IEECP

INSTITUTE FOR EUROPEAN ENERGY AND CLIMATE POLICY

Impacts of policies on low-income households in the target countries

Study on the impacts of policies to decarbonize residential buildings on energy poverty in CEE/SEE and mitigation strategies

Author(s)

Ivana Rogulj, Vlasios Oikonomou, Jean-Sébastien Broc, Giulia Pizzini, Axelle Gallerand, Mara Oprea, Christos Tourkolias

Special thanks to:
Sergio Tirado Herrero, Aniko Palffy, Rui Fragoso, Jan Pojar, Jiri Karasek, Juraj Krisovic, Joao Pedro Gouveia, Eleonora Gaydarova, Ana Otilia Nutu, Jaume Loffredo, Martha Myers, Davide Sabbadin, Roland Gladushenko, Pascal Guillaume, Emmanuelle Causse, Federica Sabbati, Louise Sunderland, Samuel Thomas, Thomas Nowak, Anna Kompatscher, Cristina Pricop, Hélène Sibileau

Published in January 2022 by the Institute for European Energy and Climate Policy (IEECP) and funded by the European Climate Foundation.

How to cite this report: Institute for European Energy and Climate Policy (IEECP) (2022). "Status of energy poverty and policies to address it in CEE/SEE countries."

IEECP is a non-for-profit, independent research foundation working, since 2015, on science-based climate change mitigation, energy efficiency and renewable energy policy, with an international interdisciplinary team of experts generating and disseminating scientific knowledge. We work closely with EU institutions, international organisations, national, regional and local governments, think-tanks, NGOs, academics and the business world to lead the transition to climate neutrality and to a sustainable energy future for various sectors. We build valued partnerships with renowned organisations from across Europe as we believe collaboration and creating a community helps carrying our ideas and results further, to shape, together, a low-emissions, resilient future. www.ieecp.org

Institute for European Energy and Climate Policy Stichting - IEECP
Amsterdam Sloterdijk Teleport Towers, Kingsfordweg 151,
1043GR Amsterdam, The Netherlands
KvK: 64602214; VAT: NL0855739198

www.ieecp.org - info@ieecp.org

TABLE OF CONTENTS

1. SCOPE OF THE DOCUMENT

1.1 Introduction

This report presents the initial findings of *Workstream 2*, the quantification of three new policies, which are examined within the framework of the study. Based on data gathered from a variety of sources (primarily Eurostat, EU building codes and Household Budget Survey), the assessment is carried out, including the elaboration of chosen scenarios. The evaluation of effects from introduced polices to low-income households and the derived conclusions are part of the *Workstream 3* (WS3) document.

The important prerequisite was to determine low–income groups of each country, which will be referred to by the modelling and measures at national level. The modelling itself, after data gathering and validation from the national expert group, included calculations of baseline final energy consumption of low-income households. Subsequently, the evolution of the introduction of three proposed policies was determined based on expert knowledge of national and EU level stakeholder groups. The policies referred to are:

- *The EU Minimum Energy Performance Standards (MEPS)*
- *EU Emissions Trading System extension to fuel suppliers in buildings and transport sector*
- *Phasing out of fossil fuel boilers*

The proposed policies' introductions are calculated in relation to the business-as-usual (BaU) scenario(s) (the costs, investments and replacement rates) in five scenarios with different combinations of policies and the pace of introduction.

The results of *Workstream 2* include the total costs of every introduced scenario, including energy expenditure and cost of investments and are accompanied by the presentation of comparison between scenarios in the joint graphs. These serve as inputs for *WS3*.

The results also include the calculation of the allocation of allowances that the obligatory parties from included Member States would receive as well as the distribution of other allowances. The revenues from the ETS2 will be used in *WS3* for the financing of proposed measures.

1.2 Definition of low- income households

For the purpose of this evaluation, low-income households are considered those in the first income quintile. The absolute income depends on the Member State included.

The median disposable income per Member State is shown in Figure 1. When comparing the median income of MS included with average EU income, it is obvious that citizens of each MS already have lower median incomes than the average EU income.

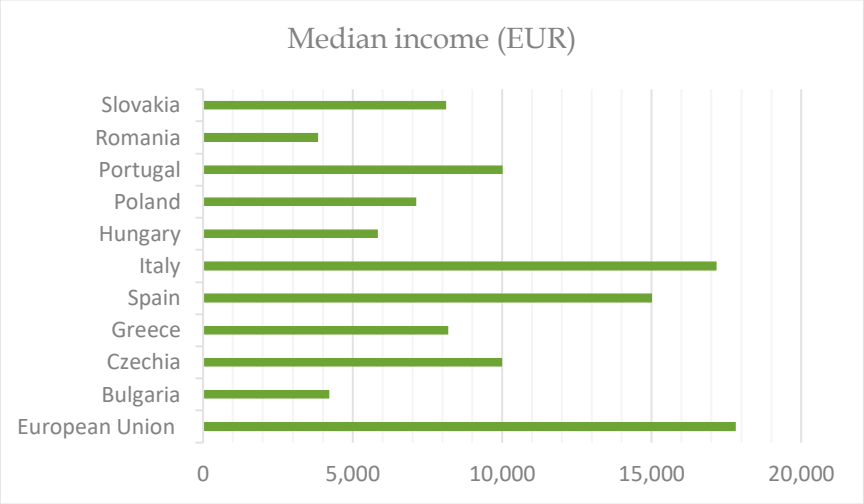

Figure 1 Median income in the included Member States, source: Mean and median income by age and sex - EU-SILC and ECHP surveys, EUROSTAT

Figure 2 shows the percentage of citizens in the first quintile to which modelling and later introduced policies refer to. The distribution of income is in line with the EU average, with which some distributional conclusions could be also upscaled to other EU countries.

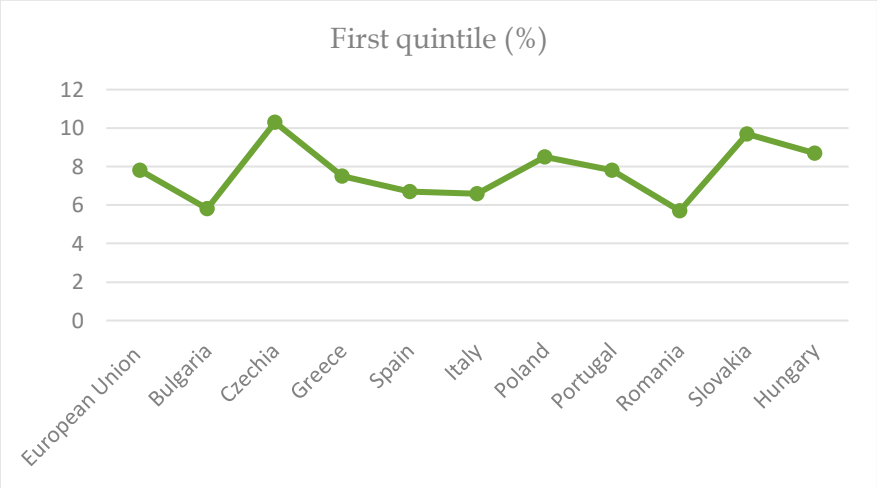

Figure 2 Percentage of the citizens in the first income quintile, source: Distribution of income by quantiles - EU-SILC and ECHP surveys, EUROSTAT

Number of low-income households per country

Based on income distribution per specific country, the number of households that have been used in the calculation are shown in Table 1. The importance of these numbers is that they primarily show how many households are being used for modelling purposes, but also indicate the number of households which measures are being developed for.

Table 1 Number of low-income households per included Member State

Country	Bulgaria	Czechia	Greece	Hungary	Italy	Poland	Portugal	Romania	Slovakia	Spain
Number of low-income HH	188,581	890,668	503,841	677,332	2,766,058	2,180,614	263,033	1,125,840	379,060	1,870,251

1.3 Data collection

The energy expenditure that was reported to the Households Budget Survey was the basis for determining the actual final energy consumption of low-income households in combination with additional data such as utilized fuels, the households' size, the building's area, and construction age of the building. If assumptions were used for the unavailable data, they are described in the country report. The module on how to distribute and evaluate the difference between the actual energy consumption of low-income households and the total population is described in the next chapter – modelling of baseline.

The final energy consumption of low-income households for different types of buildings (based on the energy performance and subsequently the building codes in each country) is calculated through the indicative dataset as presented in the table below:

Table 2 Dataset for the calculation of the baseline energy consumption of low-income households

Input Parameters								
Number (absolute) of low-income households (dwellings)								
Average income (€)								
Average number of occupants								
Average area (m2)								
Average expenses for electricity (€)								
Average expenses for thermal energy (€)								
Number of renovated buildings (%) (renovation rate)								
Percentage of utilized fuels for thermal uses (%) Energy prices (€/MWh) (with and without taxes)	*Electricity*	*Heating oil*	*Natural gas*	*Biomass*	*District heating*	*Solar thermal*	*LPG*	*Other*

Data collection included the following steps:

1: Finding results of the most recent Households Budget Survey conducted by the National Statistical Authority, for each country separately. Information about the Households Budget Survey is provided in the following table for the examined countries.

Table 3 Data sources for the HBS (links)

Country	Bulgaria	Czechia	Greece	Hungary	Italy	Poland	Portugal	Romania	Slovakia	Spain
Year	2019	2019	2019	2019	2019	2019	2016	2016	2016	2019

2: Collecting information about electricity, gas and other fuels expenditures both for the total households and for the households that belong to the different income decile.

3: Accessing primary data of the Households Budget Survey to identify more disaggregated information.

To be able to build and calibrate the *BaU* scenario in the heating and cooling sector of the targeted countries, the following dataset was also needed:

Table 4 Data needed for the BaU scenario

Space heating									
Modelling parameters									
Heating degree days									
Installed capacity of heating system (kW/building)									
Utilization factor (%)									
Useful energy for space heating (kWh/building)									
Percentage of utilized fuels for space heating (%) Efficiency of heating systems	*Heating oil*	*Natural gas*	*Biomass-Central system*	*Biomass-Individual system*	*District heating*	*Heat pumps-Conventional*	*Heat pumps-High efficient*	*Electricity*	*Other*
Calculations									
Final energy consumption (GWh)	*Heating oil*	*Natural gas*	*Biomass*	*District heating*	*Electricity*	*Other*			
Space Cooling									
Modelling parameters									
Cooling degree days									
Utilization factor (%)									
Installed capacity of cooling system (kW/building)									
Percentage of cooling systems (%) Performance of cooling systems	*Conventional systems*	*High- efficient systems*							
Calculations									
Final energy consumption (GWh)									
Domestic hot water (DWH)									
Modelling parameters									
Consumption of DWH (lt/member & day)									
Useful energy (kWh/building)									
Percentage of utilized fuels for DHW (%) Performance of DHW systems	*Electricity*	*Natural gas*	*Heating oil*	*Solar thermal*					
Calculations									
Final energy consumption (GWh)	*Electricity*	*Natural gas*	*Heating oil*	*Solar thermal*					
Cooking									
Modelling parameters									
Demand for cooking (kWh/dwelling)									
Percentage of utilized fuels for cooking (%) Performance of cooking systems	*Electricity*	*LPG*	*Natural gas*	*Biomass*					
Lighting and appliances									
Modelling parameters									
Demand for lighting (kwh/m2) Percentage of lighting systems (%) Percentage of electric appliances (%) Performance of electric appliances (kwh/appliance)									
Calculations									
Final energy consumption (GWh) - Electricity									

1.4 Development of the business-as-usual calculation

In this section, the methodological approach for the development of the *BaU* calculation is described using the "step" methodology.

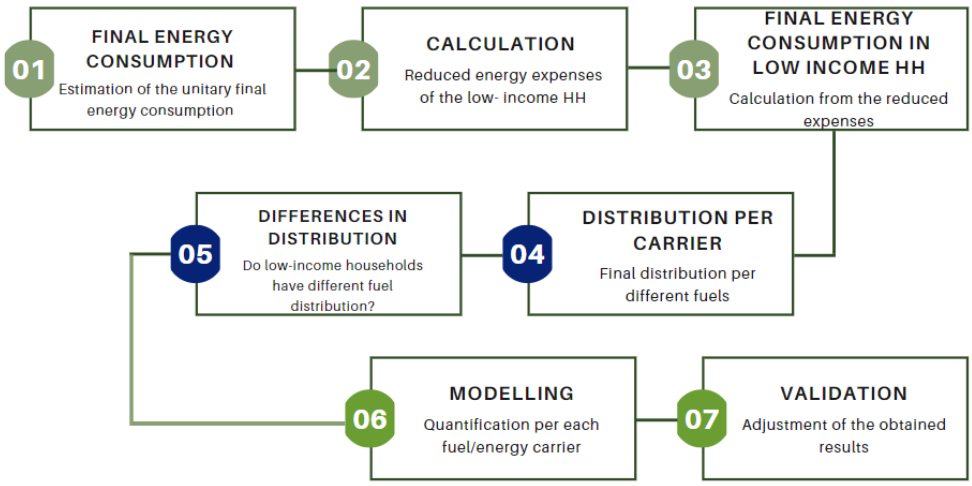

Figure 3 Step by step approach to BaU scenario development

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household according to data on the disaggregated final energy consumption of households (*data: Eurostat*).

Step 2: Calculation of reduced energy expenses of households belonging to the lowest income decile in comparison with energy expenses of the average household (*data: HBS*).

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in Step 2.

Step 5: Identification of utilised means of heating and cooking for the case of households which belong to the lowest income decile (*data: HBS*).

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) as well as identified energy expenses (Step 2).

1.5 Resulting final energy consumption in *BaU* year

Detailed data is available in the per-country analysis. To compare the status of low-income households from the perspective of energy consumption in the baseline situation and baseline year (2019), the results are presented in the same graph:

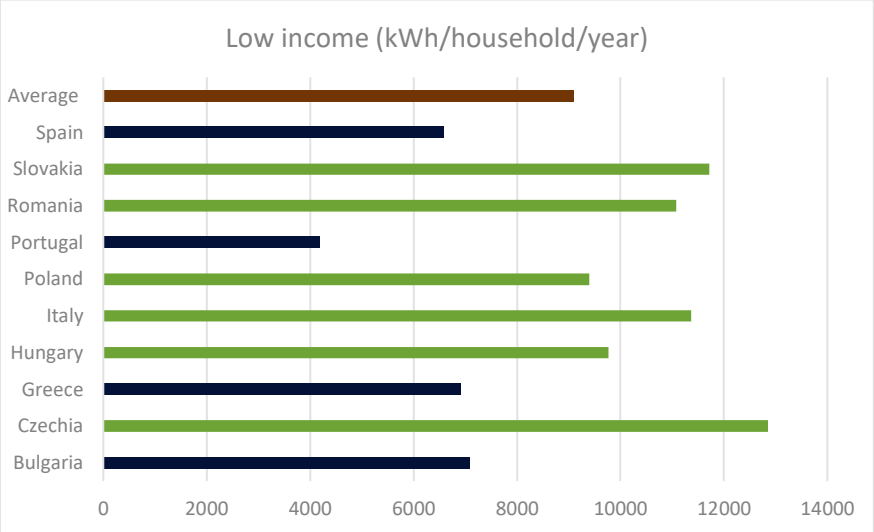

Figure 4 Energy consumption/low-income households

Calculation details and distribution of fuels and uses of energy is shown in the country-specific documents. The baseline situation we evaluated based on the dataset is also shown, along with the comparison between the average household and the low-income household from the perspective of energy consumption. The results are shown for the year 2019.

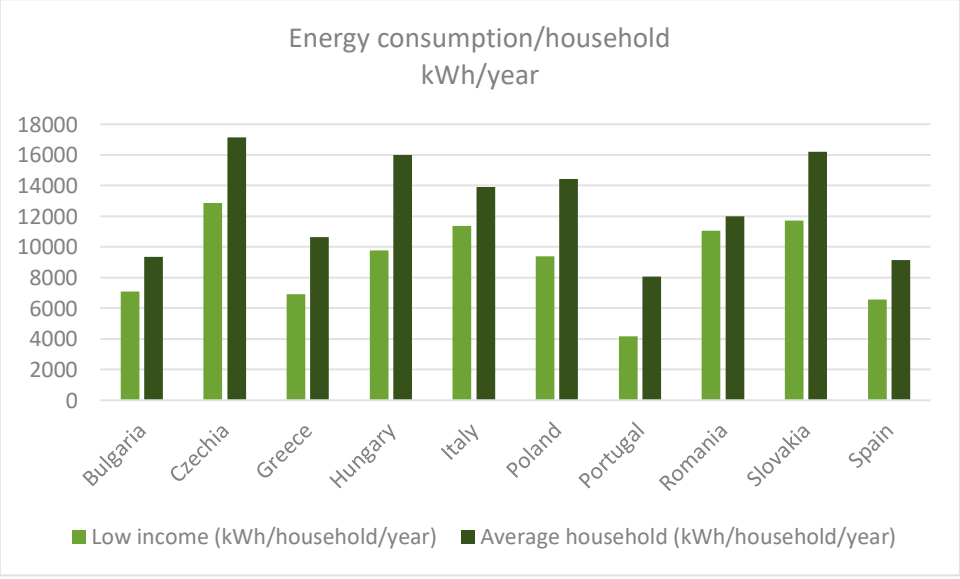

Figure 5 Comparison between average and low-income household energy consumption

2. INTRODUCED POLICIES

The three targeted policies and how they are introduced to the modelling scenarios is described below.

2.1 General description of the introduced policies

The three policy proposals explored in this study are:

Minimum Energy Performance Standards (MEPS)

MEPS target existing buildings, aiming to encourage deep renovations that "*meet a minimum performance standard by a given date or at a chosen trigger point in the building lifecycle*".[1] The Energy Performance of Buildings directive includes the renovation of the worst performing buildings; those in Energy Performance Certificate (EPC) classes G or F. The G rating corresponds to the 15% worst performing buildings in each country, with the remaining buildings in the country distributed proportionately among the other classes between G and A which corresponds to zero-emission buildings. Residential buildings which are interesting for the study will have to be renovated from G to at least F by 2030, and to at least E by 2033.[2] Although evidence of the measured impacts of MEPS is limited, the Impact Assessment of the Energy Performance of Buildings Directive (EPBD) concluded that MEPS can support achieving final energy savings and energy expenditures reduction, as well as generate construction activity. The impact assessment did not isolate the impacts of MEPS on energy poverty, nor did it address specificities regarding the CEE and SEE regions.

EU Emissions Trading System extension (ETS2)

The EC has proposed a new emissions trading system (referred to in this document as ETS2), which will put a price on emissions from the building and the road transport sectors. This system is also cap and trade like ETS1 and it is regulated upstream, meaning it does not directly involve buildings or cars but suppliers of the directly distributed fuels. The new system is designed to start from 2026. These sectors will still be covered by the Effort Sharing Regulation, which means national policies will continue to contribute to reducing emissions in the sectors.[3] Carbon pricing is considered to be the measure creating the market for innovative solutions, but it is dependent on the energy price elasticities (and cross-price elasticities) in each country as well as on the consumers' responsiveness to price increases. The impacts of the ETS price in these sectors could however generate higher costs to households (hence leading to higher energy poverty) in Central and Eastern as well as Southern Europe.

Phasing out of fossil fuel boilers

To proceed with the decarbonization of heating and cooling in residential sectors, the installation or sale of new fossil boilers should be phased out by 2030 as boilers have a lifetime of around 20 years. There is, however, a potential of locking in poor households in using obsolete technologies, as heat pumps are more expensive in terms of their upfront investment

[1] https://c4eforum.net/louise-sunderland-getting-the-most-out-of-forthcoming-minimum-energy-performance-standards
[2] https://ec.europa.eu/commission/presscorner/detail/en/QANDA_21_6686
[3] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542

while the running costs of heat pumps are likely to be lower than those of fossil boilers due to their higher efficiency. The only way for securing the minimization of such a lock-in is a stable and clear policy framework that can enable poor households to make the switch to renewable energy heating systems. There is an ongoing revision of the Ecodesign and energy labelling measures for space and water heaters that is likely going to lead to a downgrading of gas boilers to the lowest two energy labels and a discussion on the phase-out of the sale of inefficient fossil heating systems. Nevertheless, what is mostly remarked in the ten countries showcased in this study is that, in their decarbonization phase, they a) opt for natural gas as a new fuel for heating, enlarging their existing gas pipelines in the domestic sector, and b) still make use or introduce several subsidies for fossil fuel heating in natural gas boilers, under the umbrella of energy efficiency measures. The phasing out of fossil fuel boilers should therefore indicate a clear timeline to avoid further lock-ins and increase of costs for shifting natural gas boilers.

2.2 Introduction of policies to the model and scenario development

The policies are introduced to the modeling scenarios with an interactive process through the Stakeholder Board, involving most prominent experts in the area. Some of the scenarios include only one of the proposed policies, while others include a combination of policies which will be described in the following section.

2.2.1 Horizontal assumptions of the modelling scenarios

Baseline year

Within the modelling procedure, 2019 was used as the baseline year. The estimation of the final energy consumption of low-income households was performed through the implementation of an approach based on the collected data regarding the expenses of the households (including low-income ones), as described in the previous sections.

Changes in final energy consumption

The final energy consumption in the baseline case is evaluated on an annual basis in the period 2021-2030 according to the EU Reference Scenario 2020. It should be noted that no increase was considered for the period 2031-2050 due to the implementation of the various policies.

ETS1 The assumptions for the evolution of the ETS1 (

Figure 6) prices were derived from the EU Reference Scenario 2020.

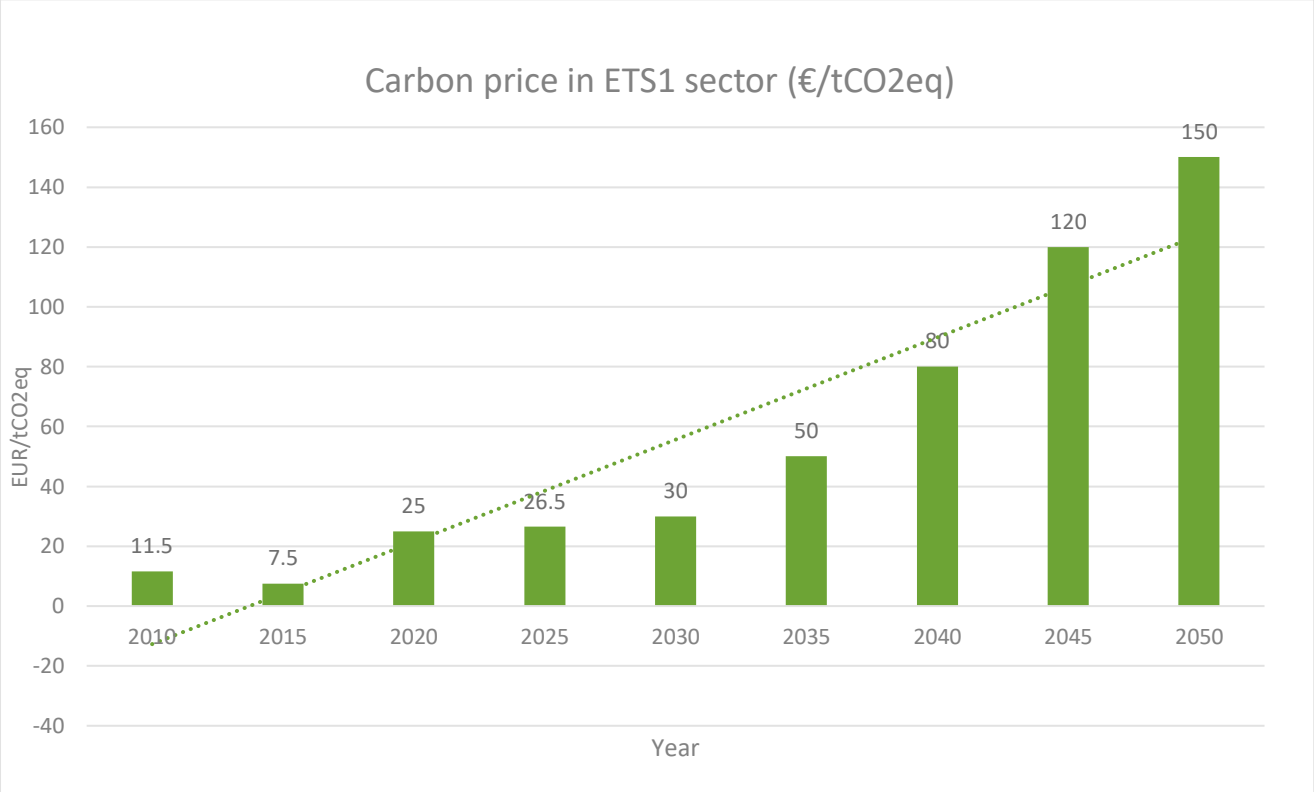

Figure 6 Scenario for the evolution of ETS1 price until 2050

Moreover, the carbon intensity of the electricity production sector in 2030, 2040 and 2050, according to the EU Reference Scenario 2020 for each MS, was taken into account for the calculation of the electricity price's increase due to the ETS1 price.

ETS2

ETS2 prices are a result of the study, which Vivid Economics conducted for ECF. It should be noted that for the case of the ETS2 price, two different scenarios were explored to model the electricity price evolution until 2040. Scenario 1 was selected for the case of carbon pricing policy, while Scenario 2 was selected for combination of policies. Finally, it is assumed that after 2040 the ETS2 price will remain constant.

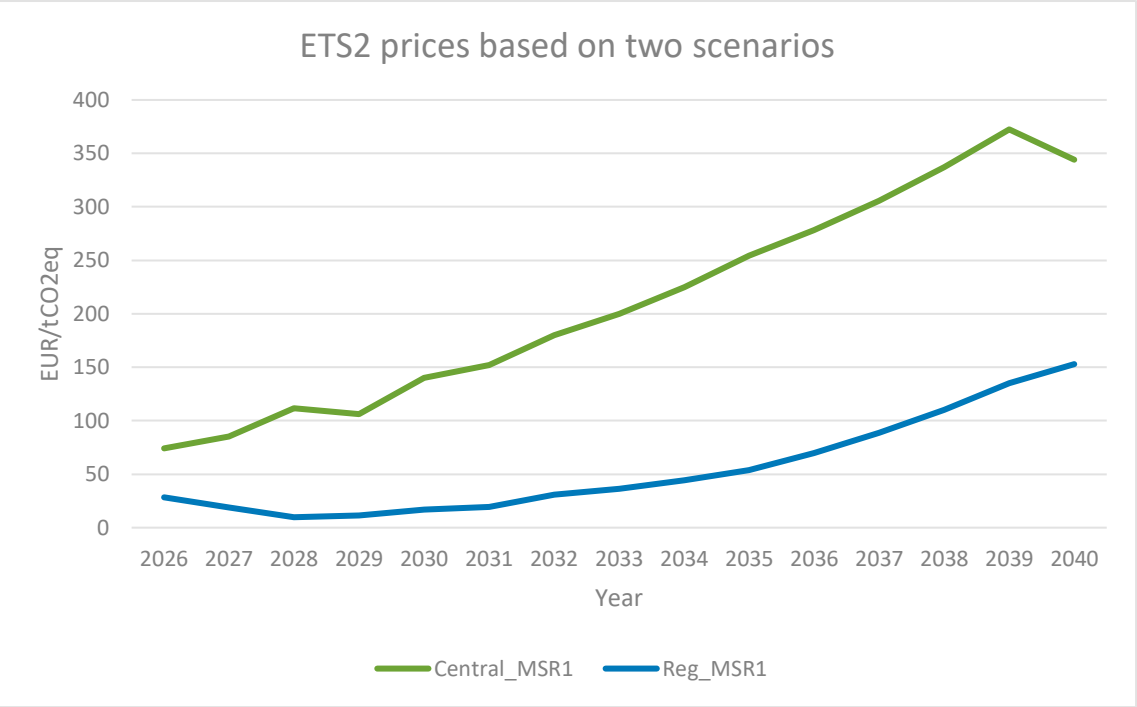

Figure 7 Scenario for the evolution of ETS2 price until 2040

Fossil fuels prices

An increase of fossil fuels prices was considered for the period of 2019-2050 according to the utilized forecasts within the framework of the EU Reference Scenario 2020 for the case of heating oil, natural gas, coal and LPG and was described per MS in the respective section.

Figure 8 Fossil fuel prices – reference

2.2.2 Descriptions of the introduced policies' scenarios

Elasticities of demand for all the scenarios are determined in the per-country documents. Elasticities were only available on the average level of households.

Baseline scenario **Assumptions**: No implementation of additional policies. The foreseen increases of energy prices within the framework of the EU Reference Scenario 2020 were taken into account. Scenario 1 was considered for the projection of the electricity price.
Scenario 1 **Assumptions**: Scenario 1 was considered for the projection of ETS2 price. The foreseen increases of energy prices within the framework of the EU Reference Scenario 2020 were taken into account in additional to the increase due to the carbon pricing. Scenario 1 was selected for the projection of the electricity price.
Scenario 2 **Assumptions**: Mandatory phase-out of heating oil and solid fossil fuels in 2030 and natural gas (including LNG) in 2040. It was considered that the actual phase-out will have occurred after five years (heating oil and solid fossil fuels in 2035 and natural gas and LNG in 2045), and heat pumps will replace the existing heating systems. The installation cost of the heat pumps was assumed equal to €8,000.
Scenario 3 **Assumptions**: Establishment of MEPS for achieving energy class E in 2035. 50% of the affected households (75% of the total low-income households) will renovate their buildings until 2030 and remaining buildings until 2035. Assumptions for buildings' energy upgrade: Renovation cost: €10,000/dwelling and delivered final energy savings: 30%. In 2040 all the building will be upgraded to energy class D (Assumptions for buildings' energy upgrade: Renovation cost: €5,000/dwelling and delivered final energy savings: 10%). It should be noted that the renovation costs for the case of Hungary was assumed to be slightly higher (€13,500/dwelling and €6,500/dwelling in 2035 and 2040 respectively).
Scenario 4 **Assumptions**: Combination of Scenarios 2 and 3
Scenario 5 **Assumptions**: Combination of Scenarios 1, 2 and 3.

The modelling of the policies occurred successively. Firstly, the impact of the ETS2 price was calculated, while the introduction of MEPS was considered in a second phase to estimate the reduction of the final energy consumption. Finally, the phasing out of the fossil fuels boilers was examined for the combined assessment of the examined policies. It should be highlighted that the energy efficiency principle was applied both in the introduction of MEPS and the phasing out of the fossil fuels boiler, as a meaningful reduction of energy consumption was assumed in the case of MEPS and the installation of heat pumps was considered for replacing the existing fossil fuel as it is the most energy efficient option.

