DECARBONISATION OF THE HOUSEHOLD HEATING SECTOR IN THE VISEGRAD COUNTRIES

V4ETTP Working paper

REKK

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EXECUTIVE SUMMARY

Our study provides a detailed overview of the current state of the residential heating sector in the Visegrad countries (V4 - Slovakia, Hungary, Czechia, Poland) in order to inform recommendations to reduce emissions from this challenging but high potential segment.

Czechia and Poland are most reliant on solid biofuels (fuelwood) and coal, while Hungary and Slovakia have two of the highest shares of natural gas in the European Union (EU27). All of the V4 countries consume more than the EU27 average of solid biofuels; biomass accounts for almost all of the renewable heat production while electrification and other renewable alternatives are well below the EU27 average.

Czechia and Hungary have significantly higher 2030 renewable heating and cooling targets than Poland and Slovakia but V4 national energy and climate plans (NECPs) include very little details on measures for heat decarbonisation outside of the primary role of biomass. Only Czech and Slovak targets include a share of heat pumps, and only Czechia and Poland have implemented boiler replacement schemes to reduce local air emissions.

With such a high dependency on fossil fuels, it is no surprise that GHG emissions per household in the V4 are well above the EU27 average. At the same time, energy consumption per house is also well above the EU27 average mainly because of aging Soviet-era heat networks and building stocks. District heating (DH) networks are widespread in V4 urban areas with a high percentage of household connections, but the share in final heat consumption is lower because of the basic energy requirements of smaller units.

The Russian-Ukrainian war has had a major impact on the sector, leading to a significant drop in V4 residential and industrial natural gas consumption in the first quarter of 2023 compared to the 2019-2021 average. This was mostly driven by behavioural change in response to higher prices, but also energy efficiency investments from the previous year and households switching to alternative fuels such as wood and coal.

In the case of both individual and DH, V4 energy efficiency measures need to come first to ensure electrification and renewables themselves operate most efficiently, especially given the poor condition of legacy building infrastructure. After residential buildings have been renovated, individual and network fossil-based heating will need to be replaced. In the case of the former, the options are electrification or biomass, and for the latter either focusing on coal to efficient combined heat and power plants (CHPs) using natural gas or directly to renewables like geothermal and solar energy, bypassing coal and gas inputs.

The study led to the following general policy recommendations for all V4 countries:.

- Improving the energy efficiency of buildings through deep renovation is clearly the most effective way to decarbonise residential heating (the lowest hanging fruit) and a prerequisite for fuel switching (e.g. installing a heat pump). The "efficiency first" principle needs to be put into practice.

- DH can integrate several renewable energy and waste heat sources in large quantities and cost-effectively. The V4 countries must ensure the preservation and, where economically justified, the expansion of these networks which they can jointly represent at the EU level.
- The effective rollout of heat pumps for individual heating requires preconditions, including improving the energy efficiency of buildings, upgrading the electricity grid, increasing demand-side flexibility and improving the supply chain.
- Biomass is affordable and relatively abundant, particularly suitable for remote 'off-grid' areas where there are few alternatives. At the same time, sufficiency, sustainability and impact on air quality should be carefully monitored and evaluated.
- Household price regulation acts as a double-edged sword, protecting vulnerable consumers from high prices but keeping energy prices artificially low to discourage investment in energy efficiency. Energy poverty needs to be more clearly defined for targeted regulated pricing that should be gradually phased out with increased support for energy efficiency investments.

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1 INTRODUCTION

The V4 Energy Think Tank Platform (V4ETTP) was founded in 2018 by four representative think tanks, aiming to facilitate coordinated regional energy-related and policy-oriented research and analysis building on the expertise of each member institutions in the field of energy studies. Within the framework of this cooperation, four regional policy papers are typically published each year which provide the backdrop for stakeholder workshops to discuss the policy implications of the conclusions.

The 2023 V4ETTP work plan emphasizes regional solutions to the unprecedented energy market situation caused by Russia's war in Ukraine, which of course makes the case for accelerating the energy transition. This is the second of four working papers prepared as a joint effort between research colleagues from REKK (Hungary), SFPA (Slovakia) AMO (Czechia) and OSW (Poland). It was presented for discussion among representative V4 experts from government, academia, and industry associations at a workshop held on 14 September 2023 in Budapest, titled, *"The Visegrad Four countries' responses to the energy crisis"*.

For Hungary and, to a lesser extent Slovakia, the transition to renewables in heat will substitute for natural gas, and thereby also improve energy security. In Poland and Czechia renewables in heat will mostly substitute for coal and contribute to decarbonization.

Heating of residential buildings is one of the main contributors to local air pollution. Biomass is categorized as renewable but can be highly emitting and unsustainable without the right regulations in place. Use of biomass should not endanger natural forests and biodiversity in the long term. In addition to climate, environmental and security considerations, governments are also responsible for addressing the social-economic dynamic and risk of energy poverty resulting from high heat prices.

The paper sets out to provide a comparative overview of the residential heating sector in the V4 and, based on this, recommend actions and pathways for heat decarbonisation in each country. It is structured as the following: First, presenting residential heat sector data with a dedicated chapter for DH. Second, covering near- and long-term options for decarbonising individual and district heating. Third, compiling current national strategic goals and measures in the residential heating sector. The final chapter concludes with policy recommendations for each V4 country.

2 THE CURRENT SITUATION OF THE RESIDENTIAL HEATING SECTOR IN THE V4 COUNTRIES

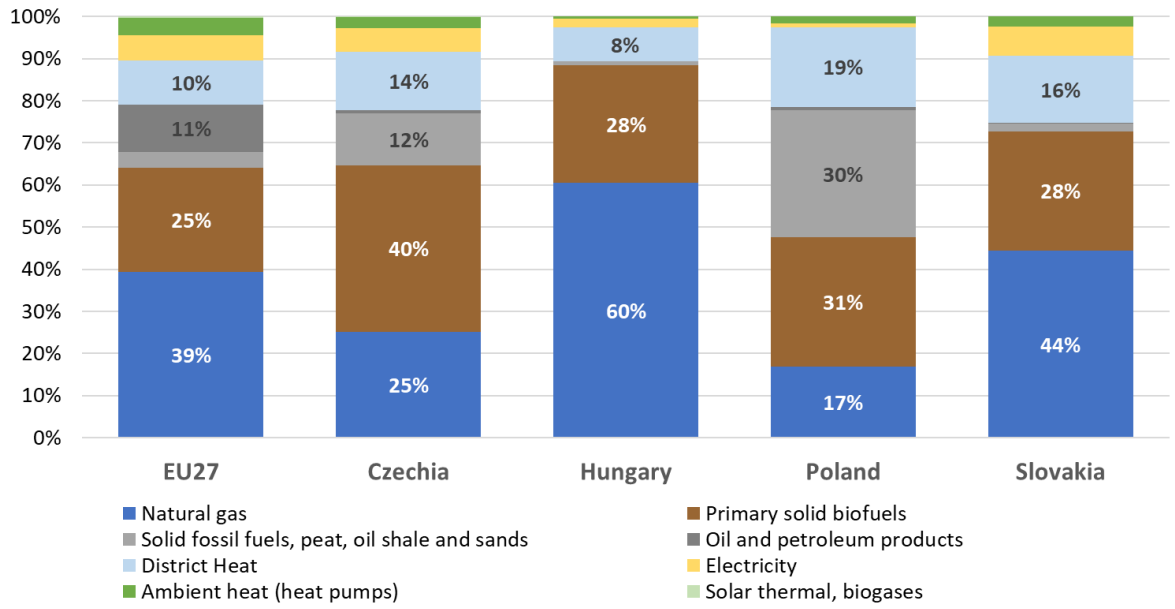
2.1 STATE OF PLAY: INDIVIDUAL RESIDENTIAL HEATING

Figure 1 provides a breakdown of the fuel mix in V4 household space heating.

- **V4 households use the most energy for heating:** The share of household energy used for heating within the total household energy consumption is higher in the V4 than the EU27 average (64%), especially Slovakia (75%) and Hungary (73%).
- **Hungary and Slovakia use gas and biomass**: The share of natural gas in household space heating in Hungary (60%) and Slovakia (44%) is above the EU average (39%).
- **Czechia and Poland use biomass and coal**: The share of natural is much lower in Czechia (25%) and Poland (17%), which rely more heavily on biomass (fuelwood) and coal.
- **Use of biomass (fuelwood) is widespread:** Biomass is the dominant heating source in Czechia (40%) and Poland (31%) and above the EU27 average in Hungary and Slovakia.
- **District heating is more widespread in the V4 than in the EU27:** The prevalence of residential DH is similar in Czechia, Poland and Slovakia (14-19% of energy consumption) and much lower in Hungary (8%).
- **Renewable heating and electrification is lagging behind the EU27**: The share of other renewables outside of biomass likes heat pumps, solar thermal, and biogas are lower than the EU27, especially in Hungary and Poland.

Figure 1 shows the household heating inputs in the V4 compared to the EU27 average, which are more dependent on fossil fuels.

FIGURE 1. FUEL MIX OF HOUSEHOLD SPACE HEATING IN THE V4, 2021



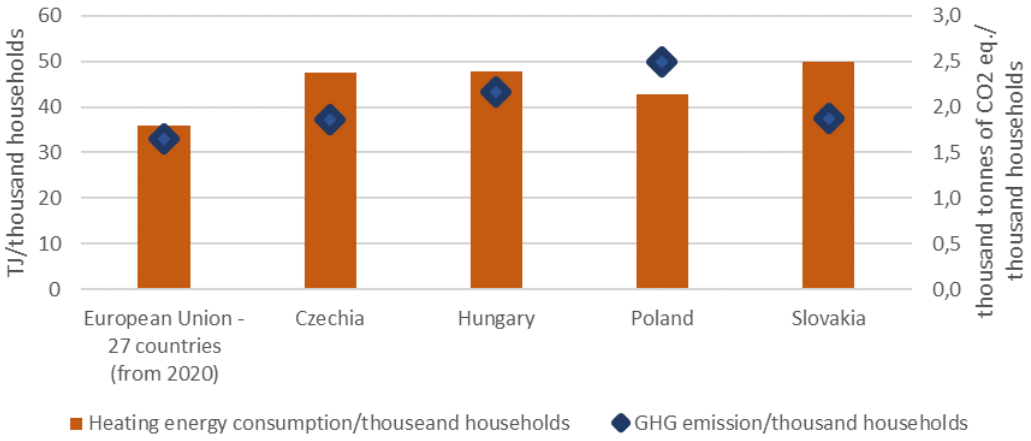
Source: Eurostat

Figure 2 shows the amount of heating energy consumed per household in the V4 compared to the EU27 average. With building stock rates among the worst performing in the EU, it is not surprising that V4 households consume more heat energy than the EU27 average[1]. The main factors are efficiency of heating devices, the thermal insulation of buildings, the average heated floor area, the baseline internal temperature, and climate, which differs for the V4 compared to other EU member states.

The other metric in Figure 2, GHG emissions per household, measures direct emissions from solid fossil fuels, natural gas and oil, but not the indirect emissions from electric heat pumps, DH or biofuels. Poland has the highest GHG emissions per household, owing to the dominant role of coal and high energy intensity of heating, compared to Czechia which has the lowest, reflecting the strong role of primary solid biomass.

