hungary's security of supply by reducing import requirements. By feeding hydrogen produced from electricity into the natural gas network[103], its storage will also become possible, which is particularly important in view of the size of Hungarian gas storage capacities. There are a number of open points as regards the technical possibilities for feeding hydrogen into the gas network, such as the resistance of gas pipelines against corrosion or the behaviour of final customer equipment; we will support the review of these points within the framework of pilot projects.

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[103] Regular tests are conducted regarding the feed-in of hydrogen into the natural gas storage facility; a pilot project is implemented as a first step. A possible goal is to store hydrogen blended with methane.

Electrolysis can offer a solution to the partial satisfaction of hydrogen demand in non-energy producing sectors, mainly in oil refining, fertiliser production and in the pharmaceutical industry. Hydrogen is traditionally produced from natural gas; the replacement of the latter is desirable both in terms of the security of supply achieved through reduced import requirements and climate protection. The steam reforming of natural gas often produces CO_2 emissions, and high-pressure water vapour – necessary for the process – is also most often produced through the burning of fossil fuels.

Owing to hydrogen's diverse use in energy production and industry, and its possible storage, it may serve as a link between the electricity and natural gas sectors; sector coupling can support the electricity sector in integrating renewable energy production and enhancing system flexibility, and support the natural gas sector not only through its greening, but also by reducing import requirements and thereby strengthening the security of supply.

ii. Where applicable, cooperation with other Member States in this area, including, where appropriate, information on how the SET Plan objectives and policies are being translated to a national context

- **Cooperation between V4 countries in RDI**

Participants of regular consultations are working on raising awareness of economic and science 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.

A V4 Innovation Task Force was established and a Memorandum of Understanding signed. The Task Force aims to develop closer, coordinated cooperation between V4 countries in innovation. Its main objectives include the encouragement of V4 start-ups, sharing of experience and best practices relating to national SME/start-up support programmes in the field of regional cooperation, implementation of joint promotional and networking campaigns, and joint participation in foreign workshops, start-up events and fairs. As a result of the work of the Task Force, an agreement was concluded between the V4 countries on 1 October 2015, which focuses on regional cooperation relating to start-ups and innovation, and on the promotion of the innovation potential of the region (Memorandum of Understanding for Regional Cooperation in the Areas of Innovation and Start-ups).

As regards cooperation between V4 countries, it is worth noting the think. BDPST conference, which is held each year since 2016 with the collaboration of the Antall József Knowledge Centre, the Ministry of Foreign Affairs and Trade, and the International Visegrad Fund. One of the conference's key objectives is the strengthening of cooperation between V4 countries in the field of research, innovation and future technologies.

- **RDI cooperation platform of V4 countries in the field of energy**

We have launched consultations with our V4 partners on options for establishing a specifically energy based innovation platform. The member states are expected to hold consultations in early 2020 on this topic.

- **Strategic Energy Technology Plan (SET-Plan)**

The European Commission plans to encourage the Energy Union to carry out research and development and to achieve its leading role in renewable energy technologies by implementation of the revised SET-Plan, which was drawn up by the European Commission in 2008 to encourage technology based climate and energy policies for 2020. Hungary is currently only represented in two of the 10 technical working groups (TWG):

- SET Plan – CCUS[104] TWG, TWG 9),
- SET-Plan – Nuclear safety TWG, TWG 10).

- **Other nuclear RDI cooperation**

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

Hungary joined the CERN[105] – based in Geneva – in 1992. In recent years Hungary has become very engaged in the preparation, operation of experiments conducted at the CERN, in the evaluation of obtained data and in the interpretation of physical results. According to the Wigner Institute for Particle and Nuclear Physics of the Hungarian Academy of Sciences, 'based on the level of Hungarian contribution, 1 % of the CERN is a Hungarian research institute, the place where Hungarian research in high energy physics is conducted.'[106]

  - **Research and innovation in thermonuclear plasma physics within the framework of EURATOM**

Research and innovation in thermonuclear plasma physics is carried out within the framework of EURATOM, through international cooperation, mainly with and in relation to European large equipment. Hungarian researchers have achieved important results even by international standards in the research of the turbulent state of plasma and the behaviour of macroscopic pieces of matter added to plasma.[107]

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

The European member organisations of the European Safeguards Research and Development Association, established in 1969, operate in the field of nuclear safeguards. The main goal of the organisation is to

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[104] Carbon capture, utilisation, storage.

[105] The world's largest particle physics laboratory.

[106] http://www.rmki.kfki.hu/kutatas/CERN.html

[107] http://www.rmki.kfki.hu/plasma/rolunk.html

coordinate and promote research and development in the field of nuclear safeguards.

- **International cooperation within the framework of Horizon 2020**[108]

Up to 29 October 2019, 253 Hungarian tenderers participated in the relevant energy and climate protection categories within the framework of Horizon 2020. In the various international projects Hungarian project members were awarded Union funds in the total value of 51 million EUR (see details in point i. of Chapter 4.6). The **FutureFlow**[109] international research and innovation project – in the value of 13 million EUR – is noteworthy among these projects, which is implemented with involvement of the Hungarian transmission system operator (MAVIR Zrt.).[110] The FutureFlow project will link the cooperating regulatory areas of system operators in four Central and Southern European countries (ELES – Slovenia, APG – Austria, MAVIR – Hungary, TRANSELECTRICA – Romania) to maintain security of the transmission system. The project is implemented between 2016 and 2020.

- **Participation in the QUANT-ERA, FLAG-ERA and M-ERA-NET programmes**

The main objective of the ERA[111]-NET programmes is to enhance the coordination of publicly funded research programmes implemented at national and regional levels, organise national and regional research within a network and to mutually open up research programmes at national and regional levels.

- ***Participation in the M-ERA-NET programme:*** The M-ERA-NET programme aims to strengthen coordination of European research programmes in the field of materials science and engineering through joint calls. (There are three Hungarian projects – all in the field of physics.)
- ***Participation in the FLAG-ERA II programme:*** 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. (There are five Hungarian projects, two of them are related to energy[112].)
- ***Participation in the QuantERA programme*****:** Within the framework of the FET programme of Horizon 2020, in May 2016 the European Commission announced the launch of its new flagship research initiative in the field of quantum technology. The flagship initiatives will be implemented with projects supported with EU, national and own funds, enabling cooperation in international

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[108] To lay the groundwork for implementing the SET-Plan on the demand side, the energy priorities of the RDI framework programme (Horizon 2020) for the 2014–2020 budgetary period were defined on the basis of the SET-Plan.

[109] Full name of the project: FutureFlow – Designing eTrading Solutions for Electricity Balancing and Redispatching in Europe

[110] http://www.futureflow.eu/?page_id=214

[111] European Research Area

[112] Both projects are implemented by the Centre for Energy Research (Institute of Technical Physics and Materials Science) of the Hungarian Academy of Sciences.

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. (So far Hungary has not been involved in energy related projects.)

- **European Institute of Innovation and Technology**

The European Institute of Innovation and Technology (EIT) of the EU operates in the field of (higher) education, research and innovation, coordinating education, industry, business and research in a given field to promote a knowledge-based economy and enhance competitiveness in Europe. With its organisation aimed at integrating the three sectors, the EIT operates as a centre of excellence. The seat of the EIT is in Budapest in accordance with Decision 2008/634/EC.

The activity of the institute focusses on the establishment of knowledge and innovation partnerships across Europe. The basis of cooperation is provided by the Knowledge and Innovation Communities (KICs) – with participating higher education institutions, research organisations and undertakings – and their cooperating partners. The EIT covers 25 % of the expenditures of such long-term R&D cooperation. The remaining amount is financed by the communities. Hungarian institutions are not participating as a core partner, but are involved in all KICs:

- Climate-KIC (Climate change mitigation and adaptation): Budapest University of Technology and Economics (BME),
- Bioenergy Competence Centre, Public Foundation for Industrial Development, University of Debrecen,
- KIC InnoEnergy (Sustainable energy): Bay Zoltán Alkalmazott Kutatási Non-profit Kft.

- **Intergovernmental cooperation in science and technology (SaT)[113]**

Hungary signed intergovernmental and interinstitutional agreements on cooperation in science and in technology (SaT) with 36 and 10 countries, respectively. The National Research, Development and Innovation Office (NRDIO) is responsible for their implementation. The Office and its predecessor institutions signed interinstitutional agreements on cooperation with organisations of an additional 9 countries in charge of R&D policies and financing.

A key objective of bilateral SaT relations is to support RDI cooperation between the two participating countries through tendering. International SaT relations are also supported by SaT attachés posted at 11 locations (Berlin, Brussels (EU), London, Moscow, New York, San Francisco, Paris, Beijing, Seoul, Tel Aviv, Tokyo and New Delhi), who are responsible for collecting information on the RDI policies of host countries, promoting Hungarian scientific and technological achievements, assisting the development of relations

[113] https://nkfih.gov.hu/hivatalrol/nemzetkozi-kapcsolatok

between the research and innovation communities of the two countries, and for supporting the launch of cooperation. The NRDIO operates – jointly with the Ministry of Foreign Affairs and Trade – the SaT attaché network responsible for scientific and technological diplomacy.

Beyond the foregoing the NRDIO is also involved in a number of international SaT cooperation projects and represents the interests of Hungary (EUREKA), and ensures participation in ESFRI and its working groups to coordinate the research infrastructure. It also coordinates professional tasks and representation relating to Hungarian participation in specific international research infrastructures (ITER, CERN etc.), and coordinates expertise. Cooperation in R&D policy-making (OECD) supports the development of Hungarian policies.

To ensure that Hungary's energy industry is also successful and innovative on international markets, it is necessary to encourage more international cooperation in relation to energy technologies and RDI in the field of energy, and to develop new relations. Accordingly, international RDI cooperation is also successful at international level and important in terms of Hungarian priorities, but new opportunities should also be explored.

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

The National Research, Development and Innovation Fund (NRDI Fund) managed by the **NRDIO** plays an important role in Hungarian RDI financing; it is a State extra-budgetary fund exclusively providing national public funding for RDI. The source of funding is the innovation levy paid by undertakings and supplemented with budgetary funds. It aims to ensure foreseeable financing for encouraging R&D and value-adding innovation based on Hungarian and foreign research results. The NRDI Fund has the function of supplementing and balancing EU funding based on national or even geographical criteria. The NRDI Fund provides balanced incentives for blue-sky research, targeted development and innovative enterprises.

There are no Hungarian thematic invitations to tender yet; energy RDI projects can be supported within the framework of market-driven RDI invitations to tender. Such an invitation to tender has already been launched in May 2019[114], and is expected to be relaunched in early 2020. We are also exploring the possibility of encouraging Hungarian RDI in energy with thematic tenders launched specifically in the field of energy.

When approving the Annual Development Budget – based on the proposal of the NRDIO, the body responsible for policy at the time – the Government decided on the schedule and budget of non-refundable and refundable RDI tender schemes of **operational programmes financed by the EU** (EDIOP, CCHOP). Pursuant to Government Decree No 106/2018 of 15 June 2018 amending Government Decrees concerning certain development policies in relation to governmental structural reform, as of 16 June 2018, in relation to the priorities of EDIOP and CCHOP 2, the MIT is the ministry responsible for policy-making instead of the

[114] https://nkfih.gov.hu/palyazoknak/nkfi-alap/piacvezerelt-kfi-projektek-2019-111-piaci-kfi/palyazati-felhivas-2019-111-piaci-kfi

NRDIO.

We are also launching pilot projects to promote energy innovation with financing from carbon credit revenues. We will decide on the extension of innovative solutions based on the findings of the pilot projects, and plan financing with use of funds of operational programmes in the 2021-2027 period and the Modernisation Fund.

The Government also plans to play an active role in promoting options for direct EU tenders among Hungarian market participants, universities and research establishments, e.g. within the framework of the CEF, Horizon Europe, InvestEU, EUROSTAR and EURATOM programmes, advancing their participation in international consortiums.

The European Investment Bank (EIB) can provide credit for financing efforts combating climate change. The European Investment Fund (EIF, member of the European Investment Bank Group) can support micro, small and medium-sized enterprises in innovation, R&D, entrepreneurship, growth and job creation with venture capital and risk financing instruments.

The aim is to exploit opportunities offered by the Innovation Fund to the full extent. In relation to projects focussing on highly innovative technologies and on large projects representing European added value, resulting in a substantial emissions reduction, the fund can offer options for sharing risks and thereby support implementation of highly innovative ideas.

An even higher investment of foreign private capital is also justified. The Hungarian Investment Promotion Agency (HIPA) – established to support working capital investments – can play an important role in this area.

4. PRESENT SITUATION AND FORECASTING WITH EXISTING POLICIES

4.1. Projected evolution of main exogenous factors influencing the energy system and GHG emissions

i. Macroeconomic forecasts (GDP and population growth)

The GDP and changes in population are important factors in energy consumption and GHG emissions. In addition to oil prices, these factors exert the largest influence over the future performance of sectors.

The basic influencing factors of present and expected population size are to a major degree expressed in energy consumption models of buildings and in a number of other sectors. Based on microcensus data for the year 2016, **in 2016 the permanent population equalled 9.55 million, the resident population equalled 9.8 million.**

The current calculation is based on the most recent official **population forecast** prepared by the Hungarian Demographic Research Institute (HDRI) of the Hungarian Central Statistical Office (HCSO) in 2015, which projects three different future scenarios (baseline, high, low) up to 2060. The UN also prepares country-specific population forecasts based on three scenarios; these project a population of 8.9, 9.1 and 9.5 million by 2030. **Our calculations are based on the HDRI forecast**, which estimates a population of 9.17 million in 2030 and 8.56 million in 2050.

The table below summarises sources of the three key variables used in the NECP.

Variable	Source
Explanatory variables	
GDP volume index, historical data and forecast up to 2050 (1995 = 100 %)	Source of actual data: HCSO National accounts; forecast by the European Commission
Population, historical data and forecast up to 2050 (thousands of persons)	Actual data based on HCSO Demography, forecasting based on modelling of Hungarian Demographic Research Institute
Oil price, historical data and forecast up to 2050 (USD/bbl)	Actual data and forecast by Reuters

Table 12 – Variables used for forecasting demand in certain sectors and their source[115]

[115] The figure below shows actual values of the three used explanatory variables (between 1995 and 2018) and their indicated forecast.

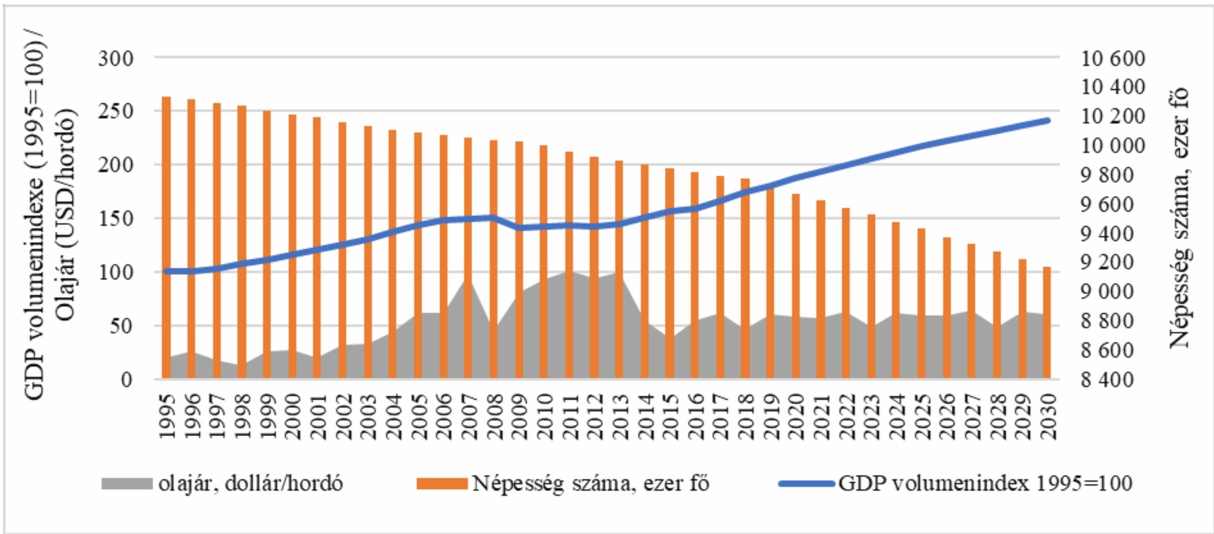

Figure 2 – GDP volume index, oil price time series (left axis), population (right axis)[116]

Source: HCSO, Hungarian Demographic Research Institute, EC, Reuters

HU	**EN**
GDP volumenindexe (1995=100)/ Olajár (USD/hordó)	GDP volume index (1995 = 100)/ Oil price (USD/bbl)
Népesség száma, ezer fő	Population, thousands of persons
olajár, dollár/hordó	oil price (USD/bbl)

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

We are summarising below key factors for each sector, which determine the performance of the sectors, and thereby partly their energy consumption and GHG emissions.

Households

The number of households is an important indicator mainly in terms of the number of household equipment, as large equipment with the highest energy consumption are commonly used in all households, thus the number of households affects energy consumption as well. The number of households is determined by population size and other cultural and social, economic factors.

Both Hungarian and European trends in recent decades indicate a rise in the number of single-member households (HCSO, 2015). In the 1970s an average Hungarian household consisted of almost three persons; based on surveys conducted in the 2010s, this figure is currently only around 2.4.

Based on the preliminary calculation applied in the model, showing a moderately slowing decline based on HCSO STADAT data, in 2050 the average household will consist of 2.14 persons.

[116] Actual data between 1995 and 2018, followed by forecast

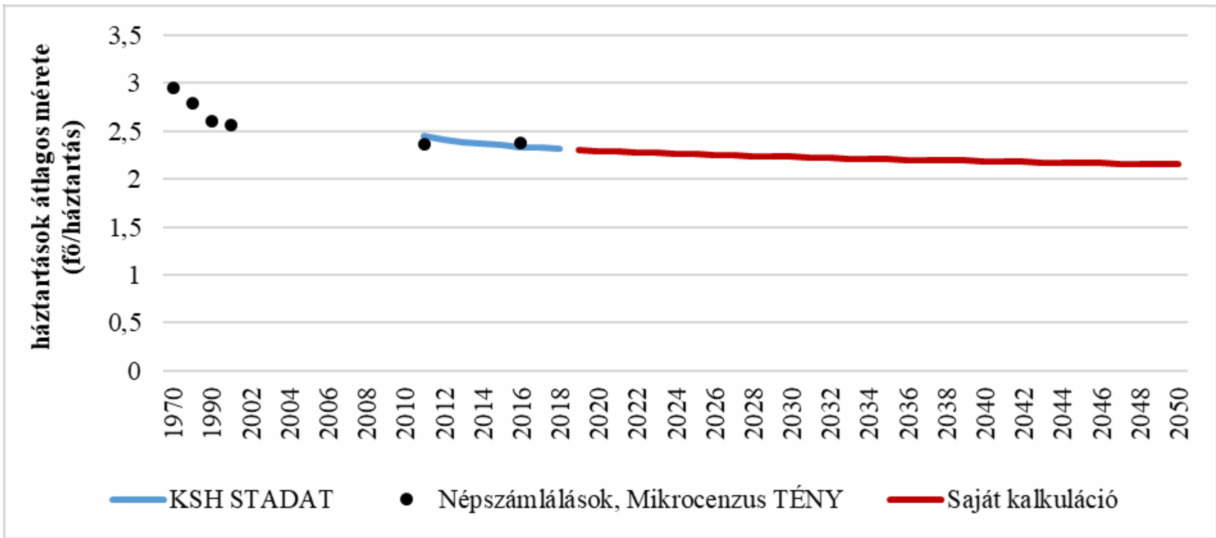

Figure 3 – Average household size (in the breakdown of decades up to 2001, followed by a yearly breakdown)

Source: HCSO, 2018, own calculation

HU	**EN**
háztartások átlagos mérete (fő/háztartás)	average household size (persons/household)
KSH STADAT	HCSO STADAT
Népszámlálások, Mikrocenzus TÉNY	Censuses, Microcensus ACTUAL DATA
Saját kalkuláció	Own calculation

The 2011 census indicated over 4.1 million Hungarian households; the 2016 microcensus showed a decline to around 4 million households.

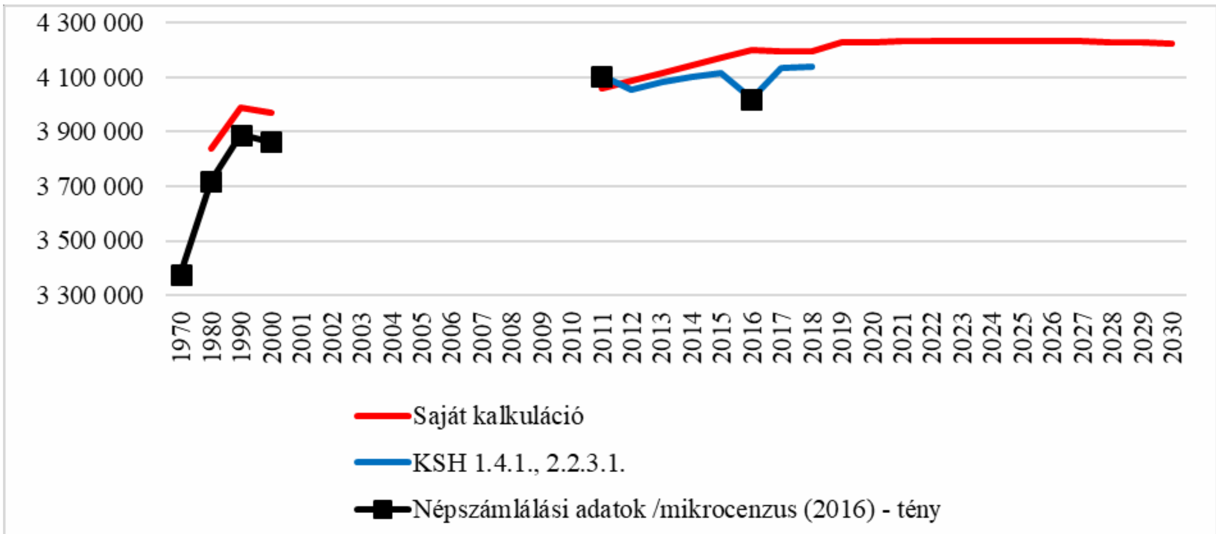

Figure 4 – Measured and calculated household number data and forecasts (in the breakdown of decades up to 2001, followed by a yearly breakdown)

Source: HCSO (2011, 2017, 2018), own calculation

HU	**EN**
KSH 1.4.1, 2.2.3.1	HCSO 1.4.1, 2.2.3.1
Népszámlálási adatok /mikrocenzus (2016) - tény	Census data / microcensus (2016) – actual data
Saját kalkuláció	Own calculation

Data published by HCSO STADAT suggest that in line with European trends, **the number of Hungarian households will continue to decline in the future.** The forecast presented hereunder is based on the above population forecast and the expected average size of households, indicating a moderate rise in the number of households up to 2024 (up to 4.24 million households), followed by a moderate decline up to 2050 (4.13 million households).

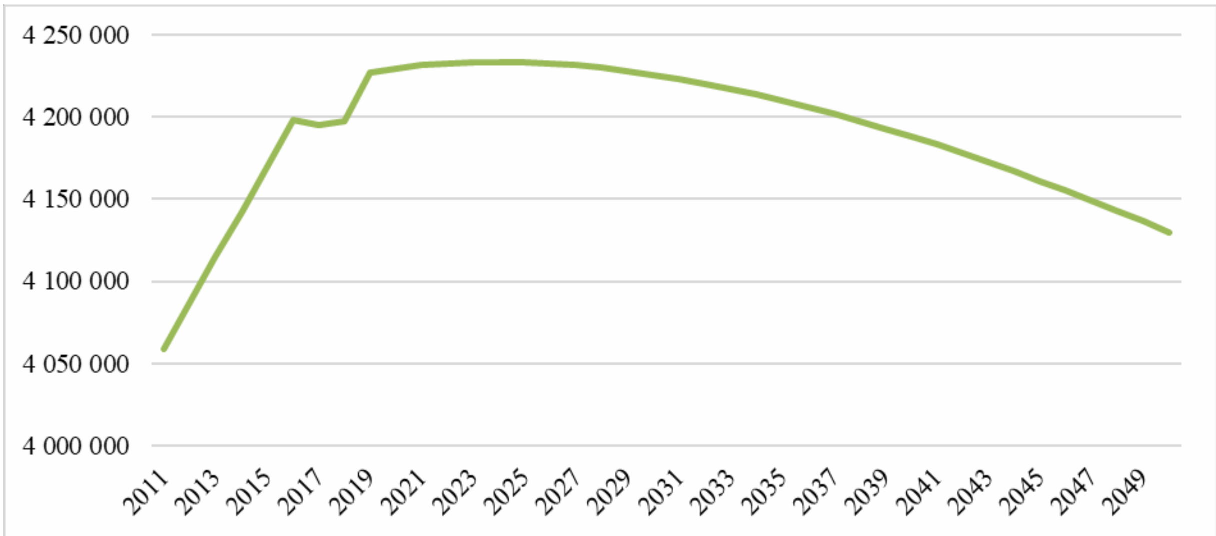

Figure 5 – Number of households in Hungary up to 2050

Source: HCSO, 2018, own calculation

Residential building stock

In the modelling process we assumed that the number of inhabited dwellings will align with the number of households. As a result of the shrinking size of households, **by 2050 the overall number of households will decrease less than the population size.** By 2050 there will be 3 975 000 households in Hungary over the 4 202 000 households in 2016. We also assume, however, that the number of dwellings per 100 households – equalling approximately 92 dwellings in 2016 – will reach 100 by 2050, i.e. all households will live in own dwellings.

At the time of the last census (2011) there were 2.73 million buildings in Hungary; the 2016 microcensus indicates a moderate decline to 2.68 million buildings. The National Building Energy Performance Strategy (NBEPS) counted 2.7 million buildings (Ministry for National Development (MND), 2015), the study serving as a basis for the above counted 2.36 million (Csoknyai, 2013)[117], and the TABULA-EPISCOPE[118] counted 2.64 million. According to the NBEPS, 96 % of buildings are single-family houses, 3 % are conventional apartment blocks and 1 % are industrialised apartment blocks.

Source	Year	Building stock (bldgs)
HCSO Microcensus	2016	2 675 300
HCSO Census	2011	2 732 171
National Building Energy Performance Strategy (2015)	2011–2013	2 702 183
NBEPS background study (Csoknyai, 2013)	2001–2011	2 358 908
TABULA-EPISCOPE	2001–2011	2 640 543

Table 13 – Building stock of Hungary based on different sources

In relation to inhabited dwellings it is important to distinguish the total dwelling stock, and within this stock, the number of inhabited dwellings. The NBEPS and its background studies consider the total dwelling stock, while the present work considers inhabited dwellings in calculations. It is very likely, namely, that there is no habitual living in uninhabited dwellings, i.e. no energy is consumed. Moreover, very little information is available on these buildings; most statistics cover inhabited dwellings.

According to the 2011 census, there were around 4.4 million dwellings, with 3.9 million inhabited dwellings, i.e. roughly one half of a million dwellings were vacant. The number of dwellings moderately increased between 2011 and 2017 by around 50 000, while the number of inhabited dwellings decreased by around 60 000 between 2011 and 2016. Based on our assumption that the number of households with own dwellings is increasing, **the number of inhabited dwellings will not decrease with the number of households, but increase from the value in 2016** (3 854 000 inhabited dwellings) **by approximately 2.5 % by 2050.**

Source	Year	Number of dwellings (pcs)	Number of inhabited dwellings (pcs)

[117] Épülettipológia a hazai lakóépület-állomány energetikai modellezéséhez (Háttértanulmány a Nemzeti Épületenergetikai Stratégiához (Building typology for the energy modelling of the Hungarian residential building stock (Background study for the National Building Energy Performance Strategy)), prepared by: Dr Tamás Csoknyai, 2013)

[118] https://episcope.eu

HCSO Census	2011	4 390 302	3 912 429
HCSO Microcensus	2016	4 404 518	3 854 405
HCSO Dwellings statistics (xstadat)	2017	4 427 805	

Table 14 – Stock of dwellings based on HCSO data

We divided the stock of dwellings into types of building, and introduced additional categories within building types based on the heating method. In relation to building types we used 2011 census data (which also serves as a basis for the NBEPS) because the 2016 microcensus is not representative in this regard. Within types of individual buildings we considered data of the 2016 microcensus in relation to heating methods.

When forecasting the total building stock we considered the TRENECON[119] forecast in relation to terminated inhabited dwellings, the annual number of which will reach 5 561 dwellings by 2026, then decline and remain stable at 4 446 terminated dwellings annually. We distributed the forecast number of terminated dwellings among building types, where there are four times as many terminated buildings built before 1945 than built after 1980.

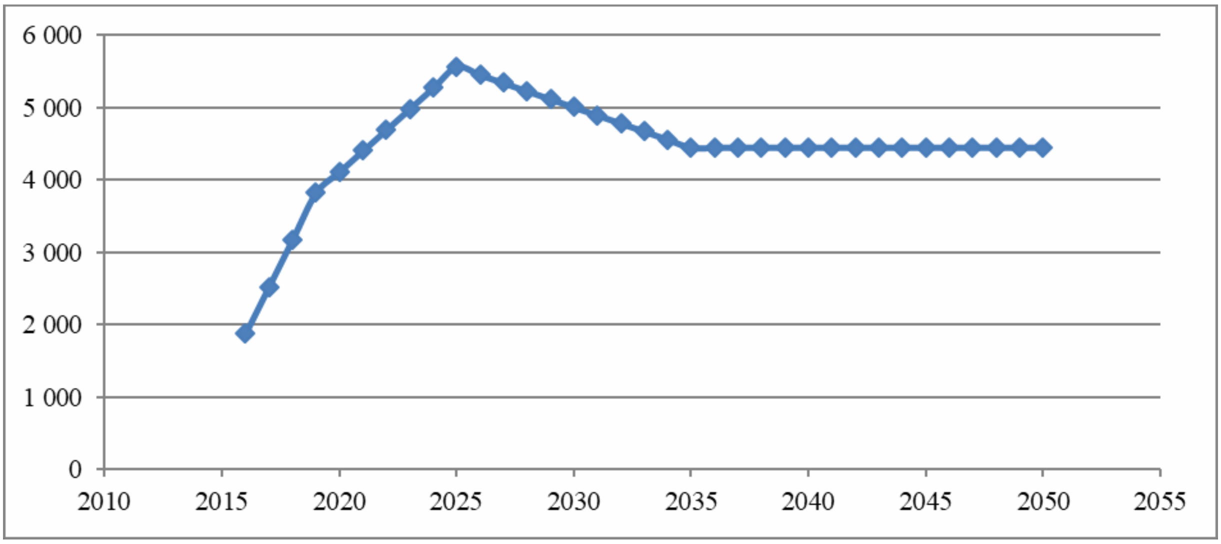

Figure 6 – Annual number of terminated dwellings, dwellings/year

Source: TRENECON

Newly built housing aims to satisfy growing demand for dwellings, on the one hand, and to replace terminated dwellings, on the other. Accordingly, the figure below shows housing construction trends. The forecast also considers the target value of the convergence programme up to 2020; as a result, the **volume of housing construction is high up to 2020, but is then followed by an uneven trend**, yet the volume is on

[119] http://www.trenecon.hu/

average lower than levels planned in the near future.

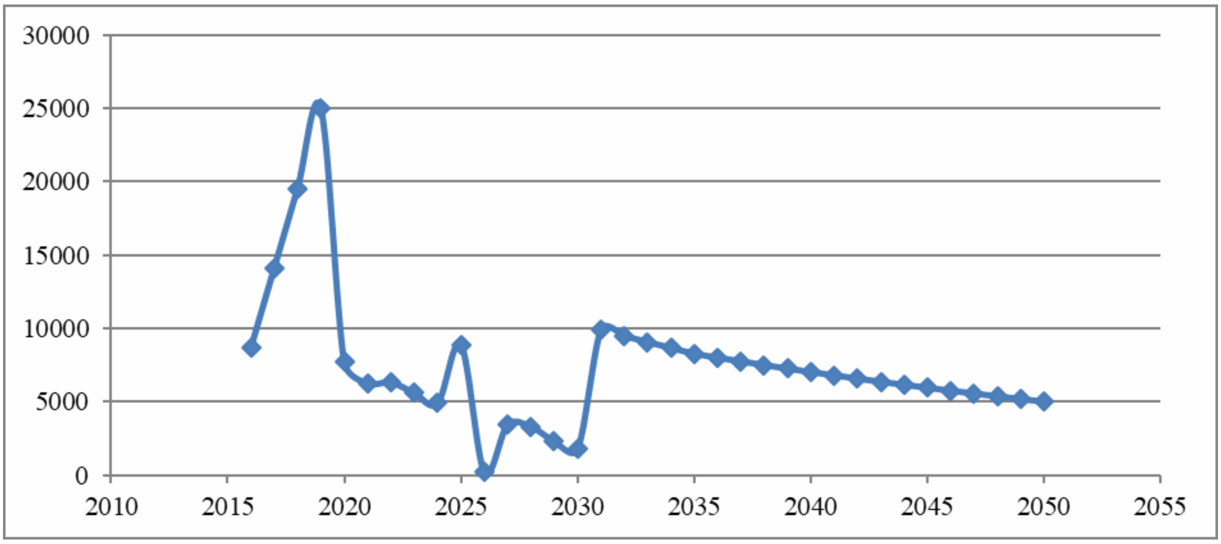

Figure 7 – Annual construction of new housing, dwellings/year

Source of actual data: HCSO

The energy efficiency level implemented for newly built dwellings is selected by the model by endogenous means, based on the additional cost of more efficient buildings, the cost of saved energy and aids.

Uniform, detailed and regularly updated databases are not available on the renovation investments of dwellings, thus we can only rely on the results of ad hoc data collection.

As a background study of the NBEPS, ÉMI conducted a national survey covering 20 842 buildings, with a field assessment of the level of renovation, by visual inspection carried out outside of dwellings.

	Single-family houses	Apartment blocks	Tower block apartments
Row houses and semi-detached houses	9-40 %	>50 %	
With thermal insulation	5-30 %		
Partially insulated + with thermal insulation	5-60 %		50 %
Doors/windows (houses built before 2011)	27-75 %	40-50 %	20-50 %

Table 15 – Results of the national survey of ÉMI

Source: National Building Energy Performance Strategy (2015)

ÉMI also reported results of a sociological survey, suggesting that **most renovated buildings were only partly renovated**; complex renovation also using renewable sources of energy is scarce. Seventy-four per cent of buildings performed window replacements and insulation, 74 % performed façade insulation, 41 % performed roof insulation, 36 % performed heating system upgrades, and only 2 % registered use of renewables (Albert Bogsch, ÉMI: National Building Energy Performance Strategy ppt).

The **Hungarian Energy Efficiency Institute (HEEI) conducted one of the most recent surveys in 2016**, conducting 2 507 phone interviews within the framework of national representative research. According to the results, **41 % of respondents implemented some form of energy efficiency investment in the past 5 years.** Sixty-seven per cent of them replaced windows, 42 % implemented thermal insulation and 31 % replaced boilers.

The HCSO also has two data sources relating to building renovation: the 2016 microcensus and the 2015 analysis entitled ‘Where do we live? – Housing, 2015’. The Negajoule study and the housing renovation survey conducted by the HEEI also provide data.

The **2016 census of the HCSO** surveyed the types of renovation works between 2006 and 2016 in inhabited dwellings. Based on this survey, **895 000 dwellings implemented thermal insulation, 670 000 dwellings upgraded the heating system and/or switched to renewable fuels, and 1 468 907 dwellings replaced doors/windows.**

The table below shows results of the different surveys.

	Replacement of doors/windows	Wall insulation	Heating system upgrade	Renovation period	Source
Single-family house	21 %	23 %	13 %	up to 2011	Negajoule (2011)
Non-tower apartment block	33 %	21 %	20 %		
Tower block apartment	39 %	39 %	19 %		
Total buildings	1 200 000		0	2006-2015	Based on 2015 HCSO analysis 'Where do we live?'
				2016-2018	
Total buildings	350 000		130 000	planned renovation	
before 1919	80 668	36 787	47 630	2007-2016	HCSO Microcensus 2016
1919-1945	121 790	62 800	62 874		
1946-1960	170 420	82 272	70 536		
1961–1970	270 371	143 483	103 392		
1971–1980	444 084	266 357	162 414		
1981–1990	276 886	174 476	124 626		
1991–2000	67 836	64 854	54 921		
2001-2011	32 130	57 014	38 896		
2012-2016	4 722	7 267	5 336		
Total	1 468 907	895 310	670 625		
of which: district heating (by transmission pipeline from the heating centre)	353 260	197 017	84 312		
Total dwellings	31 %	17 %	13 %	2011-2016	HEEI

Table 16 – Results of building renovation surveys

Source: HCSO

Based on the difference between the theoretical primary heating energy requirement calculated in conformity with ISO standards, also in consideration of the renovation rate, and actually consumed energy we estimated a **heating deficiency ratio** that expresses the amount of heating energy saved by households that would be necessary to maintain a minimum 20°C temperature in buildings during the entire year. This ratio varies **within the 35-42 % range, depending on the type of building.**

For forecasting we assumed that the heating deficiency ratio would decrease by 0.27 % with 1 % GDP growth.

We calculated renovation costs based on the TRENECON database, with assumptions shown in the table below.

	Cost-effective renovation		Nearly zero renovation	
	Energy demand after renovation, kWh/m²/year	**Renovation cost, HUF/building**	**Energy demand after renovation, kWh/m²/year**	**Renovation cost, HUF/building**
single-family house under 80 sqm –1945	140	3 721 304	100	4 615 516
single-family house over 80 sqm –1945	128	5 610 300	100	6 191 130
single-family house under 80 sqm 1946-1980	139	3 372 811	100	4 581 456
single-family house over 80 sqm 1946-1980	135	4 234 578	100	5 714 384
single-family house 1981-1990	109	2 962 510	86	4 653 625
single-family house 1991-2000	114	3 217 550	92	4 973 000
single-family house or terraced house 2001–	123	2 717 619	91	3 916 359
apartment block with 4-9 dwellings –2000	111	10 019 914	92	18 962 718
apartment block with 4-9 dwellings 2001–	99	9 087 167	82	17 140 466
Apartment block with 10 or more dwellings –1945	99	57 932 377	95	57 114 222
Apartment block with 10 or more dwellings 1946-2000, brick and other	95	23 035 877	67	41 385 955
Apartment block with 10 or more dwellings, medium-sized or large concrete blocks	85	21 870 559	78	23 611 783
Apartment block with 10 or more dwellings 1946-1980, tower block apartments	84	49 221 119	74	51 243 796
Apartment block with 10 or more dwellings, 1981-, tower block apartments	84	37 992 734	74	39 965 742
Apartment block with 10 or more dwellings 2001-	84	35 549 674	74	26 053 478

Table 17 – Building renovation parameters

Source: TRENECON

The model calculates the renovation ratio of the building stock endogenously. Renovation is implemented if it is worth it on the basis of investment costs, saved energy and available aid. In relation to all building types the model selects from among a maintained current level of renovation, a cost-effective level and a nearly zero renovation level.

Public and commercial buildings

Data is unavailable in relation to the type and floor area of commercial buildings (this term is used to define all buildings not falling within the category of residential or public buildings). With lacking data, calculations were made according to the method below:

1. Baseline data were based on all energy consumption data in the energy balance sheet.
2. Based on data of energy performance certificates issued between 2016 and 2018, available at the Lechner Knowledge Centre, breakdown of data included in the entire energy balance sheet into different final consumption categories.
3. Breakdown of heating, cooling and domestic hot water (DHW) data into building types, based on ratios of the energy performance certificates.

The energy consumption of public and commercial buildings is in the following breakdown: consumption of heating, cooling, DHW, ventilation, lighting and other energy. Other energy demand was estimated according to expert estimates.

	Primary energy demand of heating	Primary energy demand of DHW	Primary energy demand of ventilation	Primary energy demand of cooling	Energy demand of lighting	Other
kWh/m^2/year	214.94	20.52	3.54	1.90	19.94	29.91
%	73.9 %	7.1 %	1.2 %	0.7 %	6.9 %	10.3 %

Table 18 – Energy consumption of public and commercial buildings

Based on the study of Comfort Consulting Kft., in 2012 there were a total of 37 871 public buildings in Hungary. This figure includes 32 176 local authority buildings and 5 695 State buildings.

According to figures updated on the basis of HCSO data, there were 32 233 local authority buildings in 2016. We do not have accurate data on the number of State buildings, but according to the 2018 report of the State Audit Office (SAO) on reviewing the energy efficiency of public buildings[120], the floor area of central

[120] State Audit Office (2018): Review of the energy efficiency of public buildings. Report. (https://asz.hu/storage/files/files/jelentes/2018/18144.pdf)

government buildings to be renovated under Act LVII of 2015 on energy efficiency decreased as a result of reorganisations, therefore we assume that the number of State-owned buildings also dropped to some extent, but did not increase in any case. Since the number of State buildings is low compared to the number of local authority buildings, we consider the change in their number to be negligible, therefore we are using earlier data included in the study referred to above.

Public buildings, however, only account for a small share of the non-residential building stock, therefore it was not possible to use the data of Comfort Consulting[121] for estimating the total stock of **public and commercial buildings.** Data relating to building types in the energy performance certificates are used instead. The estimate prepared in this manner is presumably not representative, as the energy performance certificates are commonly issued in two cases: for tendering and in case of a sale or rental. For this reason the distribution of building types within the database is determined by the buildings subject to the tender and the buildings sold or rented out (in the latter category building types not commonly sold or rented out, such as schools and health establishments, are under-represented). (These data therefore need to be subsequently corrected when more reliable data are available.)

The typology defined in the background study of the NBEPS represented the baseline in relation to public buildings as well. The aforementioned background study defines five main categories based on building functionality:

- Health and social buildings;
- Office buildings;
- Commercial buildings;
- Cultural buildings;
- Educational buildings.

These categories are in some cases limited and do not cover all functions. The available data, for example, do not enable an understanding of State and local authority owned sports facilities, notwithstanding that these are assumed to consume a substantial amount of energy.

We do not assume deficient heating in relation to commercial and public buildings. When forecasting the building stock, the total floor area of buildings belonging to all building types were assumed to increase proportionately to the GDP. When estimating growth, a 0.3 flexibility coefficient was uniformly applied to all use (education, health, office etc.). Similarly to residential buildings, new buildings partly satisfy growing demand and partly replace terminated buildings. The assumed annual building termination rate is 1.17 % based on the TRENECON database.

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[121] www.comfortconsulting.hu

Transport

To enable comparison of the transport emissions modelling results with Hungarian GHG emissions trends, data consistent with the national inventory submission (NIS) had to be taken as a basis for determining transport demand, therefore the baseline was represented by transport statistics determined by Eurostat and DG MOVE on the basis of the principle of territoriality[122]. The time series relating to transport performance, however, are incomplete and only applicable to a few years in relation to several categories, therefore it is not possible to estimate future demand on the basis of historical data. Based on the above, in some cases forecasting was made on the basis of data of Hungarian business associations (i.e. not according to the principle of territoriality), which we adjusted with estimates. Passenger-km (pkm) was used for passenger transport and tonne-kilometres (tkm) for the carriage of goods. For modelling, a separate forecast was prepared for each mode of transport.

<u>Passenger transport</u>

We projected trends in the public transportation segment of local passenger transport with the help of regression. Regarding future demand for certain modes of transport, we assumed that their share within public transportation will be similar to the baseline year.

Among individual modes of transport we forecast the quantity of the passenger-km of cars with regression, and determined its share in local transport in proportion to vehicle kilometres for 'built-in areas' provided in the 'transport flows' tables of Eurostat.

In relation to motorcycles we determined the share of local transport in a similar manner, but basic statistical data were not available for determining future demand, i.e. it was also necessary to estimate the passenger-km value for the baseline year. Three sources were available for this value. The HCSO database only provides fleet data for motorcycles; based on analyses, such fleet data do not include vehicles with a cylinder volume of less than 50 cm^3 and an engine power of less than 4 kW (moped). The national inventory submission provides annual energy consumption data relating to two-wheel motor vehicles. Unfortunately, the databases of neither the HCSO nor Eurostat provide data on mopeds, therefore we estimated their number on the basis of the most recent fleet data of TRACCS (2013) relating to the year 2010. Based on the Transport Energy Efficiency Improvement Action Plan (TEEIAP, 2013) of the National Transport Strategy (NTS), we estimated the average consumption of motorcycles to equal around 3 l/100 km and the average number of passengers to equal 1.1, based on TRACCS (2013) data. We believe that future trends in demand will mainly be determined by the number of motorcycles and mopeds, therefore we estimated the development of the vehicle fleet on the basis of the 6-year trend following the crisis after 2010. The annual average vehicle kilometres amounted to

[122] The principle of territoriality takes into account transport performance in the territory of the given country, irrespective of the nationality of the vehicle's operator. These statistics serve as a basis, for example, for determining the modal split (Eurostat).

2 102 km; the figure was derived from energy consumption indicated in the NIS, approximating the 2013 TEEIAP estimate (2 000 km). We forecast the future motorcycle passenger-km value in consideration of electric motorcycle data stated in the HCSO vehicle fleet statistics and based on the values produced in the above manner.

Combined statistics dating back several years were available in relation to transport by local bus, suburban railway, metro, tram and trolleybus. Since major changes are not observed in their trends over time (except for the one-off growth caused by the entry into service of the new metro line), we assumed that in a baseline scenario their future share in local transport will correspond to that of the baseline year. When forecasting long-distance, i.e. interurban passenger transport, we applied the method used for local transport. From the DG MOVE[123] (2018) bus transport statistics based on the territoriality principle we derived local bus transport performance data estimated for 2016, and assuming similar ratios, we calculated future demand for interurban bus transport.

In relation to rail transport, by definition the statistics follow the principle of territoriality, and since all rail passenger transport was considered as long-distance transport, we used forecasts based on original statistical data.

We determined the passenger-km data for car and motorcycle demand in proportion to the extra-urban vehicle kilometre data of flows statistics, similarly to local transport.

Among other sectors, the forecasting of demand for passenger air transport is difficult because historical passenger-km data are not available in the statistics, only airports provide passenger number data. We therefore accepted the estimates of the PRIMES model, which, similarly to the current trend, forecasts significant growth; demand for air transport (passenger-km) will triple by 2050 over the year 2015.

Carriage of goods

As regards the carriage of goods, unfortunately data on the activity of road freight transport vehicles in the territory of Hungary are unavailable in the necessary breakdown of vehicle size, only in relation to the total (foreign and domestic) mileage of freighting undertakings. We therefore estimated the distribution of tonne-kilometre data on the basis of Eurostat flows statistics and the TRACCS (2013) for size categories based on maximum load capacity. As an additional problem, in relation to light commercial vehicles, information is available only on the number of vehicles; statistical data covering the performance of goods transport ignores this category. For this reason – similarly to motorcycles – we determined the tonne-kilometre data of light commercial vehicles based on NIR energy consumption data. Based on expert estimates, we estimated tonne-kilometre data by assuming an annual mileage of 35 000 km, 0.9 tonnes average payload, 70 % average utilisation rate and a 50 % empty journey rate. We determined short and long-term transport performance on

[123] Directorate-General for Mobility and Transport (European Commission) (https://ec.europa.eu/transport/home_en)

the basis of Eurostat flows data, in proportion to vehicle kilometres measured in built-in areas and on other roads.

The transport performance of larger vehicles on domestic roads was determined with flows data (Eurostat) and tonne-kilometre ratios estimated from the average utilisation rate (HCSO, 2017). The tonne-kilometre data of short and long distance transport were determined on the basis of Eurostat domestic transport statistics in the breakdown of distance, taking as a basis the quantity of transport performance under 50 km in relation to short distances.

We were unable to define a solid model or trend line in relation to waterway-transport. Although transport performance has moderately increased since 1995, since 2004 it has remained essentially unchanged at the level of 1 800-2 000 million tonne-kilometres. We therefore relied on the forecast of the PRIMES model: we assumed a 1 % average annual increase in performance. We estimated future demand for transport via pipelines by regression, which is dependent on the GDP and oil prices.

Forecast

The table below shows forecast transport demand values in a 10-year breakdown.

	2016	2020	2030	2040	2050
Passenger transport, local (million passenger-km)					
Bus (local)	4 385	4 309	3 729	3 358	3 140
Tram	1 233	1 211	1 048	944	883
Trolleybus	197	193	167	151	141
Metro	1 830	1 798	1 556	1 401	1 310
Suburban railway	539	530	458	413	386
Motorcycle (local)	618	646	706	766	826
Car (local)	13 024	14 151	17 078	19 293	21 364
Passenger transport, interurban (million passenger-km)					
Bus (interurban)	13 436	14 926	16 039	17 307	18 662
Car (interurban)	43 653	47 429	57 240	64 665	71 605
Passenger train	7 653	8 501	9 135	9 858	10 629
Motorcycle (interurban)	1 151	1 204	1 315	1 427	1 539
Carriage of goods, short-distance (million tkm)					
Light commercial vehicle (max. 3.5 t)	708	955	1 510	1 915	2 284
Goods vehicle (max. 12 t)	1 602	2 161	3 417	4 334	5 169
Carriage of goods, long-distance (million tkm)					
Light commercial vehicle (max. 3.5 t)	2 671	3 603	5 698	7 227	8 619

Goods vehicle (max. 12 t)	2 713	3 659	5 787	7 339	8 753
Goods vehicle (over 12 t)	20 169	27 208	43 025	54 567	65 077
Freight train	10 528	12 065	15 081	17 382	19 788
Other demand					
Waterway-transport, million tkm	1 975	2 096	2 429	2 816	3 264
Transport via pipelines, million tkm	5 850	6 578	7 833	8 752	9 650
Transport by air, million passenger-km	4 216	4 919	8 028	10 549	12 876

Table 19 – Forecasting of transport demand

Source: Eurostat, HCSO

Agriculture, forest management and fishing

We estimated the energy consumption of the agricultural sector up to 2050. In the course of forecasting we took into account GDP growth and assumed that half of energy consumption in this sector will increase at the pace of real GDP change. We also took into account an efficiency factor, according to which we estimate 0.3 % annual savings also in consideration of historical trends. As a result of these effects as well, we projected increasing energy consumption. While energy consumption in the agricultural sector equalled 27.2 PJ in 2016, we estimate that the value will increase to 31.6 PJ in 2030 and to 34.4 PJ in 2050.

Industry

We divided the energy consuming industrial sectors into 31 subsectors, which provide results in a more detailed breakdown than the energy balance sheet. In relation to each subsector we applied an econometric method to forecast production output up to 2050 based on the GDP, household and oil price trends presented above. We forecast the output of analysed subsectors or of production (e.g. million tonnes of tile), or the fuel demand consumed in production. We performed an econometric analysis of each subsector to determine how key variables affected produced quantities or the quantity of consumed fuel in the past, and prepared a forecast for 2050 with the explanatory variables, based on the observed correlations. While a sharp increase is observed in certain sectors (e.g. construction sector), some subsectors are stagnating (e.g. manufacture of textiles) or declining (e.g. lime production).

The table below summarises the dependent variables of estimates based on regression and their units of measurement, the explanatory variables and their parameters (variables belonging to cells containing the parameter estimates) and the adjustment parameters defined by the method. We separately indicated the coefficients of determination (R^2, %) expressing the models' explanatory power and the empirical values of Durbin-Watson (DW) statistics or of the Durbin h-statistics.

The trend of estimated values was forecast up to 2030 and point estimation performed for 2050 on the basis of parameters. In addition to the point estimates we also accounted for a 95 % confidence interval of estimates, which indicates the uncertainty of estimation.

Dependent Variable	R2	DW	Durbin h	Constant	GDP volume index	Population, thousands of persons	Oil price, USD/bbl	Delay	Adjustment parameter
Volume index of agricultural production 1995 = 100	80	2.13		724.8	0.286	-0.063	-0.247		-0.068
Volume index of construction output 1995 = 100	84		0.15	-3,800.4	3.153	0.350		0.045	0.016
Industrial volume index 1995 = 100	98	1.67		-230.9	3.625				0.114
Electricity, gas volume index 1995 = 100	82		-0.17	-597.3	0.387	0.060		0.484	-0.152
Manufacturing industry volume index 1995 = 100	98	1.63		-309.4	4.527				0.133
Car fleet at the end of the year	99		0.52	-81 183.0	9 581.0			0.578	0.084
Car, million passenger-km	95		-0.89	6.7	0.091		0.63	-0.142	
Total transport performance, million tonne-km	98		0.27	-15 061.5	230.4		58.76	0.558	0.044
Rail transport performance, million tonne-km	81		1.91	-20 371.6	101.1	1.838		0.365	0.175
Road transport performance, million tonne-km	98		0.51	125 732.0		-11.783	45.85	0.670	0.092
Waterway-transport performance, million tonne-km	47		1.59	388.7				0.764	0.226
Interurban passenger transport, million pkm	88	1.74		-133 303.0	179.9	13.387			0.116
Local passenger transport, million pkm	96		0.00	176.1		0.283	-7.69	0.695	-0.001
Mining, quarrying volume index 1995 = 100	37	1.48		45.2	0.28		-0.23		0.133
Volume index of the production of food products, beverages, tobacco products, 1995 = 100	80		0.42	73.107		-0.006		0.851	0.070
Volume index of textile, clothing and leather articles production, 1995 = 100	81		0.71	35.995				0.612	0.104
Wood, paper, printing volume index, 1995 = 100	95		2.35	-17.276	1.964			-0.431	0.219
Manufacture of coke and refined petroleum products volume index, 1995 = 100	70	2.13		-1 116.18	0.718	0.110			-0.068
Chemical product manufacturing volume index, 1995 = 100	82	2.06		-5.415	0.777				-0.036
Manufacture of rubber, plastic and non-metallic mineral products volume index, 1995 = 100	97	1.52		-316.862	3.922				0.202
Pharmaceuticals production volume index, 2000 = 100	90	2.44		1 218.48	0.209	-0.113	0.392		-0.225
Basic metals and fabricated metal products volume index, 1995 = 100	87	1.7		-1 701.48	2.479	0.151	-0.188		0.148
Computer electronics, optical product manufacturing volume index, 2000 = 100	90		-0.26	-2 883.15	3.786	0.242	0.631	0.466	-0.050

Electrical equipment manufacturing volume index, 1995 = 100	87	1.6		-29 754.8	23.802	2.748			0.176
Machinery and equipment manufacturing volume index, 1995 = 100	93		0.03	38.3				0.940	0.007
Vehicle manufacturing volume index, 1995 = 100	97	1.1		12 697.6	12.673	-1.364			0.433
Other manufacturing industry volume index, 1995 = 100	98	1.48		5 700.28		-0.546	-0.319		0.234
Manufacture of glass and glass products	88	1.57		1 181.57	0.776	-0.115			0.144
Manufacture of ceramic, clay building materials	86		-0.17	21.15			-0.170	0.864	-0.034
Manufacture of porcelain and ceramic products	76		-0.07	-2.05			0.354	0.811	-0.013
Manufacture of cement, lime and plaster	92	1.67		-4 004.64	2.68	0.372			0.153
Manufacture of articles of concrete, cement and plaster	88		1.02	-3 273.64	3.77	0.283		0.394	0.120
Manufacture of non-metallic mineral products	87	1.59		-2 045.97	2.87	0.178			-0.192

Table 20 – Parameter estimates of adjusted models and model parameters

Based on the above parameter estimates and forecast oil prices, population and GDP growth it is possible to determine on a sectoral basis the production of individual subsectors and the quantity of energy used for production. The table below summarises factors forecast in relation to specific subsectors, the baseline values and emissions of the given sectors in 2030 and 2050.