3. CALCULATION OF THE AUCTION VOLUMES IN THE ETS2

As ETS2 has introduced adverse effects, but also revenues to help with the consequences on the low-income group, the objective of this work is to evaluate ETS2 auctions and to calculate revenues in *WS3* and compare them with the needs deriving from the disposable income gap or low energy performance of buildings.

Based on the study prepared by Vivid Economics for T&E and ECF, the total number of auctions in the ETS2 will decrease as shown in Table 5.

Table 5 Auctions prior and after MSR adjustment

Year	Auctions prior to MSR adjustment Unit: Million allowances Scenario: Central case with MSR1	Auctions after MSR adjustment Unit: Million allowances Scenario: Central case with MSR1
2026	1,289	1,289
2027	935	935
2028	779	745
2029	722	655
2030	665	665
2031	707	707
2032	650	650
2033	593	593
2034	536	536
2035	479	479
2036	422	422
2037	365	365
2038	308	308
2039	252	252
2040	195	195

The sharing of auctions is determined by the share of current emissions in the targeted sectors based on data collected under the Effort Sharing Regulation, as described in the introduction on the policy.

Auctioning

The Commission is proposing to apply emissions trading in new sectors where sharper reductions are needed to reach the 2030 target. Therefore, emissions from fuels used in road transport and buildings will be covered by a new, separate emissions trading system. It will become operational as of 2025, with a cap on emissions set from 2026, based on data collected under the Effort Sharing Regulation. During the first year, fuel suppliers will be required to hold a greenhouse gas emissions permit and to report their emissions for 2024 and 2025. The cap in the new ETS will be reduced annually to yield emissions reductions of 43% in 2030 compared

to 2005.[4] **The emission cap is allocated to fuel suppliers** as described in the policy introduction.

- As both the building and road transport sectors are under no competitive pressure from outside the Union and are not exposed to a risk of carbon leakage, allowances for buildings and road transport will only be allocated via auctioning without there being any free allocation.[5]
- The Innovation Fund, currently sourced from the existing ETS in 2021-2030, would include 150 million allowances from the ETS 2.
- The total volumes of the auctions described in the section above are distributed based on the emissions from "Fit for 55" Mix scenario data[6]. The data has been evaluated.

Social Climate Fund

The Commission proposes to set up a new Social Climate Fund to address social impacts of emissions trading in road transport and buildings sectors on vulnerable households, micro-enterprises and transport users. Resources from this Fund should correspond to approximately 25% of the expected auction revenues from the new system in 2026-2032.

[4] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0551&rid=7
[6] https://energy.ec.europa.eu/excel-files-mix-scenario_en#details

Table 6 Allocation of ETS2 auctions

Distribution based on 2016-2018 average emissions													
Unit: Million allowances													
Scenario: Central case with MSR1													
				0.8%	*2.3%*	*1.8%*	*8.8%*	*13.2%*	*1.9%*	*8.1%*	*1.5%*	*2.1%*	*0.9%*	
	Auctions prior to MSR adjustment	**Auctions after MSR adjustment**	**Allocation after Innovation fund**	**BG**	**CZ**	**EL**	**ES**	**IT**	**HU**	**PL**	**PT**	**RO**	**SK**	**Central_ MSR1**
2026	1,289	1,289	1,139	9.5	26.4	21.0	100.3	150.8	21.7	92.6	17.3	23.4	9.8	74.2
2027	935	935	785	6.5	18.2	14.5	69.1	103.9	14.9	63.8	11.9	16.1	6.7	85.1
2028	779	745	595	5.0	13.8	11.0	52.4	78.8	11.3	48.4	9.0	12.2	5.1	111.9
2029	722	655	505	4.2	11.7	9.3	44.4	66.9	9.6	41.1	7.7	10.4	4.3	106.0
2030	665	665	515	4.3	11.9	9.5	45.3	68.2	9.8	41.8	7.8	10.6	4.4	140.2
2031	707	707	557	4.6	12.9	10.3	49.0	73.7	10.6	45.3	8.5	11.4	4.8	152.2
2032	650	650	500	4.2	11.6	9.2	44.0	66.2	9.5	40.7	7.6	10.3	4.3	180.1
2033	593	593	443	3.7	10.3	8.2	39.0	58.7	8.4	36.0	6.7	9.1	3.8	199.9
2034	536	536	386	3.2	9.0	7.1	34.0	51.1	7.4	31.4	5.9	7.9	3.3	224.7
2035	479	479	329	2.7	7.6	6.1	29.0	43.6	6.3	26.8	5.0	6.8	2.8	254.3
2036	422	422	272	2.3	6.3	5.0	24.0	36.1	5.2	22.1	4.1	5.6	2.3	278.2
2037	365	365	215	1.8	5.0	4.0	19.0	28.5	4.1	17.5	3.3	4.4	1.8	305.9
2038	308	308	158	1.3	3.7	2.9	13.9	21.0	3.0	12.9	2.4	3.2	1.4	337.3
2039	252	252	102	0.8	2.4	1.9	8.9	13.4	1.9	8.3	1.5	2.1	0.9	372.4
2040	195	195	45	0.4	1.0	0.8	3.9	5.9	0.8	3.6	0.7	0.9	0.4	344.3

4. RESULTS AND CONCLUSIONS

The energy costs for low-income groups in all countries which ban new fossil fuel boilers do not seem to change substantially and neither for the ETS2 as a standalone measure. Through the combination of measures, the relative energy costs (in comparison to the baseline) remain constant or decrease over time as a result of the combination of lower energy consumption and higher energy prices for these policy scenarios. However, it must be taken into consideration that this assumption is rather conservative for low-income households. The conclusion comes from the research on the specific price elasticities of low-income households.

Due to lack of data on low-income groups' elasticities, we have used the average elasticities. However, research shows that there is "*heterogeneity in households' reactions to energy price fluctuations. … Such high sensitivity, equivalent to the capacity of a household to handle problematic situations – such as an increase in prices – to satisfy its energy needs, is supported by high income level. We stress that, in our sample, the set of fuel-poor households that have higher elasticity do not necessarily correspond to low-income households, because only one-third of them are income-poor*"[7] This research means that the energy poor have high elasticities only if they are not income poor, which is not the case for our analysed groups. Other streams of research also show that "*increases in carbon taxes can increase…, the existing level of poverty*".[8] As such, the households living in inadequate conditions would respond very strongly to the price signal, unless they are in the low-income group, which is our case. This is supported by the research on investments which shows that the vulnerable households, use higher discount rate in comparison to the average households due to their use of the discounting gap, meaning that they prefer short term solutions. This also means that is very hard for vulnerable households to escape poverty because they do not always have the possibility to engage in actions that are sustainable in long term. [9]

This would mean that the average response to price rise due to ETS2 introduction is a conservative assumption and does not include investments from the side of the household that would be needed to react to price changes such as fuel switches or increased energy efficiency. If savings in energy expenditure would not originate from the above-mentioned fuel switch and energy efficiency, they must come from lower energy consumption. Taking into consideration that the target group is low-income, although part of the energy savings could be a result of behavioural energy efficiency measures, most would be caused by simple reductions of energy consumption by reducing comfort,

[7] D. Charlier, S. Kahouli (2018). From residential energy demand to fuel poverty: income-induced non-linearities in the reactions of households to energy price fluctuations. FAERE Working Paper, 2018.11. https://www.iaee.org/ej/ejexec/EJ402_Kahouli_ExecSum.pdf

[8] Miguel A. Tovar Reaños, Fuel for poverty: A model for the relationship between income and fuel poverty. Evidence from Irish microdata, Energy Policy, Volume 156, 2021,112444, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2021.112444.

[9] Damigos, D.; Kaliampakou, C.; Balaskas, A.; Papada, L. Does Energy Poverty Affect Energy Efficiency Investment Decisions? First Evidence from a Stated Choice Experiment. Energies 2021, 14, 1698. https://doi.org/10.3390/en14061698

causing economic and social stress. This would shift more low- income households into a state of vulnerability, thus influencing arrears, lower comfortability levels (ability to keep warm) and consequentially resulting in reduced health and social statuses of the household. In other words, the response to the increase of the energy costs due to the ETS2 would not be a structural effect, but rather a short to medium-term response that cannot be considered an energy efficiency improvement. The main problem hindering a structural change (through energy upgrades of buildings or heating installations) is the difficulty in the upfront financing of costs for such systems by low-income groups, if proper compensation mechanisms are not present.

The introduction of MEPS and scenarios including MEPS with other policies shows a steep fall of energy consumption and positively influences the condition of the dwellings occupants live in. This is mostly the result of the establishment of MEPS achieving energy class E in existing buildings for 2035, most of the affected households belong to low-income groups, therefore most (75% in our assumption) would be targeted with the measure that results in energy savings.

When looking into results of policies for low- income households, the medium-long run expenditure side decreases, the comfort level improves, and higher disposable income results. This is of course the case if the introduced measure does not directly influence the energy costs of households, which is only possible if the policy instruments alleviate the cost increase that are introduced (this is further explored in *WS3).* As a basis, policies should aim at financing both the upfront costs for installing the heating equipment or upgrading the buildings, but also the increased energy costs in the form of social policies (similar to incumbent short-term measures for the increased costs during the current energy price crisis).

The analysis of auctions of ETS allowances shows the allocations aligned with the current ESR emissions of specific countries. Countries have different fuel mixes in their heating sector, signifying that the auctioned allowances introduced would proportionally assist them in targeting the energy transition in all sectors, including households. However, there is no relation between the heating energy mix and the level of energy poverty, therefore the methodology used in the Social Climate Fund to assist the countries with disproportionally high energy poverty levels is utterly important. Details of these allocations and how countries would use them are described in *WS3*.

5. ANNEX – RESULTS FOR MEMBER STATES

5.1 BULGARIA

5.1.1 Determination of baseline

Step 1: Estimation of the unitary final energy consumption for different end-uses of the average household in Bulgaria according to the data about the disaggregated final energy consumption of households (*data: Eurostat*).

Table 7 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	9336
Space heating	4863
Space cooling	44
DHW	1695
Cooking	800
Other	1934

Energy carrier	Average household (kWh/HH)
Total	9336
Electricity	4030
Natural gas	330
Oil	85
Solid fossil fuels	442
District heat	1330
Solar thermal	47
Biomass	3071

Step 2: Calculation of the reduced energy expenses of the households, which belong to the lowest income decile compared with the energy expenses of the average households (*data: HBS*).

Table 8 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	18%
Natural gas	100%
Oil	18%
Solid fossil fuels	55%
District heat	84%
Solar thermal	0%
Biomass	-5%

Step 3: Calculation of the unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration the reduced energy expenses as estimated in Step 2.

Table 9 Energy consumption of low-income household

End uses	Low-income HH (kWh/HH)
Total	7084
Space heating	3776
Space cooling	37
DHW	1020
Cooking	661
Other	1589

Step 4: Calculation of the unitary final energy consumption of households, which belong to the lowest income decile, for the different consumed energy carriers taking into consideration the reduced energy expenses as estimated in the Step 2.

Table 10 Energy consumption of low-income household distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	7084
Electricity	3312
Natural gas	0
Oil	70
Solid fossil fuels	200
District heat	215
Solar thermal	47
Biomass	3239

Step 5: Identification of the utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Number of low-income households (dwellings): **188,581**

Table 11 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	625	71	7	153	93	300
Heating oil	1	0		0		
LPG	13	0		0	12	
Natural gas	0	0		0	0	
Solar thermal	9			9		
Biomass	611	579		13	19	
District heating	41	24		16		

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Coal and other	38	37		1	1	
Total	1336	712	7	192	125	300

Step 7: Validation and adjustment of the obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and the identified energy expenses (Step 2).

Cost deviation equal to **-13%** assuming the following prices:

Table 12 Utilised energy prices in Bulgaria

Energy carrier	Energy price (€/MWh)
Heating oil	100
Electricity	98
Natural gas	38
Biomass	28
District heating	51
Solar thermal	0
LPG	160
Coal and other	50

5.1.2 Modelling the impacts of the examined policies in Bulgaria

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 13 Energy prices in the baseline scenario for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	38	49	61	72	84	87	91
Solid fossil fuels	50	55	60	64	67	71	74
Electricity	98	99	100	103	106	110	114
LPG	160	187	213	240	267	293	320

Final energy consumption (GWh)

Table 14 Final energy consumption in baseline scenario in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	597	597	597	597	597
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	25	25	25	25	25
Electricity	71	73	73	72	71	69	68
Coal and other	37	36	34	33	32	32	31
Total	712	732	730	728	726	723	721
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	153	157	157	154	152	148	145
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0

District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	1	1	1	1	1
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
Total	192	198	197	194	192	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	592	610	610	610	610	610	610
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	42	42	42	42	42
Electricity	232	238	236	233	229	224	219
Coal and other	37	37	35	34	33	32	31
Total	911	936	934	929	924	918	913

Total energy costs (million €)

Table 15 Total energy costs in baseline scenario in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	17	17	17	17	17
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	24	24	24	25	25
Coal and other	2	2	2	2	2	2	2
Total	43	45	45	45	46	46	47

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 16 Energy prices in the Scenario 1 for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	178	234	247	278	309
Natural gas	38	49	95	137	145	159	174
Solid fossil fuels	50	55	121	178	176	199	221
Electricity	98	99	100	103	106	110	114
LPG	160	187	258	324	347	388	429

Final energy consumption (GWh)

Table 17 Final energy consumption in Scenario 1 in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	597	597	597	597	597
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	25	25	25	25	25
Electricity	71	73	73	72	71	69	68
Coal and other	37	36	15	11	9	8	7
Total	712	732	710	705	703	699	697
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	153	157	157	154	152	148	145
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0
District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
Total	192	198	196	194	191	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	1	1	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	592	610	610	610	610	610	610
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	42	42	42	42	42
Electricity	232	238	236	233	229	224	219
Coal and other	37	37	15	11	10	8	7
Total	911	936	914	906	901	894	888

Total energy costs (million €)

Table 18 Total energy costs in Scenario 1 in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	17	17	17	17	17
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	24	24	24	25	25
Coal and other	2	2	2	2	2	3	3
Total	43	45	45	45	46	47	47

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 19 Energy prices in the Scenario 2 for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	38	49	61	72	84	87	91
Solid fossil fuels	50	55	60	64	67	71	74
Electricity	98	99	100	103	106	110	114
LPG	160	187	213	240	267	293	320

Final energy consumption (GWh)

Table 20 Final energy consumption in Scenario 2 in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	597	597	597	597	597
Ambient heat	0	0	0	6	6	6	6
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	25	25	25	25	25
Electricity	71	73	73	74	73	71	70
Coal and other	37	36	34	0	0	0	0
Total	712	732	730	703	702	700	698
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	153	157	157	154	152	149	146
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0
District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	1	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9

Total	192	198	197	194	191	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	592	610	610	610	610	610	610
Ambient heat	0	0	0	6	6	6	6
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	42	42	42	42	42
Electricity	232	238	236	236	232	227	222
Coal and other	37	37	35	0	0	0	0
Total	911	936	934	904	900	895	890

Total energy costs (million €)

Table 21 Total energy costs in Scenario 2 in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	17	17	17	17	17
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	24	24	24	25	25
Coal and other	2	2	2	0	0	0	0
Total	43	45	45	43	44	44	45

Table 22 Investments foreseen in Scenario 2 in Bulgaria

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	69	0	1	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS C IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (71 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (71 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 25 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 50%.

Energy prices

Table 23 Energy prices in the Scenario 3 for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	38	49	61	72	84	87	91
Solid fossil fuels	50	55	60	64	67	71	74
Electricity	98	99	100	103	106	110	114
LPG	160	187	213	240	267	293	320

Final energy consumption (GWh)

Table 24 Final energy consumption in Scenario 3 in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	485	394	394	394	394
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	20	16	16	16	16
Electricity	71	73	59	47	47	46	45
Coal and other	37	36	28	22	21	21	20
Total	712	732	593	480	479	477	476
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	6	5	4	4	4
Total	7	7	6	5	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	153	157	157	154	152	148	145
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0
District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	1	1	1	1	1

Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
Total	192	198	197	194	192	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	592	610	498	407	407	407	407
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	37	33	33	33	33
Electricity	232	238	221	206	203	198	194
Coal and other	37	37	28	23	22	21	21
Total	911	936	795	679	675	670	665

Total energy costs (million €)

Table 25 Total energy costs in Scenario 3 in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	14	11	11	11	11
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	22	21	21	22	22
Coal and other	2	2	2	1	1	2	2
Total	43	45	40	36	36	37	37

Table 26 Investments foreseen in Scenario 3 in Bulgaria

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	1768	1768	0	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 27 Energy prices in the Scenario 4 for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	38	49	61	72	84	87	91
Solid fossil fuels	50	55	60	64	67	71	74
Electricity	98	99	100	103	106	110	114
LPG	160	187	213	240	267	293	320

Final energy consumption (GWh)

Table 28 Final energy consumption in Scenario 4 in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	485	394	394	394	394
Ambient heat	0	0	0	4	4	4	4
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	20	16	16	16	16
Electricity	71	73	59	6	5	4	4
Coal and other	37	36	28	0	0	0	0
Total	712	732	593	421	421	419	419
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	6	5	4	4	4
Total	7	7	6	5	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	153	157	157	154	152	149	146
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0
District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	1	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
Total	192	198	197	194	191	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0

LPG	0	0	0	0	0	0	0
Biomass	592	610	498	407	407	407	407
Ambient heat	0	0	0	4	4	4	4
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	37	33	33	33	33
Electricity	232	238	221	164	162	157	154
Coal and other	37	37	28	0	0	0	0
Total	911	936	795	619	616	611	608

Total energy costs (million €)

Table 29 Total energy costs in Scenario 4 in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	14	11	11	11	11
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	22	17	17	17	18
Coal and other	2	2	2	0	0	0	0
Total	43	45	40	30	30	30	31

Table 30 Investments foreseen in Scenario 4 in Bulgaria

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	69	0	1	0
Building envelope	0	1768	1768	0	0	0
Total	0	1768	1837	0	1	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 31 Energy prices in the Scenario 5 for Bulgaria

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	139	164	189	230	271
Natural gas	38	49	65	83	101	123	145
Solid fossil fuels	50	55	68	83	97	134	170
Electricity	98	99	100	103	106	110	114
LPG	160	187	219	254	289	340	391

Final energy consumption (GWh)

Table 32 Final energy consumption in Scenario 5 in Bulgaria

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	579	597	485	394	394	394	394
Ambient heat	0	0	0	4	4	4	3
Solar thermal	0	0	0	0	0	0	0
District heating	24	25	20	16	16	16	16
Electricity	71	73	59	5	5	4	3
Coal and other	37	36	26	0	0	0	0
Total	712	732	591	419	419	418	418
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	6	5	4	4	4
Total	7	7	6	5	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	153	157	157	154	152	149	145
Natural gas	0	0	0	0	0	0	0
Heating oil	0	0	0	0	0	0	0
District heating	16	17	17	17	17	17	17
LPG	0	0	0	0	0	0	0
Biomass	13	13	13	13	13	13	13
Coal and other	1	1	1	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	9	9	9	9	9	9	9
Total	192	198	197	194	191	188	185
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	0	0	0	0	0

Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	592	610	498	407	407	407	407
Ambient heat	0	0	0	4	4	4	3
Solar thermal	9	9	9	9	9	9	9
District heating	41	42	37	33	33	33	33
Electricity	232	238	221	164	161	157	153
Coal and other	37	37	27	0	0	0	0
Total	911	936	793	617	615	610	607

Total energy costs (million €)

Table 33 Total energy costs in Scenario 5 in Bulgaria

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	0	0	0	0	0	0	0
LPG	0	0	0	0	0	0	0
Biomass	17	17	14	11	11	11	11
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	23	23	22	17	17	17	17
Coal and other	2	2	2	0	0	0	0
Total	43	45	40	30	30	30	31

Table 34 Investments foreseen in Scenario 5 in Bulgaria

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	60	0	1	0
Building envelope	0	1768	1768	0	0	0
Total	0	1768	1828	0	1	0

Synopsis

Comparison of final energy consumption

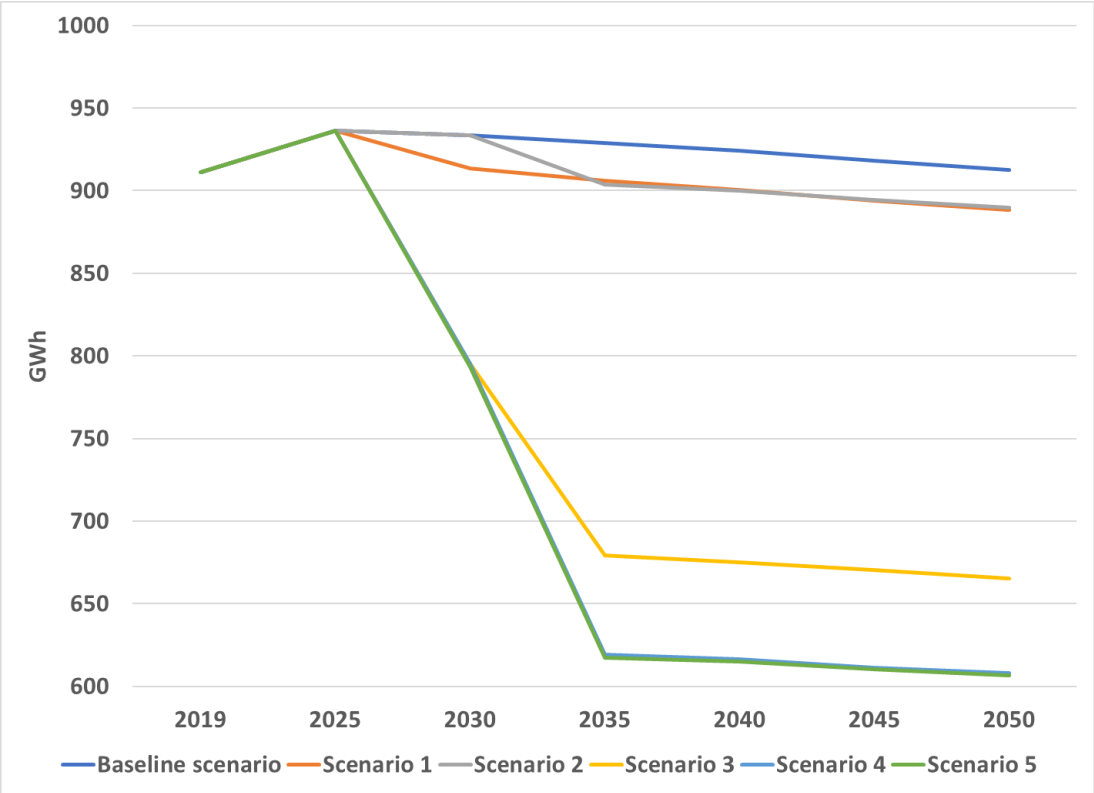

Figure 9 Comparison of final energy consumption between scenarios in Bulgaria

Comparison of investments in different scenarios

Figure 10 Investments in different scenarios in Bulgaria

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	69	0	1	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	1768	1768	0	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	69	0	1	0
	Building envelope	0	1768	1768	0	0	0
	Total	0	1768	1837	0	1	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	60	0	1	0
	Building envelope	0	1768	1768	0	0	0
	Total	0	1768	1828	0	1	0

Comparison of the total energy costs

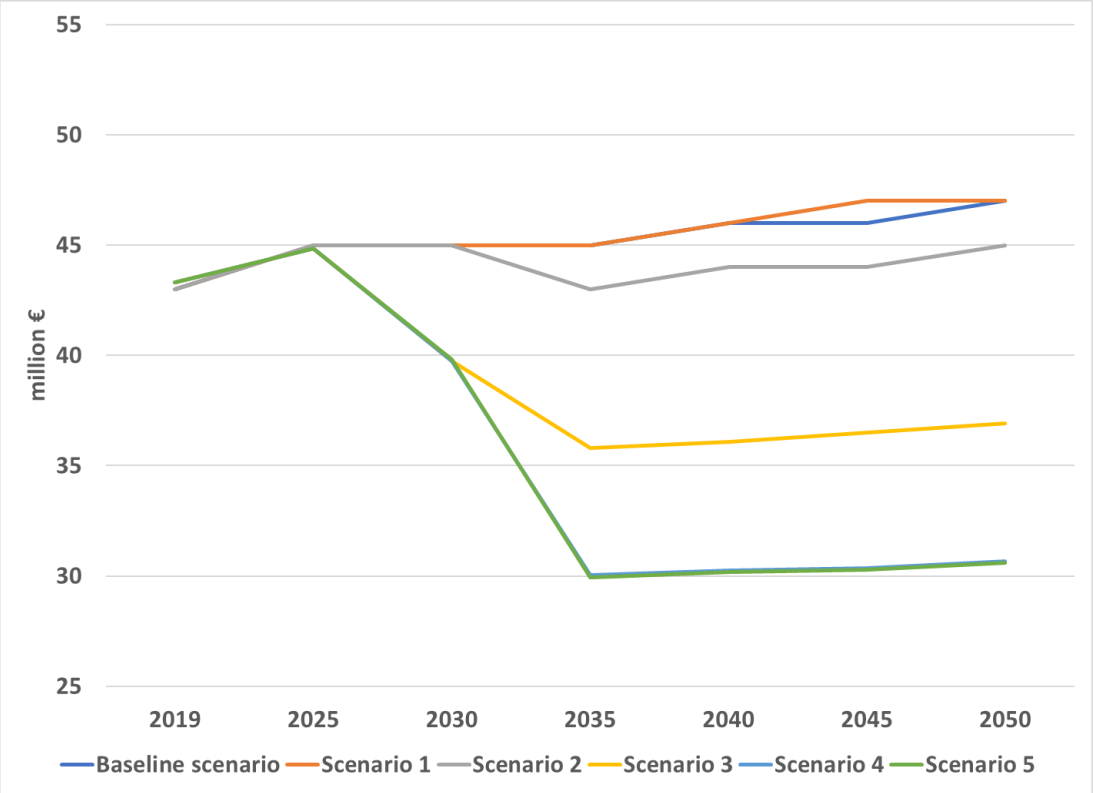

Figure 11 Comparison of final energy costs between scenarios in Bulgaria

5.2 CZECHIA

5.2.1 Determination of baseline

Step 1: Estimation of the unitary final energy consumption for different end-uses of the average household in Czechia according to the data about the disaggregated final energy consumption of households (*data: Eurostat*).

Table 35 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	17138
Space heating	11814
Space cooling	14
DHW	2859
Cooking	1045
Other	1406

Energy carrier	Average household (kWh/HH)
Total	17138
Electricity	3163
Natural gas	4329
Oil	108
Solid fossil fuels	1907
District heat	2342
Solar thermal	35
Ambient heat	391
Biomass	4863

Step 2: Calculation of the reduced energy expenses of households, which belong to the lowest income decile compared with the energy expenses of the average households (*data: HBS*).

Table 36 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	25%
Oil	80%
LPG	80%
Natural gas	28%
Solar thermal	0%
Biomass	26%
Ambient heat	25%
District heat	16%
Solid fossil fuels	26%

Step 3: Calculation of the unitary final energy consumption of the households, which belong to the lowest income group, for different end-uses taking into consideration the reduced energy expenses as estimated in Step 2.

Table 37 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	12856
Space heating	8829

End uses	Low-income HH (kWh/HH)
Space cooling	11
DHW	2195
Cooking	761
Other	1061

Step 4: Calculation of the unitary final energy consumption of the households, which belong to the lowest income decile, for the different consumed energy carriers taking into consideration the reduced energy expenses as estimated in Step 2.

Table 38 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	12856
Electricity	2385
Natural gas	3138
Oil	22
Solid fossil fuels	1413
District heat	1966
Solar thermal	35
Ambient heat	295
Biomass	3603

Step 5: Identification of the utilised means of heating and cooking for the case of households, which belong to the lowest income decile and assessment of additional data (*data: HBS*).

Adjustments have been made by the involved country expert.

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Number of low-income households (dwellings): **890,668**

Table 39 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	2124	400	10	466	333	915
LPG	19	15		0	4	
Natural gas	2795	1835		638	322	
Solar thermal	15	0		11		4
Ambient heat	263	162		90		11
Biomass	3209	3044		133	17	15
District heating	1751	1181		570		
Coal and other	1259	1222		35	1	
Total	11435	7859	10	1943	677	945

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of the households for different end-uses (Step 3) and energy carriers (Step 4) and the identified energy expenses (Step 2).