[1] Marie Rousselot, Frédéric Pinto Da Rocha (2021): Energy efficiency trends in buildings in the EU

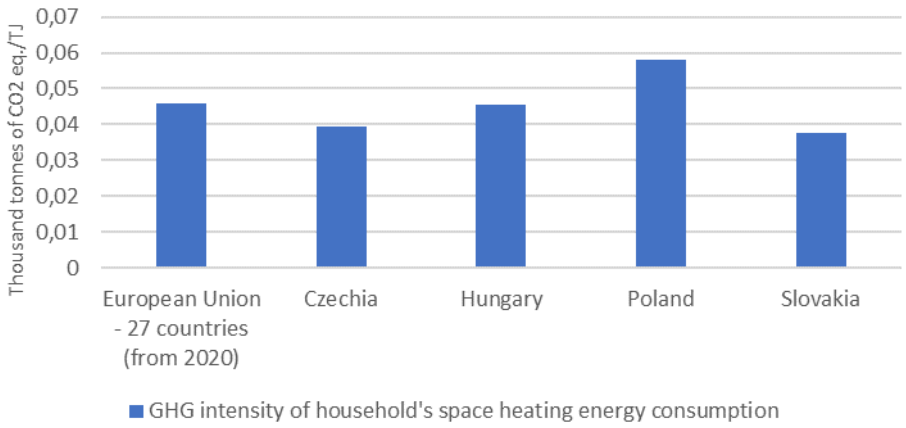
FIGURE 2. HEATING ENERGY CONSUMPTION AND GHG EMISSIONS PER THOUSAND HOUSEHOLDS IN THE V4, 2021



Source: Eurostat

Figure 3 shows the GHG intensity related to each unit of energy consumed which is calculated by dividing energy consumption with GHG emissions per household. Poland ranks the highest, well above the EU27 average, while Hungary is at the average and Czechia and Slovakia are below.

FIGURE 3. GHG INTENSITY OF HOUSEHOLD SPACE HEATING IN THE V4, 2021



Source: Eurostat

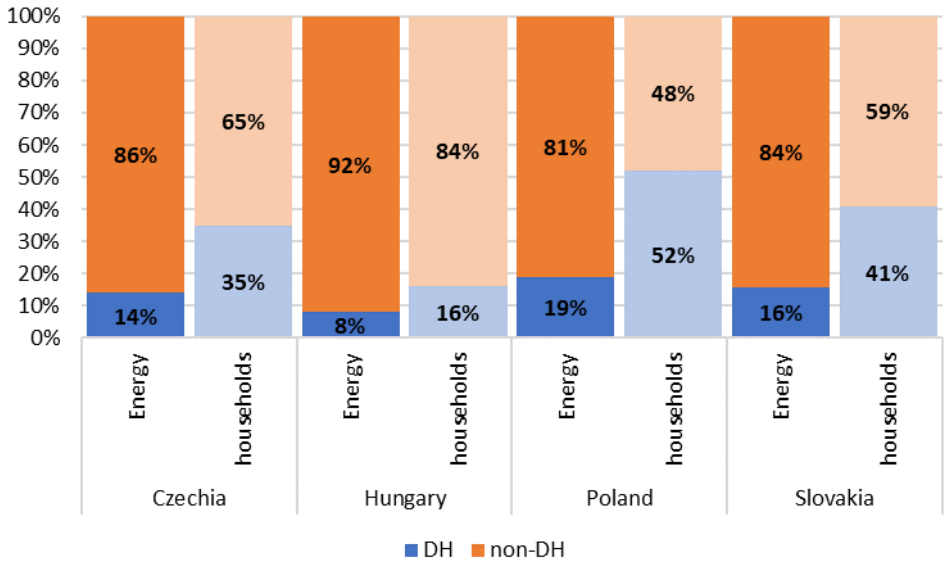
2.2 STATE OF PLAY: DISTRICT HEATING

DH networks are widespread in V4 urban areas, with 52% of households connected in Poland, 41%[2] in Slovakia, 35% in Czechia, and 16% in Hungary. These are typically smaller homes (flats) with lower heat energy needs than detached individual houses, which makes the share of DH

[2] There are small discrepancies in Slovak data sources. According to the Statistical Office from 2021, 761,000 households are connected to DH (32%) accounting approximately 40% of people - citizens.

in total energy significantly lower than the share of consumers, shown in Figure 4. Nonetheless, DH is much more prevalent in the V4 than the EU27 average.

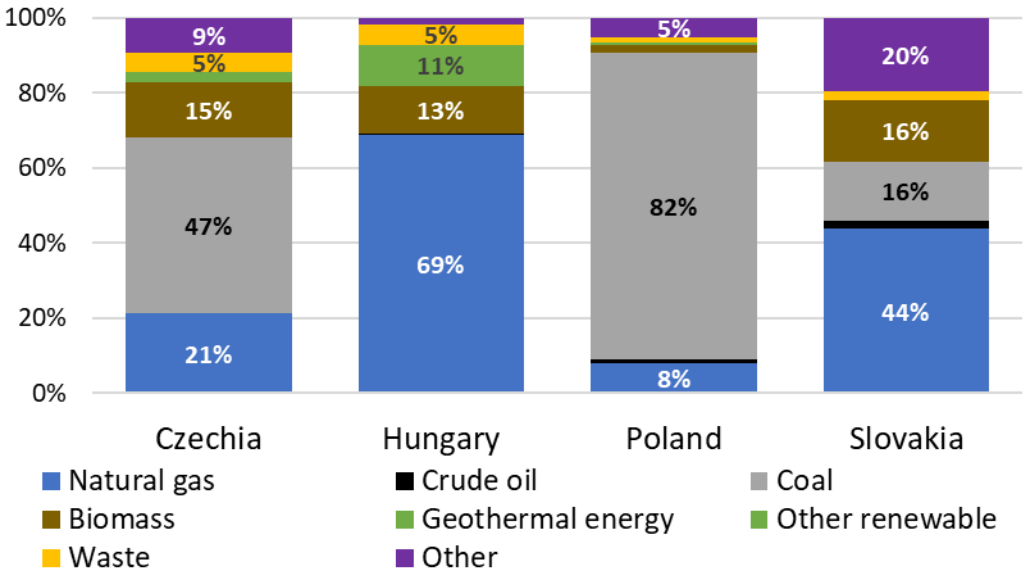
FIGURE 4. SHARE OF DISTRICT HEATING IN FINAL ENERGY CONSUMPTION AND NUMBER OF HOUSEHOLDS IN THE V4, 2021



Source: Eurostat, Hungarian DH statistics

Figure 5 shows the DH fuel mix of the V4 countries. In Poland 82% of DH is generated using local coal, mostly in large CHP plants, making it highly carbon intensive. Czechia's DH mix is more diverse, but still predominately coal based (47%), with larger shares of natural gas (21%) and biomass (15%). Slovakia's DH production is most dependent on natural gas (44%) followed by biomass (16%) and coal (16%). In Hungary, natural gas is by far the dominant DH input (69%), followed by biomass (13%) and geothermal energy (11%).

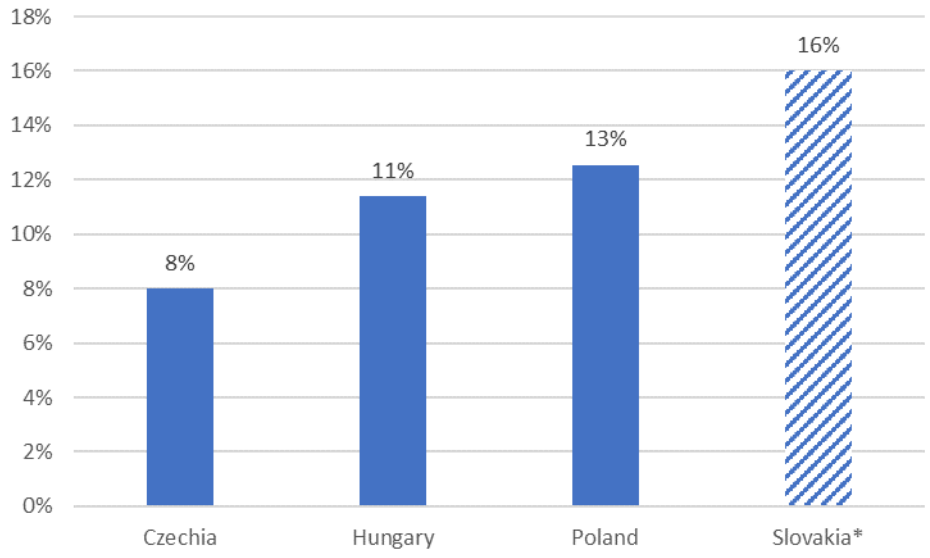
FIGURE 5. FUEL MIX OF DISTRICT HEATING IN THE V4, 2021



Source: Eurostat, Hungarian DH statistics

Figure 6 shows estimated network losses in the V4, which are around 10% of total energy produced. Insulation and retrofitting of pipes can reduce the network losses, but DH systems are costly to maintain, requiring constant monitoring and upkeep.

FIGURE 6. DISTRICT HEATING NETWORK LOSSES IN THE V4, 2021



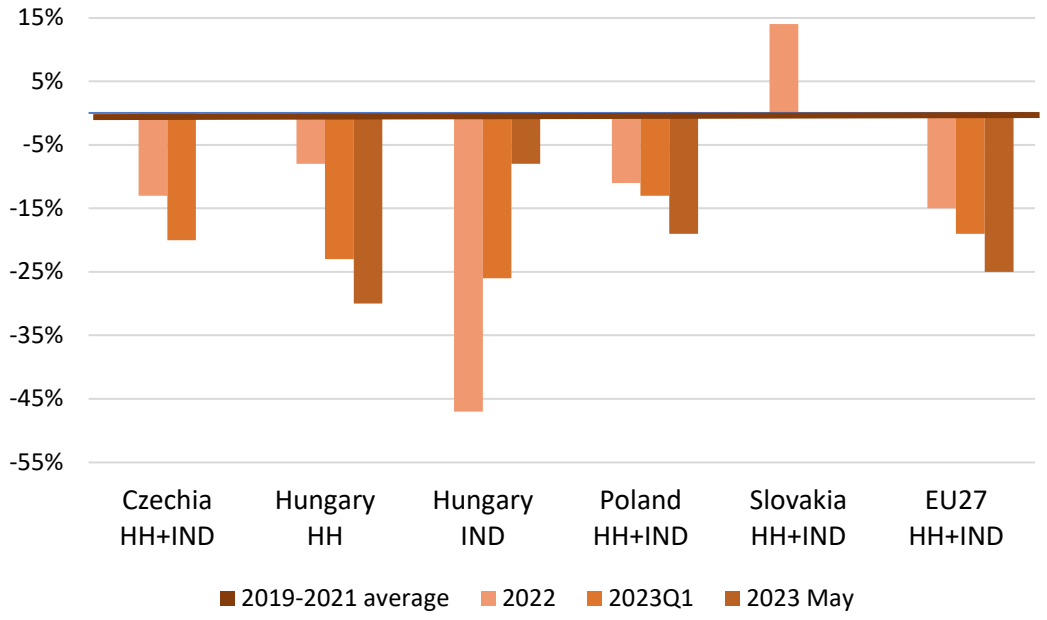
Source: Source: Hungarian DH statistics, URE,

** In the case of Slovakia, only 2017 data was available*

2.3 THE IMPACT OF THE RUSSIAN-UKRAINIAN WAR ON THE HOUSEHOLD HEATING SECTOR

Due to the outbreak of the Russian-Ukrainian war, EU member states are moving to secure alternative gas supplies and reduce overall gas demand. At the European Union level it was agreed for member states to reduce gas demand by 15% between August 2022 and March 2023 compared to the previous five-year average (and extended to March 2024[3]). Aggregate natural gas consumption by households and industry in the V4 countries shows an even steeper (13-23%) decrease than the 15% envisaged by the EU (Figure 7). This is primarily in response to high gas prices, but also switching to alternative fuels (wood, coal) where available.