Industrial sector	Subsector	Unit	2016	2030	2050
Iron and steel industry	Production of iron and steel – blast furnace	PJ	13.26	22.92	30.96
	Production of iron and steel – electric arc furnace (EAF)	PJ	0.80	1.39	1.88
	Other	PJ	3.32	5.74	7.75
Manufacture of chemicals and pharmaceuticals	Manufacture of ammonia	PJ	9.17	13.45	17.92
	Manufacture of olefin	PJ	11.34	16.63	22.17
	Chlorine production	PJ	3.82	5.61	7.47
	Other	PJ	36.81	54.00	71.96
Manufacture of basic non-ferrous metals		PJ	4.89	9.60	14.73
	Cement / clinker	PJ	6.46	5.64	1.94
	Lime	PJ	10.85	9.47	3.25
	Glass – sheet glass	Mt	0.20	0.31	0.45
	Glass – Hollow glass	Mt	0.13	0.20	0.28
	Glass – Light sources, lamps	Mt	0.08	0.13	0.18

Manufacture of non-metallic mineral products	**Glass – insulating material**	Mt	0.05	0.08	0.11
	Ceramics – Bricks	Mt	0.74	0.83	0.35
	Ceramics – Tiles	Mt	0.02	0.02	0.01
	Ceramics – Sanitary products	Mt	0.02	0.02	0.01
	Ceramics – Fireproof	Mt	0.00	0.01	0.00
	Other	PJ	0.00	0.00	0.00
Vehicle manufacturing		PJ	9.49	22.79	36.22
Manufacture of machinery		PJ	16.99	17.46	18.57
Mining and quarrying		PJ	0.99	2.11	2.52
Manufacture of food products, beverages and tobacco products		PJ	24.54	31.45	39.65
Manufacture of paper, printing	**Paper ETS**	Mt	0.81	1.32	1.76
	Paper pulp, cellulose ETS	Mt	0.02	0.03	0.05
	Paper and pulp NETS, printing industry	Mt	2.33	3.80	5.06
Wood processing (not incl. furniture production)		PJ	3.10	5.04	6.71
Construction industry		PJ	9.78	19.18	29.44
Textile and leather industry		PJ	1.76	1.81	1.81
Other industrial sectors		PJ	11.11	21.78	33.44
Material consumption		PJ	59.92	87.90	117.14

Table 21 – Estimated production or energy consumption of industrial subsectors in 2016, 2030 and 2050

iii. Global energy trends, international fossil fuel prices, EU ETS carbon price

The key independent variables include the price of oil, natural gas, coal, biomass and the CO_2 quota, which significantly affect the modelling values, such as total energy consumption and GHG emissions.

The price of petroleum is based on the value included in the most recent EIA Annual Energy Outlook. The wholesale price of natural gas and the price of coal is based on values provided in the strategy paper 'National Energy Strategy 2030' prepared in parallel with this Plan. The former forecast projected Hungarian wholesale natural gas prices based on the European Gas Market Model prepared by the Regional Centre for Energy Policy Research (REKK). For forecasting biomass prices we used REKK's own estimate.

	Source	2016	2020	2025	2030	2040	2050
Brent oil price, $(2018)/bbl	EIA AEO (2019)	42.7	73.3	81.7	93.0	105.2	107.9
Natural gas wholesale price, €(2018)/MWh	Energy Strategy	16.0	20.2	23.4	25.5	28.3	29,2
Coal price, €(2018)/GJ	Energy Strategy	2.8	2,3	2,3	2,3	2,3	2,3
CO_2 quota, €(2018)/t	ICIS (2019), European Commission – with transfer based on REKK estimate	4.6	23.1	36.4	18.8	50.0	88.0
Biomass price, HUF(2018)/GJ	REKK estimate	1 500	1 800	1 800	1 800	1 800	1 800

Table 22 – Forecast of the wholesale price of main energy sources, 2016-2050

In addition to wholesale prices, the values of other retail price components also have a significant impact, such as various taxes, network access fees, wholesale and retail margins. These were individually determined in relation to each fuel and each sector. We assumed that their values will not change over the analysed period.

iv. Changes to technological costs

The development of technologies produces three types of effects: (i) the average cost of technologies may decrease, (ii) the useful efficiency of the same technology may increase, and (iii) a completely new technology may be introduced that has a different cost structure (investment and operating cost). We present below these changes, with a focus on sectors analysed in detail. We did not analyse energy consumption in agriculture, only on an aggregated basis, hence the development of technology cannot be presented, either. Due mainly to the structural, organisational and technological complexity of sectors, a detailed analysis at technological level was possible only in relation to a few industrial subsectors. We present these below.

We present below in detail the future technological costs and their changes over the analysed period in relation to electricity and heat generation, the transport and building sectors.

Electricity and heat generation

In the electricity and heat generation sector we distinguish a total of 22 different technologies. Fourteen of these technologies only relate to electricity generation, 5 to combined heat and power generation facilities and only 3 to heat generation. Except for five technologies, these are already available, thus they can already be applied in the first five years. The overhaul of wind power stations will be possible only at the end of the life-cycle of currently operating 330 MW wind power capacities, while power stations with CCS will be available only after 2030.

	Technology	Useful life	Useful efficiency, %		
			2020	2030	2040
Renewable electricity generation	Geothermal	30	36 %	36 %	36 %
	Wind power stations – new	25	-*	-*	-*
	Wind power stations – overhaul	25	-*	-*	-*
	Solid biomass	40	30 %	30 %	30 %
	PV – household-scale	25	-*	-*	-*
	PV – medium-scale	25	-*	-*	-*
	PV – large-scale	25	-*	-*	-*
Conventional power plants	Coal power plant, without CCS	55	42 %	44 %	46 %
	Coal power plant, with CCS	55	42 %	44 %	46 %
	OCGT, without CCS	40	47 %	49 %	51 %
	OCGT, with CCS	40	47 %	49 %	51 %
	CCGT, without CCS	30	56 %	58 %	60 %
	CCGT, with CCS	30	56 %	58 %	60 %
	Nuclear	50	33 %	33 %	33 %
Cogeneration plants	Natural gas	15	43 %	45 %	47 %
	Solid biomass	15	25 %	25 %	25 %
	Biogas – landfill	25	90 %	90 %	90 %
	Biogas – waste water	25	90 %	90 %	90 %
	Biogas – agricultural	25	90 %	90 %	90 %
	Gas boiler	30	92 %	92 %	92 %

Heat generators	**Geothermal**	20	100 %	100 %	100 %
	Biomass boiler	15	85 %	85 %	85 %

* : Not relevant, as no transformation loss or variable fuel cost is included in the energy balance sheet

Table 23 – Assumed useful life of electricity and heat generating facilities, and changes in their useful efficiency between 2020 and 2040

	Technology	**Investment cost, €/kW**			**Annual fixed cost, €/kW**	**Annual variable cost, €/GJ**
		2020	**2030**	**2040**	**Unchanged during the period**	
Renewable electricity generation	**Geothermal**	5 217	5 217	5 217	95.7	0.0
	Wind power stations – new	1 670	1 572	1 480	35.0	0.0
	Wind power stations – overhaul	1 069	1 006	947	35.0	0.0
	Solid biomass	870	870	870	34.8	0.0
	PV – household-scale	1 332	1 080	891	10.0	0.0
	PV – medium-scale	922	747	616	7.0	0.0
	PV – large-scale	717	581	479	5.0	0.0
Conventional power plants	**Coal power plant, without CCS**	2 586	2 460	2 339	28.3	1.3
	Coal power plant, with CCS	5 472	4 705	4 045	66.2	1.3
	OCGT, without CCS *	879	877	876	6.7	0.7
	OCGT, with CCS *	1 688	1 496	1 326	13.8	0.7
	CCGT, without CCS *	922	918	913	14.0	1.3
	CCGT, with CCS *	1 747	1 502	1 291	28.9	1.3
	Nuclear	4 348	4 348	4 348	108.0	2.2
Cogeneration plants	**Natural gas**	820	816	812	19.3	5.6
	Solid biomass	3 000	3 000	3 000	3.3	4.9
	Biogas – landfill	1 750	1 750	1 750	262.5	0.0
	Biogas – waste water	5 625	5 625	5 625	281.3	0.0
	Biogas – agricultural	3 008	3 008	3 008	423.8	0.0
	Gas boiler	94	94	94	5.8	0.3

Heat generators	**Geothermal**	1 400	1 400	1 400	17.2	0.0
	Biomass boiler	281	281	281	10.6	0.3

***: In relation to OCGT, the table only shows variable costs in addition to fuel costs. Since OCGTs represent a significantly simpler technology than CCGTs, their operating cost is lower. Source of data: REKK data.*

Table 24 – Representative cost data of electricity and heat generating facilities

Source: REKK data

Transport

In relation to motorcycles we assumed a moderate role of diesel propulsion at the present and in the future for engine-driven two- and three-wheel vehicles. Although hybrid vehicles exist, their spread is slow (concentrated mainly in Asia) and their future role is uncertain. This is attributable to the fact that the doubled propulsion system adds additional weight and complexity to relatively small vehicles (increasing service costs). The introduction of a few models is expected in the higher performance segment, however, as the range of electric propulsion in vehicles used for shorter, local transport mainly satisfies needs, and the range is expected to further increase in the future. For the above reason, currently only petrol-fuelled and electric technologies are considered as options. Technological development is reflected by the increased efficiency of motorcycles and the cost reduction potential of electric vehicles (consistently with the expected decline in battery costs, amounting to 25 % of vehicle value).

In terms of new car technologies, hydrogen fuel cell cars are included in the model, which will be available from 2025. Available technologies are also continuously developing up to 2030, resulting in lower consumption and regular changes in purchase costs. In line with literature, the cost of electric and hydrogen fuel cell vehicles will decrease, while the cost of vehicles with internal combustion engines will increase, as increasingly complex technological solutions are needed to meet the continuously tightening emissions requirements.

In relation to buses, in addition to modern diesel, hybrid, CNG and electric vehicles, the model also considered the introduction of hydrogen fuel cell vehicles, new diesel buses, and hybrid and fuel cell vehicles in long-distance transport. Among hybrid technologies we only considered conventional hybrid propulsion, because in long-distance transport the distance travelled during the electric shift may be low due to time loss caused by charging time, and in local transport the new types of charging solutions (e.g. fast chargers installed at stops) may render installation of the dual propulsion system superfluous over time.

Based on interviews conducted with transport providers (BKV, MÁV-Start) and data provided by them, rail vehicles using alternative fuels are not expected to be used before 2030, and a substantial decrease in consumption is not expected, either, in relation to more modern electric technologies compared to the current younger (0-5 year old) vehicles. Therefore the model does not cover new tram and metro technologies; instead, technologies equivalent to technologies (CAF, Alstom) currently in use are expected. In relation to suburban railways we defined a new fictitious technology that is more efficient than the old suburban railway technology with the difference in unit consumption observed between young and old trams and metro vehicles. The new technology is available in the model from 2020, as new vehicles were not purchased yet in 2019. The consumption of new rail vehicles will not change until 2030; suburban railway vehicles are expected to show improvement similarly to other rail vehicles.

Based on information provided by MÁV-Start, the Stadler KISS electric multiple units will be entered into service from 2020, which – owing to their multi-level design – will be more efficient than current multiple units. Accordingly, the technology analogous to that of the KISS multiple units is available in the model from 2020. Since 0-5 year old diesel passenger trains are not in service, it was necessary to define a new technology, where the decrease in consumption equals the improved efficiency of rail vehicles.

The new vehicles accepted by the model can be petrol, diesel, electric, chargeable hybrid and CNG-fuelled vehicles in the LCV category for short distances, and petrol and diesel vehicles for long distances. The hydrogen fuel cell technology for LCVs is not yet included in the model, as currently there are no hydrogen-fuelled LCVs in service yet; the hydrogen-fuelled vehicles in use are converted hybrids used for experimentation purposes. In relation to categories with a higher load capacity, the chargeable (diesel) hybrid version is not an option for reasons noted in relation to buses – only conventional hybrid technology is considered. In relation to natural gas propulsion, we considered CNG in the category of vehicles below 12 tonnes and LNG for vehicles of over 12 tonnes. Based on new models introduced in the category of heavy goods vehicles we assume that electric and hydrogen propulsion may be introduced as an alternative in the future for vehicles weighing over 3.5 tonnes.

Building sector

We are not expecting either changes in renovation costs or an increase in efficiency in the building sector, therefore technological costs are not changing in this sector, either.

Industrial sectors

We defined several types of new technology in relation to the industrial sectors analysed in detail: standard, commonly applied technologies and so-called advanced technologies, most of which are already available. These technologies may vary not only on the basis of investment and operating costs, but also in efficiency and the composition of fuel consumption. The table below shows the number of standard and advanced technologies in the individual subsectors in our calculations.

		Standard technology	Advanced technology
Iron and steel industry	Blast furnace	1	4
	Electric arc furnace	1	1
Manufacture of chemicals	Ammonia	2	2
	Olefins	2	2

and pharmaceuticals	**Chlorine**	2	0
Manufacture of non-metallic mineral products	**Glass – sheet glass**	1	4
	Glass – Hollow glass	1	4
	Glass – Light sources, lamps	1	3
	Glass – insulating material	1	2
	Ceramics – Bricks	1	5
	Ceramics – Tiles	1	5
	Ceramics – Sanitary products	1	2
	Ceramics – Fireproof	1	4
Manufacture of food products, beverages and tobacco products		1	0
Manufacture of paper, printing	**Paper ETS**	2	5
	Paper pulp, cellulose ETS	1	3
	Paper and pulp NETS, printing industry	1	1

Table 25 – Number of new technological options in industrial sectors analysed in detail

4.2. Dimension of decarbonisation

4.2.1. GHG emissions and removals

i. Trends in current GHG emissions and removals in the EU ETS, in sectors falling within the scope of the Effort Sharing Regulation, LULUCF sectors and in different energy sectors

The 2019 National Inventory Submission[124] of Hungary provides details of historical changes in GHG emissions; this chapter provides a brief summary.

In 2017 the (gross) GHG emissions of Hungary, not including LULUCF, equalled 63.8 million tonnes CO_2 **equivalent over the 93.7 million tonnes** CO_2 **equivalent in 1990 (decrease of 31.9 %).** Per capita gross emission is around 6.5 tonnes, which is below the EU average.

[124] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019

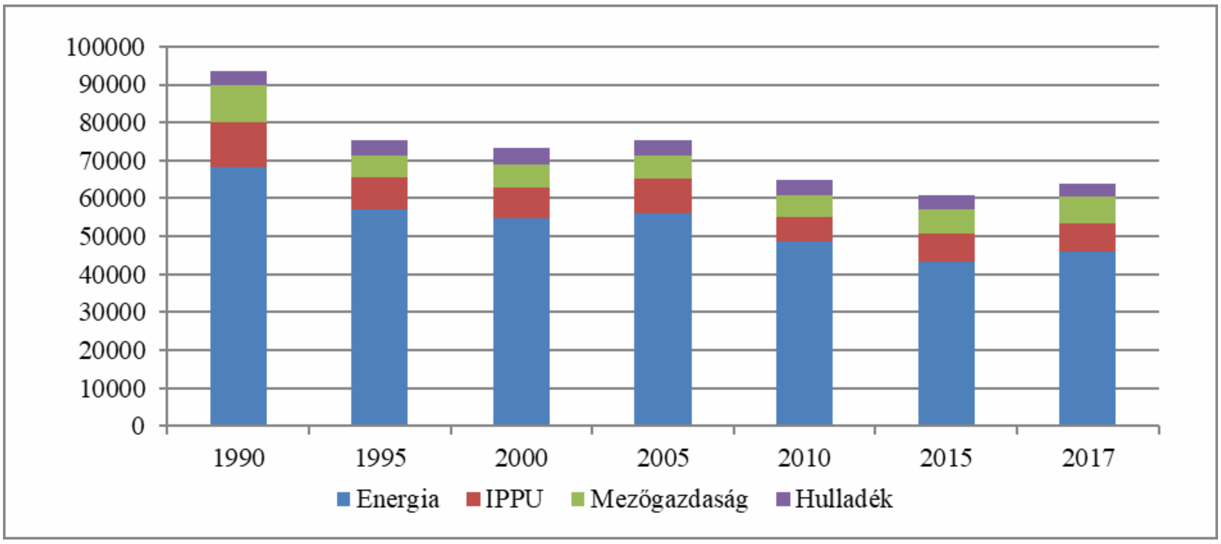

Figure 8 – Greenhouse gas emissions per sector, 1990-2017 (kt CO_{2eq})

Source: National Inventory Submission, 2019

HU	**EN**
Energia	Energy
IPPU	IPPU
Mezőgazdaság	Agriculture
Hulladék	Waste

This significant decrease is attributable partly to the regime change that resulted in the sharp decline in national economic output. Production decreased in almost all economic sectors, including the GHG intensive energy sector, industry and agriculture. Thereafter, between 2005 and 2013, emissions declined by 25 % after roughly 14 years of stagnation. The global financial and economic crisis severely affected the performance of the Hungarian economy and thereby the level of GHG emissions, which fell by 8 % between 2008 and 2009. Following a moderate increase in 2010, emissions declined for 4 years. Meanwhile the downturn in economic performance reversed in the first quarter of 2010 and surpassed pre-crisis levels in 2015. Emissions again increased from 2013 to 2017 by 12 %, with all economic sectors contributing to the rise.

CO_2 is the most relevant greenhouse gas of anthropogenic origin, accounting for 77 % of total emissions. Carbon dioxide is mainly produced in the energy sector through the burning of fossil fuels.

Hungary's CO_2 emissions decreased by 44 % overall since the mid-1980s.

Energy sector

Most of total emissions (72 %) are produced in the energy sector. Carbon dioxide from the burning of fossil fuels accounts for the largest share (96 %) of GHG emissions in the energy sector. **Natural gas is the**

most important fossil fuel in Hungary, accounting for 44 % of fuel consumption emissions. In the middle of the past decade natural gas held an even larger share of 55 %. Liquid fuels and coal have a share of 30 % and 10 %, respectively.

Within the energy sector, the energy industry accounts for the largest share with 30 %, closely followed by transport and categories of other sectors (e.g. trade, households) with 28 % each. Bleed emissions relating to the production, processing, conversion, distribution of oil and natural gas only contribute 2 % to sectoral emissions.

Transport emissions increased by 31 % since 2013. In the past three years gross electricity generation increased by 3 %. The increase in natural gas based electricity generation was particularly high at 20 %, but still equalled only half of the figure measured in 2007 and 2008. As a basic feature of the Hungarian energy industry, half of electricity is generated from nuclear sources and only 40 % from fossil fuels. Hungarian electricity imports remain high at 30 %.

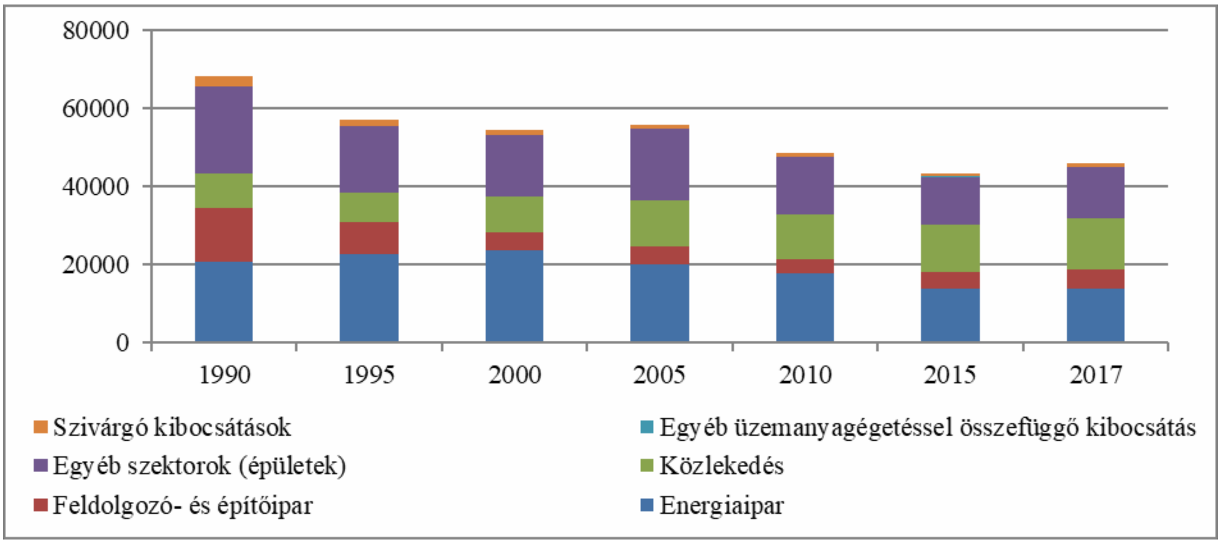

Figure 9 – Energy sector emissions based on sources from 1990 to 2017, kt CO_{2eq}

Source: National Inventory Submission, 2019

HU	**EN**
Szivárgó kibocsátások	Bleed emissions
Egyéb szektorok (épületek)	Other sectors (buildings)
Feldolgozó- és építőipar	Manufacturing and construction sector
Egyéb üzemanyagégetéssel összefüggő kibocsátás	Emissions from the burning of other fuels
Közlekedés	Transport

Energiaipar	Energy industry

Retail sector emissions have also steadily increased in the past three years. Household fuel consumption increased in 2017 by 2 %. In the same period biomass consumption declined by 6 % and natural gas consumption rose at the same rate. Coal consumption also increased. Notwithstanding that retail natural gas consumption increased by 27 % since 2014, it remains 16 % below the average for the past decade.

Manufacturing industry emissions also increased in recent years.

Effort Sharing Decision (ESD)

Emissions under the ESD, covering sectors, not falling within the scope of the ETS, **totalled 43.14 million tonnes in 2017.**

Most emissions under the ESD are attributable to transport, buildings, agriculture and waste management sectors, but emissions from industrial energy consumption and F-gases are also contributors.

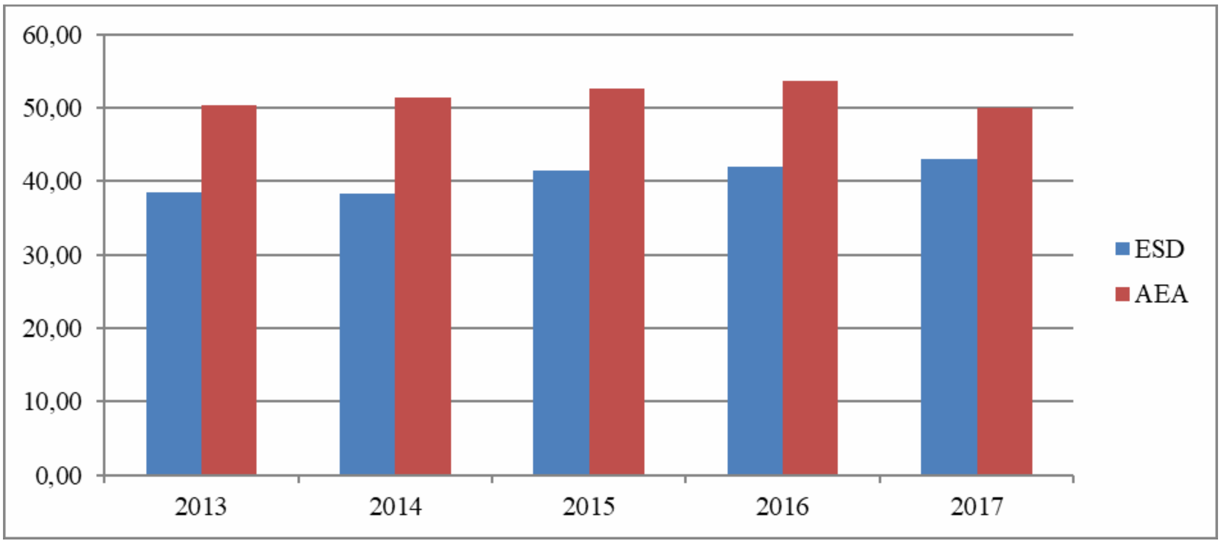

Figure 10 – Emissions under the ESD (2013-2017, kt CO_{2eq})[125]

Source: EUTL

Transport emissions increased by 9.3 % since 2005.

At the same time, emissions from fuel consumption in the service industry, agriculture and by households decreased by 29 % over the year 2005. Following the typically declining trend of recent years, however, household emissions increased in 2015, primarily as a result of the 13 % rise in gas consumption.

[125] AEA: Annual emission allocation

In 2017 **agriculture** accounted for 11 % of total emissions. Agricultural activities result in CH_4 and N_2O emissions; most of Hungary's N_2O emissions (87 %) are produced in this sector. The GHG emissions of agriculture have been steadily increasing since 2011, mainly as a result of increases in fertiliser use, the bovine population and dairy production per cow.

The **waste sector** accounts for 5 % of total emissions. The disposal of solid waste in landfills accounts for most of emissions (84 %), followed by waste water treatment (11 %), composting (4 %) and waste incineration not for energy purposes (1 %). The rise in emissions came to a halt in the past decade, followed by a 19 % decline between 2005 and 2017.

F-gas emissions accounted for 3 % of total emissions in 2017. F-gas emissions were highest in 2015, followed by a significant decline, and an increase again in 2017.

EU ETS

The **ETS GHG emissions** (not including air transport) **of Hungary amounted to 20.1 million tonnes** CO_2 **equivalent in 2017, decreasing by 26 % over the year 2005.**

Hungary's EU ETS GHG emissions continuously declined between 2009 and 2014, with the exception of a minor shift in 2010. The trend again reversed after 2014, with total emissions increasing by around 10 % up to 2017.

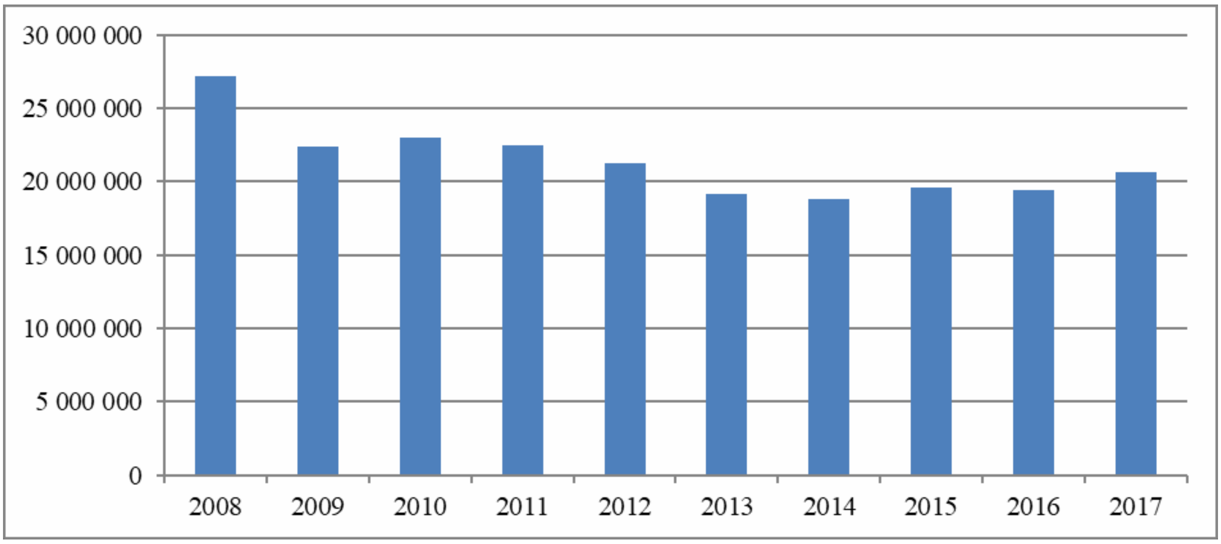

Figure 11 – Emissions under the EU ETS, 2008-2018 (kt CO_{2eq})

Source: EEA

Land-use, land-use change and forestry (LULUCF)

The **LULUCF sector is regarded overall as a sink, owing to the substantial** CO_2 **capture of forests** resulting from significant volumes of forestation and sustainable forest management in recent decades. A trend cannot be identified in the sector’s net sink rate due to the complex dynamics of the accounted processes; results significantly fluctuate. The average sink rate equalled 3.5 million CO_2 equivalent, fluctuating between 0.4 million tonnes (2000) and 5.8 million tonnes CO_{2eq}. In 2017, forests captured 4.9 million tonnes CO_2.

ii. Projections of sectoral developments with existing national and Union policies and measures at least until 2040 (including for the year 2030)

Annex 4 contains the detailed results of GHG projections. In relation to the LULUCF categories, one scenario with existing measures (WEM) and one with additional measures (WAM) was drawn up.

In relation to the agriculture and waste sectors, the WAM scenario does not include actual additional measures; the difference between the WEM and WAM is attributable to emissions reduction required in the sectors.[126] Only a WEM scenario was prepared in relation to the other categories. The forecasting baseline is not uniform. In relation to the energy sector the base year is 2016, while the year is 2017 in relation to all other categories.

Summary

Under the WEM scenario, by 2030 the total gross GHG emissions of Hungary – without LULUCF – is expected to decrease to 62.8 thousand CO_{2eq}**,** indicating a 1.5 % decrease over the year 2017, and **a 33 % decrease over the year 1990, falling short of the minimum 40 % target.** Total net emissions with LULUCF will fall to 62.3 thousand kt CO_{2eq}.

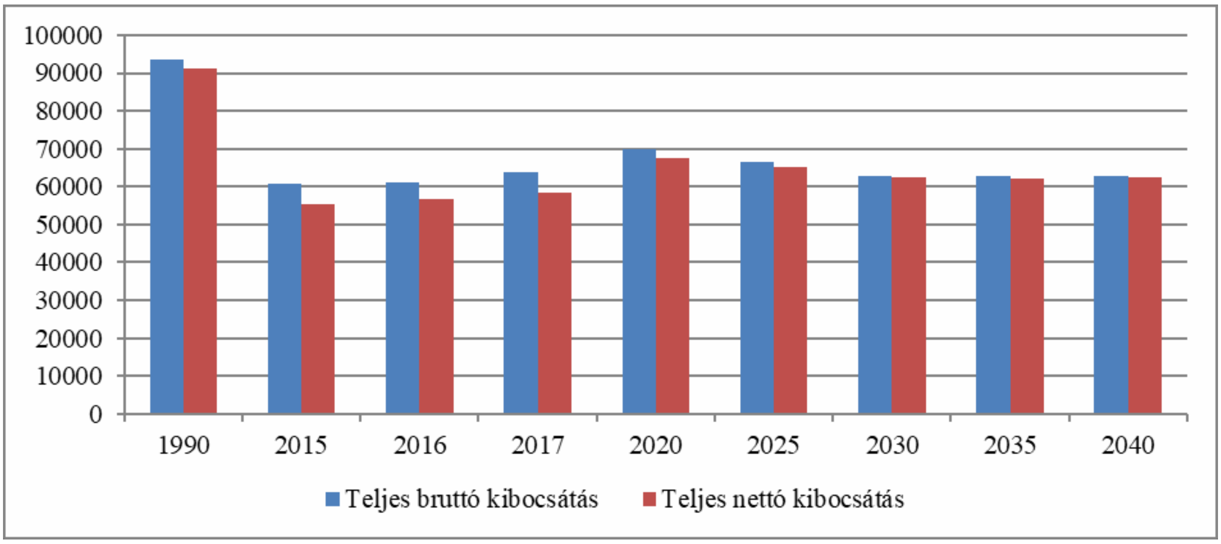

Figure 12 - GHG emissions with existing policies and measures, 2016-2040 (kt CO_{2eq})

Source of actual data: National Inventory Submission, 2019

[126] The forecasting baseline is not uniform. In relation to the categories of energy and disposal of solid waste in landfills, the base year is 2016, while the year is 2015 in relation to all other categories. The final version of the NECP - to be drawn up in 2019 - will apply a uniform base year.

HU	EN
Teljes bruttó kibocsátás	Total gross emissions
Teljes nettó kibocsátás	Total net emissions

Under the WEM scenario, CO_2 will remain the largest GHG. Its emission will increase by 1 % until 2030 over the year 2017. CH_4 and N_2O emissions will decrease by 3.5 % and increase by 3.2 %, respectively, while F-gas emissions will decrease by 74.65 %. We are not accounting for the appearance of NF_3 in the Hungarian inventory.

EU ETS emissions decrease by 9.3 % over the year 2017, while **ESD/ESR emissions increase by 2.1 % under the WEM scenario.**

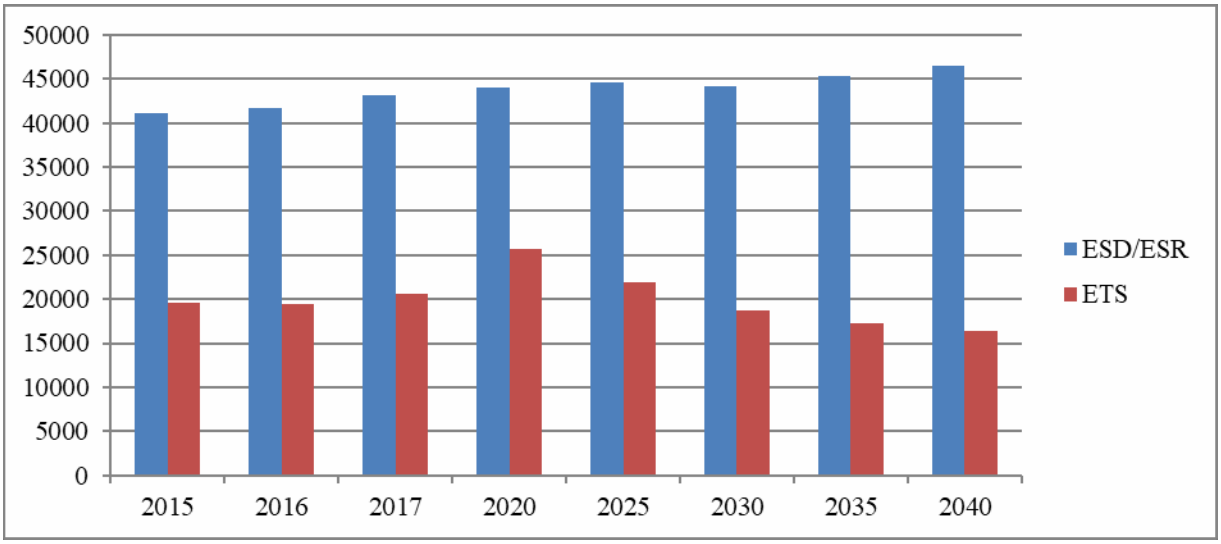

Figure 13 - ETS and ESR emissions with existing policies and measures, 2015-2040 (kt CO_{2eq})

Source of actual data: National Inventory Submission, 2019

The LULUCF sector will remain a net sink, but CO_2 capture will decrease by 90 % by 2030.

Energy

Under the WEM scenario GHG emissions will significantly change by 2040. The initial substantial increase – by 7.7 % by in 2025 over the year 2017 – will be followed by a decline, thus by 2030 emissions levels will fall back to the level of 2017, and will essentially stay at this level in 2040 as well.

In 2017, mainly the energy industry (30.2 %), transport (28.5 %), households (18.6 %) and industry (10.7 %) contributed to energy emissions. **By 2040 the individual sectors' contribution to total emission will significantly change. By 2030 transport will be the largest contributor among the above sectors**, as it will maintain its level (28.7 %), whereas the energy industry will only account for 20.6 % of energy emissions. **The highest increase in GHG emissions will be measured in industry** by 2030 and 2040, thus at the end of the analysed period this sector will produce 20.2 % of energy emissions. While emissions will increase by 88 % up to 2030 compared to the value for 2017, such increase will reach 119 % by 2040. The above is attributable to the forecast of rising demand, to be satisfied by the sector mainly with oil and coal.

Non-energy emissions

In 2030, emissions from industrial processes and product usage are expected to exceed the level in 2017 by 10.3 %. The increase is attributable to two different trends. In 2030, CO_2 emissions from industrial processes are expected to exceed the level in 2017 by 11.7 %, while fluorinated greenhouse gas emissions will significantly decrease by 2030 as a result of prohibitions of relevant EU regulations and the hydro-fluorocarbon quota scheme.

Emissions are expected to increase in agriculture. The sector is expected to emit **10 %** more GHGs in 2030, mainly attributable to a growing animal population.

Waste emissions will decline by 23 % by 2030. The decrease is mainly driven by the declining quantity of waste disposed in landfills. Due to the expected rise in demand, e**missions from international air transport will be 15 % higher in 2030 than in 2017.**

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) as well as per technology in each of these sectors

In 2017 the share of renewables within gross final energy consumption[127] already equalled 13.3 % in Hungary. Between 1994 and 2017 the share of renewable energy within gross final energy consumption increased from 2.2 % to 7.5 % in electricity consumption, from 0.9 % to 6.8 % in transport, and from 6.5 % to 19.6 % in heating and cooling, mainly resulting from the use of biomass. Hungary's possibilities for using renewable energy are mainly exploited in the heating sector; **in 2016, 83 % of renewable energy was used for heating and cooling, 9 % for electricity generation and 8 % for transport.**

The actual use of biomass – providing the bulk of renewable energy – significantly depends on the price and consumption of other energy sources. The consumption of natural gas – as an alternative to household biomass – is steadily increasing in parallel with Hungarian GDP growth. Furthermore, the offer price of biomass for energy is to a major extent determined by demand for pulpwood and paper wood, in addition to import opportunities.

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[127] Indicator of the share of renewable energy sources within gross final energy consumption, official indicator for monitoring the 2020 target defined in 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.

In recent years the most dynamic increases were observed in solar power generation, renewable based district heating, heat pump systems and in the use of biofuels with mandatory blending ratios.

	Total use of renewable energy in gross final energy consumption PJ	Share of renewables within gross final energy consumption %
Total renewable energy consumption within gross final energy consumption	**108.4**	**13.3**
Electricity	12.3	7.5
Heating and cooling	88.6	19.6
Transport	7.4	6.8

Table 26 - Share of renewable energy in gross final energy consumption per sector, 2017

Source: Eurostat

Electricity (GWh)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Water	208.5	215.4	216.7	222.5	228.3	229.8	232.3	231.6
Wind	517.6	645.4	700.9	704.1	704.2	701.3	705.7	702.9
Solar	0.9	1.4	7.9	24.6	67.0	141.0	244.0	349.0
Solid biomass	2 034.3	1 526.9	1 333.0	1 429.2	1 702.0	1 661.0	1 492.8	1 646.0
All other renewables	262.2	332.1	321.8	402.8	424.4	500.3	578.3	495.0
Total	**3 023.4**	**2 721.3**	**2 580.4**	**2 783.3**	**3 125.9**	**3 233.3**	**3 253.1**	**3 424.5**
Transport (ktoe)								
Electricity in road transport	0.0	0.0	0.0	0.3	0.3	0.4	0.6	0.6
Electricity in rail transport	16.2	18.2	16.6	22.3	22.8	24.9	27.0	29.1
Electricity in all other modes of transport	0.0	0.0	0.0	0.2	0.2	0.3	0.3	0.3
Biofuels	174.0	164.8	154.5	142.3	193.3	174.0	185.9	148.0
Other renewables	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	248.0	230.0	216.2	214.8	266.8	296.5	323.4	303.0
Heating, cooling (ktoe)								
Final energy consumption	1 800	2 054	2 199	2 289	1 885	2 001	1 969	1 920
Derived heat	78	84	77	114	121	163	204	191

Heat pumps	-	-	2	3	4	5	5	7
Total	1 878	2 138	2 278	2 407	2 011	2 168	2 179	2 117

Table 27 - Quantity of consumed renewable energy within gross final energy consumption per sector and technology, 2017

Source: Eurostat

ii. Indicative forecasting of development based on existing policies until 2030 (outlook up to 2040)

Under the WEM scenario, the share of renewables will moderately increase in Hungary from around 14.1 % in 2016 to 14.7 % in 2030, followed by a stagnating trend until the mid-2030s. The increase, however, will reverse and equal a 13.3 % share in 2040. In 2016 the heating and cooling sector accounted for 82 % of total renewable energy consumption, followed by electricity consumption with 10 % and the transport sector with 7 %. **By 2030 the share of renewable energy consumption** within total renewable energy consumption in **the electricity sector will significantly increase mainly as a result of the 2.5 GW PV capacity** expected to be implemented by 2030. Renewable energy production in the electricity sector will increase to over 530 ktoe, accounting for 17 % of total renewable energy consumption. The **share of renewables within the transport sector will also increase significantly** to 13 % by 2030. By 2030 the use of renewables will increase by an overall rate of 23 % over the year 2016, which is more than the 18 % rise in gross final customer demand forecast up to 2030 under existing measures.

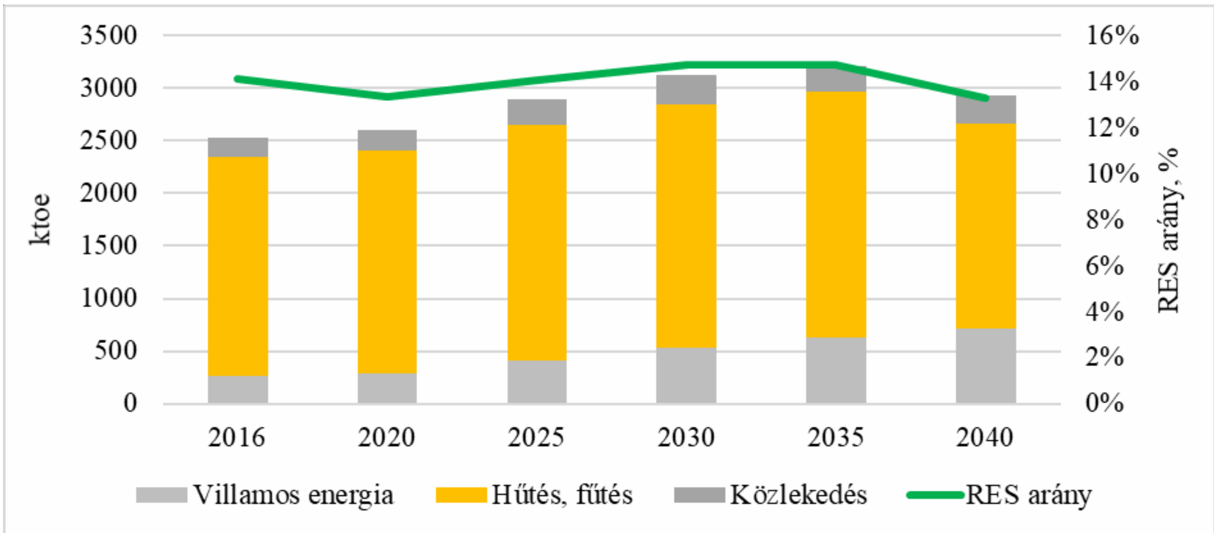

Figure 14 – Consumption of renewable sources of energy in individual sectors (ktoe) and the rate of total renewable energy consumption (%)

Source of actual data: Eurostat

HU	**EN**

ktoe	ktoe
RES arány, %	RES rate, %
Villamos energia	Electricity
Hűtés, fűtés	Cooling, heating
Közlekedés	Transport

Currently **biomass use accounts for a dominant share of renewables** in Hungary. In 2016 biomass accounted for more than 80 % of total renewable energy consumption, which is predominantly based on the fuel wood consumption of the poorest population segment. Currently the use of geothermal energy accounts for around 7 % of renewables, which has three main sources. A significant amount of energy is used for heating, most of which is utilised in greenhouses and various bath establishments. A number of geothermal district heat generating facilities have also been built in recent years. In 2016 the use of biofuels contributed 7 % to the use of renewable energy.

These ratios are expected to moderately change by 2030, resulting in more diversified use of renewable energy. The share of biomass use will remain dominant but **decrease** to 75 %. The **share of solar energy** within renewables **will significantly rise**, from the initial 1 % to around 8 % by 2030. **A moderate increase in the use of geothermal energy is also expected.**

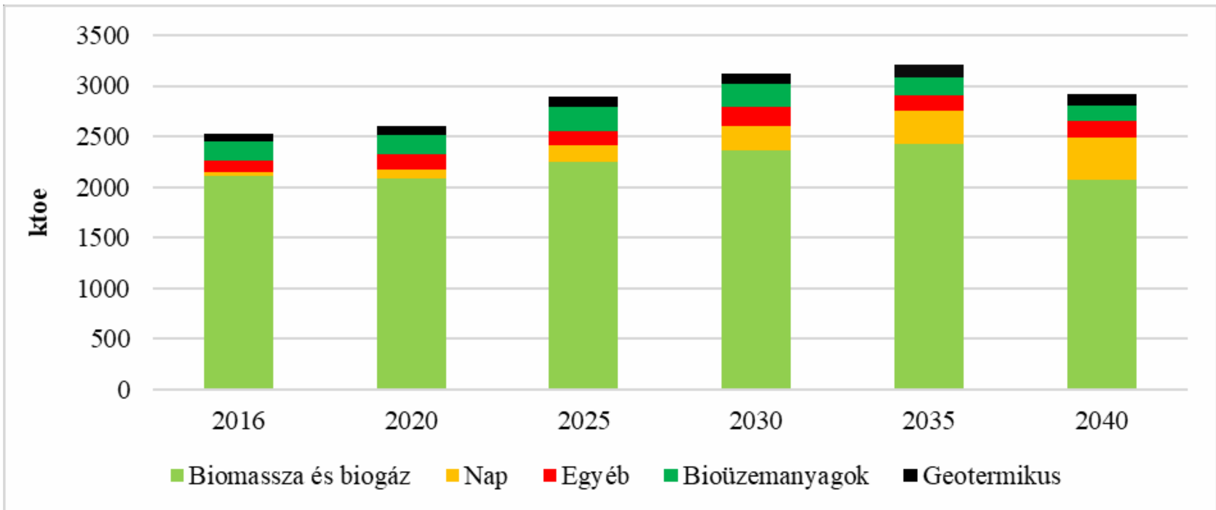

Figure 15 – Use of renewable sources of energy by fuel, ktoe

Source of actual data: Eurostat

HU	EN

Biomassza és biogáz	Biomass and biogas
Nap	Solar
Egyéb	Other
Bioüzemanyagok	Biofuels
Geotermikus	Geothermal

Renewable energy consumption in the electricity sector

Under the WEM scenario – owing to already existing renewable aids – **electricity generation from renewable sources will significantly increase in the electricity sector by 2040.** Based on our forecast, **the largest increase is expected in PV production**; the installed capacity will increase to 3.5 GW in 2030 and to 4.3 GW in 2040. Capacities used for biomass based electricity generation, still operating today, will gradually be phased out until 2035, but the total capacity will again rise to around 500 MW by 2040. We cannot observe an increase in relation to hydroelectric power plants and wind power stations, but we expect an installed capacity of 59 MW for geothermal power stations by 2040.

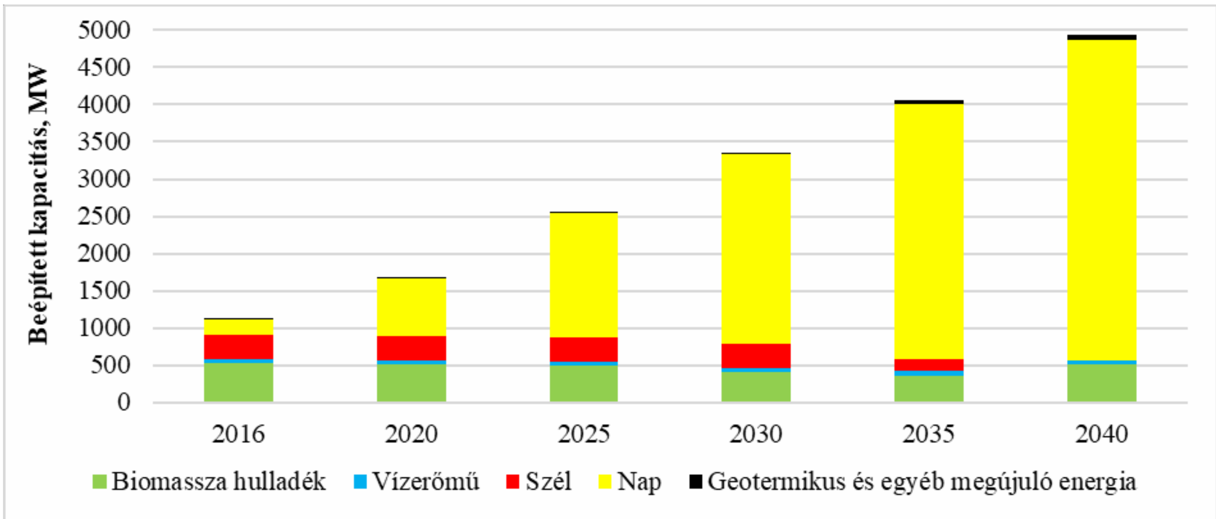

Figure 16 – Installed capacity with existing measures, MW

Source of actual data: Eurostat

HU	**EN**
Biomassza hulladék	Biomass waste
Nap	Solar
Szél	Wind

Vízierőmű	Hydroelectric power plant
Geotermikus és egyéb megújuló energia	Geothermal and other renewable energy
Beépített kapacitás, MW	Installed capacity, MW

As regards generated electricity, solar power and biomass represent a dominant share: in 2030, PV power plants and biomass power plants will account for 45 % and 35.7 % of renewable based generation, respectively. These resources are followed by wind power stations (11.9 %), hydroelectric power plants (3.9 %) and geothermal power plants (3.5 %).

Under the WEM scenario the share of renewables in this sector is steadily increasing from around 8 % in 2016 to 13.5 % in 2030 and to over 17 % in 2040.

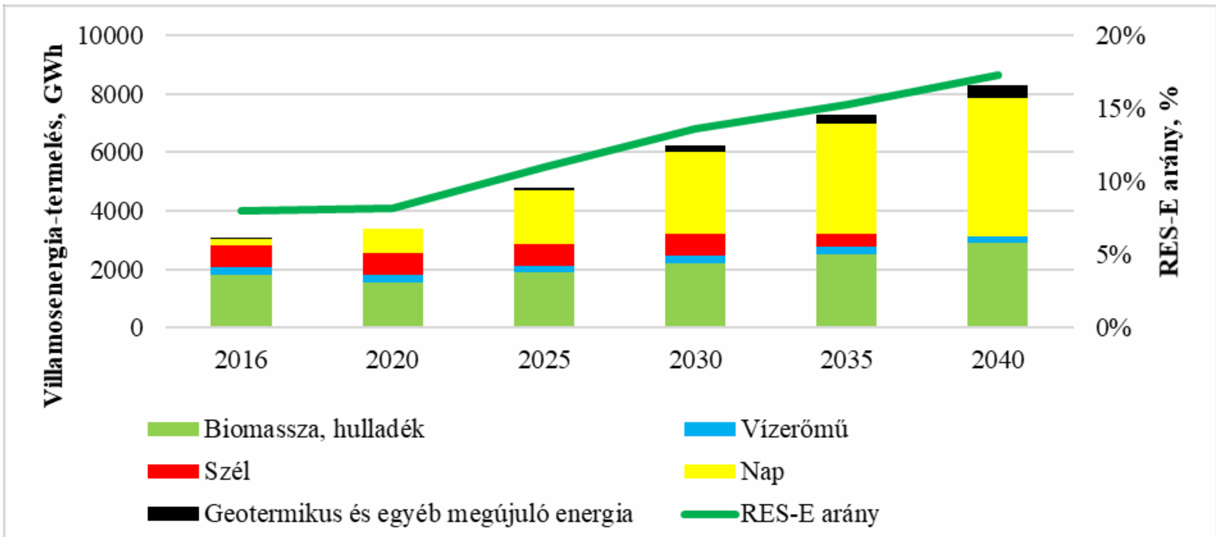

Figure 17 – Electricity generation from renewable sources and share of renewable electricity (RES-E), GWh and %

Source of actual data: Eurostat

HU	**EN**
Biomassza, hulladék	Biomass, waste
Nap	Solar
Szél	Wind
Vízierőmű	Hydroelectric power plant
Geotermikus és egyéb megújuló energia	Geothermal and other renewable energy

Villamosenergia-termelés, GWh	Electricity generation, GWh
RES-E arány, %	RES-E rate, %

Renewable energy consumption in the transport sector

By applying the multipliers described in relation to the WAM scenario, **the share of renewables in transport equalled 6.3 % in 2016**, which, even **under the WEM scenarios increases to 12.6 % by 2030**, notwithstanding that gross final customer demand in the transport sector will rise by 21 % during this period.

By 2030 advanced (second generation) biofuels will account for most of renewable energy consumption (53 %), while the use of first generation biofuels will equal 14 % within renewable energy consumption in the transport sector. The share of electricity is expected to be 21 % in 2030. Hydrogen will also play a major role by the end of the 2020s.

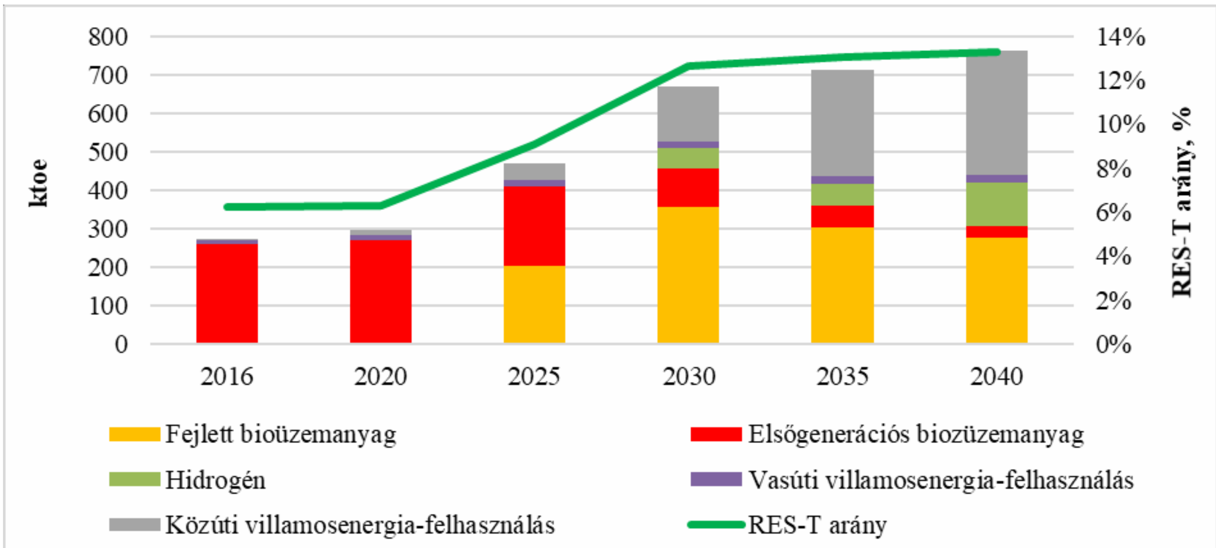

Figure 18 – Renewable energy consumption in the transport sector, and share of renewable energy in transport (RES-T, %), with multipliers, ktoe and %

Source of actual data: Eurostat

HU	**EN**
RES-T arány, %	RES-T rate, %
Fejlett bioüzemanyag	Advanced biofuel
Hidrogén	Hydrogen
Közúti villamosenergia-felhasználás	Use of electricity in road transport
Elsőgenerációs bioüzemanyag	First generation biofuel

Vasúti villamosenergia-felhasználás	Use of electricity in rail transport

Renewable energy consumption in the cooling and heating sector

Biomass has a dominant share in the cooling and heating sector; under existing measures **this is not expected to change in the longer term**, as the share of the fuel will decrease by only 0.1 percentage points compared to the current 94 % level by 2030. Geothermal energy is the second most important source, with a 4 % share in renewable energy consumption in 2016. This value will not change by 2030, either.

Based on our forecast, **the spread of solar thermal collectors is not expected without additional measures.** In summary of the trends, **the use of renewable energy for cooling and heating will increase significantly by more than 11 % by 2030, although the share of renewables will nevertheless decrease to 19.4 % from the current 20.7 % value**, followed by a continuing decline in the share of the use of renewable energy in this sector.

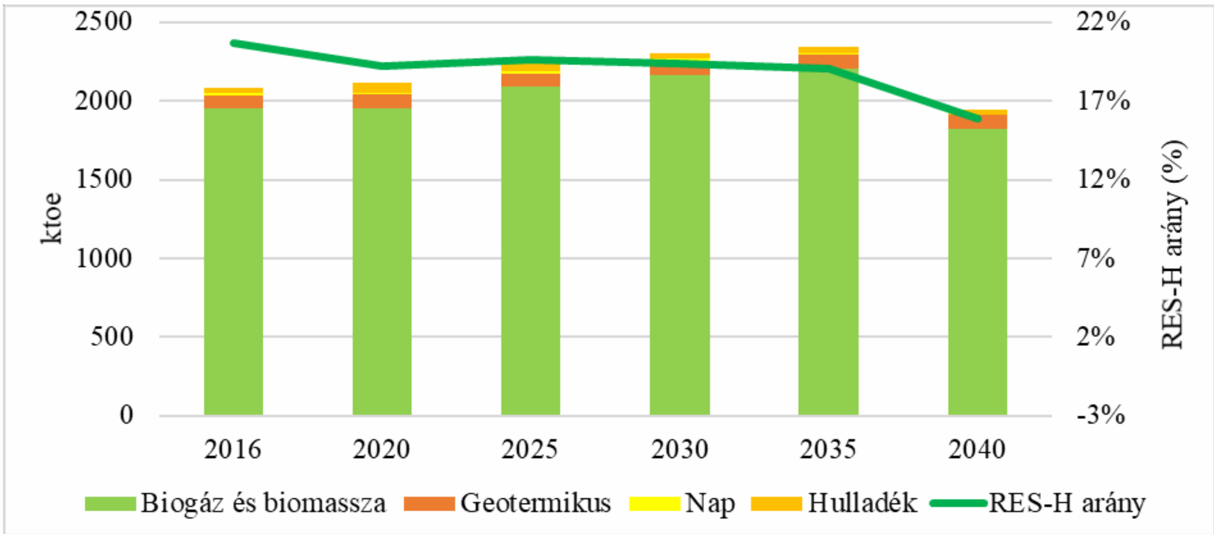

Figure 19 – Renewable energy consumption in the cooling and heating sector (ktoe), and share of renewables (RES-H, %)

Source of actual data: Eurostat

HU	EN
Biogáz és biomassza	Biogas and biomass
Geotermikus	Geothermal
Nap	Solar
Hulladék	Waste
RES-H arány	RES-H rate

4.3. Dimension of energy efficiency

i. Current primary and final energy consumption in the economy and per sector (including industry, residential, service and transport)

According to the 2017 energy balance sheet prepared on the basis of Eurostat's new methodology, Hungary's primary energy consumption equalled 1 025 PJ, with (following energy conversion, transmission and distribution, not including non-energy use) 774.68 PJ[128] reaching consumers. Final energy consumption for 2017 fell short of the 2005 level by around 10 PJ, notwithstanding that the Hungarian GDP grew on average by 1.5 % annually between 2005 and 2017.[129]

Composition of final energy consumption in 2017: industry (22 %), transport (23 %), households (36 %), and commerce and services (11 %).

