CHAMP
Local Heating & Cooling Planning

Review of the current heating & cooling framework in Bulgaria, Croatia and Greece

BSERC
black sea energy research centre

REGEA

КАПЕ
CRES

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The opinions put forward in this report are the sole responsibility of the author(s) and do not necessarily reflect the views of the German Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN).

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Summary

The CHAMP project, supported by the European Climate Initiative (EUKI), aims to assist municipalities in Bulgaria, Croatia, and Greece in complying with Article 25.6 of the revised Energy Efficiency Directive (EED), which mandates larger municipalities to develop local heating and cooling (H&C) plans. The project develops methodologies, planning tools, and training to support municipalities in transitioning to more sustainable and efficient H&C systems.

At the EU level, the H&C sector is a key target for decarbonization under the Green Deal and Fit for 55 package. Key legislation includes the Renewable Energy Directive (RED III), the EED, and the Energy Performance of Buildings Directive (EPBD), which set ambitious goals for renewable energy use, energy efficiency, and fossil fuel phase-out. EU Member States are obligated to conduct regular H&C assessments, adopt local H&C plans, and ensure progressive integration of renewable energy sources.

The report analyzes the H&C frameworks in three pilot municipalities: Pernik (Bulgaria), Rijeka (Croatia), and Veria (Greece). Each pilot case reflects the broader national context and challenges related to H&C planning, energy efficiency, and renewable energy integration.

In **Bulgaria**, the H&C framework is fragmented and lacks a dedicated national strategy. The NECP sets a 44% renewable target for H&C by 2030. The sector is dominated by firewood, electricity, and district heating in urban areas. Air quality concerns have driven public programs to replace solid-fuel stoves with cleaner technologies. However, significant gaps remain in data availability, municipal planning capacity, and the transposition of EU directives. Financial support is available, but mainly targets vulnerable households, missing middle-income groups and broader market development.

Croatia has more advanced policy planning, with several strategies targeting the renovation of buildings and modernization of heating systems. The NECP targets 47.1% renewable energy in H&C by 2030. District heating plays a limited role, and heating relies mainly on natural gas and biomass. Croatia is exploring geothermal energy development and improving energy efficiency in both public and residential buildings. Challenges include outdated infrastructure, limited penetration of district heating, and insufficient progress in meeting annual renewable energy increase obligations.

In **Greece**, the focus is on energy efficiency, electrification, and solar thermal energy. The NECP targets 52.6% RES share in H&C by 2030. Heating is primarily electric- or oil-based, with cooling needs met through air conditioning. District heating in the country can be characterized as underdeveloped, localized, and fossil-fuel dependent, with limited integration into national energy or climate planning. Greece has implemented extensive building renovation programs and is leveraging EU funds to improve energy performance. However, planning tools, enforcement mechanisms, and municipal capacity are underdeveloped.

Comparative analysis reveals shared challenges across the three countries, including low renovation rates, limited data infrastructure, insufficient municipal planning capacity, and reliance on fossil fuels. While Croatia excels in strategic planning and Bulgaria in air-quality-driven action, Greece leads in solar thermal adoption. Yet, all three countries need stronger coordination, financing instruments, and capacity building to meet EU targets.

District heating systems, where present, are outdated and fossil-fuel reliant. Transitioning to modern, low-temperature systems integrated with renewables is not yet mainstream. Consumer-level challenges include affordability, lack of information, and limited financial incentives for non-poor households. One-stop shops, tax incentives, and regulatory sandboxes are largely missing.

The report identifies multiple gaps, including incomplete legal transpositions, limited financial accessibility, lack of comprehensive national H&C strategies, and underdeveloped integration of H&C into urban planning. Although there are pilot programs and funding streams, they often operate in isolation and fail to build systemic change.

In conclusion, the report calls for comprehensive national strategies, improved data systems, targeted financial tools for all income levels, and local capacity building. Accelerated adoption of renewable technologies, modernization of district heating, and inclusive planning are crucial to achieving a sustainable, efficient, and equitable H&C sector in Bulgaria, Croatia, and Greece.

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Abbreviations

BMWK	Federal Ministry for Economic Affairs and Climate Action (Germany)
CHAMP	Clean Heat Action Municipal Planning (Project)
CHP	Combined Heat and Power
CoM	Covenant of Mayors
CRES	Center of Renewable Energy Sources and Saving
DHS	District Heating System
DHSME	Local Plan for the Reduction of Emissions (Greece)
EEA Grants	European Economic Area Grants
EED	Energy Efficiency Directive
EERSF	Energy Efficiency and Renewable Sources Fund
EIHP	Energy Institute Hrvoje Požar (Croatia)
EPBD	Energy Performance of Buildings Directive
ETS	Emissions Trading System
EU	European Union
EUKI	European Climate Initiative
EWRC	Energy and Water Regulatory Commission (Bulgaria)

FEC	Final energy consumption
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
H&C	Heating and Cooling
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technologies
LEZ	Low Emission Zone
LTRS	Long-Term Renovation Strategy
LTS	Long-Term Strategy
LWG	Local Working Group
ME	Ministry of Energy
MH	Ministry of Health
MLSP	Ministry of Labour and Social Policy
MOEW	Ministry of Environment and Water
NECP	National Energy and Climate Plan
NGO	Non-Governmental Organisation
NSI	National Statistical Institute (Bulgaria)
NZEB	Nearly Zero Energy Building
RED	Renewable Energy Directive
RES	Renewable Energy Sources
SEAK	Energy Efficiency Action Plan (Greece)
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan (Croatia)
SEDA	Sustainable Energy Development Agency (Bulgaria)

1 Introduction

1.1 About CHAMP project and current report

Article 25.6 of the recast Energy Efficiency Directive (EED1) obliges the larger EU municipalities (>45,000 inhabitants) to develop municipal heating and cooling (H&C) plans. Given the low level of readiness of Bulgaria, Croatia and Greece to implement this new obligation, the CHAMP project aims to support them by: (a) providing local authorities with planning methodology, templates, and guidelines, (b) increasing the knowledge of local authorities and (c) improving the H&C planning framework at national/local level.

The main activities of the CHAMP project include: (a) analysis and recommendations on policy, legislation, financing, data availability, (b) development of a methodology for H&C plans that meets all EED requirements, which will be tested in one pilot municipality in each country, supported by a Local Working Group (LWGs), (c) development of templates, guidelines, and proposal of planning tools and (d) preparation of capacity building materials and training of local authorities.

The key project stakeholders who can contribute to overcoming the aforementioned issues are the national government authorities responsible for implementing Article 25.6 of the recast EED, namely the Ministry of Energy and Sustainable Energy Development Agency in Bulgaria, the Ministry of Environment and Energy in Greece, and the Ministry of Economy in Croatia.

The pilot municipalities/cities of Pernik (BG), Rijeka (HR) and Veria (GR) are the primary actors, who will play an essential role in the development of the pilot plans by discussing their objectives and scope, providing data, feedback on the methodology and plans, and facilitating the communication with all other local stakeholders. Both the abovementioned national and local authorities will be involved in the project through their participation in the LWGs and bilateral discussions. Other stakeholders include H&C market actors (utilities, manufacturers, installers, large heating consumers, etc.), associations of municipalities, regional authorities, financial institutions, local/regional energy agencies, regulatory agencies, energy (research) institutes, NGOs, and consultants.