FIGURE 7. NATURAL GAS DEMAND CHANGE IN THE HOUSEHOLD (HH) AND INDUSTRY (IND) SECTOR COMPARED TO 2019-2021 AVERAGE

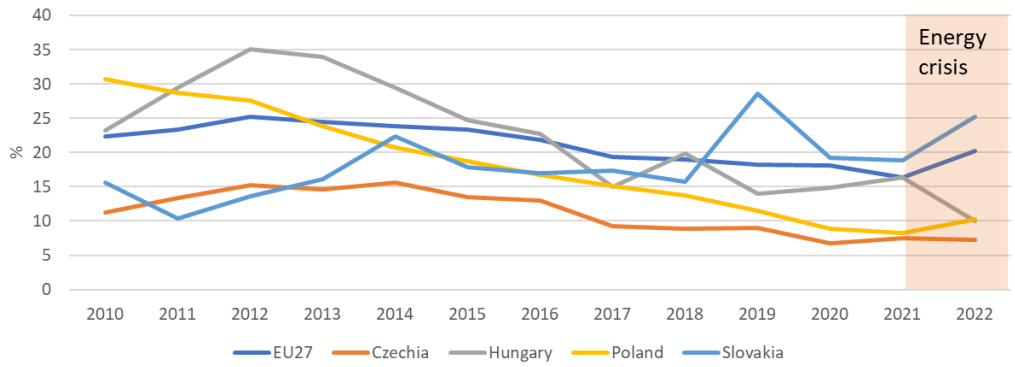


Source: Bruegel

One way to measure the impact of high heating costs is by the number of households that are unable to keep their home adequately warm, shown in Figure 8. After broadly declining over the past decade (meaning more households are able to heat) throughout the EU27, it plateaued in Czechia and Poland and even grew in Slovakia from 2020 to 2022.

[3] Ben McWilliams, Georg Zachmann (2023): European natural gas demand tracker

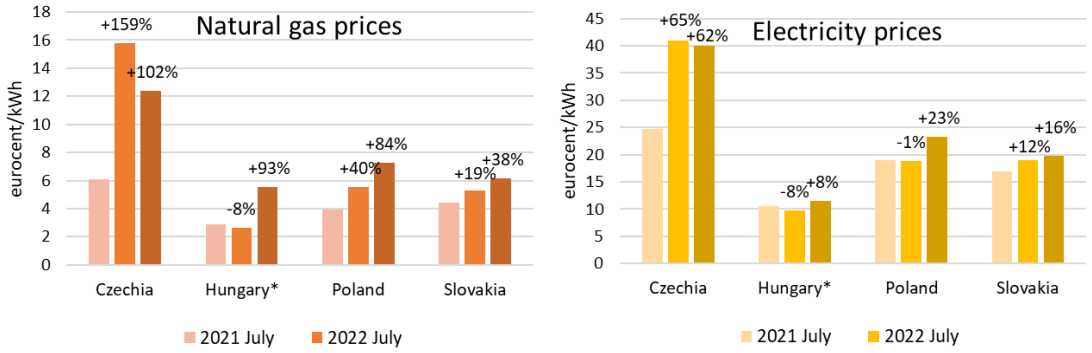
FIGURE 8. HOUSEHOLD INABILITY TO KEEP HOME ADEQUATELY WARM, V4



Source: Eurostat

Another way to measure the impact of the energy crisis and subsequent war is through residential natural gas and electricity prices. Among the V4, Czechia experienced by far the highest spike in gas and electricity prices. It is the only V4 country without regulated household prices since the markets were liberalised in 2006. Nonetheless, energy and especially gas prices rose steeply across the V4. Governments responded by capping price increases to provide some relief to households[4].

FIGURE 9. RESIDENTIAL NATURAL GAS AND ELECTRICITY PRICES COMPARED TO JULY 2021, V4



**For Hungary the average price is calculated with a value exceeding the average consumption by 20%*

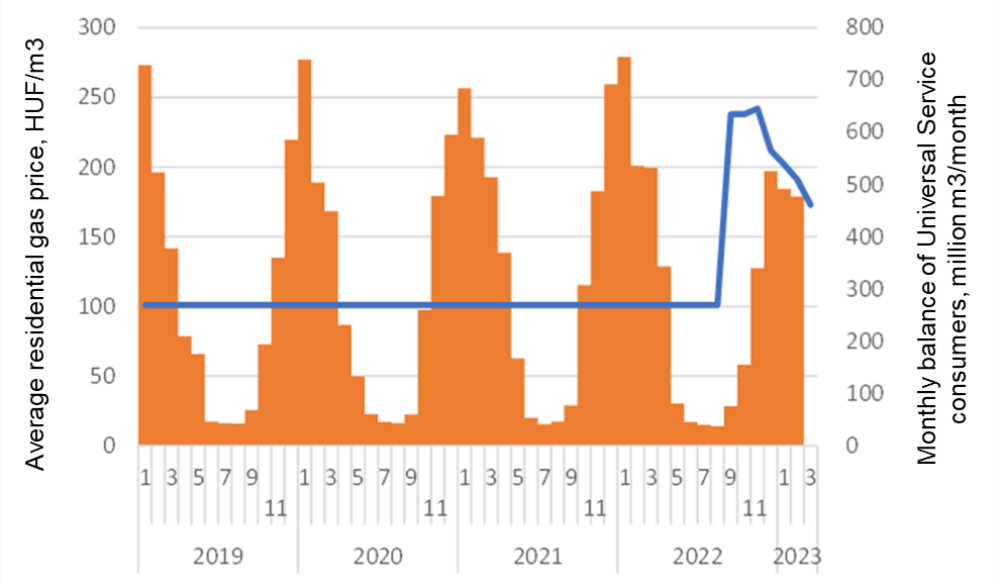
Source: Hungarian Energy and Public Utility Regulatory Authority (HEPURA)

While regulated prices protected households in Poland, Slovakia, and Hungary from dramatic consequences, greater exposure to price signals would have further reduced demand in these countries. This is especially true for Hungary, shown in Figure 10, where the government has intervened to cut end-consumer prices significantly over the past decade. However, from August 2022, a new universal service price regulation came into force, whereby households consuming more than the average level of natural gas (1729 m^3 /year) had to pay almost seven and a half times the subsidised price. Compared to 2021, the average price of pipeline natural gas paid by households increased by almost two and a half times in the third quarter of 2022.

[4] Barbara Bene (2022): Czech Republic Introduces Price Cap on Gas and Electricity. Hungary Today.

This means that around 80% of residential consumption remained below the threshold to avoid price increase and 20% paid the higher prices in the Q1 2022. A year later this rose to 85%, marking a clear impact on Hungarian household natural gas consumption behaviour.

FIGURE 10: DEVELOPMENT OF REGULATED RESIDENTIAL NATURAL GAS PRICES (HUF/M3) AND EVOLUTION OF RESIDENTIAL NATURAL GAS CONSUMPTION (ESZ), MCM/MONTH



Source: KSH, Hungarian Energy and Public Utility Regulatory Authority

3 DECARBONISATION OPTIONS IN THE HEATING SECTOR

3.1 DECARBONISATION OPTIONS FOR THE INDIVIDUAL RESIDENTIAL HEATING SECTOR

This chapter provides a brief overview of the main options for decarbonising residential heating systems. Individual heating systems are defined as apartments with heat generating equipment located inside on the premise while DH networks generate heat outside the household at a designated plant that is distributed to individual houses or blocks of flats through a network of hot water pipes.

Short-term options for the decarbonisation of household heating are those that can be implemented immediately and without significant cost. Long-term options, alternatively, require significant investment over an extended time horizon, for example installing a new heating appliance or insulating the walls.

3.1.1 SHORT TERM OPTIONS

As alluded to above, basic efficiency actions are the first best solution for reducing energy used for heating purposes and associated emissions, partly because they are easy, fast and cheap. This starts by turning down the indoor temperature of the household. Based on previous studies,[5] even a 1-degree Celsius reduction can save around 7% of energy used for heating. Another option is to reduce the heated floor area, which results in an equivalent percentage reduction in energy consumption. A change in household behaviour can also have a similarly positive effect in supressing energy consumption, for example, with programmed heating settings. There are also low-cost investment options available, for example electric radiator or, mobile air conditioning, which can also reduce gas consumption.

These tools will only be widely implemented if households are incentivized through price signals, and even so they are limited going forward since some households exhausted these gains in 2022.

3.1.2 LONG TERM SOLUTIONS

3.1.2.1 ENERGY EFFICIENCY INVESTMENTS

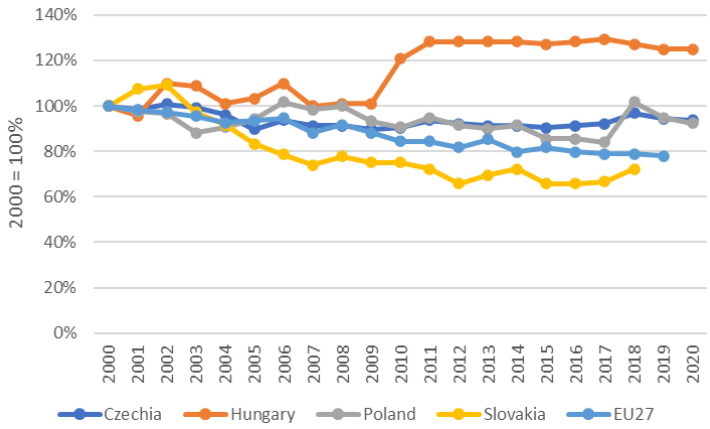
Long term energy efficiency investments can permanently reduce the amount of heating energy used by households.

[5] REKK (2023): Russian gas phaseout in Hungary, REKK (2022): The possibilities of phasing out Russian gas in the Danube Region (2022), REKK (2022): Possibilities for phasing out Russian gas for the 2022/2023 and 2023/2024 winter from the EU energy supply, European Commission (2022): Playing my part

Figure 11 shows that household energy efficiency in V4 countries has progressed more slowly than the EU between 2000 and 2019. In this period, EU27 average energy consumption per m2 for space heating declined by over 20% on average, compared to 6% in Czechia and 8% in Poland. Hungary's data series is misleading because of a statistical correction between 2009-2011, and in fact the energy consumption per dwelling did not decrease significantly thereafter. Slovakia is the outlier of the group due to a successful renovation programme targeting residential household between 1996 and 2007 that resulted in 64.7% of block of fats and 49% of family houses being renovated.[6] The program was carried out through the "State Housing Development Fund of Slovakia" the under Ministry of Transport and Construction.