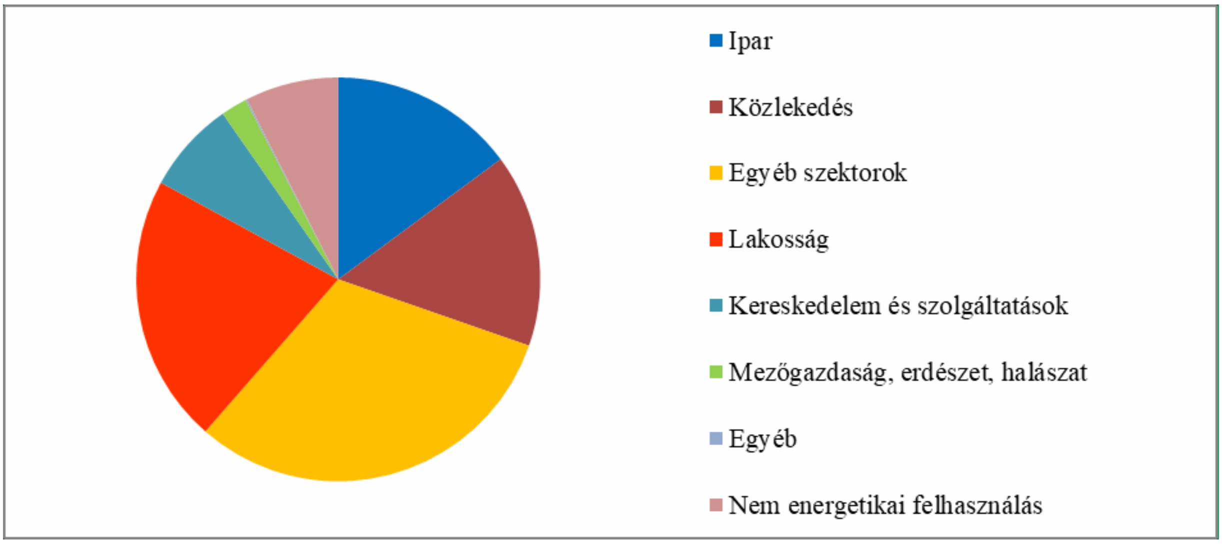

Figure 20 – Sectoral distribution of final energy consumption[130], 2017

Source of actual data: Eurostat

HU	EN
Ipar	Industry
Közlekedés	Transport
Egyéb szektorok	Other sectors
Lakosság	Retail

[128] Value of Eurostat based on the old methodology: 3 834.6 PJ (2017).

[129] Together with the 6.6 % decrease measured in the year of the 2009 crisis.

[130] Distribution is based on the old methodology, taking into account that sectoral data based on the new methodology are not yet available in the Eurostat database.

Kereskedelem és szolgáltatások	Commerce and services
Mezőgazdaság, erdészet, halászat	Agriculture, forestry, fishery
Egyéb	Other
Nem energetikai felhasználás	Non-energy use

(PJ)	2017
1. Primary energy consumption	1 116
2. Final energy consumption	845
2(a) Industrial sector	182
2(b) Transport	189
2(c) Other sectors	380
- Retail	263
- Commerce and services	90
- Agriculture, forestry and fishery	26
- Other	1
2(d) Non-energy use	94

Table 28 - National annual energy balance (2014-2017)

Source: HEA

Industrial energy consumption, however, has been increasing each year since 2009. In 2013 consumption reached the level of 2005, and in 2017 it even exceeded the level by around 18 %. As a positive development, however, energy consumption in transport falls short of the 2005 level, and energy consumption in the services sector and by households significantly declined over the year 2005. It should also be noted, however, that Hungarian households have again been consuming more energy since 2014.

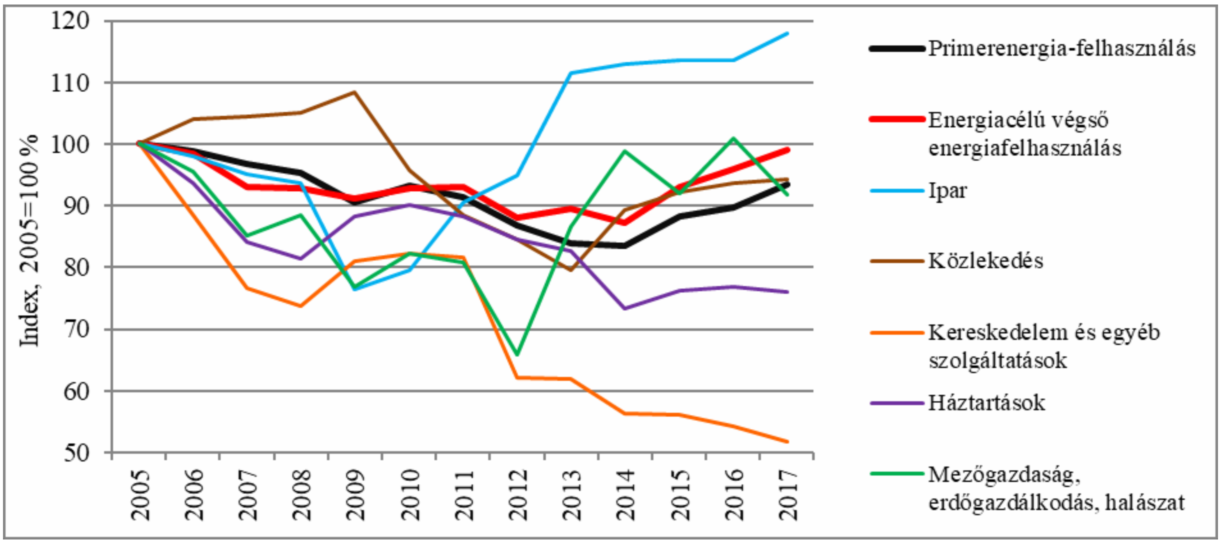

Figure 21 – Final energy consumption per sector, 2005-2017

Source of actual data: Eurostat

HU	**EN**
Primerenergia-felhasználás	Primary energy consumption
Energiacélú végső energiafelhasználás	Final energy consumption for energy purposes
Ipar	Industry
Közlekedés	Transport
Kereskedelem és egyéb szolgáltatások	Commerce and other services
Háztartások	Households
Mezőgazdaság, erdőgazdálkodás, halászat	Agriculture, forestry and fishery

The energy intensity of the Hungarian economy remains high in European comparison, which is partly attributable to the structure of the national economy.[131] On the whole, however, in almost two decades, the energy intensity of Hungarian GDP[132] has improved, in spite of the rise in the index for energy intensity between 2014 and 2017.[133]

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[131] European Commission (2017): Energy Union Factsheet – Hungary. SWD (2017) 397 final.

[132] Energy intensity indicates the amount of energy necessary for manufacturing a product or performing a process.

[133] Also taking into account energy consumption in transport.

Unfavourable trends emerge when analysing energy efficiency on a sectoral level.[134]

Although energy consumption is becoming increasingly efficient in the services sector (energy intensity has dropped by more than one half), energy efficiency in both the industrial and transport sectors – with a significantly higher share of energy consumption in recent years – has declined.

Although energy efficiency in the **industrial sector** followed a positive trend between 2000 and 2009 (energy intensity decreased during this period), a moderate overall decline is observed since 2009.

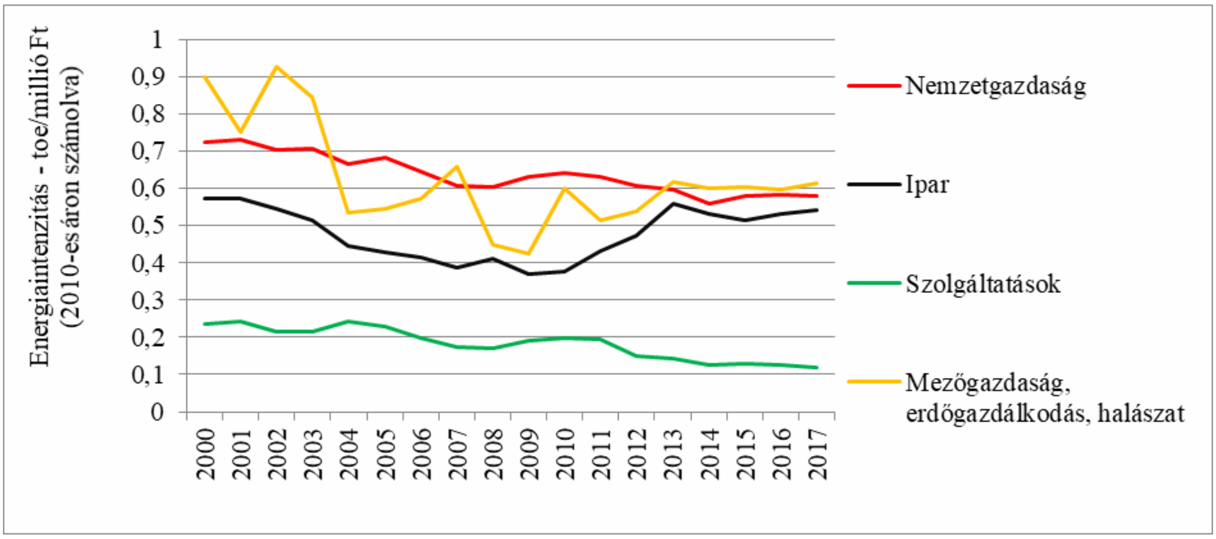

Figure 22 – Energy intensity in the national economy, industry, agriculture and services[135] between 2000 and 2017[136]

Source: Eurostat

HU	EN
Energiaintenzitás – toe/millió Ft (2010-es áron számolva)	Energy intensity – toe/HUF million (at 2010 prices)
Nemzetgazdaság	National economy
Ipar	Industry
Szolgáltatások	Services
Mezőgazdaság, erdőgazdálkodás, halászat	Agriculture, forestry and fishery

[134] The analysis is based on the old methodology, taking into account that sectoral data based on the new methodology are not yet available in the Eurostat database.

[135] Intensity was calculated on the basis of the GDP (at 2010 prices, in HUF) in relation to the national economy, and on the basis of added value (at 2010 prices, in HUF) in relation to industry.

[136] Transport, and passenger and freight transport is discussed separately. Due to statistical/classification difficulties, efficiency was analysed with different methods.

In the first half of the decade, although deteriorating energy efficiency in industry was to some extent offset after the crisis by improving fuel consumption in the **transport, passenger and freight transport sectors** (the period between 2009 and 2013 is essentially characterised by stagnating carriage of goods and a sharp decline in energy consumption[137]), the situation has worsened since 2013 in this area as well. For the above reason, improvement of the useful efficiency of energy consumption in transport should be a priority for future development.

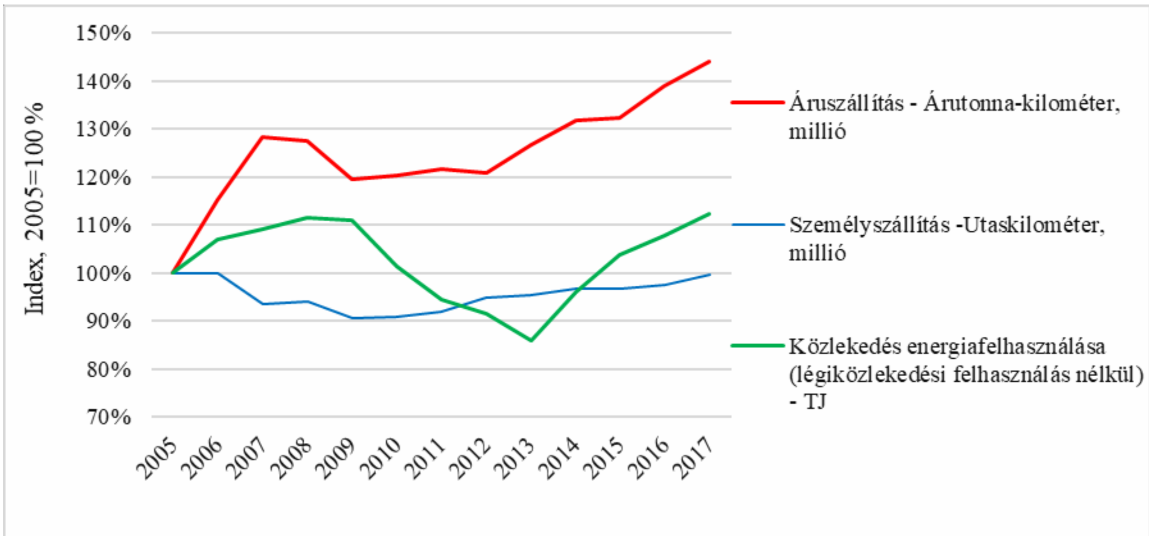

Figure 23 – Changes in passenger and freight transport[138], and in final energy consumption for transport purposes between 2005 and 2017

Source: Passenger and freight transport data: HCSO, data on energy consumption in transport: Eurostat

HU	**EN**
Áruszállítás – Árutonna-kilométer, millió	Carriage of goods – tkm, million
Személyszállítás – Utaskilométer, millió	Passenger transport – passenger-km, million
Közlekedés engergiafelhasználása (légiközlekedési felhasználás nélkül) - TJ	Energy consumption in transport (not including air transport) - TJ

In the retail/household sector the positive effect of energy efficiency investments has for years been offset by

[137] Energy consumption in transport decreased from 4 489 toe (188 PJ) to 3 460 toe (145 PJ), while the performance of goods transport stagnated at 51 000 tonne-kilometres.

[138] Not including air transport.

the rise in energy demand. In 2015 the energy used to heat one square metre of a residential building in Hungary (20.9 koe/m^2) exceeded the EU28 average by 37.5 % (after adjustment of climate differences), and no significant progress has been made compared to the level in 2005 in Hungary, either (21.1 koe/m2).[139] In consequence of these effects energy efficiency indicators deteriorated in 2015 and 2016 on an aggregate level as well. The final energy consumption per household also reflects this trend: Although energy consumption per household decreased from 64.3 GJ to 52.1 GJ between 2010 and 2014 , the final energy consumption of households increased by 7.4 GJ on average between 2015 and 2017.[140]

The trends of recent years suggest the necessity of reconsidering the energy efficiency measures applied so far, developing new incentives, introducing the **obligation** scheme[141] and the effective exploitation of awareness raising potential. Without the encouragement of energy efficiency investments and implementation of additional measures there is the risk that Hungary will remain stuck on the level of developing countries with high energy and carbon intensity, and will be unable to benefit from economic advantages offered by high energy efficiency.

EU obligations are also aimed at improving energy efficiency (Energy Efficiency Directive[142], Energy Performance of Buildings Directive[143]). In the summer of 2018, the indicative 2030 energy efficiency target of the EU was raised from 27 % to 32.5 %, which also requires Hungary to make additional efforts. Based on the foregoing, in the future we are assigning a greater priority to the efficient use of energy. In the coming years, one of the key measures of energy efficiency policies will be to apply the principle of **'energy efficiency first'** in day-to-day decision-making. Applying the principle of 'energy efficiency first' – as prescribed by Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action – contributes to achieving all of our main energy and climate policy objectives and to improving the competitiveness of the Hungarian economy.

In parallel with the key objective of maintaining the existing energy intensive industrial sectors, future industrial investments should be made in low energy and GHG intensive, high-tech industrial sectors, with a focus on energy efficiency targets, enabling support of the sustainable and competitive development of the Hungarian economic structure. Taking into account the high 40 % share of primary energy used for the heating and cooling of buildings in Hungary, the upgrade of residential buildings and non-residential buildings is also a priority. **We are planning to develop cost-effective incentives within the framework of an energy**

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[139] European Commission (2017): Energy Union Factsheet – Hungary. SWD (2017) 397 final.

[140] Data on final energy consumption is provided by Eurostat, while the number of households is based on HCSO data.

[141] Under the obligation scheme, Hungary requires energy distributors and/or retail energy trade undertakings to introduce programmes and implement measures resulting in evidenced energy savings for final customers.

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

[143] Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

efficiency obligation scheme, which drive energy efficiency investments to areas with the highest energy consumption and energy efficiency potential on a market basis.

Improvement of the efficiency of energy consumption in transport is also a task to be resolved. This task is also justified by finite fossil energy sources, increasing energy consumption, and the very close, positive correlation between energy consumption and environmental pollution.[144]

ii. Current potential for the application of high-efficiency cogeneration and efficient district heating and cooling[145]

To determine the potential it is necessary to update the assessment referred to in Article 14(1) of Directive 2012/27/EU.

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)[146]

Final energy consumption

Under the WEM scenario, Hungarian gross final energy consumption will significantly increase until 2030, by around 18 % over the year 2016.

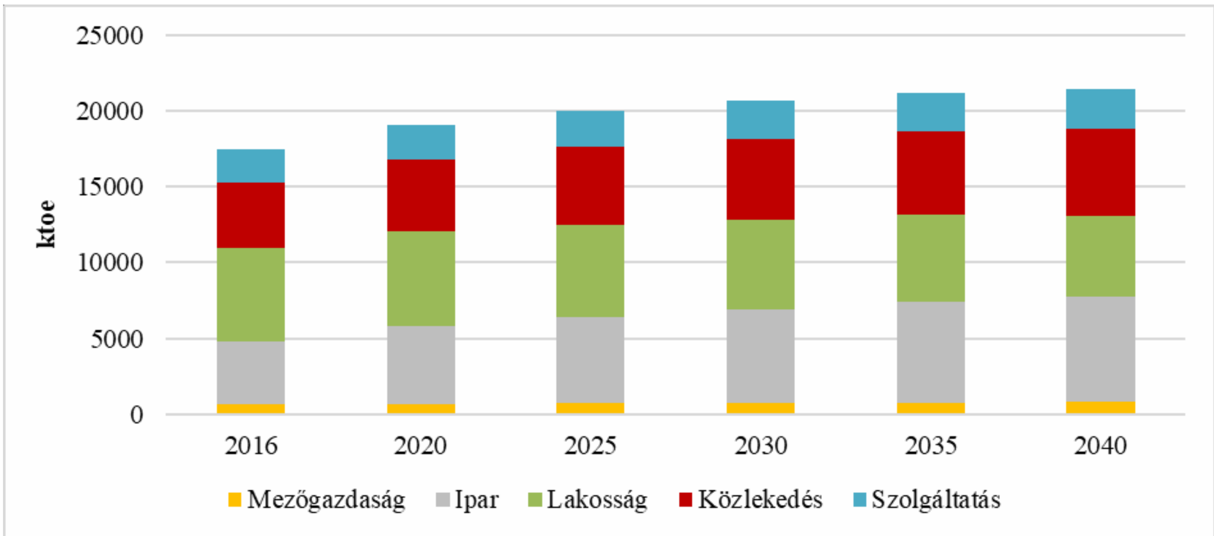

Figure 24 – Sectoral composition of gross final energy consumption under the WEM scenario, ktoe

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144 Pál Michelberger (2008): Közlekedés a XXI. században. (Transport in the 21st Century.) Magyar Tudomány, 2008/02 p. 131. (http://www.matud.iif.hu/08feb/03.html)

145 In accordance with Article 14(1) of Directive 2012/27/EU.

146 This 'business as usual' reference forecast will be the basis for the 2030 final and primary energy consumption target (described in point 2.3) and conversion factors.

Source of actual data: Eurostat

HU	EN
Mezőgazdaság	Agriculture
Ipar	Industry
Lakosság	Retail
Közlekedés	Transport
Szolgáltatás	Services

The biggest increase during this period was measured in **industry**, with **a rise in energy consumption of approximately 48 %. A significant increase was also observed in the transport sector.** Notwithstanding that transport vehicles are becoming more efficient, this effect cannot entirely offset rising demand for mobility. **In the retail sector, however, a decrease is also measured up to 2030 under a scenario without additional measures**, and the pace of the declining trend is even more pronounced in the 2030s.

The 15 % increase in the services sector is significantly smaller than in industry between 2016 and 2030, followed by stagnating energy consumption in the sector.

Although the use of coal-related products is mainly on the rise, primarily attributable to growing industrial coal use, the share of coal in 2030 still falls short of 3.5 %. The 20 % increase in electricity consumption between 2016 and 2030, however, is substantial.

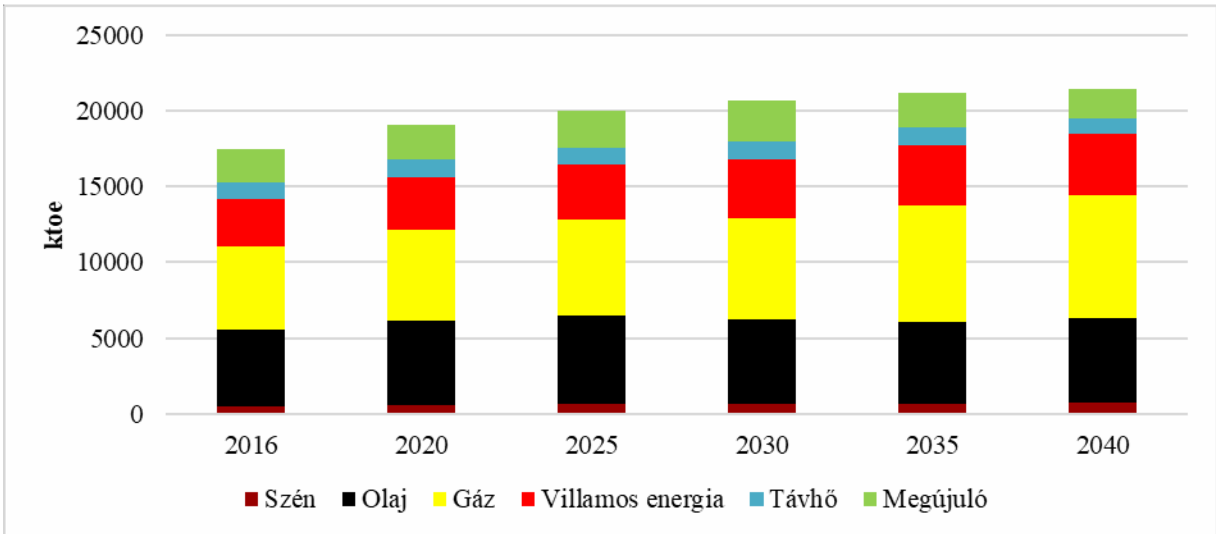

Figure 25 – Composition of gross final energy consumption in the breakdown of fuels under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

As regards composition of fuels, **due to its marginalised role in electricity generation, coal is losing relevance**, its consumption falls by one half by 2030, and its total share within primary energy consumption will be around 3 %. **The use of nuclear energy indicates a significant increase**, which will peak in 2030, when the new and old units of the Paks Nuclear Power Plant will operate in parallel. **A substantial increase is also expected in relation to renewables**; by 2030 consumption will increase by approximately 56 % over the year 2016. **Electricity imports will significantly decline in 2030; on an annual level Hungary will become almost entirely self-sufficient with the parallel operation of the Paks units**, followed by a rise in imports in the second half of the 2030s, in parallel with the decommissioning of the currently operating units.

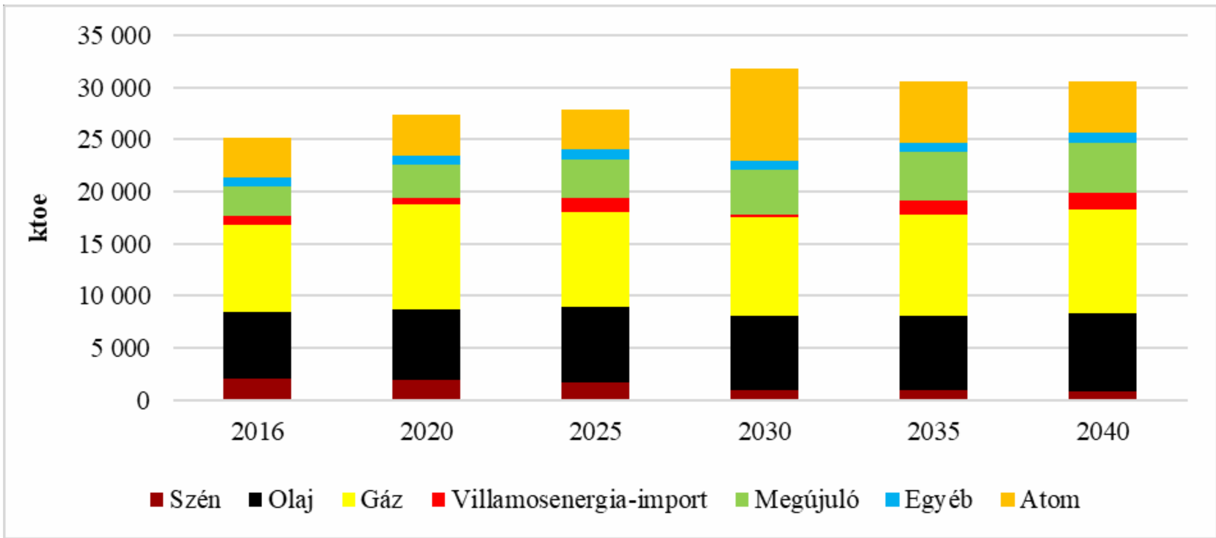

Figure 26 – Composition of primary energy consumption in the breakdown of fuels under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	EN
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia-import	Electricity imports
Atom	Nuclear
Megújuló	Renewables
Egyéb	Other

The section below presents in detail changes in fuel composition within individual gross final customer segments, and the major consumer subsegments within the given sector.

Retail

Notwithstanding the spread of better and more energy efficient heating solutions, **total heating energy consumption will increase as a result of two important factors.** Firstly, despite a shrinking population, **the total inhabited floor area will increase**. Secondly, **the heated floor area will also increase**, i.e. the unheated or underheated area is decreasing. **These effects entail the rise in energy consumption up to 2030, which, however, will be followed by a declining trend.**

Owing to the substantial energy efficiency potential of technologies, we forecast decreasing energy consumption for cooling. A moderate increase is expected in the use of DHW up to 2030, followed by a declining, stagnating trend. The energy consumption of refrigerators, freezers and washing machines will significantly decline, as the turnover rate of these equipment is relatively high, and new equipment are considerably more energy efficient. A similar trend is forecast for lighting. The energy consumption of other equipment will initially increase in parallel with economic development, but in this case, too, Hungary can expect substantial savings after 2025.

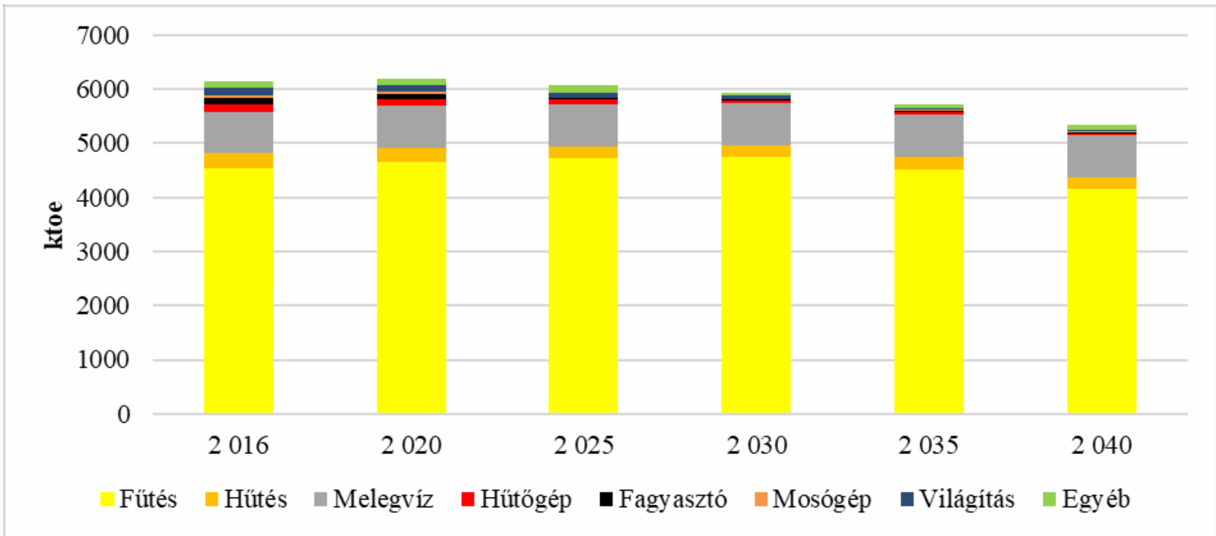

Figure 27 – Composition of retail energy consumption in the breakdown of modes of use under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Fűtés	Heating
Hűtés	Cooling
Melegvíz	DHW
Hűtőgép	Refrigerator
Fagyasztó	Freezer
Mosógép	Washing machine
Világítás	Lighting
Egyéb	Other

Natural gas and **biomass are the most common fuels in retail energy consumption. Consumption of both fuels will moderately increase up to 2030**, but it will not at any time exceed 5 % during the almost 15-year period. **In parallel with stagnating consumption of district heat, electricity consumption is also expected to significantly decline** as a result of new equipment with improved energy efficiency. With the significant increase in the penetration of household equipment, by 2040 electricity consumption will fall to one third of its level. Coal and oil consumption will almost completely disappear; their consumption will amount to only a few PJ even by 2030.

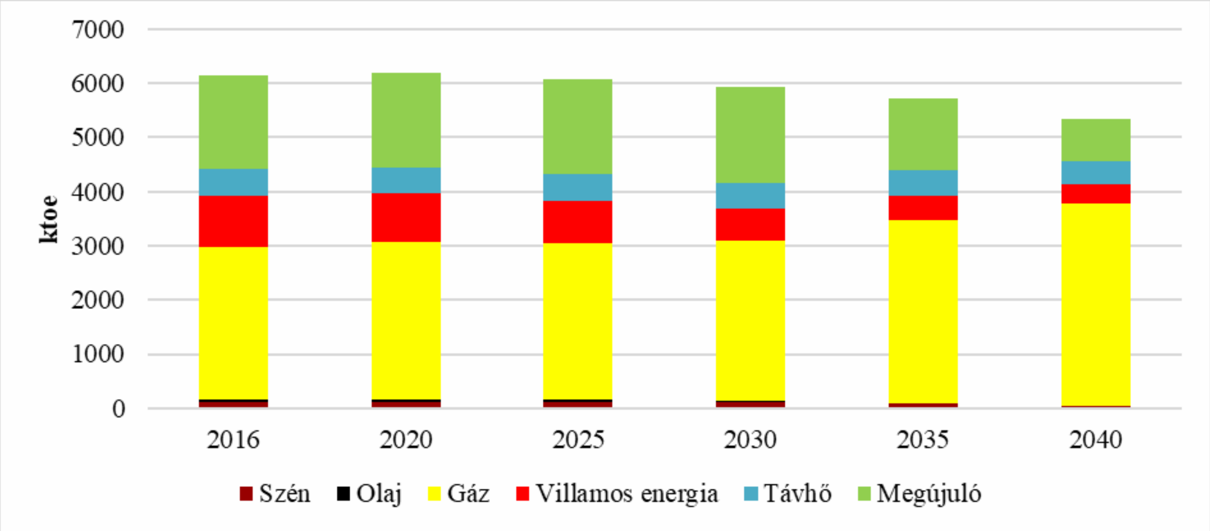

Figure 28 – Composition of retail energy consumption in the breakdown of fuels under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

Industry

Energy consumption in industry will significantly increase, reaching 6 170 ktoe in 2030.

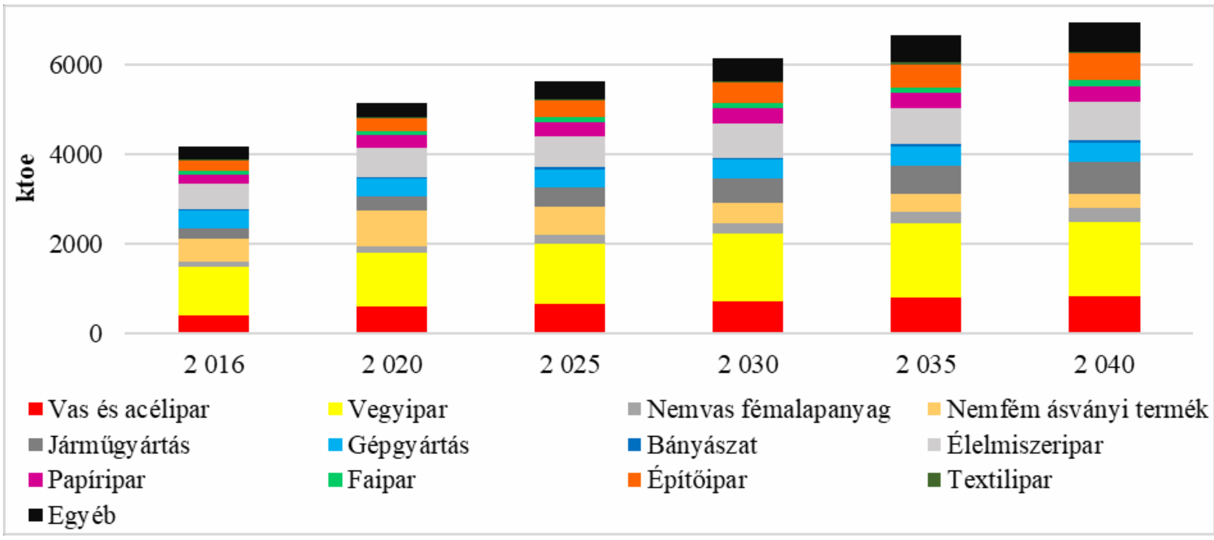

Figure 29 – Composition of industrial energy consumption in the breakdown of industrial subsectors under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Vas és acélipar	Iron and steel industry
Járműgyártás	Vehicle manufacturing
Papíripar	Paper industry
Egyéb	Other
Vegyipar	Chemical industry
Gépgyártás	Manufacture of machinery
Faipar	Wood industry
Nem vas fémalapanyag	Basic non-ferrous metals
Bányászat	Mining
Építőipar	Construction industry
Nem fém ásványi termék	Non-metallic mineral products
Élelmiszeripar	Food industry
Textilipar	Textile industry

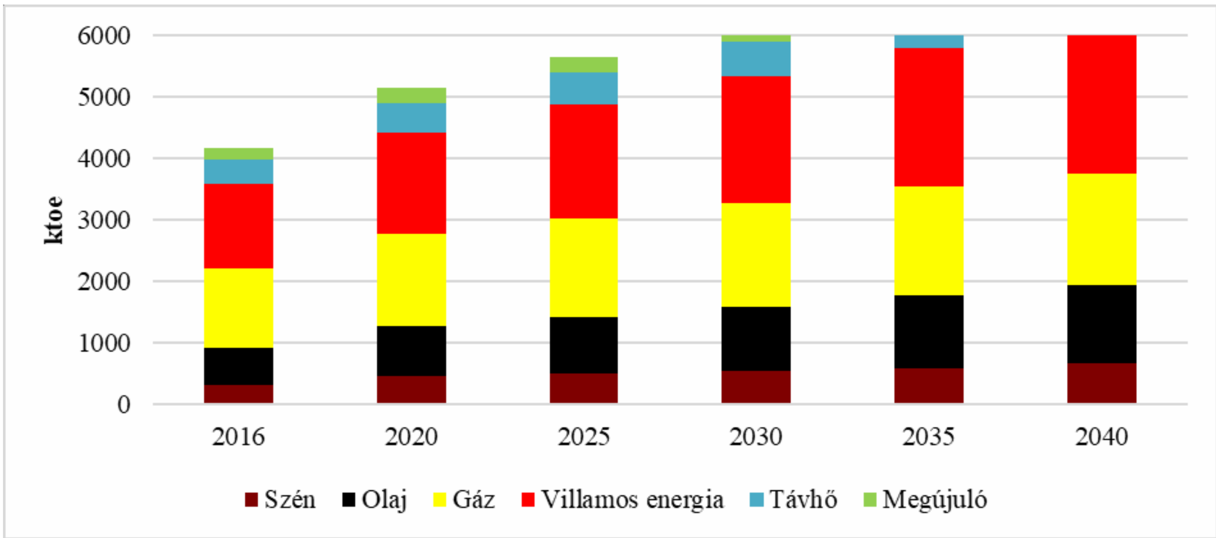

Figure 30 – Composition of energy consumption in the industrial sector in the breakdown of fuels under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	EN
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

Transport

The ratios observed in 2016 will also significantly change as early as 2030 under the WEM scenario. Firstly, **the energy consumption of cars will moderately decrease, followed by a stagnating trend.** In contrast, **the energy consumption of goods vehicles will significantly increase** in the next decades, particularly in the category of small and medium-sized vehicles. Although **rail and urban rail transport will significantly increase by 2030,** by around 30 %, **its share** within energy consumption for transport purposes **will only amount to 3.5 % in 2030.** The **energy consumption of buses** will significantly decline, which is attributable to the gradual phasing out of old, several decades' old buses from service and their replacement with modern vehicles with low consumption.

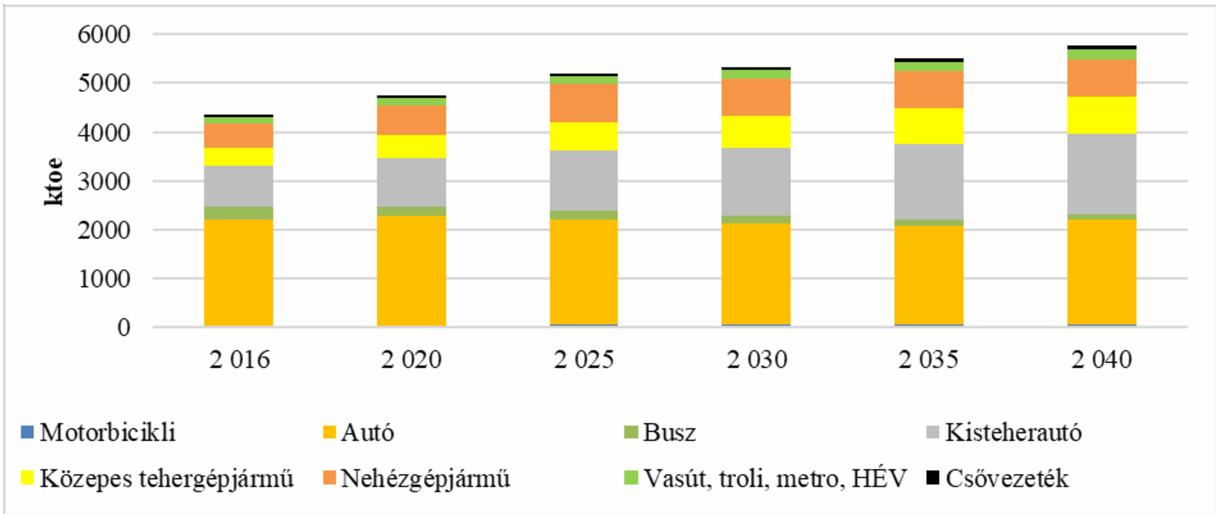

Figure 31 – Composition of energy consumption in the transport sector in the breakdown of main modes of transport under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	EN
Motorbicikli	Motorcycle
Közepes tehergépjármű	Medium goods vehicle
Autó	Car
Nehézgépjármű	Heavy goods vehicle
Busz	Bus
Vasút, troli, metro, HÉV	Rail, trolleybus, metro, suburban railway
Kisteherautó	Van
Csővezeték	Pipeline

In the transport sector the model forecasts a moderate increase in the use of oil, followed by a decline, then stagnation. In the longer term the increase is mainly caused by electricity and gas based energy consumption. While oil accounted for 92 % of total consumption in 2016, this figure will fall to 77 % in 2030.

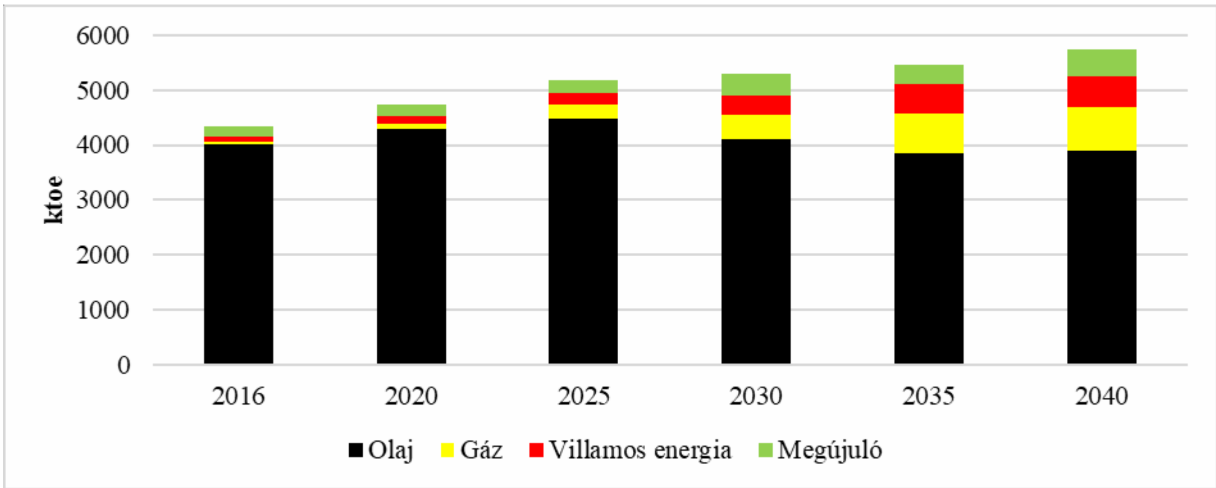

Figure 32 – Composition of energy consumption in the transport sector in the breakdown of used fuels under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	EN
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Megújuló	Renewables

Services sector

Under the WEM scenario, **energy consumption will increase** by 15 % **in the services sector.** Heating demand will rise at the highest rate, by around 39 % between 2016 and 2030, while the energy consumption of lighting and other equipment will increase overall by 22 % in the 2016–2030 period.

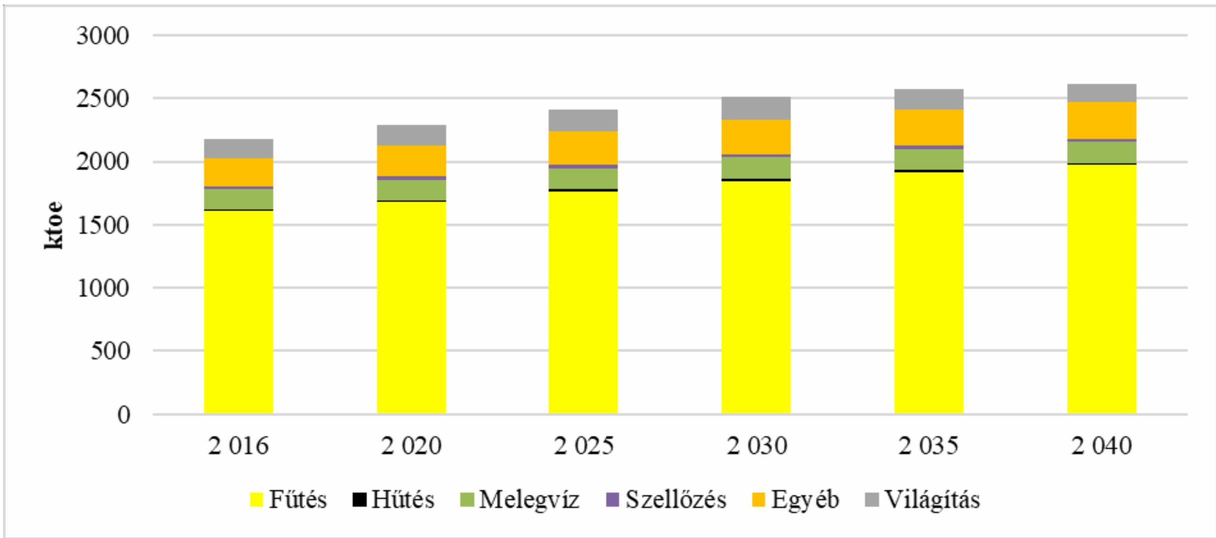

Figure 33 – Composition of energy consumption in the services sector in the breakdown of modes of use under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Fűtés	Heating
Hűtés	Cooling
Melegvíz	DHW
Szellőzés	Ventilation
Egyéb	Other
Világítás	Lighting

Final energy consumption in the **services sector** will increase by approximately 14 % between 2016 and 2030 under the WEM scenario.

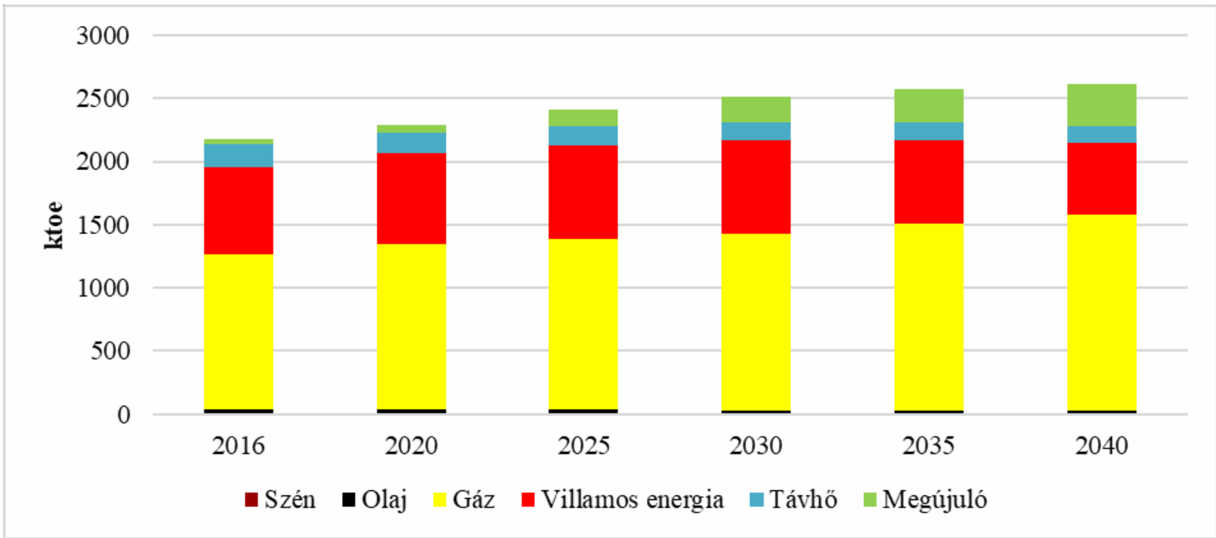

Figure 34 – Composition of fuels in the energy consumption of the services sector under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Olaj	Oil
Szén	Coal
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

The weight of renewables will sharply increase in the sector by 2030, from the current 46 ktoe value to 200 ktoe. **In addition to renewables, electricity consumption will also rise significantly** by 2030 due to the energy consumption of equipment and lighting. Natural gas consumption will increase by 13 %, while coal and oil consumption will decrease by around 17 % in the same period.

Agriculture, forestry and fishery

The energy consumption of the agriculture, forestry and fishery sector will significantly increase to 761 ktoe in 2030.

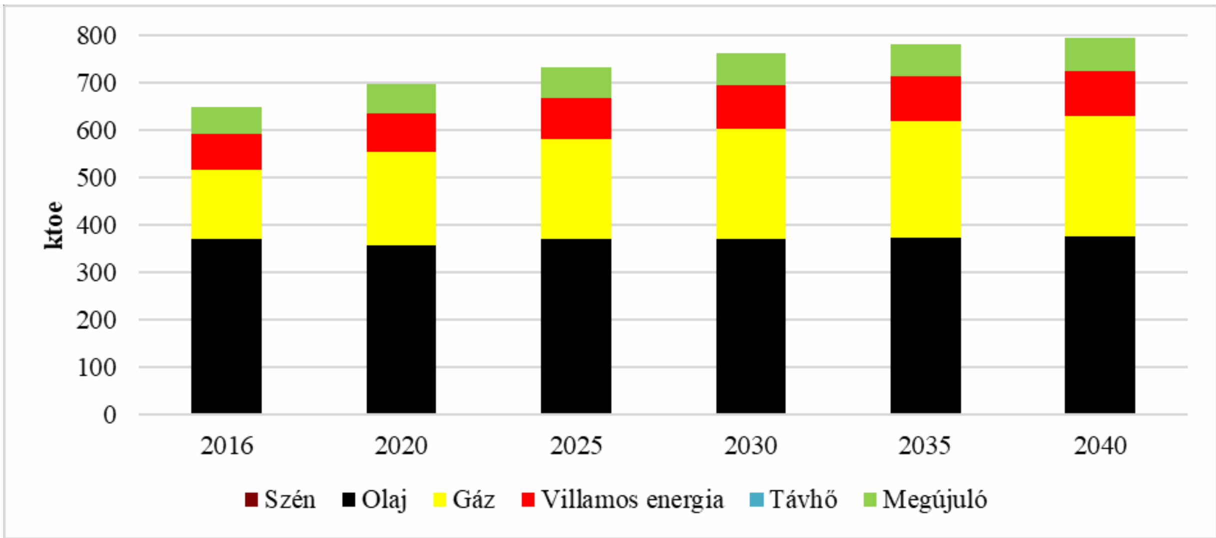

Figure 35 – Composition of fuels in the energy consumption of the agricultural sector under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Olaj	Oil
Szén	Coal
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

Primary energy consumption

Primary energy consumption will significantly increase at the end of the 2020s, mainly **as a result of higher transformation loss caused by the entry into service of the new Paks nuclear power plant units.** A falling, stagnating trend will follow after the decommissioning of the old units. A substantial increase is observed in relation to material consumption, rising from 1.8 Mtoe in 2016 to 2.7 Mtoe by 2030. We forecast a moderate increase in distribution losses caused by rising final customer demand.

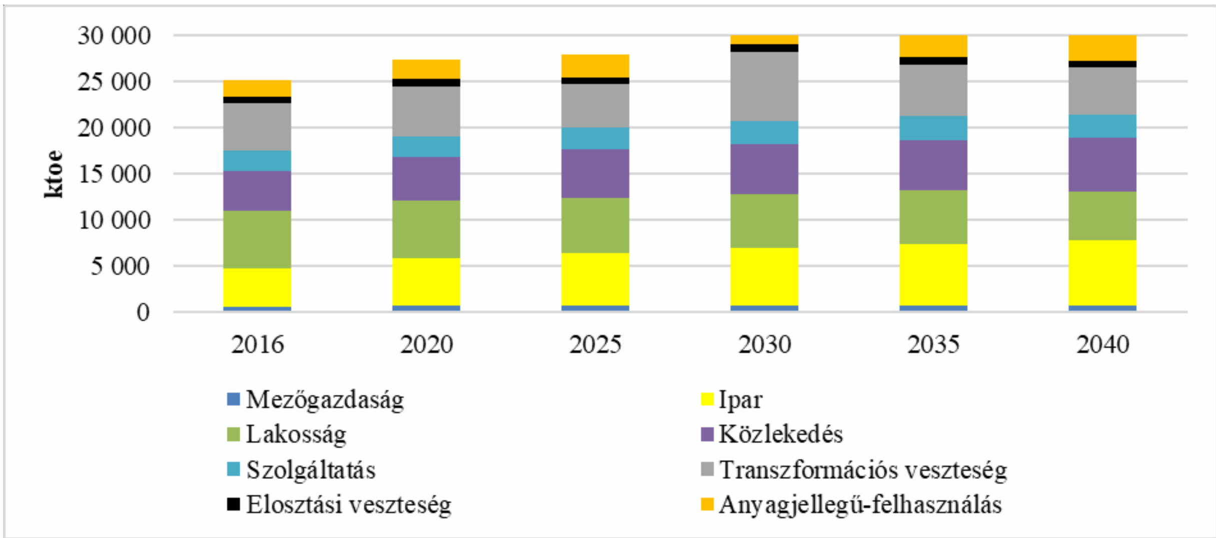

Figure 36 – Sectoral composition of primary energy consumption under the WEM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Mezőgazdaság	Agriculture
Lakosság	Retail
Szolgáltatás	Services
Elosztási veszteség	Distribution loss
Ipar	Industry
Közlekedés	Transport
Transzformációs veszteség	Transformation loss
Anyagjellegű-felhasználás	Material consumption

4.4. Dimension of energy security

i. Current energy mix, domestic energy resources, import dependency, including relevant risks

Domestic primary energy consumption

Based on fuel type, fossil fuels continue to dominate the **domestic primary energy mix. Hydrocarbons account for a dominant share**; in 2017, natural gas – Hungary's key source of energy – had a 32 % share (significantly less than the 45 % share held in 2003), while oil had a 28.5 % share in total Hungarian primary energy consumption. The **share of coal/lignite** (the Hungarian structure of coal use is primarily based on lignite), however, significantly declined from 21 % **to 8 %** – subject to minor fluctuations – with the phasing out of deep mining in Hungary between 1990 and 2017. In parallel with the above trends, **the role of renewable sources of energy is gaining relevance** in Hungary's energy consumption: the share of renewables doubled between 1990 and 2005, and between 2005 and 2017 (1990 = 2.6 %, 2001 = 5.9 %, 2017 = 11 %). **Beyond renewables, nuclear energy is the other major source of energy in the decarbonisation transition**, the share of which has been around 15 % for years. Imported electricity accounted for 4 % in 2017.

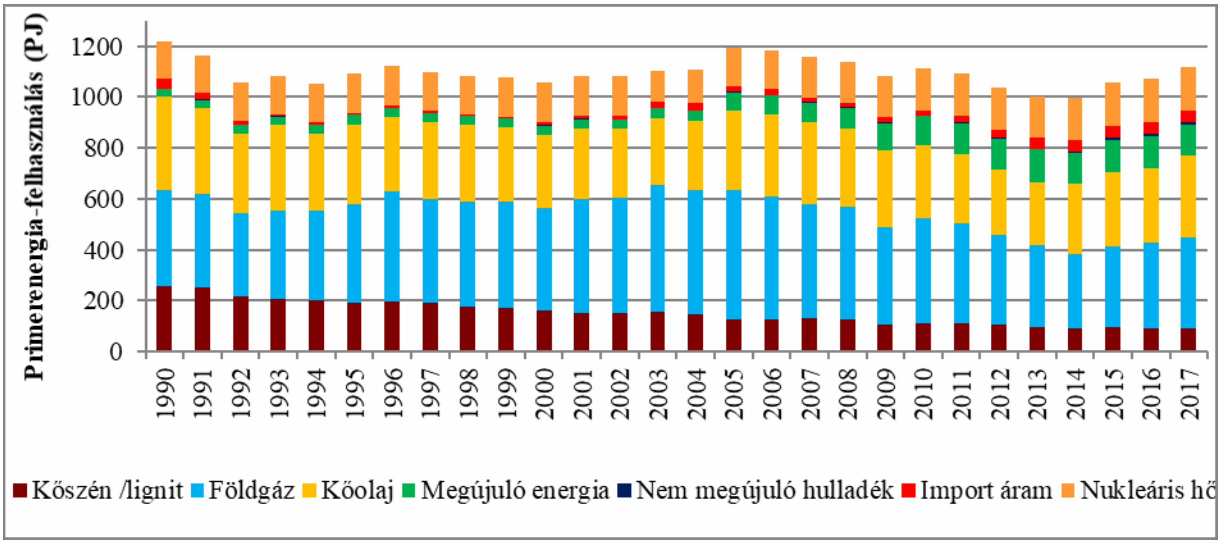

Figure 37 – Primary domestic energy consumption in Hungary

Source: Eurostat

HU	**EN**
Primerenergia-felhasználás (PJ)	Primary energy consumption (PJ)
Kőszén /lignit	Hard coal / lignite
Földgáz	Natural gas
Kőolaj	Oil
Megújuló energia	Renewable energy
Nem megújuló hulladék	Non-renewable waste
Import áram	Imported electricity
Nukleáris hő	Nuclear heat

Production of primary energy

The production of fossil fuels in Hungary is showing an overall declining trend.

Coal mining (black coal, brown coal, lignite) played a dominant role in Hungary's energy supply up to the 1960s, which was followed by a **sharp decline in the quantity of mined coal.** The downturn in coal mining was initially caused by a diminishing heavy industry. The effects of tightening pollutant emissions requirements became more pronounced later on. As a result of the above trends, in 2017 only 53.7 PJ of coal/lignite was produced in Hungary (satisfying roughly 60 % of domestic demand), which significantly falls short of the quantity of 176.8 PJ produced in 1990.