The primary project outcome is divided into three outputs:

1. Opportunities to improve the H&C planning framework at the national and regional levels are identified and communicated to the relevant decision-makers
2. Local authorities are supported in the development of quality H&C plans through guidelines and templates
3. Knowledge of local H&C planning is improved. This output is mainly relevant to the local authorities, but also to all other actors involved in planning

The present report aims to shed light on the current H&C framework, which is the first activity corresponding to the first output. The review will include: (a) H&C policy, including comprehensive assessment of H&C, available strategies, plans, and programmes, (b) legislation and regulations, including H&C-related local planning obligations and key regulations related to H&C investments, (c) available funding sources and schemes, (d) availability of data on H&C demand, building stock, and RES potential and (e) GAP analysis.

Chapter 2 of the present report covers the main legislative framework at EU level, which is related to H&C aspects, such as provisions of Directive 2413/2023/EU (RED III), Directive 1791/2023/EU (EED), etc. Chapters 3, 4 and 5 focus on the current H&C status in Bulgaria,

[1] Directive (EU) 2023/1791

Croatia and Greece respectively, with the aforementioned structure, while Chapter 6 summarises the key messages of the report and provides a comparative analysis.

1.2 About pilot cases

1.2.1 Brief description of Pernik (BG) pilot case

The Bulgarian pilot municipality for the project is Pernik. Situated in the southwestern part of the country, Pernik lies along the Struma River within the Pernik Valley, nestled between the Golo Bardo, Vitosha and Lyulin mountains.

Administrative structure

The Municipality of Pernik covers an area of 484.86 m^2 (NSI, 2025). It includes 24 settlements: the town of Pernik (the administrative center), 1 additional town (Batanovtsi), and 22 villages.

Population

As of 31.12.2024, the population of the municipality amounts to 81,170 (NSI, 2025a), continuing a steady downward trend observed over the recent years.

Climate

The Pernik Municipality falls in the temperate continental climate area of Bulgaria, including its mountainous variant, represented by the slopes of the mountains surrounding the Pernik valley. The local physicogeographical features significantly impact the region's climate by determining the formation of temperature inversions. These inversions are a prerequisite for increased frost and higher concentrations of pollutants in the surface air layer, which leads to deteriorating sanitary conditions. The average temperature in January, the coldest month, is -2°C, and the average temperature in July, the warmest month, is 19.6°C. The annual total precipitation is 606 mm, with a transitional seasonal distribution — two maxima (spring and late autumn) and two minima (summer and winter). The prevailing winds come from the north (27.3%) and northwest (20%), though southerly winds also play a significant role (18%). The average annual wind speed in Pernik is very low at 1.1 m/s. Pernik also has one of the highest percentages of quiet weather in the country (66.4%), which seriously lowers the atmosphere's self-cleaning capacity. (Pernik Municipal Council, 2017)

Economy and employment

Pernik is one of the country's main industrial centers, specializing in heavy industry. Almost all branches of material production are developed within the regional economic system. Ferrous metallurgy, electricity and heat production, mechanical engineering, and metalworking, as well as coal mining, play a leading role in the municipality's economy. In recent years, the share of light industry (mainly clothing), trade and services is increasing. (Pernik Municipal Council, 2017)

GDP per capita in Pernik district is relatively low. The share of the working-age population is below the country's average. Both employment and unemployment are declining simultaneously, but while the employment rate remains below the national average – 72.5%, versus 76.2% respectively, the unemployment rate is more favorable – 4.1% in the district, against 5.3% nationally. A characteristic of the workforce in Pernik district is the relatively large share of people with secondary education. At the same time, the share of university graduates remains relatively low, while that of people with primary or lower education is increasing and they now constitute 17%, compared to 15% in the country. (IME, 2024).

1.2.2 Brief description of City of Rijeka (HR) pilot case

The Croatian pilot municipality for the project is **City of Rijeka**. The City of Rijeka is located in Primorje-Gorski Kotar County and, as the county's capital, serves as its administrative and developmental center. The land area of the city covers 43.55 km², while the total area, including the maritime zone, amounts to 136 km².

Administrative structure

The City of Rijeka is one of the four principal development hubs within the spatial framework of the Republic of Croatia, alongside Zagreb, Split, and Osijek. Administratively is divided into 34 local committees.

Population

According to the 2021 census, the City of Rijeka has a population of 107,964 residents.

Climate

The geological location of the City of Rijeka makes it highly susceptible to precipitation, with approximately one-third of all days in the area classified as days with precipitation. The prevailing climate is a temperate humid climate without a dry season, characterized by minimal precipitation during the warmer part of the year and hot summers. The average annual air temperature is approximately 13.8 °C, with recorded absolute extremes of 38.1 °C (maximum) and –11.4 °C (minimum). This annual temperature variation in the Rijeka area creates numerous opportunities. The sea surface temperature in Rijeka Bay reaches its highest point in August (22.4 °C), which is particularly favorable for bathing tourism during the summer months. Conversely, due to lower temperatures in certain parts of the year, winter tourism is also present in the City of Rijeka, most notably at the Platak ski resort. (Development Plan of the City of Rijeka for the period 2021–2027).

Economy and employment

For decades, the City of Rijeka was a strong industrial center at both the regional and national levels, primarily reflected in the presence of numerous factories across various economic sectors, particularly the port and related activities. Today, industry accounts for a significantly smaller share of Rijeka's economy compared to 10–15 years ago, mainly due to the crisis in the shipbuilding sector. Economic sectors that are currently growing include trade, construction, science and education, ICT, service industries, and culture-related activities. These sectors are increasingly emerging as key drivers of the County's economy and economic growth in the future. The City of Rijeka is actively promoting the development of the local economy based on innovation, Industry 4.0, and information and communication technologies in order to successfully adapt to the "new" knowledge- and innovation-based economy. (Development Plan of the City of Rijeka for the period 2021–2027).

1.2.3 Brief description of Veria (GR) pilot case

The pilot municipality in Greece is Veria, which is part of the Regional Unit of Imathia and the Region of Central Macedonia.

Administrative structure

The municipality of Veria, which covers an area of 791.43 km², was established by merging the former municipality of Veria with the municipalities of Vergina, Makedonida, Dovra, and Apostolos Pavlos, in accordance with the "Kallikratis" program.
The municipality of Veria is one of the three municipalities of the Regional Unit of Imathia, along with the municipalities of Naousa and Alexandria. It serves as the seat of the Regional

Unit and occupies 46.53% of the total area of Imathia. It is located in the southwestern part of the region and borders the municipalities of Naousa, Alexandria, Pydna–Kolindros, Katerini, Servia–Velventos, Kozani, and Eordaia.

Population

As of the 2021 census, Veria has a population of 62,655 residents.