Cost deviation equal to **+78%** assuming the following prices:

Table 40 Utilised energy prices in Czechia

Energy carrier	Energy price (€/MWh)
Electricity	190
Natural gas	55
Biomass	40
District heating	64
Solar thermal	0
LPG	150
Coal and other	10

5.2.2 Modelling the impacts of the examined policies in Czechia

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 41 Energy prices in the baseline scenario for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	55	72	88	105	121	127	132
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	190	191	192	197	203	214	225
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 42 Final energy consumption in baseline scenario in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1380	1251	1152	1126	1101
LPG	15	14	13	12	12	11	10
Biomass	3044	3044	3044	3044	3044	3044	3044
Ambient heat	162	161	161	158	156	151	147
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1181	1181	1181	1181	1181
Electricity	400	399	398	392	386	374	364
Coal and other	1222	1161	1108	1078	1049	1023	999
Total	7859	7520	7285	7115	6979	6910	6846
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	10	9	9	9	9
Total	10	10	10	9	9	9	9
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	456	449	436	424
Natural gas	638	542	480	435	400	391	383
Heating oil	0	0	0	0	0	0	0

District heating	570	570	570	570	570	570	570
LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	32	31	30	29	29
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11
Total	1943	1845	1779	1726	1684	1661	1640
Space heating cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1860	1685	1552	1517	1484
LPG	15	14	13	12	12	11	10
Biomass	3177	3177	3177	3177	3177	3177	3177
Ambient heat	251	251	251	248	246	241	237
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1751	1751	1751	1751	1751
Electricity	876	873	871	857	844	819	796
Coal and other	1257	1195	1140	1109	1079	1052	1027
Total	9812	9374	9074	8851	8672	8580	8494

Total energy costs (million €)

Table 43 Total energy costs in baseline scenario in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	164	176	188	192	196
LPG	2	2	3	3	3	3	3
Biomass	127	127	127	127	127	127	127
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	111	111	111	111	111
Electricity	166	167	167	169	171	175	179
Coal and other	13	13	14	14	14	15	15
Total	556	571	585	600	615	623	631

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 44 Energy prices in the Scenario 1 for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	178	235	248	279	310
Natural gas	55	72	122	169	183	199	216
Solid fossil fuels	10	11	73	128	123	143	163
Electricity	190	191	192	197	203	214	225
LPG	150	175	245	310	331	370	410

Final energy consumption (GWh)

Table 45 Final energy consumption in Scenario 1 in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1009	813	699	623	567
LPG	15	14	11	10	9	8	7
Biomass	3044	3044	3044	3044	3044	3044	3044
Ambient heat	162	161	161	158	156	151	147
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1181	1181	1181	1181	1181
Electricity	400	399	398	392	386	374	364
Coal and other	1222	1161	0	0	0	0	0
Total	7859	7520	5803	5597	5474	5381	5310
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	10	9	9	9	9
Total	10	10	10	9	9	9	9
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	456	449	436	424
Natural gas	638	542	351	283	243	217	197
Heating oil	0	0	0	0	0	0	0
District heating	570	570	570	570	570	570	570
LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	0	0	0	0	0
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11
Total	1943	1845	1618	1543	1497	1457	1425
Space heating cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1359	1096	942	840	764
LPG	15	14	11	10	9	8	7
Biomass	3177	3177	3177	3177	3177	3177	3177
Ambient heat	251	251	251	248	246	241	237
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1751	1751	1751	1751	1751
Electricity	876	873	871	857	844	819	796
Coal and other	1257	1195	0	0	0	0	0
Total	9812	9374	7431	7150	6980	6847	6744

Total energy costs (million €)

Table 46 Total energy costs in Scenario 1 in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	166	186	204	222	238
LPG	2	2	3	3	3	4	4
Biomass	127	127	127	127	127	127	127
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	111	111	111	111	111
Electricity	166	167	167	169	171	175	179
Coal and other	13	13	0	0	0	0	0
Total	556	571	574	596	617	639	659

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 47 Energy prices in the Scenario 2 for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	55	72	88	105	121	127	132
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	190	191	192	197	203	214	225
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 48 Final energy consumption in Scenario 2 in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1380	1251	1152	0	0
LPG	15	14	13	12	12	0	0
Biomass	3044	3044	3044	3044	3044	3044	3044
Ambient heat	162	161	161	362	356	990	962
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1181	1181	1181	1181	1181
Electricity	400	399	398	472	465	707	688
Coal and other	1222	1161	1108	0	0	0	0
Total	7859	7520	7285	6322	6210	5922	5875
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	10	9	9	9	9
Total	10	10	10	9	9	9	9
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	465	458	797	775
Natural gas	638	542	480	435	400	0	0
Heating oil	0	0	0	0	0	0	0
District heating	570	570	570	570	570	570	570
LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	32	0	0	0	0
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11

Total	1943	1845	1779	1704	1663	1601	1579
Space heating cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1860	1685	1552	0	0
LPG	15	14	13	12	12	0	0
Biomass	3177	3177	3177	3177	3177	3177	3177
Ambient heat	251	251	251	452	446	1080	1052
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1751	1751	1751	1751	1751
Electricity	876	873	871	947	933	1513	1471
Coal and other	1257	1195	1140	0	0	0	0
Total	9812	9374	9074	8036	7882	7532	7463

Total energy costs (million €)

Table 49 Total energy costs in Scenario 2 in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	164	176	188	0	0
LPG	2	2	3	3	3	0	0
Biomass	127	127	127	127	127	127	127
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	111	111	111	111	111
Electricity	166	167	167	187	189	324	331
Coal and other	13	13	14	0	0	0	0
Total	556	571	585	604	618	562	569

Table 50 Investments foreseen in Scenario 2 in Czechia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	1079	0	1315	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF THE AFFECTED HOUSEHOLDS (75% OF THE TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (334 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (334 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL THE BUILDING WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 51 Energy prices in the Scenario 3 for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	55	72	88	105	121	127	132
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	190	191	192	197	203	214	225
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 52 Final energy consumption in Scenario 3 in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1225	985	839	820	802
LPG	15	14	12	10	8	8	8
Biomass	3044	3044	2702	2398	2218	2218	2218
Ambient heat	162	161	143	125	114	110	107
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1048	930	860	860	860
Electricity	400	399	353	308	281	273	265
Coal and other	1222	1161	984	849	764	745	728
Total	7859	7520	6465	5604	5085	5035	4988
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	8	7	7	7	6
Total	10	10	8	7	7	7	6
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	456	449	436	424
Natural gas	638	542	480	435	400	391	383
Heating oil	0	0	0	0	0	0	0
District heating	570	570	570	570	570	570	570

LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	32	31	30	29	29
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11
Total	1943	1845	1779	1726	1684	1661	1640
Space heating cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1704	1420	1240	1212	1185
LPG	15	14	12	10	8	8	8
Biomass	3177	3177	2834	2531	2351	2351	2351
Ambient heat	251	251	232	214	203	200	197
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1618	1500	1431	1431	1431
Electricity	876	873	825	772	737	715	695
Coal and other	1257	1195	1016	880	795	775	756
Total	9812	9374	8253	7338	6775	6702	6634

Total energy costs (million €)

Table 53 Total energy costs in Scenario 3 in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	150	148	150	153	156
LPG	2	2	2	2	2	2	2
Biomass	127	127	113	101	94	94	94
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	103	95	91	91	91
Electricity	166	167	158	152	150	153	156
Coal and other	13	13	12	11	11	11	11
Total	556	571	539	511	497	504	511

Table 54 Investments foreseen in Scenario 3 in Czechia

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	3,340	3,340	3,340	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 55 Energy prices in the Scenario 4 for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	55	72	88	105	121	127	132
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	190	191	192	197	203	214	225
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 56 Final energy consumption in Scenario 4 in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1225	985	839	0	0
LPG	15	14	12	10	8	0	0
Biomass	3044	3044	2702	2398	2218	2218	2218
Ambient heat	162	161	143	237	216	679	660
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1048	930	860	860	860
Electricity	400	399	353	317	289	416	405
Coal and other	1222	1161	984	0	0	0	0
Total	7859	7520	6465	4876	4430	4173	4143
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	8	7	7	7	6
Total	10	10	8	7	7	7	6
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	465	458	797	775
Natural gas	638	542	480	435	400	0	0
Heating oil	0	0	0	0	0	0	0
District heating	570	570	570	570	570	570	570
LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	32	0	0	0	0
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11
Total	1943	1845	1779	1704	1663	1601	1579
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1704	1420	1240	0	0

LPG	15	14	12	10	8	0	0
Biomass	3177	3177	2834	2531	2351	2351	2351
Ambient heat	251	251	232	327	305	768	750
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1618	1500	1431	1431	1431
Electricity	876	873	825	789	753	1220	1186
Coal and other	1257	1195	1016	0	0	0	0
Total	9812	9374	8253	6588	6100	5781	5728

Total energy costs (million €)

Table 57 Total energy costs in Scenario 4 in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	150	148	150	0	0
LPG	2	2	2	2	2	0	0
Biomass	127	127	113	101	94	94	94
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	103	95	91	91	91
Electricity	166	167	158	156	153	261	267
Coal and other	13	13	12	0	0	0	0
Total	556	571	539	503	490	446	452

Table 58 Investments foreseen in Scenario 4 in Czechia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	1079	0	1343	0
Building envelope	0	3340	3340	3340	0	0
Total	0	3340	4419	3340	1343	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 59 Energy prices in the Scenario 5 for Czechia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	139	164	189	230	271
Natural gas	55	72	92	115	138	162	186
Solid fossil fuels	10	11	19	32	44	78	111
Electricity	190	191	192	197	203	214	225
LPG	150	175	205	239	272	322	371

Final energy consumption (GWh)

Table 60 Final energy consumption in Scenario 5 in Czechia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1835	1560	1185	920	766	0	0
LPG	15	14	11	9	8	0	0
Biomass	3044	3044	2702	2398	2218	2218	2218
Ambient heat	162	161	143	165	150	546	531
Solar thermal	0	0	0	0	0	0	0
District heating	1181	1181	1048	930	860	860	860
Electricity	400	399	353	221	202	322	313
Coal and other	1222	1161	644	0	0	0	0
Total	7859	7520	6086	4643	4204	3946	3922
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	10	10	8	7	7	7	6
Total	10	10	8	7	7	7	6
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	466	465	463	460	453	740	720
Natural gas	638	542	464	406	366	0	0
Heating oil	0	0	0	0	0	0	0
District heating	570	570	570	570	570	570	570
LPG	0	0	0	0	0	0	0
Biomass	133	133	133	133	133	133	133
Coal and other	35	33	21	0	0	0	0
Ambient heat	90	90	90	90	90	90	90
Solar thermal	11	11	11	11	11	11	11
Total	1943	1845	1753	1671	1623	1545	1524
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	0	0	0	0	0	0	0
Natural gas	2473	2102	1650	1327	1132	0	0
LPG	15	14	11	9	8	0	0
Biomass	3177	3177	2834	2531	2351	2351	2351
Ambient heat	251	251	232	254	240	636	621
Solar thermal	11	11	11	11	11	11	11
District heating	1751	1751	1618	1500	1431	1431	1431
Electricity	876	873	825	689	662	1069	1039
Coal and other	1257	1195	665	0	0	0	0
Total	9812	9374	7848	6322	5834	5498	5453

Total energy costs (million €)

Table 61 Total energy costs in Scenario 5 in Czechia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	136	150	152	153	156	0	0
LPG	2	2	2	2	2	0	0
Biomass	127	127	113	101	94	94	94
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	111	111	103	95	91	91	91
Electricity	166	167	158	136	134	229	234
Coal and other	13	13	13	0	0	0	0
Total	556	571	541	487	478	414	419

Table 62 Investments foreseen in Scenario 5 in Czechia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	546	0	1221	0
Building envelope	0	3340	3340	3340	0	0
Total	0	3340	3886	3340	1221	0

Synopsis

Comparison of final energy consumption

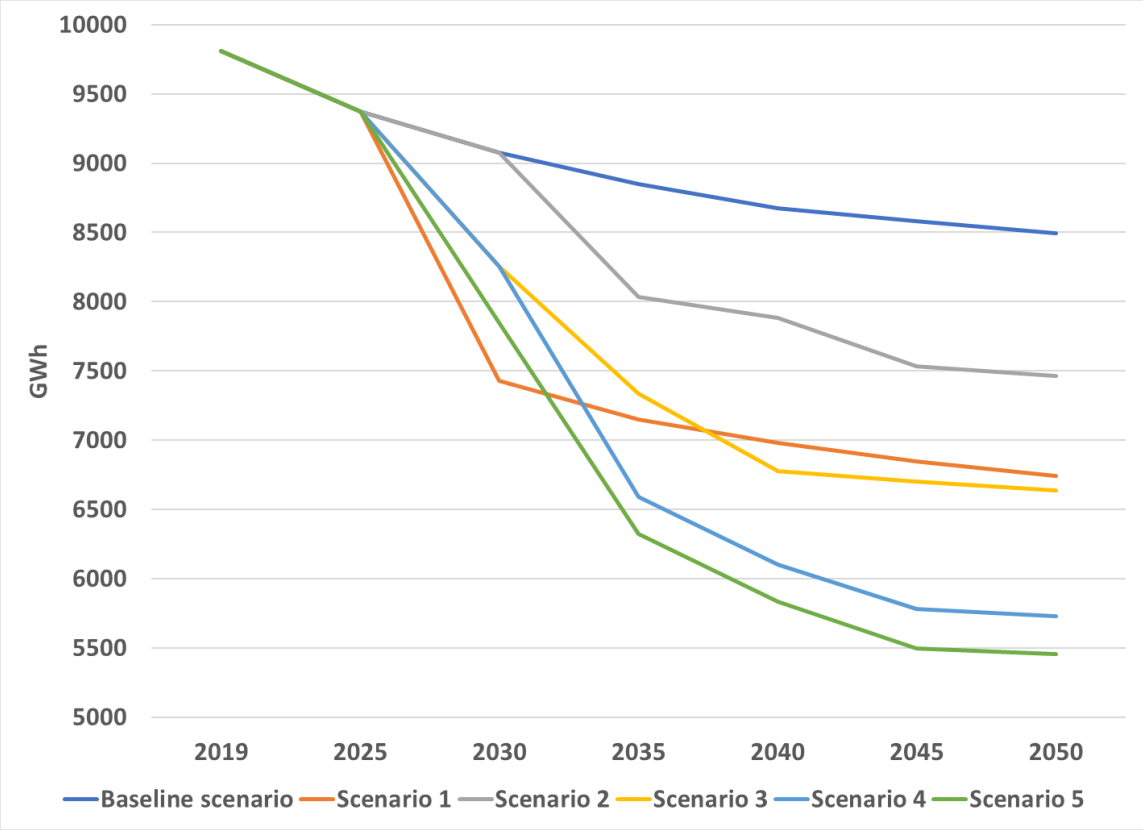

Figure 12 Comparison of final energy consumption between scenarios in Czechia

Comparison of investments in different scenarios

Figure 13 Investments in different scenarios in Czechia in Czechia

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	1079	0	1315	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	3340	3340	3340	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	1079	0	1343	0
	Building envelope	0	3340	3340	3340	0	0
	Total	0	3340	4419	3340	1343	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	546	0	1221	0
	Building envelope	0	3340	3340	3340	0	0
	Total	0	3340	3886	3340	1221	0

Comparison of the total energy costs

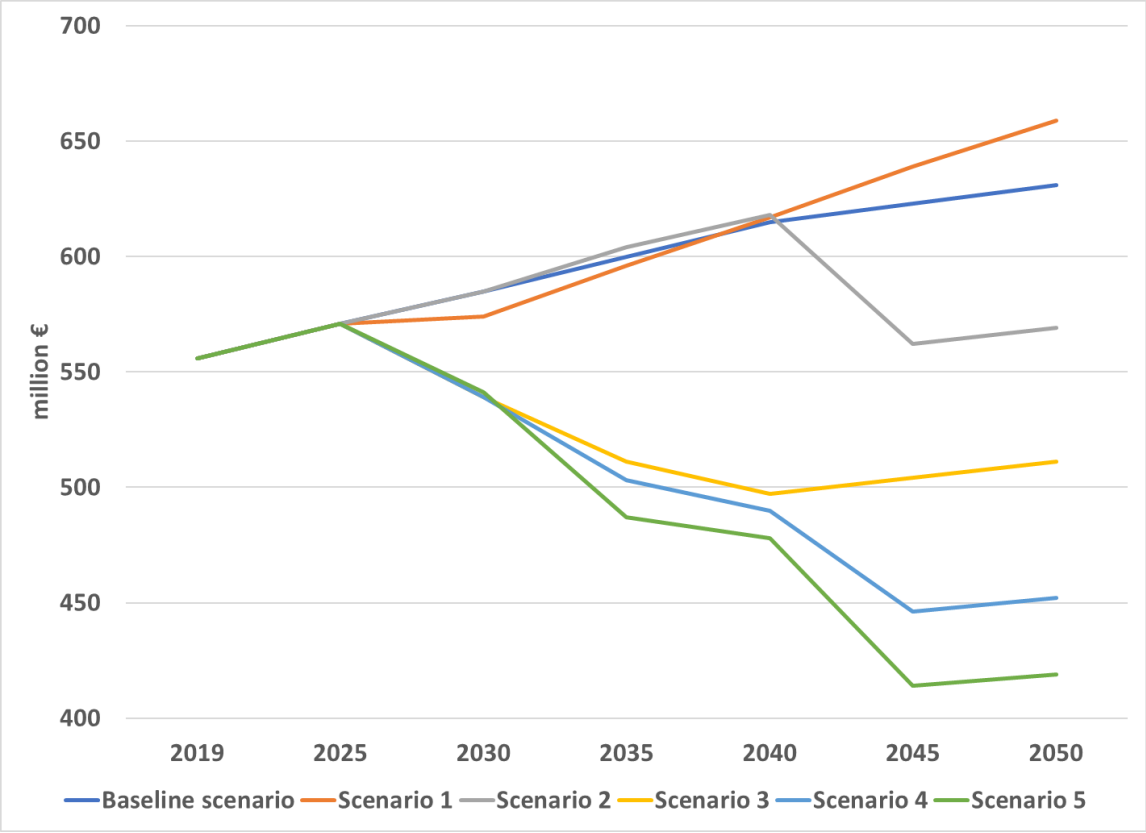

Figure 14 Comparison of final energy costs between scenarios in Czechia

5.3 GREECE

5.3.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Greece according to the data about the disaggregated final energy consumption of households (*data: Eurostat*).

Table 63 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	10640
Space heating	5965
Space cooling	529
DHW	1428
Cooking	663
Other	2055

Energy carrier	Average household (kWh/HH)
Total	10640
Electricity	3905
Oil	2805
LPG	210
Natural gas	1005
Solar thermal	716
Biomass	1658
Ambient heat	189
District heat	138
Solid fossil fuels	15

Step 2: Calculation of reduced energy expenses of the households, which belong to the lowest income decile compared with energy expenses of the average household (*data: HBS*).

Table 64 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	26%
Oil	56%
LPG	56%
Natural gas	57%
Solar thermal	0%
Biomass	20%
Ambient heat	26%
District heat	53%
Solid fossil fuels	20%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration the reduced energy expenses as estimated in Step 2.

Table 65 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	6913
Space heating	3312
Space cooling	393
DHW	1190
Cooking	489
Other	1528

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for the different consumed energy carriers taking into consideration the reduced energy expenses as estimated in Step 2.

Table 66 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	6913
Electricity	2903
Oil	1228
LPG	92
Natural gas	433
Solar thermal	716
Biomass	1323
Ambient heat	141
District heat	65
Solid fossil fuels	12

Step 5: Identification of utilised means of heating and cooking for the case of households which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Number of low-income households (dwellings): **503,841**

Table 67 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	1463	70	198	218	207	770
Heating oil	619	592		27		
LPG	46	42			5	
Natural gas	218	210		6	1	
Solar thermal	361	14		347		

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Biomass	667	633			33	
Ambient heat	71	71				
District heating	33	31		2		
Coal and other	6	6				
Total	3483	1669	198	600	246	770

Step 7: Validation and adjustment of the obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **-4%** assuming the following prices:

Table 68 Utilised energy prices in Greece

Energy carrier	Energy price (€/MWh)
Electricity	178
Heating oil	115
LPG	172
Natural gas	68
Solar thermal	0
Biomass	65
Ambient heat	0
District heating	60
Coal and other	30

5.3.2 Modelling the impacts of the examined policies in Greece

Elasticities of demand

Electricity: -0.53 and heating: -0.51.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 69 Energy prices in the baseline scenario for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	153	173	192	211	230
Natural gas	68	88	109	129	150	156	163
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	178	178	179	181	184	188	193
LPG	172	201	229	258	287	315	344

Final energy consumption (GWh)

Table 70 Final energy consumption in baseline scenario in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	525	491	463	440	419
Natural gas	210	186	164	148	136	133	130
LPG	42	40	37	35	33	31	29
Biomass	633	661	661	661	661	661	661
Ambient heat	71	77	77	76	76	75	74
Solar thermal	14	14	14	14	14	14	14
District heating	31	32	32	32	32	32	32
Electricity	70	73	73	72	72	71	70
Coal and other	6	6	6	5	5	5	5
Total	1669	1655	1589	1536	1493	1462	1436
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	198	207	207	205	203	201	198
Total	198	207	207	205	203	201	198
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	218	227	227	225	224	221	218
Natural gas	6	6	5	4	4	4	4
Heating oil	27	25	23	22	21	20	19

District heating	2	2	2	2	2	2	2
Solar thermal	347	362	362	362	362	362	362
Total	600	623	620	616	613	609	605
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	619	591	548	513	484	459	438
Natural gas	217	192	169	153	141	137	134
LPG	42	40	37	35	33	31	29
Biomass	633	661	661	661	661	661	661
Ambient heat	71	77	77	76	76	75	74
Solar thermal	361	376	376	376	376	376	376
District heating	33	34	34	34	34	34	34
Electricity	486	507	507	503	499	492	486
Coal and other	6	6	6	5	5	5	5
Total	2467	2485	2415	2357	2309	2272	2239

Total energy costs (million €)

Table 71 Total energy costs in baseline scenario in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	84	89	93	97	101
Natural gas	15	17	18	20	21	21	22
LPG	7	8	8	9	9	10	10
Biomass	41	43	43	43	43	43	43
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	87	90	90	91	92	93	94
Coal and other	0	0	0	0	0	0	0
Total	223	240	247	254	260	266	272

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 72 Energy prices in the Scenario 1 for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	192	247	263	294	326
Natural gas	68	88	139	186	204	220	236
Solid fossil fuels	30	33	89	139	136	155	174
Electricity	178	178	179	181	184	188	193
LPG	172	201	268	333	358	399	440

Final energy consumption (GWh)

Table 73 Final energy consumption in Scenario 1 in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	441	377	334	296	269
Natural gas	210	186	132	109	95	86	79
LPG	42	40	33	29	26	24	22
Biomass	633	661	661	661	661	661	661
Ambient heat	71	77	77	76	76	75	74
Solar thermal	14	14	14	14	14	14	14
District heating	31	32	32	32	32	32	32
Electricity	70	73	73	72	72	71	70
Coal and other	6	6	1	1	0	0	0
Total	1669	1655	1464	1372	1311	1259	1221
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	198	207	207	205	203	201	198
Total	198	207	207	205	203	201	198
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	218	227	227	225	224	221	218
Natural gas	6	6	4	3	3	3	2
Heating oil	27	25	20	17	15	13	12
District heating	2	2	2	2	2	2	2
Solar thermal	347	362	362	362	362	362	362
Total	600	623	615	610	606	601	597
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Heating oil	619	591	460	394	349	310	281
Natural gas	217	192	136	112	98	88	81
LPG	42	40	33	29	26	24	22
Biomass	633	661	661	661	661	661	661

Ambient heat	71	77	77	76	76	75	74
Solar thermal	361	376	376	376	376	376	376
District heating	33	34	34	34	34	34	34
Electricity	486	507	507	503	499	492	486
Coal and other	6	6	1	1	0	0	0
Total	2467	2485	2286	2186	2120	2061	2016

Total energy costs (million €)

Table 74 Total energy costs in Scenario 1 in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	89	97	105	114	122
Natural gas	15	17	19	21	23	25	26
LPG	7	8	9	10	10	11	12
Biomass	41	43	43	43	43	43	43
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	87	90	90	91	92	93	94
Coal and other	0	0	0	0	0	0	0
Total	223	240	252	264	275	288	299

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 75 Energy prices in the Scenario 2 for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	153	173	192	211	230
Natural gas	68	88	109	129	150	156	163
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	178	178	179	181	184	188	193
LPG	172	201	229	258	287	315	344

Final energy consumption (GWh)

Table 76 Final energy consumption in Scenario 2 in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	525	0	0	0	0
Natural gas	210	186	164	148	136	0	0
LPG	42	40	37	35	33	0	0
Biomass	633	661	661	661	661	661	661
Ambient heat	71	77	77	325	322	411	406
Solar thermal	14	14	14	14	14	14	14
District heating	31	32	32	32	32	32	32
Electricity	70	73	73	171	170	204	202
Coal and other	6	6	6	0	0	0	0
Total	1669	1655	1589	1386	1369	1323	1315
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	198	207	207	205	203	201	198
Total	198	207	207	205	203	201	198
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	218	227	227	243	241	241	238
Natural gas	6	6	5	4	4	0	0
Heating oil	27	25	23	0	0	0	0
District heating	2	2	2	2	2	2	2
Solar thermal	347	362	362	362	362	362	362
Total	600	623	620	612	610	606	603
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	619	591	548	0	0	0	0
Natural gas	217	192	169	153	141	0	0
LPG	42	40	37	35	33	0	0
Biomass	633	661	661	661	661	661	661
Ambient heat	71	77	77	325	322	411	406
Solar thermal	361	376	376	376	376	376	376
District heating	33	34	34	34	34	34	34
Electricity	486	507	507	619	614	647	638
Coal and other	6	6	6	0	0	0	0
Total	2467	2485	2415	2203	2182	2130	2116

Total energy costs (million €)

Table 77 Total energy costs in Scenario 2 in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	84	0	0	0	0
Natural gas	15	17	18	20	21	0	0
LPG	7	8	8	9	9	0	0
Biomass	41	43	43	43	43	43	43
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	2	2	2
Electricity	87	90	90	112	113	122	123
Coal and other	0	0	0	0	0	0	0
Total	223	240	247	186	188	167	168

Table 78 Investments foreseen in Scenario 2 in Greece

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	1303	0	488	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (85% OF THE TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (214 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (214 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 79 Energy prices in the Scenario 3 for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	153	173	192	211	230
Natural gas	68	88	109	129	150	156	163
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	178	178	179	181	184	188	193
LPG	172	201	229	258	287	315	344

Final energy consumption (GWh)

Table 80 Final energy consumption in Scenario 3 in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	458	374	323	307	292
Natural gas	210	186	143	113	95	93	91
LPG	42	40	32	26	23	22	21
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	58	53	52	52
Solar thermal	14	14	12	11	10	10	10
District heating	31	32	28	24	22	22	22
Electricity	70	73	64	55	50	49	49
Coal and other	6	6	5	4	4	4	4
Total	1669	1655	1387	1170	1041	1020	1001
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	198	207	180	156	142	140	138
Total	198	207	180	156	142	140	138
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	218	227	227	225	224	221	218
Natural gas	6	6	5	4	4	4	4
Heating oil	27	25	23	22	21	20	19
District heating	2	2	2	2	2	2	2

Solar thermal	347	362	362	362	362	362	362
Total	600	623	620	616	613	609	605
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	619	591	481	396	344	326	311
Natural gas	217	192	148	118	99	97	95
LPG	42	40	32	26	23	22	21
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	58	53	52	52
Solar thermal	361	376	375	373	372	372	372
District heating	33	34	30	26	24	24	24
Electricity	486	507	471	437	415	410	405
Coal and other	6	6	5	4	4	4	4
Total	2467	2485	2187	1942	1795	1768	1744

Total energy costs (million €)

Table 81 Total energy costs in Scenario 3 in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	74	68	66	69	72
Natural gas	15	17	16	15	15	15	15
LPG	7	8	7	7	7	7	7
Biomass	41	43	38	33	30	30	30
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	1	1	1
Electricity	87	90	84	79	76	77	78
Coal and other	0	0	0	0	0	0	0
Total	223	240	221	204	195	200	204

Table 82 Investments foreseen in Scenario 3 in Greece

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	2137	2137	2137	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 83 Energy prices in the Scenario 4 for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	153	173	192	211	230
Natural gas	68	88	109	129	150	156	163
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	178	178	179	181	184	188	193
LPG	172	201	229	258	287	315	344

Final energy consumption (GWh)

Table 84 Final energy consumption in Scenario 4 in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	458	0	0	0	0
Natural gas	210	186	143	113	95	0	0
LPG	42	40	32	26	23	0	0
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	199	181	244	240
Solar thermal	14	14	12	11	10	10	10
District heating	31	32	28	24	22	22	22
Electricity	70	73	64	143	130	207	205
Coal and other	6	6	5	0	0	0	0
Total	1669	1655	1387	1021	922	944	938
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	198	207	180	156	142	140	138
Total	198	207	180	156	142	140	138
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	218	227	227	243	241	241	238
Natural gas	6	6	5	4	4	0	0
Heating oil	27	25	23	0	0	0	0
District heating	2	2	2	2	2	2	2
Solar thermal	347	362	362	362	362	362	362
Total	600	623	620	612	610	606	603
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Heating oil	619	591	481	0	0	0	0
Natural gas	217	192	148	118	99	0	0
LPG	42	40	32	26	23	0	0
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	199	181	244	240
Solar thermal	361	376	375	373	372	372	372

District heating	33	34	30	26	24	24	24
Electricity	486	507	471	542	513	589	581
Coal and other	6	6	5	0	0	0	0
Total	2467	2485	2187	1789	1673	1690	1679

Total energy costs (million €)

Table 85 Total energy costs in Scenario 4 in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	74	0	0	0	0
Natural gas	15	17	16	15	15	0	0
LPG	7	8	7	7	7	0	0
Biomass	41	43	38	33	30	30	30
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	1	1	1
Electricity	87	90	84	98	94	111	112
Coal and other	0	0	0	0	0	0	0
Total	223	240	221	154	147	142	144

Table 86 Investments foreseen in Scenario 4 in Greece

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	1303	0	505	0
Building envelope	0	2137	2137	2137	0	0
Total	0	2137	3440	2137	505	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 87 Energy prices in the Scenario 5 for Greece

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	115	134	158	185	211	252	292
Natural gas	68	88	112	138	165	188	211
Solid fossil fuels	30	33	42	55	67	98	129
Electricity	178	178	179	181	184	188	193
LPG	172	201	234	270	306	356	406

Final energy consumption (GWh)

Table 88 Final energy consumption in Scenario 5 in Greece

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	592	566	449	0	0	0	0
Natural gas	210	186	140	108	89	0	0
LPG	42	40	32	26	22	0	0
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	193	175	231	228
Solar thermal	14	14	12	11	10	10	10
District heating	31	32	28	24	22	22	22
Electricity	70	73	64	140	127	198	196
Coal and other	6	6	4	0	0	0	0
Total	1669	1655	1374	1004	906	923	917
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	198	207	180	156	142	140	138
Total	198	207	180	156	142	140	138
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	218	227	227	242	240	240	237
Natural gas	6	6	5	4	4	0	0
Heating oil	27	25	23	0	0	0	0
District heating	2	2	2	2	2	2	2
Solar thermal	347	362	362	362	362	362	362
Total	600	623	619	611	609	605	602
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Heating oil	619	591	472	0	0	0	0
Natural gas	217	192	145	112	93	0	0
LPG	42	40	32	26	22	0	0
Biomass	633	661	577	504	461	461	461
Ambient heat	71	77	67	193	175	231	228

Solar thermal	361	376	375	373	372	372	372
District heating	33	34	30	26	24	24	24
Electricity	486	507	471	538	509	579	571
Coal and other	6	6	4	0	0	0	0
Total	2467	2485	2173	1771	1656	1667	1657

Total energy costs (million €)