Hydrocarbon production peaked in the 1980s in Hungary; a decline also followed in this sector with fluctuations. In the recent period, however, the decline in Hungarian hydrocarbon production halted as a result of successful concession tenders, with even an increase measured in recent years. In 2017, 43.9 PJ (1.05 mtoe) of crude oil and 59 PJ (around 1.7 billion m^3) of natural gas was extracted in Hungary[147], amounting to a 7.6 PJ (0.18 mtoe) surplus in oil production and a 1.7 PJ (48 million m^3) surplus in natural gas production over the year 2015.

The increase in nuclear heat generation and particularly the rise in renewable energy production supports the climate-friendly transformation of the Hungarian energy system. In consideration of Hungary's geographical characteristics, energy production from biogenic sources (biomass from forestry and

[147] In 2018 Hungary's natural gas production approximated 2 billion m^3. Source: Mining and Geological Survey of Hungary

agriculture, biogas, agro-fuels), geothermal and thermal energy, and solar energy are the main sources of renewable energy in Hungary.

Owing to the above trends, the composition of Hungarian energy production significantly changed. The **share of lignite within energy production** equalled 29 % in 1990, but only 16 % in 2005; its current share **decreased to below 12 %. A similar trend characterised the share of hydrocarbons in recent years:** the share of natural gas in 1990 equalled 26 %, falling to 21 % in 2005 and to 13 % in 2017, while the share of crude oil decreased from 16 % (1990) to 13 % (2005), and eventually to 9 % (2017). The **share of energy production from nuclear and renewable sources, however, significantly increased:** their combined share reached 65 % in 2017 (36.7 % nuclear, 28.6 % renewable energy).

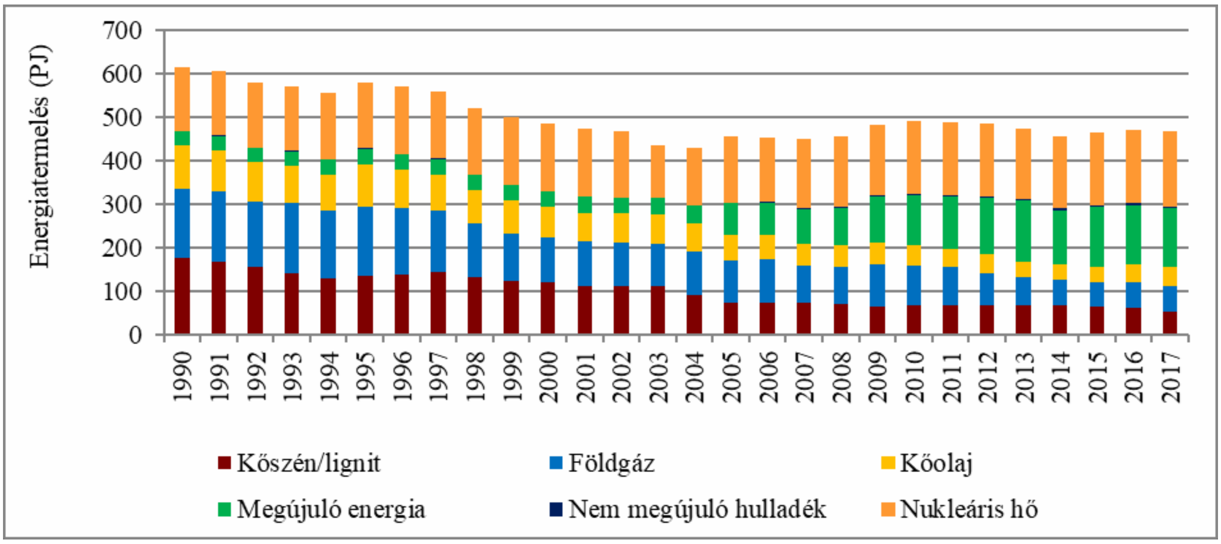

Figure 38 – Composition of Hungarian primary energy production between 1990 and 2017

Source: Eurostat

HU	**EN**
Energiatermelés (PJ)	Energy production (PJ)
Kőszén/lignit	Hard coal/lignite
Megújuló energia	Renewable energy
Földgáz	Natural gas
Nem megújuló hulladék	Non-renewable waste
Kőolaj	Oil
Nukleáris hő	Nuclear heat

Import dependency

Hungary is capable of independently satisfying only 40 % of its energy demand (37 % in 2017), therefore imports continue to account for a large share of Hungary's energy supply.

The composition of Hungary's primary energy consumption significantly increases risks inherent to the country’s energy security. **Dependence on foreign markets is highest in relation to the purchase of hydrocarbons, where import dependency exceeds 80 %.** Although the import dependency rate is higher for oil, the efficiently operating global and regional oil market, the availability of transmission alternatives (pipelines or rail/road), alternatives to pipeline supply (Friendship and Adria pipelines)[148] and the emergency oil stockpiling system guarantee efficient pricing and a high level of a security of supply on the Hungarian market. The security of supply is further strengthened by the dominant regional market position of MOL, which has a minority State shareholding. Risks underlying the security of supply are much higher in relation to natural gas, as most of natural gas is imported from Russian sources[149]. Although the high level of exposure

[148] In 2017, 80 % of imported oil (total imports: 9.8 million tonnes) was supplied from Russia, indicating a decline compared to a 95 % dependence on Russian imports in 2012. The recent reconstruction of the Adria pipeline enabled the reduction of dependence on Russian imports and use of new sources of oil supply for Hungary. Owing to the reconstruction of the section of the Druzhba I pipeline between Šahy and Százhalombatta, larger quantities of Russian oil are received through Slovakia.

[149] In recent years the largest share of natural gas imports – accounting for around two thirds of domestic consumption – is imported from Russia, but the remaining share on the Hungarian market is - on a molecular basis - also natural gas of Russian origin.

to natural gas imports is offset by flexibility[150] provided by Hungary's commercial and strategic gas storage facilities (for details see Chapter 4.5.3), high exposure to imports, dependence on a single supplier, and the central role of Ukrainian transits expose Hungary to price volatility on international markets and to risks inherent to the security of supply. Exposure can be mitigated with a diversified supply portfolio – including the full exploitation of Hungarian conventional and unconventional natural gas reserves and renewable resources, and maintained levels of nuclear capacities, in addition to diversifying import sources – and with energy efficiency measures.

The **electricity market is also characterised by growing import dependency (~30 %)**, with a 32-33 % annual rise in the share of net imports within final energy consumption since 1998, with fluctuations. **The high import requirement, however, does not cause short-term risks in the security of supply, as the high rate of net imports is accompanied by strong network interconnectivity;** the level of import capacities available from the 6 neighbouring countries equals around 50 % of total Hungarian installed power plant capacity, which is significantly higher than the 15 % target value set by the EU.

Hungary's lignite reserves and lignite mining are substantial relative to own consumption, nevertheless on average one third of Hungary's coal/lignite consumption is satisfied with imports.

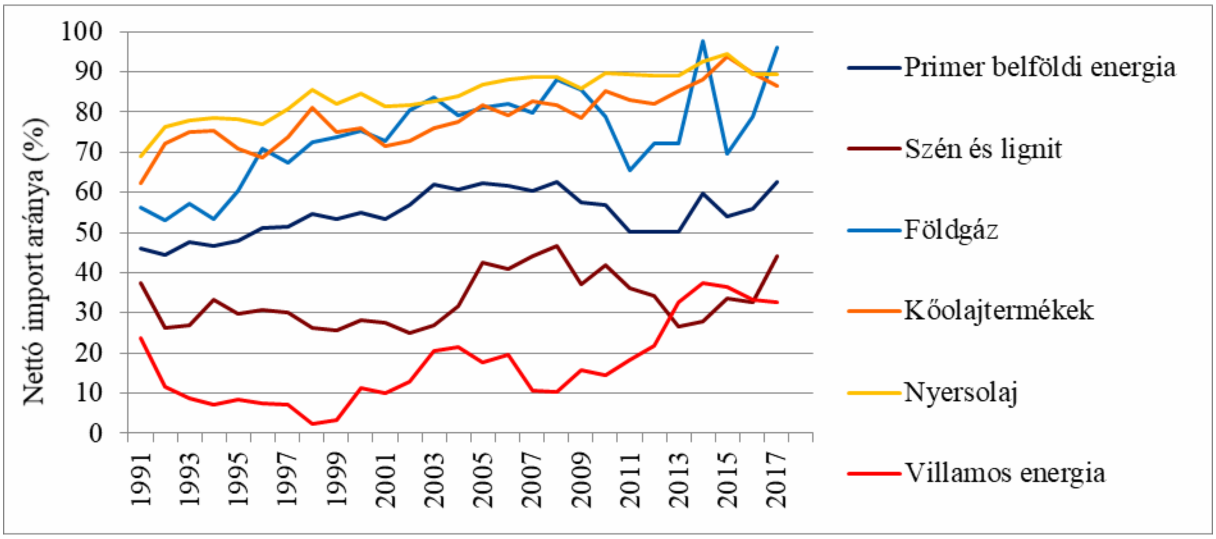

Figure 39 – Import dependency of Hungary between 1990 and 2017 (net import ratio, %)

Source: Eurostat

[150] The underground gas storage facilities play a key role in guaranteeing the security of natural gas supply and the satisfaction of winter peak demand (on a colder winter day, namely, roughly half of Hungary's natural gas is supplied from gas storage facilities).

HU	EN
Nettó import aránya (%)	Net import ratio (%)
Primer belföldi energia	Primary domestic energy
Szén és lignit	Coal and lignite
Földgáz	Natural gas
Kőolajtermékek	Petroleum products
Nyersolaj	Crude oil
Villamos energia	Electricity

Final energy consumption for energy purposes

Based on the current Eurostat methodology, between 1990 and 2017 Hungary's final energy consumption for energy purposes decreased – with fluctuations – from 793.9 PJ to 752.5 PJ (67 % of internal primary energy consumption). **Following the sharp decline caused by the regime change and the increase measured in the middle of the decade, energy consumption in the Hungarian economy declined from 2005. Recent years, however, are again revealing a rising trend:** between 2014 and 2017 final energy consumption increased each year from 662.7 PJ to 752.5 PJ. The consumption level in 2017 falls short of the level in 2005 by a small margin (760.5 PJ). The highest increase was observed in relation to oil (33.3 PJ / 0.8 Mtoe) and natural gas (30.7 PJ / 0.87 billion m^3) between 2014 and 2017, but electricity consumption also rose by 13.5 PJ (3.75 TWh). Hungary's consumption of thermal energy has also increased since 2014, from 38 PJ to 45.5 PJ.

The **composition of final energy consumption** – similarly to the composition of primary energy production – changed significantly during the past two decades. While Hungary covered 11 % of energy consumption with coal in 1990, **today the share of coal/lignite has diminished to a few per cent.** The downturn in coal consumption was accompanied by a significant rise in natural gas consumption. The share of natural gas within the energy mix was highest in 2004 (44.2 %); **by 2017 the share of gas within final energy consumption dropped to 32.5 %**, with moderate fluctuations. **The share of oil within the energy mix generally moved between 25 % and 30 %** during the relevant period, although this energy source had a share of around 29-30 % in final energy consumption in recent years (2014–2017). **The share of electricity increased from 14.3 % to 18.4 % between 1990 and 2017; during the same period the share of**

renewable energy consumption within final energy consumption rose from 3.7 % to 11.6 %[151]. (It peaked in 2013 with 14.9 %.) **In recent years Hungary's thermal energy consumption accounted for 5-6 % of final energy consumption.**

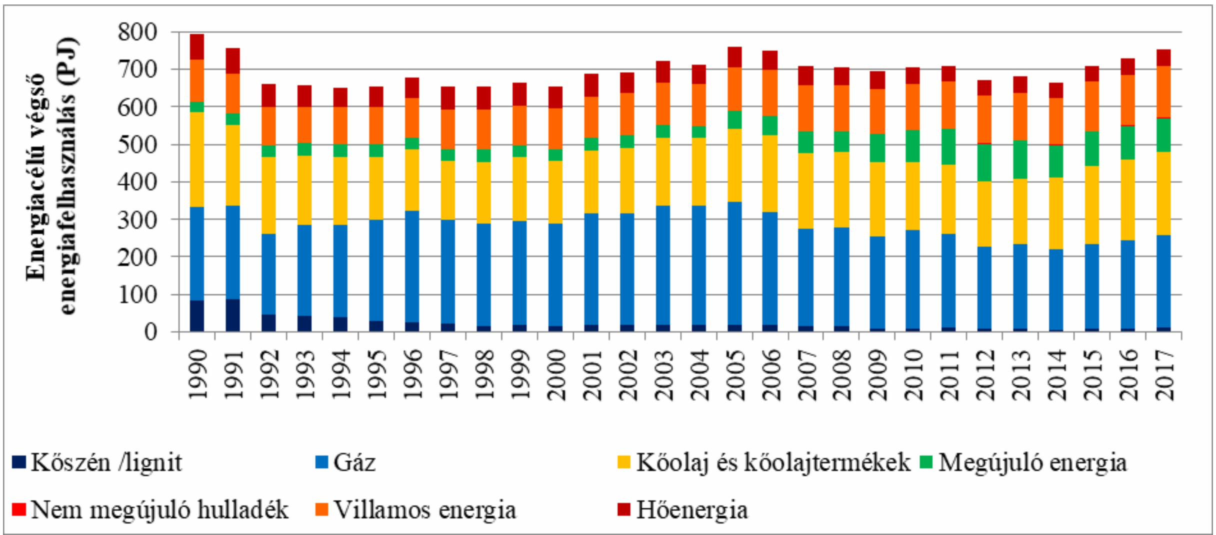

Figure 40 – Final energy consumption based on type of fuel

Source: Eurostat

HU	**EN**
Energiacélú végső energiafelhasználás (PJ)	Final energy consumption for energy purposes (PJ)
Kőszén/lignit	Hard coal/lignite
Nem megújuló hulladék	Non-renewable waste
Gáz	Gas
Villamos energia	Electricity
Kőolaj és kőolajtermékek	Oil and petroleum products
Hőenergia	Thermal energy

[151] Final energy consumption should not be confused with the share of renewable energy sources within gross final energy consumption, the latter being the official indicator for monitoring the 2020 target defined in Directive 2009/28/EC. According to the definition of Eurostat, gross final energy consumption is the total energy requirement and energy consumption of a country, which includes final energy consumption, power plant own consumption, network loss and 'statistical differences'. (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Gross_inland_energy_consumption)

Megújuló energia	Renewable energy

The household (retail), transport and industrial sectors account for the three largest shares within the energy consumption structure. Energy consumption in the household sector[152] accounts for the largest share of final energy consumption, equalling 35 % in 2017 within total final energy consumption for energy purposes (263.7 PJ), which is 3.3 percentage points less than in 2005 (38.4 %, 291.8 PJ). The transport sector is ranked second (a 25.2 % share in 2017), closely followed by the industrial sector (24.2 % in 2017). The services sector (including commercial activities) consumes one tenth of energy, while the combined share of the other sectors fell short of 4 % (3.6 %) in 2017.

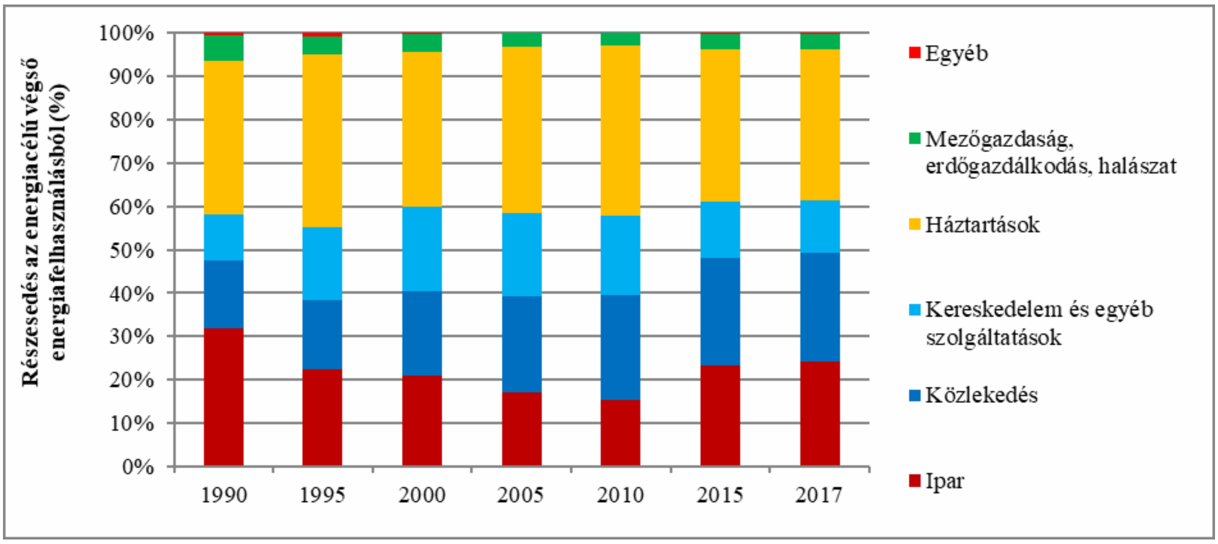

Figure 41 – Final energy consumption based on area of consumption

Source: Eurostat

HU	**EN**
Részesedés az energiacélú végső energiafelhasználásból (%)	Share within final energy consumption for energy purposes (%)
Egyéb	Other
Mezőgazdaság, erdőgazdálkodás, halászat	Agriculture, forestry and fishery
Háztartások	Households

[152] It does not include public transport, as such consumption of private consumers is considered in the transport sector.

Kereskedelem és egyéb szolgáltatások	Commerce and other services
Közlekedés	Transport
Ipar	Industry

In 2017 natural gas (47.3 %) accounted for the largest share of household energy consumption, followed by renewable sources of energy (26 %) – mainly solid biomass – and electricity (15.4 %). This ranking is continued with district heat (7.9 %), coal (2.3 %) and petroleum products (basically propane-butane gas – 1.2 %). Based on HEA data[153], **heating (74 % in 2017) accounts for three fourths of Hungarian household energy consumption.** DHW production is also a common source of energy consumption (12 %). Lighting and use of electronic devices account for 9.4 % of consumed energy. Cooking and cooling have a share of 4.5 %, with minimal consumption for cooling (0.1 %). The latter is expected to increase significantly.

Based on Eurostat data, **the share of oil within the transport sector remains high**; the share of oil and petroleum products within final energy consumption approximated 93 % in 2017 as well. In this ranking, oil is followed by renewable energy (3 %), electricity (2.3 %) and natural gas (1.5 %). **Gas** (34.3 %, consisting of 31.3 % natural gas and 2.9 % gas works gas) and **electricity** (33.1 %) **are dominant in industrial energy consumption.** Composition of final energy consumption in 2017: oil (15.3 %), district heat (8.3 %), renewable sources of energy (4.1 %), coal (3.2 %) and non-renewable waste (1.7 %). **Natural gas is dominant in the services sector** (54.3 %), but the share of electricity (33.2 %) and district heat (8.3 %) is also considerable. In 2017 renewables accounted for only 2.5 %, and the combined share of oil and non-renewable waste was below 2 %.

ii. Projections of development with existing policies and measures at least until 2040 (including for the year 2030)

Primary domestic energy consumption is expected to exceed 30 Mtoe in 2030 (1 284 PJ). This is a 15 % increase compared to 2017. Much of the increase may be attributable to the generation of the new nuclear power plant units that will replace the substantial electricity imports in 2017; as a result, transformation (repowering) loss must be settled in Hungary. Hungary is expecting a declining trend, however, between 2030 and 2040. Primary energy consumption is expected to be around 23.4 Mtoe (1 189 PJ) in 2040. (Point iii. of Chapter 4.3 and Annex 3 provide detailed results of forecasting primary energy consumption, including the sectoral breakdown.)

Final energy consumption – based on the new European methodology – **will not exceed 785 PJ in 2030.**

[153] http://mekh.hu/download/5/13/90000/8_1_Haztartasok_felhasznalasa_eves.xlsx

(Point iii. of Chapter 4.3 and Annex 3 also summarise detailed results of forecasting final energy consumption.)

With a ten-year outlook, the Hungarian economy's import dependency is expected to decline. By guaranteeing the predictability of the concession scheme and enhancing the flexibility of the system Hungary can achieve a rise in domestic hydrocarbon production. In an optimal scenario, in 2030 we can expect domestic conventional natural gas production and unconventional production to reach 2.4 billion m^3 and around 35 million m^3, respectively. A sharp upturn in unconventional natural gas production is expected after 2030; production output may reach 270 million m^3 by 2040.

The **Hungarian electricity sector will undergo substantial transformation during the projected period.** Upon analysis of the medium and long-term changes in power plant installed capacities and their forecasts, **the analysis of MAVIR Zrt. established that the fate of existing Hungarian power plants, their expected shutdown and decommissioning will be determined by shareholder decisions in due time and manner, after appropriate analysis of the electricity market.** The new power plants are needed in the next two decades mainly to replace the shut down units and only to a lesser extent on grounds of growing electricity demand. The nominal gross electric capacity of all Hungarian power plants operating today is expected to significantly decrease by 2033. According to the analysis, current capacity of around 8 600 MW will decrease to around 6 800 MW in five years, with approximately 4 500 MW remaining by 2033, the end of the reviewed period. The analysis of MAVIR Zrt. entitled 'Medium and long-term entry capacity increases of the Hungarian electricity system' summarises results of analyses performed in connection with the forecasts.

New capacities, however, will also be connected to the system. As a result of engaging the new power plant unit capacities of 2 400 MW in production and integrated renewable and other capacities, production may increase from 35 GWh to 57 GWh between 2020 and 2030, and Hungary may become self-sufficient. Import dependency is expected in the longer term (due to the disconnection of the Paks 1 units from the system).

4.5. Dimension of the internal energy market

4.5.1. Electricity interconnectivity

i. Current interconnection level and main interconnectors[154]

With the exception of Slovenia, the Hungarian electricity system is directly connected to all neighbouring countries. (See map showing the transmission network in Chapter 4.5.2.) Cross-border capacities are now available from 6 countries in a volume (NTC) corresponding to 85 % of annual consumption between 2015 and 2018, and to 62 % of maximum hourly consumption.

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[154] With reference to overviews of the existing transmission infrastructure by the TSOs.

The capacity of high-voltage cross-border lines amount to approximately 50 % of the national gross installed capacity, significantly exceeding the 15 % EU target.

The map in Chapter 4.5.2 shows voltage levels of interconnectors. The tables below summarise annual physical flows.

Interconnector	Annual flows, GWh		
	Imports	Exports	**Balance**
Ukraine	5 054.49	4.86	5 049.62
Slovakia	6 812.94	60.03	6 752.91
Romania	1 041.55	587.90	453.65
Serbia	1 226.29	271.17	955.12
Croatia	724.59	2 750.38	-2 025.79
Austria	3 753.41	590.73	3 162.68
Total	**18 613.26**	**4 265.07**	**14 348.19**

Table 29 - Annual physical flows, 2018

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

The currently available transfer capacities also enable flexibly diversifiable commercial transactions.

ii. Projections of interconnector expansion requirements (including for the year 2030)[155]

Although Hungary significantly surpasses the EU interconnectivity target, expansion of interconnectivity is justified, as limited cross-border capacities from Austria and Slovakia limit cheaper electricity imports. (Positive and negative spreads alternate at other border points.) Due to limited capacities, the Hungarian annual average wholesale electricity price (day-ahead markets, hourly averages) has for years been higher than in neighbouring countries. Based on a broad comparison in Hungary's region, Hungarian wholesale prices are relatively high (Chapter 4.5.3).

Construction of the Slovenian-Hungarian electricity interconnector is planned in the next years within the framework of PCIs.[156] (See details in point i. of Chapter 2.4.2.) After construction of the Slovakian and Slovenian high-voltage transmission lines, the total capacity of cross-border high-voltage lines will reach 64 % of national gross installed capacities.

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[155] With reference to national network development plans and regional investment plans of TSOs.

[156] The line is expected to be entered into service at the end of 2021.

Point i. of Chapter 2.4.2 and the network development plan of the electricity system ('Network Development Plan of the Hungarian Electricity System – 2017' (MAVIR Zrt.)) provide information on additional planned international interconnection projects.

Beyond the scope of the analyses performed within the framework of the Ten-year Network Development Plan referred to in point 2.4.1 ('Electricity interconnectivity'), in its network development plan of the Hungarian electricity system MAVIR Zrt. is not planning an additional expansion of cross-border capacities.

Based on the capacity calculations, with the development projects proposed in the ten-year network development plan, the international interconnections and transfer capacities of the Hungarian electricity system - in conformity with ENTSO-E requirements - allow the conducting of sufficient, secure and flexibly diversifiable commercial transactions, and do not limit electricity trade of a rational volume or the operation of the single electricity market.

It is important to note that the Hungarian system operator, MAVIR Zrt., is working on integrating the 70 % minimum capacity referred to in Article 16(8) of Regulation (EU) 943/2019 on the internal market for electricity ('Regulation'), adopted as part of the Clean Energy Package, in the network development plan as a network development planning criterion. Based on the foregoing, other investments may also become necessary in the future; these will probably mainly be internal development projects.

4.5.2. Energy transmission infrastructure

i. Key characteristics of the existing transmission infrastructure for electricity and gas[157]

Electricity market

The map and table below present the Hungarian electricity transmission network.

[157] With reference to overviews of the existing transmission infrastructure by TSOs.

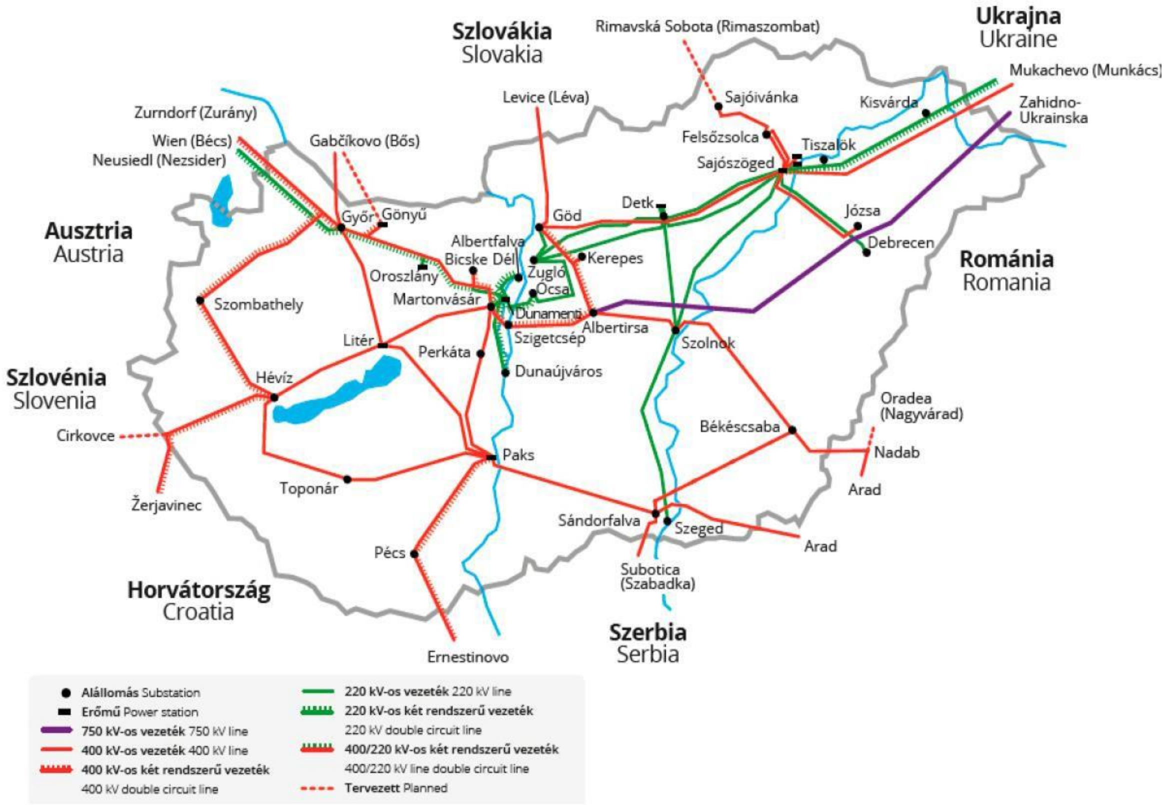

Figure 42 – The Hungarian electricity transmission network on 31 December 2017

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

The table below contains data on the route length of the transmission network.

	2014	2015	2016	2017	2018
	km	km	km	km	km
Total high-voltage overhead lines and cables	**3 810**	**3 810**	**3 811**	**3 813**	**3 813**
Total high-voltage overhead lines	3 793	3 793	3 794	3 797	3 797
of which:	268	268	268	268	268
750 kV overhead lines	2 284	2 284	2 284	2 287	2 287
400 kV overhead lines	1 099	1 099	1 099	1 099	1 099
220 kV overhead lines	142	142	142	142	142
132 kV overhead lines	17	17	17	17	17
Total high-voltage cables (132 kV)					

	3 810	**3 810**	**3 811**	**3 813**	**3 813**

Table 30 – Route length of transmission networks

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

Additional details are provided in the publication entitled 'Data on the Hungarian electricity system (ES), 2018' prepared by MAVIR Zrt. and in the related statistical tables.[158]

Reliability of the electricity system is primarily ensured through requirements/standards applicable to transmission networks and to their system operators. The enforcement of the **N-1 principle**[159] is the key requirement concerning the security of the transmission system, which means that the electricity system must be able to operate without interruption upon the contingency of a critical network element or a large power plant. **Hungary is fully meeting the N-1 requirement.**

ENTSO-E applies the so-called **remaining capacity indicator** to measure the operational security of electricity systems. Remaining capacity corresponds to actually available capacity, less peak load and upstream system operator reserves. The required rate of remaining capacity varies for countries, typically between 5 % and 10 % of installed capacity. Based on the capacity of the largest domestic units, in Hungary the system operator takes into account gross 500 MW, corresponding to more than 5 % of installed capacity calculated on 1 January 2018. Originally only domestic generating capacities are considered for calculating remaining capacity. Thus, at certain times of the year Hungary would not only fall short of the required rate, but would even produce a negative capacity. Remaining capacity adjusted with the **necessary export-import balance value**, calculated in the manner referred to above, is in this case, by definition, **sufficient even with the highest expected consumer demand**.

It may therefore be established that the draft of the power balance of the Hungarian electricity system – serving satisfaction of consumer demand – assuming higher consumer demand between February and December 2018 was met through the supply of 1 400–3 400 MW in imports. The cross-border power line capacities necessary for imports were available. The periodically inadequate technical parameters of necessary reserves pose a risk in case of further high amounts of imports expected in the future.[160]

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[158] http://mekh.hu/a-magyar-villamosenergia-rendszer-ver-2017-evi-adatai

[159] Pursuant to the Network Code of MAVIR, by application of the N-1 principle, '[the] design of the electricity system prevents both interruptions at customers during the single unavailability of the transmission network [upon failure of a system constituent], and the occurrence of overloading, voltage or frequency disturbances in the remaining operational network'.

[160] Annual gross capacity plan of Mavir Zrt. – 2019.
(http://mavir.hu/documents/10258/229076503/%C3 %89ves+kapacit%C3%A1sterv_2019_janu%C3%A1r_EL%C5%90ZET ES.pdf/a8c26566-bc20-8073-8d4a-ef747f0a9ee1)

Natural gas market

Hungary's natural gas distribution network is 84 000 km long, has substantial capacity and is in good condition. The system would be able to satisfy consumption significantly in excess of current demand.

Hungary's interconnectivity with neighbouring markets is satisfactory. In theory it is possible to physically transfer more than 34 million m^3 of natural gas daily from Hungary to its five neighbouring countries, while more than 82 million m^3 of natural gas daily could be physically transferred from three neighbouring countries to Hungary.

The tables below summarise capacity data and the daily peak entry capacity data of the Hungarian natural gas transmission system.

Capacity data	**Annual non-interruptible capacity (billion m^3)**	**Daily non-interruptible 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 capacity (million m^3)**
Entry points						
Entry point of Ukrainian/Hungarian interconnecting pipeline (Beregdaróc)	17.5	48.0	8.5	23.3	71.3	15.0
Entry point of Austrian/Hungarian interconnecting pipeline (Mosonmagyaróvár)	5.3	14.4			14.4	
Entry point of Hungarian/Romanian interconnecting pipeline (Csanádpalota)	0.1	0.2	1.7	4.6	4.8	4.6
Entry point of Hungarian/Croatian interconnecting pipeline (Drávaszerdahely)	0.0	0.0	7.0	19.2	19.2	19.2
Entry point of Hungarian/Slovakian interconnecting pipeline (Balassagyarmat)	4.4	12.0			12.0	
Domestic net production	1.7	5.3			5.3	0.0
Commercial underground storage facilities	5.1	53.1		6.5	59.6	6.5
Strategic underground storage facility	1.2**	20.0			20.0	0.0

Total entry points, not incl. strategic storage facilities	34.1	133.0	17.2	53.6	186.6	45.3
Exit points						
Exit point of Hungarian/Serbian interconnecting pipeline (Kiskundorozsma)	4.8	13.2			13.2	0.0
Exit point of Hungarian/Romanian interconnecting pipeline (Csanádpalota)	1.7	4.8			4.8	0.0
Exit point of Hungarian/Ukrainian interconnecting pipeline (Beregdaróc)	0.0	0.0	6,1	16.8	16.8	16.8
Exit point of Hungarian/Croatian interconnecting pipeline (Drávaszerdahely)	2.6	7.2	4.4	12.0	19.2	12.0
Exit point of Hungarian/Slovakian interconnecting pipeline (Balassagyarmat)		4.8	1.8		4.8	4.8
Gas transfer stations	79.9	218.9	2.9	7.9	232.0	7.9
Total exit points	89.0	244.1	15.2	12.6	290.8	41.5

** The exit points do not include blending circle exits, and storage facility and cross-border exit points.*
*** In 2019 the volume of strategic natural gas storage increased to 1.45 billion m^3.*

Table 31 – Capacity data of the natural gas transmission system, 2018

Source: FGSZ (2019): Data on the Hungarian natural gas system, 2018.

total (at 15 °C and in Nm^3)	**186.6**
- Of which: interruptible	53.6
Import	121.7
- Of which: interruptible	47.1
Transit	11.3
Commercial storage	59.6
- Of which: interruptible	6.5
Strategic storage	20.0
Production	5.3

Table 32 – Total daily entry point peak capacity of the natural gas transmission system, 2018

Pursuant to 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, the TSOs must operate permanent physical capacity allowing reverse flows of gas on all interconnections between Member States.

Hungary operates interconnector points with a reverse flow capacity with Romania, Croatia and Slovakia, among Member States.

Hungary is granted exemption for an indefinite period in relation to the Hungarian-Austrian cross-border point.[161]

In relation to the security of supply, the cited regulation also makes reference to the N-1 principle (see explanation in point i. of Chapter 2.3). The results of the calculation are summarised in the table[162] below:

EPm1	**Entry at the Austrian-Hungarian border (Mosonmagyaróvár)**	**Mm^3/day**	14.4
EPm2	**Entry at the Ukrainian/Hungarian border (Beregdaróc)**	**Mm^3/day**	56.3
Epm3	**Entry at the Slovakian/Hungarian border (Balassagyarmat)**	**Mm^3/day**	12
EPm4	**Entry at the Romanian/Hungarian border (Csanádpalota)**	**Mm^3/day**	0.2
EPm5	**Croatian/Hungarian cross-border capacity (Drávaszerdahely)**	**Mm^3/day**	0
EPm6	**Other (unscheduled entry)**	**Mm^3/day**	0
EPm summa	**Total supply capacity**	**Mm^3/day**	82.9
Pm	**Maximum technical production capacity**	**Mm^3/day**	5.5
Sm	**Maximum technical withdrawal capacity (100 %)**	**Mm^3/day**	78.6
LNGm	**Maximum technical LNG facility capacity**	**Mm^3/day**	0

[161] https://ec.europa.eu/energy/sites/ener/files/table_reverse_flows_-for_publication.pdf

[162] Key details of the calculations:

- Im: largest element of the Hungarian gas infrastructure, i.e. the Ukrainian/Hungarian cross-border entry point (Beregdaróc), the disruption of which was considered in the calculation

- Dmax: the calculation of total daily gas demand occurring once every 20 years, based on statistical probability applied to the calculation, was based on two evaluations:

- As a first step, the correlation between Hungarian natural gas consumption and temperature was analysed by linear regression, based on data relating to the gas years 2011/2012–2017/2018. (We did not analyse previous years because these represented a significantly different natural gas consumption structure compared to the current one due to changes in market structure, consumption habits and objectives.)
- As a second step, consumption data relating to extremely cold days were estimated with the generalised extreme value distribution (GEV) methodology.

Im	**Maximum entry capacity (EPm2-Beregdaróc)**	**Mm^3/day**	56.3
Dmax	**Total daily gas demand (1/20)**	**Mm^3/day**	77.4
N-1			1.43
N-1 (%)			143 %

Table 33 – Results of N-1 calculations for Hungary (2018)

Source: HEA

Based on the performed calculation, the N-1 value of Hungary is 143 %, thus it meets the Union requirements prescribed by Regulation (EU) No 994/2010 ('SoS Regulation') in relation to infrastructure requirements.

ii. Projections of network expansion requirements at least until 2040 (including for the year 2030)[163]

The projection up to 2040 carries a number of uncertainties, therefore it is not possible to specifically and reliably define the network expansion requirements. Chapter 2.4.2 discusses electricity and natural gas projects planned by the system operators (MAVIR, FGSZ) during the next ten years. The document 'Network Development Plan of the Hungarian Electricity System, 2017' prepared by MAVIR Zrt. provides details on the additional development of the electricity network.[164]

4.5.3. Electricity and gas markets, energy prices

i. Current situation of electricity and gas markets, including energy prices

The energy sector is changing at an accelerating pace, posing growing challenges for both regulators and market participants. **Owing to the spread of innovative technological solutions, the traditional, linear supply system will be replaced with a complex system difficult to centrally regulate, which accordingly requires substantial flexibility.** The table below summarises trends with a major impact on main energy market trends.

Trends	**Characteristics**
	Based on international energy market forecasts, the next two decades will be characterised by electrification; the share of electricity within total energy consumption will increase, with a rise in electricity demand among the energy sources, which, however, will lead to the consumption of more climate-friendly electricity

[163] With reference to national network development plans and regional investment plans of TSOs.

[164] https://www.mavir.hu/documents/10258/15454/HFT_2017.pdf/8826edb7-d17a-463e-8983-29b616337f76

Electrification	(nuclear power and electricity produced from renewable energy sources). As the underlying cause, as a result of tightening climate policy measures and technological development, the consumption of electricity produced by more climate-friendly means will replace a growing share of energy consumption for transport and heating purposes through the spread of electromobility and the use of heat pumps, for example. The electrification of industrial processes – posing a more complex technological challenge – will also produce a substantial effect.
Sector coupling	The convergence of energy systems (sector coupling) will intensify, involving the interconnection of the production processes of various forms of energy (electricity and heat, and fuels). The gas and electricity markets are already interconnected at a number of points. In the near future, however, sector coupling may also extend to new areas, such as the replacement of gas based heating and cooling with electricity based on renewable energy sources and heat pumps in regions with infrastructures with a low utilisation rate or which are not connected to the gas network. The convergence of energy systems is also supported by the development of energy storage technologies (e.g. battery, heat storage, power-to-gas technologies).
Decarbonisation	The structure of electricity generation will also change; electricity generation from fossil fuels will gradually diminish, to be replaced with renewable forms of energy production with low GHG emission intensity. As a major challenge associated with the decarbonisation trend, however, weather-dependent renewables offer significantly variable capacities both an intraday and seasonal basis. For the above reason, more and more types of flexibility solutions will be needed in the future.
Decentralisation	Supply based on the growing weight of renewable energy necessitates a completely different network structure. Large power plants will be replaced and/or supplemented with many smaller, decentralised production units that are commonly connected not to high-voltage networks, but to either distribution networks or operate as independent islands. The transformation not only affects the infrastructure, but classic consumer and producer roles will also change. Prosumers already exist, which not only consume but also operate as decentralised producers.
Digitalisation	The capacity of the electricity grid is limited, therefore electricity supply must operate in complete harmony in real time with the demand of millions of consumers. Although the broad application of digital technologies is a major challenge, it also offers enormous opportunities for facilitating the interconnection of energy systems and energy market participants, including producers, network operators and consumers, and to enhance the intelligence, efficiency, reliability and sustainability of networks. In digitised energy systems, communication is faster between production, demand, storage and the network. It is easier to determine who needs energy where and at what time. The digitalisation of the systems can improve the efficiency of energy production, the transfer and distribution of energy, and also offers more opportunities and choices to consumers in determining their energy consumption. In the digital world of the 21st century a growing number of energy consumers expect accessible options – e.g. mobile applications, online administration – for administering their day-to-day affairs as fast and as efficiently as possible, reducing the time needed or without the need for personal administration to enable them to meet their needs with as little personal contact as possible.

Table 34 – Main trends of the energy transition

Electricity market

A diversified national production portfolio and market integration are the two basic pillars of the current high level of the security of supply in the Hungarian electricity system.

Installed capacities in the Hungarian electricity system, system peak load

The gross installed capacity of power plants equalled 8 878.5 MW on 31 December 2018. Available capacity amounted to 7 415.9 MW. The table below provides details on installed and available capacities in 2018.

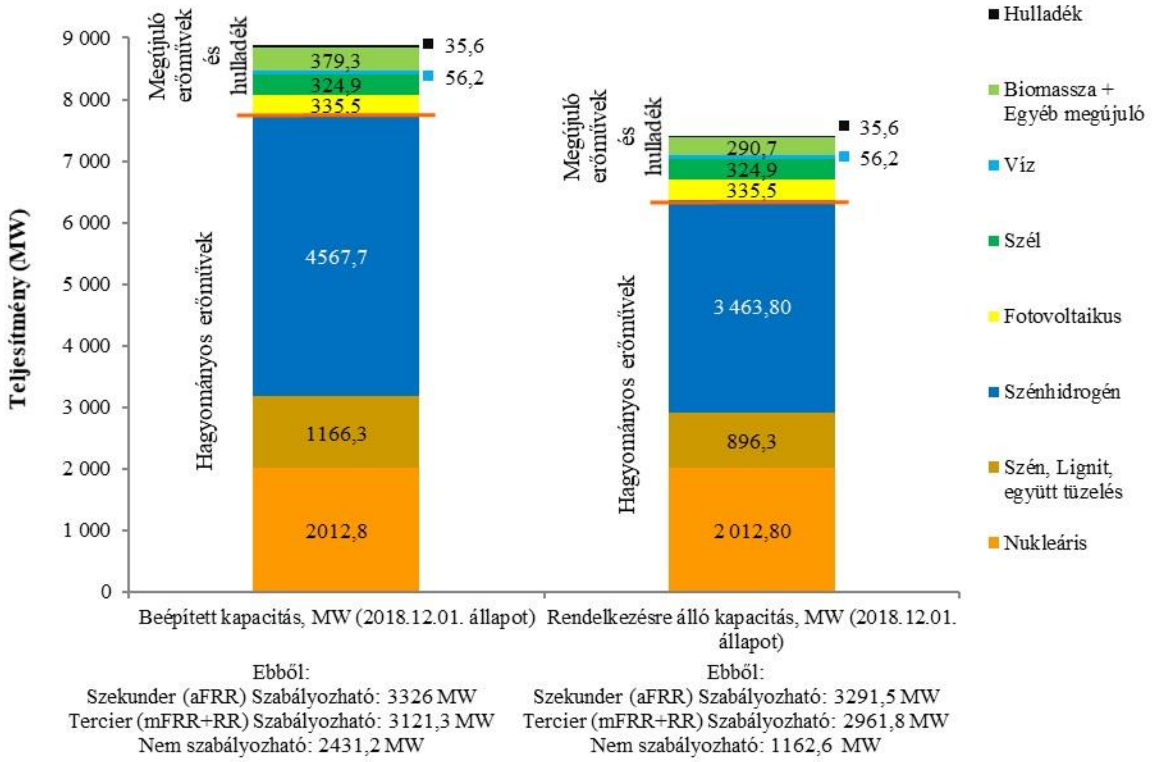


Figure 43 – Distribution of the installed capacity of all Hungarian power plants based on primary sources

Source of data: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

HU	**EN**
Teljesítmény (MW)	Capacity (MW)
Megújuló erőművek és hulladák	Renewable power plants and waste
Hagyományos erőművek	Conventional power plants
Beépített kapaciáts, MW (2018.12.01. állapot)	Installed capacity, MW (as at 01.12.2018)

Rendelkezésre álló kapaciáts, MW	Available capacity, MW
Ebből:	Of which:
Szekunder (aFRR) Szabályozható:	aFRR dispatchable:
Tercier (mFRR+RR)	mFRR+RR
Nem szabályozható:	Not dispatchable:
Hulladék	Waste
Biomassza + Egyéb megújuló	Biomass + Other renewables
Víz	Water
Szél	Wind
Fotovoltaikus	PV
Szénhidrogén	Hydrocarbon
Szén, Lignit, együtt tüzelés	Coal, lignite, co-firing
Nukleáris	Nuclear

We examined market concentration based on the 2018 data[165] of MAVIR Zrt. The largest participant on the Hungarian electricity market, the MVM Group, owes its dominant role mainly to the Paks Nuclear Power Plant. Its production portfolio includes other power plants; in 2018 this group accounted for more than one third (~37 %) of the base of Hungarian electricity generation, based on available capacity. Together with the other two largest market participants (Mátrai Erőmű Zrt., Dunamenti Erőmű Zrt.), the MVM Group owned ~60 % of installed capacity in 2018. The share of the four largest market participants (the above three + Uniper Hungary Kft. / Gönyű power plant) equalled around 66 %. If we consider the companies of the MVM Group separately, the ranking of the three largest market participants is as follows: Paksi Atomerőmű Zrt., Mátrai Erőmű Zrt., Dunamenti Erőmű Zrt. These jointly owned one half of available capacities in 2018. The share of Uniper Hungary Kft. – holding the fourth largest amount of available capacity – was also high in comparison to the other companies, thus the share held by the four largest market participants exceed 55 % in the relevant year.

In 2018 the Paks Nuclear Power Plant operated with the best utilisation rate (91.9 %). The Mátra Power Plant

[165] MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

and Gönyű Power Plant had a utilisation rate of 64.2 % and 61.7 %, respectively. In 2018, the daily fifteen-minute peak of the annual and also winter gross system load was on 19 December. Its measured value equalled 6 869 MW at -6.8 °C average daily temperature. The summer daily peak load on 21 June equalled a registered value of 6 358 MW, with a 26 °C average daily temperature.[166]

Production, consumption, import dependency

In the electricity supply of Hungary, base-load production is ensured by nuclear and lignite capacities. The gas-fired power plants capable of flexible operation play a key role in coordinating temporary fluctuations in demand and supply, and on the balancing market.

Coal-fired production and gas-fired production in Hungary sharply declined in the 2000s and 2010s, respectively. This process was generally attributable to obsolete technology, high natural gas prices and the ‘exclusive’ effect of renewable energy production with low variable costs, as the production of temporarily or permanently shut down power plants was not competitive or – with a low utilisation rate – sustainable on the electricity market. The Hungarian supply structure, however, is not common in Europe. **Imports play a key role in the capacity mix (~30 %). In Hungary there is essentially a structural demand for imports; during most of the year, domestic capacities – also considering balancing reserve demand – are insufficient for satisfying peak demand common in the period.** Gas-fired power plants, with relatively high marginal costs, still account for a large share of domestic capacities, and play an important role on the balancing/regulation markets. Since coal and water capacities with a lower marginal cost are also available in neighbouring countries, there are also a significant quantity of imports – cheaper than domestic production – based on considerations of economy.

The high import requirement is currently not causing short-term risks in the security of supply, as the cross-border capacities are strong even on an international scale. However, as noted in the Plan above, limited cross-border capacities from Austria and Slovakia limit cheaper electricity imports. (As regards price trends, the part of this chapter relating to wholesale prices is relevant.)

As in most European and regional countries, **renewable electricity production has increased** in the past 10 years in Hungary as well. Among renewables, the rise in the burning of biomass/biogas was considerable; in addition to the use of household-scale PV panels, industrial scale PV power plants began to spread only in recent years. This strategy was favourable, as only relatively cost-effective renewable technologies were gaining ground, not entailing the rapid rise in support costs. **The cost of PV electricity generation has**

166 https://www.mavir.hu/documents/10258/231457949/Havi+cs%C3%BAcsok+2001_2019_09HU_v1.pdf/e420b91f-533f- d9c0-2728-8de08aab6a7d

declined significantly, thus the market penetration of renewables is significantly increasing in Hungary. So far renewable capacities of 2 500-3 000 MW have been licensed, but an installed capacity of up to 5 000-10 000 MW may be realised by the end of the 2020s.

As regards electricity generation it is important to note that **today 62 % of domestic electricity is produced from GHG neutral sources**, as the 11 % share of renewable resources is complemented with the roughly 51 % share of nuclear production.

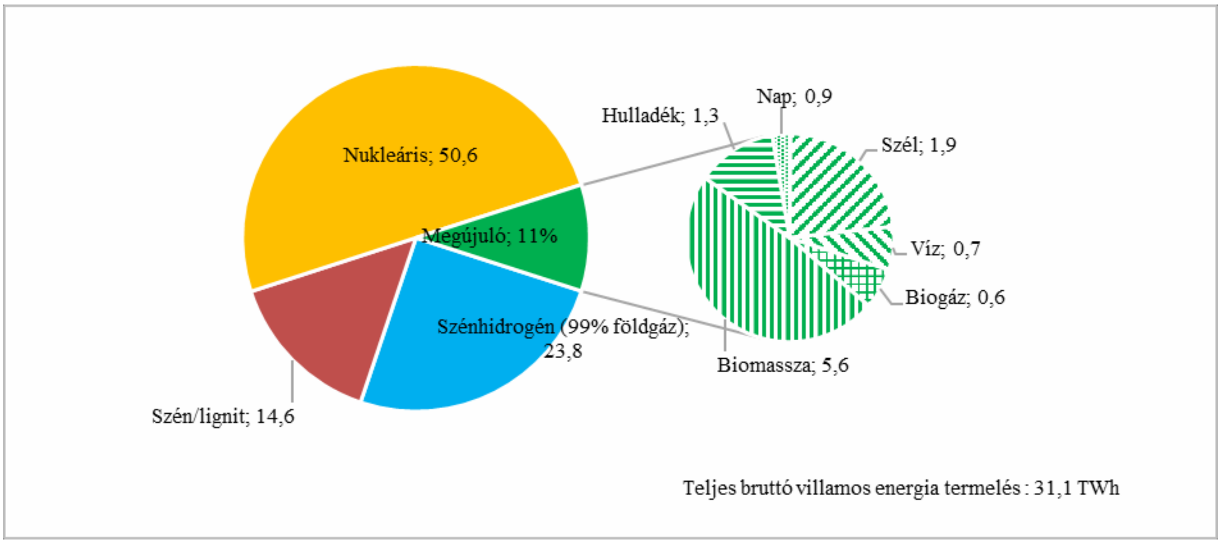


Figure 44 – Sources of Hungarian electricity generation in 2018

Source: MAVIR ZRt.[167]

HU	**EN**
Nukleáris	Nuclear
Megújuló	Renewables
Szén/lignit	Coal/lignite
Szénhidrogén (99 % földgáz)	Hydrocarbons (99 % natural gas)
Hulladék	Waste
Nap	Solar
Szél	Wind

[167] https://www.mavir.hu/web/mavir/a-teljes-brutto-villamosenergia-felhasznalas-megoszlasa

Víz	Water
Biogáz	Biogas
Biomassza	Biomass
Teljes bruttó villamos energia termelés:	Total gross electricity generation:

Gas-fired power plants significantly contribute to the reliable operation (dispatchability) of the electricity system, thus the significant decline in the production of these power plants in the past decade carries risk. As a result of the drop in demand after the global financial crisis (2008), coal based production attributable to low CO_2 prices, relatively high gas prices and the rise in renewable energy production, the utilisation rate and profitability of gas-fired power plants significantly decreased up to 2014. The profitability of gas-fired power plants recently improved.

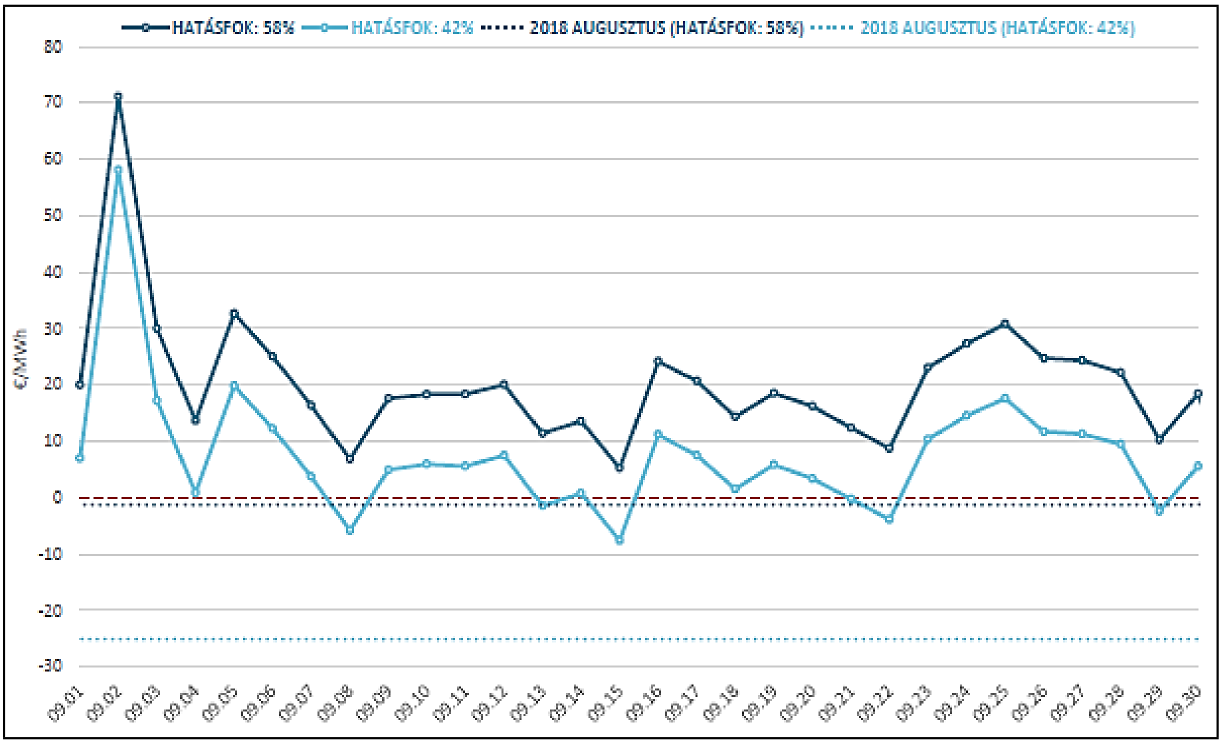


Figure 45 – Profitability of natural gas-fired power plants: clean-dark spread

Source: HEA (2019): Monthly market monitoring report: Electricity – September 2019[168]

[168] http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf

The September issue of the HEA's electricity market monitoring report notes that as a result of market trends – higher CO_2 quota prices, changes in fuel prices – the production cost of a modern CCGT fell persistently below that of coal power plants.[169]

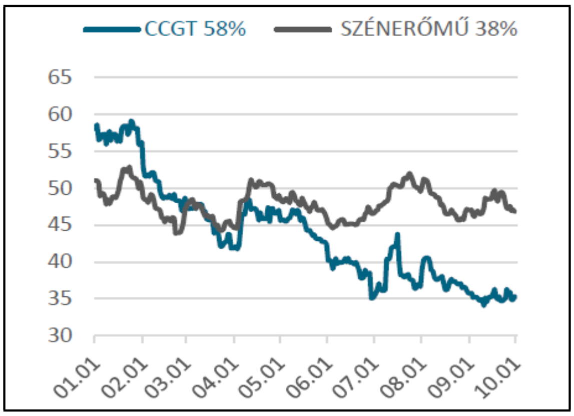


Figure 46 – Production cost of a modern natural gas-fired power plant (CCGT with 58 % useful efficiency) and a coal power plant with 38 % useful efficiency

Source: HEA (2019): Monthly market monitoring report: Electricity – September 2019[170]

HU	**EN**
CCGT	CCGT
SZÉNERŐMŰ	COAL POWER PLANT

The persistent risk inherent to the reliable operation of the Hungarian electricity system, however, is that the service life of a number of gas-fired power plants will expire in the 2020s, and substantial investments are needed to extend their service life. Without additional investments, in the next decade several Hungarian power plant units – including natural gas-fired plants – will reach the end of their service life.