Climate

According to the Regional Plan for Climate Change Adaptation of the Region of Central Macedonia, the climate is influenced by various factors, such as the terrain, distance from the sea, altitude, atmospheric systems, and specific local conditions. Overall, the Region of Central Macedonia experiences greater temperature variations compared to the rest of Greece. The coldest months are January and February, while the warmest are July and August. Rainfall occurs mainly in autumn, early winter, and spring. Winter is characterized by northern and northwesterly winds that often cause frost, while in mountainous areas, temperatures drop significantly lower, with twice as much rainfall as in the lowlands and frequent snowfalls that often last until spring.

More specifically, for the Regional Unit of Imathia, the Regional Plan notes that the climate is predominantly continental, with only a few coastal areas showing milder conditions. During the summer months, from June to September, temperatures exceed 20°C, while in winter, from November onwards, temperatures in the plains can drop well below zero. Sudden temperature drops are common, and strong local winds intensify the cold. The annual rainfall in Imathia ranges from 400 to 600 millimeters in the plains and increases in the mountainous areas, exceeding 1,200 millimeters. Snowfall is common in the mountainous regions of the area.

Economy and employment

The Regional Unit of Imathia, located in Macedonia, is an important economic hub of Greece, with activity spanning all three main sectors of the economy: primary, secondary, and tertiary. The area is particularly distinguished for its rich agricultural production, dynamic industry, and strong commercial activity, making Imathia one of the country's most significant export centers.

According to the 2021 census by the Hellenic Statistical Authority (ELSTAT), the total population of the municipality of Veria amounts to 62,655 people, of whom 26,757 are economically active. Among them, 22,266 are employed, with 3,091 people (11.6%) working in the primary sector, 3,771 people (14%) in the secondary sector, and the majority, 15,397 people (57.5%), in the tertiary sector. The number of unemployed persons in the municipality is 4,488 (16.8%), while the economically inactive population amounts to 35,902 individuals.

The structure of employment sectors clearly highlights the Municipal Unit of Veria as the central economic hub, with the majority of workers employed mainly in the tertiary sector, but also a significant proportion of unemployed individuals. The Municipal Unit of Apostolos Pavlos holds an important share in the primary and secondary sectors, while the smaller municipal units, such as Vergina and Makedonida, have limited participation in the municipality‘s economic activity. Unemployment is mainly concentrated in the two largest municipal units, with the Municipal Unit of Veria having the highest share.

2 EU legislation

The EU legislative framework for heating and cooling lies within the wider EU legislative framework on energy, following the vision of the European Union's Green Deal for Europe's economy and society to become climate-neutral by 2050. The European Green Deal, sealed

with the European Climate Law, sets out the legal obligation Europe to become climate-neutral by 2050, but also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.

As a key component of the European Union's Green Deal, came the Fit for 55 package, consisting of a wide range of legislative proposals and policy reforms that touch on energy, transport, industry, and taxation. The package includes, among others, updates on EU Emissions Trading System (ETS), the Effort Sharing Regulation (also known as ETS2) setting national emissions targets for sectors not covered by the ETS (e.g. transport, buildings, agriculture). It includes also the revision of Renewable Energy Directive (RED III), the recast of the Energy Efficiency Directive and of Energy Performance Building Directive, as well as the Social Climate Fund, which provides financial support for vulnerable households and small businesses to manage the costs of the green transition.

Heating and cooling accounts for approximately **50% of the European Union's total final energy consumption**[2], making this sector a central focus in the EU's energy and climate policies. This significant share has remained consistent over the past decade, underscoring the importance of decarbonizing heating and cooling to meet the EU's climate targets. Under the Fit for 55 package, several measures directly target this sector:

- **Buildings Sector in ETS2**: A new emissions trading system (ETS2) will apply to the building sector, effectively pricing carbon in heating fuels used in residential and commercial buildings.
- **Energy Efficiency Directive**: Through the Energy Efficiency First Principle and other provisions of this Directive, energy efficiency is brought forward, encouraging the renovation of existing buildings to improve insulation and reduce energy demand for heating and cooling.
- **Renewable Energy Integration**: The revised Renewable Energy Directive sets higher targets for the use of renewables in heating and cooling (e.g. heat pumps, district heating from biomass or geothermal sources).
- **Minimum Energy Performance Standards**: Introduced to push for the phase-out of worst-performing buildings and support retrofits that reduce heating and cooling emissions.
- **Funding Support**: Through the Social Climate Fund and other EU mechanisms (like the Recovery and Resilience Facility), there will be financing to support low-income households in upgrading heating systems and improving energy performance.

Thus, it can be seen that the European Union has established a comprehensive legislative framework to promote the decarbonisation, efficiency, and integration of heating and cooling systems within the broader energy transition. This framework supports the deployment of renewable energy sources, improves energy efficiency, and fosters synergies between electricity, heating, and cooling networks.

More specifically, the revised **Renewable Energy Directive (RED III[3])**, effective from November 2023, increased the EU-binding minimum renewable energy target to 42.5% by 2030, aiming for 45% share of energy from renewable sources in the Union's gross final consumption, as mentioned in Article 3. For the heating and cooling sector, as described in Article 23 of RED III, the EU Member States are now mandated to annually increase the share of renewables by at least 0.8% from 2021 to 2025 and by at least 1.1% from 2026 to 2030. There is also Article 22a, dedicated to mainstreaming renewable energy in industry. This Article sets the obligation to Member States to increase the share of renewable energy sources used

[2] https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en
[3] Directive (EU) 2023/2413

for final energy and non-energy purposes in the industry sector with an indicative increase of at least 1.6% as an annual average calculated for the periods 2021 to 2025 and 2026 to 2030. Article 15a deals with mainstreaming renewable energy in buildings. It determines an indicative national share of renewable energy produced on-site or nearby as well as renewable energy taken from the grid in final energy consumption in buildings in 2030, consistent with the indicative target of at least a 49% share of energy from renewable sources in the building sector in the Union's final energy consumption in 2030. Finally, Article 24 deals with district heating and cooling. It sets the obligation to Member States to increase the share of renewable energy sources and waste heat and cooling in district heating and cooling by an indicative percentage of 2.2% as an annual average calculated for the periods 2021 to 2030, compared to 2020.

In addition, there is the recast of **Energy Efficiency Directive (EED)**, which is in force since October 2023 and legally enshrines the "energy efficiency first" principle, as mentioned in Article 3. It obliges EU countries to consider energy efficiency in all relevant policies and significant investment decisions. Additionally, in line with Article 25 paragraph 1, EU countries are requested to carry out a comprehensive heating and cooling assessment, and notify to the Commission when completed. These assessments should be carried out every 5 years, together with integrated National Energy and Climate Plans. Notably, EU Member States, in order to carry out the comprehensive assessment of heating and cooling, should conduct a cost-benefit analysis across their entire territory, based on climatic conditions, economic feasibility and technical suitability. This leads to the identification of the most resource- and cost-efficient solutions to meet heating and cooling requirements, taking into account the Energy Efficiency First principle. Moreover, municipalities with population exceeding 45,000 are also required to develop local heating and cooling plans, promoting efficient district heating and cooling systems, according to Article 25 paragraph 7.