The weak performance of some V4 countries can be partly explained by statistical anomalies. The sudden increase in household energy consumption in Hungary in 2010 and Poland in 2018 are probably the result of a change in the statistical data collection method used to measure biomass use. As a result of the statistical corrections, the share of residential solid biomass more than doubled in both countries (between 2008 and 2012 in Hungary and between 2017 and 2018 in Poland).[7]

FIGURE 11. CHANGE IN ENERGY CONSUMPTION PER DWELLING FOR SPACE HEATING WITH CLIMATIC CORRECTIONS (2000 = 100%)



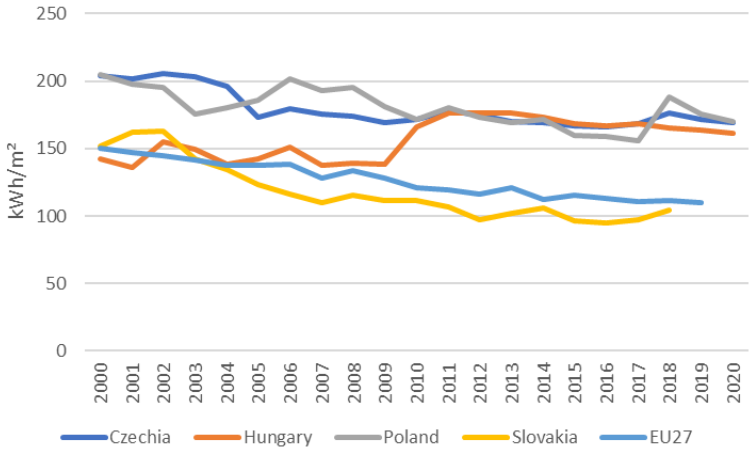
Source: Odyssee

With climate correction, Czechia, Hungary and Poland are near the same level of energy consumption per square meter (161-170 kWh/m^2/year), shown in Figure 12. This is significantly higher than the EU27 average (110 kWh/m^2/year), which Slovakia remains slightly below in 2018 (104 kWh/m^2/year), the last data point.

[6] Federica Prandin, Andriy Chubik (2022): Adapting EU energy efficiency targets to V4+ regional context

[7] Paweł Wiejski (2022): The accounting trick behind Poland meeting its EU renewable energy target

FIGURE 12: SPACE HEATING ENERGY CONSUMPTION PER M², CLIMATE CORRECTED



Source: Odysee

Based on these statistics we can conclude that V4 households (especially in Czechia, Hungary, Poland) have very high heat saving and efficiency potential for home renovations, various thermal insulation investments (façade, roof, attic floor, the entire building), as well as heat system investment, such as replacing the boiler or radiators and automation and programming.

3.1.2.2 SWITCHING FROM FOSSIL FUELS TO OTHER FUELS

3.1.2.2.1 Biomass

Biomass is the oldest most widespread heating technology due to its accessibility and affordability. Moreover, since many households switched from solid biomass to gas-fired boilers, the equipment is still available. For example, dual heating still exists in many detached houses in Hungary. As shown in Figure 1, biomass is the largest source of heating in Czechia and the second largest in Hungary, Poland and Slovakia.

Biomass is only realistic for detached houses in rural "off-grid" areas. Particularly in more densely populated areas, low-efficiency, outdated wood-burning stoves, are very detrimental to public health, emitting pollutants from incomplete combustion and gaseous NOx and SOx.[8] According to the EPHA position paper, "the health costs associated with outdoor air pollution stemming from the residential building sector (estimated by CE Delft at 29 billion euros) are higher than those due to transport", with over 30% coming from the use of traditional wood burning stoves.[9]

Modern biomass boilers and stoves (especially those using pellets) can meet strict emissions limits and are more suitable for heating, but V4 households still use fuelwood rather than pellet

[8] See IEA (2019): Does household use of solid biomass-based heating affect air quality?

[9] See EPHA (2022): The impact of residential heating and cooking on air quality in Europe and CE Delft (2022): Health-related social costs of air pollution due to residential heating and cooking. In the EU27 and UK

furnaces, which requires drying and storing, and is less convenient for households compared to natural gas or heat pumps.

Continued demand for fuelwood in the V4 might be unsustainable. Exceeding the rate of natural annual forestry growth is not compatible with the principles of responsible forest management, and can drive up the price. In response to concerns about the sustainability and carbon neutrality of biomass, the 2022 amendment to the Renewable Energy Directive introduced tightened the sustainability criteria.

3.1.2.2.2 Electrification of individual heating

Individual household heating can be electrified through the installation of a variety of heat pumps, electric storage heaters or electric radiators. The key issue is efficiency and performance. Older or poorly installed heat pumps can significantly add to overall costs for owners. Easy-to install air-source heat pumps have a seasonal performance factor (SFP) of 2.2-4.2 compared to ground-source heat pumps in the range of 3-5.4.[10] This means that 1 kWh of electricity produces 3-4 kWh of thermal energy. While prices of heat pumps are falling they are still much more expensive than gas boilers in most countries depending on subsidies, and this does not factor indirect costs of insulation to enable low-temperature heating and upgrading the electricity networks to meet increased loads.

3.1.2.2.3 Increasing the role of district heating systems

Connecting to the DH system is another pathway for individual fossil-fuel-based heating units to decarbonize where economically efficient, which will be densely populated areas with high heat demand close to the sources. This includes big cities and also small-towns where larger apartment buildings or local demand centers such as kindergartens, hospitals, pools, and offices are in close proximity. Of course, the DH system will need renewable potential available to exploit simultaneously.

3.2 DECARBONISATION OPTIONS IN THE DISTRICT HEATING SECTOR

DH is generated at a city heat plant and distributed to individual houses or blocks of flats through a network of hot water pipes. The advantage of DH over individual heating is that it can integrate a wide range of renewable energy and waste heat sources. In fact, expansion of DH networks is a key pillar of heat decarbonisation for several European countries, including Germany, France, the Netherlands, and UK.

10 IRENA (2022): Renewable solutions in end-uses: Heat pump costs and markets

3.2.1 GEOTHERMAL

Geothermal energy is sustainable, carbon neutral, and unaffected by volatility of energy prices and fuel supply disruptions, however the construction is a high-risk and capital intensive endeavour. The presence and quality of the geothermal resource (temperature and flow rate) cannot be proven until the first exploration well is drilled, and the up-front cost of drilling can account for up to 50% of the total project cost. Furthermore re-injection, which is required to manage the excess thermal water (containing sulphur, salts, minerals, and waste heat), can also encounter technical difficulties. The unique geological and drilling risks require specialized financing schemes.

The compatibility of geothermal energy into existing DH systems depends on the temperature of the thermal water, the energy efficiency of the building stock and the system configuration. For moderate 60-70°C temperatures typical of the region, heat pumps may require prior insulation and energy efficiency investment.

A flagship report produced as part of the 2014 GeoDH project estimated the share of the V4 population that can be reached by geothermal DH: Czechia and Poland 10%, Slovakia 50%, Hungary 90%. Despite this potential, geothermal heat production remains marginal, accounting for less than 3% of total DH production in Europe.[11]

3.2.2 BIOMASS

Biomass heating is a mature technology with reliable operating characteristics, moderate up-front costs and low investment risks. The technical integration of biomass combustion plants into existing DH systems is technically straightforward; it does not depend on the flow temperature of the heating networks or the condition of the building stock. Consequently, biomass combustion is by far the most widely used renewable energy source in European DH systems, accounting for 36%.[12]

There are a wide range of inexpensive biomass inputs readily available for heating plants: roundwood, wood chips and other forestry residues (branches, leaves, bark, etc.) and agricultural residues (straw, husks, stalks, leaves, seeds, roots, etc.). The direct environmental impact of biomass combustion can be moderated by air pollution control technologies. However, road congestion and air pollution from biomass deliveries, as well as noise and space requirements for on-site fuel handling, require careful siting in urban areas.

The carbon neutrality of biomass energy with respect to short-term carbon emissions versus long-term carbon sequestration is being re-evaluated and faces the risk of tightening EU regulations. Similarly, the sustainability of domestic fuelwood production in the V4 is coming under question, especially with plans to increase consumption. Particularly, Hungary, Poland and Slovakia are approaching harvesting and annual incremental forest area limitations.

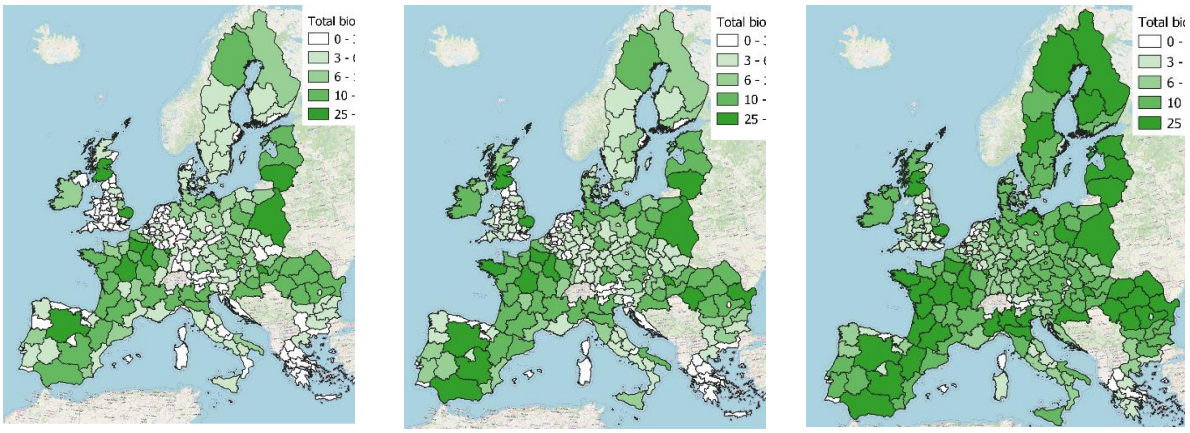
[11] Euroheat & Power (2023): DHC Market Outlook Insight & Trends

[12] Euroheat & Power (2023): DHC Market Outlook Insight & Trends

The ENSPRESO project estimated biomass potential in the EU28 using unique models across three distinct scenarios for low, medium and high biomass potential shown in Figure 13.[13] It defines three types of biomass:

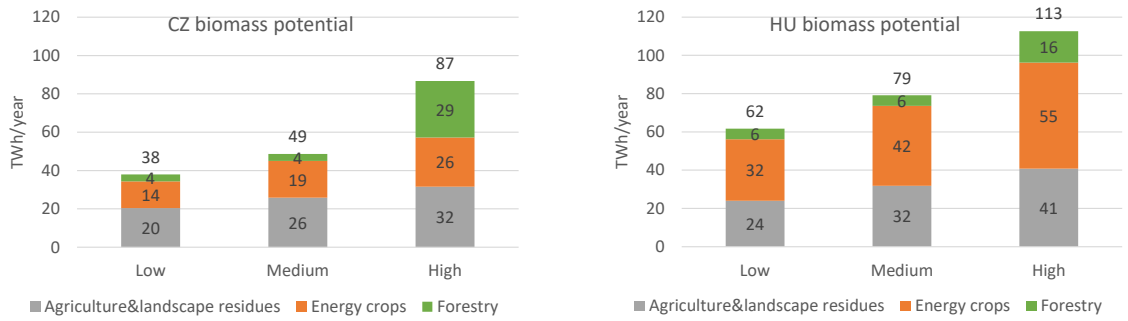
1. agricultural - dedicated energy crops and agricultural residues such as dry and wet manure, olive pits pruning and straw;
2. forestry biomass - including roundwood logging and forest residues such as woodchips and sawdust;
3. waste biomass - roadside landscaping, industrial and municipal solid waste.