Table 89 Total energy costs in Scenario 5 in Greece

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	79	75	0	0	0	0
Natural gas	15	17	16	15	15	0	0
LPG	7	8	7	7	7	0	0
Biomass	41	43	38	33	30	30	30
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	2	2	2	2	1	1	1
Electricity	87	90	84	97	94	109	110
Coal and other	0	0	0	0	0	0	0
Total	223	240	222	154	147	140	142

Table 90 Investments foreseen in Scenario 5 in Greece

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	1270	0	463	0
Building envelope	0	2137	2137	2137	0	0
Total	0	2137	3407	2137	463	0

Synopsis

Comparison of final energy consumption

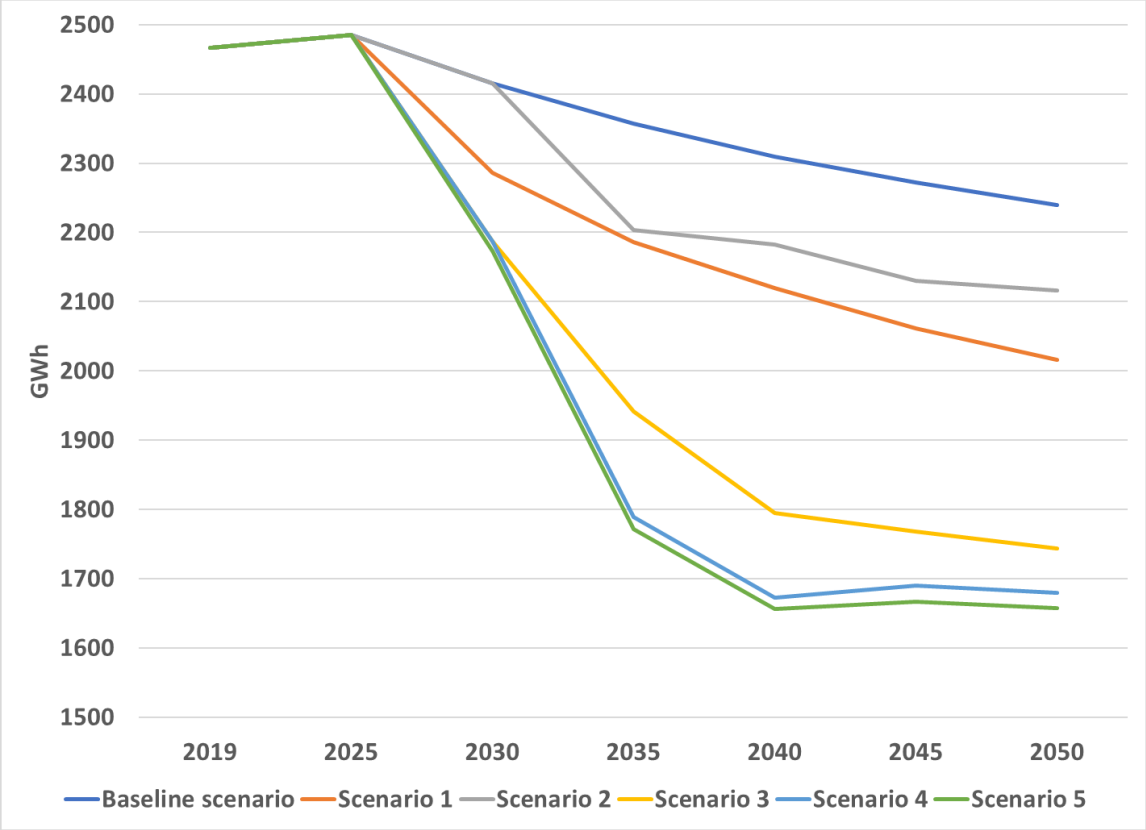

Figure 15 Comparison of final energy consumption between scenarios in Greece

Comparison of investments in different scenarios

Figure 16 Investments in different scenarios in Greece

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	1303	0	488	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	2137	2137	2137	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	1303	0	505	0
	Building envelope	0	2137	2137	2137	0	0
	Total	0	2137	3440	2137	505	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	1270	0	463	0
	Building envelope	0	2137	2137	2137	0	0
	Total	0	2137	3407	2137	463	0

Comparison of the total energy costs

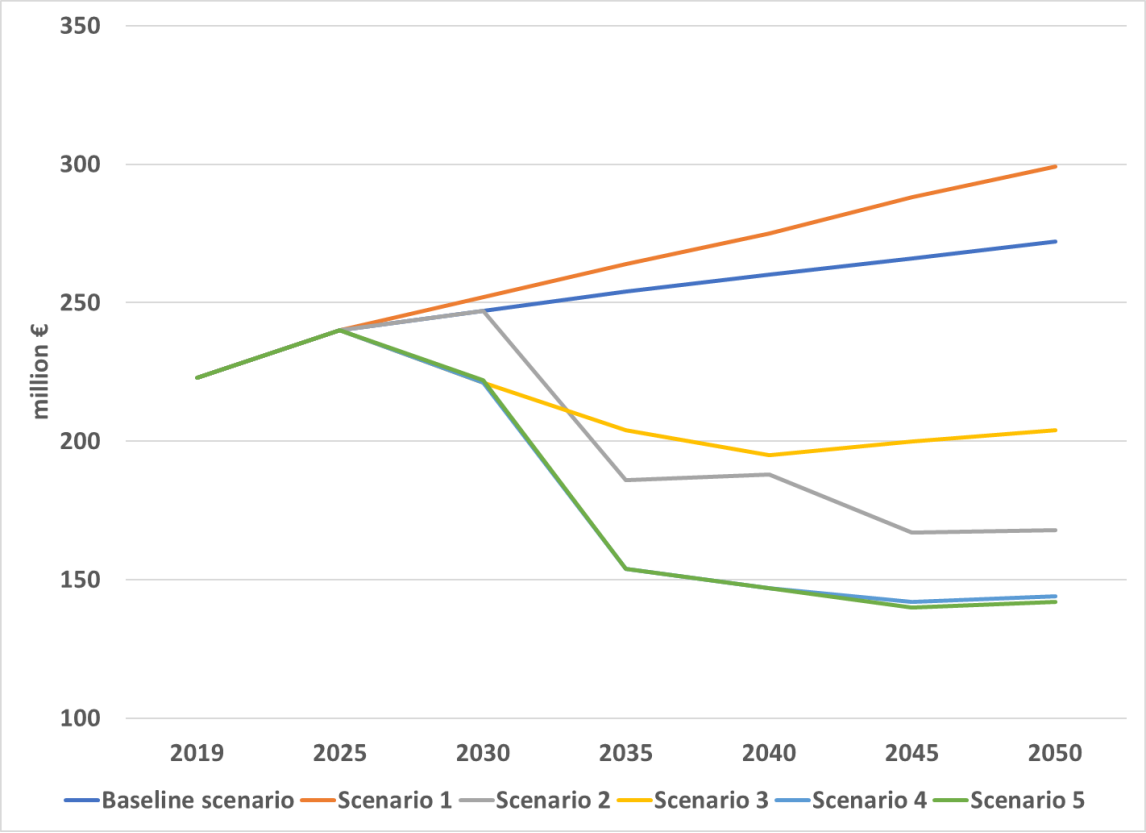

Figure 17 Comparison of final energy costs between scenarios in Greece

5.4 HUNGARY

5.4.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Hungary according to the data about the disaggregated final energy consumption of households (*data: Eurostat*).

Table 91 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	16008
Space heating	11316
Space cooling	38
DHW	2103
Cooking	798
Other	1753

Energy carrier	Average household (kWh/HH)
Total	16008
Electricity	2817
Natural gas	7876
Oil	208
Solid fossil fuels	199
Ambient heat	26
District heat	1283
Biomass	3562
Solar thermal	37

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with the energy expenses of the average household (*data: HBS*).

Table 92 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	17%
Natural gas	53%
Oil	-107%
Solid fossil fuels	-3%
District heat	59%
Ambient heat	17%
Biomass	-22%
Solar thermal	0%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration the reduced energy expenses as estimated in Step 2.

Table 93 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	11606
Space heating	8084

End uses	Low-income HH (kWh/HH)
Space cooling	32
DHW	1380
Cooking	655
Other	1455

Step 4: Calculation of unitary final energy consumption of the households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration the reduced energy expenses as estimated in the Step 2.

Table 94 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	11606
Electricity	2338
Natural gas	3702
Oil	431
Solid fossil fuels	205
Ambient heat	22
District heat	526
Biomass	4346
Solar thermal	37

Step 5: Identification of utilised means of heating and cooking for the case of the households, which belong to the lowest income decile and assessment of additional data (*data: HBS*).

Adjustments have been made by the involved country expert.

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Number of low-income households (dwellings): **677,332**

Table 95 Final energy consumption in the low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	1566	53	4	468	56	985
Heating oil	0	0		0		
LPG	292	37		41	213	
Natural gas	2507	2076		257	173	
Solar thermal	25			25		
Biomass	2944	2892		50	1	
Ambient heat	15	15				
District heating	356	263		93		
Coal and other	139	139		0	0	
Total	7844	5476	4	935	444	985

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and the identified energy expenses (Step 2).

Cost deviation equal to **+89%** assuming the following prices:

Table 96 Utilised energy prices in Hungary

Energy carrier	Energy price (€/MWh)
Heating oil	113
Electricity	113
Natural gas	34
Biomass	15
District heating	30
Solar thermal	0
LPG	150
Coal and other	15

5.4.2 Modelling the impacts of the examined policies in Hungary

Elasticities of demand

Electricity: -0.10 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 97 Energy prices in the baseline scenario for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	34	44	54	65	75	78	82
Solid fossil fuels	15	17	18	19	20	21	22
Electricity	113	113	114	117	121	128	134
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 98 Final energy consumption in baseline scenario in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	1574	1426	1314	1284	1256
LPG	37	34	32	30	28	27	26
Biomass	2892	2915	2915	2915	2915	2915	2915
Ambient heat	15	15	15	15	15	15	15
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	265	265	265	265	265
Electricity	53	54	54	54	53	53	53
Coal and other	139	133	127	123	120	117	114
Total	5476	5196	4982	4829	4711	4676	4644
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	4	4	4	4	4	4	4
Total	4	4	4	4	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	468	471	471	470	468	466	463
Natural gas	257	221	195	177	163	159	156
Heating oil	0	0	0	0	0	0	0

District heating	93	94	94	94	94	94	94
LPG	41	38	35	33	31	30	28
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25
Total	935	900	871	849	832	824	817
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2334	2000	1769	1603	1476	1443	1412
LPG	79	73	67	63	60	57	54
Biomass	2942	2966	2966	2966	2966	2966	2966
Ambient heat	15	15	15	15	15	15	15
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	359	359	359	359	359
Electricity	525	529	529	527	526	523	520
Coal and other	139	133	127	123	120	117	114
Total	6415	6100	5858	5682	5547	5505	5465

Total energy costs (million €)

Table 99 Total energy costs in baseline scenario in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	96	104	110	113	115
LPG	12	13	13	14	15	16	16
Biomass	44	44	44	44	44	44	44
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	11	11	11	11	11
Electricity	59	60	60	62	64	67	70
Coal and other	2	2	2	2	2	2	3
Total	207	218	227	237	247	253	259

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 100 Energy prices in the Scenario 1 for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	198	259	273	307	341
Natural gas	34	44	90	133	140	154	169
Solid fossil fuels	15	17	82	140	135	157	178
Electricity	113	113	114	117	121	128	134
LPG	150	175	247	314	335	375	415

Final energy consumption (GWh)

Table 101 Final energy consumption in Scenario 1 in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	855	653	548	474	424
LPG	37	34	27	24	21	19	17
Biomass	2892	2915	2915	2915	2915	2915	2915
Ambient heat	15	15	15	15	15	15	15
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	265	265	265	265	265
Electricity	53	54	54	54	53	53	53
Coal and other	139	133	0	0	0	0	0
Total	5476	5196	4132	3925	3818	3741	3689
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	4	4	4	4	4	4	4
Total	4	4	4	4	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	468	471	471	470	468	466	463
Natural gas	257	221	106	81	68	59	53
Heating oil	0	0	0	0	0	0	0
District heating	93	94	94	94	94	94	94
LPG	41	38	30	26	23	21	19
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25
Total	935	900	777	747	729	715	704
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	0	0	0	0	0	0	0
Natural gas	2334	2000	961	734	616	533	476
LPG	79	73	58	50	44	40	36
Biomass	2942	2966	2966	2966	2966	2966	2966
Ambient heat	15	15	15	15	15	15	15
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	359	359	359	359	359
Electricity	525	529	529	527	526	523	520
Coal and other	139	133	0	0	0	0	0
Total	6415	6100	4913	4676	4552	4461	4398

Total energy costs (million €)

Table 102 Total energy costs in Scenario 1 in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	87	97	108	119	129
LPG	12	13	14	16	17	18	20
Biomass	44	44	44	44	44	44	44
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	11	11	11	11	11
Electricity	59	60	60	62	64	67	70
Coal and other	2	2	0	0	0	0	0
Total	207	218	216	230	244	259	273

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 103 Energy prices in the Scenario 2 for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	34	44	54	65	75	78	82
Solid fossil fuels	15	17	18	19	20	21	22
Electricity	113	113	114	117	121	128	134
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 104 Final energy consumption in Scenario 2 in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	1574	1426	1314	0	0
LPG	37	34	32	30	28	0	0
Biomass	2892	2915	2915	2915	2915	2915	2915
Ambient heat	15	15	15	38	38	781	776
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	265	265	265	265	265
Electricity	53	54	54	63	63	357	355
Coal and other	139	133	127	0	0	0	0
Total	5476	5196	4982	4738	4623	4318	4312
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	4	4	4	4	4	4	4
Total	4	4	4	4	4	4	4
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	468	471	471	500	498	665	662
Natural gas	257	221	195	177	163	0	0
Heating oil	0	0	0	0	0	0	0
District heating	93	94	94	94	94	94	94
LPG	41	38	35	33	31	0	0
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25

Total	935	900	871	879	862	835	832
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2334	2000	1769	1603	1476	0	0
LPG	79	73	67	63	60	0	0
Biomass	2942	2966	2966	2966	2966	2966	2966
Ambient heat	15	15	15	38	38	781	776
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	359	359	359	359	359
Electricity	525	529	529	567	565	1027	1021
Coal and other	139	133	127	0	0	0	0
Total	6415	6100	5858	5621	5490	5158	5148

Total energy costs (million €)

Table 105 Total energy costs in Scenario 2 in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	96	104	110	0	0
LPG	12	13	13	14	15	0	0
Biomass	44	44	44	44	44	44	44
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	11	11	11	11	11
Electricity	59	60	60	66	68	131	137
Coal and other	2	2	2	0	0	0	0
Total	207	218	227	239	249	186	193

Table 106 Investments foreseen in Scenario 2 in Hungary

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	138	0	1547	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF THE AFFECTED HOUSEHOLDS (75% OF THE TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (254 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (254 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 13.5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL THE BUILDING WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 6.5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 107 Energy prices in the Scenario 3 for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	34	44	54	65	75	78	82
Solid fossil fuels	15	17	18	19	20	21	22
Electricity	113	113	114	117	121	128	134
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 108 Final energy consumption in Scenario 3 in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	1397	1123	957	935	915
LPG	37	34	28	24	21	20	19
Biomass	2892	2915	2587	2296	2124	2124	2124
Ambient heat	15	15	13	12	11	11	11
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	235	209	193	193	193
Electricity	53	54	48	42	39	39	38
Coal and other	139	133	113	97	88	85	83
Total	5476	5196	4421	3803	3432	3407	3383
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	4	4	4	3	3	3	3
Total	4	4	4	3	3	3	3
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	468	471	471	470	468	466	463
Natural gas	257	221	195	177	163	159	156
Heating oil	0	0	0	0	0	0	0
District heating	93	94	94	94	94	94	94

LPG	41	38	35	33	31	30	28
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25
Total	935	900	871	849	832	824	817
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2334	2000	1592	1300	1120	1094	1071
LPG	79	73	64	57	52	49	47
Biomass	2942	2966	2638	2347	2175	2175	2175
Ambient heat	15	15	13	12	11	11	11
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	329	303	287	287	287
Electricity	525	529	523	515	510	507	505
Coal and other	139	133	113	97	88	85	83
Total	6415	6100	5297	4656	4268	4234	4204

Total energy costs (million €)

Table 109 Total energy costs in Scenario 3 in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	87	84	84	86	87
LPG	12	13	13	13	13	14	14
Biomass	44	44	40	35	33	33	33
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	10	9	9	9	9
Electricity	59	60	59	60	62	65	68
Coal and other	2	2	2	2	2	2	2
Total	207	218	210	203	201	207	212

Table 110 Investments foreseen in Scenario 3 in Hungary

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	3429	3429	3302	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 111 Energy prices in the Scenario 4 for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	34	44	54	65	75	78	82
Solid fossil fuels	15	17	18	19	20	21	22
Electricity	113	113	114	117	121	128	134
LPG	150	175	200	225	250	275	300

Final energy consumption (GWh)

Table 112 Final energy consumption in Scenario 4 in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	1397	1123	957	0	0
LPG	37	34	28	24	21	0	0
Biomass	2892	2915	2587	2296	2124	2124	2124
Ambient heat	15	15	13	25	23	564	561
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	235	209	193	193	193
Electricity	53	54	48	33	31	262	260
Coal and other	139	133	113	0	0	0	0
Total	5476	5196	4421	3711	3349	3143	3139
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	4	4	4	3	3	3	3
Total	4	4	4	3	3	3	3
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	468	471	471	500	498	665	662
Natural gas	257	221	195	177	163	0	0
Heating oil	0	0	0	0	0	0	0
District heating	93	94	94	94	94	94	94
LPG	41	38	35	33	31	0	0
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25
Total	935	900	871	879	862	835	832
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2334	2000	1592	1300	1120	0	0

LPG	79	73	64	57	52	0	0
Biomass	2942	2966	2638	2347	2175	2175	2175
Ambient heat	15	15	13	25	23	564	561
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	329	303	287	287	287
Electricity	525	529	523	536	532	930	925
Coal and other	139	133	113	0	0	0	0
Total	6415	6100	5297	4593	4214	3981	3973

Total energy costs (million €)

Table 113 Total energy costs in Scenario 4 in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	87	84	84	0	0
LPG	12	13	13	13	13	0	0
Biomass	44	44	40	35	33	33	33
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	10	9	9	9	9
Electricity	59	60	59	63	64	119	124
Coal and other	2	2	2	0	0	0	0
Total	207	218	210	204	202	160	166

Table 114 Investments foreseen in Scenario 4 in Hungary

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	138	0	1556	0
Building envelope	0	3429	3429	3302	0	0
Total	0	3429	3567	3302	1556	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 115 Energy prices in the Scenario 5 for Hungary

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	156	184	212	256	301
Natural gas	34	44	59	76	93	116	139
Solid fossil fuels	15	17	26	39	52	88	123
Electricity	113	113	114	117	121	128	134
LPG	150	175	206	240	274	324	375

Final energy consumption (GWh)

Table 116 Final energy consumption in Scenario 5 in Hungary

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2076	1779	1320	1002	822	0	0
LPG	37	34	28	23	19	0	0
Biomass	2892	2915	2587	2296	2124	2124	2124
Ambient heat	15	15	13	19	17	435	433
Solar thermal	0	0	0	0	0	0	0
District heating	263	265	235	209	193	193	193
Electricity	53	54	48	25	23	202	201
Coal and other	139	133	85	0	0	0	0
Total	5476	5196	4317	3573	3199	2954	2951
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	4	4	4	3	3	3	3
Total	4	4	4	3	3	3	3
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	468	471	471	498	497	629	625
Natural gas	257	221	184	158	140	0	0
Heating oil	0	0	0	0	0	0	0
District heating	93	94	94	94	94	94	94
LPG	41	38	35	32	30	0	0
Biomass	50	51	51	51	51	51	51
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	25	25	25	25	25	25	25
Total	935	900	860	858	836	798	795
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0

Natural gas	2334	2000	1505	1159	962	0	0
LPG	79	73	63	55	49	0	0
Biomass	2942	2966	2638	2347	2175	2175	2175
Ambient heat	15	15	13	19	17	435	433
Solar thermal	25	25	25	25	25	25	25
District heating	356	359	329	303	287	287	287
Electricity	525	529	523	527	523	833	829
Coal and other	139	133	85	0	0	0	0
Total	6415	6100	5181	4434	4038	3756	3749

Total energy costs (million €)

Table 117 Total energy costs in Scenario 5 in Hungary

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	88	88	88	89	0	0
LPG	12	13	13	13	13	0	0
Biomass	44	44	40	35	33	33	33
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	11	11	10	9	9	9	9
Electricity	59	60	59	62	63	106	111
Coal and other	2	2	2	0	0	0	0
Total	207	218	212	207	207	148	153

Table 118 Investments foreseen in Scenario 5 in Hungary

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	84	0	1292	0
Building envelope	0	3429	3429	3302	0	0
Total	0	3429	3513	3302	1292	0

Synopsis

Comparison of final energy consumption

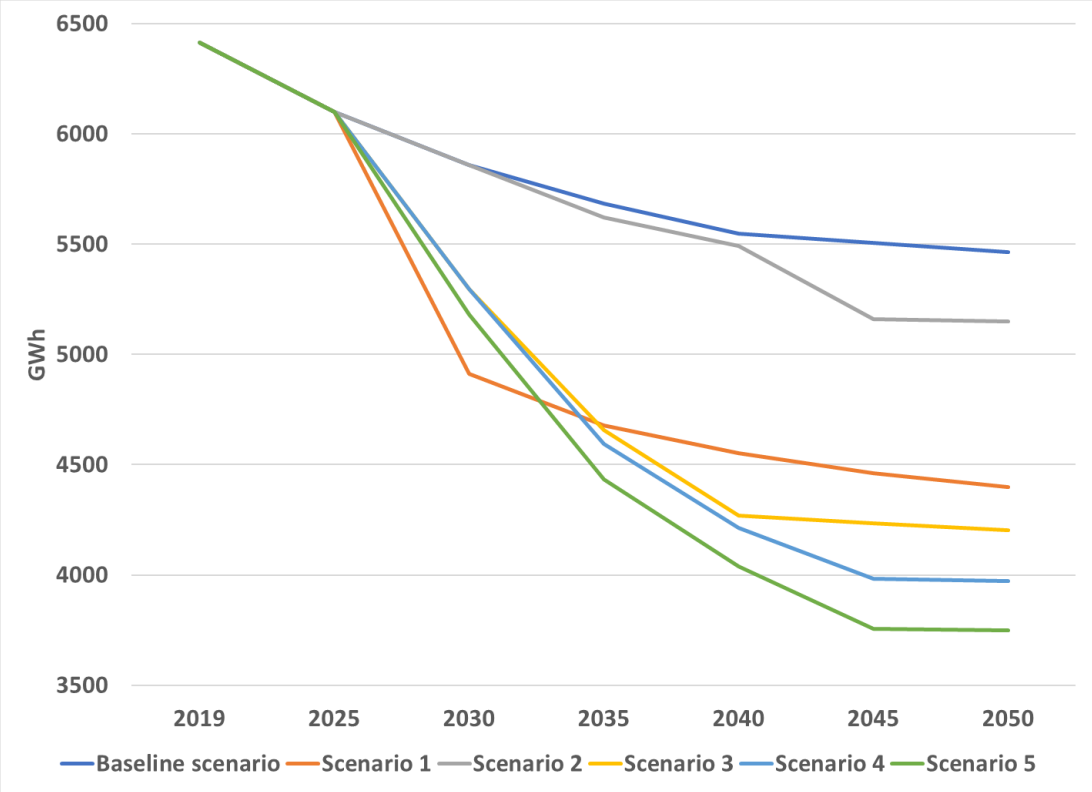

Figure 18 Comparison of final energy consumption between scenarios in Hungary

Comparison of investments in different scenarios

Figure 19 Investments in different scenarios in Hungary

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	138	0	1547	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	3429	3429	3302	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	138	0	1556	0
	Building envelope	0	3429	3429	3302	0	0
	Total	0	3429	3567	3302	1556	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	84	0	1292	0
	Building envelope	0	3429	3429	3302	0	0
	Total	0	3429	3513	3302	1292	0

Comparison of the total energy costs

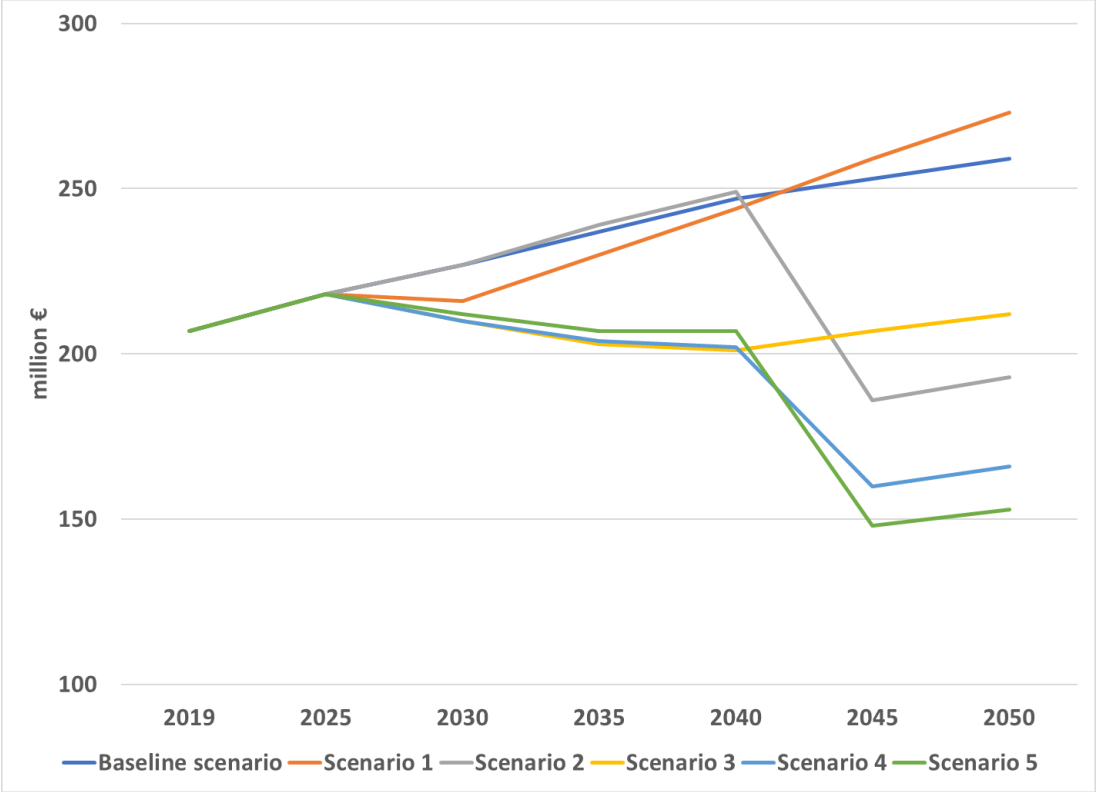

Figure 20 Comparison of final energy costs between scenarios in Hungary

5.5 ITALY

5.5.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of average household in Italy according to data about disaggregated final energy consumption of households (*data: Eurostat*).

Table 119 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	13915
Space heating	9240
Space cooling	118
DHW	1678
Cooking	891
Other	1988

Energy carrier	Average household (kWh/HH)
Total	13915
Electricity	2523
Natural gas	7216
Oil	387
LPG	500
Solid fossil fuels	0
District heat	397
Solar thermal	75
Ambient heat	43
Biomass	2772

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of average households (*data: HBS*).

Table 120 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	6%
Natural gas	25%
Oil	49%
LPG	33%
Solid fossil fuels	74%
District heat	49%
Solar thermal	0%
Ambient heat	49%
Biomass	2%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration the reduced energy expenses as estimated in Step 2.

Table 121 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	**11366**
Space heating	7369

End uses	Low-income HH (kWh/HH)
Space cooling	111
DHW	1320
Cooking	695
Other	1870

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration the reduced energy expenses as estimated in the Step 2.

Table 122 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	11366
Electricity	2374
Natural gas	5444
Oil	199
LPG	333
Solid fossil fuels	0
District heat	202
Solar thermal	75
Ambient heat	22
Biomass	2716

Step 5: Identification of utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying the consumed energy carriers.