The revised **Energy Performance of Buildings Directive (EPBD[4]) 2024** is the latest iteration of the EU's Directive focusing on improving the energy performance of buildings. Article 3 and Annex II set 2050 as the deadline for the full elimination of fossil fuel heating systems, a target that must be achieved through National Building Renovation Plans (BRPs), which will provide a strategic framework for transitioning to renewable energy heating solutions. It mandates in Article 9 that all new buildings must be nearly zero-energy by specific deadlines and requires in Article 7 Member States to set minimum energy performance standards for new constructions and major renovations. The Directive also emphasizes the integration of renewable energy sources in Article 8 and the use of smart technologies to optimize building operations in Article 14.

To address social impacts, the EU established the **Social Climate Fund**, which will operate from 2026 to 2032 with a budget of €86.7 billion. The fund is designed to help vulnerable households, small businesses, and transport users cope with rising costs linked to the carbon pricing of fuels. EU Member States will be required to develop national social climate plans, outlining how the funds will be used—whether for direct financial support or for investments in energy-efficient housing and clean transport. This fund represents a crucial step toward ensuring that the green transition is fair and does not disproportionately burden lower-income citizens.

[4] Directive (EU) 2024/1275

3 Current H&C status in Bulgaria

3.1 H&C policy framework

National level

Bulgaria's Updated National Energy and Climate Plan (NECP) 2021–2030 (ME, MOEW, 2024) commits to a 44.01% share of renewable energy in the gross final consumption in the H&C sector by 2030. The **Long-Term Strategy (LTS)** (MOEW, 2022), where Bulgaria commits to Climate Neutrality by 2050, is not yet updated but the share of RES H&C in 2050 according to the 2050 horizon in the NECP is now pointed at 75.59%. The country does not have a developed national heating and cooling strategy yet.

For several years since around the first draft of the NECP, Bulgaria has also had a draft **Sustainable Energy Development Strategy till 2030/2050** (ME, 2023), adopted by a decision of the Council of Ministers under the Energy Act. However, with its introduction the strategy had a clash with some of the NECP context and commitments and is now completely obsolete with the new revised NECP.

Municipal planning and local initiatives

For over a decade, Bulgarian municipalities have engaged in sustainable energy planning, initially through Sustainable Energy Action Plans (SEAPs) developed under the Covenant of Mayors. These early plans, however, focused mainly on public buildings and transportation often neglecting private housing and district heating systems, especially when operated under concession. It wasn't until the current EU Multiannual Financial Framework (2021–2027) and growing public pressure over poor air quality that municipalities began actively addressing heating in private homes. This shift has involved fuel quality regulations, public awareness campaigns, and programs to replace inefficient solid-fuel heating appliances.

Under the Ambient Air Quality Directive and the national Clean Ambient Air Act (Council of Ministers, 1996), municipalities are legally required to adopt Air Quality Improvement Programs, targeting major pollution sources - primarily the household use of wood and coal. To support these efforts, the government provides funding under priority Axis 5 of Programme Environment, allocating BGN 610 million (2021 - 2027) to 21 municipalities. The program enables an estimated 85,000 households to receive modern, energy-efficient heating appliances - mostly air-to-air heat pumps - free of charge, on condition they permanently decommission their old solid-fuel stoves. The program builds on earlier pilots that upgraded over 16,500 household systems and is now being scaled up in cities like Sofia, Plovdiv, Ruse, Burgas, Pleven, and Smolyan, where winter smog is most severe.

A complementary initiative is the **LIFE IP Clean Air project** (2018–2025) (CINEA, 2025), co-funded by the EU LIFE programme. With a budget of €16.7 million, it brings together six major municipalitie - —Sofia, Burgas, Ruse, Stara Zagora, Veliko Tarnovo, and Montana - to coordinate local clean heating efforts. The project supports the transition from wood and coal to cleaner heating alternatives such as pellets, gas, or district heating, and helps integrate local programs with national policy goals.

Many municipalities continue to participate in the Covenant of Mayors through updated Sustainable Energy and Climate Action Plans (SECAPs), which now include targets for efficient heating, building renovations, and small-scale renewables. Sofia, for example, has implemented targeted programs to electrify or gasify heating in certain neighborhoods and expand district heating coverage as part of its Program for Improving Ambient Air Quality 2021–2026 (Sofia, 2021).

In parallel, major district heating companies - in Sofia, Plovdiv, Burgas, Varna and others - are undertaking modernization projects with EU support, including boiler upgrades, pipeline insulation improvements, and integration of biomass or waste heat.

The **MultiHome project** (https://www.multihome-project.eu/) in the Plovdiv Region (since 2023), funded under the LIFE Clean Energy Transition programme, is piloting a one-stop-shop for residential energy renovations. Led by the Energy Agency of Plovdiv, it brings together local authorities, banks, service providers, and citizens to support comprehensive retrofits, including heating system upgrades, insulation, and renewables. By focusing on apartment blocks and single-family homes, and involving “lead user” households as ambassadors, the project helps address technical and financial barriers to clean heating and complements national retrofit schemes

Sofia has implemented Bulgaria's first **Low Emission Zone (LEZ)** (Sofia, 2023) to address persistent air pollution challenges. The LEZ aims to reduce emissions from older, high-polluting vehicles and domestic heating systems. The LEZ was introduced in phases, starting on 1 December 2023, targeting vehicles with the lowest emissions standards (Euro 1) within the city's "small ring" area. From 1 December 2024, restrictions expanded to include Euro 2 vehicles. By winter 2025, the LEZ will extend to the "great ring" area, with further restrictions planned through 2027. Additionally, from 2025, a separate LEZ focusing on domestic heating will be implemented, aiming to phase out solid fuel use citywide by 2029.

The LEZ operates during the winter months (from 1st of December to 28th of February) when air pollution levels are typically highest. Enforcement is carried out through automated systems using cameras and license plate recognition to identify non-compliant vehicles. Violations incur fines ranging from BGN 50 for individuals to BGN 200 for companies. The upcoming measures related to heating and cooling are still not announced.

As of now, Sofia is the only Bulgarian city with an active LEZ. However, other cities such as Plovdiv, Burgas, Ruse, Stara Zagora, and Veliko Tarnovo have considered implementing similar zones to combat air pollution, though specific plans and timelines have yet to be established.