FIGURE 13: ESTIMATED BIOMASS POTENTIAL IN THE EU28 NUTS-2 REGIONAL LEVEL

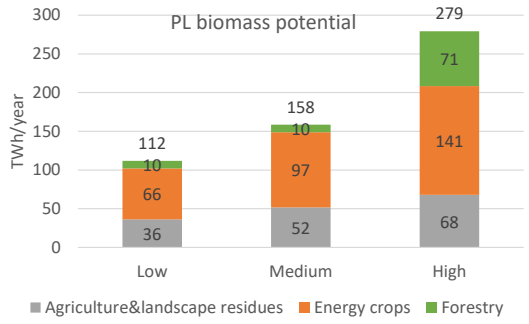


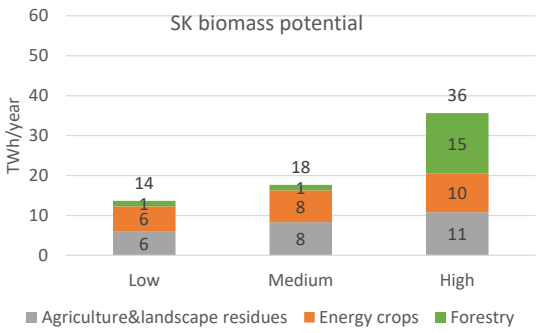
source: ENSPRESO database

FIGURE 14. BIOMASS POTENTIAL FOR THE V4 COUNTRIES



[13] Details on methodology are provided in P. Ruiz, W. Nijs, D. Tarvydas, A. Sgobbi, A. Zucker, R. Pilli, R. Jonsson, A. Camia, C. Thiel, C. Hoyer-Klick, F. Dalla Longa, T. Kober, J. Badger, P. Volker, B.S. Elbersen, A. Brosowski, D. Thrän: ENSPRESO - an open, EU-28 wide, transparent and coherent database of wind, solar and biomass energy potentials. Energy Strategy Reviews, Volume 26, 2019, 100379,.





Source: ENSPRESO database

3.2.3 SOLAR

Solar collectors have a unique seasonality production profile, producing around 75% of heat in the summer months outside the heating season. The capacity and output of solar collectors must be designed for summer demand and can only serve as a supplementary heat source, covering up to 20% of annual heat demand. Solar can be supplementary to seasonal storage, but only for utility scale solar parks and heating systems that can absorb the capital cost.

Large ground-mounted fields of solar collectors are more economical than rooftop collectors due to economies of scale. The specific investment cost of large solar parks with thousands of square metres of surface area is approximately half that of a rooftop installation covering a few hundred square metres. However, cheap sites / land suitable for solar fields may be far from urban centres, so in some cases long pipelines are required.

Solar district heating systems are not yet widespread in Europe. Even Denmark, which has by far the largest solar district heating capacity in the EU (over 1100 $MW_{th,}$) produces only about 2% of its total DH from solar collectors.[14]

3.2.4 HEAT PUMPS

Heat pumps use electricity to transfer thermal energy from a low temperature heat source (such as outdoor air or water) to a high temperature heat sink (such as an indoor space). For large-scale installations of 500 kW_{th} or more, a wide range of heat sources can be used: sewage water, ambient water (sea, lake, river), ground and geothermal water, and industrial waste heat (e.g. data centres). Heat pump efficiency can vary widely depending on the temperature and availability of heat source, the flow temperature of the heating system and the COP (coefficient of performance). This also affects the cost structure, with higher temperature heat source and lower flow temperature associated with higher COP and lower OPEX.

Heat pumps integrated with thermal storage and CHPs can enable the flexible and efficient integration of large amounts of intermittent electricity from wind turbines and photovoltaics.

[14] Katinka Johansen, Sven Verner (2022): Something is sustainable in the state of Denmark: A review of the Danish district heating sector

Synthetic refrigerants, the most common large-scale heat pumps, possess high levels of global warming potential (GWP). The EU introduced multiple bans on fluorinated gases like HCFCs (hydrochlorofluorocarbons) and HFOs (hydrofluoroolefins) in the latest F-gas regulation restricting their use.

While small-scale heat pumps are growing in popularity, large-scale heat pumps are not prevalent in Europe. Of the 2.5 GWh installed capacity, over 90% is located in Scandinavia, representing about 1% of the total installed DH capacity in the EU.[15]

[15] Euroheat & Power (2022): Large Heat Pumps in District Heating and Cooling Systems

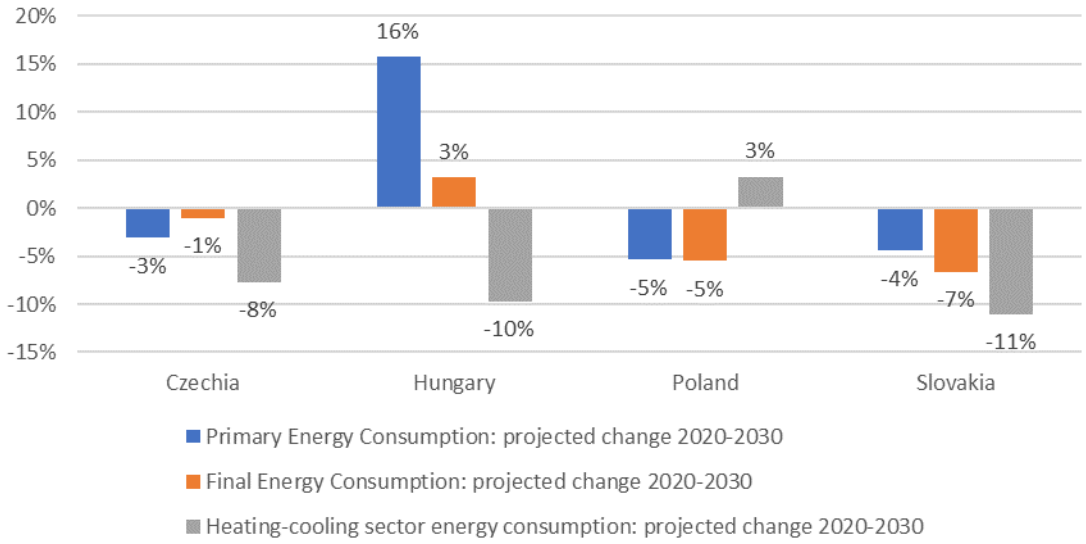
4 GOALS AND MEASURES OF THE V4 COUNTRIES

4.1 V4 OVERVIEW: FUTURE TARGETS BASED ON NECPS

Although National Energy and Climate Plans (NECPs) are still under revision, the first version submitted to the European Commission in 2019-2020 provides the starting point for 2030 projections and targets. Within this document are mandatory to forecasts for national primary and final energy consumption and the level of renewables in electricity, heating and cooling, transport. Although the scope is much broader than residential heating, it is indicative of the direction each V4 country is planning.

As Figure 155 shows, Czechia, Poland and Slovakia expect a slight decline in primary and final energy consumption between 2020 and 2030. Hungary as the outlier, with primary energy consumption increasing significantly (16%) and final energy consumption slightly. This is, however, mostly attributable to industrial production, with little impact on the household sector. As far as energy consumption in the heating and cooling sector, Hungary projects the second largest decline (-10%) after Slovakia (-11%), and similar to Czechia (-8%). Poland is the outlier in this indicator, projecting a small growth.

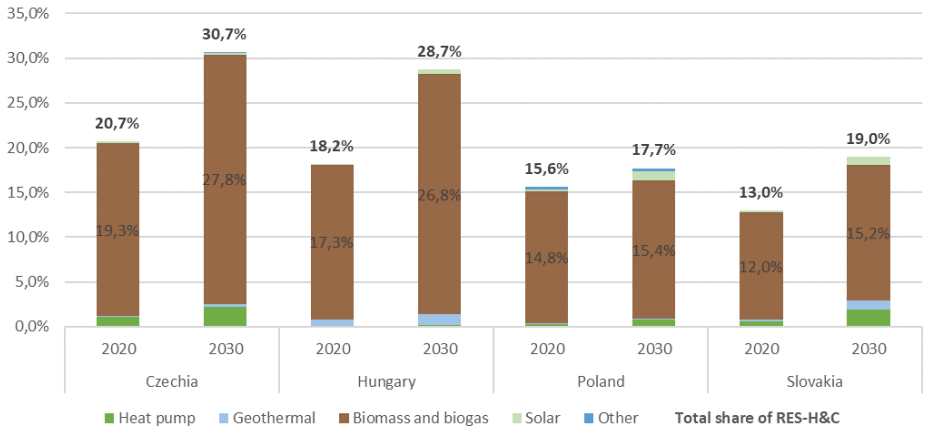
FIGURE 15: PRIMARY, FINAL AND HEATING AND COOLING SECTOR'S ENERGY CONSUMPTION PROJECTIONS



Source: NECPs

Figure 166 shows the 2020 and 2030 renewable shares of the heating and cooling sector in the V4. The Czech (30,7%) and Hungarian (28,7%) targets are significantly higher than the Slovak (19%) and Polish (17,7%). Currently biomass makes up more than 90% of the renewable share, and this composition is not expected to change much by 2030. As far as alternative renewable sources, only the share of heat pumps are included among Czech and Slovak targets, 2,3%, 1,9% respectively.

FIGURE 16: SHARE OF RENEWABLES IN HEATING AND COOLING SECTOR IN 2020 AND 2030



Source: NECPs

4.2 MEASURES AFFECTING THE HEATING SECTOR IN THE RRF PLANS

In the period between 2021 and 2027, EU member states have the opportunity to receive significant grants and loans within the framework of the largest EU financial package to date, the NextGenerationEU. The main element of this program is the Recovery and Resilience Facility (RRF), which aims to help European member states prepare for the green and digital transitions. More than €700 billion is available to implement reforms and investments that cover the following areas: green transition; digital transformation; smart, sustainable and inclusive growth; social and territorial cohesion; health, and economic, social and institutional resilience; policies for the next generation.[16]

Therefore, it is important to determine how the RRFs will be used to decarbonize the domestic heating sector and support energy efficiency of buildings. Table 1 provides an overview of the RRF plans most relevant to the heating sector based on data from the European Commission.[17][18]

[16] This will focus on the €338 billion in grants. The total EU budget (combination of NextGenerationEU and the long term budget) for the 2021-2027 period is 2,02 trillion euros.

[17] European Commission (2022): Recovery and resilience facility: Country pages

[18] Hungary's plan was under public consultation at the time of ths writing https://www.palyazat.gov.hu/rrf-repower-eu-tarsadalmasitasa

TABLE 1. OVERVIEW OF THE RRF PLANS OF THE V4

	Czechia	Hungary	Poland	Slovakia
Grant requested (billion EUR)	7	5,8	23,9	6,3
Share of green transition measures	42%	48%	43%	43%
Measures related to the building sector (billion EUR)	1,6	0,765	3,5	0,528
Share of measures related to the building sector (compare to the total RRF grants)	22,9%	12,5%	14,6%	8,4%
Main measures related to the building sector	renovation programmes to increase the energy efficiency of residential and public buildings, including childcare and long-term care facilities	supporting the replacement of windows in almost 12,000 houses, energy efficient renovation for early age childcare facilities, schools and in the healthcare sector	large-scale energy-efficiency renovations of residential and public buildings, with phase-out of and public support for coal-fired boilers	improve energy and green performance of at least 30,000 residential units
Received grants until 2023 q3 (%)	26%	0%	0%	31%

Source: Czechia RRF factsheet, Hungary RRF Plan (under public consHungary RRF Plan (under public consultation)ltation), Poland RRF factsheet, Slovakia RRF factsheet, ngeutracker.org

Among the V4, only Poland applied for loans on top of the subsidies provided, totalling €11.5 billion, about half of the €23.9 billion in grants. Czechia will receive €7 billion in grants, Slovakia €6.3 billion, and Hungary €5.8 billion. The planned programs can be divided into three major areas: green transition, digital transition and economic and social resilience. The green transition includes measures affecting the heating and transportation sectors and accounts for 40-50% of the total support in V4 countries.