Number of low-income households (dwellings): **2,766,058**

Table 123 Final energy consumption in the low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	6566	102	307	611	374	5172
Heating oil	551	493		58		
LPG	922	584		161	177	
Natural gas	15058	11465		2282	1312	
Solar thermal	209	12		196		
Ambient heat	60	60				
Biomass	7513	7180		273	60	
District heating	558	487		71		
Coal and other	0	0		0	0	

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Total	31438	20384	307	3652	1923	5172

Step 7: Validation and adjustment of the obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **12%** assuming the following prices:

Table 124 Utilised energy prices in Italy

Energy carrier	Energy price (€/MWh)
Heating oil	113
Electricity	248
Natural gas	80
Biomass	40
District heating	115
Solar thermal	0
LPG	170
Coal and other	30

5.5.2 Modelling the impacts of the examined policies in Italy

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 125 Energy prices in the baseline scenario for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	80	104	128	152	176	184	192
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	248	249	249	253	256	263	270
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 126 Final energy consumption in baseline scenario in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	420	394	372	353	337
Natural gas	11465	9745	8620	7812	7196	7032	6879
LPG	584	535	497	466	440	418	399
Biomass	7180	7180	7180	7180	7180	7180	7180
Ambient heat	60	60	60	60	59	59	58
Solar thermal	12	12	12	12	12	12	12
District heating	487	487	487	487	487	487	487
Electricity	102	102	102	101	100	99	97
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	17380	16513	15847	15641	15450
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	307	307	306	304	301	297	293
Total	307	307	306	304	301	297	293
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	611	611	610	605	600	592	584
Natural gas	2282	1939	1716	1555	1432	1399	1369

Heating oil	58	53	49	46	43	41	39
District heating	71	71	71	71	71	71	71
LPG	161	147	137	128	121	115	110
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196
Total	3652	3291	3052	2874	2737	2688	2643
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	551	505	469	440	415	395	377
Natural gas	13746	11684	10336	9367	8627	8431	8248
LPG	745	683	634	594	561	533	509
Biomass	7454	7454	7454	7454	7454	7454	7454
Ambient heat	60	60	60	60	59	59	58
Solar thermal	209	209	209	209	209	209	209
District heating	558	558	558	558	558	558	558
Electricity	1020	1019	1018	1009	1002	988	974
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	20738	19691	18886	18626	18386

Total energy costs (million €)

Table 127 Total energy costs in baseline scenario in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	71	75	78	82	85
Natural gas	1100	1215	1323	1424	1518	1551	1584
LPG	127	135	144	152	159	166	173
Biomass	298	298	298	298	298	298	298
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	64	64	64	64	64
Electricity	253	253	253	255	257	260	263
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	2153	2267	2375	2421	2467

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 128 Energy prices in the Scenario 1 for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	191	247	262	294	326
Natural gas	80	104	159	211	232	250	268
Solid fossil fuels	30	33	91	143	140	160	179
Electricity	248	249	249	253	256	263	270
LPG	170	198	267	332	357	398	440

Final energy consumption (GWh)

Table 129 Final energy consumption in Scenario 1 in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	350	299	266	236	214
Natural gas	11465	9745	7171	5996	5257	4797	4440
LPG	584	535	442	389	350	316	290
Biomass	7180	7180	7180	7180	7180	7180	7180
Ambient heat	60	60	60	60	59	59	58
Solar thermal	12	12	12	12	12	12	12
District heating	487	487	487	487	487	487	487
Electricity	102	102	102	101	100	99	97
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	15806	14525	13712	13185	12779
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	307	307	306	304	301	297	293
Total	307	307	306	304	301	297	293
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	611	611	610	605	600	592	584
Natural gas	2282	1939	1427	1193	1046	955	884
Heating oil	58	53	41	35	31	27	25
District heating	71	71	71	71	71	71	71
LPG	161	147	122	107	96	87	80
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196
Total	3652	3291	2740	2481	2314	2201	2113
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	551	505	391	334	297	263	239
Natural gas	13746	11684	8598	7190	6303	5752	5324
LPG	745	683	564	495	447	403	370
Biomass	7454	7454	7454	7454	7454	7454	7454
Ambient heat	60	60	60	60	59	59	58
Solar thermal	209	209	209	209	209	209	209
District heating	558	558	558	558	558	558	558
Electricity	1020	1019	1018	1009	1002	988	974
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	18852	17309	16328	15684	15184

Total energy costs (million €)

Table 130 Total energy costs in Scenario 1 in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	75	83	90	98	105
Natural gas	1100	1215	1367	1517	1658	1778	1890
LPG	127	135	151	165	178	192	205
Biomass	298	298	298	298	298	298	298
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	64	64	64	64	64
Electricity	253	253	253	255	257	260	263
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	2208	2382	2545	2689	2825

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 131 Energy prices in the Scenario 2 for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	80	104	128	152	176	184	192
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	248	249	249	253	256	263	270
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 132 Final energy consumption in Scenario 2 in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	420	0	0	0	0
Natural gas	11465	9745	8620	7812	7196	0	0
LPG	584	535	497	466	440	0	0
Biomass	7180	7180	7180	7180	7180	7180	7180
Ambient heat	60	60	60	258	256	4474	4413
Solar thermal	12	12	12	12	12	12	12
District heating	487	487	487	487	487	487	487
Electricity	102	102	102	179	178	1852	1827
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	17380	16396	15750	14006	13920
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	307	307	306	304	301	297	293
Total	307	307	306	304	301	297	293
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	611	611	610	757	751	2104	2075
Natural gas	2282	1939	1716	1555	1432	0	0
Heating oil	58	53	49	0	0	0	0
District heating	71	71	71	71	71	71	71
LPG	161	147	137	128	121	0	0
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196

Total	3652	3291	3052	2981	2845	2644	2616
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	551	505	469	0	0	0	0
Natural gas	13746	11684	10336	9367	8627	0	0
LPG	745	683	634	594	561	0	0
Biomass	7454	7454	7454	7454	7454	7454	7454
Ambient heat	60	60	60	258	256	4474	4413
Solar thermal	209	209	209	209	209	209	209
District heating	558	558	558	558	558	558	558
Electricity	1020	1019	1018	1240	1231	4253	4195
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	20738	19680	18896	16948	16829

Total energy costs (million €)

Table 133 Total energy costs in Scenario 2 in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	71	0	0	0	0
Natural gas	1100	1215	1323	1424	1518	0	0
LPG	127	135	144	152	159	0	0
Biomass	298	298	298	298	298	298	298
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	64	64	64	64	64
Electricity	253	253	253	313	315	1118	1131
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	2153	2251	2355	1481	1493

Table 134 Investments foreseen in Scenario 2 in Italy

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	528	0	10596	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (1.04 MILLION BUILDINGS) AND REMAIN UNTIL 2035 (1.04 MILLION BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 135 Energy prices in the Scenario 3 for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	80	104	128	152	176	184	192
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	248	249	249	253	256	263	270
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 136 Final energy consumption in Scenario 3 in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	373	310	271	257	246
Natural gas	11465	9745	7651	6153	5243	5123	5012
LPG	584	535	441	367	321	305	291
Biomass	7180	7180	6373	5656	5231	5231	5231
Ambient heat	60	60	54	47	43	43	42
Solar thermal	12	12	11	10	9	9	9
District heating	487	487	432	384	355	355	355
Electricity	102	102	90	79	73	72	71
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	15424	13006	11546	11395	11257
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	307	307	272	239	220	217	214
Total	307	307	272	239	220	217	214
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	611	611	610	605	600	592	584
Natural gas	2282	1939	1716	1555	1432	1399	1369
Heating oil	58	53	49	46	43	41	39
District heating	71	71	71	71	71	71	71

LPG	161	147	137	128	121	115	110
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196
Total	3652	3291	3052	2874	2737	2688	2643
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	551	505	422	356	314	299	285
Natural gas	13746	11684	9366	7708	6674	6523	6381
LPG	745	683	578	495	442	420	401
Biomass	7454	7454	6646	5929	5505	5505	5505
Ambient heat	60	60	54	47	43	43	42
Solar thermal	209	209	207	206	205	205	205
District heating	558	558	503	455	426	426	426
Electricity	1020	1019	972	924	893	880	868
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	18748	16120	14503	14300	14113

Total energy costs (million €)

Table 137 Total energy costs in Scenario 3 in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	64	60	59	62	64
Natural gas	1100	1215	1199	1172	1175	1200	1225
LPG	127	135	131	126	125	131	136
Biomass	298	298	266	237	220	220	220
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	58	52	49	49	49
Electricity	253	253	242	233	229	231	234
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	1959	1881	1857	1893	1929

Table 138 Investments foreseen in Scenario 3 in Italy

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	10373	10373	10373	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 139 Energy prices in the Scenario 4 for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	151	170	188	207	226
Natural gas	80	104	128	152	176	184	192
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	248	249	249	253	256	263	270
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 140 Final energy consumption in Scenario 4 in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	373	0	0	0	0
Natural gas	11465	9745	7651	6153	5243	0	0
LPG	584	535	441	367	321	0	0
Biomass	7180	7180	6373	5656	5231	5231	5231
Ambient heat	60	60	54	169	155	3229	3185
Solar thermal	12	12	11	10	9	9	9
District heating	487	487	432	384	355	355	355
Electricity	102	102	90	118	108	1510	1489
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	15424	12856	11422	10334	10270
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	307	307	272	239	220	217	214
Total	307	307	272	239	220	217	214
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	611	611	610	757	751	2104	2075
Natural gas	2282	1939	1716	1555	1432	0	0
Heating oil	58	53	49	0	0	0	0
District heating	71	71	71	71	71	71	71
LPG	161	147	137	128	121	0	0
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196
Total	3652	3291	3052	2981	2845	2644	2616
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	551	505	422	0	0	0	0
Natural gas	13746	11684	9366	7708	6674	0	0

LPG	745	683	578	495	442	0	0
Biomass	7454	7454	6646	5929	5505	5505	5505
Ambient heat	60	60	54	169	155	3229	3185
Solar thermal	209	209	207	206	205	205	205
District heating	558	558	503	455	426	426	426
Electricity	1020	1019	972	1114	1079	3830	3778
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	18748	16076	14486	13195	13099

Total energy costs (million €)

Table 141 Total energy costs in Scenario 4 in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	64	0	0	0	0
Natural gas	1100	1215	1199	1172	1175	0	0
LPG	127	135	131	126	125	0	0
Biomass	298	298	266	237	220	220	220
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	58	52	49	49	49
Electricity	253	253	242	282	277	1007	1018
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	1959	1869	1846	1276	1287

Table 142 Investments foreseen in Scenario 4 in Italy

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	528	0	10646	0
Building envelope	0	10373	10373	10373	0	0
Total	0	10373	10900	10373	10646	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 143 Energy prices in the Scenario 5 for Italy

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	113	132	156	182	209	250	291
Natural gas	80	104	132	162	192	216	241
Solid fossil fuels	30	33	43	55	68	100	132
Electricity	248	249	249	253	256	263	270
LPG	170	198	232	268	304	354	405

Final energy consumption (GWh)

Table 144 Final energy consumption in Scenario 5 in Italy

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	493	452	365	0	0	0	0
Natural gas	11465	9745	7497	5897	4950	0	0
LPG	584	535	435	356	307	0	0
Biomass	7180	7180	6373	5656	5231	5231	5231
Ambient heat	60	60	54	163	150	2930	2890
Solar thermal	12	12	11	10	9	9	9
District heating	487	487	432	384	355	355	355
Electricity	102	102	90	115	105	1375	1357
Coal and other	0	0	0	0	0	0	0
Total	20384	18575	15257	12581	11108	9901	9842
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	307	307	272	239	220	217	214
Total	307	307	272	239	220	217	214
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	611	611	610	752	746	1969	1942
Natural gas	2282	1939	1681	1490	1352	0	0
Heating oil	58	53	48	0	0	0	0
District heating	71	71	71	71	71	71	71
LPG	161	147	135	124	116	0	0
Biomass	273	273	273	273	273	273	273
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	196	196	196	196	196	196	196
Total	3652	3291	3015	2907	2755	2510	2483
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	551	505	413	0	0	0	0
Natural gas	13746	11684	9178	7387	6302	0	0
LPG	745	683	570	481	423	0	0
Biomass	7454	7454	6646	5929	5505	5505	5505
Ambient heat	60	60	54	163	150	2930	2890
Solar thermal	209	209	207	206	205	205	205
District heating	558	558	503	455	426	426	426
Electricity	1020	1019	972	1106	1071	3561	3512
Coal and other	0	0	0	0	0	0	0
Total	24343	22172	18544	15727	14082	12627	12539

Total energy costs (million €)

Table 145 Total energy costs in Scenario 5 in Italy

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	62	67	64	0	0	0	0
Natural gas	1100	1215	1209	1194	1207	0	0
LPG	127	135	132	129	129	0	0
Biomass	298	298	266	237	220	220	220
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	64	64	58	52	49	49	49
Electricity	253	253	242	280	275	936	947
Coal and other	0	0	0	0	0	0	0
Total	1904	2033	1971	1892	1880	1206	1216

Table 146 Investments foreseen in Scenario 5 in Italy

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	516	0	10101	0
Building envelope	0	10373	10373	10373	0	0
Total	0	10373	10888	10373	10101	0

Synopsis

Comparison of final energy consumption

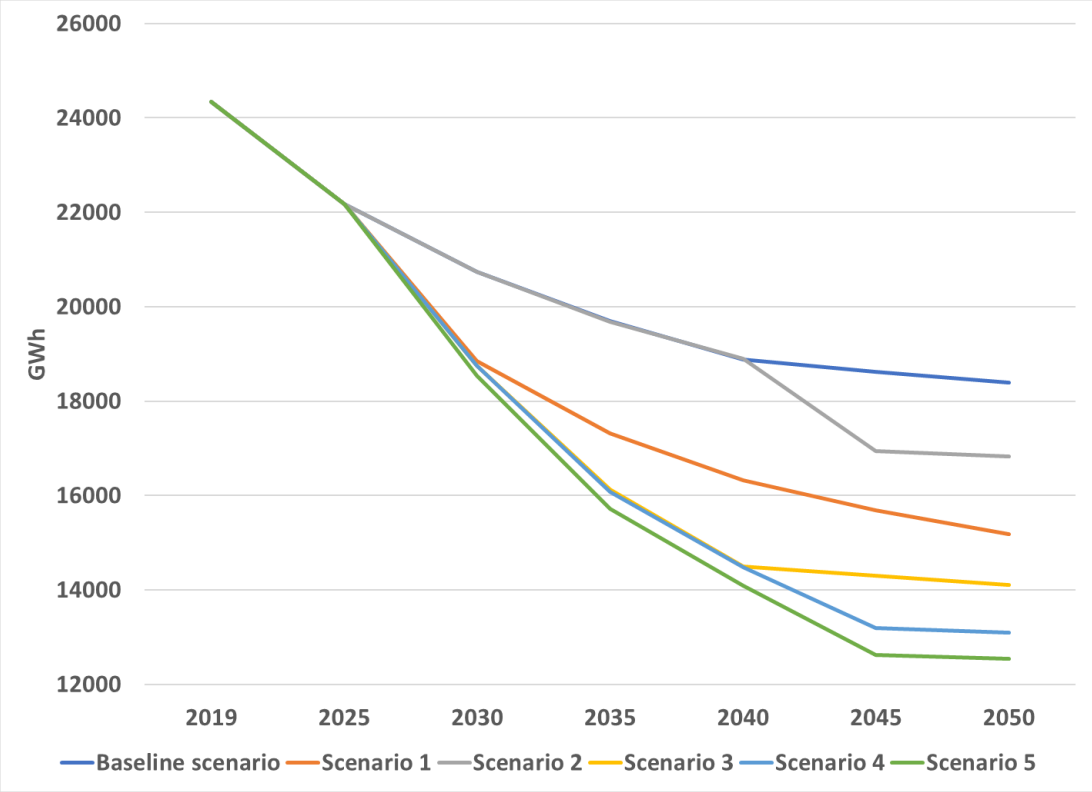

Figure 21 Comparison of final energy consumption between scenarios in Italy

Comparison of investments in different scenarios

Figure 22 Investments in different scenarios in Italy

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	528	0	10596	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	10373	10373	10373	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	528	0	10646	0
	Building envelope	0	10373	10373	10373	0	0
	Total	0	10373	10900	10373	10646	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	516	0	10101	0
	Building envelope	0	10373	10373	10373	0	0
	Total	0	10373	10888	10373	10101	0

Comparison of the total energy costs

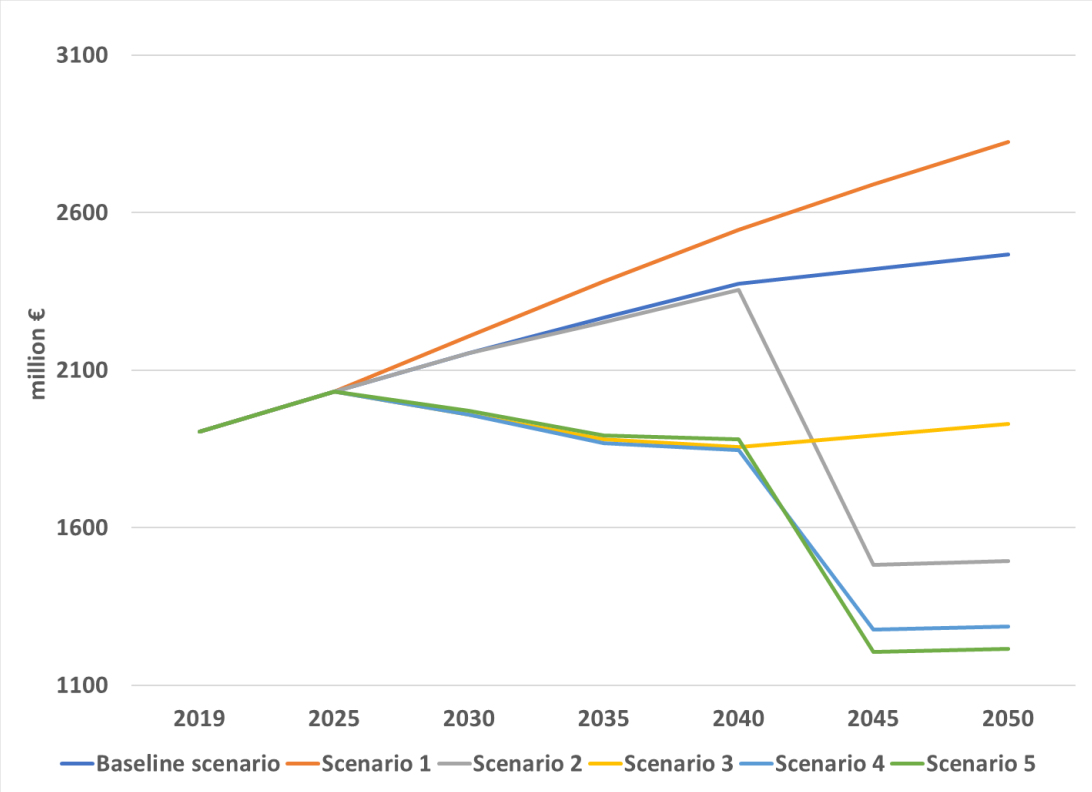

Figure 23 Comparison of final energy costs between scenarios in Italy

5.6 POLAND

5.6.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Poland according to data on the disaggregated final energy consumption of households (*data: Eurostat*).

Table 147 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	14417
Space heating	9105
Space cooling	0
DHW	2485
Cooking	1293
Other	1534

Energy carrier	Average household (kWh/HH)
Total	14417
Electricity	1979
Natural gas	2849
Heating oil	55
LNG	456
Solid fossil fuels	4080
District heat	2843
Solar thermal	52
Ambient heat	185
Biomass	1919

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of the average household (*data: HBS*).

Table 148 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	35%
LPG	35%
Heating oil	35%
Natural gas	35%
Solar thermal	0%
Biomass	35%
Ambient heat	35%
District heat	35%
Solid fossil fuels	35%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Table 149 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	9399
Space heating	5925

End uses	Low-income HH (kWh/HH)
Space cooling	0
DHW	1634
Cooking	841
Other	998

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in the Step 2.

Table 150 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	9399
Electricity	1288
Natural gas	1854
Heating oil	36
LNG	297
Solid fossil fuels	2654
District heat	1850
Solar thermal	52
Ambient heat	121
Biomass	1248

Step 5: Identification of utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying consumed energy carriers.

Number of low-income households (dwellings): **2,180,614**

Table 151 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	2808	125	0	203	304	2176
Heating oil	78	69		9		
LPG	647	26		31	591	
Natural gas	4042	2160		1071	811	
Solar thermal	113	6		107		
Ambient heat	263	184		79		
Biomass	2722	2440		227	56	
District heating	4033	2713		1320		
Coal and other	5788	5199		517	73	

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Total	20495	12921	0	3563	1835	2176

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **34%** assuming the following prices:

Table 152 Utilised energy prices in Poland

Energy carrier	Energy price (€/MWh)
Electricity	125
Heating oil	90
LPG	80
Natural gas	45
Solar thermal	0
Biomass	20
Ambient heat	0
District heating	50
Coal and other	20

5.6.2 Modelling the impacts of the examined policies in Poland

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 153 Energy prices in the baseline scenario for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	120	135	150	165	180
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	20	22	24	25	27	28	29
Electricity	125	127	129	138	147	158	170
LPG	80	93	107	120	133	147	160

Final energy consumption (GWh)

Table 154 Final energy consumption in baseline scenario in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	59	55	52	49	47
Natural gas	2160	1836	1624	1472	1356	1325	1296
LPG	26	23	22	20	19	18	18
Biomass	2440	2440	2440	2440	2440	2440	2440
Ambient heat	184	182	181	174	168	161	154
Solar thermal	6	6	6	6	6	6	6
District heating	2713	2713	2713	2713	2713	2713	2713
Electricity	125	124	122	118	114	109	104
Coal and other	5199	4939	4714	4583	4463	4351	4247
Total	12921	12326	11881	11581	11330	11172	11025
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	203	201	200	192	186	177	170
Natural gas	1071	910	805	730	672	657	643

Heating oil	9	9	8	8	7	7	6
District heating	1320	1320	1320	1320	1320	1320	1320
LPG	31	28	26	24	23	22	21
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	468	455	443	432	422
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107
Total	3563	3372	3240	3142	3064	3028	2995
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	67	63	59	56	54
Natural gas	3231	2746	2430	2202	2028	1982	1939
LPG	56	51	48	45	42	40	38
Biomass	2667	2667	2667	2667	2667	2667	2667
Ambient heat	263	261	260	253	247	240	233
Solar thermal	113	113	113	113	113	113	113
District heating	4033	4033	4033	4033	4033	4033	4033
Electricity	328	325	322	310	299	286	275
Coal and other	5715	5429	5183	5039	4906	4783	4670
Total	16484	15698	15121	14724	14394	14200	14020

Total energy costs (million €)

Table 155 Total energy costs in baseline scenario in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	8	8	9	9	10
Natural gas	145	161	175	188	201	205	209
LPG	4	5	5	5	6	6	6
Biomass	53	53	53	53	53	53	53
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	202	202	202	202	202
Electricity	41	41	42	43	44	45	47
Coal and other	114	119	124	128	131	134	137
Total	567	589	609	627	645	655	664

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 156 Energy prices in the Scenario 1 for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	165	222	232	262	292
Natural gas	45	59	107	151	162	177	193
Solid fossil fuels	20	22	86	143	138	159	181
Electricity	125	127	129	138	147	158	170
LPG	80	93	152	207	216	244	272

Final energy consumption (GWh)

Table 157 Final energy consumption in Scenario 1 in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	45	37	33	28	26
Natural gas	2160	1836	1081	854	727	640	578
LPG	26	23	16	13	11	10	9
Biomass	2440	2440	2440	2440	2440	2440	2440
Ambient heat	184	182	181	174	168	161	154
Solar thermal	6	6	6	6	6	6	6
District heating	2713	2713	2713	2713	2713	2713	2713
Electricity	125	124	122	118	114	109	104
Coal and other	5199	4939	0	0	0	0	0
Total	12921	12326	6604	6355	6212	6107	6030
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	203	201	200	192	186	177	170
Natural gas	1071	910	536	423	361	317	287
Heating oil	9	9	6	5	4	4	4
District heating	1320	1320	1320	1320	1320	1320	1320
LPG	31	28	19	16	14	12	11
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	0	0	0	0	0
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107
Total	3563	3372	2494	2369	2297	2243	2204

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	51	42	37	32	29
Natural gas	3231	2746	1618	1277	1088	958	865
LPG	56	51	35	29	25	22	20
Biomass	2667	2667	2667	2667	2667	2667	2667
Ambient heat	263	261	260	253	247	240	233
Solar thermal	113	113	113	113	113	113	113
District heating	4033	4033	4033	4033	4033	4033	4033
Electricity	328	325	322	310	299	286	275
Coal and other	5715	5429	0	0	0	0	0
Total	16484	15698	9098	8724	8509	8350	8234

Total energy costs (million €)

Table 158 Total energy costs in Scenario 1 in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	8	9	10	11	12
Natural gas	145	161	172	193	214	233	251
LPG	4	5	5	6	7	7	8
Biomass	53	53	53	53	53	53	53
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	202	202	202	202	202
Electricity	41	41	42	43	44	45	47
Coal and other	114	119	0	0	0	0	0
Total	567	589	483	507	529	552	573

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 159 Energy prices in the Scenario 2 for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	120	135	150	165	180
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	20	22	24	25	27	28	29
Electricity	125	127	129	138	147	158	170
LPG	80	93	107	120	133	147	160

Final energy consumption (GWh)

Table 160 Final energy consumption in Scenario 2 in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	59	0	0	0	0
Natural gas	2160	1836	1624	1472	1356	0	0
LPG	26	23	22	20	19	0	0
Biomass	2440	2440	2440	2440	2440	2440	2440
Ambient heat	184	182	181	1068	1031	1746	1675
Solar thermal	6	6	6	6	6	6	6
District heating	2713	2713	2713	2713	2713	2713	2713
Electricity	125	124	122	473	456	738	708
Coal and other	5199	4939	4714	0	0	0	0
Total	12921	12326	11881	8191	8021	7643	7542
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	203	201	200	357	344	940	902
Natural gas	1071	910	805	730	672	0	0
Heating oil	9	9	8	0	0	0	0
District heating	1320	1320	1320	1320	1320	1320	1320
LPG	31	28	26	24	23	0	0
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	468	0	0	0	0
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107

Total	3563	3372	3240	2844	2773	2673	2635
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	67	0	0	0	0
Natural gas	3231	2746	2430	2202	2028	0	0
LPG	56	51	48	45	42	0	0
Biomass	2667	2667	2667	2667	2667	2667	2667
Ambient heat	263	261	260	1146	1110	1825	1754
Solar thermal	113	113	113	113	113	113	113
District heating	4033	4033	4033	4033	4033	4033	4033
Electricity	328	325	322	829	801	1679	1610
Coal and other	5715	5429	5183	0	0	0	0
Total	16484	15698	15121	11035	10793	10316	10176

Total energy costs (million €)

Table 161 Total energy costs in Scenario 2 in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	8	0	0	0	0
Natural gas	145	161	175	188	201	0	0
LPG	4	5	5	5	6	0	0
Biomass	53	53	53	53	53	53	53
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	202	202	202	202	202
Electricity	41	41	42	114	117	266	274
Coal and other	114	119	124	0	0	0	0
Total	567	589	609	563	579	521	529

Table 162 Investments foreseen in Scenario 2 in Poland

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	6987	0	2958	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (818 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (818 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 163 Energy prices in the Scenario 3 for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	120	135	150	165	180
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	20	22	24	25	27	28	29
Electricity	125	127	129	138	147	158	170
LPG	80	93	107	120	133	147	160

Final energy consumption (GWh)

Table 164 Final energy consumption in Scenario 3 in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	52	43	38	36	34
Natural gas	2160	1836	1442	1159	988	965	944
LPG	26	23	19	16	14	13	13
Biomass	2440	2440	2165	1922	1778	1778	1778
Ambient heat	184	182	160	137	122	117	112
Solar thermal	6	6	5	4	4	4	4
District heating	2713	2713	2408	2137	1977	1977	1977
Electricity	125	124	109	93	83	79	76
Coal and other	5199	4939	4184	3610	3251	3170	3095
Total	12921	12326	10544	9122	8255	8140	8033
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	203	201	200	192	186	177	170
Natural gas	1071	910	805	730	672	657	643
Heating oil	9	9	8	8	7	7	6
District heating	1320	1320	1320	1320	1320	1320	1320

LPG	31	28	26	24	23	22	21
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	468	455	443	432	422
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107
Total	3563	3372	3240	3142	3064	3028	2995
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	60	51	45	43	41
Natural gas	3231	2746	2247	1889	1660	1622	1587
LPG	56	51	45	40	37	35	34
Biomass	2667	2667	2392	2149	2004	2004	2004
Ambient heat	263	261	239	216	201	196	191
Solar thermal	113	113	112	112	111	111	111
District heating	4033	4033	3728	3457	3297	3297	3297
Electricity	328	325	308	285	269	257	246
Coal and other	5715	5429	4652	4065	3695	3602	3517
Total	16484	15698	13784	12264	11319	11168	11028

Total energy costs (million €)

Table 165 Total energy costs in Scenario 3 in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	7	7	7	7	7
Natural gas	145	161	162	162	164	168	171
LPG	4	5	5	5	5	5	5
Biomass	53	53	48	43	40	40	40
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	186	173	165	165	165
Electricity	41	41	40	39	39	41	42
Coal and other	114	119	112	103	99	101	103
Total	567	589	560	531	519	527	534

Table 166 Investments foreseen in Scenario 3 in Poland

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	8177	8177	8177	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 167 Energy prices in the Scenario 4 for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	120	135	150	165	180
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	20	22	24	25	27	28	29
Electricity	125	127	129	138	147	158	170
LPG	80	93	107	120	133	147	160

Final energy consumption (GWh)

Table 168 Final energy consumption in Scenario 4 in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	52	0	0	0	0
Natural gas	2160	1836	1442	1159	988	0	0
LPG	26	23	19	16	14	0	0
Biomass	2440	2440	2165	1922	1778	1778	1778
Ambient heat	184	182	160	699	624	1151	1104
Solar thermal	6	6	5	4	4	4	4
District heating	2713	2713	2408	2137	1977	1977	1977
Electricity	125	124	109	913	816	841	807
Coal and other	5199	4939	4184	0	0	0	0
Total	12921	12326	10544	6851	6200	5751	5669
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	203	201	200	357	344	940	902
Natural gas	1071	910	805	730	672	0	0
Heating oil	9	9	8	0	0	0	0
District heating	1320	1320	1320	1320	1320	1320	1320
LPG	31	28	26	24	23	0	0
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	468	0	0	0	0
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107
Total	3563	3372	3240	2844	2773	2673	2635
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	60	0	0	0	0
Natural gas	3231	2746	2247	1889	1660	0	0

LPG	56	51	45	40	37	0	0
Biomass	2667	2667	2392	2149	2004	2004	2004
Ambient heat	263	261	239	778	703	1230	1183
Solar thermal	113	113	112	112	111	111	111
District heating	4033	4033	3728	3457	3297	3297	3297
Electricity	328	325	308	1270	1160	1781	1708
Coal and other	5715	5429	4652	0	0	0	0
Total	16484	15698	13784	9695	8973	8424	8304

Total energy costs (million €)

Table 169 Total energy costs in Scenario 4 in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	7	0	0	0	0
Natural gas	145	161	162	162	164	0	0
LPG	4	5	5	5	5	0	0
Biomass	53	53	48	43	40	40	40
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	186	173	165	165	165
Electricity	41	41	40	175	170	282	291
Coal and other	114	119	112	0	0	0	0
Total	567	589	560	557	544	487	496

Table 170 Investments foreseen in Scenario 4 in Poland

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	6987	0	2793	0
Building envelope	0	8177	8177	8177	0	0
Total	0	8177	15164	8177	2793	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 171 Energy prices in the Scenario 5 for Poland

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	90	105	125	149	173	213	252
Natural gas	45	59	76	96	116	140	163
Solid fossil fuels	20	22	31	45	58	93	127
Electricity	125	127	129	138	147	158	170
LPG	80	93	112	134	156	194	232

Final energy consumption (GWh)