3.2 Legislative framework

National legislation

Bulgaria’s heating and cooling sector is governed by several key laws and regulations. **Energy Act, Energy Efficiency Act, and Energy from Renewable Sources Act** form the core legal framework, all of which include provisions affecting heating and cooling:

- **Energy Act (**Council of Ministers, 2003) – This is the principal law regulating energy activities in Bulgaria. It **governs the generation, import/export, transmission, distribution, and trade of electricity, thermal energy (heat), and natural gas**, as well as oil pipeline transport. The Energy Act also establishes the powers of state authorities in formulating energy policy, market regulation, and control over the sector. In the heating context, the Energy Act provides the legal basis for **district heating (топлофикация)** – heat production and supply are licensed and regulated under this law similarly to electricity and gas. It mandates requirements for heat supply companies, including service obligations and pricing regulations, and it entrusts the national energy regulator with oversight of heat utilities. The law has been amended multiple times (notably in line with EU energy directives) since its promulgation in 2003.
- **Energy from Renewable Sources Act** (Council of Ministers, 2011) – This law specifically addresses the promotion and use of renewable energy. It governs the

production and consumption of energy from renewable sources in **three forms: (1) electricity, (2) thermal energy and cooling energy, and (3) transport fuels**. It covers renewable heating and cooling alongside renewable electricity. The RES Act transposes EU directives on renewables (including provisions from the Renewable Energy Directive) into national law. It sets out incentive schemes, such as feed-in tariffs or premiums for renewable heat and power, guarantees of origin, and conditions for integrating renewable-based heat into district heating networks. This law underpins initiatives to use biomass, geothermal, solar thermal, and waste heat in heating systems by creating a framework for support (grants, obligation schemes, etc.) and simplifying permit procedures.

- **Energy Efficiency Act** (Council of Ministers, 2015) – This law governs the national policy for improving energy efficiency across all sectors of the economy. It establishes the institutional framework and measures to achieve energy savings, which directly impact heating and cooling given that space heating is the largest component of household energy use. The Act sets binding national energy saving targets and provides for instruments such as **energy efficiency obligation schemes, building energy codes, energy audits and certification, and incentive programs**. Under this law, for instance, large municipalities must develop local energy efficiency programs (often dovetailing with heating upgrades), and public buildings are required to meet certain efficiency standards. **State policy on energy efficiency in the heat sector** – e.g. requirements for periodic efficiency checks of boiler and air-conditioning systems, and promotion of high-efficiency cogeneration – is grounded in this Act (transposing the EU Energy Efficiency Directive).
- In addition to these primary laws, several **secondary regulations** further detail the H&C framework. For example, **Ordinance №16-334 on Heat Supply** (ME, 2007) sets technical and contractual rules for district heating services – it covers heat metering, billing, and the rights of heat consumers in multi-apartment buildings.
- On the environmental side, the **Clean Ambient Air Act** (Council of Ministers, 1996) implements EU air quality standards and indirectly influences heating by empowering municipalities to restrict high-pollution fuels and by establishing the requirement for Air Quality Improvement Programs mentioned earlier. This law (administered by the Ministry of Environment) has been used to ban the use of certain coal types or unseasoned wood in domestic heating in some cities during smog episodes.

Key regulations

- **Ordinance No.16-334 of 6 April 2007 on Heat Supply** (ME, 2007) – Defines technical, contractual, and economic conditions for heat supply services. Sets rules on consumer metering, billing, and service quality.
- **Regulation No. 12 on Emission Limits in Ambient Air** (MH, MOEW, 2010) - Sets emission thresholds for harmful substances, including those from residential heating.
- **Regulation on Solid Fuel Quality Requirements** (Council of Ministers, 2020) - Sets minimum quality standards for solid fuels used in domestic heating to reduce pollution.
- **Ordinance No. RD-07-5 of 16 May 2008** (MLSP, 2008) - Governs the conditions and procedures for granting targeted heating aid to vulnerable households in Bulgaria. Through it Bulgaria operates a **targeted heating subsidy program** for vulnerable households during the winter months. According to the NECP, around 320,000 individuals and families receive subsidies for heating aid each year to ensure access to adequate amount of warmth. It defines the criteria for energy poverty and outlines

the process for applying for support, which is typically provided as a lump sum during the heating season.

- **Natural Gas Pricing Methodology** - Determins permissible technological losses during the transmission, distribution, and storage of natural gas (EWRC, 2012)
- **District Heating Pricing Methodology** - Determins the permissible technological losses during heat energy transmission (EWRC, 2005).

Government and regulatory authorities

The **Ministry of Energy** is the lead policymaker for the energy sector, including heating and cooling. The ministry drafts and updates strategic plans, such as the NECP and Energy Strategy, initiates legislation (Energy Act and related ordinances), and oversees the energy industries. Within H&C, the Ministry is responsible for formulating support programs (e.g. incentive schemes for efficient heating), supervising state-owned energy companies (such as district heating utilities in which the state has a stake), and coordinating with municipalities on local energy projects. The Ministry also chairs the interministerial working groups on climate and energy policy, ensuring H&C measures are integrated into climate action. It is the parent institution of the Sustainable Energy Development Agency (SEDA) and works closely with the regulator EWRC on implementing policy. The Ministry of Energy regularly issues **secondary legislation and strategic documents** that affect heating and cooling, and **was integral in the development of the National Recovery and Resilience Plan** (which includes financing for building insulation and renewable energy systems)

The **Ministry of Environment and Water** (MOEW) is responsible for environmental policy and climate change and thus plays an important role in the heating domain due to air pollution and emissions concerns. MOEW develops and enforces the Air Quality legislation and is in charge of the Programme Environment (Operational programme under the EU MFF) where under the Priority Axis 5 focusing on clean air the programme finances household heating conversions. Through its Climate Change directorate, MOEW also contributes to the NECP (notably the heating and cooling decarbonisation aspects) and manages climate-related funding. MOEW supervises the Executive Environment Agency and the regional environmental inspectorates, which monitor air pollution from heating and ensure compliance with standards (e.g. banning local use of certain fuels on high-smog days). Thus, MOEW is the key institution linking heating policies with environmental outcomes – for instance, it sets emissions norms for biomass boilers and runs public awareness campaigns on burning cleaner fuels. The Ministry often works jointly with the Ministry of Energy on programs like the LIFE IP Clean Air (MOEW is a coordinating beneficiary), illustrating the cross-cutting nature of H&C governance. It oversees municipal environmental planning, and leads the national implementation of the EU Emissions Trading Scheme 2 (ETS2) and its connection to Social Climate Plans.

The **Ministry of Regional Development and Public Works (MRDPW)** oversees housing policy, building renovation targets, and the territorial aspects of Just Transition funding. MRDPW influences heating through building codes and the management of the **National Programme for Energy Efficiency of Residential Buildings** (which financed panel-block renovations, indirectly improving heating efficiency) (Council of Ministers, 2015a).

Together, these three ministries - either individually or in coordination - drive the national policy and programmatic framework for heating and cooling in Bulgaria.

The **Ministry of Finance (MF)** handles funding allocations and tax policy (e.g. VAT reduction for district heating or subsidies for energy poor households).