Energy efficiency of buildings is prioritized differently across the V4 countries. Czechia has committed by far the most, about one quarter of the funds (€1,6 billion), compared with Hungary (12,5%, €765 million), Slovakia (8.4%, €528 million for family homes), and Poland (15%, €3,5 billion).

V4 energy efficiency measures and programs are primarily aimed at two areas. The first is large-scale renovations of family houses. Slovakia is targeting the renovation of 30,000 family homes,

not only in energy performance but climate adaptation, including water retention systems and green roofs. In order to achieve at least 30% primary energy savings on average, Slovakia will open regional centres to promote recycled construction materials. Czechia also plans to increase the number of energy consultation centres and requalification of workers programs in green technologies and materials. Hungary is targeting the renovation of 20,000 households and Poland will phase out a public subsidy for coal-fired boilers. Hungary, Czechia and Poland are emphasizing the renovation of public institutions, primarily early-age care facilities, kindergartens, schools and long-term care facilities.

Within the V4 there is also a large discrepancy in grant payments to date. Slovakia and Czechia received similar amounts (31% and 26%), while Hungary and Poland are still negotiating with the Commission to receive their first tranche.

4.3 CZECHIA

The MURE database provides a simple collection of measures targeting household space heating and provides an indication of potential savings. Czech policy operates with a mix of mandatory standards and financial support schemes shown in Table 2.

TABLE 2. POLICIES TARGETED AT RESIDENTIAL SPACE HEATING IN CZECHIA

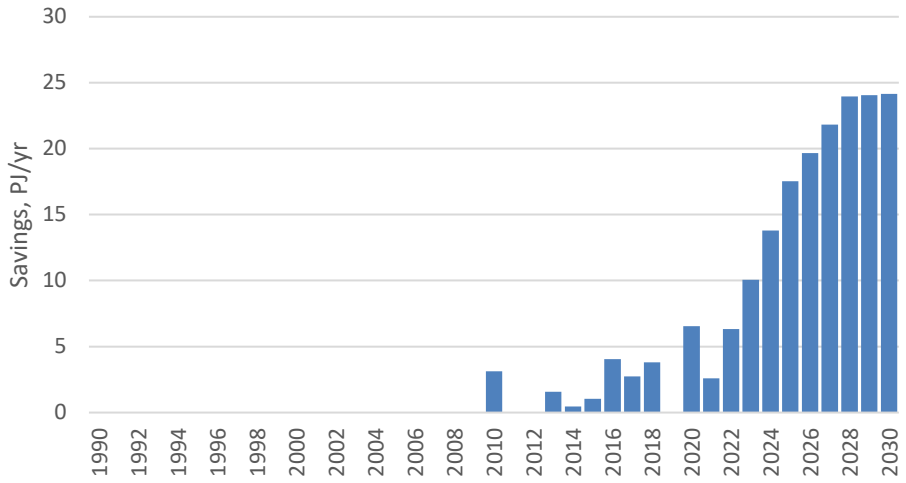
Title	Type	Years	Semi-Quantitative Impact
Loans to municipalities to upgrade housing	Financial	2001-	Low
Prohibition of solid fuel boilers of 1st and 2nd class	Mandatory standards	2022-	Medium
New Green Savings Programme 2021+	Financial	2022-2027	High
Operational Programme Environment 2014 - 2020 (part households)	Financial	2015-2020	High
Joint Boiler Replacement Promotion Scheme	Financial	2013-	Low
Integrated Regional Operational Programme 2014-2020	Financial	2015-2020	Medium
JESSICA Programme	Financial	2014-	Low
Regeneration of pre-fabricated concrete buildings - PANEL, NEW PANEL and PANEL 2013+ Programmes	Financial	2001-2020	Low
New Green Savings Programme 2014-2020	Financial	2014-2024	Medium
Support for the modernisation of housing stock by means of building society savings schemes	Mandatory standards	1995-	Medium

Source: MURE database

Semi-quantitative impact: low saving less than 0.1% of the sector energy consumption; medium saving 0.1-0.5% of the sector energy consumption; high saving over 0.5% of the sector energy consumption[19]

As shown in Figure 17, the expected 2030 savings from household space heating measures is 25 PJ, 11% of 2021 consumption.

FIGURE 17. EXPECTED ENERGY SAVINGS IN RESIDENTIAL SPACE HEATING FROM RELATED POLICIES IN CZECHIA



Source: MURE database

In Czechia, the reduction of local emissions and air pollution is becoming a central issue for the government. A boiler replacement scheme operating since 2013 aims to replace inefficient fossil fuel boilers in single-family households through grants and interest-free loans. Within the framework of the program, inefficient coal-fired boilers can be replaced with high-efficiency coal or coal and biomass-fired boilers. By 2020, approximately 82,000 boilers were replaced, but according to estimates, there are still another 300,000 obsolete devices that need to be replaced. In 2018, the program added a third phase, subsidizing the replacement of coal boilers with heat pumps, gas condensing boilers and biomass boilers.

In parallel with the support program, the government is gradually regulating outdated boilers by applying stricter emission standards. The Air Protection Act prohibits the use of first and second emission-class boilers after September 2022, which affects approximately 450,000 devices in use.

[19] Semi-quantitative expert estimates on measured impacts grouped into three categories: measures saving less than 0.1% of the sector energy consumption (low impact measures), measures saving 0.1 to less than 0.5% of the sector energy consumption (medium impact measures), and measures saving more than 0.5% (high impact measures). For measures in the cross-cutting database, the percentages refer to the overall final energy consumption of the country. These estimates were made by the National Teams in the MURE project possessing excellent policy knowledge. Nearly 90% of all measures in the database have been classified accordingly.

Concurrently, the New Green Savings Programme aims to improve household energy efficiency and reduce GHG emissions. It provides grants for measures combining general energy efficiency improvements and less emission-intensive heating sources. The Operational Programme Environment can provide up to 100% support for low-income households for such dual-purpose investments.[20] In Czechia, energy efficiency of buildings receives special attention in the Long-term Renovation Strategy[21] document. According to the analysis of the current situation, the lack of trained and skilled professionals is a major barrier for deep household renovations. This also affects the quality of the renovation, which may lead to less-than-optimal improvements in energy efficiency.

In order to further support deep renovations, the government introduced non-subsidy financial mechanisms, such as concessional loans and guarantees, to the support schemes and plans to simplify the legal and administrative framework. It will also launch an energy consultation program and information campaign.

District heating

Present situation

About 40% of households remain connected to DH following a nearly 10% over the last decade.[22] The main reason for the decline in Czechia DH is eroding competitiveness is a regulatory anomaly, common in all V4 countries. Large coal-fired DH systems fall under the EU ETS (Emission Trading System) and are subject to EU legislation for pollutants, while individual heating is not subject to these regulations and enjoys favourable tax treatment and environmental standards. As a result, consumers are opting out of the centralised DH systems in favor of individual heating sources. As the IEA review stated, „The economic viability of the sector is at stake".

Outlook and strategies

One of the main priorities of the Czech energy policy for space heating is to maintain/preserve the efficient DH networks by converting coal-based co-generation to gas, at least until other alternatives prove capable of replacing it. The share of coal in DH was lowered by 10%, from 68% in 2010 to 58% in 2019, with the aim of achieving another 20% by 2035. The government plans to prioritise coal supplies to high-efficiency heating plants in large and medium-sized heat supply systems and concentrate the use of natural gas on small and medium-sized heating systems.[23]

State energy policy sets a target for DH sourcing of at least 20% from renewable energy sources and at least 60% from CHP by 2040. To reach these, the government introduced a €1.2 billion

[20] https://www.iea.org/reports/czech-republic-2021
[21] https://energy.ec.europa.eu/system/files/2020-10/cz_2020_ltrs_official_translation_en_0.pdf
[22] IEA (2022) report declines from 68% in 2010 to 60% in 2019
[23] State Energy Policy of Czechia, Prague – December 2014

support scheme financed by the EU Modernisation Fund.[24] The programme offers direct grants paid on the basis of effectively incurred costs for projects aimed at (i) modernizing existing coal-fired heat generation unit into one suitable for biomass combustion; and (ii) replacing existing units with renewable energy sources or high-efficiency cogeneration based on waste to energy (waste incineration) or natural gas. Grants are awarded on the basis of effectively incurred costs limited to the „funding gap" of the project (the extra cost of a green investment compared to the less green alternative).[25]

4.4 HUNGARY

The MURE database did not provide quantitative estimates for the potential savings of Hungarian policies listed in Table 3.

TABLE 3. POLICIES TARGETED AT RESIDENTIAL SPACE HEATING IN HUNGARY

Title	Type	Years	Semi-Quantitative Impact
EU-related: Energy Performance of Buildings (Directive 2002/91/EC) – Energy review of heat producing sets and air conditioning systems	Mandatory standards, Mandatory information	2008-	Medium
Residential loan scheme for energy efficiency and renewable energy based modernizations of the building stock	Financial	2017-2020	Low
Individual measurements, application of mini heat centres in district heating	Mandatory standards	2005-	Low
Subsidies for residential energy efficiency purposes („Warmth of Homes")	Financial	2014-2020	Low

Source: MURE database, downloaded: 2023 August

Semi-quantitative impact: low saving less than 0.1% of the sector energy consumption;
medium saving 0.1-0.5% of the sector energy consumption;
high saving over 0.5% of the sector energy consumption[26]

[24] European Commission - Press release. State aid: Commission approves €1.2 billion Czech scheme to promote
green district heating, Brussels, 16 December 2022 https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7680

[25] State Aid SA.103821 (2022/N) – Czechia. Support scheme for the production of heat in district heating under the Modernization Fund. European Commission, Brussels, 16.12.2022

[26] Semi-quantitative expert estimates on measured impacts grouped into three categories: measures saving less than 0.1% of the sector energy consumption (low impact measures), measures saving 0.1 to less than 0.5% of the sector energy consumption (medium impact measures), and measures saving more than 0.5% (high impact measures). For measures in the cross-cutting database, the percentages refer to the overall final energy consumption of the country. These estimates were made by the National Teams in the MURE project possessing excellent policy knowledge. Nearly 90% of all measures in the database

Several support programs have been implemented to support renewable investments in heating systems, targeting solar, heat pumps, and, under certain conditions, geothermal energy.[27] The most prominent is the "Warmth of Homes" program launched in 2014, which dispersed nearly €10 million to finance 310,000 household renovations in five years. Each year targeted different types of household upgrades, ranging from the replacement of household appliances (refrigerators, washing machines etc.) to complete energy overhauls, including the modernization of heating systems, the replacement of convectors, the complete energetic modernization of family houses and condominiums, and the replacement of windows and doors.[28] However, the actual share of complex energy renovations remains relatively low and the programme has proven to have little impact on household energy consumption.

District heating

Present situation

The 17% of households connected to DH networks in Hungary is the lowest in the V4. Its reliance on natural gas is exceptional by both regional and European standards; natural gas boilers and CHP units accounted for 70% of DH supply in 2021. Even so, biomass and geothermal have made significant inroads into the sector and together account for almost a quarter of total DH supply.[29]

The Hungarian DH sector has been subject to tightening regulation over the years. In 2011, natural gas, electricity and DH prices were frozen, before a series of three consecutive, rapid fire, price cuts between 2013 and 2014 under the government's utility cost reduction programme.[30] Since the end of the CHP subsidy scheme in 2011, DH suppliers have accumulated heavy losses and increasingly depend on state aid financed by industrial electricity customers. The sector was hit particularly hard by the gas spike in 2022. Unable to raise household prices, losses multiplied, and required extraordinary public financial intervention. According to our estimates, past annual support levels of 100-130 million EUR annually increased by more than 10 times in the 2022-2023 gas year.