[169] HEA (2019): Monthly market monitoring report: Electricity – September 2019 (http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf)

[170] http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf

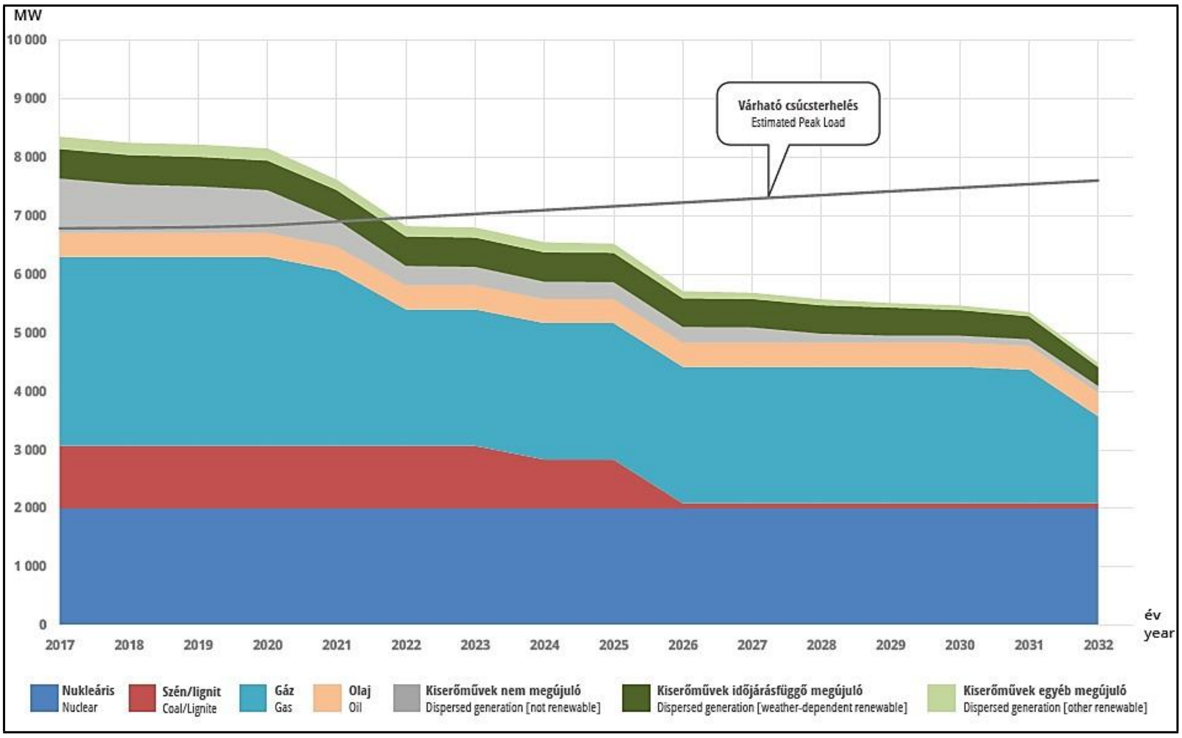


Figure 47 – Projected power plant capacities and peak loads (2017-2032)

Source: MAVIR ZRt.

Hungary satisfies one third of **consumed electricity** with imports; 40 % of consumed electricity originates from self-produced GHG neutral sources. The larger share of such electricity is provided by nuclear energy, but electricity generated from renewable resources is also growing. Use of renewable energy accounted for a share of 4.4 % in 2005, increasing to 7.1 % in 2010 and to 7.5 % in 2018.

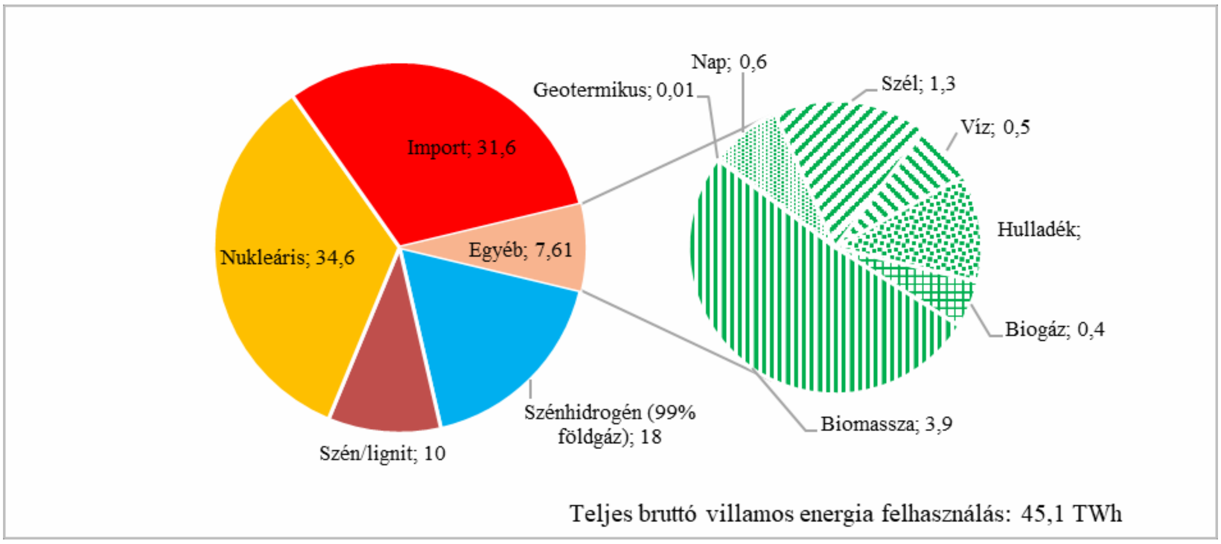


Figure 48 – Total gross electricity consumption in 2018

Source: MAVIR ZRt.[171]

HU	**EN**
Nukleáris	Nuclear
Import	Imports
Egyéb	Other
Megújuló	Renewables
Szén/lignit	Coal/lignite
Szénhidrogén (99 % földgáz)	Hydrocarbons (99 % natural gas)
Hulladék	Waste
Nap	Solar
Geotermikus	Geothermal
Szél	Wind
Víz	Water
Biogáz	Biogas
Biomassza	Biomass
Teljes bruttó villamos energia felhasználás:	Total gross electricity consumption:

Monthly quantity and average price of balancing energy used by the system operator

The average fees of positive activated balancing energy increased.

[171] https://www.mavir.hu/web/mavir/a-teljes-brutto-villamosenergia-felhasznalas-megoszlasa

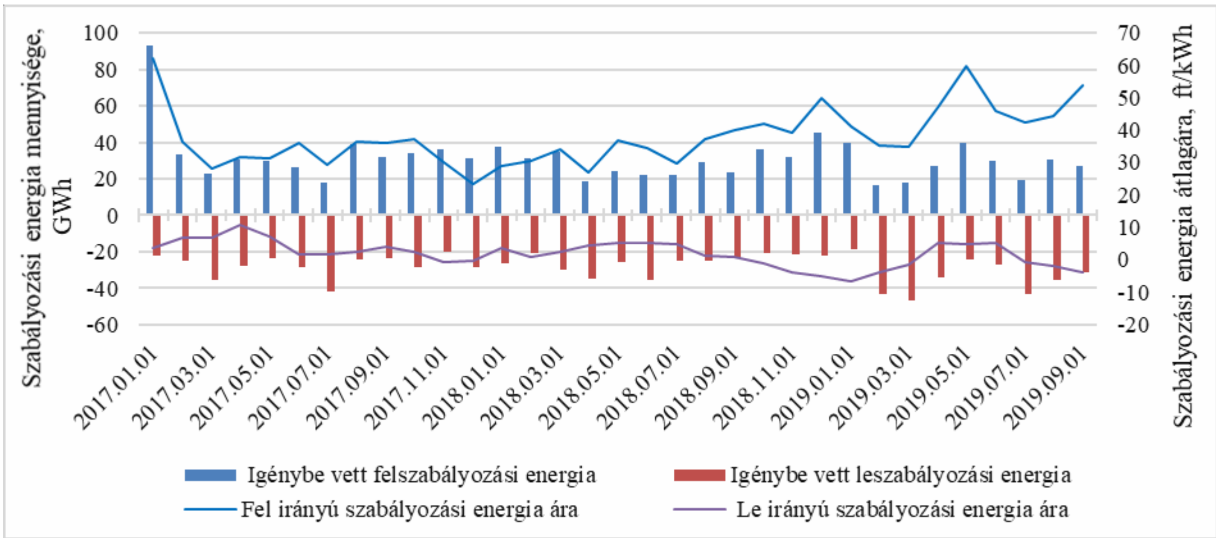


Figure 49 – **Monthly quantity and average price of used balancing energy**

Source: HEA (2019): Monthly market monitoring report: Electricity – September 2019[172]

HU	EN
Szabályozási energia mennyisége, GWh	Quantity of balancing energy, GWh
Szabályozási energia átlagára, ft/kWh	Average price of balancing energy, HUF/kWh
Igénybe vett felszabályozási energia	Used upward regulation energy
Fel irányú szabályozási energia ára	Price of upward regulation energy
Igénybe vett leszabályozási energia	Used downward regulation energy
Le irányú szabályozási energia ára	Price of downward regulation energy

Electricity flows

The electricity market of Hungary is considerably open, as it operates cross-border interconnections with all neighbouring countries (Austria, Slovakia, Romania, Serbia, Ukraine, Croatia) with the exception of Slovenia. Hungary satisfies approximately one third of its annual demand with imports, although its exports – mainly toward the south – are also substantial. Among ENTSO-E countries Hungary has the sixth highest net import

[172] http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf Original source of data published by the HEA: MAVIR ZRt. (www.mavir.hu)

ratio.[173]

The figures below show international electricity sales.

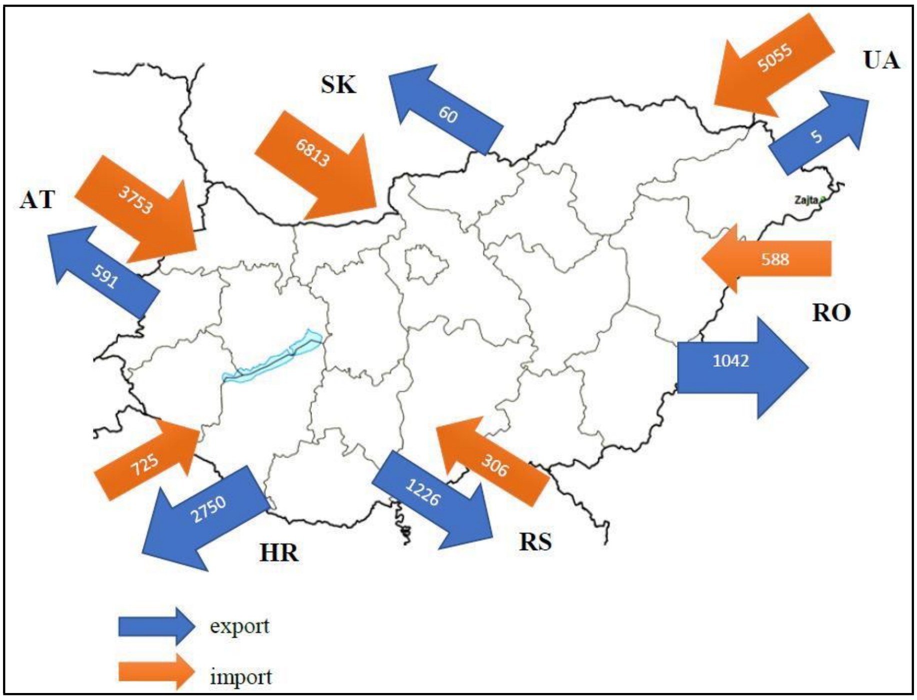


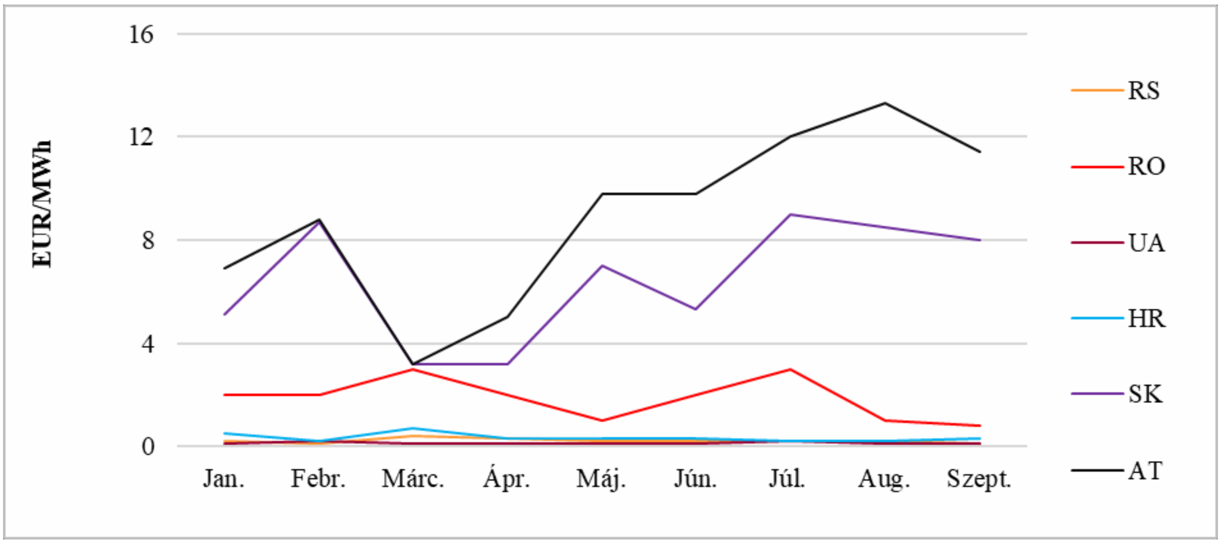
Figure 50 – Actual electricity flows, GWh (2018)

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

The use of cross-border capacities for imports was high in the north and low toward the Balkans.

The figure below shows the clearing prices of monthly cross-border capacity auctions for imports.

[173] REKK (2019): Modelling of the Hungarian wholesale electricity market and analysis of its security of supply up to 2030, under different power plant scenarios. (The study was prepared on behalf of the Ministry of Innovation and Technology.)



Legend: RS: Serbia, RO: Romania, UA: Ukraine, HR: Croatia, SK: Slovakia, AT: Austria

Figure 51 – Clearing prices of monthly cross-border capacity auctions for imports

Source: MAVIR ZRt. (August 2019): Monthly market report, August. 13 September 2019

Market integration

Market integration has also strengthened in recent years. As part of the Third Energy Package adopted by the EU in 2009, Regulation (EC) No 714/2009 prescribed the establishment of interconnected **electricity markets.** Initially only the Czech-Slovakian day-ahead market coupling operated in Hungary's region, which was joined by Hungary in September 2012 as a result of the Czech-Slovakian-Hungarian market coupling project, resulting in the launch of net transfer capacity (NTC) based day-ahead implicit allocation on the Hungarian-Slovakian border as well. The currently operating '4M MC' market coupling was launched on 19 November 2014 with the joining of Romania.[174]

The flow-based day-ahead target model is currently implemented within the framework of the Core Flow Based Market Coupling Project (Core FB MC). The TSOs and NEMOs[175] of Austria, Belgium, Czechia, France, Netherlands, Croatia, Poland, Luxembourg, Hungary, Germany, Romania, Slovakia and Slovenia are actively working on the implementation of the European single internal energy market by implementing the Core FB MC.

Point i. of Chapter 3.4.2 provides information on this NTC based interim coupling project and intraday market integration (XBID), and on initiatives concerning balancing market integration.

[174] Source: https://www.mavir.hu/web/mavir/masnapi-piac-osszekapcsolas

[175] APG, EXAA, EMCO, EPEX SPOT, ELIA, CEPS, OTE, RTE, TENNET BV., HOPS, CROPEX, PSE, TGE, MAVIR, HUPX, 50 Hertz, Amprion, EnBW, TENNET GmbH, OPCOM, and Transelectrica

The already implemented market integration measures produced a number of results. These include, for example, the improvement of the security of supply, market efficiency and liquidity. Market coupling also resulted in more stable electricity prices on the regional energy markets.

Operation of the Hungarian electricity market

Approximately 190 power plants operate on the Hungarian market. Mavir Zrt. carries out TSO activities. In 2017, six distribution companies and three universal service providers operated on the market. There were 102 licensed active trading companies, 52 of which held limited operating licenses.

The two figures below summarise the operating model of the Hungarian electricity market.

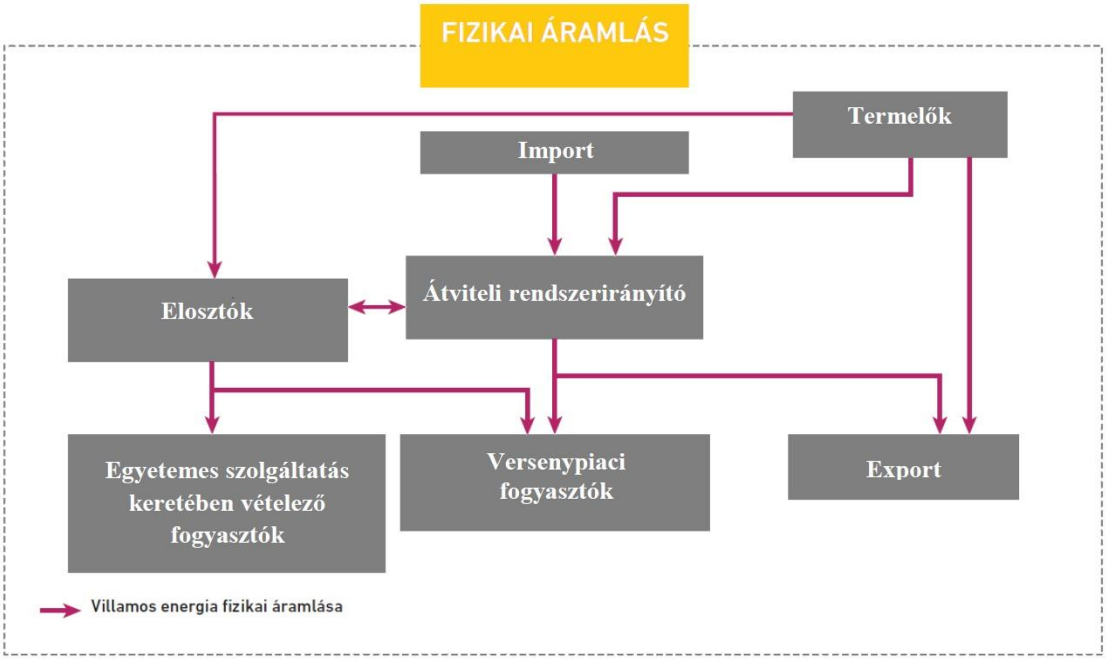


Figure 52 – Operating model of the Hungarian electricity market – physical flows

Source: MAVIR ZRt. (2018): Data on the Hungarian electricity system (ES), 2017.

HU	**EN**
FIZIKAI ÁRAMLÁS	PHYSICAL FLOWS
Import	Imports
Termlelők	Producers
Elosztók	Distributors

Átviveli rendszerirányító	TSO
Egyetemes szolgáltatás keretében vételező fogyasztók	Consumers with off-take from universal services
Versenypiaci fogyasztók	Competitive market consumers
Villamos energia fizikai áramlása	Physical flow of electricity

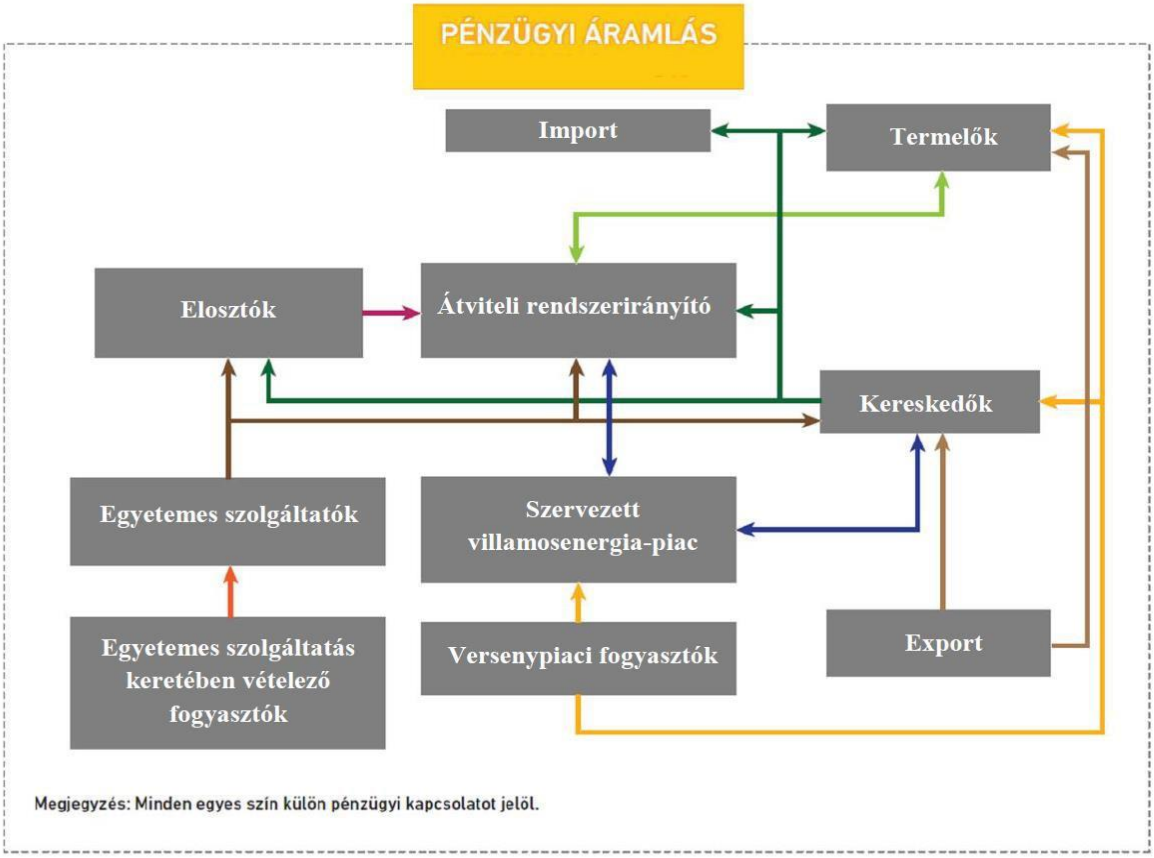


Figure 53 – Operating model of the Hungarian electricity market – financial flows

Source: MAVIR ZRt. (2018): Data on the Hungarian electricity system (ES), 2017.

HU	**EN**
PÉNZÜGYI ÁRAMLÁS	FINANCIAL FLOWS
Import	Imports
Termlelők	Producers
Elosztók	Distributors

Kereskedők	Traders
Egyetemes szolgálatók	Universal service providers
Szervezett villamosenergia-piac	Regulated electricity market
Átviveli rendszerirányító	TSO
Egyetemes szolgáltatás keretében vételező fogyasztók	Consumers with off-take from universal services
Versenypiaci fogyasztók	Competitive market consumers
Megjegyzés: Minden egyes szín külön pénzügyii kapcsolatot jelöl.	Note: Each colour marks a separate financial relationship.

The retail market is of a dual structure. Prices are determined by the market in the **open market segment**. **Customers eligible for universal service** may purchase electricity at capped administrative prices. In 2018, traders sold electricity in the quantity of 11 697 GWh to consumers of universal services. Ninety-five per cent of this quantity satisfied retail customer demand.

The figures below show electricity sales.

Figure 54 - Quantity of electricity sold to consumers of universal services in 2018, GWh

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

HU	EN
1 MWh-nál kisebb éves fogyasztású	Retail customers with annual

lakossági fogyasztók	consumption of less than 1 MWh
1 – 2,5 MWh éves fogyasztású lakossági fogyasztók 5 – 15 MWh éves fogyasztású lakossági fogyasztók	Retail customers with annual consumption of 1–2.5 MWh Retail customers with annual consumption of 5–15 MWh
15 MWh vagy annál nagyobb éves fogyasztású lakossági fogyasztók	Retail customers with annual consumption of 15 MWh or more
20 MWh-nál kisebb éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of less than 20 MWh
20 – 500 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 20–500 MWh
500 vagy annál nagyobb éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 500 MWh or more

In 2018, traders sold electricity from the open market in the quantity of 26 522 GWh to consumers. Ninety-nine per cent of this quantity satisfied non-retail customer demand.

The figures below show electricity sales on the open market.

Figure 55 – Quantity of electricity sold to customers on the free market in 2018, GWh

Source: MAVIR ZRt. (2019): Data on the Hungarian electricity system (ES), 2018

HU	**EN**
20 MWh-nál kisebb éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of less than 20 MWh
Lakossági fogyasztók	Retail customers
20 - 500 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 20–500 MWh
500 – 2 000 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 500–2 000 MWh
2 000 – 20 000 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 2 000–20 000 MWh
20 000 – 70 000 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 20 000–70 000 MWh
70 000 – 150 000 MWh éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 70 000–150 000 MWh
150 000 MWh-nál nagyobb éves villamosenergia-fogyasztású nem lakossági felhasználók	Non-retail customers with annual electricity consumption of 150 000 MWh or more

Power exchange

As an important part of electricity market liberalisation in Hungary, in July 2010 the **Hungarian Regulated Electricity Market** was launched with the subsidiary of MAVIR Zrt., which has become an essential platform of electricity trading in Hungary. The core activity of the HUPX – reference pricing and exchange trading platform operation – effectively contributes to the development of the Hungarian electricity market. Based on its regulatory and approved trading framework, it contributes to strengthening the liquidity and improving the efficiency of the Hungarian energy market, and also supports the flow of working capital within the sector on a regional level.

Although the volume of intraday trading on the HUPX is continuously rising, the day-ahead market remains dominant; a larger share of renewables and/or an expansion of cross-border capacities would be needed for the intraday market to attain levels of Western European markets.

The **HUPX day-ahead market (DAM)** had 58 members in 2018, with 12 founding members. In 2018, total traded quantity on the day-ahead market increased by 7.16 % (from 18 578 593.9 MWh to 19 908 782.4 MWh).

Average daily traded quantity equalled 54 547.5 MWh, the highest volume of daily trading equalled 75 013.0 MWh[176] (this amounted to record daily trading since establishment of the HUPX DAM market).

	2017	**2018**	**Change %**
HUPX average base-load price (EUR/MWh)*	50.35	51	0.64
HUPX average peak-load price (EUR/MWh)*	59.6	57.36	-2.24
HUPX base-load trimmed mean price (EUR/MWh)**	50.12	51.05	0.93
HUPX peak-load trimmed mean price (EUR/MWh)**	59.17	57.39	-1.78
OTC base-load trimmed mean price (EUR/MWh)**	50.89	51.37	0.48
OTC peak-load trimmed mean price (EUR/MWh)**	N/A	N/A	N/A
Highest traded price (EUR/MWh)	300.1	124.95	-58.36
Lowest traded price (EUR/MWh)	0.04	-25.97	-65 025
Total turnover (EUR)	934 072 017	1 034 031 922	10.7
Total volume (GWh)	18 578.593	19 908.7824	7.17
Average daily traded volume (GWh)	50.9018	54.5475	7.16
Highest daily traded volume	73 604.7	75 013	1.91

Table 35 – HUPX – DAM data

Source: HUPX192[177]

The **HUPX intraday market has been steadily growing since its establishment**, with growing volumes and continuous trading. The IDM trading platform was launched on 9 March 2016 with 25 members; it now has 31 members.

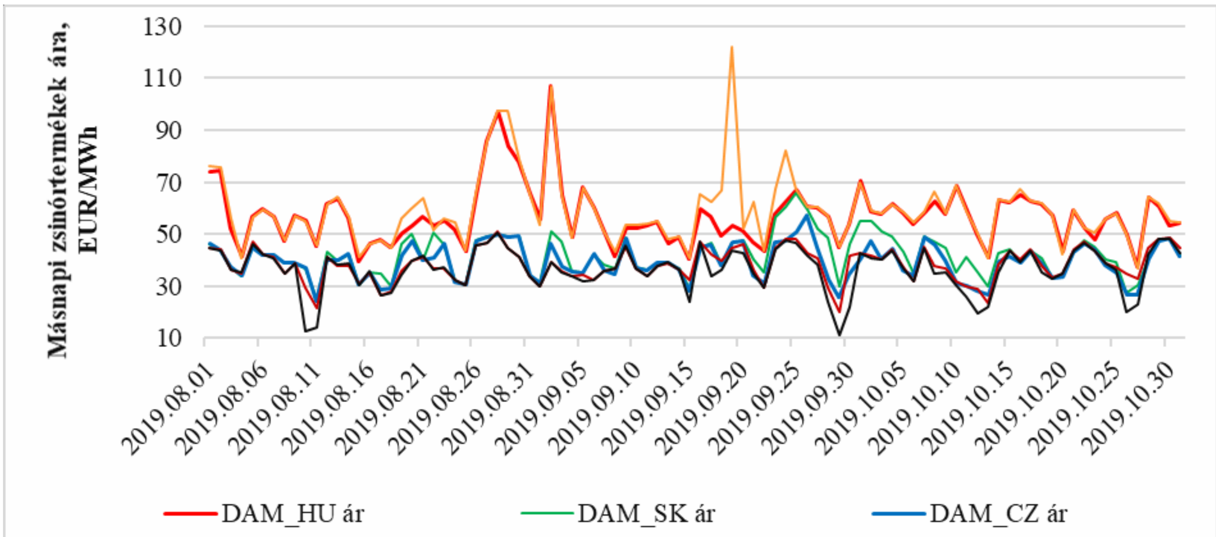
[176] With delivery on 25 October 2018.

[177] https://hupx.hu/uploads/Piaci%20adatok/DAM/havi/2018/HUPX_DAM_OLAP_Yearly_external_4MMC_2018.pdf

In 2018 the intraday trading volume amounted to 55.09 GWh. The OTC quantity equalled 14.41 GWh, indicating a **significant OTC registration volume in addition to exchange transactions.** The highest daily turnover equalled 0.8 GWh[178], the highest monthly turnover equalled 7.69 GWh in 2018. Seventy-seven per cent and 21 % of turnover consisted of hourly and 15-minute products, respectively. Randomly defined block orders accounted for a 2 % share. Prices were in the range between -2 EUR/MWh and +130 EUR/MWh.[179]

Wholesale prices in Hungary and in the region:

Due to limited capacities, the Hungarian (and Romanian) average wholesale electricity price (DAM, daily average base-load prices) is higher than in countries of the region.



Legend: HU: Hungary, SK: Slovakia, CZ: Czechia

Figure 56 – Daily average day-ahead base-load prices in Hungary and in the region, 1 August 2019 – 31 October 2019

Source: HEA (2019): Monthly market monitoring report: Electricity – September 2019[180], Source of CZ data: HUPX[181]

HU	EN

[178] With delivery on 25 October 2018.

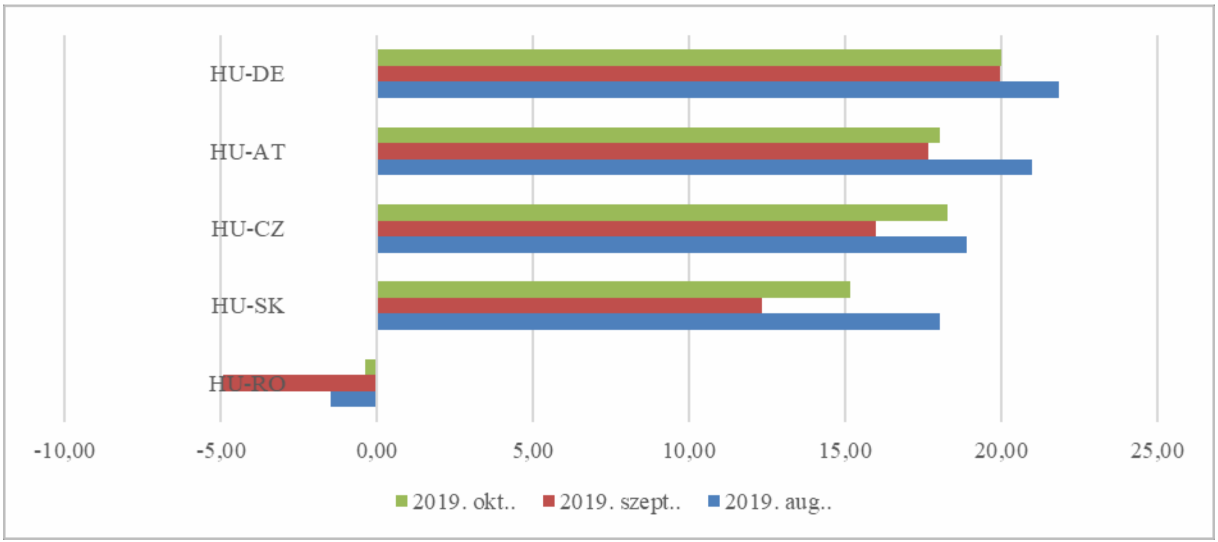
[179] https://hupx.hu/uploads/Piaci%20adatok/ID/ID_Yearly_2018_public.pdf

[180] http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf Original source of data published by the HEA: MAVIR ZRt. (www.mavir.hu)

[181] Original source of data published by the HEA: www.hupx.hu, www.eex.com, www.mercatoelettrico.org

Másnapi zsínórtermékek ára, EUR/MWh	Price of day-ahead base-load products, EUR/MWh
DAM_HU ár	DAM_HU price
DAM_SK ár	DAM_SK price
DAM_CZ ár	DAM_CZ price

The monthly average spread between the Hungarian-Romanian and Slovakian-Czech-Austrian-German prices approximates (or even exceeds) 20 EUR/MWh. The September electricity market monitoring report of the HEA notes that 'on 2 September the base-load price equalled 106.94 EUR/MWh on the Hungarian and Romanian market, the daily average price difference was around 70 EUR/MWh compared to the Slovakian-Austrian-German market, and around 100 EUR/MWh between 6 a.m. and 9 p.m.'[182]



Legend: HU: Hungary, DE: Germany, AT: Austria, CZ: Czechia, SK: Slovakia, RO: Romania

Figure 57 – Monthly average spreads in the region

Source: HEA[183]

Even based on a broad European comparison, Hungarian wholesale prices are relatively high.

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[182] HEA (2019): Monthly market monitoring report: Electricity – September 2019 (http://mekh.hu/download/3/de/b0000/havi_piacmonitoring_riport_villamos_energia_2019_szeptember.pdf)

[183] Original source of data published by the HEA: www.hupx.hu, www.eex.com, www.mercatoelettrico.org

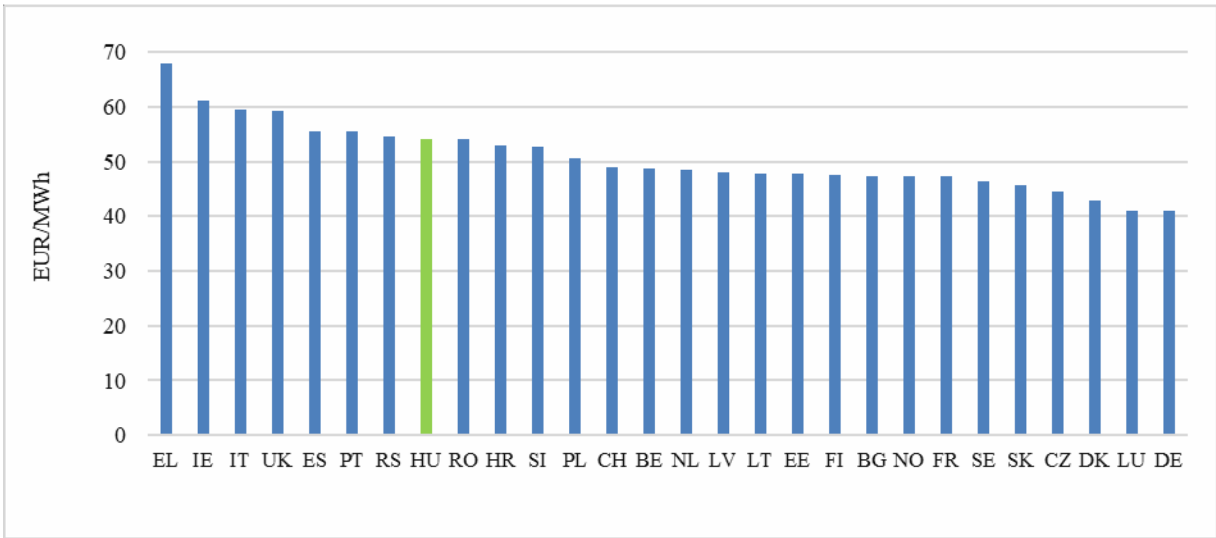


Figure 58 – Wholesale base-load prices on the European markets in Q1 2019

Source: Quarterly Report on European Electricity Markets. Market Observatory for Energy DG Energy Volume 12 (issue 1; 1st quarter of 2019) (https://ec.europa.eu/energy/sites/ener/files/quarterly_report_on_european_electricity_markets_q1_2019_final.pdf)

Further details on retail energy prices are provided in subpoint iii. of Chapter 4.6.

Additional details on current electricity markets are provided in the monthly market reports[184] published by MAVIR Zrt., in the publication entitled 'Data on the Hungarian electricity system (ES), 2017'[185], also issued by MAVIR Zrt. and in the monthly market monitoring reports of the HEA[186].

Natural gas market

Consumption, production, imports and exports

In 2018, 31 % of Hungarian primary energy demand was satisfied with natural gas. Hungarian natural gas consumption has been declining since 2005. The decline was initially attributable to energy efficiency projects launched in connection with significant gas price increases in 2006 and 2007 for final customers, and to the economic downturn in 2008 and 2009. Since the low measured in 2014, consumption has again been rising on account of economic stabilisation and relatively favourable price levels on the natural gas wholesale market since 2015. Annual natural gas consumption in Hungary fluctuated between 7.6 and 9 billion m^3

[184] Available at: https://www.mavir.hu/web/mavir/havi-piac-jelentesek

[185] http://mekh.hu/a-magyar-villamosenergia-rendszer-ver-2018-evi-adatai

[186] www.mekh.hu

between 2014 and 2017[187], reaching around 9.9 billion m^3 [188] in 2018.

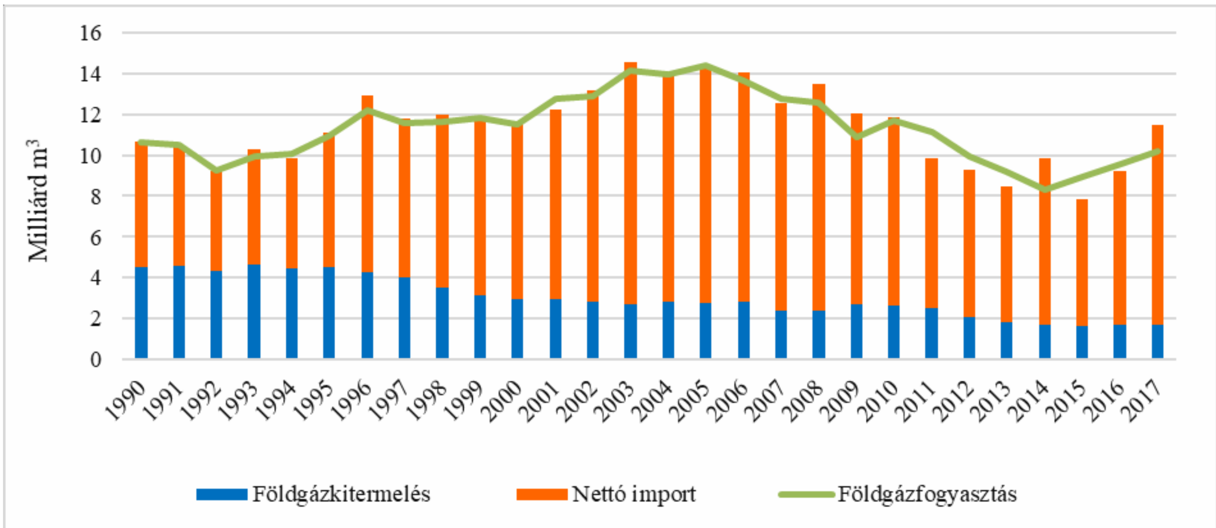


Figure 59 – Production, import and consumption of natural gas in Hungary between 1997 and 2017

Source: Eurostat

HU	**EN**
Milliárd m^3	billion m^3
Földgázkitermelés	Natural gas production
Nettó import	Net imports
Földgázfogyasztás	Natural gas consumption

Domestic net production accounted on average for 20 % of the final customer market in recent years, i.e. **80 % of Hungary's gas supply relies on imports.** Based on data of Eurostat and the Mining and Geological Survey of Hungary, the declining trend in domestic natural gas production is reversing: the volume of 1.6 billion m^3 in 2015 increased to 1.73 billion m^3 in 2018. The quantity may even reach around

[187] Hungarian Energy and Public Utility Regulatory Authority: Risk assessment of the security of natural gas supply in Hungary in accordance with the requirements of 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.

[188] Source: Hungarian Energy and Public Utility Regulatory Authority

2 billion m^3[189] (19.54 TWh) in 2019.

Hungarian imports are mainly supplied from the north. In 2018 (and in 2019) more than 70 % of gas is delivered through the entry point at Beregdaróc. The supply of gas from the west is restricted by limited capacities.

Exports are essentially transits. Hungary conducts a large volume of transit flows to the east (toward Ukraine and Romania) and south (toward Serbia, Croatia). The figure below indicates gas trade.

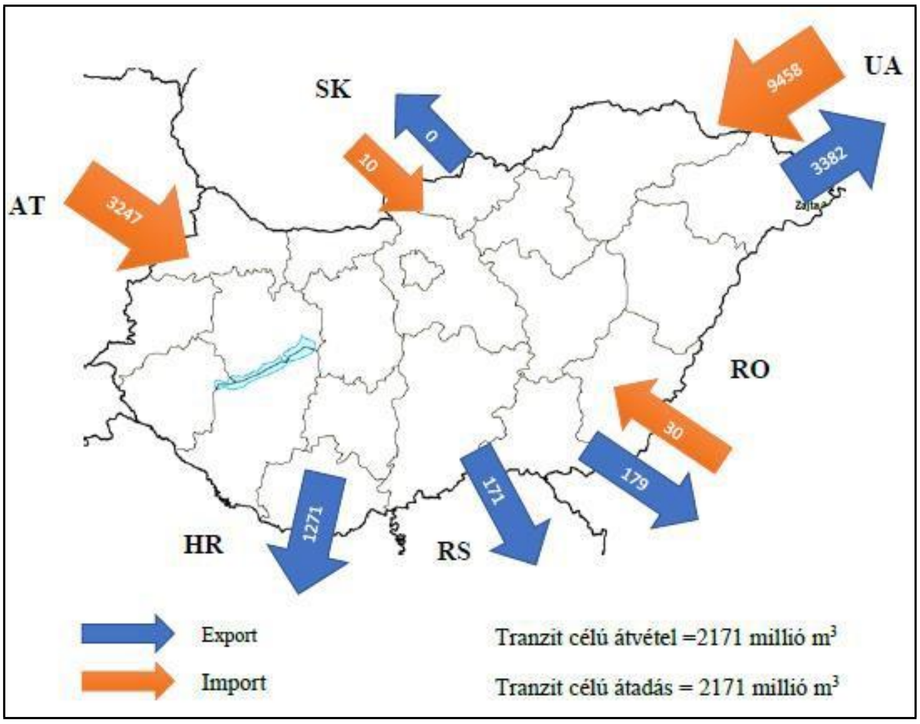


Figure 60 – Gas trade in the main directions, 2018 (million m^3)

Source: FGSZ (2019): Data on the Hungarian natural gas system, 2018.

HU	EN
Tranzit célú átvétel = 2171 millió m^3	Transit off-take = 2 171 million m^3
Tranzit célú átadás	Transit transfers

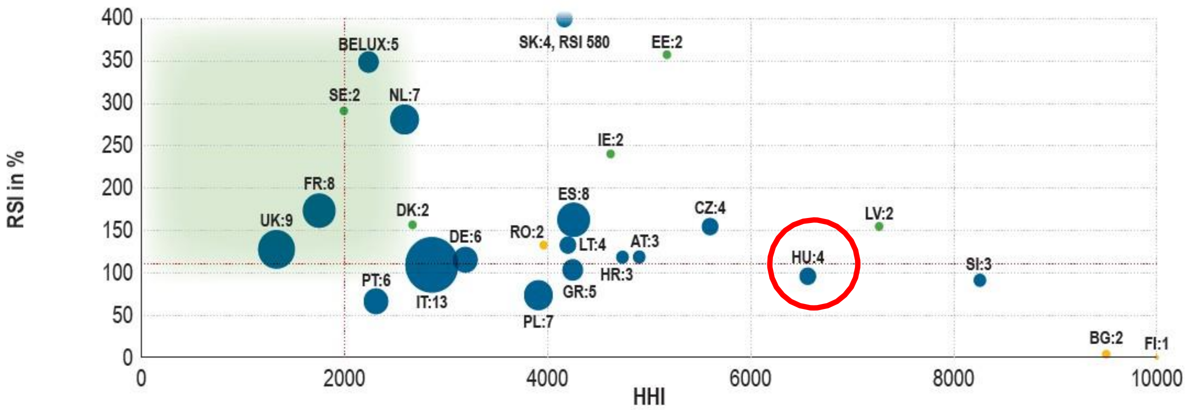
Adequacy of Hungary's gas supply from external sources

Although the adequacy of the natural gas infrastructure significantly improved on the Hungarian gas market (N-1 rule, cross-border capacities, storage capacities) and the concentration of supply capacities also

[189] Source: Mining and Geological Survey of Hungary

decreased after the entry into service of the Slovakian-Hungarian interconnector in 2015, **Hungary is still classified among countries with a more risky gas market.**

The figure below shows the number of supply sources, the annual Residual Supply Index[190] (RSI) not including withdrawal capacities and the Herfindahl-Hirschman Index[191] (HHI) measuring market concentration of companies on the supply side. The figure clearly indicates that Hungary is classified among more risky markets.



Markets with 3 or more potential sources (entry point)

Markets with less than 3 sources, but connection to diversified hub

Markets with less than 3 sources, no connection to diversified hub

Figure 61 – RSI, HHI and number of import sources in 2017

Source: ACER (2018): ACER Market Monitoring Report 2017 – Gas Wholesale Markets Volume. 03/10/2018

Data available at: https://aegis.acer.europa.eu/chest/dataitems/56/view

Storage of natural gas

Hungary operates substantial natural gas storage (commercial and reserve) **capacities even on a regional level** (6.3 billion m^3/61.55 TWh), which are significantly higher than Hungarian final customer demand, therefore 100 % of the capacity of storage facilities at the start of the gas year was not used in recent years. Due to the uncertainty of Ukrainian transit deliveries, however, Hungarian gas storage facilities were used up to 100 % capacity before start of the 2019/2020 winter; the Hungarian system received a slightly larger

[190] The indicator shows whether supply can be ensured in case of the temporary, short-term loss of the largest import capacity. In case of a value higher than 100 %, loss of capacity does not cause a disruption in supply.

[191] A value between 1 and 10 000. HHI = 10 000 indicates maximum concentration.

quantity than thought possible. Use of maximum capacity was necessary for two reasons: firstly, the difference in the winter and summer price of natural gas in Europe was high, thus it made sense for traders to buy; secondly, and more importantly, the gas transit agreement between Russia and Ukraine expired, and the Government was intent on approaching the current heating period by guaranteeing the security of gas supply, regardless of the outcome of relations between the two countries.

The table below summarises key data on Hungarian storage facilities:

Name	**Mobile capacity (Mm^3/year)**	**Theoretical withdrawal capacity (Mm^3/day)**
Hajdúszoboszló (Magyar Földgáztároló Zrt., 'MFGT')	1 640	19.8
Zsana (MFGT)	2 170	28
Pusztaederics (MFGT)	340	2.9
Kardoskút (MFGT)	280	2.9
Algyő, Szőreg (MMBF Zrt.) ***Of which: for reserves***	1 900 *1 450**	25 *20*
Total	**6 330**	**78.6**

* : *In 2019 the volume of strategic natural gas storage increased to 1.45 billion m^3.*

Table 36 – Key data on Hungarian natural gas storage facilities

Source: HEA

The storage facilities significantly contribute to satisfying winter daytime consumption demand; based on data for January-March 2019, on average 40 % of consumption was satisfied with stored supplies, and this contribution could reach around 65 % for several days. Commercial natural gas storage facilities satisfy seasonal and short-term – daily and hourly – flexibility demands. Storage plays an important role in ensuring the system balance; its relevance in the security of supply is enhanced by the option of satisfying peak consumption demand and the physical availability of natural gas.

Pursuant to the sectoral regulation of natural gas, on 1 October of each year the universal service provider must possess – directly or indirectly – natural gas reserves stored in Hungarian natural gas storage facilities corresponding to at least 60 % of highest winter consumption during the past 120 months. Pursuant to the decree on the amount of emergency stockpiles of natural gas[192], the amount of emergency stockpiles of natural

[192] Decree No 13/2015 of 31 March 2015 of the Minister for National Development on the amount of emergency stockpiles of natural gas

gas is determined by the minister in charge of energy affairs, which is currently 1.45 billion m^3.

Regional trends

In recent years the largest share of natural gas imports – accounting for around two thirds of domestic consumption – is imported from Russia, but the remaining share on the Hungarian market is - on a molecular basis - also natural gas of Russian origin. As a major risk on the natural gas market, the future of the largest, Ukrainian supply route has become uncertain primarily for geostrategic reasons, and problems may also arise in connection with the technical condition of the Ukrainian transmission network. Currently the east-west direction of transmission is dominant in the Hungarian natural gas transmission system, which is also supported by the implemented natural gas transmission system. In the future, however, natural gas imports from Russia will not necessarily only arrive through Ukraine. If **the Russian-Ukrainian situation escalates, the supply route through Ukraine may be replaced with entry from the south, which would necessitate additional investments for receiving larger volumes**, reducing the flexibility of the natural gas transmission system. In case of transmission from the direction of Serbia, the cessation of demand for natural gas transits toward Serbia and ultimately to Bosnia and Herzegovina would entail additional costs. Storage demand linked to transits would also diminish. If gas is supplied to the region through the Nord Stream 2 pipeline, Russian gas would reserve transfer capacities built for importing gas from the west at competitive prices into the region.

Role of natural gas in electricity generation

Natural gas-fired power plants play an important role in the supply of electricity in Hungary; beyond the Paks Nuclear Power Plant, natural gas-fired power plants play a key role. In 2017 electricity generated from natural gas accounted for approximately 25 %[193] of total generated electricity. Its share steadily increased from 20.8 %[194] in 2014 in parallel with the rise in gross domestic electricity production by around 9.6 %. As the main cause of the increase, while the global price of natural gas did not change significantly, electricity prices increased, which boosted revenues of natural gas-fired power plants. Owing to their fast dispatchability, natural gas-fired power plants in Hungary are mainly essential for ensuring dispatchable reserves for the electricity system and the uninterrupted operation of the electricity system.

Operation of the Hungarian natural gas system

Pursuant to the provisions of Act XL of 2008 on the supply of natural gas and Government Decree No 19/2009 of 30 January 2009 implementing Act XL of 2008 on the supply of natural gas, the

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[193] MAVIR, Distribution of sources of Hungarian electricity generation in 2017.

[194] Medium and long-term entry capacity increases of the Hungarian electricity system, 2015.

transmission system operator (FGSZ), natural gas storage facility licence holders and natural gas distributors operate an interconnected natural gas system. Ten regional distribution companies operate the natural gas distribution systems; five of these large companies carry out most of regional distribution. Storage is provided by two companies (Magyar Földgáztároló Zrt., MMBF Földgáztároló Zrt.).

As a result of the natural gas market's liberalisation in 2004, the **retail market is of a dual structure**. Prices are determined by the market in the open market segment. Customers eligible for universal service may purchase natural gas at capped administrative prices.

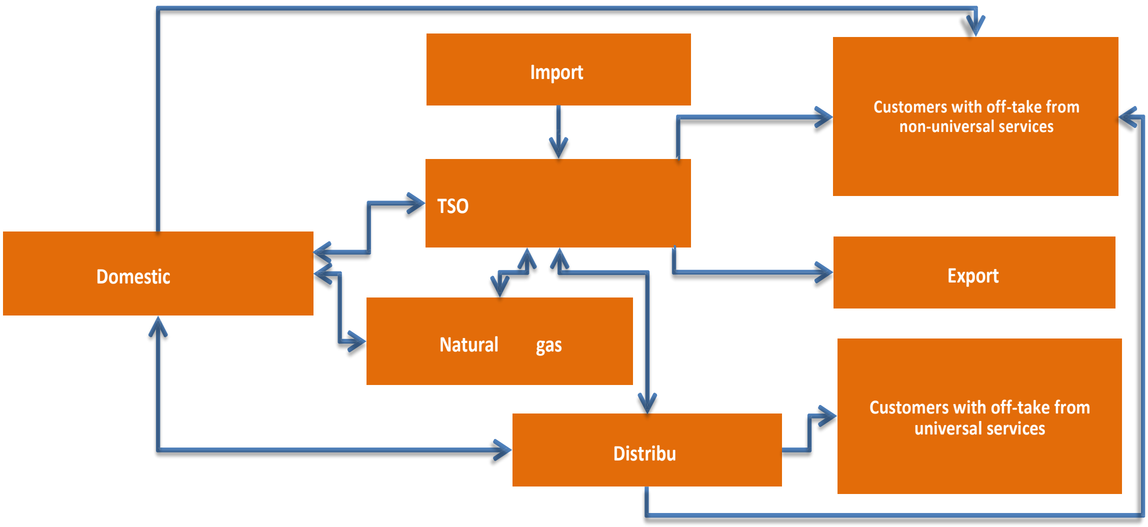

Figure 62 – Operating model of the Hungarian natural gas industry

Source: FGSZ (2019): Data on the Hungarian natural gas system, 2018.

HU	**EN**
Import	Imports
Hazai termelől	Hungarian producers
Szállításirendszer-üzemltető	TSO
Földgáztárolók	Natural gas storage facilities
Elosztók	Distributors
Nem egyetemi szolgáltatás keretében vételező felhasználók	Customers with off-take from non-universal services
Export	Exports
Egyetemi szolgáltatás keretében vételező	Customers with off-take from universal

fogyasztók	services

Retail customers are eligible for universal service (in 2018, other customers with purchased capacities of up to 20 m^3/h, local authorities, and persons living in municipal rented dwellings for up to the amount necessary for their habitation). Customers not eligible for universal service either purchased energy from the open market in the past, or entered the open market upon termination of their right to universal service (customers with low and medium consumption, and district heat generators).

The table below indicates data on natural gas customers receiving universal service and those purchasing on the open market.

Data on customers receiving universal service [million m^3]				
Year	**2015**	**2016**	**2017**	**2018**
Total	3 535	3 869	4 014	3 711
Total retail customers	3 133	3 451	3 624	3 353
Total non-retail customers	402	418	389	358
Data on customers purchasing on the open market [million m^3][1]				
Year	2015	2016	2017	2018
Total	4 513	4 677	5 040	4 807
Total retail customers	57	0	0	3
Total non-retail customers	4 456	4 677	5 040	4 804

Table 37 – Data on customers receiving universal service and customers purchasing on the open market

Source: FGSZ (2019): Data on the Hungarian natural gas system, 2018.

<u>Gas consumption patterns</u>

The figure below shows changes to Hungarian natural gas consumption patterns over time.

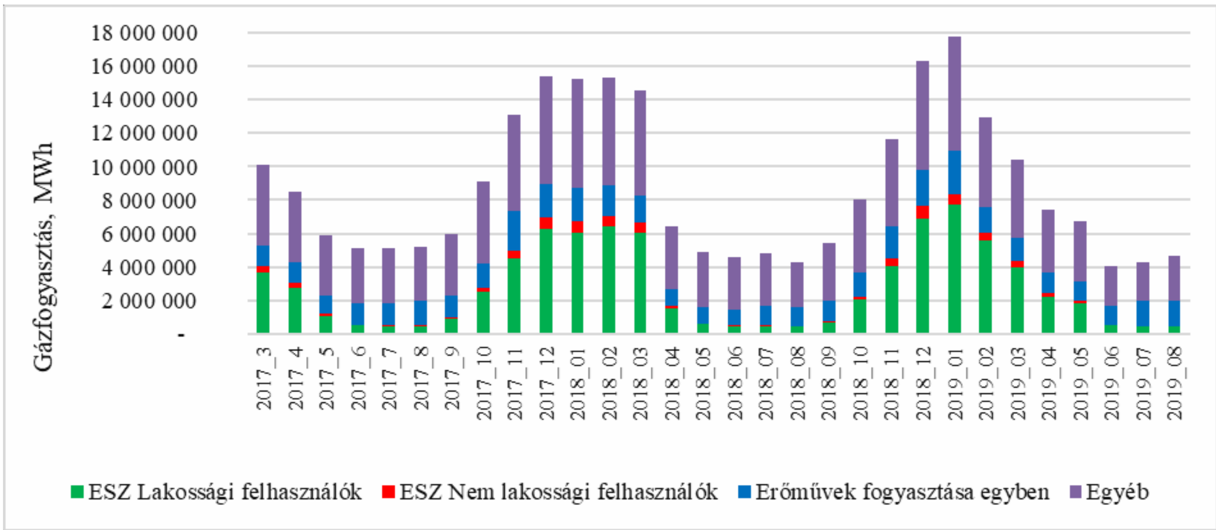

Figure 63 – Gas consumption patterns, March 2017 – September 2019

Source: HEA: Monthly market monitoring report – Natural gas – September 2019[195]

HU	**EN**
Gázfogyasztás, MWh	Gas consumption, MWh
ESZ Lakossági felhasználók	Universal service, retail customers
ESZ Nem lakossági felhasználók	Universal service, non-retail customers
Erőművek fogyasztása egyben	Power plant consumption combined
Egyéb	Other

Hungarian gas market concentration

In 2018 there were 45 natural gas traders and 62 natural gas traders with limited licenses in 2018. Data in the table below show that Hungarian gas market concentration has significantly declined in recent years.