Regulation of the heating sector is ensured by an independent regulator. The **Energy and Water Regulatory Commission (EWRC)**, established by the Energy Act, is the national

regulator overseeing electricity, gas, **district heating**, and water utilities. EWRC's mandate in heating includes **licensing heat production and supply companies, approving heat tariffs and price models, and setting rules for quality of service**. The Regulatory Commission sets heat energy prices for end consumers in centralized heating systems (typically on an annual basis) to ensure they are cost-based and to protect consumers from monopoly power of district heating providers. EWRC also reviews and approves investment plans of district heating companies and monitors their financial and technical performance. By law, EWRC must promote efficiency and fairness; it operates under principles outlined in the Energy Act and the RES Act. (Notably, EWRC decisions have facilitated the use of renewable fuels in some district heating systems by allowing cost recovery for biomass or waste-heat projects.) The regulator is independent from the executive government, and reports annually to Parliament on the state of the energy (including heating) and water sectors. EWRC's role is crucial for H&C as it can influence the economics of switching from individual heating to district heating or vice versa through its tariff policies.

The **Sustainable Energy Development Agency (SEDA)** is an executive agency under the Ministry of Energy, focused on energy efficiency and renewable energy promotion. SEDA's mandate in the heating/cooling sphere includes **implementing the Energy Efficiency Act's provisions**: it oversees energy savings obligations, maintains databases of energy consumption, and evaluates the impact of efficiency measures in households and industries. For example, SEDA collects data from energy suppliers on savings achieved (which often come from helping consumers upgrade heating appliances or insulate homes). It also administers certification programs for **energy auditors and building energy performance**, which directly affect heating demand by improving building insulation and heating system tuning. On renewables, SEDA monitors progress toward renewable heat targets and can advise on or operate incentive schemes (in the past, SEDA helped manage grant schemes for solar water heaters and biomass boilers for households). The agency has regional offices and works with municipalities by providing methodological support for local energy plans (many municipalities rely on SEDA's guidance to craft their building retrofitting and clean heat programs). Each year, SEDA publishes a report on the **status of energy efficiency** in Bulgaria, which includes statistics on heating energy consumption and savings achieved through various programs. SEDA is thus a technical backbone institution ensuring that H&C-related measures (like the national appliance replacement program or building insulation initiatives) are properly evaluated, and that Bulgaria stays on track with its energy efficiency commitments that heavily intersect with heating and cooling.

The Executive Environment Agency (ExEA (often abbreviated **EEA Bulgaria**) is a specialized agency under MOEW. It is responsible for **environmental monitoring and reporting**, which includes crucial aspects related to heating and cooling. ExEA operates the national systems for **ambient air quality monitoring** – it runs a network of monitoring stations in cities that measure pollutants like PM_{10} and NO_2, the data from which is used to assess the impact of residential heating emissions on air quality. The Agency provides the official information on air quality to the public and EU (e.g. informing whether municipalities comply with air quality standards). ExEA also compiles the country's **annual greenhouse gas inventory** and other emission inventories, which cover emissions from fuel combustion in the residential and commercial sectors. In this capacity, it quantifies the carbon impact of heating and cooling and tracks progress in emission reductions (for instance, it will quantify how the replacement of tens of thousands of coal stoves translates into CO_2 and PM emission cuts). Moreover, ExEA manages environmental data and maintains registers such as the EU Emissions Trading Scheme installations – relevant when large cogeneration plants feeding district heating are ETS-regulated. In summary, while ExEA does not directly implement H&C policies, it provides the **scientific and data support** to underpin those policies. Its air quality

measurements trigger local action (e.g. if pollution is too high, municipalities must act on heating sources), and its reporting on GHG emissions from heating informs national policy evaluation (like NECP updates).

3.3 Final energy consumption

3.3.1 Utilized fuels and technologies

Heating and cooling (H&C) sector in Bulgaria is shaped by a legacy of inefficient technologies, uneven access to infrastructure, and a fragmented policy approach. Despite recent efforts to modernize heating systems - particularly through national programmes targeting the replacement of old stoves and air pollution reduction - there remains significant untapped potential to improve overall energy efficiency. This is particularly true for firewood use, which still accounts for more than a third of all heating in occupied dwellings. Yet, firewood is largely viewed by policymakers only through the lens of urban air quality, with limited measures taken in rural or sparsely populated areas where its use is most prevalent and where illegal logging or informal supply chains persist. This creates a major policy blind spot, as more efficient firewood use-through modern stoves, improved combustion, and better insulation-could reduce overall consumption, curb emissions, and ease pressure on Bulgaria's forests.

Heating

At the national level, the most commonly used heating sources are electricity and firewood, followed by district heating.

Electricity is used both directly (resistive heaters) and via heat pumps (the vast majority being split-type room air conditioners).

Wood is combusted in stoves and boilers, often co-fired with coal. A significant proportion of the heating devices are with poor efficiency.

District heating (DH) networks are available in 12 towns. Most of the plants run on gas (CHP units and boilers), but several large plants still use coal. In some cases, biomass is also used (in separate boilers or co-fired with coal). The district heating in Sofia, which alone represents more than all other 11 altogether in terms of consumers and heat volumes, runs entirely on gas. The annual consumption of natural gas in Bulgaria is around 3 bcm and District Heating of Sofia consumes roughly a third of this quantity which is almost entirely imported.

Credible data on the shares and distribution of fuels and technologies is only available for residential buildings – country level data from the 2021 Census (NSI, 2023) is given in Table 1.

Table 1: Number and share of occupied dwellings in Bulgaria – by energy used for heating

Heat source for heating	Number of dwellings	Share of dwellings (%)
Electricity	1 241 240	47.7%
Firewood	944 332	36.3%
District heating	347 421	13.3%
Coal	125 227	4.8%
Pellets	107 812	4.1%
Natural gas network	64 945	2.5%
LPG	20 348	0.8%

* Altogether wood and coal briquettes, CNG, LFO/diesel, solar, and RES (excl. solar) represent 1%
** Respondents could select more than one option

Among the 47.7% dwellings using electricity it is not clear what is the split between resistive heaters and heat pump units, but in the same Census 43% of the dwellings declared having

an air conditioner. Notably, in the 2011 Census this share was 23% (i.e. an increase by approx. 80%). At the same time Eurostat data (Eurostat, 2024) shows that only 12% of FEC in households comes from electricity.

Most 2021 Census data (given above for residential buildings) is also available by municipalities. At that level the distribution among the utilized fuels and technologies varies widely, depending on the availability / development of district heating and gas networks, the proximity to forests / mountains (thus firewood price), and other factors. This is illustrated for three municipalities in Figure 1.

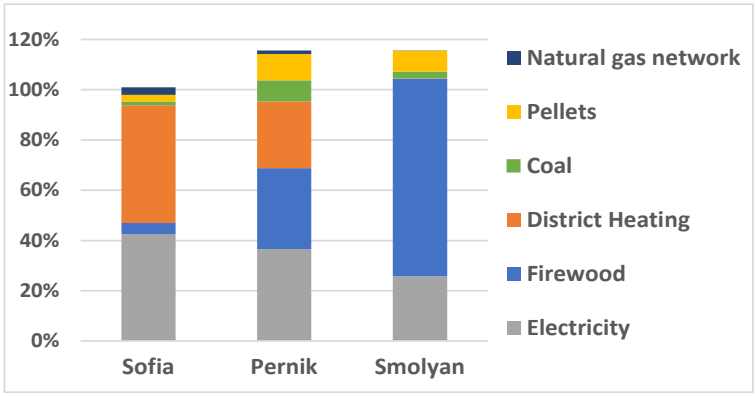


Figure 1: Share of dwellings by energy used for heating (in Sofia, Pernik, and Smolyan municipalities)

Domestic hot water

Outside DH and gas networks, the dominant technology for heating of domestic hot water are electric boilers for direct use. Such are available in 74% of all dwellings in the country and in the vast majority of non-residential buildings, that are not connected to district heating. According to Eurostat data (Eurostat, 2024), in terms of FEC electricity and DH cover 90% (61% and 29%, respectively).