Table 172 Final energy consumption in Scenario 5 in Poland

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	69	63	51	0	0	0	0
Natural gas	2160	1836	1384	1066	883	0	0
LPG	26	23	19	15	13	0	0
Biomass	2440	2440	2165	1922	1778	1778	1778
Ambient heat	184	182	160	511	456	892	856
Solar thermal	6	6	5	4	4	4	4
District heating	2713	2713	2408	2137	1977	1977	1977
Electricity	125	124	109	666	595	637	611
Coal and other	5199	4939	3450	0	0	0	0
Total	12921	12326	9751	6321	5705	5288	5226
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	203	201	200	310	299	789	757
Natural gas	1071	910	773	671	601	0	0
Heating oil	9	9	8	0	0	0	0
District heating	1320	1320	1320	1320	1320	1320	1320
LPG	31	28	25	23	21	0	0
Biomass	227	227	227	227	227	227	227
Coal and other	517	491	386	0	0	0	0
Ambient heat	79	79	79	79	79	79	79
Solar thermal	107	107	107	107	107	107	107
Total	3563	3372	3125	2736	2654	2522	2489
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	78	72	58	0	0	0	0

Natural gas	3231	2746	2157	1737	1483	0	0
LPG	56	51	44	38	34	0	0
Biomass	2667	2667	2392	2149	2004	2004	2004
Ambient heat	263	261	239	590	535	971	935
Solar thermal	113	113	112	112	111	111	111
District heating	4033	4033	3728	3457	3297	3297	3297
Electricity	328	325	308	976	894	1426	1368
Coal and other	5715	5429	3837	0	0	0	0
Total	16484	15698	12876	9057	8358	7810	7715

Total energy costs (million €)

Table 173 Total energy costs in Scenario 5 in Poland

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	7	8	7	0	0	0	0
Natural gas	145	161	164	167	173	0	0
LPG	4	5	5	5	5	0	0
Biomass	53	53	48	43	40	40	40
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	202	202	186	173	165	165	165
Electricity	41	41	40	134	131	226	233
Coal and other	114	119	120	0	0	0	0
Total	567	589	571	523	514	431	438

Table 174 Investments foreseen in Scenario 5 in Poland

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	5479	0	2523	0
Building envelope	0	8177	8177	8177	0	0
Total	0	8177	13657	8177	2523	0

Synopsis

Comparison of final energy consumption

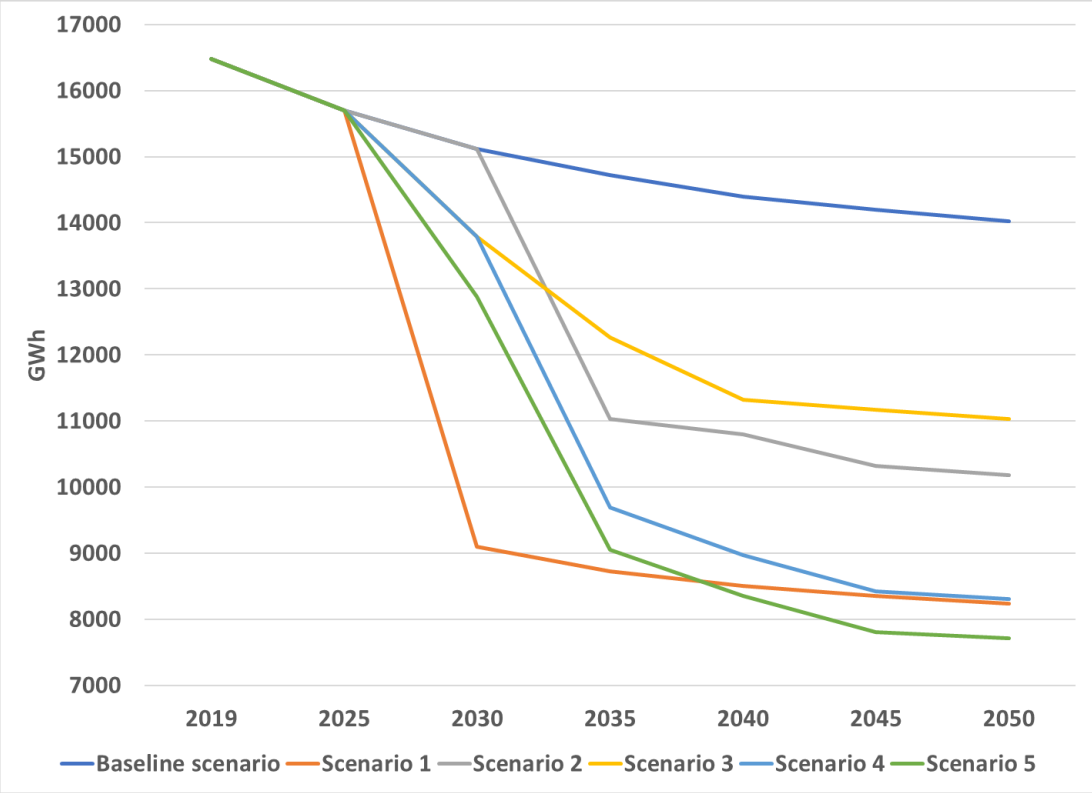

Figure 24 Comparison of final energy consumption between scenarios in Poland

Comparison of investments in different scenarios

Figure 25 Investments in different scenarios in Poland

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	6987	0	2958	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	8177	8177	8177	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	6987	0	2793	0
	Building envelope	0	8177	8177	8177	0	0
	Total	0	8177	15164	8177	2793	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	5479	0	2523	0
	Building envelope	0	8177	8177	8177	0	0
	Total	0	8177	13657	8177	2523	0

Comparison of the total energy costs

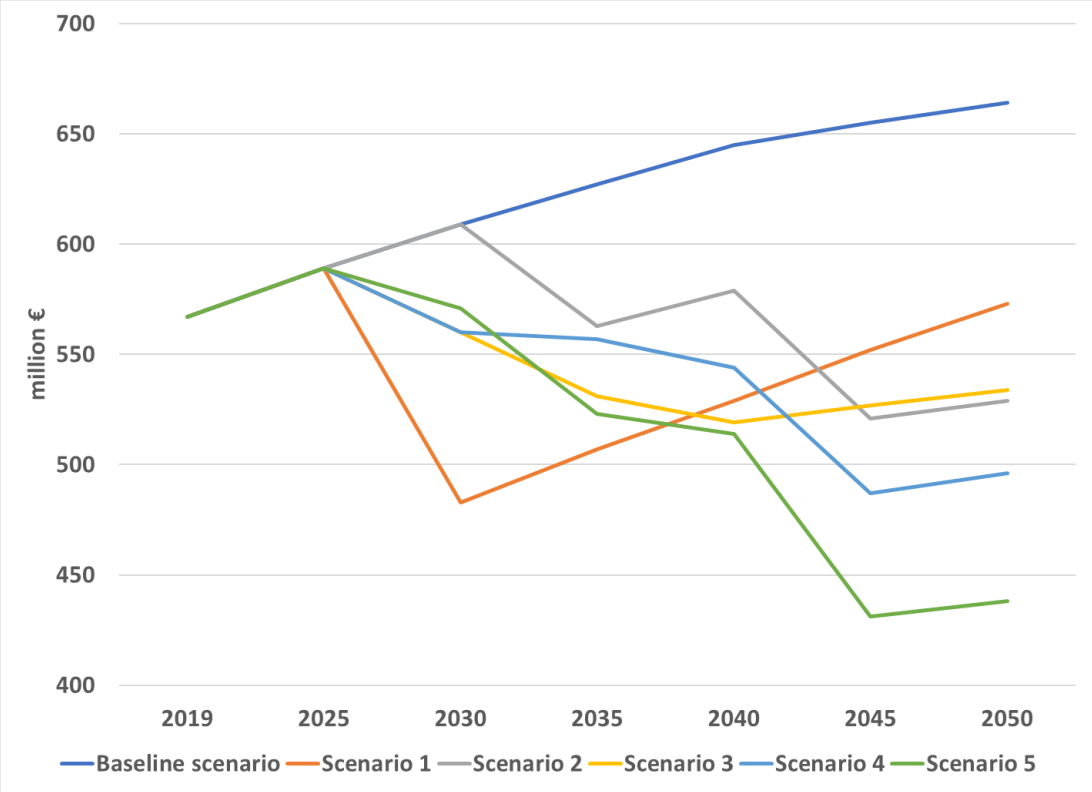

Figure 26 Comparison of final energy costs between scenarios in Poland

5.7 PORTUGAL

5.7.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Portugal according to data about disaggregated final energy consumption of households (*data: Eurostat*).

Table 175 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	8081
Space heating	2207
Space cooling	51
DHW	1425
Cooking	2919
Other	1480

Energy carrier	Average household (kWh/HH)
Total	8081
Electricity	3188
Natural gas	797
Oil	1141
Solid fossil fuels	0
District heat	2
Biomass	2113
Solar thermal	162
Ambient heat	678

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of the average household (*data: HBS*).

Table 176 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	45%
Natural gas	30%
Oil	43%
Solid fossil fuels	100%
District heat	100%
Biomass	67%
Solar thermal	0%
Ambient heat	45%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Table 177 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)

End uses	Low-income HH (kWh/HH)
Total	4184
Space heating	981
Space cooling	28
DHW	908
Cooking	1454
Other	813

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in the Step 2.

Table 178 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	4184
Electricity	1750
Natural gas	559
Oil	648
Solid fossil fuels	0
District heat	0
Biomass	692
Solar thermal	162
Ambient heat	372

Step 5: Identification of utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying consumed energy carriers.

Number of low-income households (dwellings): **263,033**

Table 179 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	460	42	7	11	187	214
Heating oil	21	13		8		
LPG	150	4		80	67	
Natural gas	147	5		91	52	
Solar thermal	43	3		39		
Biomass	182	94		11	78	
Ambient heat	98	98				
District heating	0	0		0		

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Coal and other	0	0		0	0	
Total	1.100	258	7	239	383	214

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **-13%** assuming the following prices:

Table 180 Utilised energy prices in Portugal

Energy carrier	Energy price (€/MWh)
Heating oil	135
Electricity	240
Natural gas	94
Biomass	91
District heating	50
Solar thermal	0
LPG	156
Coal and other	30

5.7.2 Modelling the impacts of the examined policies in Portugal

Elasticities of demand

Electricity: -0.616 and heating: -0.353.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 181 Energy prices in the baseline scenario for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	180	203	225	248	270
Natural gas	94	122	150	179	207	216	226
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	241	242	242
LPG	156	182	207	233	259	285	311

Final energy consumption (GWh)

Table 182 Final energy consumption in baseline scenario in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	12	11	11	10	10
Natural gas	5	4	4	4	3	3	3
LPG	4	3	3	3	3	3	3
Biomass	94	94	94	94	94	94	94
Ambient heat	98	98	98	98	98	98	97
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	42	42	42	42	41
Coal and other	0	0	0	0	0	0	0
Total	258	257	255	254	253	253	252
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	11	11	11	11	11	11	11
Natural gas	91	81	75	70	66	65	64
Heating oil	8	7	7	7	6	6	6

District heating	0	0	0	0	0	0	0
LPG	80	75	71	68	65	63	61
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39
Total	239	224	213	205	198	195	191
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	21	19	18	18	17	16	16
Natural gas	95	85	78	73	69	68	67
LPG	83	78	74	71	68	66	64
Biomass	105	105	105	105	105	105	105
Ambient heat	98	98	98	98	98	98	97
Solar thermal	43	43	43	43	43	43	43
District heating	0	0	0	0	0	0	0
Electricity	60	60	60	60	60	60	60
Coal and other	0	0	0	0	0	0	0
Total	504	488	476	467	459	455	451

Total energy costs (million €)

Table 183 Total energy costs in baseline scenario in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	3	4	4	4	4
Natural gas	9	10	12	13	14	15	15
LPG	13	14	15	17	18	19	20
Biomass	10	10	10	10	10	10	10
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	14	14	14	14	14
Coal and other	0	0	0	0	0	0	0
Total	49	52	54	57	60	62	63

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 184 Energy prices in the Scenario 1 for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	225	289	307	344	382
Natural gas	94	122	185	245	270	290	311
Solid fossil fuels	30	33	98	155	152	173	195
Electricity	240	240	240	241	241	242	242
LPG	156	182	253	320	342	382	423

Final energy consumption (GWh)

Table 185 Final energy consumption in Scenario 1 in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	10	9	9	8	7
Natural gas	5	4	3	3	3	3	2
LPG	4	3	3	3	2	2	2
Biomass	94	94	94	94	94	94	94
Ambient heat	98	98	98	98	98	98	97
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	42	42	42	42	41
Coal and other	0	0	0	0	0	0	0
Total	258	257	253	252	250	249	248
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	11	11	11	11	11	11	11
Natural gas	91	81	66	59	54	51	48
Heating oil	8	7	6	6	5	5	4
District heating	0	0	0	0	0	0	0
LPG	80	75	64	58	54	50	47
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39
Total	239	224	198	184	174	166	160
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	21	19	16	15	14	13	12
Natural gas	95	85	70	62	57	53	50
LPG	83	78	67	61	57	52	49
Biomass	105	105	105	105	105	105	105
Ambient heat	98	98	98	98	98	98	97
Solar thermal	43	43	43	43	43	43	43
District heating	0	0	0	0	0	0	0
Electricity	60	60	60	60	60	60	60
Coal and other	0	0	0	0	0	0	0
Total	504	488	459	443	431	423	416

Total energy costs (million €)

Table 186 Total energy costs in Scenario 1 in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	4	4	5	5	6
Natural gas	9	10	13	15	17	19	21
LPG	13	14	17	20	22	25	27
Biomass	10	10	10	10	10	10	10
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	14	14	14	14	14
Coal and other	0	0	0	0	0	0	0
Total	49	52	58	63	68	73	78

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 187 Energy prices in the Scenario 2 for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	180	203	225	248	270
Natural gas	94	122	150	179	207	216	226
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	241	242	242
LPG	156	182	207	233	259	285	311

Final energy consumption (GWh)

Table 188 Final energy consumption in Scenario 2 in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	12	0	0	0	0
Natural gas	5	4	4	4	3	0	0
LPG	4	3	3	3	3	0	0
Biomass	94	94	94	94	94	94	94
Ambient heat	98	98	98	103	103	107	106
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	42	44	44	45	45
Coal and other	0	0	0	0	0	0	0
Total	258	257	255	251	251	249	249
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	7	7	7	7
Total	7	7	7	7	7	7	7
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	11	11	11	77	77	192	192
Natural gas	91	81	75	70	66	0	0
Heating oil	8	7	7	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	80	75	71	68	65	0	0
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39

Total	239	224	213	265	258	242	242
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	21	19	18	0	0	0	0
Natural gas	95	85	78	73	69	0	0
LPG	83	78	74	71	68	0	0
Biomass	105	105	105	105	105	105	105
Ambient heat	98	98	98	103	103	107	106
Solar thermal	43	43	43	43	43	43	43
District heating	0	0	0	0	0	0	0
Electricity	60	60	60	129	128	245	244
Coal and other	0	0	0	0	0	0	0
Total	504	488	476	523	516	498	498

Total energy costs (million €)

Table 189 Total energy costs in Scenario 2 in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	3	0	0	0	0
Natural gas	9	10	12	13	14	0	0
LPG	13	14	15	17	18	0	0
Biomass	10	10	10	10	10	10	10
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	14	31	31	59	59
Coal and other	0	0	0	0	0	0	0
Total	49	52	54	70	72	69	69

Table 190 Investments foreseen in Scenario 2 in Portugal

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	91	0	52	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (99 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (99 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 191 Energy prices in the Scenario 3 for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	180	203	225	248	270
Natural gas	94	122	150	179	207	216	226
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	241	242	242
LPG	156	182	207	233	259	285	311

Final energy consumption (GWh)

Table 192 Final energy consumption in Scenario 3 in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	10	9	8	7	7
Natural gas	5	4	3	3	2	2	2
LPG	4	3	3	2	2	2	2
Biomass	94	94	83	74	68	68	68
Ambient heat	98	98	87	77	71	71	71
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	37	33	30	30	30
Coal and other	0	0	0	0	0	0	0
Total	258	257	227	200	185	184	184
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	7	7	7	6	5	5	5
Total	7	7	7	6	5	5	5
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	11	11	11	11	11	11	11
Natural gas	91	81	75	70	66	65	64
Heating oil	8	7	7	7	6	6	6
District heating	0	0	0	0	0	0	0

LPG	80	75	71	68	65	63	61
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39
Total	239	224	213	205	198	195	191
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	21	19	17	15	14	14	13
Natural gas	95	85	78	72	68	67	66
LPG	83	78	74	70	67	65	63
Biomass	105	105	94	85	79	79	79
Ambient heat	98	98	87	77	71	71	71
Solar thermal	43	43	42	42	42	42	42
District heating	0	0	0	0	0	0	0
Electricity	60	60	55	50	47	47	47
Coal and other	0	0	0	0	0	0	0
Total	504	488	447	411	388	384	380

Total energy costs (million €)

Table 193 Total energy costs in Scenario 3 in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	3	3	3	3	4
Natural gas	9	10	12	13	14	14	15
LPG	13	14	15	16	17	19	20
Biomass	10	10	9	8	7	7	7
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	13	12	11	11	11
Coal and other	0	0	0	0	0	0	0
Total	49	52	52	52	53	55	57

Table 194 Investments foreseen in Scenario 3 in Portugal

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	986	986	986	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 195 Energy prices in the Scenario 4 for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	180	203	225	248	270
Natural gas	94	122	150	179	207	216	226
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	241	242	242
LPG	156	182	207	233	259	285	311

Final energy consumption (GWh)

Table 196 Final energy consumption in Scenario 4 in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	10	0	0	0	0
Natural gas	5	4	3	3	2	0	0
LPG	4	3	3	2	2	0	0
Biomass	94	94	83	74	68	68	68
Ambient heat	98	98	87	68	62	65	65
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	37	89	82	64	63
Coal and other	0	0	0	0	0	0	0
Total	258	257	227	238	220	199	199
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	6	5	5	5
Total	7	7	7	6	5	5	5
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	11	11	11	77	77	192	192
Natural gas	91	81	75	70	66	0	0
Heating oil	8	7	7	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	80	75	71	68	65	0	0
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39
Total	239	224	213	265	258	242	242
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	21	19	17	0	0	0	0
Natural gas	95	85	78	72	68	0	0

LPG	83	78	74	70	67	0	0
Biomass	105	105	94	85	79	79	79
Ambient heat	98	98	87	68	62	65	65
Solar thermal	43	43	42	42	42	42	42
District heating	0	0	0	0	0	0	0
Electricity	60	60	55	172	164	261	261
Coal and other	0	0	0	0	0	0	0
Total	504	488	447	509	483	447	446

Total energy costs (million €)

Table 197 Total energy costs in Scenario 4 in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	3	0	0	0	0
Natural gas	9	10	12	13	14	0	0
LPG	13	14	15	16	17	0	0
Biomass	10	10	9	8	7	7	7
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	13	41	40	63	63
Coal and other	0	0	0	0	0	0	0
Total	49	52	52	78	78	70	70

Table 198 Investments foreseen in Scenario 4 in Portugal

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	91	0	43	0
Building envelope	0	986	986	986	0	0
Total	0	986	1078	986	43	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 199 Energy prices in the Scenario 5 for Portugal

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	135	158	185	217	248	295	342
Natural gas	94	122	155	189	224	252	281
Solid fossil fuels	30	33	43	57	71	107	142
Electricity	240	240	240	241	241	242	242
LPG	156	182	213	248	282	333	384

Final energy consumption (GWh)

Table 200 Final energy consumption in Scenario 5 in Portugal

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	13	12	10	0	0	0	0
Natural gas	5	4	3	3	2	0	0
LPG	4	3	3	2	2	0	0
Biomass	94	94	83	74	68	68	68
Ambient heat	98	98	87	68	62	65	65
Solar thermal	3	3	3	3	3	3	3
District heating	0	0	0	0	0	0	0
Electricity	42	42	37	89	82	63	63
Coal and other	0	0	0	0	0	0	0
Total	258	257	226	238	219	199	199
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	7	7	7	6	5	5	5
Total	7	7	7	6	5	5	5
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	11	11	11	76	76	183	183
Natural gas	91	81	74	68	63	0	0
Heating oil	8	7	7	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	80	75	70	66	63	0	0
Biomass	11	11	11	11	11	11	11
Coal and other	0	0	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	39	39	39	39	39	39	39
Total	239	224	211	260	252	233	233
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	21	19	17	0	0	0	0

Natural gas	95	85	77	70	66	0	0
LPG	83	78	73	69	65	0	0
Biomass	105	105	94	85	79	79	79
Ambient heat	98	98	87	68	62	65	65
Solar thermal	43	43	42	42	42	42	42
District heating	0	0	0	0	0	0	0
Electricity	60	60	55	170	163	252	251
Coal and other	0	0	0	0	0	0	0
Total	504	488	444	503	477	437	437

Total energy costs (million €)

Table 201 Total energy costs in Scenario 5 in Portugal

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	3	3	3	0	0	0	0
Natural gas	9	10	12	13	15	0	0
LPG	13	14	16	17	18	0	0
Biomass	10	10	9	8	7	7	7
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	14	14	13	41	39	61	61
Coal and other	0	0	0	0	0	0	0
Total	49	52	52	79	80	68	68

Table 202 Investments foreseen in Scenario 5 in Portugal

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	89	0	40	0
Building envelope	0	986	986	986	0	0
Total	0	986	1075	986	40	0

Synopsis

Comparison of final energy consumption

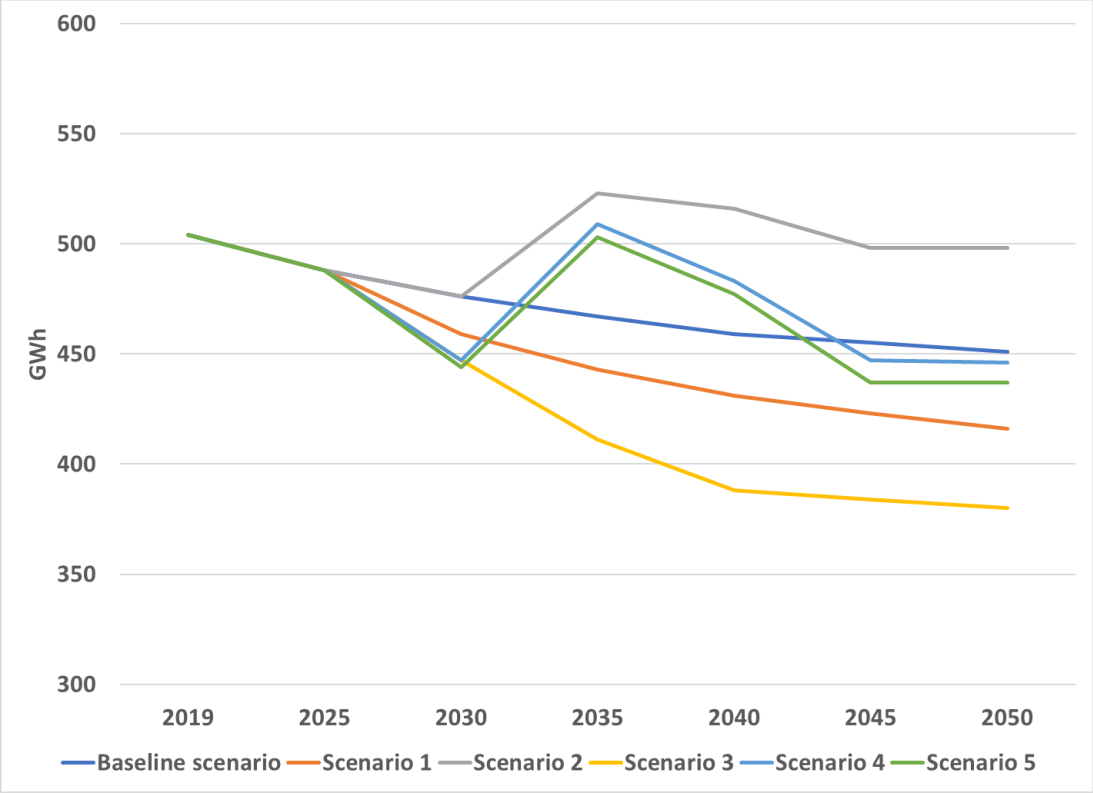

Figure 27 Comparison of final energy consumption between scenarios in Portugal

Comparison of investments in different scenarios

Figure 28 Investments in different scenarios in Portugal

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	91	0	52	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	986	986	986	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	91	0	43	0
	Building envelope	0	986	986	986	0	0
	Total	0	986	1078	986	43	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	89	0	40	0
	Building envelope	0	986	986	986	0	0
	Total	0	986	1075	986	40	0

Comparison of total energy costs

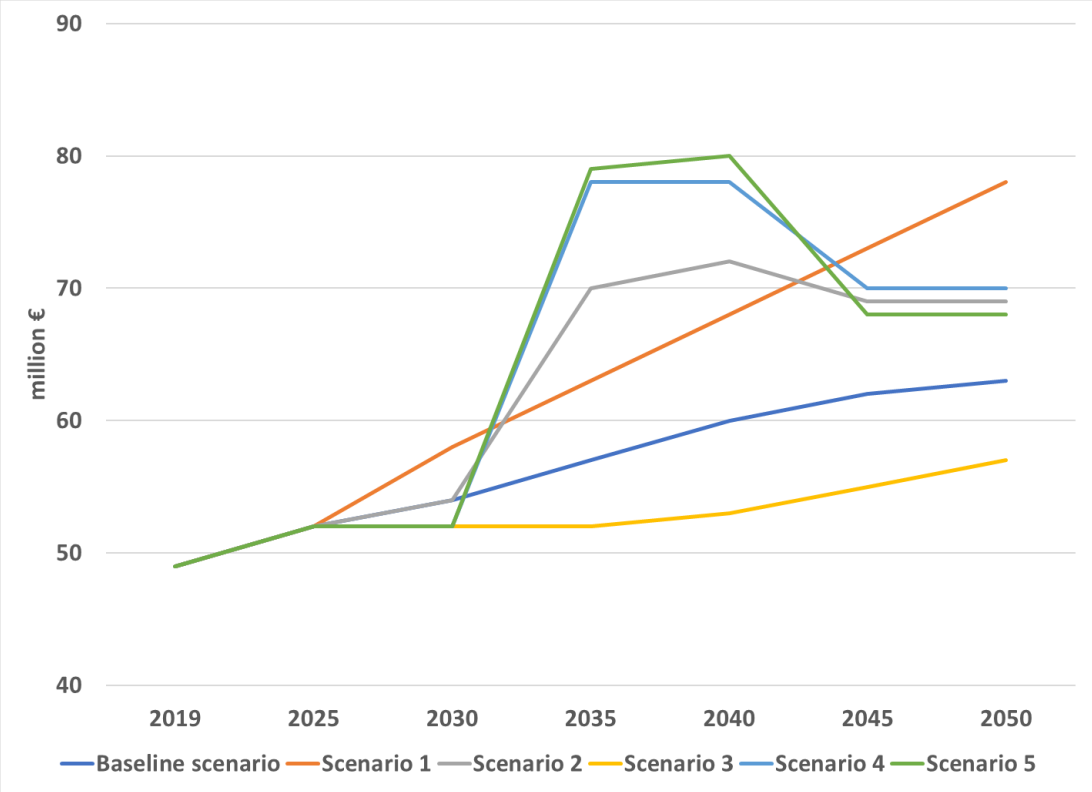

Figure 29 Comparison of final energy costs between scenarios in Portugal

5.8 ROMANIA

5.8.1 Determination of baseline

Step 1: Estimation of the unitary final energy consumption for different end-uses of the average household in Romania according to data on disaggregated final energy consumption of households (*data: Eurostat*).

Table 203 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	11987
Space heating	7460
Space cooling	39
DHW	1639
Cooking	1207
Other	1642

Energy carrier	Average household (kWh/HH)
Total	11987
Electricity	1730
Natural gas	3881
Oil	64
LPG	443
Solid fossil fuels	63
District heat	1091
Solar thermal	0
Ambient heat	0
Biomass	4715

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of the average household (*data: HBS*).

Table 204 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	6%
Natural gas	9%
Oil	7%
LNG	7%
Solid fossil fuels	7%
District heat	7%
Solar thermal	0%
Ambient heat	6%
Biomass	7%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Table 205 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	11074
Space heating	6887
Space cooling	37
DHW	1503
Cooking	1105
Other	1542

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in the Step 2.

Table 206 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	11074
Electricity	1625
Natural gas	3513
Oil	59
LPG	413
Solid fossil fuels	59
District heat	1016
Solar thermal	0
Ambient heat	0
Biomass	4389

Step 5: Identification of the utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying consumed energy carriers.