	2015	**2016**	**2017**[196]	**2018**
Data on sales to non-retail final customers				
Number of companies selling to non-retail final customers (No)	32	33	28	27

[195] mekh.hu/download/e/9e/b0000/havi_piacmonitoring_riport_foldgaz_2019_szeptember.pdf

[196] Sales on the CEEGEX are not included.

Share of undertakings with a share of more than 5 % [%]	73 %	70 %	83 %	80 %
Total share of undertakings with the 3 largest shares [%]	49 %	49 %	46 %	45 %
Herfindahl–Hirschman-index: 1	1 838	2 186	2 128	1 987
Data on sales to retail final customers				
Number of companies selling to retail final customers [No]	7	4	2	2
Share of undertakings with a share of more than 5 % [%]	98 %	100 %	100 %	100 %
Total share of undertakings with the 3 largest shares [%]	82 %	100 %	100 %	100 %
Herfindahl–Hirschman-index:[197]	2 628	4 202	10 000	9 984
Data on wholesale selling[2]				
Number of companies selling on the wholesale market [No]	28	37	43	43
Share of undertakings with a share of more than 5 % [%]	88 %	84 %	83 %	80 %
Total share of undertakings with the 3 largest shares [%]	88 %	84 %	68 %	75 %
Herfindahl–Hirschman-index:	5 677	4 839	2 440	2 884

Table 38 – Natural gas market concentration

Source: FGSZ (2019): Data on the Hungarian natural gas system, 2018.

Wholesale market

- ***Hungarian Gas Balancing Point (HGBP)***[198]

The HGBP has operated since 2010, showing slow, but steady growth over the years. As a result, total turnover in 2018 amounted to over 115 TWh[199]. Of the above figure, OTC trading accounted for 108.82 TWh, exchange trading equalled 6.78 TWh.

- ***CEEGEX Central Eastern European Regulated Natural Gas Market***

The CEEGEX Central Eastern European Regulated Natural Gas Market was launched on 2 January 2013 in Hungary. CEEGEX Zrt. holds a licence for operating a regulated natural gas market within the meaning of Section 114 of Act XL of 2008 on the supply of natural gas (hereinafter ‘Gas Act’). Trading was established based on the model of international liquid markets. CEEGEX is a fully electronic, clearing based regulated market enabling spot natural gas transactions with Hungarian delivery, and it also provides other services approved in accordance with the CEEGEX management structure. With its Trayport GlobalVision system,

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[197] Herfindahl–Hirschman-index: index determined by the ratio of the number of market participants to sales; the index equals 10 000 for one market participant.

[198] Virtual entry and exit point of the high-pressure transmission system, the capacity of which is infinite.

[199] https://www.oxfordenergy.org/wpcms/wp-content/uploads/2019/07/European-traded-gas-hubs-a-decade-of-change-Insight-55.pdf?v=7516fd43adaa

CEEGEX Zrt. enables trading in day-ahead, intraday and local commodity trading for market members on a trading platform that also operates well on key Western European exchanges. **CEEGEX aims to establish a liquid regional gas market reliant on the available infrastructure, in conformity with international practice, which provides a secure and reliable long-term solution.** In the medium and long term, the operation of CEEGEX also contributes to improving the energy and energy policy position of Hungary.

Trading is physically transacted to the Hungarian Gas Balancing Point (HGBP). Delivery is guaranteed by FGSZ.

With expanded trading of natural gas products and the further increase in membership (currently 36 members), a number of monthly trading records were broken in 2019; the total volume traded in 2018 was already surpassed in the first half of this year. In May the total traded volume on the spot market reached 3.71 TWh, a 21 % increase over the old record, which was registered in April with 2.95 TWh.[200]

The figure below shows volumes traded this year.

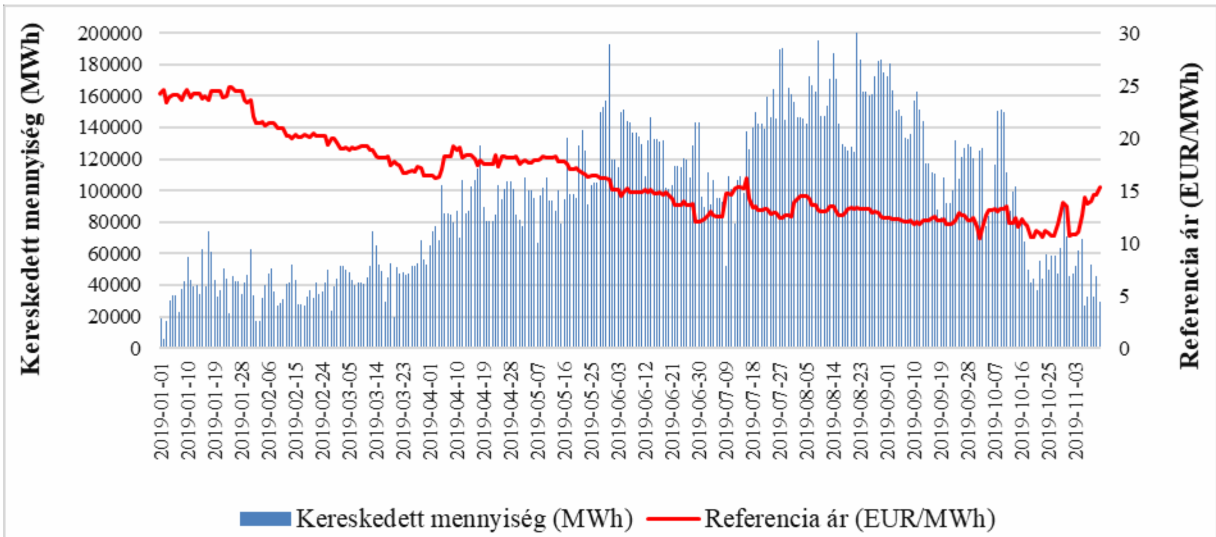


Figure 64 – Trading volume on the CEEGEX DAM relating to the given delivery date in 2019

Source: CEEGEX[201]

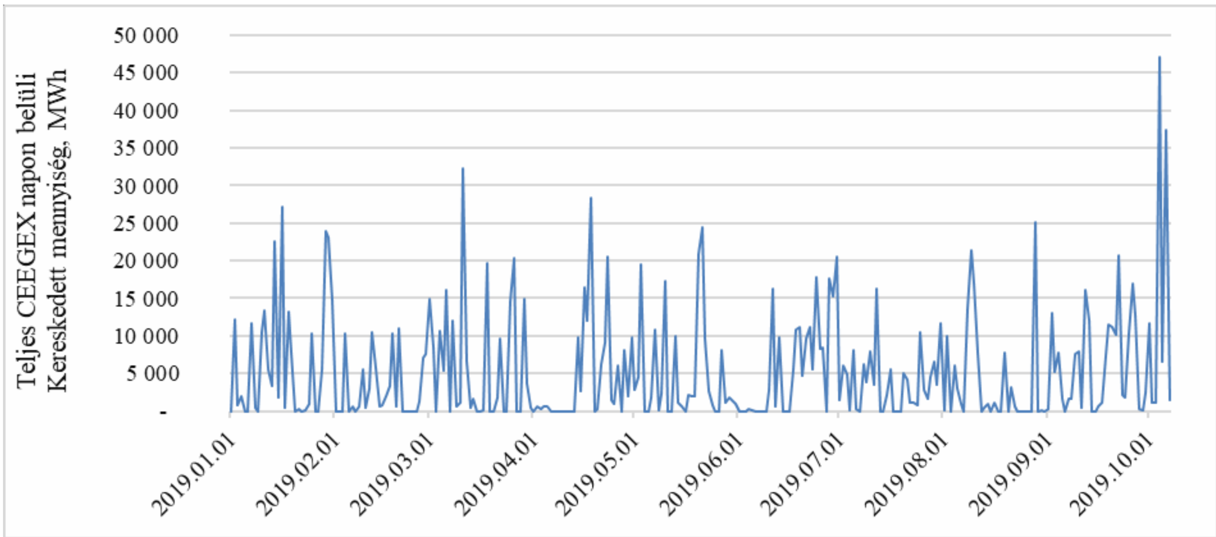
HU	**EN**
Kereskedett mennyiség (MWh)	Traded volume (MWh)

[200] https://ceegex.hu/hu/hirek/sorra-dolnek-meg-a-rekordok-a-ceegex-piacan/13

[201] https://ceegex.hu/hu/piaci-adatok/napi

Referencia ár (EUR/MWh)	Reference price (EUR/MWh)

The volume of intraday hourly trading significantly falls short of volumes traded on the DAM. The traded volume amounts to a few hundred or few thousand MWh daily.



*: daily amount of hourly traded volumes

Figure 65 – Aggregate trading volume* of the CEEGEX intraday market in 2019

Source: CEEGEX (https://ceegex.hu/hu/piaci-adatok/oras)

HU	EN
Teljes CEEGEX napon belüli kereskedett mennyiség, MWh	CEEGEX total intraday traded volume, MWh

The liquidity and price signalling role of CEEGEX, the Hungarian gas exchange, has recently strengthened mainly as a result of Ukraine's European gas purchases, although most of wholesale is still conducted through bilateral transactions.

- ***Wholesale prices:***

The main achievement of capacity upgrades implemented in conformity with objectives defined in the National Energy Strategy, adopted in 2011, is ensuring availability of alternative gas sources beyond the Russian ones, implementation of import capacities not controlled by the Russian party and establishment of competition on the wholesale market. On the Hungarian gas market, gas products purchased by different traders from Russian sources and purchased on Western European exchanges are competing with each other.

Import diversification and the establishment of competition on the wholesale market has almost eliminated the competitive disadvantage of Hungarian gas customers compared to Western European customers since early 2014. In recent years **the expansion of import opportunities and the availability of alternative trade routes significantly contributed to the decline in domestic gas prices:** While gas cost 4-5 EUR/MWh more (based on border prices) on the Hungarian wholesale market than in Germany or Austria[202] in 2012, the difference is now reduced to 1–3 EUR/MWh.[203]

[202] https://aegis.acer.europa.eu/chest/dataitems/51/view

[203] https://aegis.acer.europa.eu/chest/dataitems/51/view

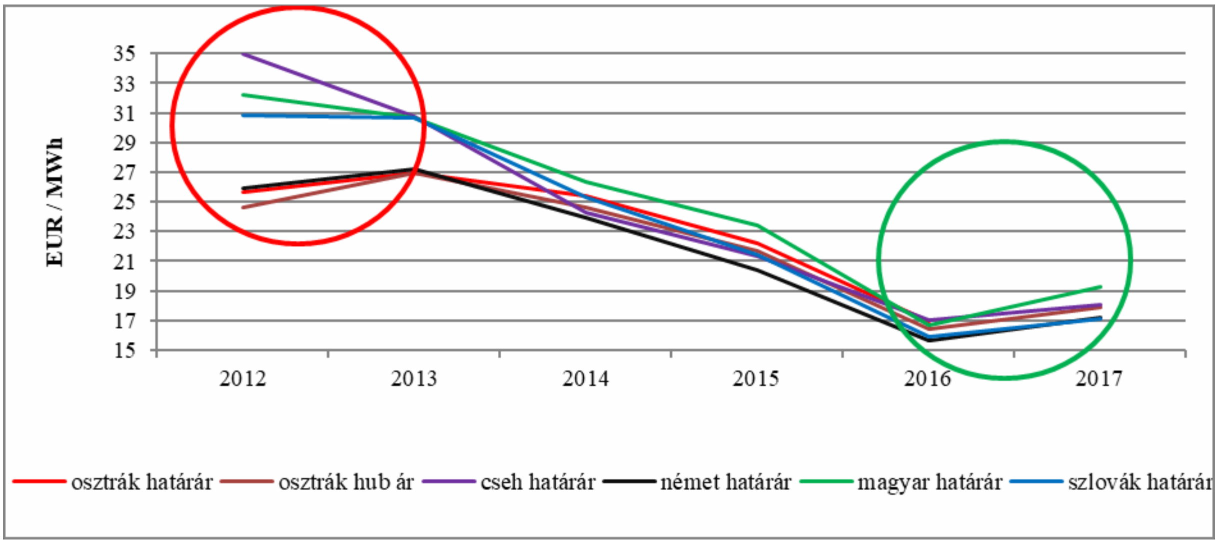


Figure 66 – Supplier gas prices, 2012-2017

Source: ACER

HU	EN
osztrák határár	Austrian border price
osztrák hub ár	Austrian hub price
cseh határár	Czech border price
német határár	German border price
magyar határár	Hungarian border price
szlovák határár	Slovakian border price

During the past year **spot gas prices significantly decreased on the CEEGEX** and on major European markets. Gas prices on the CEEGEX, however, are still higher.

The figure below shows recent trends in spot natural gas prices and their decline.

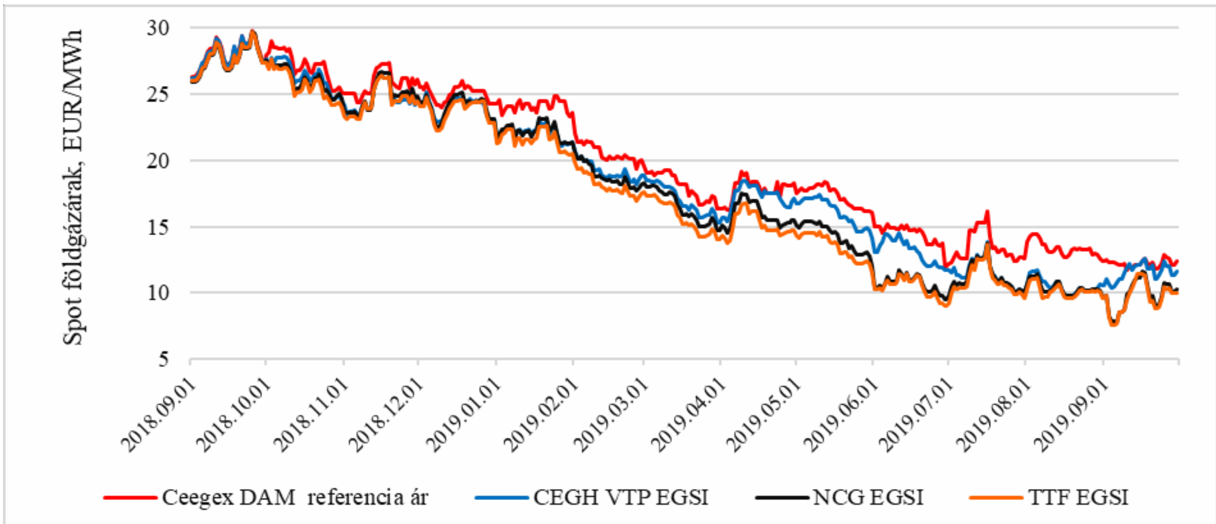


Figure 67 – Spot gas prices on the CEEGEX and major European markets[204]

Source: HEA: Monthly market monitoring report – Natural gas – September 2019[205]

HU	**EN**
Spot földgázárak, EUR/MWh	Spot natural gas prices, EUR/MWh
Ceegex DAM referencia ár	Ceegex DAM reference price
CEGH VTP EGSI	CEGH VTP EGSI
NCG EGSI	NCG EGSI
TTF EGSI	TTF EGSI

The **decline in prices played an important role in enabling all Hungarian traders to import gas from the Austrian gas exchange**, thus – until there are available cross-border capacities – the Hungarian wholesale market gas price cannot rise above the level of 'Austrian exchange price + delivery cost' in the longer term, and the implemented Hungarian-Slovakian interconnection (MGT pipeline) expanded options for access to Western European markets.

[204] Note: DAM: Day Ahead Market. CEGH: Central European Gas Hub (Austria).

NCG: NetConnect Germany. TTF: Title Transfer Facility (Netherlands). EGSI: European Gas Spot Market Index. Index calculated on the basis of trading conducted on the day preceding the given day on the different PEGAS markets.

[205] mekh.hu/download/e/9e/b0000/havi_piacmonitoring_riport_foldgaz_2019_szeptember.pdf

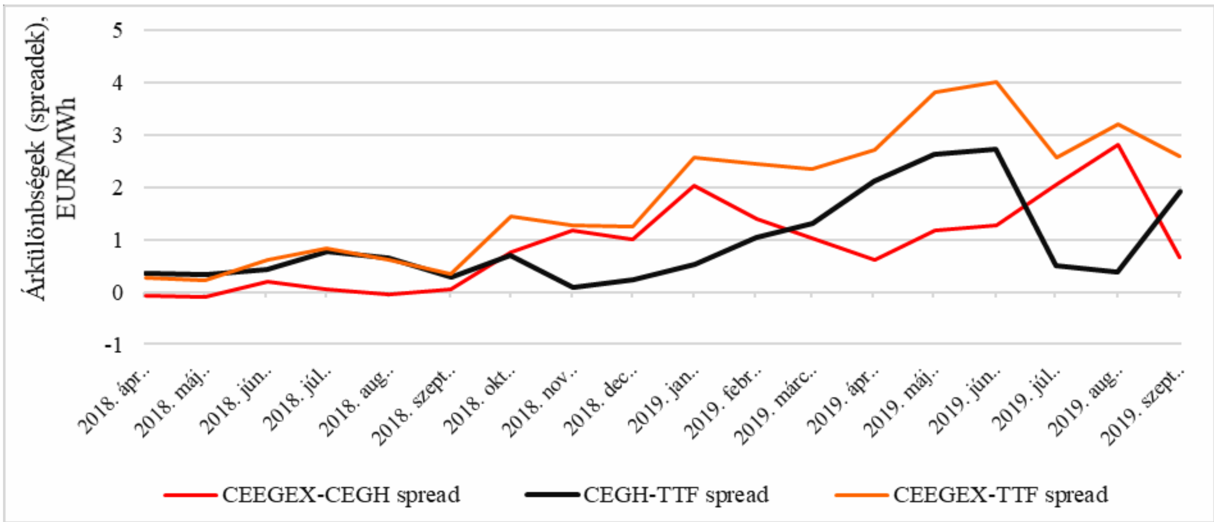


Figure 68 – Spreads between CEEGEX, CEGH and TTF[206]

Source: HEA: Monthly market monitoring report – Natural gas – September 2019[207]

HU	EN
Árkülönbségek (spreadek), EUR/MWh	Spreads, EUR/MWh

Competition between traders also contributed to significantly more favourable conditions for renegotiating terms of the Russian long-term agreement at the end of 2015.

(Further information on retail prices are provided in subpoint iii. of Chapter 4.6.) Additional details on the current natural gas market are provided in the publication[208] entitled 'Data on the Hungarian natural gas system, 2018', issued by FGSZ Zrt., and in the monthly market monitoring reports[209] of the HEA.

ii. Projections of development with existing policies and measures at least until 2040 (including for the year 2030)

Electricity market

Union regulation, Hungarian targets and energy policy priorities, and trends on international energy markets all point in the direction of electrification; as a result of tightening climate policy measures and technological development, the consumption of electricity produced by more climate-friendly means will replace a growing share of energy consumption for transport and heating purposes. Supply based on the growing weight of renewable energy and increasing consumption resulting from electrification necessitates a completely

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[206] Note: CEGH: Central European Gas Hub (Austria). TTF: Title Transfer Facility (Netherlands).

[207] mekh.hu/download/e/9e/b0000/havi_piacmonitoring_riport_foldgaz_2019_szeptember.pdf

[208] http://mekh.hu/a-magyar-foldgazrendszer-2018-evi-adatai

[209] www.mekh.hu

different network structure. The few large power plants will be supplemented with many smaller, decentralised production units that are commonly connected not to high-voltage transmission networks, but to medium- and low-voltage networks, and it will also be necessary to exploit dispatching capabilities available within the distribution networks (e.g. demand side response, energy storage). The number of household-scale PV systems connected to the grid is rapidly growing in parallel with the rise in electricity demand, thus consumers turned prosumers are becoming more active and conscious players on the market aiming to control their consumption and overhead costs.

Availability of the adequate quantity and composition of capacities is key on the electricity market. The capacity analyses of MAVIR Zrt., its document entitled 'Medium and long-term entry capacity increases of the Hungarian electricity system, 2018'[210] in particular provide information relating to the above.

Gas market and gas-based electricity generation

Natural gas consumption has been declining in recent years mainly as a result of a sharp drop in natural gas demand necessary for electricity production. The role of natural gas in electricity generation was not replaced by other energy sources, but rather electricity imports displaced it among sources. This is presumably attributable to the fact that natural gas based electricity generation in Hungary is currently not competitive with imported electricity. The risk inherent to the reliable operation of the Hungarian electricity system is that the service life of a number of gas-fired power plants will expire in the 2020s, and substantial investments are needed to extend their service life.

Based on the Ten-year Network Development Plan of FGSZ, the natural gas demand of customers supplied by distribution network operators is expected to stagnate. The demand of industrial consumers directly supplied by the natural gas transmission system is continuously growing, while the gas demand of power plant customers is expected to increase in a few years.

Based on forecasts of Hungarian producers, without additional measures, annual net production in the period between the 2018/2019 and 2027/2028 gas years will drop from 1.835 billion m^3/year to 0.633 billion m^3/year, equalling a 1.202 billion m^3/year decline; domestic production will decrease to 34.4 % of the current level (indicating an annual 1.2 billion m^3 rise in import requirements by the end of the period).

The plan also notes that with the approved upgrades, entry point capacities are expected to increase from 132.796 Mm^3/day to 135.250 Mm^3/day in the next 10 years. By the end of the reviewed period, entry capacity will increase by 20.454 Mm^3/day over the baseline period and surplus entry capacity will increase from 18.453 Mm^3/day to 29.450 Mm^3/day, taking into account contracted transit demand.

Also taking into account capacities increased with RO-HU phase II, Croatian medium-level, Slovenian and

210 https://www.mavir.hu/documents/10258/15461/Forr%C3%A1selemz%C3%A9s_2018_IG.pdf/fc043982-a8ea-e49f-6061- 418b254a6391

Serbian entries at the entry points, entry point capacities are expected to increase from 132.796 Mm^3/day to 170.370 Mm^3/day in the next 10 years. By the end of the reviewed period, entry capacity will increase by 37.574 Mm^3/day over the baseline period and surplus entry capacity will increase from 18.453 Mm^3/day to 41.050 Mm^3/day, taking into account contracted transit demand.

Also taking into account capacities increased with 'RO-HU phase II entries, Croatian medium-level entries, and without Ukrainian entry' at the entry points, entry point capacities are expected to sharply decrease from the 2020/2021 gas year from 132.796 Mm^3/day to 100.450 Mm^3/day in the next 10 years (upon possible loss of entry from Ukraine). The decline is substantial notwithstanding that medium-level entry from Croatia was also taken into account, and delivery toward Ukraine and Serbia was not taken into account.

Integration of electricity and gas markets

The integration efforts still in progress facilitate the implementation of more efficient trade flows, the balancing of demand and supply side volatility between countries, and improve the security of supply. Market integration also supports maximising the cost-effectiveness of satisfying Hungarian electricity demand. Congestion, however, may arise both on the electricity and gas markets; this problem should be addressed with additional measures.

4.6. Dimension of 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)

In 2017, R&D expenditures accounted of an average of 2.06 % of the GDP in EU Member States. This ratio is 1.35 % (1.53 % in 2018) in Hungary – 0.71 percentage points less than the EU average – placing Hungary 13th in the Member State ranking. Between 2010 and 2017, Hungary climbed five places in the ranking of GDP-proportionate R&D expenditures.[211]

Current key priorities of energy R&D in Hungary: energy efficiency, energy production, renewable energy, alternative propulsion in transport; distribution, transmission and storage of energy, nuclear development - consistently with improved energy security and reduced dependence on energy imports.

The main directions of RDI were defined on the basis of the distribution of State R&D+D expenditures and the distribution of R&D aids awarded under tendering schemes, taking into account that the Government does not possess accurate information on private investments. The distribution of State R&D+D expenditures was reviewed on the basis of data provided to the IEA.

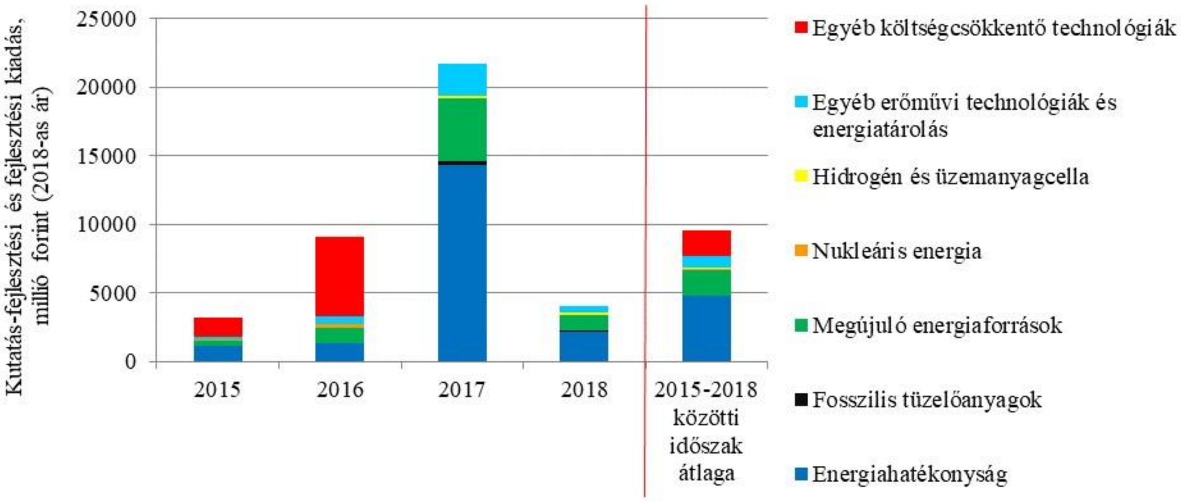

Figure 69 - Distribution of State R&D+D expenditures by technology, 2016-2018[212] [213]

Source: IEA[214]

HU	EN

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[211] HCSO (2018): Research and development, 2018. Hungarian Central Statistical Office (http://www.ksh.hu/docs/hun/xftp/idoszaki/tudkut/tudkut18.pdf)

[212] A reliable detailed breakdown is not available for energy efficiency.

[213] Other cost-cutting technologies: Energy system analysis, basic research, activity not classified elsewhere.

[214] http://wds.iea.org/WDS/TableViewer/tableView.aspx

Kutatás-fejlesztési és fejlesztési kiadás, millió forint (2018-as ár)	R&D+D expenditures, HUF million (at 2018 prices)
Egyéb költségcsökkentő technológiák	Other cost-cutting technologies
Egyéb erőművi technológiák és energiatárolás	Other power plant technologies and energy storage
Hidrogén és üzemanyagcella	Hydrogen and fuel cells
Nukleáris energia	Nuclear energy
Megújuló energiaforrások	Renewable energy sources
Fosszilis tüzelőanyagok	Fossil fuels
Energiahatékonyság	Energy efficiency
2015-2018 közötti időszak átlaga	Average for the 2015-2018 period

Between 2015 and 2018 the Hungarian State spent an average of HUF ~9.5 billion (~29.9 million EUR) **annually on R&D+D activities.** Efficiency research and development was the key R&D field. In the 2016–2018 period, development expenditures aimed at improving energy efficiency accounted for one half of total energy research financing. The share of renewable sources of energy within expenditures already reached 19 % (only 5 % in 2010) in the average of the three reviewed years. The category of other cost-cutting technologies also equalled a share of 19 % in the same period. Nuclear energy, fossil fuels, and hydrogen and fuel cells each accounted for 1 % of total R&D expenditures, while the Hungarian State spent around one tenth of funds on developing other electricity generation and storage technologies.

In international comparison, the share of Hungarian expenditures spent on renewable energy approximates the average share within the EU (EU average in 2018: 27.4 %, Hungarian value: 26.3 %).

	HU	AT	DE	PL*	SK	US	EU	JP
Energy efficiency	6.9	66.9	140.8	11.6	2.6	1 057.8	299.8	581.4
Fossil fuels	0.2	0.6	46.5	11.6	0.0	483.7	49.0	142.7
Renewable energy sources	3.4	22.4	207.6	21,1	0.9	639.5	350.4	371.2
Nuclear energy	0.0	1.8	213.0	0.0	0.3	914.1	94.4	878.0
Hydrogen and fuel cells	0.7	8,1	27.6	0.3	0.1	97.4	99.0	166.2
Other power plant technologies and energy storage	1.7	22.4	111.8	7.3	0.3	34.7	208.6	154.6

Other cost-cutting technologies	0.0	21.9	308.3	4.7	0.0	2 755.3	179.8	152.6
Total	12.8	144.1	1 055.6	56.8	4.2	6 053.9	1 281.0	2 446.5

Table 39 – R&D+D expenditures in Hungary, in the EU and other OECD member states in 2018, million EUR (at 2018 prices)[215]

Source: IEA[216]

In international comparison, the share of Hungarian expenditures spent on renewable energy approximates the average share within the EU (EU average in 2018: 27.4 %, Hungarian value: 26.3 %).

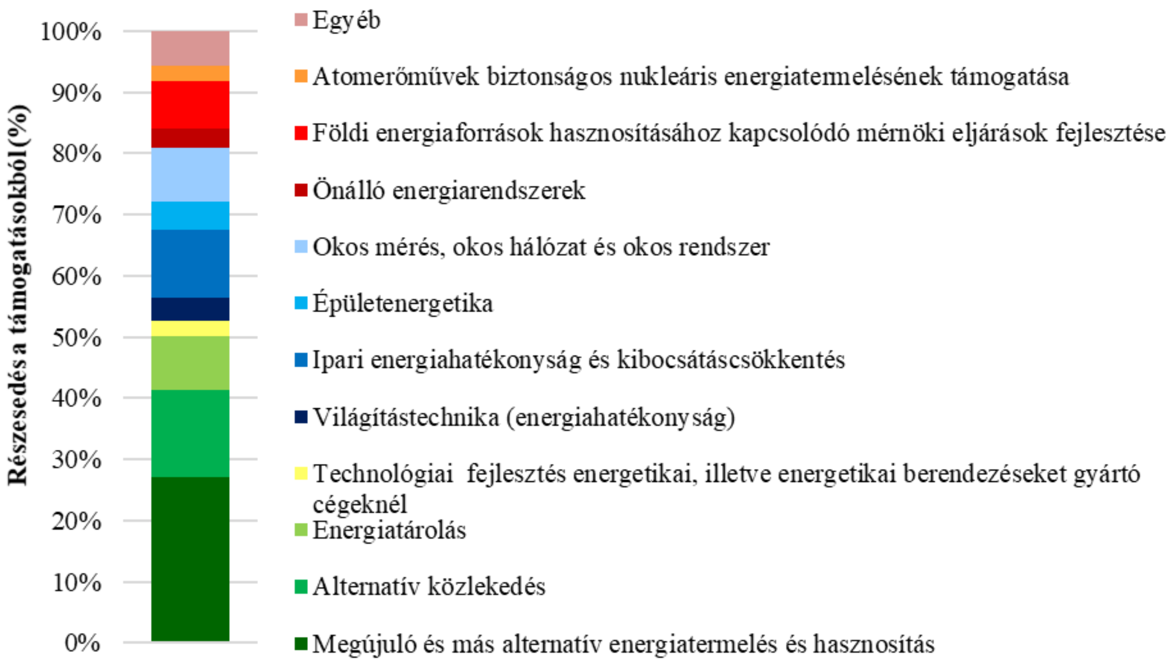

Figure 70 – Distribution of funds of the NRDI Fund and Structural Funds allocated to energy projects with a primary focus on R&D

Source: NRDIO[217]

HU	**EN**
Részesedés a támogatásokból (%)	Share of funds (%)
Egyéb	Other
Atomerőművek biztonságos nukleáris	Support of safe nuclear power plant

[215] Data for 2018 were not available in relation to nuclear energy, therefore data for 2017 were considered.

[216] http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx

[217] https://nkfih.gov.hu/palyazoknak/palyazatok/tamogatott-projektek

energiatermelésének támogatása	energy production
Földi energiaforrások hasznosításához kapcsolódó mérnöki eljárások fejlesztése	Development of engineering procedures relating to the use of terrestrial energy resources
Önálló energiarendszerek	Independent energy systems
Okos mérés, okos hálózat és okos rendszer	Smart metering, smart grid and smart system
Épületenergetika	Building energy performance
Ipari energiahatékonyság és kibocsátáscsökkentés	Industrial energy efficiency and emissions reduction
Világítástechnika (energiahatékonyság)	Lighting technology (energy efficiency)
Technológiai fejlesztés energetikai, illetve energetikai berendezéseket gyártó cégeknél	Technological development of energy and energy equipment manufacturing companies
Alternatív közlekedés	Alternative transport
Megújuló és más alternatív energiatermelés és hasznosítás	Production and recovery of renewable and other alternative energy

Projects supported under the **Horizon 2020 programme** should also be noted when assessing Hungary's energy related R&D activity. As regards the clean energy transition, mainly pillar III (‘Societal challenges’) offers options for support. The following thematic areas are relevant among activities of the pillar:

- Secure, clean and efficient energy
- Smart, green and integrated transport
- Climate action, environment, resource efficiency and raw materials
- Euratom Research and Training Programme, 2014-2018

The table below provides data of a European comparison.

	HU	AT	CZ	DE	PL	SK	SI	RO	Other EU	EU total
Secure, clean and efficient energy (m EUR)	15	122	20	510	21	6	37	24	2 407	3 162

Smart, green and integrated transport (m EUR)	17	134	44	744	15	5	23	21	2 780	3 786
Euratom (m EUR)	8	0	17	346	4.8	3	7	5	1 343	1 734
Climate action, environment, resource efficiency and raw materials	11	51	8	252	16.0	3	20	11	543	915
Other non-energy and climate protection priority projects (m EUR)	217	974	245	5 175	282.1	73	159	127	25 015	32 268
Share of energy and climate protection funds within total H2020 funds awarded to tenderers of the given country (m EUR)	19	24	26	26	16.8	19	35	33	22	23

Table 40 – H2020 funds awarded to energy and climate protection projects

Source: Horizon Dashboard[218]

Within the framework of Horizon 2020, there were 253 supported Hungarian tenders in the above categories up to 29 October 2019. Hungarian project members were awarded Union funds in the total value of 51 million EUR.[219]

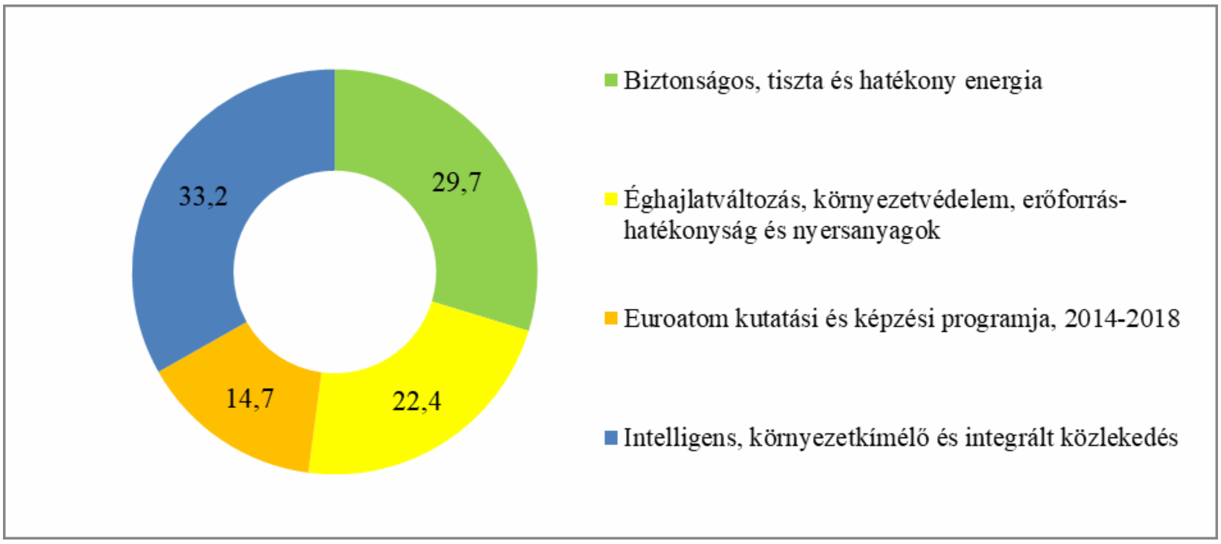

Figure 71 – Distribution of funds awarded to Hungarian participants in clean transition categories of the H2020 programme (%)

Source: European Commission[220]

HU	**EN**

[218] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard

[219] https://cordis.europa.eu/project/rcn/207192_en.html

[220] https://ec.europa.eu/research/horizon2020/index.cfm?pg=country-profiles-detail&ctry=Hungary

Biztonságos, tiszta és hatékony energia	Secure, clean and efficient energy
Éghajlatváltozás, környezetvédelem, erőforrás-hatékonyság és nyersanyagok	Climate action, environment, resource efficiency and raw materials
Euratom kutatási és képzési program, 2014-2018	Euratom Research and Training Programme, 2014-2018
Intelligens, környezetkímélő és integrált közlekedés	Smart, green and integrated transport

In the relevant period, projects in the category of 'smart, green and integrated transport' were dominant, but projects in the 'secure, clean and efficient energy' category were also well represented.

The experience of the **Hungarian Investment Promotion Agency** (HIPA) can also support determining the status of clean energy technologies. In 2014, the HIPA was involved in 60 awarded investment projects. The total value of the investments equalled 1.662 billion EUR. Based on projects of the year 2014, around one half of investment volume was related to the automotive industry (868.14 m EUR). **The second largest volume of investment targeted the renewable energy sector (199 m EUR).**[221] **The HIPA notes that in the field of electromobility – a technology of the near future – Hungary has a special position not only in the region, but in the whole of Europe.** Hungary is not only leading in major R&D capacities relating to electric power trains (AVL, Bosch, Thyssenkrupp), but is also top-ranked in battery manufacturing; among the five largest Asian companies manufacturing batteries for electric vehicles, three chose Hungary as the seat of their European manufacturing centres: Samsung SDI, SK Innovation and GS Yuasa. After the above decisions, suppliers of major producers are also targeting Hungary (e.g. Bumchun, Doosan, INZI Controls, Shinheung, Toray).[222]

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

R&D financing

In 2018 the amount of Hungarian R&D expenditures (public and private) exceeded HUF 654 billion, amounting to 1.53 % of the GDP. In the same year a little over HUF 129 billion was spent on R&D from R&D targeted funds of the State budget.[223] **In 2018, 4.4 % of public R&D expenditures were directly related to energy**; this ratio was 2.1 % for total R&D expenditures (including private expenditures). In the

[221] HIPA (2015): Hungarian investment promotion is also successful in a regional comparison. Press release. Budapest, 20 January 2015.

[222] https://hipa.hu/hu_HU/az-e-mobilitas-teruleten-is-komoly-lehetosegek-varnak-juthatnak-a-magyar-beszallitokra

[223] http://www.ksh.hu

relevant year, electricity, gas, steam supply and air conditioning accounted for one tenth of total energy R&D.[224]

Only estimates can be used for assessing private RDI investments. According to a report[225] also serving as a basis for a 2017 Commission report, in 2013 (last available year) the value of private investments serving the research and technological development priority areas of the EU equalled 31 million EUR (0.2 % of similar private investments in the EU).

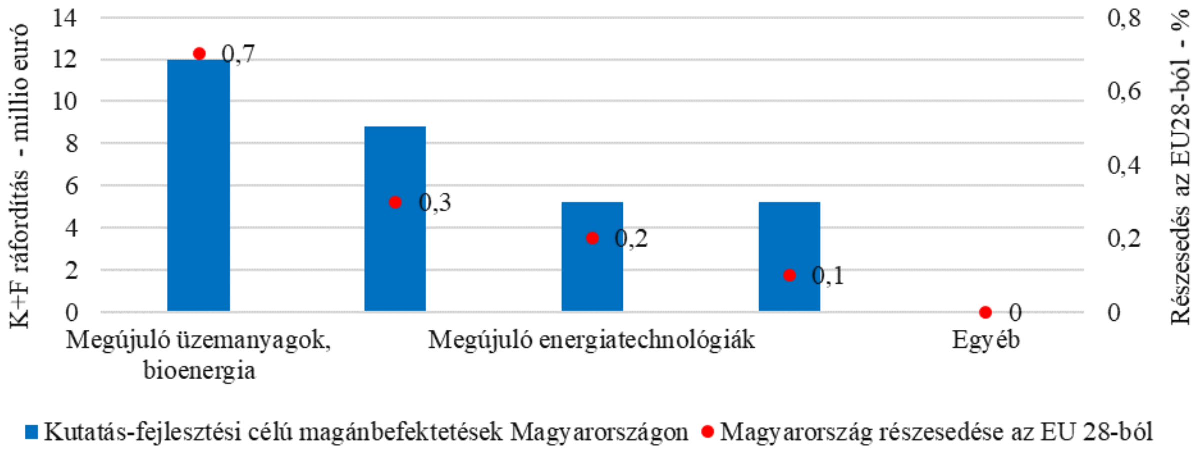

Figure 72 – Distribution of R&D private investments covering SET Plan activity in 2013

Source: JRC Science Hub – European Commission (2017). JRC. Science for Policy Report. Energy R&I financing and patenting trends in the EU. Country dashboards 2017 edition. (2017). p. 34.[226]

HU	EN
K+F ráfordítás – millió euró	R&D expenditures – m EUR
Megújuló üzemanyagok, bioenergia	Renewable fuels, bioenergy
Megújuló energiatechnológiák	Renewable energy technologies
Egyéb	Other
Részesedés az EU28-ból - %	Share within EU28 – %
Kutatás-fejlesztési célú magánbefektetések Magyarországon	R&D private investments in Hungary
Magyarország részesedése az EU28-ból	Hungary's share within EU28

[224] A further breakdown is not available.

[225] JRC Science Hub – European Commission (2017). JRC. Science for Policy Report. Energy R&I financing and patenting trends in the EU. Country dashboards 2017 edition. (2017). https://ec.europa.eu/jrc

[226] https://ec.europa.eu/jrc

The focus was on sustainable transport, accounting for 53 % of such investments. The above segment was followed by development investments in efficient systems (28 %). The report estimated the share of renewable energy sources at 17 %.

Staff size in R&D

A database is not available for the size of R&D staff exclusively focussing on energy development. The Central Statistical Office (CSO) only aggregates the number of researchers at companies classified in the category of electricity, gas and steam supply, air conditioning. In 2018 there were only 62 researchers, developers employed full-time in this field. In Hungary data relating to research staff size are collected mainly in the breakdown of scientific disciplines (and not industrial sectors).

The background to RDI in energy is primarily, but not exclusively based on researchers working in the fields of technology and natural sciences. In 2018, 17 902 researchers in technology and 10 870 researchers in natural sciences were registered. Results in a given scientific field can be utilised in several economic sectors.

Patent data

The table below aggregates data on patents registered in Hungary in relation to low CO_2 emissions energy technologies.

Technological fields, technologies	Number of Hungarian patent applications					European patents validated in Hungary					Applications with definitive patent protection on 24.10.2019
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	
Wind energy	3	2	2	1	2	0	0	0	0	0	11
Solar and geothermal energy	7	7	1	0	1	2	1	0	0	0	48
Sea water energy	1	0	1	0	1	0	0	0	0	0	4
Waterpower	3	1	0	0	1	0	0	0	0	0	6
Biomass	1	0	0	0	1	0	0	0	0	0	12
Waste recovery for energy purposes	12	7	1	0	2	3	1	0	0	0	92
Automotive technologies	0	7	1	3	1	6	0	0	0	0	41
Energy efficiency	4	2	1	0	0	1	0	0	0	1	120
Storage, battery technology	1	1	0	0	0	4	1	0	0	0	14
Other technologies relevant to climate change (capture of methane, nuclear energy)	1	0	0	0	1	1	0	0	0	0	69

Table 41 – Data on patents registered in Hungary in relation to low CO_2 emissions energy technologies (2014-2018)[227]

Source: Hungarian Intellectual Property Office

The international comparison is based on the number of applications received by the European Patent Office. Source of data is the OECD, which aggregates patents relating to environment and clean energy.

[227] The table is meaningful only horizontally, as a specific invention may simultaneously belong to several technological fields.

		World	OECD	EU28	CZ	PL	SK	HU	Share of Hungary within registered European (EU28) patents (%)
	Total patents	127 623	119 417	52 500	126.0	228.2	27.7	68.2	0.1
Patents relating to environment and clean energy	**Share of patents relating to environment and clean energy within total patents**	10	10	11	6.3	9.2	31.3	14.9	0.2
	Climate change mitigating technologies relating to buildings	1 345	1 269	631	2.0	7.0	0.0	3.7	0.6
	Technologies aimed at mitigating the effects of climate change in relation to the production, transmission and distribution of energy	3 773	3 623	1 724	2.0	3.0	1.0	3.7	0.2
	GHG capture, storage, separation or disposal	201	195	70	0.0	2.0	0.0	0.5	0.7
	Environmental management	3 863	3 737	1 869	2.0	8.0	4.0	4.0	0.2
	Climate change mitigating technologies related to transport	4 090	4 004	1 580	1.0	0.0	0.0	2.0	0.1
	Adaptation technologies related to water	649	628	283	1.0	0.0	0.7	1.0	0.4
	Climate change mitigating technologies in the production, processing of goods	1 730	1 600	777	3.0	4.0	1.0	1.0	0.1
	Climate change mitigating technologies related to waste water treatment or waste management	437	409	238	2.0	1.0	4.0	4.0	1.7

Table 42 – Number of patents relating to environment and clean energy registered by the EPO[228] in 2018

Source: OECD[229]

iii. Breakdown of current price elements that make up the main three price components (energy, network, taxes/levies)

Electricity prices

Owing to price controls, Hungarian retail electricity prices are among the lowest in the European

[228] European Patent Office

[229] https://stats.oecd.org

Union. The second lowest retail electricity price – behind Bulgaria – was registered in Hungary in 2018. The energy fee (40.2 %) and network access fee (38.6 %) account for the largest share of retail electricity prices. The tax component in Hungary is very low (21.2 %).

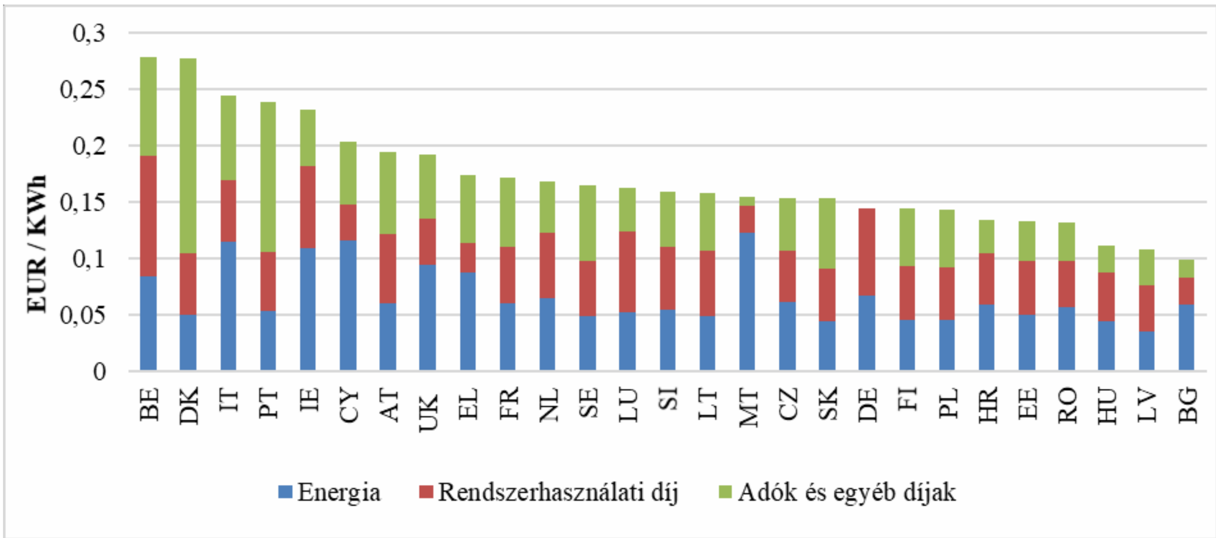

Figure 73 – Household electricity prices in 2018 (all consumption bands)

Source: Eurostat

HU	**EN**
Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

On the retail market, industrial (non-household) electricity prices are significantly lower than household prices. The figures below illustrate differences in price composition among Member States.

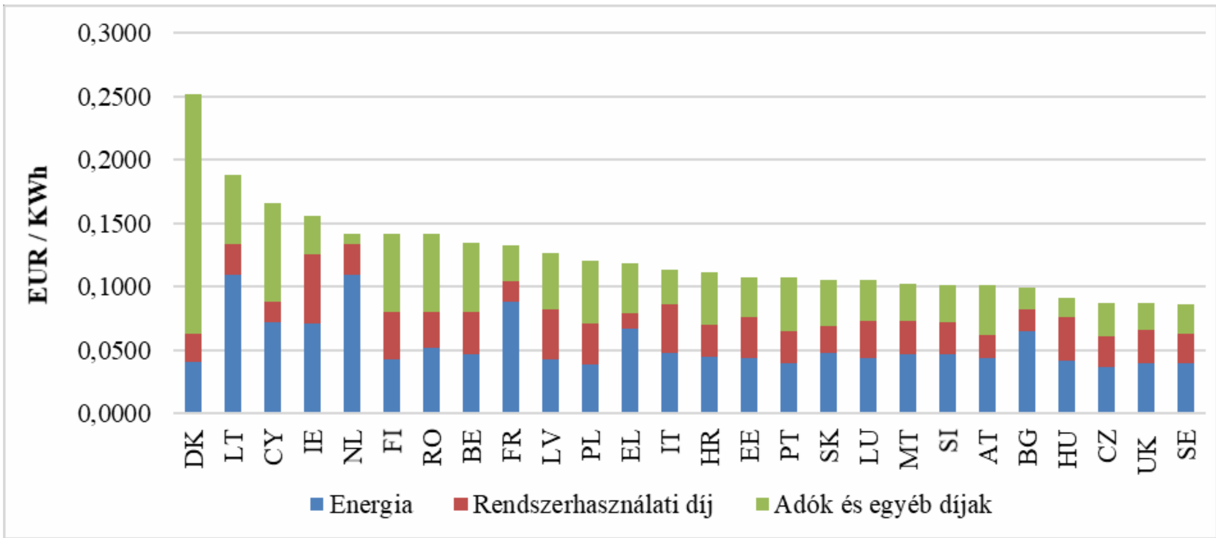

Figure 74 – Industrial electricity prices in the medium consumption category*, 2018*: consumption category: 500-1 999 MWh

Source: Eurostat

HU	**EN**
Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

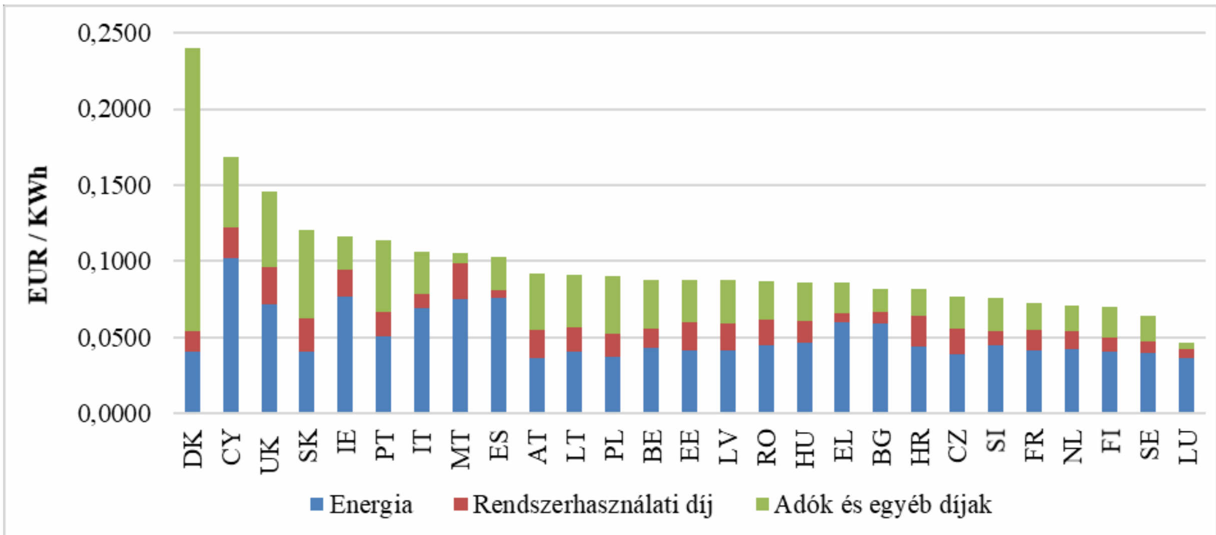

Figure 75 – Industrial electricity prices in the high consumption category, 2018[230]

Source: Eurostat

[230] consumption category: 20 000–69 999 MWh

HU	EN
Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

The main price component for industrial operators is the price of energy (as product) itself, mainly in relation to large consumers.

The taxes and levies on electricity are low for industrial consumers for competitiveness reasons, and the share of the payable network access fee is also lower compared to retail prices.

Price of natural gas

While electricity prices are partly determined by fossil fuel prices (together with other, typically national or regional price factors), natural gas prices are based exclusively on global fossil fuel – including oil – prices.

Owing to price controls, **Hungarian retail natural gas prices are among the lowest in Europe.** In 2018 prices were lower only in Romania. Taking into account that most Hungarian households heat with natural gas, a low tax component is essential. Retail prices are therefore determined to a significant degree by wholesale product prices. In Hungary the price of energy makes up one half of the gas price. In 2018 the network access fee and taxes accounted for 26 % and 21 % of the price, respectively.

The figure below shows components of the retail natural gas price.

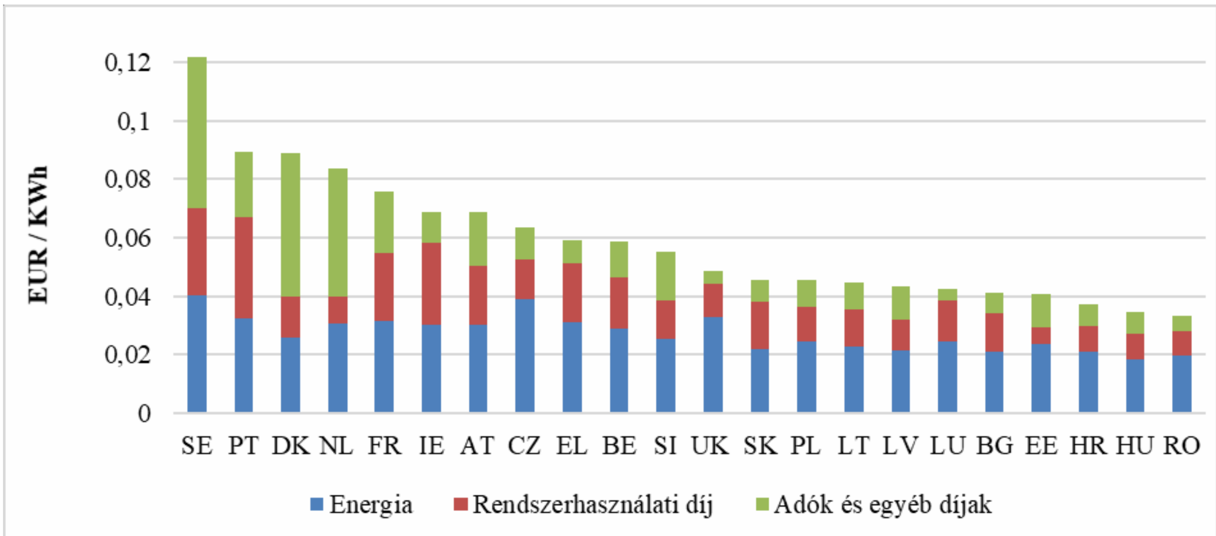

Figure 76 – Household gas prices in 2018 (all consumption bands)

Source: Eurostat

HU	EN

Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

The figure below shows natural gas prices paid by medium-sized and large industrial companies.