Cooling

Regarding space cooling, electricity-driven compression heat pumps are the only technology of practical importance. In commercial and office buildings these are represented by air/water cooled chillers, VRFs and split type air conditioners. In residential - 43% of the dwellings have one or more air conditioners installed.

There are no existing district cooling systems in Bulgaria. However, EVN Bulgaria, through its Plovdiv-based district heating subsidiary EVN Toplofikatsia, has launched an initiative aiming to utilize the existing district heating infrastructure for space cooling purposes as well. The system uses the hot water in the district heating network to produce cold water locally in several connected buildings via absorption chillers, thus offering an alternative to conventional electricity-driven chillers. The project builds on the cogeneration capabilities of the company and represents an innovative example of decentralized trigeneration. While technical and operational details remain limited, the initiative signals an expansion of EVN's urban energy services.

Industries and power plants most commonly use evaporative cooling towers and compression chillers (both electricity-driven) along with various other technologies.

3.3.2 Building stock data

In 2023, Bulgaria had a building stock of around 4 mln. dwellings with floor area > 400 mln. m² (NSI, 2025b; DG-ENERGY, 2024). Around 76% of buildings were built before 1990, 85% - before 2000, and only 6-7% after 2010.

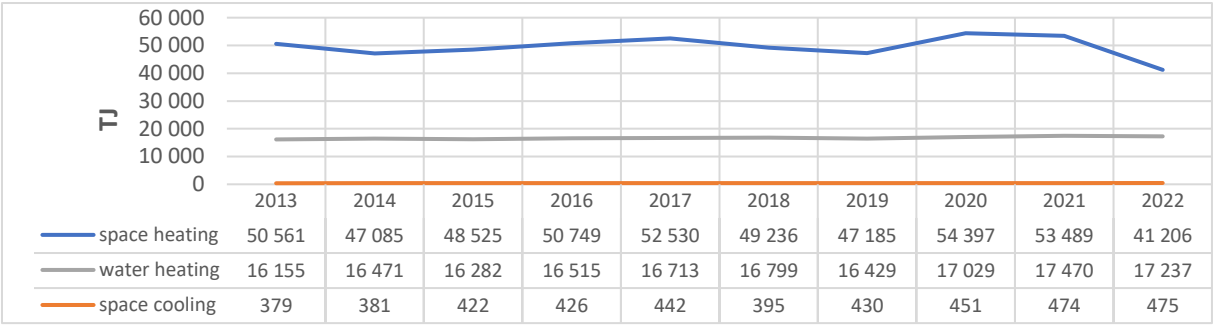
The building stock is dominated by residential buildings (97% in terms of number, and 78% in terms of floor area). Their number has grown continuously in recent decades, but according to the 2021 Census data, 39% of the dwellings are permanently unoccupied.

3.3.3 Final energy consumption data and historical trends

Historically, the specific energy consumption for heating in Bulgaria has been decreasing due to the aggregated effects of numerous factors like: population decrease, applied EE measures to buildings' envelope, the long-term practice of individual heat metering and billing, the improved end-users' awareness and control, the increasing energy prices, the growing share of heat pumps (mostly air conditioners), and considerably higher energy efficiency of new buildings, etc.

In absolute quantities however, these effects have been counteracted by the increasing building stock (respectively, more heated volumes), as well as by improved thermal comfort.

The data in Figure 2 (Eurostat, 2025) confirms the above trend for residential buildings – the quantities for space heating and water heating are fairly stable before the COVID effects in 2020.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
space heating	50 561	47 085	48 525	50 749	52 530	49 236	47 185	54 397	53 489	41 206
water heating	16 155	16 471	16 282	16 515	16 713	16 799	16 429	17 029	17 470	17 237
space cooling	379	381	422	426	442	395	430	451	474	475

Figure 2: Disaggregated H&C final energy consumption in households in Bulgaria (2013-2022)

The data above is at the national level only (not accessible by regions/municipalities).

In terms of energy sources used in households, the major trends given by statistics (Eurostat, 2025a) are:

- Growing share of electricity since 2021 (stable within 40-42% before that; 52% in 2023)
- Decreasing share of solid biomass fuels since 2021 (stable around 32-33% before that)
- Drastic decline of solid fossil fuels (coal represented 10% in 2012; < 2% in 2022 & 2023)
- Stable share of district heating (around 14%)
- Small weight of natural gas (growing from 2% in 2013 to average of 4% after 2020).

On the other hand, the cooling energy consumption in buildings has increased in the recent decade – with the increase of the purchase power and quality of life, the availability of air-conditioning in all new office/commercial buildings, and the rapid increase of the availability of air conditioners in dwellings and in old administrative buildings. For residential buildings this trend can be confirmed by the steady increase in the 2012-2022 data for electricity consumption for cooling in households (Figure 2).

Despite the above, in absolute values cooling energy consumption is still far below that for heating and hot water (especially in residential buildings, where it is in the order of 1%).

3.3.4 Planned consumption trends until 2050

Energy consumption for heating and hot water preparation is planned to decrease due mainly to the negative population growth rates and the improved energy efficiency of the building stock. Regarding the latter, the 2024 update of Bulgaria's Integrated Energy and Climate Plan (ME, MOEW, 2024) gives ambitious indicative targets for renovation of residential and non-residential building stock (Table 2). These targets have been set with a view of achieving the

country's obligations under Article 7 of Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018.

Table 2: Indicative interim targets for renovation of residential and non-residential building stock

Type	Indicator	Units	Period		
			2021-2030	2031-2040	2041-2050
Residential	Energy savings	GWh/y	2 477	5 694	6 294
	Renovated area	m^2	19 026 656	43 735 175	48 343 297
	Specific energy savings	kWh/(m^2.y)	130	130	130
Non-residential	Energy savings	GWh/y	440	808	1 035
	Renovated area	m^2	3 176 852	5 835 493	7 479 718
	Specific energy savings	kWh/(m^2.y)	139	138	138
TOTAL	Renovated % of building stock area for renovation	%	7.9	17.5	19.8

As of 2025 achieving the 2030 target seems unrealistic.

The targets are related to the 2030 targets set in the WAM scenario of the Long-Term National Strategy for Supporting the Renovation of the National Building Stock of Residential and Non-Residential Buildings by 2050 (Council of Ministers, 2021): 27.9% primary energy savings and 31.67% final energy consumption reduction for residential and non-residential buildings.

The cooling energy consumption's upward trend is planned to continue (despite the envisaged renovations), driven primarily by the increase of cooling use in households. The respective data from the 2024 update of Bulgaria's Integrated Energy and Climate Plan (ME, MOEW, 2024) is shown in Figure 3.