Outlook and strategies

The cornerstone of Hungary's National Energy Strategy (NES) is to reduce its dependence on imported natural gas. The primary tool is the Energy Efficiency Obligation (EEO), introduced in 2021, which aims to lower residential gas consumption by 2 billion cubic metres through energy efficiency improvement. It will also reduce the share of gas in the DH sector to below 50% by replacing gas boilers with renewable energy technologies.

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have been classified accordingly. https://www.odyssee-mure.eu/php/scoreboard-combined/documents/european-energy-efficiency-scoreboard-methodology.pdf

[27] https://iea.blob.core.windows.net/assets/9f137e48-13e4-4aab-b13a-dcc90adf7e38/Hungary2022.pdf

[28] https://www.otthonmelege.hu/otthon-melege-program

[29] Data of the Hungarian District Heating Sector 2021 (Hungarian Energy and Public Utility Regulatory Authority – Association of Hungarian District Heating Enterprises)

[30] Csaba Weiner and Tekla Szep (2022): The Hungarian utility cost reduction programme: An impact assessment

The planned (but not yet elaborated) Green District Heat program is intended to be the key instrument to drive the partial replacement of natural gas in DH generation. The program aims to upgrade efficiency of DH systems with over 100,000 GJ heat consumption by increasing the share of renewable and CHP to over 50%. As the NES states, „The fuel switch in the district heating sector accounts for the lion`s share of renewable energy growth in the heating and cooling sector."

The 2020 NECP relies heavily on biomass to increase the share of renewables in the heating sector, forecasting more than a 40% increase by 2030%.[31] However, there are doubts as to whether increasing or even maintaining the current share is sustainable in the long term. The NES, therefore, established a different order of priorities for greening DH, looking to geothermal and waste, while only sustainably produced biomass would be used to meet the remaining heat demand.[32]

To assist geothermal projects the Mining and Geological Survey of Hungary has launched a digital online Geothermal Information Platform („OGRE") to provide up-to-date and reliable geological, hydrogeological and geophysical data via a user-friendly and publicly accessible website.[33] The government has also changed the procedure for obtaining approval for geothermal energy extraction in an effort to streamline the process, though, feedback from industry has been mixed, highlighting the complexities facing geothermal energy production. [34][35]

4.5 POLAND

The energy consumption of buildings in Poland is well above the EU average (150-200 kWh/m^2), meaning there is a large potential for saving. The widespread use of coal in heat is responsible for the majority of local air pollution resulting in serious health issues for citizens. Table 4 lists the government programmes to help replace solid-fuel boilers with more efficient gas fired units. Previous iterations of the programme did not require building insulation or encourage households to invest in sustainable solutions, such as renewable heating or heat pumps. However, the latest 2023 version has been expanded to include replacement of boilers with heat pumps, electric heating, and insulation of buildings.

Switching from coal to gas reduces the sectors' carbon footprint and relieves air pollution in densely populated areas, but still emits methane and remains a volatile imported commodity. Moreover, changing heating systems are major investments for households and can easily create lock-in to natural gas heating for 15-25 years.

[31] The draft 2023 revision of the NECP slightly reduces the growth rate of biomass consumption to 34%.
[32] Ministry of Innovation and Technology - Hungary (2020): National Energy Strategy 2030
[33] Geothermal Information Platform – OGRE
[34] Supervisory Authority of Regulated Activities (2022): Geothermal Energy
[35] Hungarian Water Well Drillers Association (2023): Changes in the legislation on wells with primarily geothermal utilization

The national strategy will phase out coal-based boilers by urban households from 2030 and rural households from 2040. One-time subsidies are available for this and the support scheme for coal-base boilers was discontinued in 2021.

TABLE 4. POLICIES TARGETED AT RESIDENTIAL SPACE HEATING IN POLAND

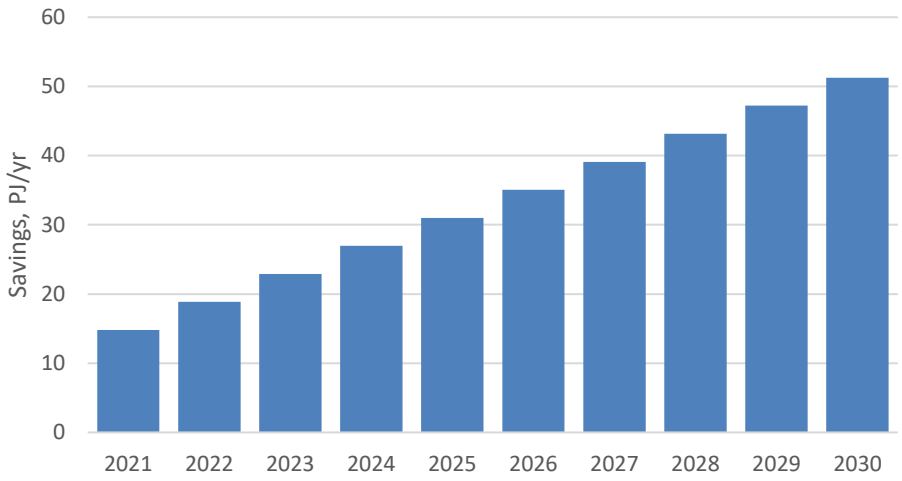
Title	Type	Years	Semi-Quantitative Impact
Requirements for new and modernised buildings	Mandatory standards	2014-	Low
EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Certificates of energy performance for buildings	General programme	2009-	Low
Thermo-modernization tax relief	Fiscal	2019-2030	High
"My Electricity" Programme	Financial	2019-2025	Low
"Clean Air" Programme	Financial	2018-2029	High

Source: MURE database

Semi-quantitative impact: low saving less than 0.1% of the sector energy consumption; medium saving 0.1-0.5% of the sector energy consumption; high saving over 0.5% of the sector energy consumption[36]

Figure 18 shows that by 2030, residential space heating programmes will deliver over 50 PJ savings in energy consumption, which is 8% of consumption in 2021.

FIGURE 18. EXPECTED SAVINGS FOR RESIDENTIAL SPACE HEATING POLICIES IN POLAND



[36] Semi-quantitative expert estimates on measure impacts which group the measures in three categories: measures saving less than 0.1% of the sector energy consumption (low impact measures), measures saving 0.1 to less than 0.5% of the sector energy consumption (medium impact measures), and measures saving more than 0.5% (high impact measures). For measures in the cross-cutting database the percentages refer to the overall final energy consumption of the country. These estimates have been made by the National Teams in the MURE project, who have an excellent knowledge of the policy in their countries. Nearly 90% of all measures in the database have been classified in such a manner.

Source: MURE database

District Heating

Current situation

Poland has the largest and most coal-dominated DH sector in the V4, with 40% of households connected and around 80% of heat generated from coal. Over the last decade, DH demand fell by around 10% despite being the cheapest household heating option.[37]

In Poland, DH development is a top priority for reducing urban air pollution and mitigating health effects. Almost 20% of Polish households in cities and 67% in rural areas still use individual coal boilers that seriously degrade air quality, resulting in the highest levels of airborne particulate matter (both PM10 and PM2.5) in the EU. According to the World Health Organization, 33 out of Europe's 50 most polluted cities are in Poland.[38]

Outlook and strategies

The main objectives of the Polish energy policy for the DH sector are: (i) connecting 1.5 million new households to district heating by 2030 to achieve 70% households connectivity in municipalities; (ii) increasing the use and efficiency of DH and co-generation by replacing coal with renewable, waste and gas based co-generation; (iii) developing a nationwide heating map highlighting the potential of district heating and co-generation) (iv) and activation of regional energy and heat strategies.[39]

Connecting new consumers to the network requires significant infrastructure and an overhaul of the price regulation. The Euroheat and Power country report asserts that, „the tariff approval system significantly limits the justification of costs for modernizing and extending the heat network".[40] In 2021, the Energy Regulatory Office (URE) changed the regulatory model „to ensure an adequate return on capital for those companies which are willing to undertake investments supporting the energy and climate policy objectives".[41]

In parallel with grid expansion, Poland is focusing on replacing coal-fired heating plants with high-efficiency CHP plants using gas, renewable energy or waste. The energy strategy stipulates that by 2030, 85% of heating or cooling systems with a contracted capacity of more than 5 MW but less than 50 MW (usually in places with less than 50,000 inhabitants) should meet a high energy efficiency standard.[42]

To meet this target, the government introduced a support scheme for high-efficiency CHP (with a GHG emission limit of 450 kg/MWh), which excludes coal-based units and encourages the

[37] IEA (2022): Poland 2022 - Energy Policy Review
[38] Euronews (2019): Poland among Europe's worst for smog
[39] Ministry of Climate and Environment (2021): Energy Policy of Poland until 2040
[40] Małgorzata Kwestarz (2019): Euroheat and Power Country by Country: Poland
[41] Energy Regulatory Office Poland (2023): District heating sector in numbers: latest URE report
[42] Ministry of Climate and Environment (2021): Energy Policy of Poland until 2040

use of renewables, waste and natural gas. The support is paid as a CHP premium on top of the market price for electricity determined by the amount of heat supplied to the DH network.[43]

It is important to underline that Poland more than any other V4 country is prioritising natural gas in the decarbonisation of the heat sector, still labelling it a transitional fuel. Consequently, the government is planning major investments across the natural gas system, expanding transmission and distribution networks, pipeline interconnections and gas-fired power generation capacity.

4.6 SLOVAKIA

Approximately 70% of existing residential buildings were built before 1990. The State Fund for Housing Development, under the Ministry of Transport and Construction of Slovakia, is the main source of long-term low-interest loans for the retrofitting and insulation residential flats and family homes.

Family houses make up a significant share of residential dwellings, which the Recovery and Resilience Plan targeted for the first national complex renovation programme. Contrary to the previous subsidy programmes targeting heating device replacement, the current grant is conditional on at least 30% primary energy savings, including home insulation, replacement of windows, as well as the heating source, green roofs, installation of shading technology and asbestos removal.[44]

The MURE database found only small savings from Slovakia's policies, listed in Table 5, and most were not quantified.