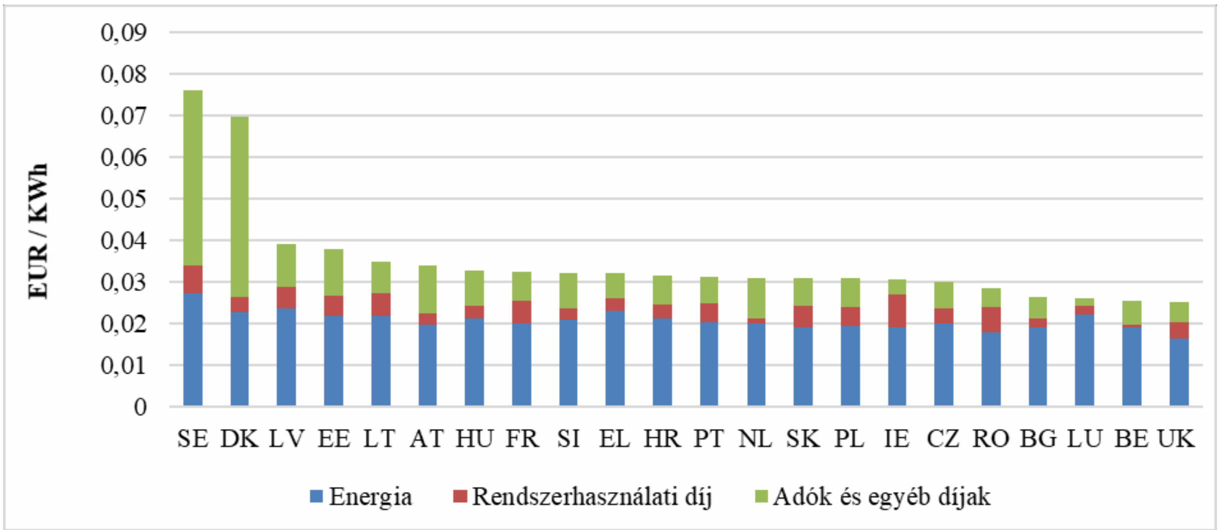

Figure 77 – Gas prices of medium-sized industrial operators in 2018[231]

Source: Eurostat

HU	EN
Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

[231] consumption category: 10 000 GJ–99 999 GJ

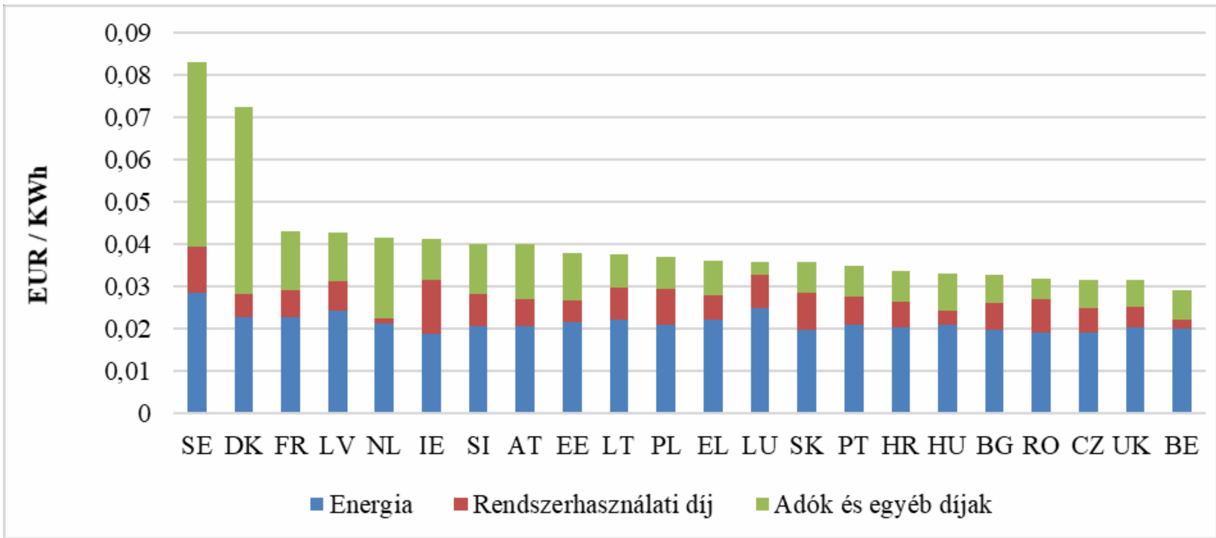

Figure 78 – Gas prices of large industrial operators in 2018[232]

Source: Eurostat

HU	EN
Energia	Energy
Rendszerhasználati díj	Network access fee
Adók és egyéb díjak	Taxes and other fees

iv. Description of energy subsidies, including for fossil fuels

Efficient renewable subsidies also available to alternative technologies

The feed-in system (FIS) was introduced to encourage electricity generation from renewable energy sources and waste, where electricity may be sold with a statutory feed-in tariff that is higher than the market price. Due to legislative changes, however, new FIS subsidy eligibility is no longer granted for applications lodged after 31 December 2016.

The REAS scheme, serving the subsidisation of electricity generated from renewable energy sources[233], entered into effect on 1 January 2017; it was extended and modified as a result of legislative changes in October and November of 2017. Chapter 3.2.1 provides information on the REAS.

Financing programmes of the EU relating to renewable energy and the NRDI Fund financed by Hungary indirectly support investments in the sector (for details see point i. of this chapter). The Warm Home

[232] consumption category: 100 000 GJ–999 999 GJ

[233] Decree No 13/2017 of 8 November 2017 of the HEA on operating aid provided for electricity generated from renewable energy sources.

Programme is also worth noting, which has so far supported Hungarian households in upgrading building energy performance in the value of around HUF 26 billion.

Fossil fuels do not receive direct subsidies in Hungary. Products and services on the market receive indirect subsidies. Subsidies provided to support specific sectors and social groups are justified in the interests of society as a whole and are compliant with legal requirements in force. The level of indirect fossil fuel subsidies in Hungary (subsidies as a percentage of tax revenues) approximate the OECD average and slightly fall short of the average of European OECD member states.

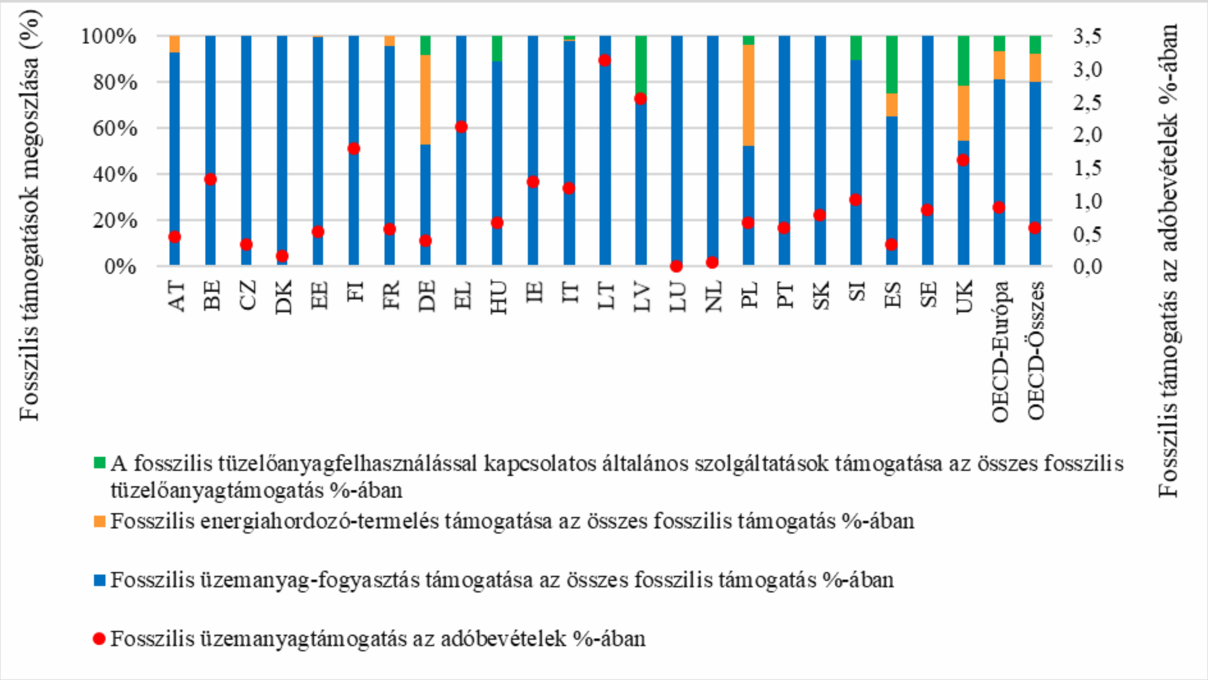

Figure 79 – Fossil fuel subsidies, 2018

Source: OECD[234]

HU	**EN**
Fosszilis támogatások megoszlása (%)	Distribution of fossil fuel subsidies (%)
Fosszilis támogatás az adóbevételek %-ában	Fossil fuel subsidies in % of tax revenue
OECD-Európa	OECD – Europe
OECD-Összes	OECD – All
A fosszilis tüzelöanyagfelhasználással kapcsolatos általános szolgáltatások	Subsidisation of general services relating to the use of fossil fuels in % of total

[234] https://stats.oecd.org/

támogatása az összes fosszilis g tüzelőanyagtámogatás %-ában	fossil fuel subsidies
Fosszilis energiahordozó-termelés támogatása az összes fosszilis támogatás %-ában	Subsidisation of fossil fuel production in % of total fossil fuel subsidies
Fosszilis üzemanyag-fogyasztás támogatása az összes fosszilis támogatás %-ában	Subsidisation of fossil fuel consumption in % of total fossil fuel subsidies
Fosszilis üzemanyagtámogatás az adóbevételek %-ában	Fossil fuel subsidies in % of tax revenue

5. IMPACT ASSESSMENT OF PLANNED POLICIES AND MEASURES

5.1. Effects of planned policies and measures described in Section 3 on energy systems 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.

GHG emissions

Summary

Under the WAM scenario, GHG emissions will significantly decline by 2040. The rate of the decrease will be 8 % between 2017 and 2030 and roughly 17 % between 2017 and 2040. Thus, under the WAM scenario, a **total decrease of 7 600 kt** CO_{2eq} **is expected** by 2040, which would realise the targeted 40 % reduction **over the level in 1990.**

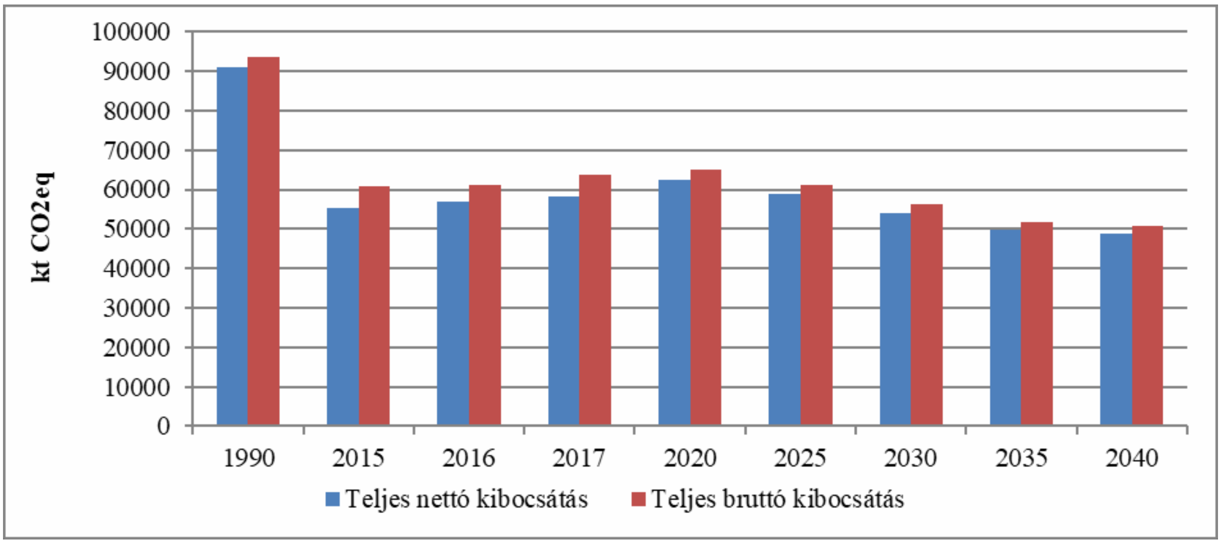

Figure 80 – GHG emissions with additional policies and measures, 1990–2040 (kt CO_{2eq})

Source of actual data: National Inventory Submission, 2019

HU	EN
Teljes nettó kibocsátás	Total net emissions
Teljes bruttó kibocsátás	Total gross emissions

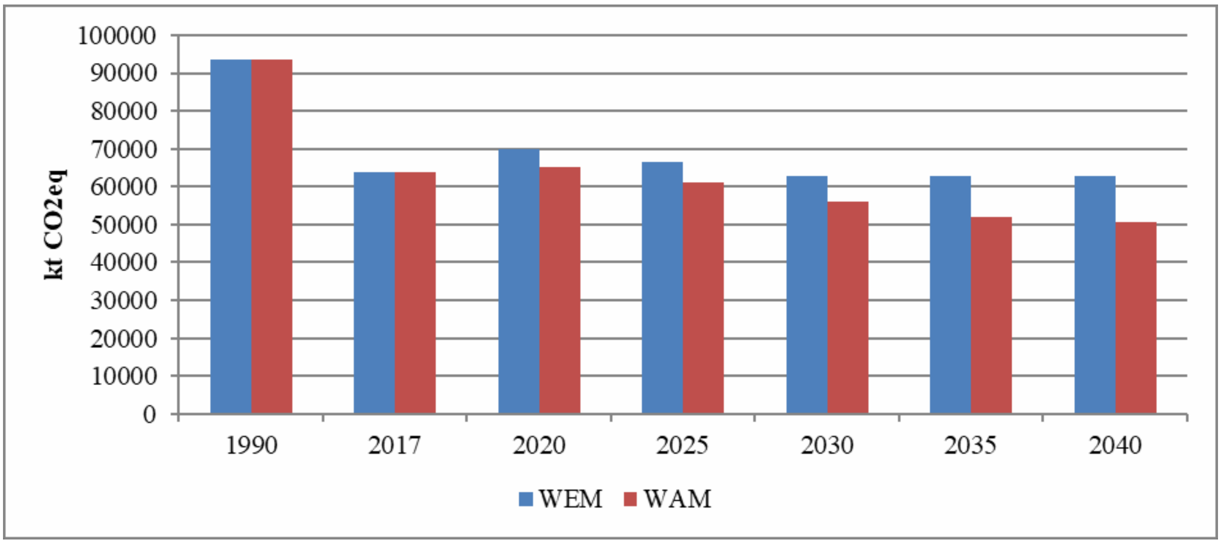

Figure 81 – GHG emissions under the WEM and WAM scenarios

Source of actual data: National Inventory Submission, 2019

CO_2 **will remain the main GHG, but its emission will fall by 10 % between 2017 and 2030.** By 2030, CH_4 emissions are expected to drop by 12 %, N2O emissions by 8 % and F-gas emissions by 73.4 %. NF_3 is not expected to appear in the Hungarian inventory.

Under the WAM scenario, **emissions under the EU ETS will decrease by 7.5 % by 2030 over the value in 2017,** while **emissions under the ESD/ESR will decline by 14.1 % during the same period.**

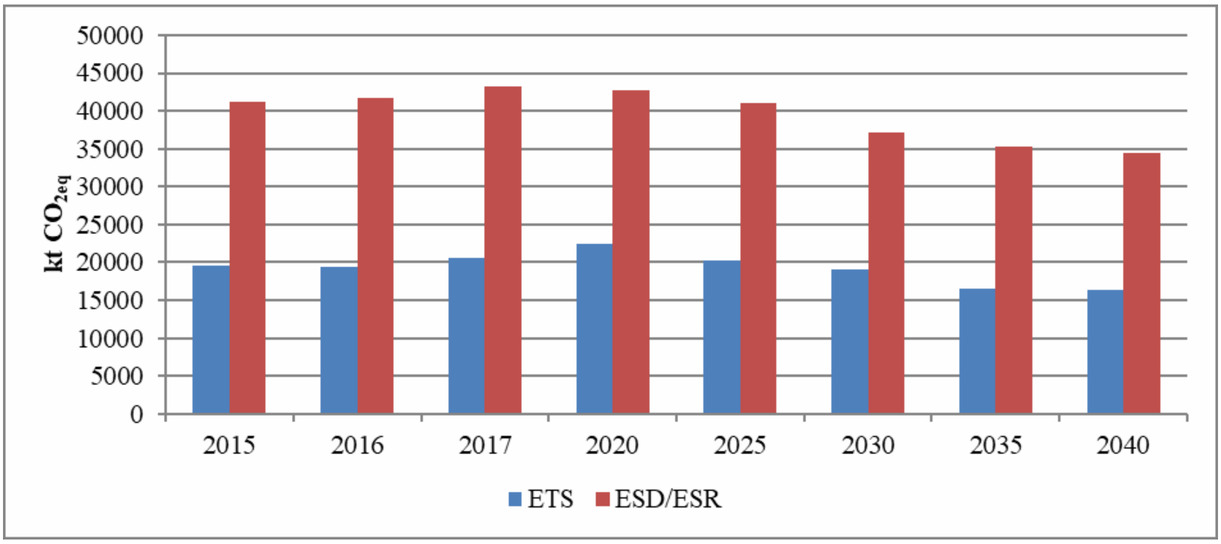

Figure 82 – ETS and ESR emissions with additional policies and measures, 2015-2040

Source of actual data: National Inventory Submission, 2019

The LULUCF sector will remain a net sink, but CO_2 capture will decrease by 63 % by 2030.

Energy

Under the WAM scenario, GHG emissions **from energy sources** will significantly decline **by 2040**. GHG emissions will fall by more than 12 % by 2030 over the year 2017, and overall by almost 25 % by 2040. Thus, with additional measures, by 2040 GHG emissions **will decrease** overall by 5 700 kt CO_{2eq}.

In 2017, mainly the energy industry (30.2 %), transport (28.5 %), households (18.6 %) and industry (10.7 %) contributed to energy emissions. Under the WAM scenario, **by 2040 the individual sectors' contribution to total emission will significantly change.**

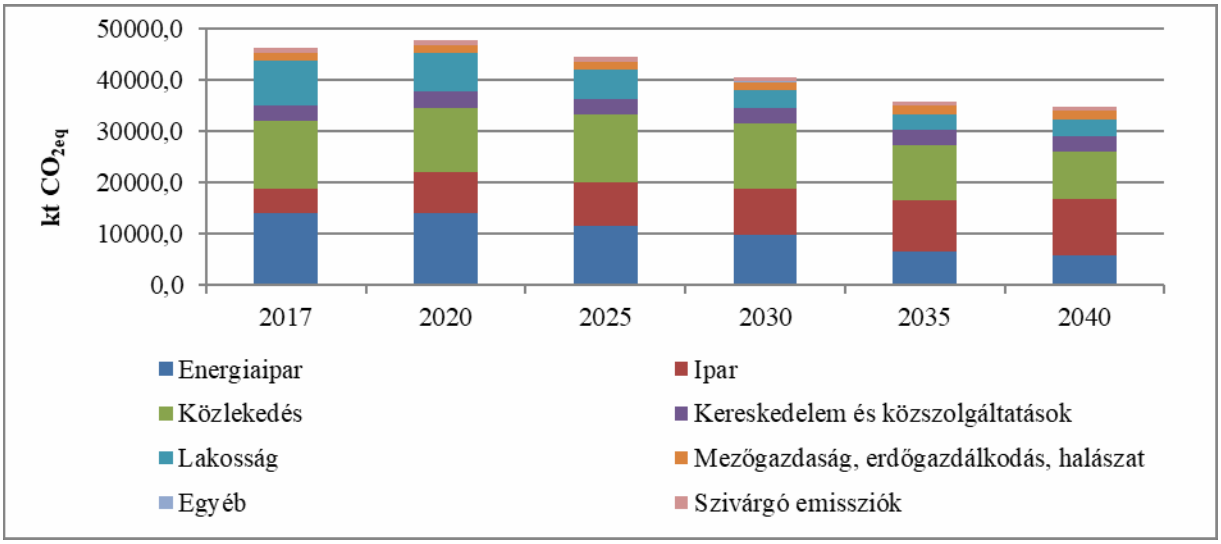

Figure 83 – GHG emissions by sector, under the WAM scenario, kt CO_{2eq}

Source of actual data: National Inventory Submission, 2019

HU	**EN**
Energiaipar	Energy industry
Közlekedés	Transport
Lakosság	Retail
Egyéb	Other
Ipar	Industry
Kereskedelem és közszolgáltatások	Commerce and public services
Mezőgazdaság, erdőgazdálkodás, halászat	Agriculture, forestry and fishery
Szivárgó emissziók	Bleed emissions

Among the key sectors, by 2030 the transport sector will become the largest emitter, maintaining its currently high share (28.7 %). The **largest increase** in the amount and share of **GHG emissions is expected in the industry by 2040.** While emissions will increase by 85 % by 2030 over the value for 2017, an increase of around 120 % is expected between 2017 and 2040. The above is attributable to the forecast of rising demand, to be satisfied by the industrial sector mainly with oil and coal. At the same time, **a sharp decline in GHG emissions** (similarly to the WEM scenario) **is expected in the energy industry:** 30 % by 2030 and 58 % by 2040. Thus, in 2040 the energy industry is expected to only account for 17 % of energy sector emissions. The **decline in emissions is expected to be largest in the retail segment**, mainly attributable to falling natural gas consumption and the increasing use of electricity and renewable energy sources. Emission will sharply decline up to 2030, by 60 % compared to 2017, but the rate of the decline will significantly slow, reaching 63 % in 2040. The sector will account for around 9 % of total GHG emissions in 2030 and 2040.

Non-energy sectors

In relation to the agriculture and waste sectors, the WAM scenario does not include actual additional measures; the difference between the WEM and WAM is attributable to emissions reduction required in the sectors.

Renewable energy

In terms of the future, as opposed to the WEM scenario, under the WAM scenario the share of renewable energy consumption will dynamically grow up to 2030, followed by only moderate growth.

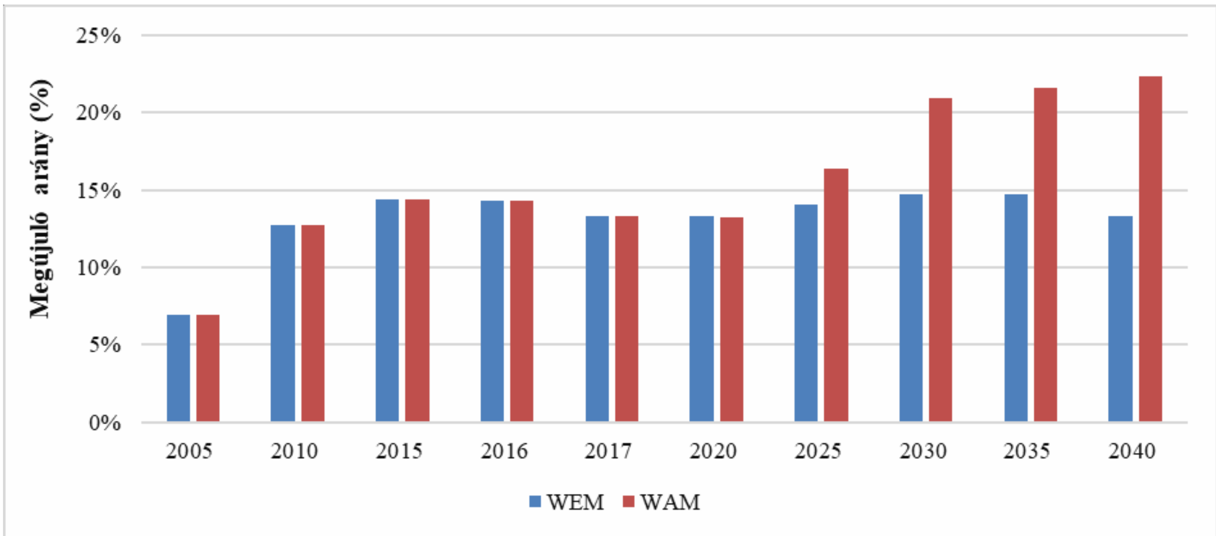

Figure 84 – Share of renewable energy (%) in gross final energy consumption under the WEM and WAM scenarios

Source of actual data: Eurostat

HU	EN

Megújuló arány (%)	Share of renewables (%)

Under the WAM scenario, the share of renewable energy consumption will reach 21 % by 2030, and increase to 22.4 % by 2040. Growth will be linear in the 2020s. The rise in total renewable energy consumption between 2016 and 2030 will exceed 60 %.

The electricity sector is the main engine of the rise in renewable energy consumption. While energy production of the sector based on renewable energy sources amounted to 262 ktoe in 2016, this figure will be more than three and a half times higher in 2030, equalling 970 ktoe. **However, cooling and heating will continue to account for more than two thirds of renewable energy consumption.** The increased share of renewables in the transport sector is highest in the use of second generation biofuels and of electricity on the road, although the latter is registered not in the transport but the electricity sector when assessing the total target.

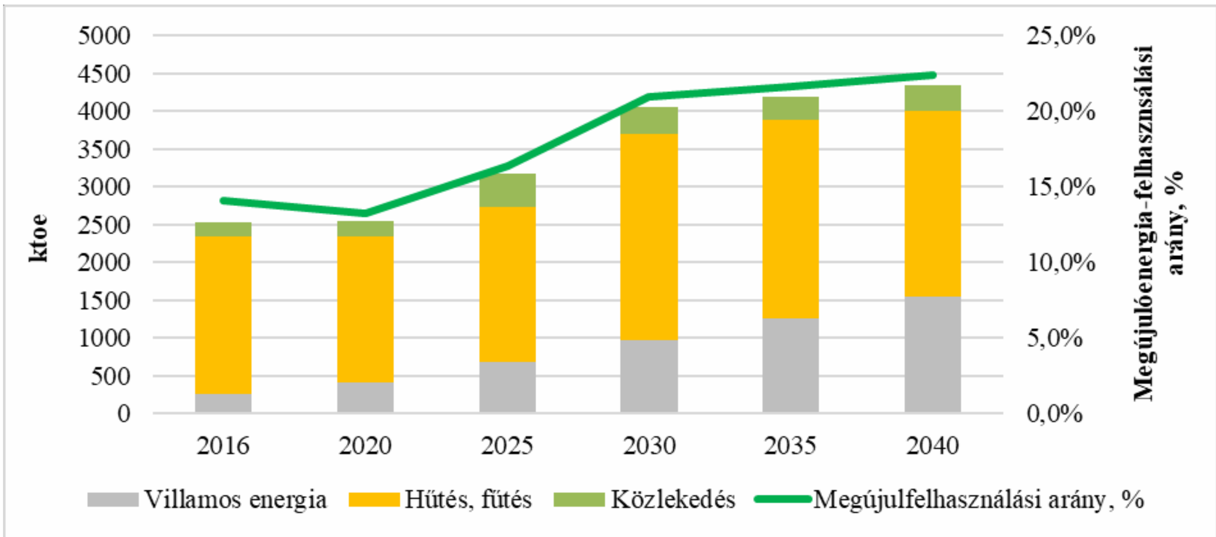

Figure 85 – Consumption of renewable sources of energy in individual sectors (ktoe) and the rate of total renewable energy consumption (%) under the WAM scenario

Source of actual data: Eurostat

HU	**EN**
Villamos energia	Electricity
Hűtés, fűtés	Cooling, heating
Közlekedés	Transport
Megújulfelhasználási arány, %	Share of the use of renewables, %
Megújulóenergia-felhasználási arány, %	Share of the use of renewable energy, %

Since four fifths of total renewable energy consumption was based on biomass in 2016, Hungary **has set the target of diversifying the composition of renewable energy consumption.** By 2030, the dominance of biomass can be reduced with **an upturn in solar energy.** Under the WAM scenario, in parallel with growing use of solar energy, the use of both geothermal and other renewable sources of energy will increase. The use of biomass, however, will still account for more than two thirds of total renewable energy consumption in 2030.

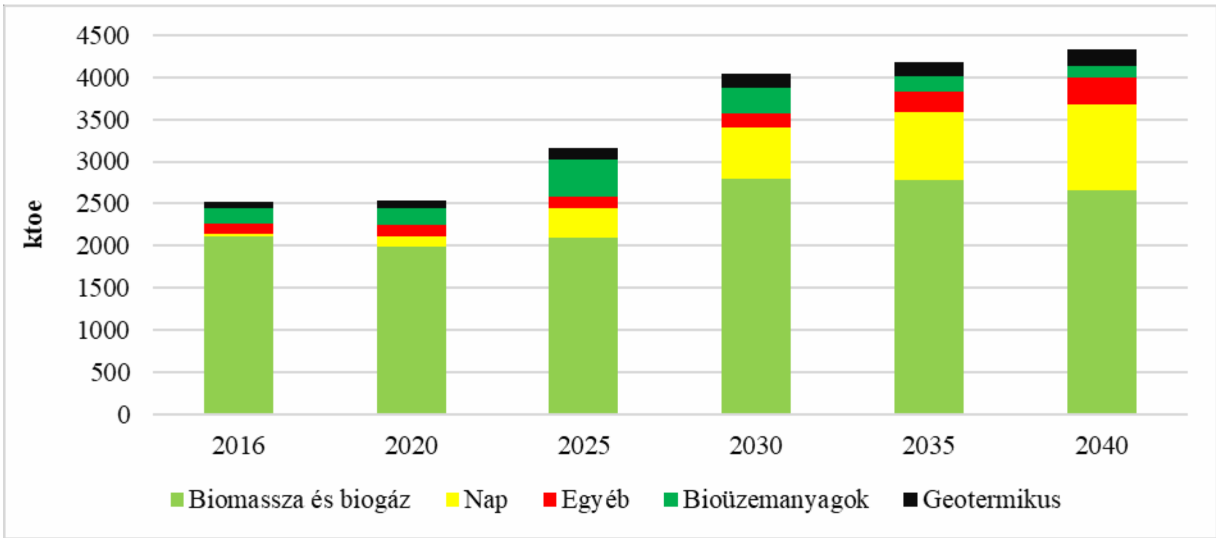

Figure 86 – Use of renewable sources of energy in the breakdown of sources under the WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Biomassza és biogáz	Biomass and biogas
Nap	Solar
Egyéb	Other
Bioüzemanyagok	Biofuels
Geotermikus	Geothermal

Renewable energy consumption in the electricity sector

As a result of additional measures, among regenerative sources of energy, the use of solar energy is expected to increase most in the electricity sector. **The total installed PV capacity of over 1 GW in 2020 will increase to 2.5 GW by 2025, to over 6 GW by 2030 and may approximate even 12 GW by the 2040s.** Thus, with additional measures, the system may have available around 4 000 MW more and over 8 000 MW more PV capacity in 2030 and 2040, respectively, than under the WEM scenario.

Biomass and geothermal capacities are also expected to increase. The biomass waste capacity will increase by around 60 % in 2030 over the level in 2016, followed by a temporary downturn in the level of installed capacity, to be then followed by renewed growth up to 2040. Geothermal capacity is also expected to grow at a moderate pace; Hungary is expecting installed capacity of 60 MW in 2030 and 104 MW in 2040.

Current wind capacity (approximately 330 MW) is expected to be maintained.

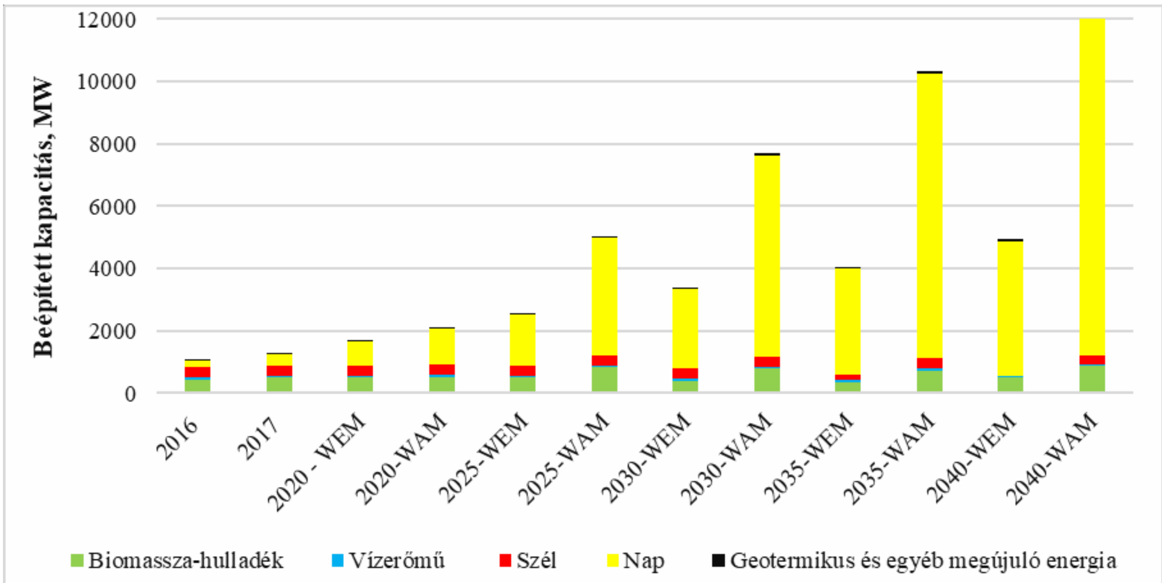

Figure 87 – Installed renewable capacity under the WEM and WAM scenarios, MW

Source of actual data: Eurostat

HU	**EN**
Beépített kapacitás, MW	Installed capacity, MW
Biomassza-hulladék	Biomass waste
Vízerőmű	Hydroelectric
Szél	Wind
Nap	Solar
Geotermikus és egyéb megújuló energia	Geothermal and other renewable energy

In 2016 **electricity from renewable resources** amounted to roughly 3 TWh. **Under the WAM scenario this figure can even rise above 11 TWh by 2030**, and even reach 17 TWh by 2040. Under the WAM scenario Hungarian power plants will be able to produce by around 80 % (5 069 TWh) more renewables based electricity than under the WEM scenario.

Under the WAM scenario, the share of renewable energy within total electricity consumption will increase from 8 % in 2016 to over 21 % in 2030, and exceed 29 % in 2040. Compared to the WEM scenario, this amounts to a 7.7 percentage point and 12 percentage point surplus in 2030 and 2040, respectively.

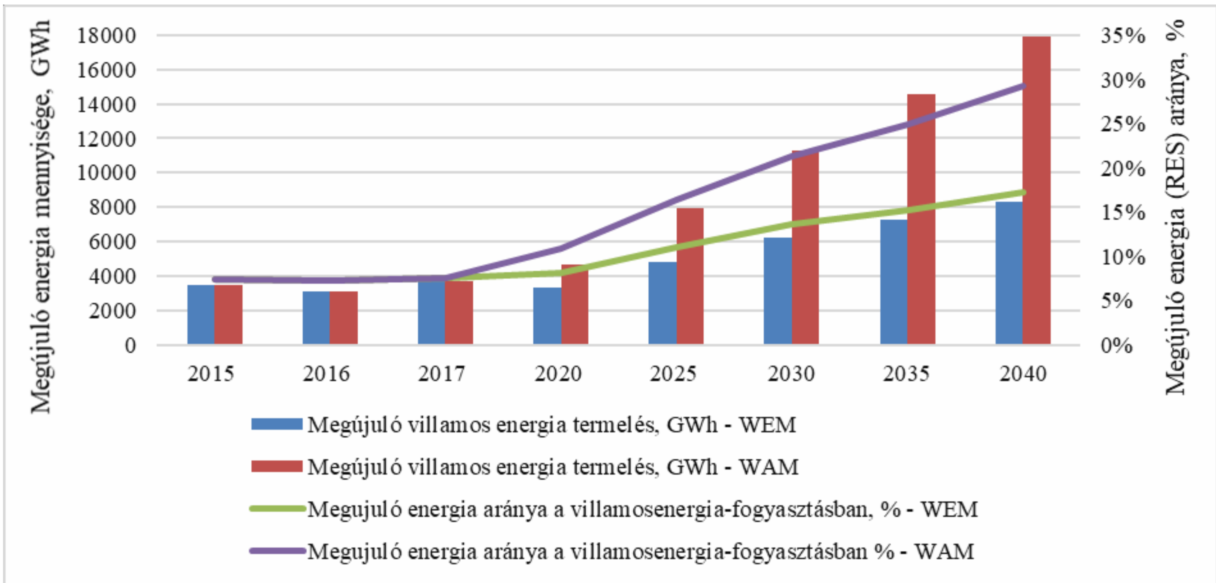

Figure 88 – Electricity generation from renewable sources and share of renewable electricity within consumption (RES-E, %) under the WEM and WAM scenarios, GWh and %

Source of actual data: Eurostat

HU	**EN**
Megújuló energia mennyisége, GWh	Quantity of renewable energy, GWh
Megújuló energia (RES) aránya, %	Share of renewable energy (RES), %
Megújuló villamos energia termelés, GWh – WEM	Renewable electricity generation, GWh – WEM
Megújuló villamos energia termelés, GWh – WAM	Renewable electricity generation, GWh – WAM
Megújuló energia aránya a villamosenergia-fogyasztásban, % - WEM	Share of renewable energy in electricity consumption, % – WEM
Megújuló energia aránya a villamosenergia-fogyasztásban, % - WAM	Share of renewable energy in electricity consumption, % – WAM

The figure below shows the composition of electricity generated from renewable energy sources under the WEM scenario. **Under the WAM scenario the quantity of electricity generated with solar energy will dynamically increase.** In 2030, 58 % of electricity from renewable energy sources will be generated by PV power plants; this share will further increase to 66 % by 2040 (a share of only 7 % in 2016). The share of biomass will decline in parallel from 60 % in 2016 to 29 % in 2030.

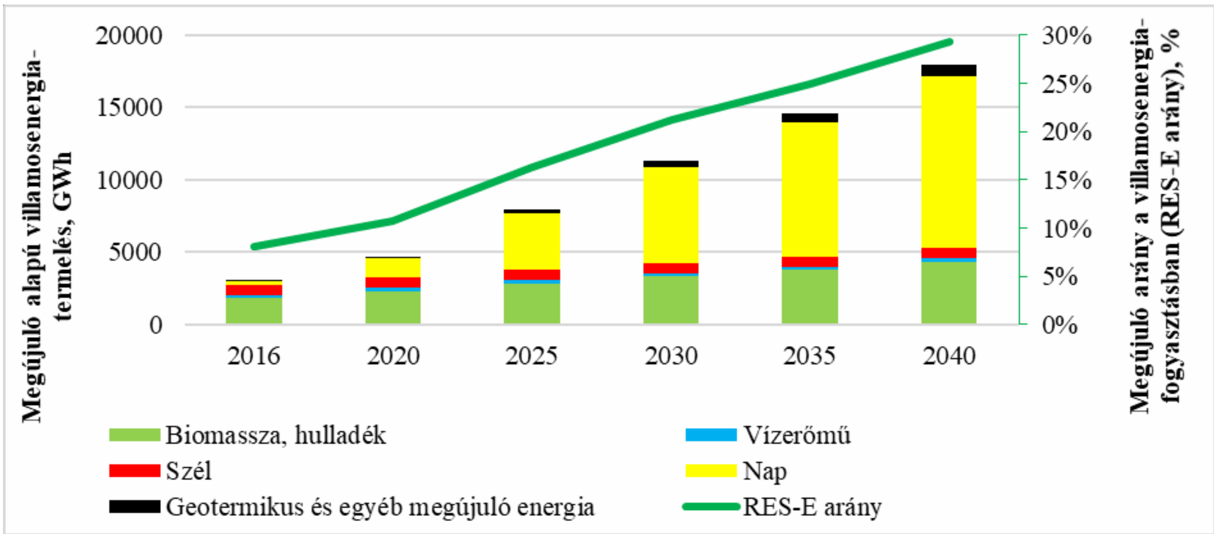

Figure 89 – Electricity generated from renewable sources and share of renewable electricity in consumption (RES-E, %) under the WAM scenario, GWh and %

Source of actual data: Eurostat

HU	EN
Megújuló alapú villamosenergia-termelés, GWh	Electricity generation from renewable sources, GWh
Megújuló arány a villamosenergia-fogyasztásban (RES-E arány), %	Share of renewables in electricity consumption (RES-E rate), %
Biomassza, hulladék	Biomass, waste
Szél	Wind
Geotermikus és egyéb megújuló energia	Geothermal and other renewable energy
Vízierőmű	Hydroelectric power plant
Nap	Solar
RES-E arány	RES-E rate

Under the WAM scenario, the share of renewable energy within total electricity consumption will increase from 8 % in 2016 to over 20 % in 2030, and possibly exceed 29 % in 2040.

Renewable energy consumption in the transport sector:

Currently **biofuels account for the largest share of renewable energy consumption in the transport sector, while electricity consumption in the rail segment is less substantial.** Although the number of electric vehicles has increased recently, they play a minor role in ‘clean’ transport.

Under the WAM scenario, gross final consumption of energy from renewable sources in transport will increase significantly.

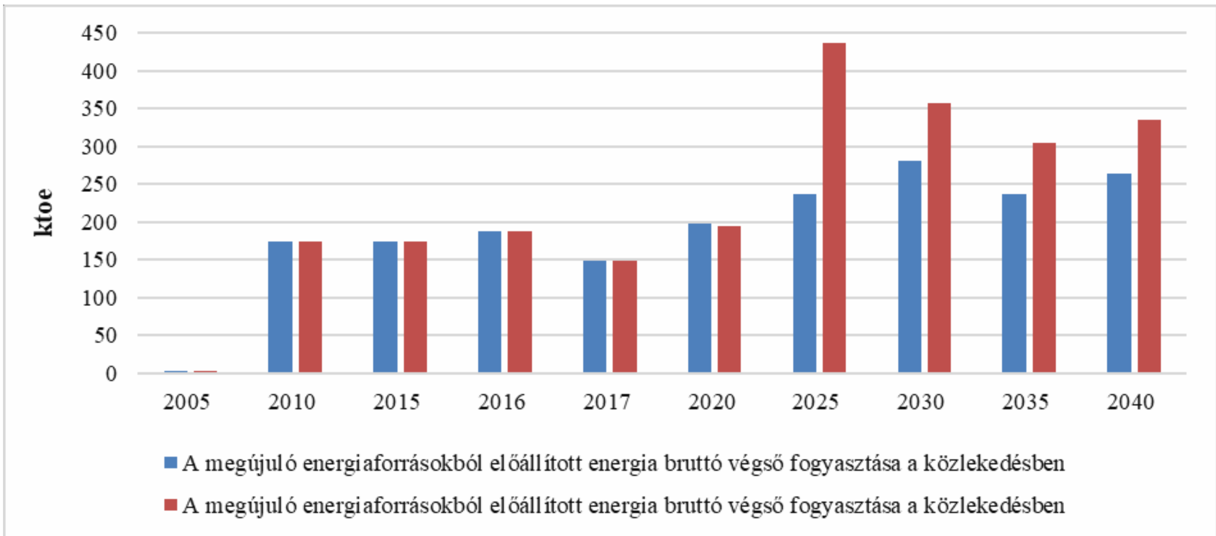

Figure 90 – Renewable energy consumption in the transport sector, and share of renewable energy in transport (RES-T, %), without multipliers, under the WEM and WAM scenarios, ktoe and %

Source of actual data: Eurostat

HU	EN
A megújuló energiaforrásokból előállított energia bruttó végső fogyasztása a közlekedésben	Gross final consumption of energy from renewable sources in transport

To facilitate the comparability of figures before and after the period, from 2020 – in conformity with the Renewable Energy Directive[235] – we are forecasting the figures below with multipliers. Calculation is based on multiplication by one and a half, four and two in relation to renewable energy consumption in the rail segment, road transport and advanced biofuels, respectively. As an additional important methodological change, from 2020 only the share of renewables in the domestic electricity sector may be used for calculation, the EU average may no longer be used. For the calculations, modelling was based on this assumption for the entire period.

The share of renewables in transport – also taking into account multipliers – **equalled 6.3 % in 2016, which will increase to 16.9 % by 2030** as a result of additional measures. This value is 4.2 percentage points

[235] 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).

higher than under the WEM scenario. The higher increase compared to the WEM scenario is attributable to rising electricity consumption in road transport, on the one hand, and the partial replacement of first generation biofuels with second generation biofuels, on the other (second generation biofuels are considered with double weight based on the methodology). **Rising renewable electricity consumption in road transport is partly attributable to the increase in the number of electric cars in absolute value and partly to the expected significant increase in the share of renewable electricity** in the next decades. **This factor also drives the increase of renewable energy consumption in rail transport.** Eligible renewable energy consumption in this subsegment is increasing almost fourfold. **In 2030 advanced biofuels and first generation biofuels** (including consumption of used frying oil) **will account for a 45 % and 20 % share in the sector's renewable energy consumption, respectively.** Hydrogen may also play a major role in transport by the end of the 2020s.

Renewable energy consumption in road transport will account for one quarter of renewable energy consumption in the transport sector.

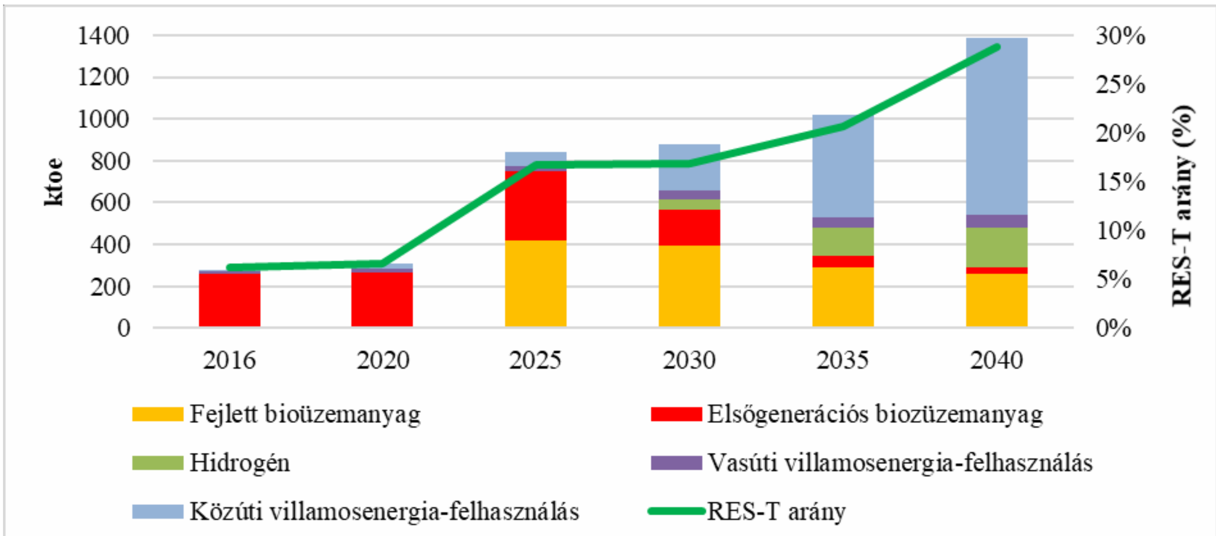

Figure 91 – Renewable energy consumption in the transport sector, and share of renewable energy in transport (RES-T, %), with multipliers and additional measures, ktoe and %

Source of actual data: Eurostat

HU	**EN**
RES-T arány (%)	RES-T rate (%)
Fejlett bioüzemanyag	Advanced biofuel
Hidrogén	Hydrogen
Közúti villamosenergia-felhasználás	Use of electricity in road transport
Elsőgenerációs bioüzemanyag	First generation biofuel

Vasúti villamosenergia-felhasználás	Use of electricity in rail transport
RES-T arány	RES-T rate

Renewable energy consumption in the cooling and heating sector

The share of biomass in the renewable energy consumption of the cooling and heating sector is currently very high. Its share is not expected to change in the long term, either, not even under the WAM scenario.

Biomass based thermal energy production will increase by 28 % between 2016 and 2030, followed by stagnation after 2030. The **quantity of geothermal energy consumption** in this segment **will increase to around 58 % by 2030;** the subsegment's share within total renewable energy consumption, however, will only increase to 5 %. Only minor changes are forecast in relation to other fuels.

Based on the foregoing, **the share of renewable energy consumption in the cooling and heating sector will increase from around 20.7 % currently to 28.7 % by 2030.** The share – without additional measures – is expected to decrease thereafter, equalling 25.5 % in 2040.

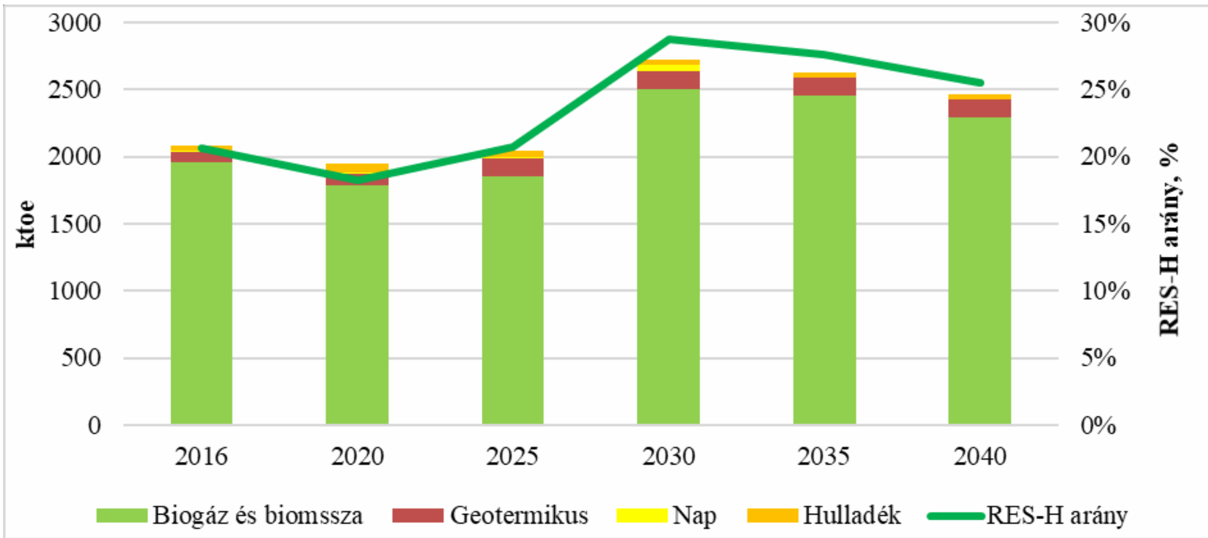

Figure 92 – Renewable energy consumption in the cooling and heating sector (ktoe), and share of renewables (RES-H, %) under the WAM scenario, ktoe, %

Source of actual data: Eurostat

HU	**EN**
RES-H arány, %	RES-H rate, %
Biogáz és biomassza	Biogas and biomass

Geotermikus	Geothermal
Nap	Solar
Hulladék	Waste

Dimension of energy efficiency

Final energy consumption

By implementing all of the new policy measures listed in Chapter 3, significantly more energy savings may be achieved in the **retail sector** than within the current policy framework. **Final energy consumption under the WAM scenario will be 31 % less in 2030 than final energy consumption forecast under the WEM scenario.**

Under the WAM scenario, **as result of implementing the planned additional measures, in 2030 final energy consumption in the retail sector will be one third lower than the value for 2016.**

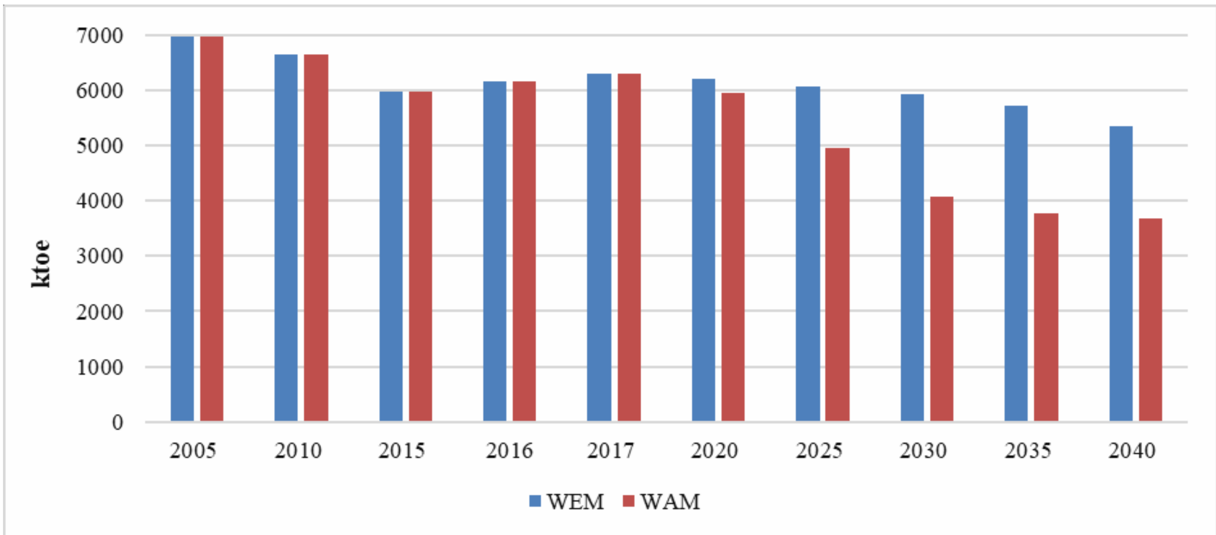

Figure 93 – Comparison of final energy consumption in the retail sector under the WEM and WAM scenarios – impact of new policy measures, ktoe

Source of actual data: Eurostat

Natural gas consumption will decrease most within declining final energy consumption in the retail sector; based on planned measures retail natural gas consumption will fall by around **50 %** between 2016 and 2030 (approximately 2 billion m^3, around 1 500 ktoe). (The share of natural gas within district heat generation also declined significantly; with additional measures the share of natural gas in district heat generation can fall by one half.)

Consumption patterns will significantly change between 2016 and 2030. The **share of natural gas** – 45 %

in 2016 – **will decrease to 32 % by 2030.** The **share of electricity is expected to increase from 15 % to over 28 %.** The share of renewable energy will be at current levels: 27-28 %.

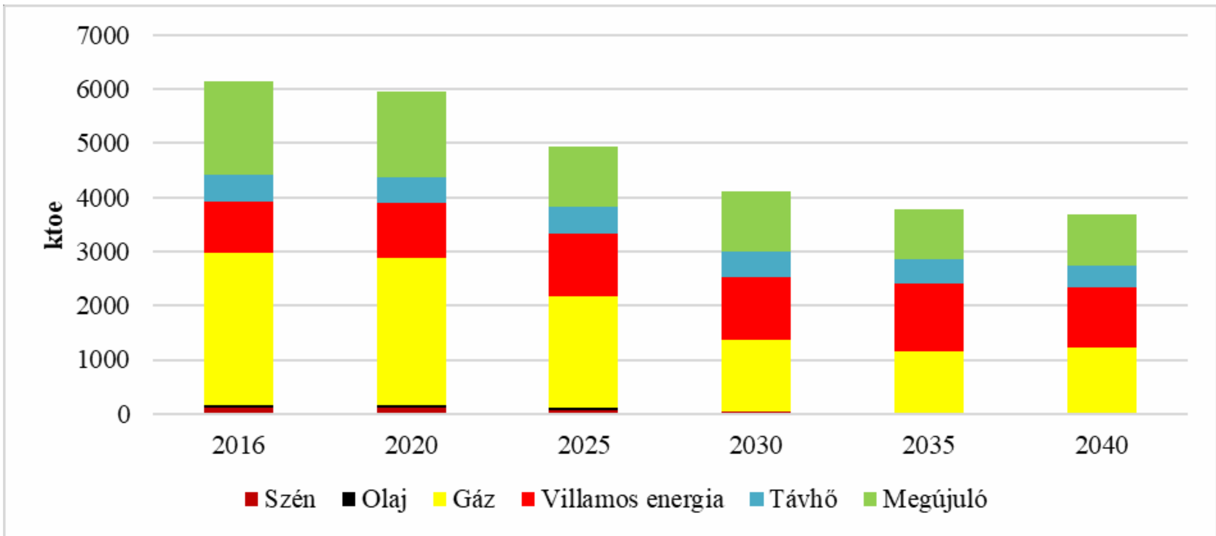

Figure 94 – Projection of retail final energy consumption and change in composition – impact of new policy measures, WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

A **minor increase in final energy consumption in the tertiary / services sector is forecast under both the WEM and WAM scenarios.** A significant difference between forecasts of the two scenarios is expected only in 2040, when additional measures will reduce energy consumption by 4 % compared to the WEM scenario.