Number of low-income households (dwellings): **1,125,840**

Table 207 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	1830	16	42	35	1	1736
Heating oil	67	0		14	53	
LPG	465	1		97	367	
Natural gas	3955	2315		899	740	
Solar thermal	0	0		0		

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Ambient heat	0	0				
Biomass	4942	4232		632	78	
District heating	1144	1144		0		
Coal and other	66	46		15	5	
Total	12467	7753	42	1692	1244	1736

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **3%** assuming the following prices:

Table 208 Utilised energy prices in Romania

Energy carrier	Energy price (€/MWh)
Heating oil	80
Electricity	135
Natural gas	40
Biomass	20
District heating	50
Solar thermal	0
LPG	170
Coal and other	10

5.8.2 Modelling the impacts of the examined policies in Romania

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 209 Energy prices in the baseline scenario for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	107	120	133	147	160
Natural gas	40	52	64	76	88	92	96
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	135	135	136	139	142	147	152
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 210 Final energy consumption in baseline scenario in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	2020	1979	1823	1781	1743
LPG	1	1	1	1	0	0	0
Biomass	4232	4232	4232	4232	4232	4232	4232
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	16	73	130	186	183	180	177
Coal and other	46	43	41	40	39	38	37
Total	7753	7418	7187	7009	6850	6804	6761
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	42	41	41	41	40	40	39
Total	42	41	41	41	40	40	39
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	35	35	35	35	34	34	33
Natural gas	899	765	676	613	565	552	540
Heating oil	14	13	12	11	10	10	9

District heating	0	0	0	0	0	0	0
LPG	97	89	82	77	73	69	66
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	14	13	13	13	12
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
Total	1692	1547	1451	1381	1327	1309	1293
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	14	13	12	11	11	10	10
Natural gas	3215	2881	2697	2592	2387	2333	2282
LPG	97	89	83	78	73	70	67
Biomass	4864	4864	4864	4864	4864	4864	4864
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	92	149	206	261	258	253	249
Coal and other	61	58	55	53	52	51	50
Total	9487	9007	8679	8431	8217	8153	8093

Total energy costs (million €)

Table 211 Total energy costs in baseline scenario in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	1	1	1	2
Natural gas	129	150	173	197	210	215	219
LPG	17	18	19	20	21	22	23
Biomass	97	97	97	97	97	97	97
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	38	29	29	29	29
Electricity	12	20	28	36	37	37	38
Coal and other	1	1	1	1	1	1	1
Total	314	335	357	381	396	402	408

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 212 Energy prices in the Scenario 1 for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	151	204	213	240	268
Natural gas	40	52	97	140	149	163	178
Solid fossil fuels	10	11	72	126	121	141	161
Electricity	135	135	136	139	142	147	152
LPG	170	198	271	339	363	405	448

Final energy consumption (GWh)

Table 213 Final energy consumption in Scenario 1 in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	1339	1196	1015	890	801
LPG	1	1	0	0	0	0	0
Biomass	4232	4232	4232	4232	4232	4232	4232
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	16	73	130	186	183	180	177
Coal and other	46	43	0	0	0	0	0
Total	7753	7418	6464	6186	6003	5874	5782
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	42	41	41	41	40	40	39
Total	42	41	41	41	40	40	39
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	35	35	35	35	34	34	33
Natural gas	899	765	430	337	286	250	226
Heating oil	14	13	9	7	6	5	5
District heating	0	0	0	0	0	0	0
LPG	97	89	72	63	57	51	47
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
Total	1692	1547	1179	1074	1015	973	942
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**

Heating oil	14	13	9	7	6	6	5
Natural gas	3215	2881	1770	1533	1301	1140	1027
LPG	97	89	73	64	57	52	47
Biomass	4864	4864	4864	4864	4864	4864	4864
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	92	149	206	261	258	253	249
Coal and other	61	58	0	0	0	0	0
Total	9487	9007	7684	7301	7059	6886	6764

Total energy costs (million €)

Table 214 Total energy costs in Scenario 1 in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	1	2	2	2
Natural gas	129	150	172	214	237	259	280
LPG	17	18	20	22	23	25	27
Biomass	97	97	97	97	97	97	97
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	38	29	29	29	29
Electricity	12	20	28	36	37	37	38
Coal and other	1	1	0	0	0	0	0
Total	314	335	357	400	425	449	472

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 215 Energy prices in the Scenario 2 for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	107	120	133	147	160
Natural gas	40	52	64	76	88	92	96
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	135	135	136	139	142	147	152
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 216 Final energy consumption in Scenario 2 in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	2020	1979	1823	0	0
LPG	1	1	1	1	0	0	0
Biomass	4232	4232	4232	4232	4232	4232	4232
Ambient heat	0	0	0	8	8	1017	999
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	16	73	130	189	186	584	573
Coal and other	46	43	41	0	0	0	0
Total	7753	7418	7187	6980	6821	6405	6376
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	42	41	41	41	40	40	39
Total	42	41	41	41	40	40	39
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	35	35	35	117	115	672	660
Natural gas	899	765	676	613	565	0	0
Heating oil	14	13	12	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	97	89	82	77	73	0	0
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	14	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0

Total	1692	1547	1451	1439	1385	1304	1292
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Heating oil	14	13	12	0	0	0	0
Natural gas	3215	2881	2697	2592	2387	0	0
LPG	97	89	83	78	73	0	0
Biomass	4864	4864	4864	4864	4864	4864	4864
Ambient heat	0	0	0	8	8	1017	999
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	762	572	572	572	572
Electricity	92	149	206	346	342	1296	1273
Coal and other	61	58	55	0	0	0	0
Total	9487	9007	8679	8460	8246	7749	7708

Total energy costs (million €)

Table 217 Total energy costs in Scenario 2 in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	0	0	0	0
Natural gas	129	150	173	197	210	0	0
LPG	17	18	19	20	21	0	0
Biomass	97	97	97	97	97	97	97
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	38	29	29	29	29
Electricity	12	20	28	48	49	190	193
Coal and other	1	1	1	0	0	0	0
Total	314	335	357	391	405	316	319

Table 218 Investments foreseen in Scenario 2 in Romania

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	52	0	2368	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (422 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (422 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 219 Energy prices in the Scenario 3 for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	107	120	133	147	160
Natural gas	40	52	64	76	88	92	96
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	135	135	136	139	142	147	152
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 220 Final energy consumption in Scenario 3 in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	1876	1685	1462	1429	1398
LPG	1	1	0	0	0	0	0
Biomass	4232	4232	3756	3334	3084	3084	3084
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	16	73	147	197	190	187	183
Coal and other	46	43	37	32	28	28	27
Total	7753	7418	6494	5698	5181	5144	5109
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	42	41	37	32	29	29	28
Total	42	41	37	32	29	29	28
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	35	35	35	35	34	34	33
Natural gas	899	765	676	613	565	552	540
Heating oil	14	13	12	11	10	10	9
District heating	0	0	0	0	0	0	0

LPG	97	89	82	77	73	69	66
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	14	13	13	13	12
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
Total	1692	1547	1451	1381	1327	1309	1293
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Heating oil	14	13	12	11	10	10	10
Natural gas	3215	2881	2553	2298	2027	1980	1937
LPG	97	89	83	78	73	70	66
Biomass	4864	4864	4388	3966	3716	3716	3716
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	92	149	219	264	254	249	245
Coal and other	61	58	50	45	41	40	39
Total	9487	9007	7982	7112	6538	6482	6430

Total energy costs (million €)

Table 221 Total energy costs in Scenario 3 in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	1	1	1	2
Natural gas	129	150	163	175	178	182	186
LPG	17	18	19	20	21	22	23
Biomass	97	97	88	79	74	74	74
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	34	23	21	21	21
Electricity	12	20	30	37	36	37	37
Coal and other	1	1	1	1	1	1	1
Total	314	335	335	335	332	338	343

Table 222 Investments foreseen in Scenario 3 in Romania

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	4222	4222	4222	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 223 Energy prices in the Scenario 4 for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	107	120	133	147	160
Natural gas	40	52	64	76	88	92	96
Solid fossil fuels	10	11	12	13	13	14	15
Electricity	135	135	136	139	142	147	152
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 224 Final energy consumption in Scenario 4 in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	1876	1685	1462	0	0
LPG	1	1	0	0	0	0	0
Biomass	4232	4232	3756	3334	3084	3084	3084
Ambient heat	0	0	0	5	5	814	800
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	16	73	147	74	78	362	355
Coal and other	46	43	37	0	0	0	0
Total	7753	7418	6494	5549	5045	4676	4655
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	42	41	37	32	29	29	28
Total	42	41	37	32	29	29	28
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	35	35	35	117	115	672	660
Natural gas	899	765	676	613	565	0	0
Heating oil	14	13	12	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	97	89	82	77	73	0	0
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	14	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
Total	1692	1547	1451	1439	1385	1304	1292
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	14	13	12	0	0	0	0
Natural gas	3215	2881	2553	2298	2027	0	0

LPG	97	89	83	78	73	0	0
Biomass	4864	4864	4388	3966	3716	3716	3716
Ambient heat	0	0	0	5	5	814	800
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	92	149	219	224	223	1063	1044
Coal and other	61	58	50	0	0	0	0
Total	9487	9007	7982	7020	6460	6009	5976

Total energy costs (million €)

Table 225 Total energy costs in Scenario 4 in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	0	0	0	0
Natural gas	129	150	163	175	178	0	0
LPG	17	18	19	20	21	0	0
Biomass	97	97	88	79	74	74	74
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	34	23	21	21	21
Electricity	12	20	30	31	32	156	158
Coal and other	1	1	1	0	0	0	0
Total	314	335	335	327	326	251	254

Table 226 Investments foreseen in Scenario 4 in Romania

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	51	0	2569	0
Building envelope	0	4222	4222	4222	0	0
Total	0	4222	4273	4222	2569	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 227 Energy prices in the Scenario 5 for Romania

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	80	93	112	134	155	193	230
Natural gas	40	52	68	86	105	127	149
Solid fossil fuels	10	11	19	31	43	76	110
Electricity	135	135	136	139	142	147	152
LPG	170	198	232	269	305	358	410

Final energy consumption (GWh)

Table 228 Final energy consumption in Scenario 5 in Romania

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	2315	2116	1804	1560	1316	0	0
LPG	1	1	0	0	0	0	0
Biomass	4232	4232	3756	3334	3084	3084	3084
Ambient heat	0	0	0	2	2	669	657
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	16	73	147	71	75	296	291
Coal and other	46	43	24	0	0	0	0
Total	7753	7418	6409	5418	4893	4465	4448
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	42	41	37	32	29	29	28
Total	42	41	37	32	29	29	28
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	35	35	35	112	111	568	558
Natural gas	899	765	647	559	500	0	0
Heating oil	14	13	11	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	97	89	81	75	70	0	0
Biomass	632	632	632	632	632	632	632
Coal and other	15	14	9	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
Total	1692	1547	1416	1378	1312	1200	1190
Space heating, cooling and DHW	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**

Heating oil	14	13	12	0	0	0	0
Natural gas	3215	2881	2451	2119	1815	0	0
LPG	97	89	82	75	70	0	0
Biomass	4864	4864	4388	3966	3716	3716	3716
Ambient heat	0	0	0	2	2	669	657
Solar thermal	0	0	0	0	0	0	0
District heating	1144	953	677	450	417	417	417
Electricity	92	149	219	215	215	893	877
Coal and other	61	58	33	0	0	0	0
Total	9487	9007	7861	6828	6234	5694	5666

Total energy costs (million €)

Table 229 Total energy costs in Scenario 5 in Romania

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1	1	1	0	0	0	0
Natural gas	129	150	167	183	190	0	0
LPG	17	18	19	20	21	0	0
Biomass	97	97	88	79	74	74	74
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	57	48	34	23	21	21	21
Electricity	12	20	30	30	31	131	133
Coal and other	1	1	1	0	0	0	0
Total	314	335	339	335	337	226	228

Table 230 Investments foreseen in Scenario 5 in Romania

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	24	0	2229	0
Building envelope	0	4222	4222	4222	0	0
Total	0	4222	4246	4222	2229	0

Synopsis

Comparison of final energy consumption

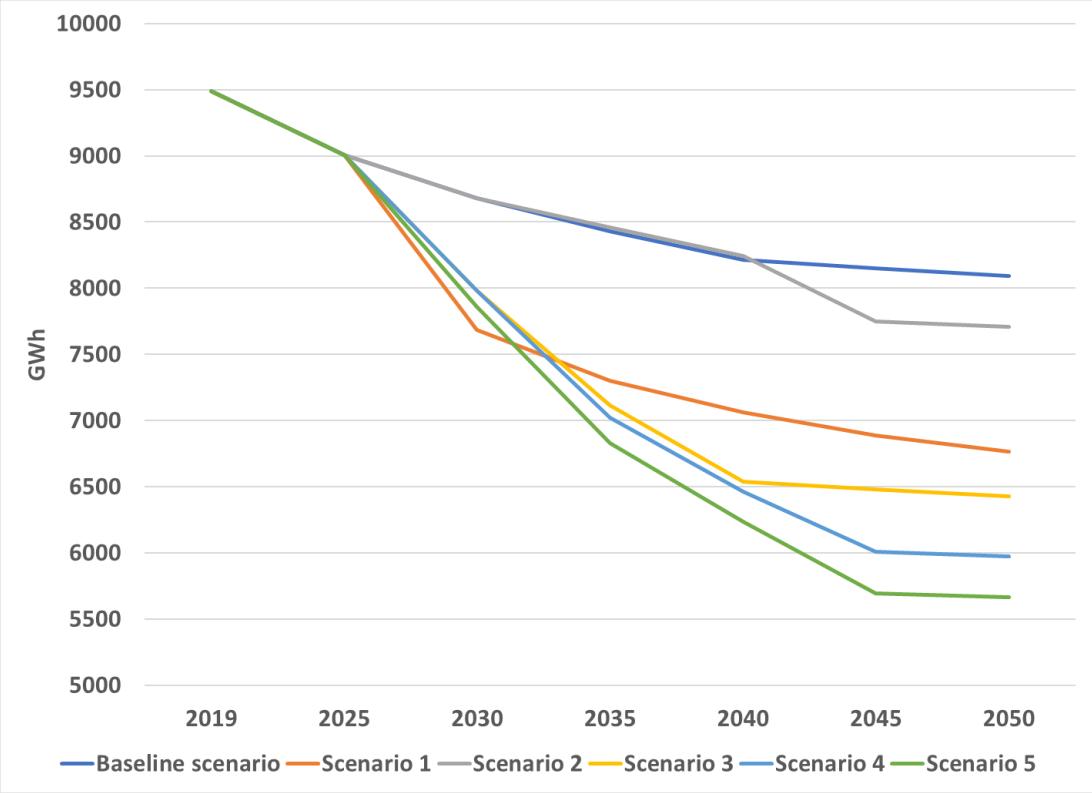

Figure 30 Comparison of final energy consumption between scenarios in Romania

Comparison of investments in different scenarios

Figure 31 Investments in different scenarios in Romania

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	52	0	2368	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	4222	4222	4222	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	51	0	2569	0
	Building envelope	0	4222	4222	4222	0	0
	Total	0	4222	4273	4222	2569	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	24	0	2229	0
	Building envelope	0	4222	4222	4222	0	0
	Total	0	4222	4246	4222	2229	0

Comparison of total energy costs

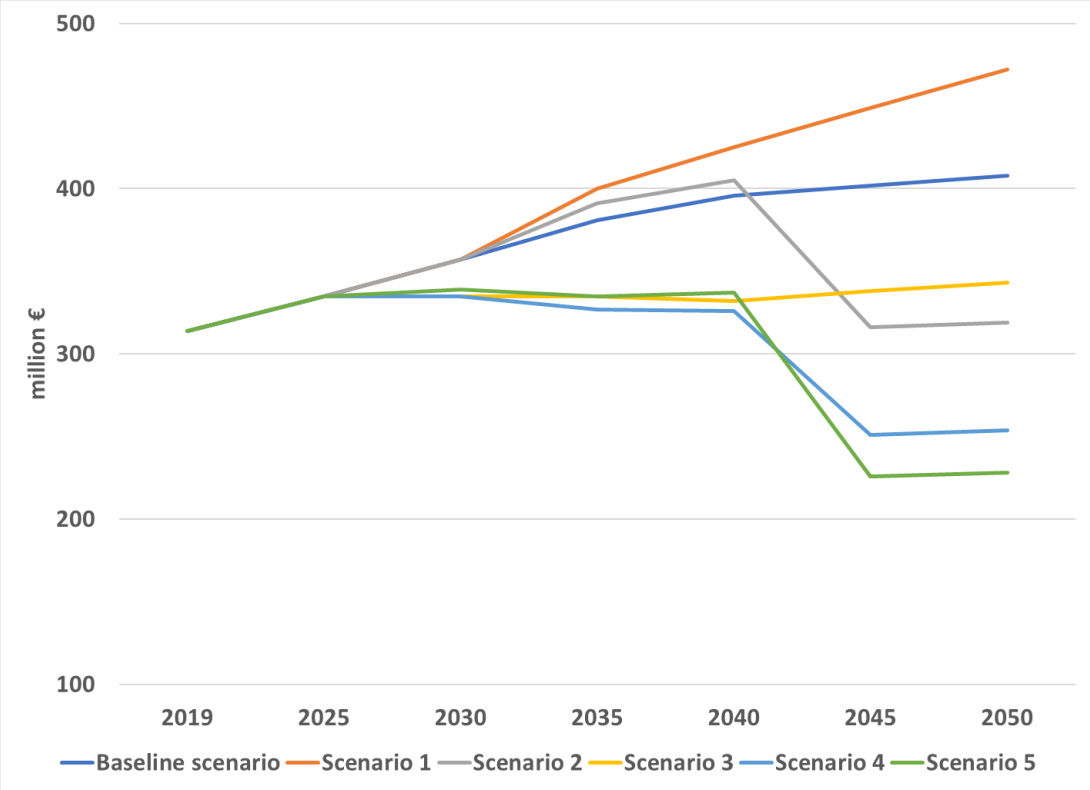

Figure 32 Comparison of final energy costs between scenarios in Romania

5.9 SLOVAKIA

5.9.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Slovakia according to data about disaggregated final energy consumption of households (*data: Eurostat*).

Table 231 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	16212
Space heating	11803
Space cooling	20
DHW	2037
Cooking	700
Other	1652

Energy carrier	Average household (kWh/HH)
Total	16212
Electricity	2877
Natural gas	6873
LPG	47
Solid fossil fuels	164
District heat	2479
Solar thermal	42
Ambient heat	172
Biomass	3559

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of the average household (*data: HBS*).

Table 232 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	28%
Natural gas	28%
Oil	28%
LNG	28%
Solid fossil fuels	28%
District heat	28%
Solar thermal	100%
Ambient heat	28%
Biomass	28%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Table 233 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	11715

End uses	Low-income HH (kWh/HH)
Space heating	8529
Space cooling	14
DHW	1472
Cooking	506
Other	1194

Step 4: Calculation of unitary final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in the Step 2.

Table 234 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	11715
Electricity	2079
Natural gas	4966
LPG	34
Solid fossil fuels	119
District heat	1791
Solar thermal	30
Ambient heat	124
Biomass	2571

Step 5: Identification of utilised means of heating and cooking for the case of households, which belong to the lowest income decile (*data: HBS*).

No change

Step 6: Modelling each different end-use separately for quantifying consumed energy carriers.

Number of low-income households (dwellings): **379,060**

Table 235 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	788	178	5	104	49	452
Heating oil	0	0		0		
LPG	13	8		4	2	
Natural gas	1882	1520		230	132	
Solar thermal	11	1		10		1
Ambient heat	47	47				
Biomass	975	891		81	3	
District heating	679	561		118		
Coal and other	45	27		12	6	

Total	4441	3233	5	558	192	453

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **-55%** assuming the following prices:

Table 236 Validation numbers

Energy carrier	Energy price (€/MWh)
Heating oil	100
Electricity	185
Natural gas	45
Biomass	40
District heating	80
Solar thermal	0
LPG	170
Coal and other	30

5.9.2 Modelling the impacts of the examined policies in Slovakia

Elasticities of demand

Electricity: -0.55 and heating: -0.50.

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 237 Energy prices in the baseline scenario for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	185	185	185	188	190	194	197
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 238 Final energy consumption in baseline scenario in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	1143	1036	954	932	912
LPG	8	7	6	6	6	5	5
Biomass	891	891	891	891	891	891	891
Ambient heat	47	47	47	47	46	46	46
Solar thermal	1	1	1	1	1	1	1
District heating	561	561	561	561	561	561	561
Electricity	178	178	178	177	175	174	172
Coal and other	27	26	25	24	23	23	22
Total	3233	3003	2852	2742	2658	2633	2610
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	5	5	5	5	5	5	5
Total	5	5	5	5	5	5	5
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	104	104	104	103	102	101	100
Natural gas	230	196	173	157	144	141	138
Heating oil	0	0	0	0	0	0	0

District heating	118	118	118	118	118	118	118
LPG	4	3	3	3	3	3	2
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	10	10	10	10	9
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10
Total	558	522	499	482	468	464	459
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1750	1488	1316	1193	1098	1073	1050
LPG	11	10	9	9	8	8	8
Biomass	972	972	972	972	972	972	972
Ambient heat	47	47	47	47	46	46	46
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	679	679	679	679	679
Electricity	287	287	287	285	283	280	278
Coal and other	39	37	35	34	33	33	32
Total	3796	3531	3356	3229	3131	3102	3074

Total energy costs (million €)

Table 239 Total energy costs in baseline scenario in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	95	102	109	111	113
LPG	2	2	2	2	2	2	3
Biomass	39	39	39	39	39	39	39
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	54	54	54	54	54
Electricity	53	53	53	54	54	54	55
Coal and other	1	1	1	1	1	1	1
Total	228	237	245	252	259	262	265

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 240 Energy prices in the Scenario 1 for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	178	234	247	278	309
Natural gas	45	59	106	150	160	176	191
Solid fossil fuels	30	33	96	153	149	170	192
Electricity	185	185	185	188	190	194	197
LPG	170	198	271	339	364	406	449

Final energy consumption (GWh)

Table 241 Final energy consumption in Scenario 1 in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	770	610	520	458	414
LPG	8	7	6	5	4	4	4
Biomass	891	891	891	891	891	891	891
Ambient heat	47	47	47	47	46	46	46
Solar thermal	1	1	1	1	1	1	1
District heating	561	561	561	561	561	561	561
Electricity	178	178	178	177	175	174	172
Coal and other	27	26	1	1	1	1	0
Total	3233	3003	2455	2292	2200	2135	2089
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	5	5	5	5	5	5	5
Total	5	5	5	5	5	5	5
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	104	104	104	103	102	101	100
Natural gas	230	196	117	92	79	69	63
Heating oil	0	0	0	0	0	0	0
District heating	118	118	118	118	118	118	118
LPG	4	3	3	2	2	2	2
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	0	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10
Total	558	522	432	407	392	382	374
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	0	0	0	0	0	0	0
Natural gas	1750	1488	887	702	599	528	477
LPG	11	10	8	7	7	6	5
Biomass	972	972	972	972	972	972	972
Ambient heat	47	47	47	47	46	46	46
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	679	679	679	679	679
Electricity	287	287	287	285	283	280	278
Coal and other	39	37	2	1	1	1	1
Total	3796	3531	2893	2704	2597	2522	2468

Total energy costs (million €)

Table 242 Total energy costs in Scenario 1 in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	94	105	116	127	136
LPG	2	2	2	2	3	3	3
Biomass	39	39	39	39	39	39	39
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	54	54	54	54	54
Electricity	53	53	53	54	54	54	55
Coal and other	1	1	0	0	0	0	0
Total	228	237	243	255	266	277	288

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 243 Energy prices in the Scenario 2 for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	185	185	185	188	190	194	197
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 244 Final energy consumption in Scenario 2 in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	1143	1036	954	0	0
LPG	8	7	6	6	6	0	0
Biomass	891	891	891	891	891	891	891
Ambient heat	47	47	47	51	51	582	576
Solar thermal	1	1	1	1	1	1	1
District heating	561	561	561	561	561	561	561
Electricity	178	178	178	178	177	387	383
Coal and other	27	26	25	0	0	0	0
Total	3233	3003	2852	2724	2641	2421	2412
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	5	5	5	5	5	5	5
Total	5	5	5	5	5	5	5
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	104	104	104	108	108	236	234
Natural gas	230	196	173	157	144	0	0
Heating oil	0	0	0	0	0	0	0
District heating	118	118	118	118	118	118	118
LPG	4	3	3	3	3	0	0
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	10	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10

Total	558	522	499	477	464	445	443
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1750	1488	1316	1193	1098	0	0
LPG	11	10	9	9	8	0	0
Biomass	972	972	972	972	972	972	972
Ambient heat	47	47	47	51	51	582	576
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	679	679	679	679	679
Electricity	287	287	287	292	290	628	622
Coal and other	39	37	35	0	0	0	0
Total	3796	3531	3356	3207	3110	2871	2860

Total energy costs (million €)

Table 245 Total energy costs in Scenario 2 in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	95	102	109	0	0
LPG	2	2	2	2	2	0	0
Biomass	39	39	39	39	39	39	39
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	54	54	54	54	54
Electricity	53	53	53	55	55	122	122
Coal and other	1	1	1	0	0	0	0
Total	228	237	245	252	260	215	216

Table 246 Investments foreseen in Scenario 2 in Slovakia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	27	0	1087	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (334 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (334 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 247 Energy prices in the Scenario 3 for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	185	185	185	188	190	194	197
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 248 Final energy consumption in Scenario 3 in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	1014	816	695	679	664
LPG	8	7	6	5	4	4	4
Biomass	891	891	791	702	649	649	649
Ambient heat	47	47	42	37	34	34	33
Solar thermal	1	1	0	0	0	0	0
District heating	561	561	498	442	409	409	409
Electricity	178	178	158	139	128	127	125
Coal and other	27	26	22	19	17	17	16
Total	3233	3003	2531	2160	1936	1918	1902
Space cooling	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	5	5	5	4	4	4	4
Total	5	5	5	4	4	4	4
Domestic hot water (DWH)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Electricity	104	104	104	103	102	101	100
Natural gas	230	196	173	157	144	141	138
Heating oil	0	0	0	0	0	0	0
District heating	118	118	118	118	118	118	118

LPG	4	3	3	3	3	3	2
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	10	10	10	10	9
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10
Total	558	522	499	482	468	464	459
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1750	1488	1187	973	839	820	803
LPG	11	10	9	8	7	6	6
Biomass	972	972	872	783	730	730	730
Ambient heat	47	47	42	37	34	34	33
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	616	560	527	527	527
Electricity	287	287	266	246	234	232	229
Coal and other	39	37	33	29	27	26	26
Total	3796	3531	3035	2646	2408	2386	2365

Total energy costs (million €)

Table 249 Total energy costs in Scenario 3 in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	85	83	83	85	87
LPG	2	2	2	2	2	2	2
Biomass	39	39	35	31	29	29	29
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	49	45	42	42	42
Electricity	53	53	49	46	45	45	45
Coal and other	1	1	1	1	1	1	1
Total	228	237	222	209	202	204	206

Table 250 Investments foreseen in Scenario 3 in Slovakia

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	1421	1421	1421	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 251 Energy prices in the Scenario 4 for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	133	150	167	183	200
Natural gas	45	59	72	86	99	104	108
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	185	185	185	188	190	194	197
LPG	170	198	227	255	283	312	340

Final energy consumption (GWh)

Table 252 Final energy consumption in Scenario 4 in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	1014	816	695	0	0
LPG	8	7	6	5	4	0	0
Biomass	891	891	791	702	649	649	649
Ambient heat	47	47	42	34	31	418	414
Solar thermal	1	1	0	0	0	0	0
District heating	561	561	498	442	409	409	409
Electricity	178	178	158	45	42	201	200
Coal and other	27	26	22	0	0	0	0
Total	3233	3003	2531	2044	1830	1678	1672
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	5	5	5	4	4	4	4
Total	5	5	5	4	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	104	104	104	108	108	236	234
Natural gas	230	196	173	157	144	0	0
Heating oil	0	0	0	0	0	0	0
District heating	118	118	118	118	118	118	118
LPG	4	3	3	3	3	0	0
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	10	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10
Total	558	522	499	477	464	445	443
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1750	1488	1187	973	839	0	0

LPG	11	10	9	8	7	0	0
Biomass	972	972	872	783	730	730	730
Ambient heat	47	47	42	34	31	418	414
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	616	560	527	527	527
Electricity	287	287	266	158	153	441	437
Coal and other	39	37	33	0	0	0	0
Total	3796	3531	3035	2525	2298	2126	2118

Total energy costs (million €)

Table 253 Total energy costs in Scenario 4 in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	85	83	83	0	0
LPG	2	2	2	2	2	0	0
Biomass	39	39	35	31	29	29	29
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	49	45	42	42	42
Electricity	53	53	49	30	29	85	86
Coal and other	1	1	1	0	0	0	0
Total	228	237	222	191	186	157	157

Table 254 Investments foreseen in Scenario 4 in Slovakia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	27	0	1142	0
Building envelope	0	1421	1421	1421	0	0
Total	0	1421	1448	1421	1142	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 255 Energy prices in the Scenario 5 for Slovakia

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	100	117	139	164	189	230	271
Natural gas	45	59	76	96	116	139	162
Solid fossil fuels	30	33	43	57	70	105	140
Electricity	185	185	185	188	190	194	197
LPG	170	198	232	269	306	358	411

Final energy consumption (GWh)

Table 256 Final energy consumption in Scenario 5 in Slovakia

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	1520	1292	975	751	623	0	0
LPG	8	7	6	5	4	0	0
Biomass	891	891	791	702	649	649	649
Ambient heat	47	47	42	33	30	350	347
Solar thermal	1	1	0	0	0	0	0
District heating	561	561	498	442	409	409	409
Electricity	178	178	158	45	41	171	170
Coal and other	27	26	20	0	0	0	0
Total	3233	3003	2489	1978	1756	1580	1575
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	5	5	5	4	4	4	4
Total	5	5	5	4	4	4	4
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	104	104	104	108	107	213	211
Natural gas	230	196	166	144	129	0	0
Heating oil	0	0	0	0	0	0	0
District heating	118	118	118	118	118	118	118
LPG	4	3	3	3	3	0	0
Biomass	81	81	81	81	81	81	81
Coal and other	12	11	9	0	0	0	0
Ambient heat	0	0	0	0	0	0	0
Solar thermal	10	10	10	10	10	10	10
Total	558	522	491	464	448	422	420
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0

Natural gas	1750	1488	1141	896	752	0	0
LPG	11	10	9	7	6	0	0
Biomass	972	972	872	783	730	730	730
Ambient heat	47	47	42	33	30	350	347
Solar thermal	11	11	11	11	11	11	11
District heating	679	679	616	560	527	527	527
Electricity	287	287	266	156	152	388	384
Coal and other	39	37	29	0	0	0	0
Total	3796	3531	2985	2446	2208	2005	1999

Total energy costs (million €)

Table 257 Total energy costs in Scenario 5 in Slovakia

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	0	0	0	0	0	0	0
Natural gas	79	87	87	86	87	0	0
LPG	2	2	2	2	2	0	0
Biomass	39	39	35	31	29	29	29
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	54	54	49	45	42	42	42
Electricity	53	53	49	29	29	75	76
Coal and other	1	1	1	0	0	0	0
Total	228	237	224	193	189	146	147

Table 258 Investments foreseen in Scenario 5 in Slovakia

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	21	0	1011	0
Building envelope	0	1421	1421	1421	0	0
Total	0	1421	1443	1421	1011	0