[43] European Commission (2019): State Aid SA.51192 (2019/N) – Poland – CHP Support and State aid
[44] Slovak Environment Agency: Opatrenia, na ktoré môžete získať príspevok

TABLE 5. POLICIES TARGETED AT RESIDENTIAL SPACE HEATING IN SLOVAKIA

Title	Type	Years	Semi-Quantitative Impact
Improvement of thermal technical propreties of buildings - Promotion of the Additional Thermal Insulation of Residential Buildings	Financial	2004-	High
Mandatory technical requirements on insulation of heating and domestic hot water distribution pipes	Mandatory standards	2012-	Low
The performance of heat generators for space heating and the production of hot water in non-industrial buildings	Mandatory information, Mandatory standards	2005-	Low
Maximum Indoor Temperature Limits in the Heating Period	Mandatory standards	2005-	Medium
EU-related: Energy Performance of Buildings (Directive 2002/91/EC) - Energy Performance Certificates for Buildings	Mandatory standards, Mandatory information	2006-	Low
Improvement of thermal-technical properties of buildings - Single family houses	Financial	2014-	Low
Improvement of thermal-technical properties of blocks of flats through the State Housing Development Fund	Financial	2014-2020	High
Provision of energy services in buildings	Financial	2014-2020	Low
Improvement of thermal technical properties of buildings – Ekofond	Financial	2009-	Low
Improvement of thermal technical properties of buildings - Governmental Programme of Thermal Insulation	Financial	2009-	Low
Hydronic balancing of the heating and domestic hot water systems	Mandatory standards	2008-	Low

Source: MURE database

Semi-quantitative impact: low saving less than 0.1% of the sector energy consumption; medium saving 0.1-0.5% of the sector energy consumption; high saving over 0.5% of the sector energy consumption[45]

Natural gas is the dominant fuel for both individual heating and DH while biomass accounts for most of the renewable share. The Energy Policy strategy from 2014 notes several positive

[45] Semi-quantitative expert estimates on measured impacts grouped into three categories: measures saving less than 0.1% of the sector energy consumption (low impact measures), measures saving 0.1 to less than 0.5% of the sector energy consumption (medium impact measures), and measures saving more than 0.5% (high impact measures). For measures in the cross-cutting database, the percentages refer to the overall final energy consumption of the country. These estimates were made by the National Teams in the MURE project possessing excellent policy knowledge. Nearly 90% of all measures in the database have been classified accordingly.

attributes of biomass, including energy self-sufficiency, economic growth and reducing greenhouse gas emissions.[46] However, there are several problems with wood management in the country, especially logging in non-forest lands which leads to unaccounted wood flows.[47] This has led a revision in subsequent strategic documents, focusing more on biomethane and geothermal energy.

The 2019 NECP sets out to increase the renewables share of individual heat and DH networks, including biogas production from livestock excrement, biodegradable municipal waste and waste form services sector to replace natural gas in heating plants.

Although Slovakia possesses vast untapped geothermal energy, it has been slow to develop. The government labels it the most expensive renewable technology[48] but will support its expansion. The first step was taken in the RePowerEU chapter of the Recovery and Resilience Plan in an effort to streamline the permitting processes and explore potential of existing wells.[49]

The Green Households programme under the Slovak Innovation and Energy Agency has been instrumental in supporting heat pumps installations over the years, but given the low overall investment return (14-18 years) location matters, and heat pumps are considered a better fit for Southern parts of the country.

Moreover, there are several hydrogen pilot initiatives led by energy companies. SPP-d, which owns and operates gas pipeline a distribution network connected to more than 1.5 million delivery points, initiated a hydrogen blending project in the village Blatná na Ostrave.[50]

District Heating

Present situation

Similar to Poland and Czechia, Slovakia has an extensive DH system, with around 32% of households connected. However, unlike Poland or Czechia, the Slovak DH sector is mainly fuelled by natural gas (44%) and increasingly biofuels, which together have largely replaced coal in heat and power generation, reducing its share to below 16%.

The overarching challenge for Slovak and all V4 DH sectors is that, as stated by the IEA, „it struggles with legacy DH systems that were built to supply larger volumes of high-temperature heat and are over dimensioned today".[51] Several parts of the distribution system „operated at excess capacity due to the significant decrease in heat consumption over the last 15 years", resulting in increasing distribution losses that are almost double the EU average.[52] This situation has led customers to disconnect and switch to gas boilers.

[46] Ministry of Economy of the Slovak Republic (2014): Energy Policy of the Slovak Republic
[47] Ministerstvo pôdohospodárstva a rozvoja vidieka SR (2022): Zelená správa 2022
[48] Inštitút environmentálnej politiky (2022): Analýza vplyvov balíka Fit for 55
[49] https://www.planobnovy.sk/site/assets/files/3330/repowereu.pdf
[50] TERAZ.sk (2022): Šéf SPP-D: Skúšky pridávania vodíka do zemného plynu sú zatiaľ úspešné
[51] IEA (2018): Energy Policies of IEA Countries: Slovak Republic 2018 Review
[52] Martina Olejníková (2017): Euroheat and Power Country by Country: Slovakia

Slovak legislation is aiming to maintain and increase the efficiency of DH networks by (i) making it mandatory for newbuild houses to be connected (where feasible) and (ii) making the right for consumers to disconnect conditional on the efficiency of DH supply.

Outlook and strategies

One of the main objectives of the Slovak energy policy for the heat sector is to „develop efficient centralised heat supply system" and to „support high-efficiency cogeneration of heat and electricity".[53] However, progress with the installation of high-efficiency cogeneration units has been slower than anticipated, leading the government to introduce a new support scheme for high efficiency gas cogeneration CHP plants to replace existing coal capacities.

The operational support is provided either in the form of a feed-in premium (allocated through an auction/tender) or a feed-in tariff (allocated through administrative procedure), depending on the size of the installation (smaller units are eligible for FiT and larger ones for FiP). If properly implemented, the programme should convert 80 small DH systems to reach 6.5% high-efficiency DH cogeneration by 2025.[54]

The Slovak energy policy anticipates an increasing share of renewables in the heat sector together with high efficiency CHP plants. The biomass share has more than doubled since the mid-2010s , but there are mounting concerns that forests in several regions are under threat from excessive logging and poor management.[55]

Individual heating

From 2017 to 2019, the share of natural gas grew from 15.6% to 16.6%, along with electricity, , which indicates a transition to more modern technologies.[56] However, from 2021 in response to the rising electricity and natural gas prices, individual households have been switching from natural gas to cheaper biomass.

[53] Ministry of Economy of the Slovak Republic (2014): Energy Policy of the Slovak Republic
[54] European Commission (2021): State Aid SA.54318 (2020/NN) – Slovakia Support of electricity from high efficient cogeneration of electricity and heat
[55] IEA (2018): Energy Policies of IEA Countries: Slovak Republic 2018 Review
[56] Statistical Office of the SR (2021): Slovak Statistics and Demography

5 POLICY CONCLUSIONS

5.1 POLICY RECOMMENDATIONS FOR V4 IN GENERAL

- Improving the energy efficiency of buildings through deep renovation is clearly the most effective way to decarbonise residential heating (the lowest hanging fruit) and a prerequisite for fuel switching (e.g. installing a heat pump). The "efficiency first" principle needs to be put into practice.
- The advantage of district heating over individual heating is that it can integrate a wide range of renewable energy sources and different waste heat sources in large quantities and cost-effectively. Preventing disconnection and promoting network expansion are goals that the V4 countries can jointly represent at the EU level.
- Heat pumps are seen as the first alternative for decarbonising individual heating, and in recent years the technology has gradually become more competitive and widespread. However, the electrification of heating requires a number of conditions to be met, including improving the energy efficiency of buildings, upgrading the electricity grid, increasing demand-side flexibility and improving the supply chain.
- Switching to biomass is considered a viable option in many cases, particularly in remote 'off-grid' areas where there are few other options for switching to low-carbon energy sources/heating technologies, but sufficiency, sustainability and impact on air quality should be carefully examined.
- Household price regulation is a double-edged sword: we can protect vulnerable consumers from the adverse effects of sharp price rises, but keeping energy prices artificially low discourages investment in energy efficiency. It should be limited to consumers in need and gradually phased out (in parallel with increased support for energy efficiency investments).

5.2 POLICY RECOMMENDATIONS FOR CZECHIA

- When decarbonising central heating systems, it is necessary to assess not only the possibilities on the resource side, but above all the possibilities to reduce consumption on the customer side. Energy efficiency and energy savings should be considered as a source of energy, not just as a boundary condition.
- The process of decarbonisation of the heating sector should follow a certain hierarchy. The first step should be strategic planning of the future development of consumption. Heat demand should be addressed primarily through savings (see previous point). The next step should be the use of existing waste heat sources (e.g., from the sewage network, industrial or computing processes, excess heat from commercial centres and their cooling technologies, etc.). Subsequently, available sustainable local sources should be

involved, such as solar thermal collectors (in combination with heat storage), biomass, geothermal energy, or the energy use of sorted and treated waste.

- Transformation of the heating sector should be supported by the introduction of new business models for heating companies towards the provision of complex energy services to end customers ("heat as a service") or regulation services for the electricity system. The integration of waste heat sources can be facilitated by business models used abroad (e.g., "open district heating").
- The decarbonization of individual heating should be supported by the continuation of existing state support programs, financed primarily from the trading of emission allowances. At the same time, it would be advisable to think about possibly narrowing down the group of beneficiaries so that the benefits of the subsidies can be drawn primarily by low-income households.

5.3 POLICY RECOMMENDATIONS FOR HUNGARY

- Due to the end-user price regulation and fixed priced for households, there were no incentives to invest in energy efficiency as the payback time for investments was too high for households. We recommend a price regulation which shields the consumers from extreme volatility but in the long-term consumers should pay the actual cost of energy they consume.
- Quality of the Hungarian building stock is poor, due to lack of energy efficiency investment in the past years. A targeted building insulation programme could considerably reduce the volume and cost of energy consumed by households.
- Natural gas is still a widespread mode of heating. No formal ban exists on installing natural gas boilers.
- Mandatory connection of new buildings to existing district heating systems should ensure the economic operation of the DH networks. Disconnections are rare, but should be discouraged.
- Hungary has great geothermal potential. Option for DH systems to replace gas-fired heat generation with geothermal sources should be thoroughly studied in all DH system operators.
- When replacing boilers, preference should be given to heat pumps. Monetary state support should be provided for heat pumps over fossil fuel boilers.
- Before replacing boilers, households should prioritize building insulation.

5.4 POLICY RECOMMENDATIONS FOR POLAND

- The heating demand of buildings in Poland is well above the EU average, high even in the context of the V4. Further improvement of energy efficiency should be a priority as it contributes to decarbonisation, improves air quality and reduces energy poverty.
- Energy transition requires significant investment in insulation or boiler replacement, which may not be affordable for poor households. Energy renovation programmes should be tailored to households in need, including vulnerable consumers such as the elderly or those living in fuel poverty.
- Increasing the share of households connected to the district heating network is an exemplary decision by Polish policymakers. However, in order to achieve this, it should be supported by various measures, including a comprehensive reform of the district heating price regulation to ensure an adequate return on capital for the investments supporting this move.
- Encouraging local (municipal) energy planning, supported by heat maps showing the potential of district heating, is an appropriate response to the challenge of extending the district heating network. Heat planning requires support from different parts of the public administration (e.g. planning, environment or urban planning authorities) to create a favourable regulatory environment for these initiatives.

5.5 POLICY RECOMMENDATIONS FOR SLOVAKIA

- Energy crisis reflected in high rise of fossil fuels on the markets called for the actions of the government. However, energy compensations for all households and industry do not motivate for energy savings. We recommend to focus on information and saving campaigns rather than financial compensations for all.
- While there have been several successful programmes within apartment buildings renovations and family houses are receiving also the attention, there has been a potential of thermal savings in public buildings. Their systematic renovation would be of a great benefit.
- Coal is not problematic as in Czechia or Poland, however, unproper individual heating has been source of local air pollution. Targeting energy poverty to renovate and replace heating source would be of a great benefit.
- There has been an untapped geothermal potential in Slovakia and speeding up the first pilot into DH would be of a great benefit, especially for Eastern part of the country.
- Similarly to other areas in energy, more support for research and innovation would bring not only desired benefits in terms of RES deployment and system efficiency, but would bring also benefits of international recognition of bringing innovative solutions in global energy transition efforts.