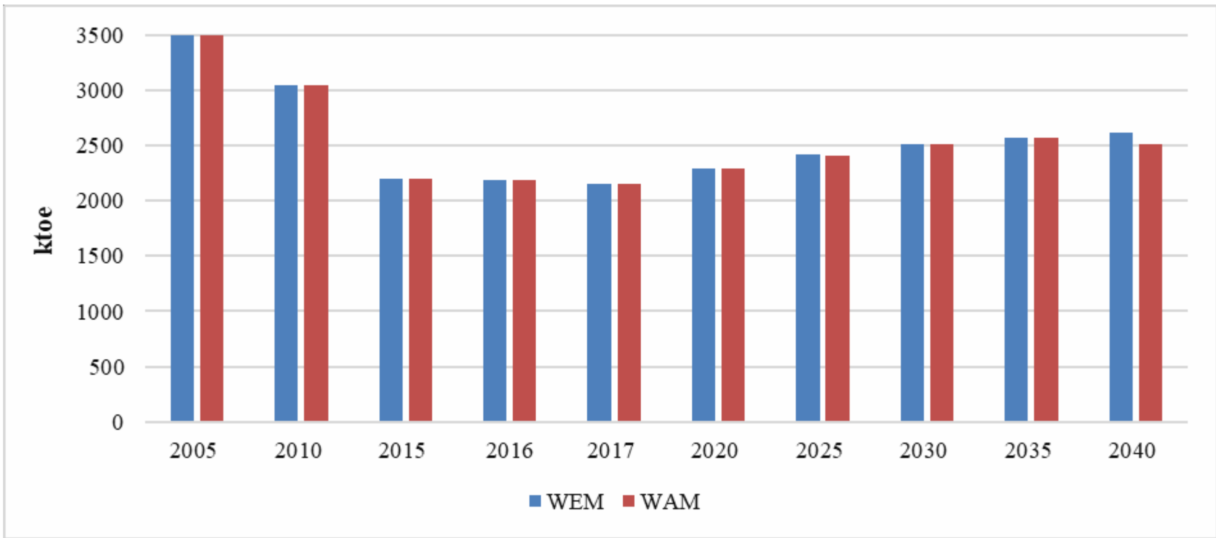

Figure 95 – Comparison of final energy consumption in the tertiary sector under the WEM and WAM scenarios – impact of new policy measures, ktoe

Source of actual data: Eurostat

Under the WAM scenario, the quantity of energy consumed in the services sector will increase by 10.2 % between 2016 and 2030. The **largest increase in quantity and share is forecast in renewable energy consumption** between 2016 and 2030: the rise in renewable energy consumption will reach 435 ktoe during this period, indicating a rise of over 900 % over the year 2016. Electricity consumption will also increase during the same period by 9.8 % (increase of 68 ktoe). A significant decline, however, is expected in natural gas consumption (a decrease of 121 ktoe, 9.9 % over the year 2016) and district heat consumption (decrease of 36 ktoe, 20 % over the year 2016).

As the most important structural change, the share of natural gas will decrease from 56 % in 2016 to 44 % in 2030, with an increase in the share of renewable sources of energy from 2 % to 19 %.

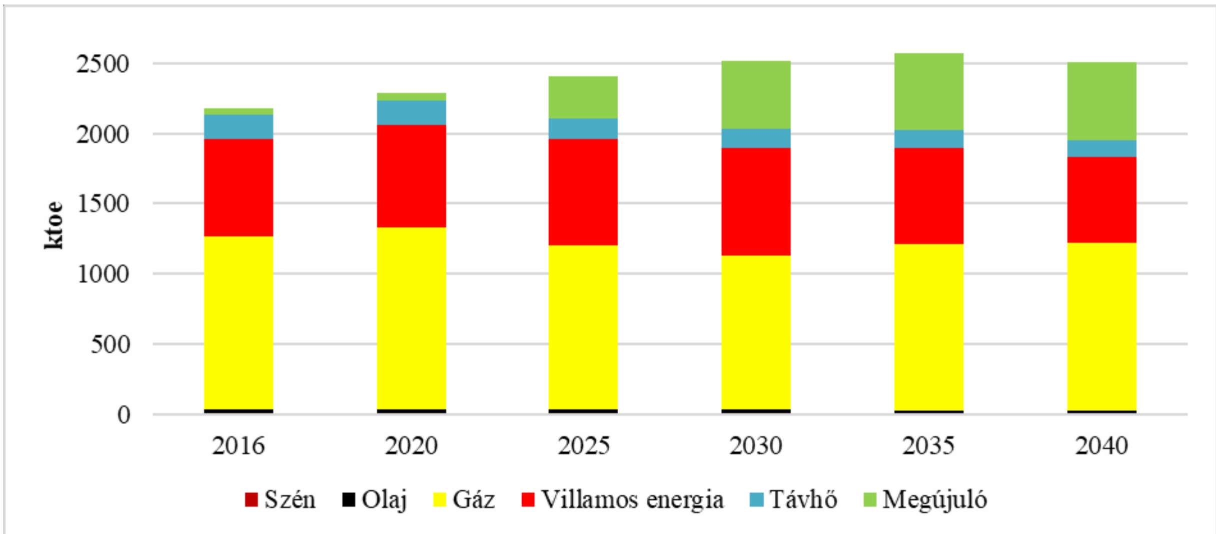

Figure 96 – Projection of final energy consumption in the tertiary sector and change in composition – impact of new policy measures, WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

In the tertiary sector, the **energy consumption of public services will decrease further** as a result of implemented new policy measures, while the energy consumption of market services is expected to increase based on the dynamic growth of added value and related infrastructure.

In relation to the industrial sector, there are no major differences in energy consumption data forecast under the WEM and WAM scenarios. Both the WEM and WAM scenarios **forecast** a significant rise in energy consumption. **Under both scenarios, industrial energy consumption in 2030 will be more than 50 % higher than in 2016.**

The near identity of energy consumption values forecast for 2030 under the two scenarios is attributable to the following factors:

- Firstly, the two scenarios assume identical production patterns and an identical increase in production value, i.e. energy efficiency is the only source of the difference;
- The existing energy efficiency aids have substantial incentivising power;
- The tightening standards, which are mandatory in all EU Member States, and provisions of the Energy Efficiency Directive (2012/27/EU) were already considered in the WEM scenario;
- The new policy measures result in a faster increase in housing construction under the WAM scenario, resulting in higher energy savings in the retail sector, but projecting higher energy consumption resulting from the manufacturing of building materials in Hungary.

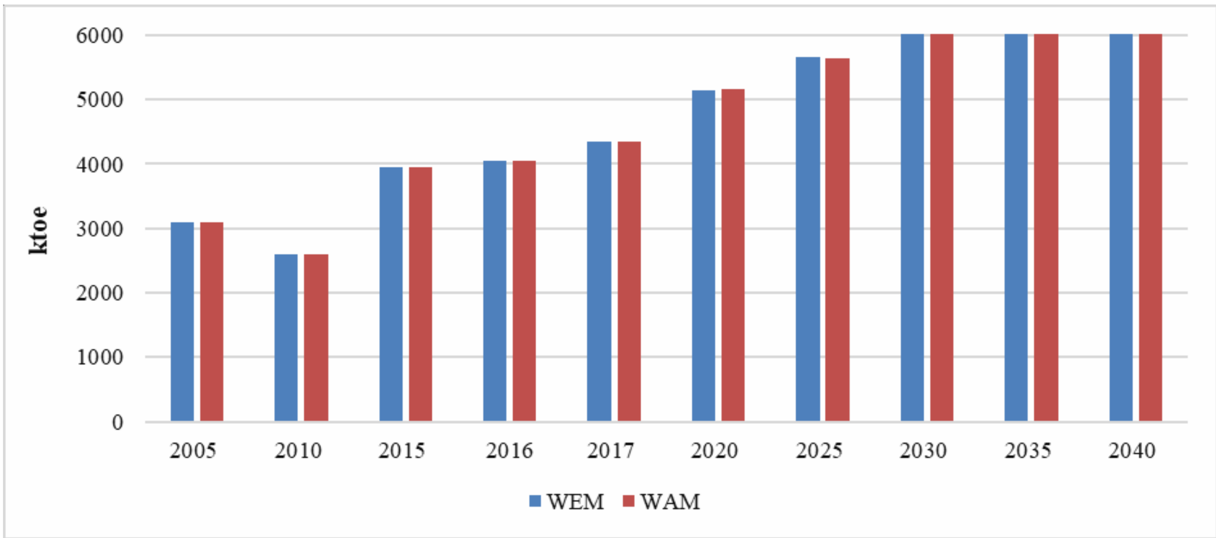

Figure 97 – Comparison of final energy consumption in the tertiary sector under the WEM and WAM scenarios – impact of new policy measures, ktoe

Source of actual data: Eurostat

Upon analysis of the composition of growing **industrial energy consumption, in terms of share, between 2016 and 2030 renewable energy consumption** (74 % increase), **and coal and oil consumption** (67 % increase for both) **are expected to increase at the highest rate. In terms of absolute value, electricity consumption will rise at the highest rate:** Between 2016 and 2030 industrial electricity consumption will rise from 1 369 ktoe to 2 059 ktoe, resulting in 690 ktoe in additional electricity consumption in 2030 over the year 2016.

The extent of change in consumption patterns potentially occurring in the retail or services sector is not expected in industry. As a key change, the share of natural gas consumption within total industrial energy consumption will fall from 31 % to 27 % between 2016 and 2030.

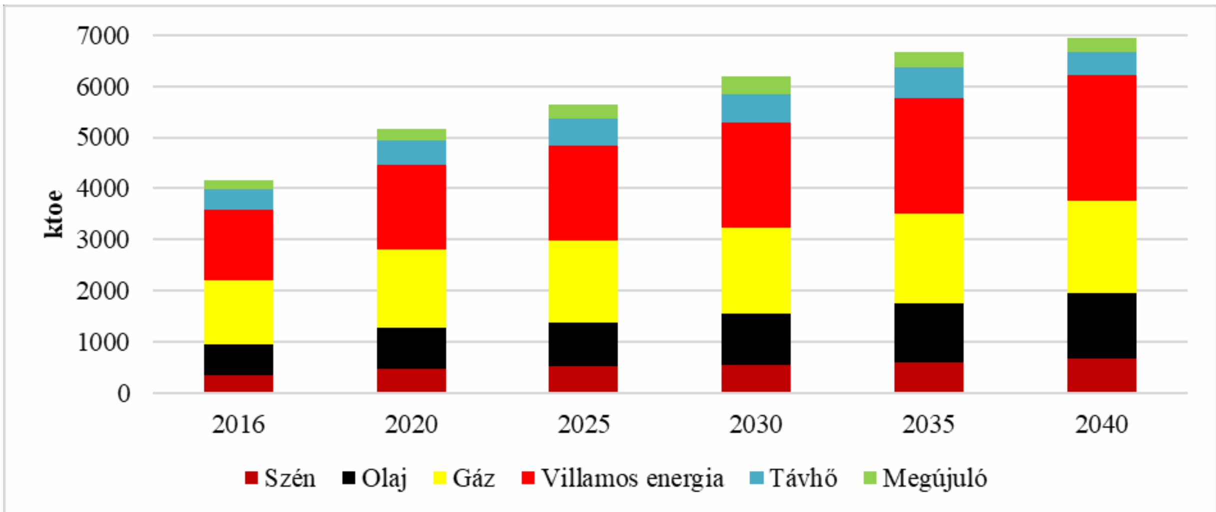

Figure 98 – Projection of final energy consumption in the industrial sector and change in composition – impact of new policy measures, WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

The difference between energy consumption in the **transport sector** in the WEM and WAM scenarios will be approximately 112 ktoe in 2030, i.e. **the new policy measures can reduce energy consumption in transport by 2.6 % compared to the trajectory under the existing measures**.

Upon the combined implementation of the new policy measures – resulting in the faster spread of electric vehicles and a decline in the fuel consumption of motor vehicles with traditional propulsion – the **increase in energy consumption in transport may be reduced to 19.3 % between 2016 and 2030**. (For comparison: the increase is 21.9 % under the WEM scenario.)

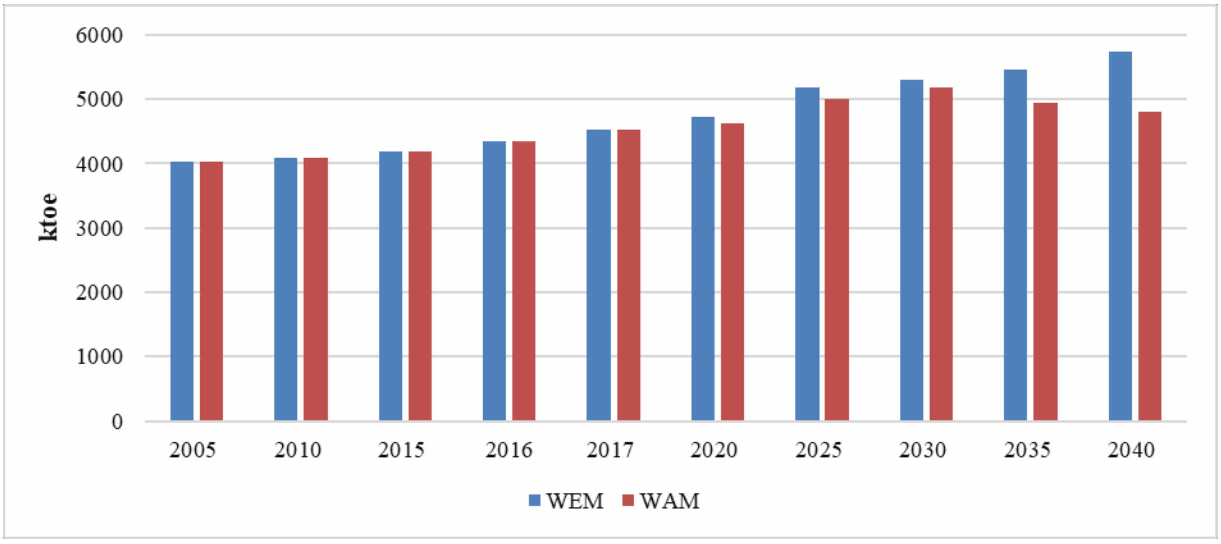

Figure 99 – Comparison of final energy consumption in transport under the WEM and WAM scenarios – impact of new policy measures, ktoe

Source of actual data: Eurostat

Under the WAM scenario, the share of the energy value of oil-based fuels may be reduced to 75 % by 2030 in terms of the entire transport sector.

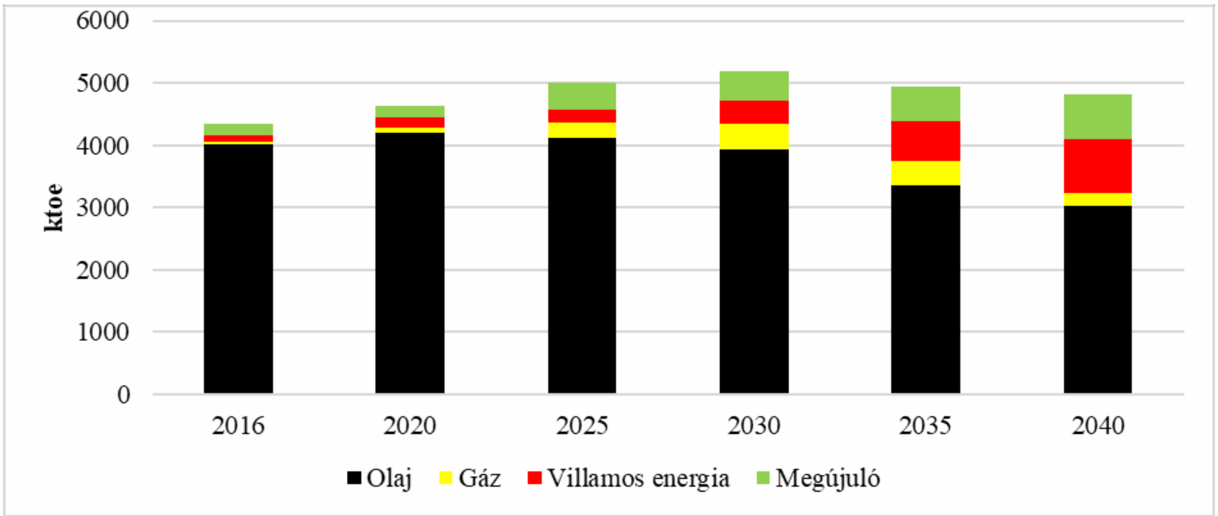

Figure 100 – Projection of final energy consumption in transport and change in composition, impact of new policy measures, not incl. international air transport, WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity

Megújuló	Renewables

There are no significant forecasting differences between the WEM and WAM scenarios in the **agriculture, forestry and fishery sector.** Both scenarios forecast a 17 % increase between 2016 and 2030.

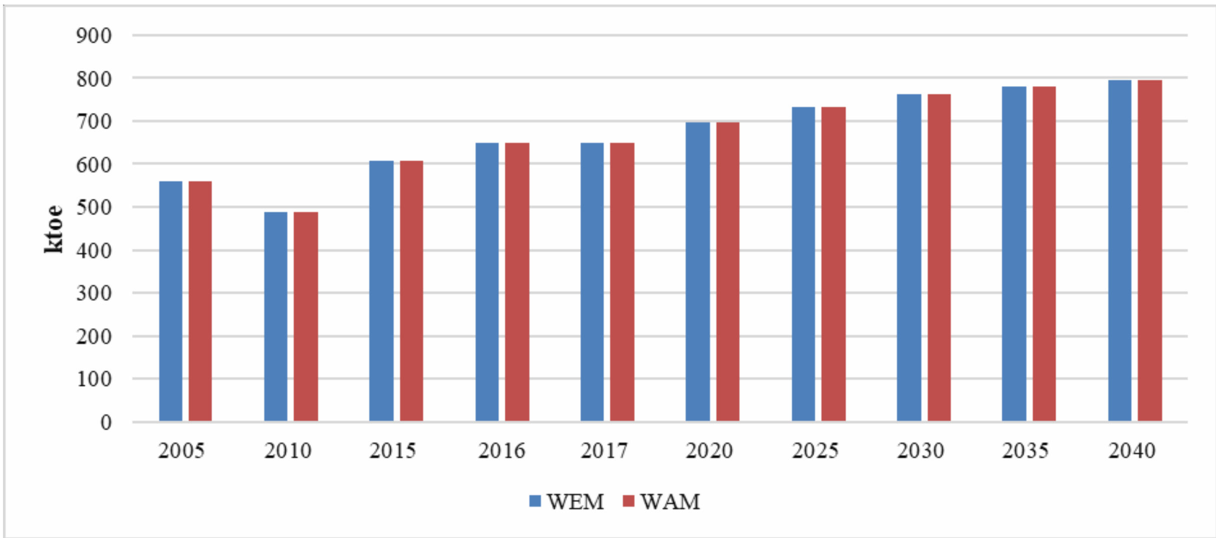

Figure 101 – Comparison of final energy consumption in the agriculture, forestry and fishery sector under the WEM and WAM scenarios – impact of new policy measures

Source of actual data: Eurostat

The figure below shows the energy consumption patterns of the agriculture, forestry and fishery sector by fuel type. Between 2016 and 2030 natural gas consumption will increase significantly by 61 % (increase of 89 ktoe).

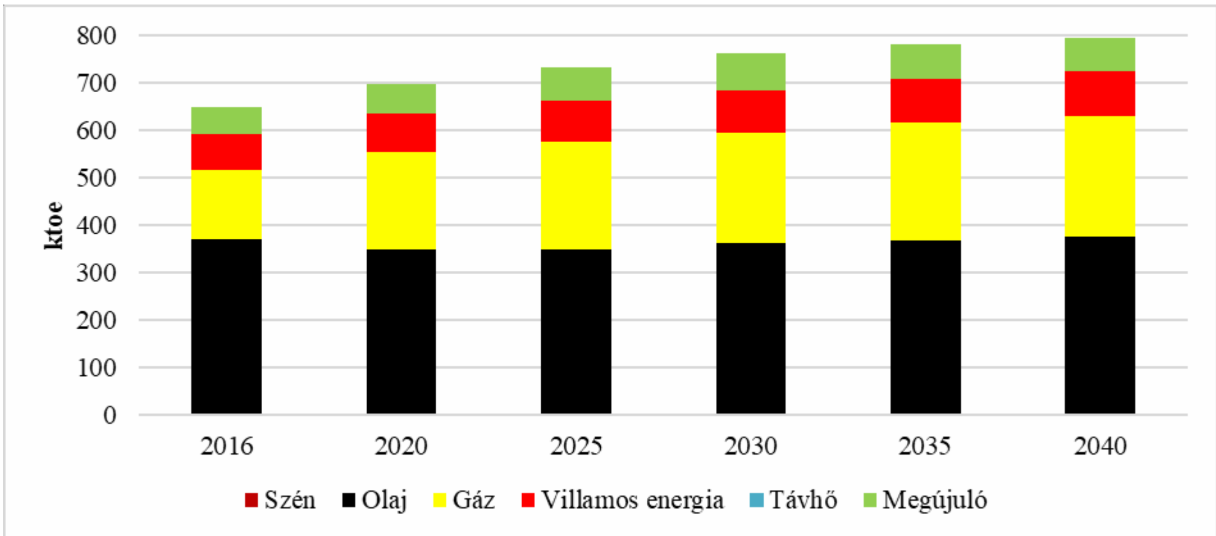

Figure 102 – Projection of final energy consumption in the agriculture, forestry and fishery sector and change in composition in consideration of the impact of new policy measures, WAM scenario, ktoe

Source of actual data: Eurostat

HU	**EN**
Szén	Coal
Olaj	Oil

Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

Finally, we review below expected **aggregate final energy consumption.**

The value of total final energy consumption under the WAM scenario in 2030 is 1 939 ktoe (~81 PJ) **less than the value forecast under the WEM scenario.**

In consideration of the impact of existing policy measures, a 15.9 % increase in final energy consumption was projected between 2016 and 2030, without significant changes to the internal distribution of used energy sources. By implementation of additional measures, this rate of increase can be reduced; **under the WAM scenario only a 5 % increase is expected between 2016 and 2030.** Also taking into account average annual GDP growth of 4 %, it follows from the above that **the value of final energy consumption relative to the GDP, i.e. the energy intensity indicator, will improve.**

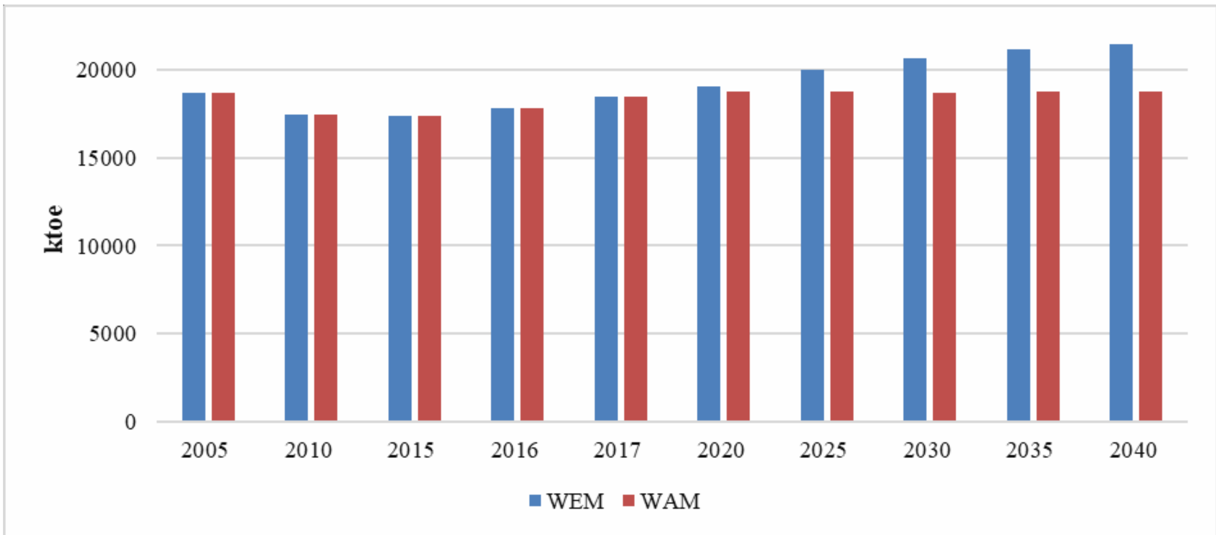

Figure 103 – Comparison of final energy consumption under the WEM and WAM scenarios – impact of new policy measures, ktoe

Source of actual data: Eurostat

The value of the GDP final energy intensity indicator is expected to decrease by 38.6 % between 2005 and 2030 (from 0.199 toe/1 000 EUR to 0.123 toe/1 000 EUR). **The value is expected to decrease by 25 % between 2016 and 2030. An additional improvement of the intensity indicator is expected by 2040**, falling further to 0.106 toe/1 000 EUR.

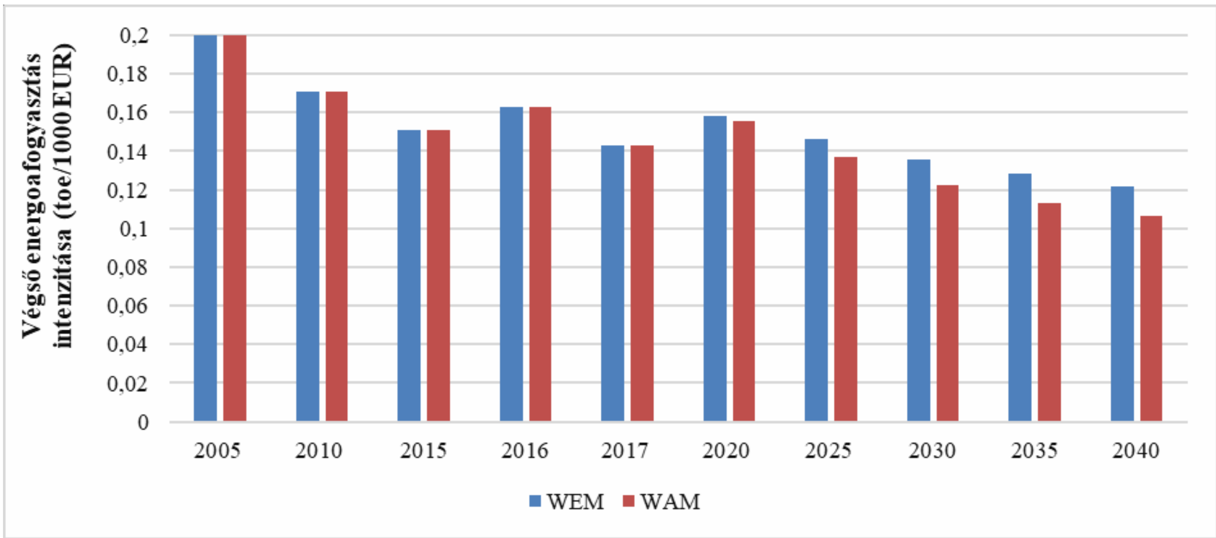

Figure 104 – Projection of the GDP intensity of final energy consumption (final energy consumption/GDP), impact of new policy measures, under the WEM and WAM scenarios, toe/1 000 EUR

Source of actual data: Eurostat

HU	**EN**
Végső energiafogyasztás intenzitása (toe/1000 EUR)	Final energy consumption intensity (toe/1 000 EUR)

The figure below shows forecast aggregate final energy consumption under the WAM scenario.

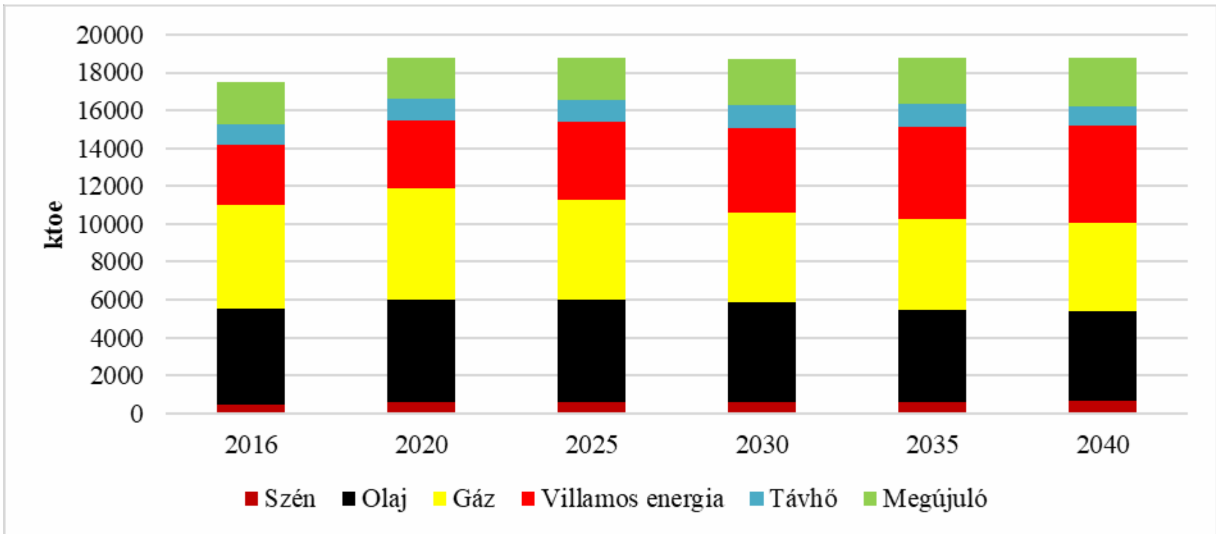

Figure 105 – Projection of final energy consumption and change in patterns – impact of new policy measures, WAM scenario, ktoe

Source of actual data: Eurostat

HU	EN
Szén	Coal
Olaj	Oil
Gáz	Gas
Villamos energia	Electricity
Távhő	District heat
Megújuló	Renewables

Primary energy consumption

Primary energy consumption will significantly increase at the end of the 2020s. A substantial increase is expected under both the WEM and WAM scenarios mainly as a result of higher transformation loss caused by the entry into service of the new Paks nuclear power plant units. A falling, stagnating trend will follow the decommissioning of the old units.

Upon implementation of the new policy measures, the **value of primary energy consumption** may equal **30 664 ktoe** (approximately 1 284 PJ) in **2030**, which is 29.2 % higher than the value for 2016. Implementation of the new policy measures would allow 1 109 ktoe (around 46.4 PJ) in total savings of primary energy consumption by 2030, compared to the trajectory under the existing policy measures.

Figure 106 – Comparison of primary energy consumption under the WEM and WAM scenarios – impact of new policy measures

Source of actual data: Eurostat

The primary energy intensity of the Hungarian economy, i.e. ratio of primary energy consumption to the GDP, will decrease by 31 % between 2005 and 2030 after implementation of the new policy measures. A 2.5 % decrease is expected between 2016 and 2030. Thus, the value of the indicator will fall from 0.289 toe/1 000 EUR in 2005 to 0.201 toe/1 000 EUR in 2030, and to 0.162 toe/1 000 EUR in 2040.

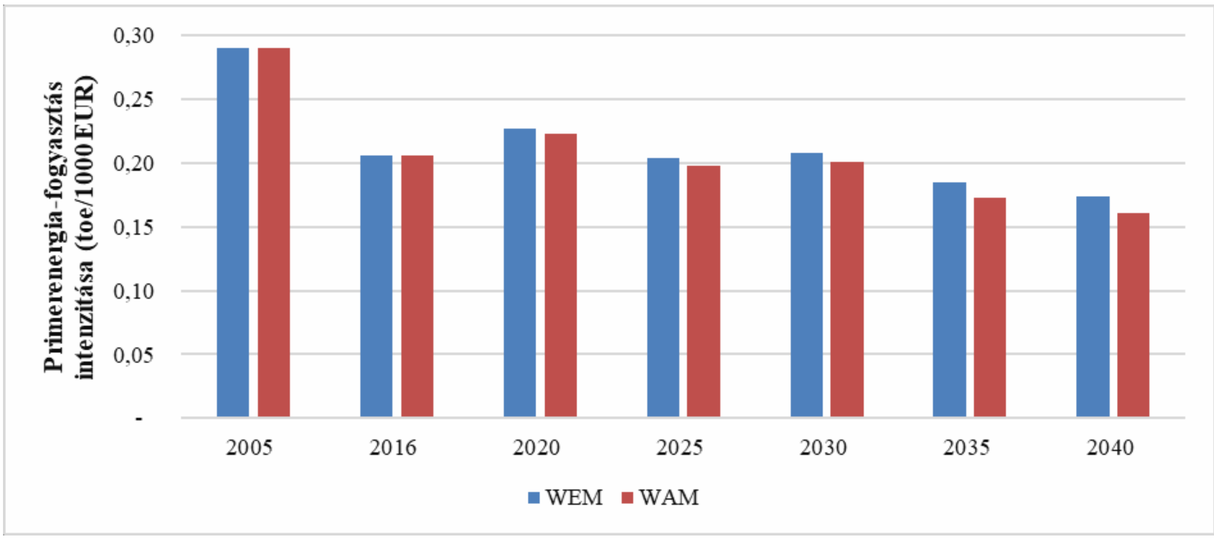

Figure 107 – Projection of the energy intensity of the Hungarian economy (primary energy consumption/GDP) under the WEM and WAM scenarios, toe/1 000 EUR

Source of actual data: Eurostat

HU	**EN**
Primerenergia-fogyasztás intenzitása (toe/1000 EUR)	Primary energy consumption intensity (toe/1 000 EUR)

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*

5.2. Macroeconomic and, to the extent feasible, the health, environmental, employment and education, skills and social impacts, including just transition aspects (in terms of costs and benefits as well as cost-effectiveness) of the planned policies and measures described in Chapter 3 at least until the last year of the period covered by the plan, including comparison to projections with existing policies and measures

Finalisation of the strategic environmental assessment (SEA) relating to the NECP objectives and measures is in progress. The preliminary findings of the SEA – not yet presented for social consultations at the time of the NECP's submission – relating to effects on other Member States are as follows:

The objectives, programmes and projects of the NECP represent substantial progress in a number of areas concerning the environmental impact of the production and consumption of energy in Hungary. Implementation of the programmes will result in a significant decline in GHG emissions, a growing share of energy production units using renewable energy sources and improved energy efficiency. **The launch of a number of measures is planned under the NECP (promotion of energy innovation, expansion of consumer choice, local energy production, support of energy communities) that may contribute to laying the groundwork for important future environmental processes.**

The NECP **not only considered environmental criteria.** Its most important objective is the **simultaneous management of conditions ensuring the security of supply, cost efficiency and environmental sustainability.**

Main observations relating to conformity with NECP environmental requirements:

- The **reduction of consumption** and termination of wasteful energy consumption should be key elements of complex energy development projects. In this regard the NECP defines a number of programmes and projects, although some commitments under the energy saving measures could be expanded (e.g. reduction of energy consumption in transport by promotion of alternative mobility, more radical reduction of industrial and retail energy consumption, more efficient use of produced waste heat etc.);
- As regards **energy efficiency** measures, the NECP does not contain an **options analysis** that would prioritise possible areas and means of intervention based on economic, environmental and social criteria;
- The NECP aims to contribute to energy objectives mainly through technical and regulatory measures; **awareness raising elements**, e.g. resulting in savings targets and the reconsideration of consumer needs, are less prioritised;
- The **renewal of the Paks nuclear power plant capacities** is key to future electricity generation;
- As regards the satisfaction of the natural gas demand of gas turbines necessary for ensuring the grid regulation of weather-dependent renewable technologies and the flexibility of the electricity generation system, notwithstanding the need for establishing a diversified supply infrastructure, the **security of supply** may also be important to address in relation to potential political and market risks. It is therefore necessary **to develop other options of grid regulation;**
- By exploring and extracting **unconventional hydrocarbon reserves** we are exhausting important

Hungarian resources **that may be of strategic importance for future generations.** Accordingly, it is necessary to conserve still available hydrocarbon reserves in Hungary;

- The NECP does not elaborate the **management of waste produced in connection with energy production.** In this regard it is necessary to ensure the long-term, safe disposal of the spent fuel assemblies of the nuclear power plant units, or to provide for appropriate recycling possibilities (if such technologies become environmentally suitable). Additionally it is necessary to provide for the appropriate recovery of waste produced after the service life of PV units planned in large quantities and the recovery of valuable materials contained in them;
- The NECP assigns an important role to energy production from biomass, which, apart from its generally positive view, may carry a number of environmental risks. It is important **to satisfy growing demand for energy from biomass with the lowest possible environmental impact**, taking into account optimal conditions for energy, forestry, soil science, agriculture, nature conservation and transport;
- The **development programmes** planned in the NECP (power plant investments, system development requirements, investment and price subsidies) **will impose major budgetary burdens.** The Strategy, however, only partly specifies the sources of development. In some areas of intervention, extra costs may lead to severe State budget strains or the suspension of planned development projects.

5.3. Overview of investment needs

i. Existing investment flows and forward investment assumptions with regard to the planned policies and measures

The TIMES model used for preparing the NECP not only accounts for investment costs but also for changes in operating costs in the field of energy.[236] The model calculates the additional costs of the measures implementing energy strategy targets, as set out in this document, among other places. It is therefore the difference between the NECP's WAM scenario (with additional measures) and the reference WEM (with existing measures) scenario.

The model covers energy-transforming sectors, the energy consumption of the household and tertiary sectors, the transport sector, and the industrial and agricultural sectors. According to its operating logic, the model seeks the most cost-effective means of satisfying the given final customer demand (e.g. million passenger-km, quantity of produced cement, lighting demand etc.) – this is considered the cost of the WEM scenario. As a limit to the model, the WAM scenario, however, includes quantifiable targets presented in Chapter 1.2 and seeks optimal costs in consideration of these. The discounted value of costs estimated for the entire period, the

[236] Estimates are not available for the cost of reducing non-energy GHG emissions.

so-called total system cost[237], is higher under the WAM scenario because the use of more expensive technologies is also necessary, e.g. for meeting higher emission reduction targets.

Modelling results

In the analysed period between 2016 and 2040, the additional, fully discounted system cost under the WAM scenario amounts to HUF 20 401 billion, equalling an average annual value of HUF 582.9 billion. The steadily increasing net additional costs peak at around 2030, because based on the modelling results, it is worth delaying investments aimed at meeting 2030 targets due to declining technological costs. As a result of new investments aimed at meeting the 2040 targets, costs again – moderately – rise after 2035. The results also suggest that although new investments are capital intensive, they can significantly reduce variable operation and maintenance costs in parallel with the more optimal use of existing technologies.

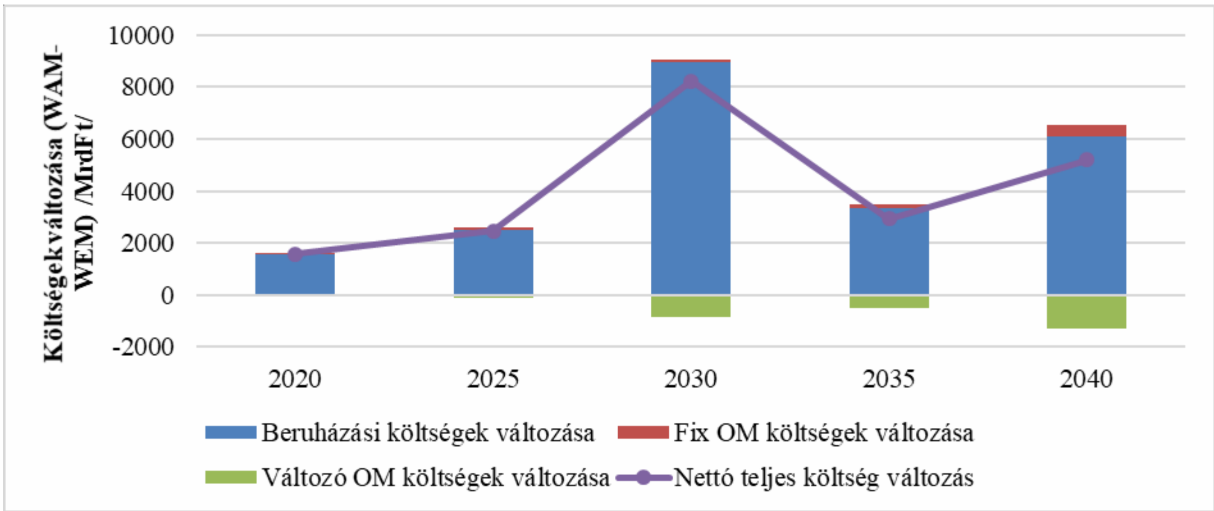

Figure 108 – Change in total net additional costs over time, per cost, under the WAM and WEM scenarios, HUF billion

HU	EN
Költségek változása (WAM-WEM) /MrdFt/	Change in costs (WAM-WEM) (bn HUF)
Beruházási költségek változása	Change in investment costs
Változó OM költségek változása	Change in variable OM costs
Fix OM költségek változása	Change in fixed OM costs
Nettó teljes költség változás	Change in total net cost

[237] Discounting is performed for the year 2016, with a 5 % long-term discount rate. The model calculates costs in euro, which we converted at a 310 HUF/EUR exchange rate assumed to be constant in the long term.

The additional cost requirement under the WAM scenario mainly arises in the retail sector: such overall cost equals of 80 %, accounting for 90 % of total costs in 2030. The investment requirement in the transport sector will reach the highest level at the end of the period. A moderate increase in additional costs is expected in electricity and heat generation, and in the services sectors; there are no differences in investment requirements under the WEM and WAM scenarios in relation to industry and agriculture.

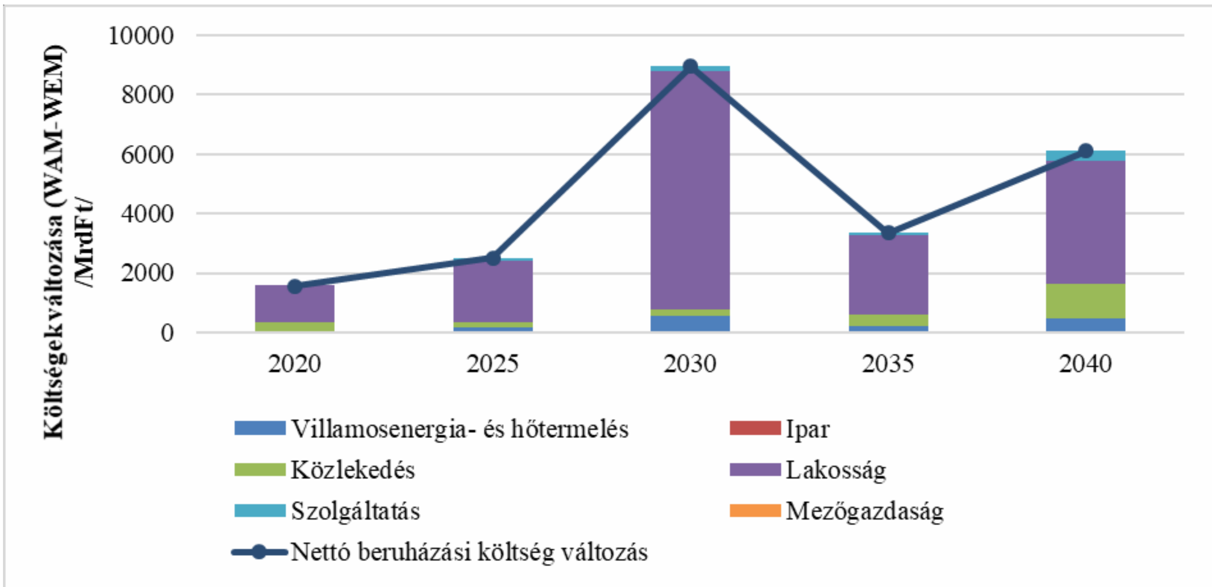

Figure 109 – Change in total net additional investment costs over time, per cost, under the WAM and WEM scenarios, HUF billion

HU	**EN**
Költségek változása (WAM-WEM) /MrdFt/	Change in costs (WAM-WEM) (bn HUF)
Villamosenergia- és hőtermelés	Electricity and heat generation
Közlekedés	Transport
Szolgáltatás	Services
Nettó beruházási költség változás	Change in net investment cost
Ipar	Industry
Lakosság	Retail
Mezőgazdaság	Agriculture

Although the total additional cost requirement under the WAM scenario is attributable to higher investment costs, fixed operation and maintenance (FOM) costs are also higher, and they also increase during the analysed period. The latter cost is particularly high in the transport sector: the new technologies introduced under the WAM scenario not only require more capital, but their fixed operation and maintenance costs are also higher.

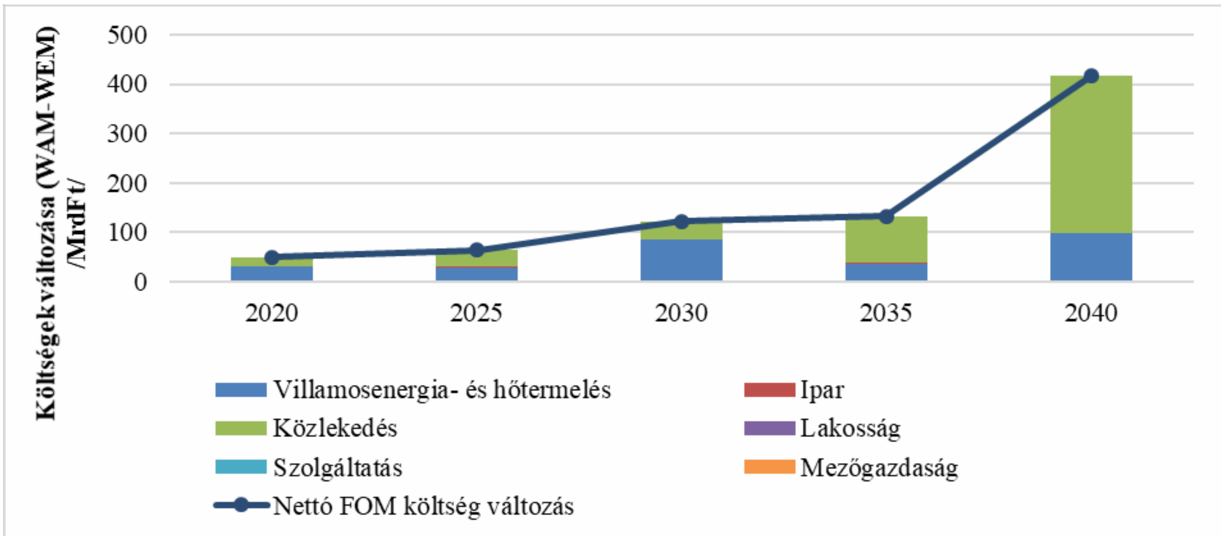

Figure 110 – Change in net additional fixed operation and maintenance costs over time, per cost, under the WAM and WEM scenarios, HUF billion

HU	**EN**
Költségek változása (WAM-WEM) /MrdFt/	Change in costs (WAM-WEM) (bn HUF)
Villamosenergia- és hőtermelés	Electricity and heat generation
Közlekedés	Transport
Szolgáltatás	Services
Nettó FOM költség változás	Change in net FOM cost
Ipar	Industry
Lakosság	Retail
Mezőgazdaság	Agriculture

The savings in variable operation and maintenance costs (VOM) resulting under the WAM scenario are mainly attributable to transport; the variable costs of transport technologies are lower overall than the level in the technological mix under the WEM scenario.

A moderate rise in costs is observed in the retail sector, however, mainly based on a significant decline in the consumption of relatively cheaper gas and its replacement with more expensive energy resources. The ‘Other’ category covers the ETS quota cost, the negative value of which indicates that – since quota prices are identical in the two scenarios – companies under the ETS use less quotas overall, i.e. their energy efficiency is improving.

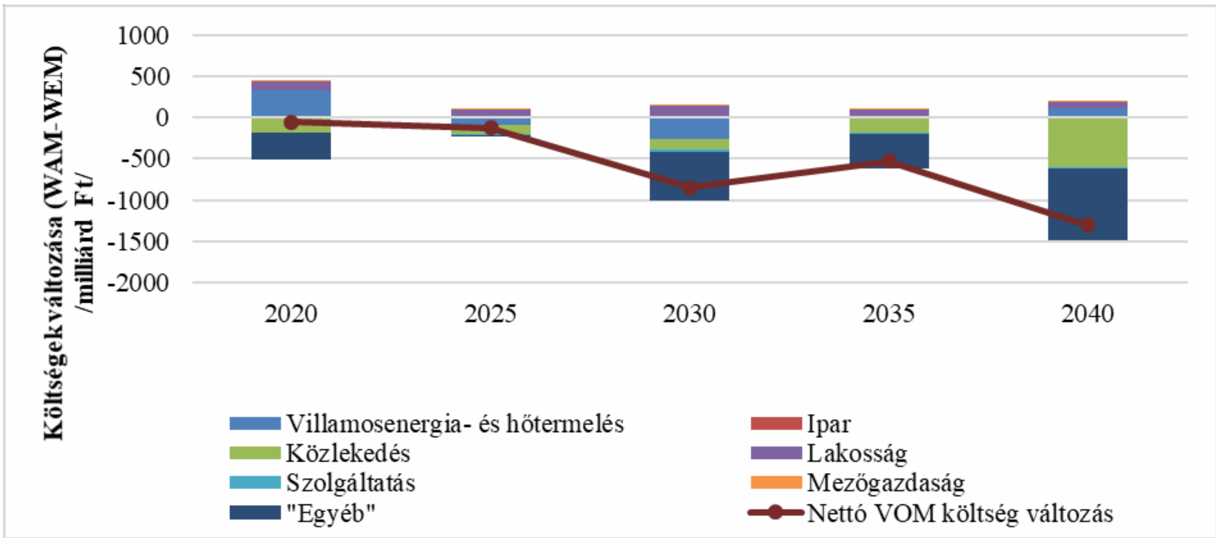

Figure 111 – Change in net additional variable operation and maintenance costs over time, per cost, under the WAM and WEM scenarios, HUF billion

HU	EN
Költségek változása (WAM-WEM) /MrdFt/	Change in costs (WAM-WEM) (bn HUF)
Villamosenergia- és hőtermelés	Electricity and heat generation
Közlekedés	Transport
Szolgáltatás	Services
“Egyéb”	‘Other’
Nettó VOM költség változás	Change in net VOM cost
Ipar	Industry
Lakosság	Retail
Mezőgazdaság	Agriculture

The planning of cohesion development funds for the next seven-year Union budgetary period (2021-2027) is under way. At least 25 % of cohesion funds should be used for implementing climate change policies. The ‘Greener, carbon free Europe’ policy objective is expected to be financed with HUF 1 300 billion in cohesion funds; these serve, *inter alia*, the transition to clean energy sources, renewable energy investments, the combating of climate change and support of clean vehicles in urban transport. Within the framework of the more ‘Connected Europe’ objective, transport and digital trans-European networks –

also targeting climate policy targets – can be supported.

In the third trading period (2013-2020) of the EU emissions trading scheme, a specific share of revenue from the sale of emission allowances (50 % of EUA III allowance sales, 100 % of EUAA aviation allowance sales) is used for budget appropriation managed under the Green Economy Financing Scheme chapter. **Between 2021 and 2030 we are planning around HUF 910 billion in carbon credit revenues**[238]**, assuming an average** CO_2 **price of 25 EUR per tonne. Of the above amount, HUF 726 billion may be spent in accordance with general rules on carbon credit revenues**[239], **i.e. 50 % thereof (HUF 363 billion) serves targeted green economy development objectives.**

Funds of the Modernisation Fund[240] **in the value of HUF 184 billion supplement 50 % of carbon credit revenues serving green economy development;** Hungary will be entitled to amounts used in accordance with current general rules on carbon credit revenues. **The Modernisation Fund – operating from 2021 – aims to enhance upgrades of energy systems and energy efficiency.** At least 70 % of available funds must be used to support investments on the priority list of the Modernisation Fund. The remaining 30 % of funds may be used to support other projects serving the modernisation of energy systems. The intensity of aid is maximum 100 % for projects on the priority list and maximum 70 % for other projects.

The priority list, subject to revision in 2024, contains the following elements:

- Electricity from renewable resources and its consumption;
- Improvement of energy efficiency, including investments in energy efficiency in the transport, buildings, agriculture and waste sectors;
- Energy storage;
- Modernisation of energy networks, including district heating pipelines and electricity transmission networks;
- Expansion of interconnection between Member States;
- Just transition in 'carbon-dependent regions', 'so as to support the redeployment, re-skilling and up-skilling of workers, education, job-seeking initiatives and start-ups'.

The application of **Article 10c derogation** in the 2021-2030 period aims at the replacement of electricity generation resulting in high GHG emissions with natural gas or other sustainable technology. Aid intensity is

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[238] The estimation of revenues is very uncertain because carbon credit prices evolve on the exchange, and they are also affected by the market stability reserve, demand for free allocation and certain political factors (e.g. Brexit). Therefore the figure is only an indicative estimate. We assumed a 335 HUF/EUR exchange rate during the period.

[239] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Article 10(3)).

[240] Financing mechanism under Article 10d. of Directive 2003/87/EC of the European Parliament and of the Council.

maximised at 70 %. Successful projects are selected by way of tender.

Among indicative targets serving fulfilment of other Hungarian energy and climate policy objectives, the Building Energy Performance Tender Programme – with a budget of HUF 0.4 billion – provides funding for the following:

- Development of energy production with renewable sources of energy;
- Increased use of renewable energy;
- Energy efficiency actions;
- Investments, measures reducing GHG emissions;
- Public awareness raising of climate policies, the green economy, energy literacy;
- Supporting the construction of low energy buildings.

Within the framework of the REAS (Renewable Energy Support Scheme) replacing the feed-in system, the HEA has the right to decide, under normative conditions, on the period of the feed-in of electricity from renewable resources and on the quantity of electricity subject to feed-in. **Within the framework of the REAS tenders launched in the near future, producers will compete for aid in the overall annual amount of HUF 2.5 billion based on offers for subsidised prices.**

In the 2021-2027 Union programming period, programmes under direct Union management will be available with increased funds for financing energy projects. These include Horizon Europe (RDI), Connecting Europe Facility (energy infrastructure), LIFE (environmental protection), EURATOM (nuclear energy), Structural Reform Support Programme (institutional and growth-enhancing reforms, climate and energy objectives), Digital Europe Programme (digitalisation), European Defence Fund (defence, military energy projects), and InvestEU (efficient transport infrastructure, green energy and innovation).

A substantial amount of private investment will also be necessary for the energy transition, for **meeting the 2030 targets** and due to the difference in funds available from investment and operating aids.

ii. Sector or market risk factors or barriers in the national or regional context

iii. Analysis of additional public finance support or resources to fill identified gaps identified under subpoint iii.

5.4. Effects of planned policies and measures described in Chapter 3 on other Member States and regional cooperation at least until the last year of the period covered by the plan, including comparison to projections with existing policies and measures

i. Impacts on the energy system in neighbouring and other Member States in the region to the extent possible

Finalisation of the strategic environmental assessment (SEA) relating to the NECP objectives and measures is in progress. The preliminary findings of the SEA – not yet presented for social consultations – relating to effects on other Member States are as follows:

The natural units found in Hungary – e.g. flowing waters, larger regions, mountains – commonly expand beyond its administrative borders. As a result, resources withdrawn from the natural environment in the course of energy production and consumption, waste deposited in the environment, substances re-entering the environment in the form of pollution are a matter of concern not only for Hungary, but also for neighbouring countries.

The joint extraction of **deep geothermal** reservoirs may be a source of conflict (e.g. along the Croatian border); without appropriate cooperation and regulation, the resource may be overused. In relation to **solid biomass**, too, there is a cross-border supply of raw material, therefore its environmental impact is produced partly in neighbouring countries. In relation to **biofuels**, Hungary is also an exporter; the environmental impact arises in Hungary, while the benefit from the replacement of fossil fuels is enjoyed in the importer country.

In transport, in the event of disasters involving the transport of goods or passengers by water, Hungary's waterways may suffer cross-border pollution.

The coupling of the region's **electricity and gas markets** is a strategic objective of the NECP, which has a profound impact on energy trade with neighbouring countries and enhances the security of supply. The investments will deepen Hungary's integration in the European energy system (supply of electricity, gas), thus changes in domestic consumption can increase or decrease the environmental impact beyond its borders.

The environmental impact of **extracting raw materials and energy sources** for domestic energy production and consumption (e.g. transport), and of **the production of imported electricity** arises beyond Hungary's borders but it is important to consider. The measures of the NECP reducing import dependency (in relation to both energy sources and electricity) mitigate these external effects. Equipment necessary for using solar energy are commonly imported products; mining of the rare earth elements used for these is also carried out outside of Hungary.

ii. Effects on energy prices, utilities and energy market integration

iii. Where applicable, impact on regional cooperation

6. References

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