Synopsis

Comparison of final energy consumption

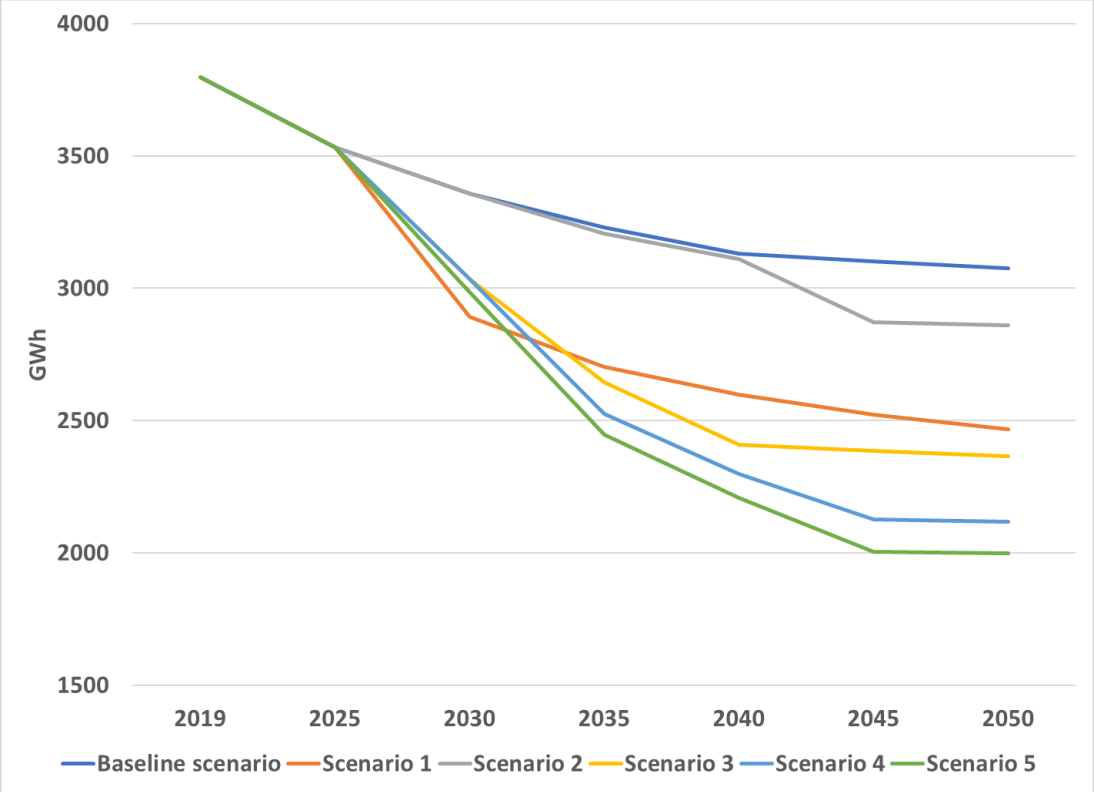

Figure 33 Comparison of final energy consumption between scenarios in Slovakia

Comparison of investments in different scenarios

Figure 34 Investments in different scenarios in Slovakia

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	27	0	1087	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	1421	1421	1421	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	27	0	1142	0
	Building envelope	0	1421	1421	1421	0	0
	Total	0	1421	1448	1421	1142	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	21	0	1011	0
	Building envelope	0	1421	1421	1421	0	0
	Total	0	1421	1443	1421	1011	0

Comparison of total energy costs

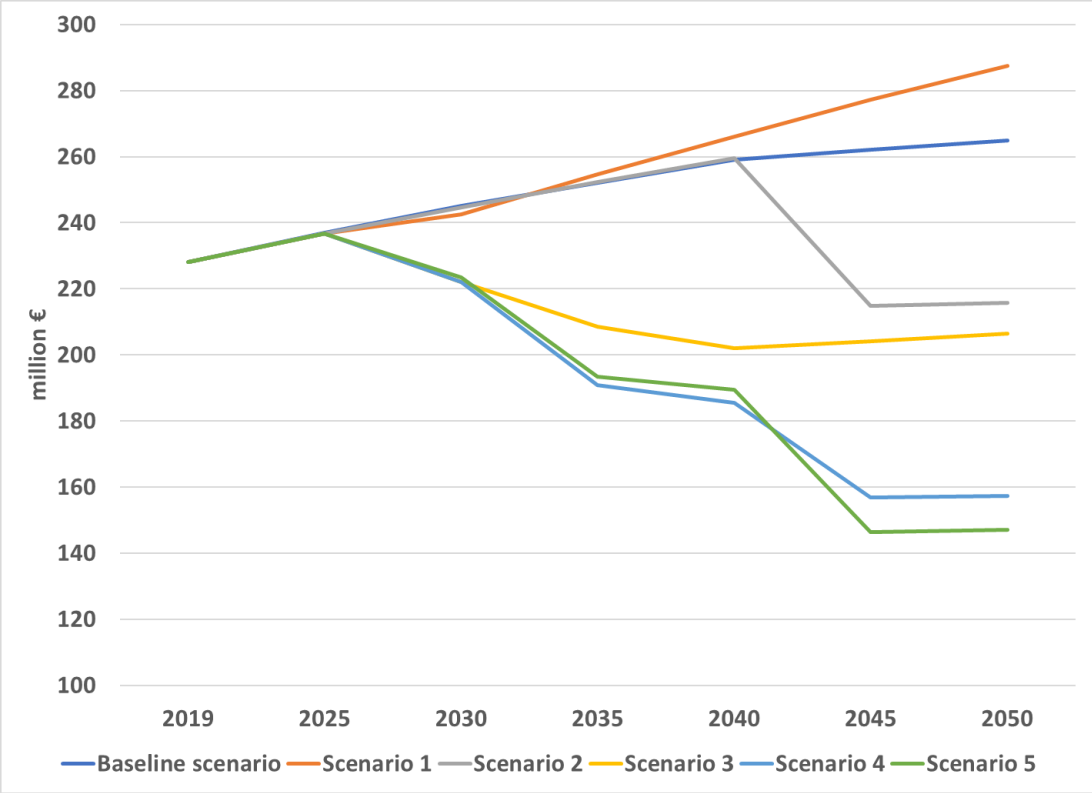

Figure 35 Comparison of final energy costs between scenarios in Slovakia

5.10 SPAIN

5.10.1 Determination of baseline

Step 1: Estimation of unitary final energy consumption for different end-uses of the average household in Spain according to data about disaggregated final energy consumption of households (*data: Eurostat*).

Table 259 Energy consumption in average household

End uses	Average household (kWh/HH)
Total	9145
Space heating	3851
Space cooling	91
DHW	1641
Cooking	688
Other	2874

Energy carrier	Average household (kWh/HH)
Total	9145
Electricity	3903
Natural gas	1872
Oil	932
LNG	560
Solid fossil fuels	40
District heat	0
Solar thermal	172
Ambient heat	98
Biomass	1568

Step 2: Calculation of reduced energy expenses of households, which belong to the lowest income decile compared with energy expenses of average households (*data: HBS*).

Table 260 Comparison of expenses between average and low-income household

Energy carrier	Reduction
Electricity	21%
Natural gas	59%
Oil	58%
LNG	-73%
Solid fossil fuels	87%
District heat	100%
Solar thermal	100%
Ambient heat	21%
Biomass	28%

Step 3: Calculation of unitary final energy consumption of households, which belong to the lowest income group, for different end-uses taking into consideration reduced energy expenses as estimated in Step 2.

Table 261 Energy consumption of low-income households

End uses	Low-income HH (kWh/HH)
Total	6587

Space heating	2468
Space cooling	72
DHW	1223
Cooking	555
Other	2269

Step 4: Calculation of final energy consumption of households, which belong to the lowest income decile, for different consumed energy carriers taking into consideration reduced energy expenses as estimated in the Step 2.

Table 262 Energy consumption of low-income households distributed by fuels

Energy carrier	Low-income HH (kWh/HH)
Total	6587
Electricity	3084
Natural gas	758
Oil	389
LNG	968
Solid fossil fuels	5
District heat	0
Solar thermal	172
Ambient heat	78
Biomass	1133

Step 5: Identification of utilised means of heating and cooking for the case of households, which belong to the lowest income decile and assessment of additional data (*data: HBS*).

Adjustments have been made by the involved country expert.

Step 6: Modelling each different end-use separately for quantifying consumed energy carriers.

Number of low-income households (dwellings): **1,870,251**

Table 263 Final energy consumption in low-income households

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Electricity	5528	166	135	430	556	4242
Heating oil	1290	1161		126		3
LPG	877	290		415	173	
Natural gas	2260	936		1047	277	
Solar thermal	231	14		216		
Ambient heat	187	185		3		
Biomass	1890	1819		46	25	
District heating	0	0		0		

Final energy consumption (GWh)	Total	Heating	Cooling	DHW	Cooking	Electric appliances & Lighting
Coal and other	0	0		0	0	
Total	12263	4571	135	2283	1030	4244

Step 7: Validation and adjustment of obtained results, which were derived by the applied modelling approach in Step 6, in conjunction with both the unitary final energy consumption of households for different end-uses (Step 3) and energy carriers (Step 4) and identified energy expenses (Step 2).

Cost deviation equal to **13%** assuming the following prices:

Table 264 Utilised energy prices in Spain

Energy carrier	Energy price (€/MWh)
Heating oil	71
Electricity	240
Natural gas	88
Biomass	54
Solar thermal	0
LPG	83
Coal and other	30

5.10.2 Modelling the impacts of the examined policies in Spain

Elasticities of demand

Electricity: -0.705, natural gas: 0.987, heating oil: -0.606 and other fuels: -0.865

Baseline scenario

ASSUMPTIONS: NO IMPLEMENTATION OF ADDITIONAL POLICIES.

THE FORESEEN INCREASES OF ENERGY PRICES WITHIN THE FRAMEWORK OF THE EU REFERENCE SCENARIO 2020 WERE TAKEN INTO ACCOUNT.

Energy prices

Table 265 Energy prices in the baseline scenario for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	95	107	119	131	143
Natural gas	88	114	141	167	193	202	211
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	242	244	246
LPG	83	96	110	124	138	151	165

Final energy consumption (GWh)

Table 266 Final energy consumption in baseline scenario in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	953	881	822	772	729
Natural gas	936	684	543	451	388	372	357
LPG	290	248	217	194	175	160	147
Biomass	1819	1819	1819	1819	1819	1819	1819
Ambient heat	185	185	185	184	184	183	182
Solar thermal	14	14	14	14	14	14	14
District heating	0	0	0	0	0	0	0
Electricity	166	166	166	165	165	164	163
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3897	3709	3566	3484	3412
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	135	134	134	133	132
Total	135	135	135	134	134	133	132
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	429	428	425	423
Natural gas	1047	765	607	505	433	416	399
Heating oil	126	113	104	96	89	84	79

District heating	0	0	0	0	0	0	0
LPG	415	355	311	277	251	229	211
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216
Total	2283	1929	1717	1572	1466	1419	1378
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1287	1157	1057	977	911	856	809
Natural gas	1983	1450	1150	956	821	787	757
LPG	704	603	528	471	426	389	358
Biomass	1865	1865	1865	1865	1865	1865	1865
Ambient heat	187	187	187	187	186	185	184
Solar thermal	231	231	231	231	231	231	231
District heating	0	0	0	0	0	0	0
Electricity	731	730	730	728	726	722	719
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	5748	5415	5166	5036	4922

Total energy costs (million €)

Table 267 Total energy costs in baseline scenario in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	101	105	109	112	116
Natural gas	174	166	162	160	159	159	160
LPG	58	58	58	58	59	59	59
Biomass	100	100	100	100	100	100	100
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	175	176	176	176	176
Coal and other	0	0	0	0	0	0	0
Total	600	595	596	598	601	606	611

Scenario 1

ASSUMPTIONS: SCENARIO 1 WAS CONSIDERED FOR THE PROJECTION OF ETS2 PRICE.

Energy prices

Table 268 Energy prices in the Scenario 1 for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	140	192	200	226	253
Natural gas	88	114	175	232	255	275	294
Solid fossil fuels	30	33	97	153	150	171	193
Electricity	240	240	240	241	242	244	246
LPG	83	96	155	209	219	247	275

Final energy consumption (GWh)

Table 269 Final energy consumption in Scenario 1 in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	615	475	397	331	288
Natural gas	936	684	360	254	198	167	144
LPG	290	248	118	82	64	49	41
Biomass	1819	1819	1819	1819	1819	1819	1819
Ambient heat	185	185	185	184	184	183	182
Solar thermal	14	14	14	14	14	14	14
District heating	0	0	0	0	0	0	0
Electricity	166	166	166	165	165	164	163
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3276	2994	2840	2727	2651
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	135	134	134	133	132
Total	135	135	135	134	134	133	132
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	429	428	425	423
Natural gas	1047	765	402	284	221	186	162
Heating oil	126	113	67	52	43	36	31
District heating	0	0	0	0	0	0	0
LPG	415	355	169	118	91	71	58
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216
Total	2283	1929	1333	1147	1048	984	939
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	1287	1157	681	527	440	367	319
Natural gas	1983	1450	762	538	419	353	306
LPG	704	603	287	200	155	120	99
Biomass	1865	1865	1865	1865	1865	1865	1865
Ambient heat	187	187	187	187	186	185	184
Solar thermal	231	231	231	231	231	231	231
District heating	0	0	0	0	0	0	0
Electricity	731	730	730	728	726	722	719
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	4744	4275	4022	3844	3723

Total energy costs (million €)

Table 270 Total energy costs in Scenario 1 in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	95	101	108	114	121
Natural gas	174	166	133	125	121	120	119
LPG	58	58	44	42	41	40	39
Biomass	100	100	100	100	100	100	100
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	175	176	176	176	176
Coal and other	0	0	0	0	0	0	0
Total	600	595	548	543	545	550	556

Scenario 2

ASSUMPTIONS: MANDATORY PHASE-OUT OF HEATING OIL AND SOLID FOSSIL FUELS IN 2030 AND NATURAL GAS (INCLUDING LNG) IN 2040.

IT WAS CONSIDERED THAT THE ACTUAL PHASE-OUT WILL HAVE OCCURRED AFTER FIVE YEARS (HEATING OIL AND SOLID FOSSIL FUELS IN 2035 AND NATURAL GAS AND LNG IN 2045), AND HEAT PUMPS WILL REPLACE THE EXISTING HEATING SYSTEMS.

Energy prices

Table 271 Energy prices in the Scenario 2 for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	95	107	119	131	143
Natural gas	88	114	141	167	193	202	211
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	242	244	246
LPG	83	96	110	124	138	151	165

Final energy consumption (GWh)

Table 272 Final energy consumption in Scenario 2 in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	953	0	0	0	0
Natural gas	936	684	543	451	388	0	0
LPG	290	248	217	194	175	0	0
Biomass	1819	1819	1819	1819	1819	1819	1819
Ambient heat	185	185	185	628	626	924	919
Solar thermal	14	14	14	14	14	14	14
District heating	0	0	0	0	0	0	0
Electricity	166	166	166	342	341	458	456
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3897	3448	3363	3216	3209
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	135	134	134	133	132
Total	135	135	135	134	134	133	132
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	755	753	1329	1322
Natural gas	1047	765	607	505	433	0	0
Heating oil	126	113	104	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	415	355	311	277	251	0	0
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216

Total	2283	1929	1717	1802	1702	1594	1587
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1287	1157	1057	0	0	0	0
Natural gas	1983	1450	1150	956	821	0	0
LPG	704	603	528	471	426	0	0
Biomass	1865	1865	1865	1865	1865	1865	1865
Ambient heat	187	187	187	631	629	927	922
Solar thermal	231	231	231	231	231	231	231
District heating	0	0	0	0	0	0	0
Electricity	731	730	730	1231	1227	1921	1910
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	5748	5385	5199	4943	4928

Total energy costs (million €)

Table 273 Total energy costs in Scenario 2 in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	101	0	0	0	0
Natural gas	174	166	162	160	159	0	0
LPG	58	58	58	58	59	0	0
Biomass	100	100	100	100	100	100	100
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	175	297	297	468	469
Coal and other	0	0	0	0	0	0	0
Total	600	595	596	615	614	568	569

Table 274 Investments foreseen in Scenario 2 in Spain

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	3554	0	2391	0

Scenario 3

ASSUMPTIONS: ESTABLISHMENT OF MEPS FOR ACHIEVING ENERGY CLASS E IN 2035.

50% OF AFFECTED HOUSEHOLDS (75% OF TOTAL LOW-INCOME HOUSEHOLDS) WILL RENOVATE THEIR BUILDINGS UNTIL 2030 (701 THOUSAND BUILDINGS) AND REMAIN UNTIL 2035 (701 THOUSAND BUILDINGS).

ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 10 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 30%.

IN 2040 ALL BUILDINGS WILL BE UPGRADED TO ENERGY CLASS D (ASSUMPTIONS FOR BUILDINGS' ENERGY UPGRADE: RENOVATION COST: 5 THOUSAND €/DWELLING AND DELIVERED FINAL ENERGY SAVINGS: 10%).

Energy prices

Table 275 Energy prices in the Scenario 3 for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	95	107	119	131	143
Natural gas	88	114	141	167	193	202	211
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	242	244	246
LPG	83	96	110	124	138	151	165

Final energy consumption (GWh)

Table 276 Final energy consumption in Scenario 3 in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	846	694	599	562	531
Natural gas	936	684	482	356	282	271	260
LPG	290	248	193	153	128	117	107
Biomass	1819	1819	1614	1433	1325	1325	1325
Ambient heat	185	185	164	145	134	133	132
Solar thermal	14	14	13	11	10	10	10
District heating	0	0	0	0	0	0	0
Electricity	166	166	147	130	120	119	119
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3459	2921	2598	2538	2486
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	119	106	97	97	96
Total	135	135	119	106	97	97	96
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	429	428	425	423
Natural gas	1047	765	607	505	433	416	399

Heating oil	126	113	104	96	89	84	79
District heating	0	0	0	0	0	0	0
LPG	415	355	311	277	251	229	211
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216
Total	2283	1929	1717	1572	1466	1419	1378
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1287	1157	950	790	688	646	611
Natural gas	1983	1450	1089	860	716	686	660
LPG	704	603	504	430	378	346	318
Biomass	1865	1865	1661	1479	1371	1371	1371
Ambient heat	187	187	166	148	136	136	135
Solar thermal	231	231	229	228	227	227	227
District heating	0	0	0	0	0	0	0
Electricity	731	730	696	665	645	642	638
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	5295	4599	4162	4054	3960

Total energy costs (million €)

Table 277 Total energy costs in Scenario 3 in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	91	85	82	85	87
Natural gas	174	166	153	144	138	139	139
LPG	58	58	56	53	52	52	53
Biomass	100	100	89	79	73	73	73
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	167	160	156	156	157
Coal and other	0	0	0	0	0	0	0
Total	600	595	555	521	502	506	509

Table 278 Investments foreseen in Scenario 3 in Spain

Investments (million €)	2025	2030	2035	2040	2045	2050
Building envelope	0	7013	7013	7013	0	0

Scenario 4

ASSUMPTIONS: COMBINATION OF SCENARIOS 2 AND 3

Energy prices

Table 279 Energy prices in the Scenario 4 for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	95	107	119	131	143
Natural gas	88	114	141	167	193	202	211
Solid fossil fuels	30	33	36	38	40	42	44
Electricity	240	240	240	241	242	244	246
LPG	83	96	110	124	138	151	165

Final energy consumption (GWh)

Table 280 Final energy consumption in Scenario 4 in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	846	0	0	0	0
Natural gas	936	684	482	356	282	0	0
LPG	290	248	193	153	128	0	0
Biomass	1819	1819	1614	1433	1325	1325	1325
Ambient heat	185	185	164	411	379	597	593
Solar thermal	14	14	13	11	10	10	10
District heating	0	0	0	0	0	0	0
Electricity	166	166	147	307	284	474	471
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3459	2671	2408	2406	2401
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	119	106	97	97	96
Total	135	135	119	106	97	97	96
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	755	753	1329	1322
Natural gas	1047	765	607	505	433	0	0
Heating oil	126	113	104	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	415	355	311	277	251	0	0
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216
Total	2283	1929	1717	1802	1702	1594	1587
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	1287	1157	950	0	0	0	0
Natural gas	1983	1450	1089	860	716	0	0

LPG	704	603	504	430	378	0	0
Biomass	1865	1865	1661	1479	1371	1371	1371
Ambient heat	187	187	166	414	382	599	596
Solar thermal	231	231	229	228	227	227	227
District heating	0	0	0	0	0	0	0
Electricity	731	730	696	1168	1134	1900	1890
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	5295	4579	4208	4098	4084

Total energy costs (million €)

Table 281 Total energy costs in Scenario 4 in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	91	0	0	0	0
Natural gas	174	166	153	144	138	0	0
LPG	58	58	56	53	52	0	0
Biomass	100	100	89	79	73	73	73
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	167	282	274	463	464
Coal and other	0	0	0	0	0	0	0
Total	600	595	555	558	538	537	538

Table 282 Investments foreseen in Scenario 4 in Spain

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	3554	0	2433	0
Building envelope	0	7013	7013	7013	0	0
Total	0	7013	10568	7013	2433	0

Scenario 5

ASSUMPTIONS: COMBINATION OF SCENARIOS 1, 2 AND 3.

Energy prices

Table 283 Energy prices in Scenario 5 for Spain

Energy prices (€/MWh)	2019	2025	2030	2035	2040	2045	2050
Heating oil	71	83	101	121	142	178	214
Natural gas	88	114	145	178	210	238	265
Solid fossil fuels	30	33	43	57	70	106	141
Electricity	240	240	240	241	242	244	246
LPG	83	96	116	138	160	198	236

Final energy consumption (GWh)

Table 284 Final energy consumption in Scenario 5 in Spain

Space heating	2019	2025	2030	2035	2040	2045	2050
Heating oil	1161	1044	810	0	0	0	0
Natural gas	936	684	462	327	252	0	0
LPG	290	248	182	135	107	0	0
Biomass	1819	1819	1614	1433	1325	1325	1325
Ambient heat	185	185	164	384	354	527	524
Solar thermal	14	14	13	11	10	10	10
District heating	0	0	0	0	0	0	0
Electricity	166	166	147	294	271	429	427
Coal and other	0	0	0	0	0	0	0
Total	4571	4160	3393	2584	2321	2292	2287
Space cooling	2019	2025	2030	2035	2040	2045	2050
Electricity	135	135	119	106	97	97	96
Total	135	135	119	106	97	97	96
Domestic hot water (DWH)	2019	2025	2030	2035	2040	2045	2050
Electricity	430	430	430	719	717	1171	1164
Natural gas	1047	765	582	464	387	0	0
Heating oil	126	113	99	0	0	0	0
District heating	0	0	0	0	0	0	0
LPG	415	355	294	245	210	0	0
Biomass	46	46	46	46	46	46	46
Coal and other	0	0	0	0	0	0	0
Ambient heat	3	3	3	3	3	3	3
Solar thermal	216	216	216	216	216	216	216
Total	2283	1929	1671	1692	1579	1436	1430
Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050

Heating oil	1287	1157	909	0	0	0	0
Natural gas	1983	1450	1045	790	638	0	0
LPG	704	603	476	379	318	0	0
Biomass	1865	1865	1661	1479	1371	1371	1371
Ambient heat	187	187	166	387	357	530	527
Solar thermal	231	231	229	228	227	227	227
District heating	0	0	0	0	0	0	0
Electricity	731	730	696	1119	1086	1697	1688
Coal and other	0	0	0	0	0	0	0
Total	6989	6223	5183	4382	3997	3825	3813

Total energy costs (million €)

Table 285 Total energy costs in Scenario 5 in Spain

Space heating, cooling and DHW	2019	2025	2030	2035	2040	2045	2050
Heating oil	92	96	92	0	0	0	0
Natural gas	174	166	151	140	134	0	0
LPG	58	58	55	52	51	0	0
Biomass	100	100	89	79	73	73	73
Ambient heat	0	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0	0
District heating	0	0	0	0	0	0	0
Electricity	175	175	167	270	263	414	415
Coal and other	0	0	0	0	0	0	0
Total	600	595	554	541	521	487	488

Table 286 Investments foreseen in Scenario 5 in Spain

Investments (million €)	2025	2030	2035	2040	2045	2050
Heat pumps	0	0	3355	0	2031	0
Building envelope	0	7013	7013	7013	0	0
Total	0	7013	10369	7013	2031	0

Synopsis

Comparison of final energy consumption

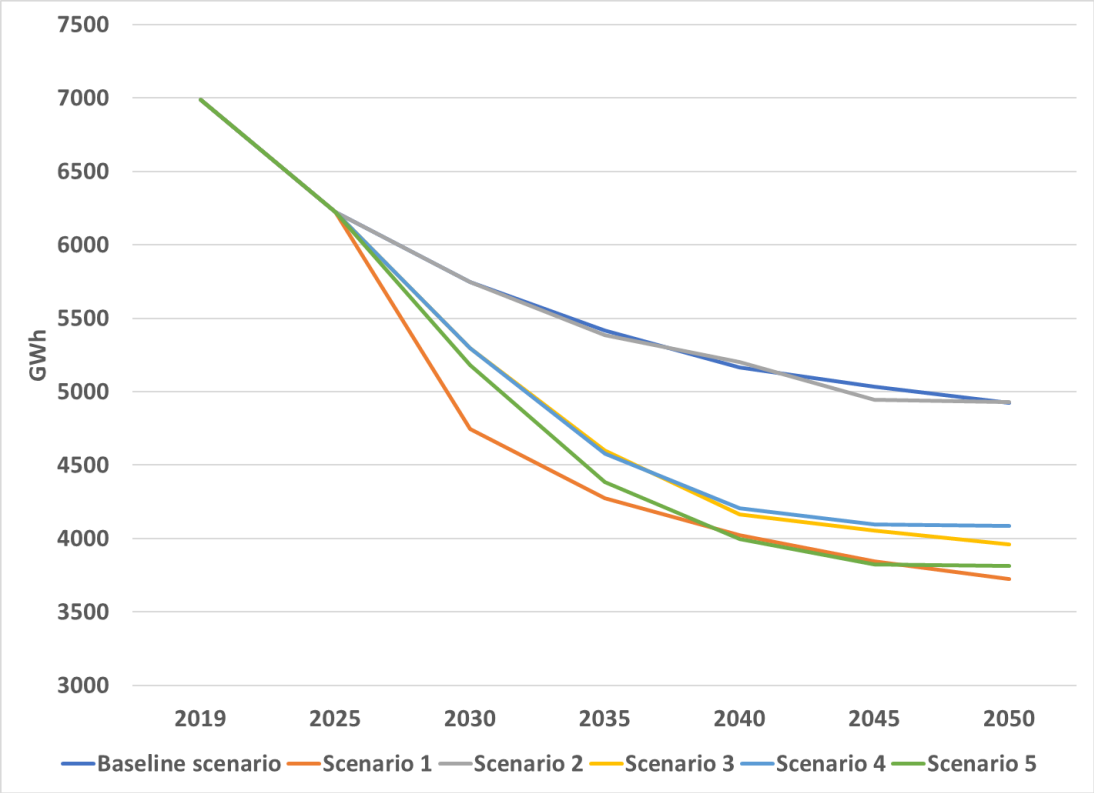

Figure 36 Comparison of final energy consumption between scenarios in Spain

Comparison of investments in different scenarios

Figure 37 Investments in different scenarios in Spain

Scenario 2	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	3554	0	2391	0
Scenario 3	Investments (million €)	2025	2030	2035	2040	2045	2050
	Building envelope	0	7013	7013	7013	0	0
Scenario 4	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	3554	0	2433	0
	Building envelope	0	7013	7013	7013	0	0
	Total	0	7013	10568	7013	2433	0
Scenario 5	Investments (million €)	2025	2030	2035	2040	2045	2050
	Heat pumps	0	0	3355	0	2031	0
	Building envelope	0	7013	7013	7013	0	0
	Total	0	7013	10369	7013	2031	0

Comparison of total energy costs

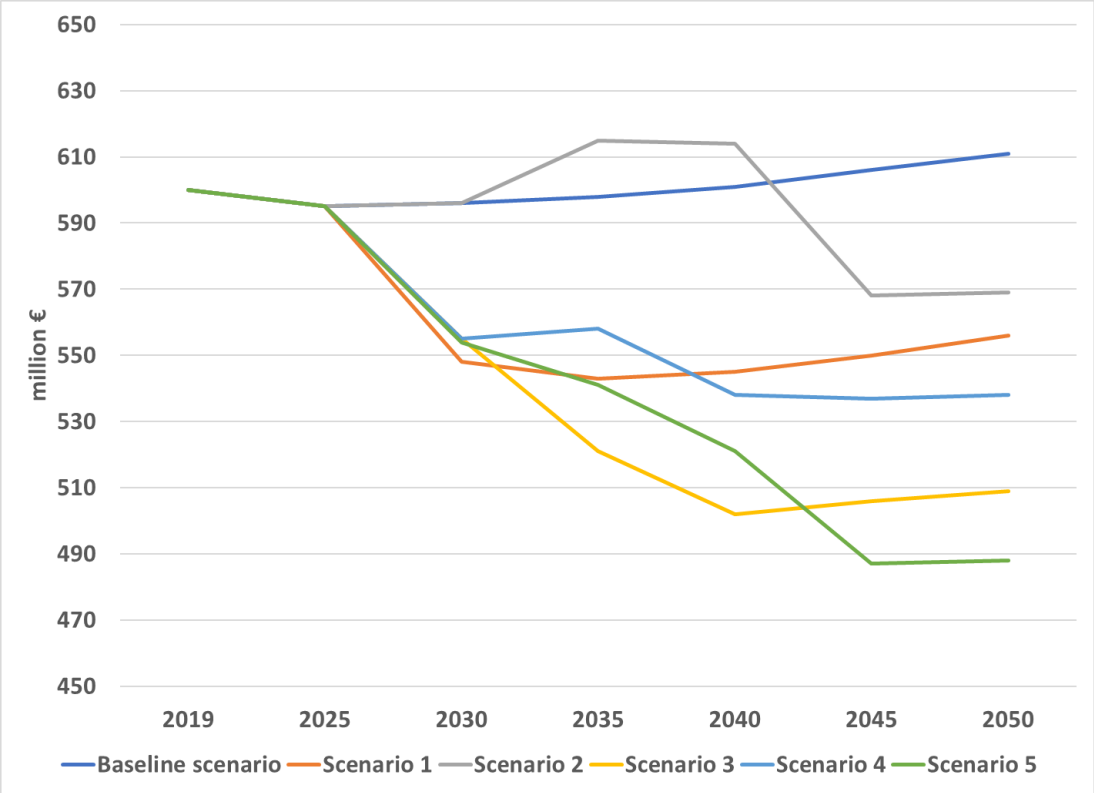

Figure 38 Comparison of final energy costs between scenarios in Spain