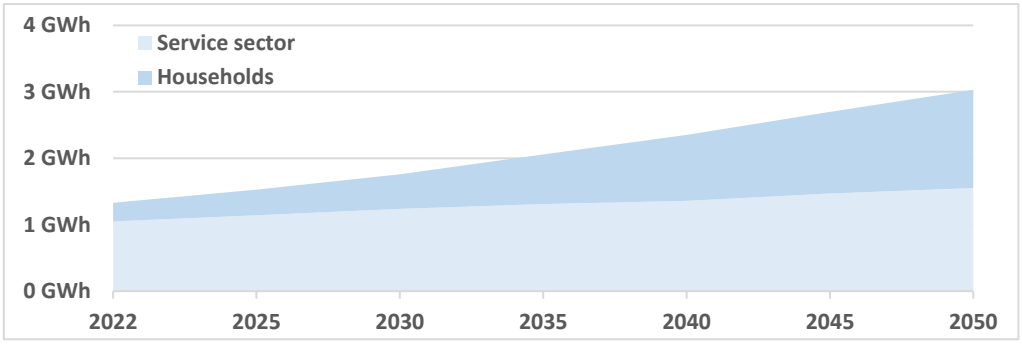


Figure 3: Planned cooling energy consumption in buildings by sector (2022-2050)

In terms of RES, the same document states that their share in the H&C sector should reach 43.66% in 2030 (being 34.88% in 2023). Increased energy production from heat pumps is projected in mid-term, and from renewable fuels of non-biological origin after 2035-2040.

3.3.5 Energy efficiency related data for building stock

Most municipalities have aggregated data on their building stock, including year of construction, functional type, ownership, total floor area, heated area, etc. All public buildings with a total floor area greater than 250 m² are obliged to perform energy efficiency audits. However, different municipalities process and summarize the data from these audits in various formats and with varying levels of detail and diligence. A centralized database is not publicly available.

Particularly for the state-owned building stock, SEDA reported (SEDA, 2025) that by the end of 2024, 22% of buildings with 34% of the floor area comply with the minimum energy characteristics' requirements. This data is available by government structures, not by municipalities.

For residential buildings statistical data at the local level is given in the 2021 Census (NSI, 2023) regarding the number and share of dwellings "with thermal insulation" and "with energy-saving windows". By 2021 at a country level these were as follows:

Table 3: Energy efficiency data for individual dwellings collected in the 2021 Census

		Yes, entirely	Yes, partially	None
with thermal insulation	% of occupied & unoccupied	24	8	68
with energy-saving windows	% of occupied & unoccupied	39	13	48
	% of occupied dwellings only	49	18	33

Based on the above, it can be estimated that at least 80% of the buildings do not comply with the minimum energy characteristics' requirements (energy efficiency class worse than "C").

The projections in Table 2 rely on 130-140 kWh/m² final energy savings resulting from building renovation, based on an implication that renovation policies should focus on buildings with energy classes E, F and G. These values are somewhat optimistic compared to:

- 100-105 kWh/m² overall weighted average projected saving, resulting from an analysis of energy audits' data published by the SEDA for 7 800 buildings built before 2010 and having EE classes worse than "C" (> 240 kWh/m²);
- 85 kWh/m² - used in a World Bank report, regarding the design for the second phase of Bulgaria's National Program for Energy Efficiency of Multifamily Buildings (World Bank, 2018).

Nevertheless, the above specific savings considered as targets at national level, should be imposed as a minimum requirement for renovations included in the heating and cooling programs/action plans at local/municipality level.

3.3.6 RES potential and utilization for heating and cooling

Solar energy

The energy from solar radiation in Bulgaria is significant - it is above the average for Europe, and about 25%-40% more compared to the Scandinavian countries.

In Bulgaria, there is already an established long-standing practice of using solar energy mostly for electricity generation and to a lesser extent for hot water for domestic needs through solar thermal systems – mainly for hotels, hospitals, kindergartens, swimming pools, and single-family residential buildings.

A typical specific final energy produced by PV and thermal solar systems are 1000-1200 kWh/(kWp.y) and 350-400 kWh/(y.m²collector area) accordingly.

Geothermal energy

EU-funded studies have identified large areas of Bulgaria as promising for geothermal energy exploration. The geothermal energy potential of the country can be divided into two promising geological provinces, to the North and South of the Balkan Mountain.

In the deeper parts of the basin in Northwestern Bulgaria, 4-6 km, the temperature is usually higher than 150°C, and in some places it can even exceed 200°C.

Both geological provinces have significant potential for deep geothermal energy for direct heat use (at a depth of 1 km to 4 km) and power generation (at a depth of 4 km to 6 km).

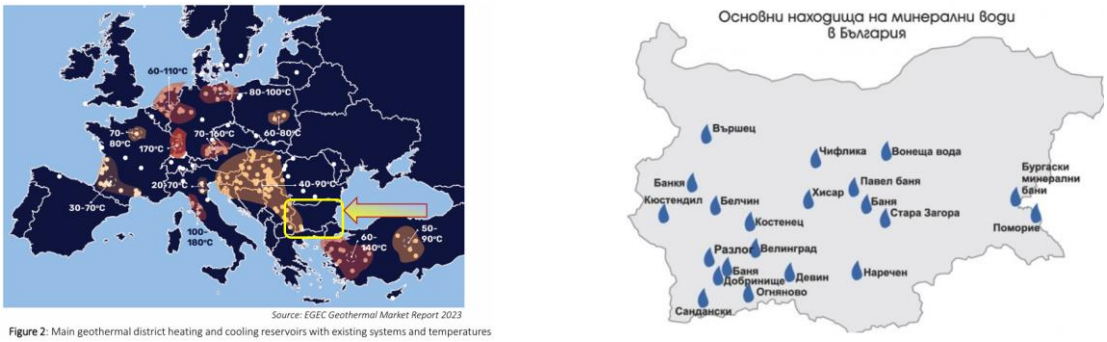


Figure 4: Allocation of geothermal energy potential in Bulgaria

The energy potential of thermal mineral waters is determined by the utilized flow rate and temperature difference (cooling) of the water.

The proven potential for hydro-thermal energy production in Bulgaria is estimated around 470 MW. The main part of the water sources (self-discharge or boreholes) is low-temperature in the range of 20–90°C. Waters with a temperature above 90°C are up to 4% of the total available flow.

Wind energy

In general, Bulgaria's wind energy potential is not significant. It is estimated that about 1 400 km² of area has an average annual wind speed of more than 6.5 m/s, which is actually a threshold for the economic feasibility of a larger scale wind energy utilization. Thus, wind energy has a moderate contribution in the country's electricity production mix (3-4%).

Biomass

In Bulgaria, there is a great potential for using biomass as an energy source, taking into account that more than 33% of the country's territory is forest areas and about 60% is agricultural arable land. Thus biomass (wood) is the largest RES contributor to the country's energy mix.

The total theoretical energy potential of biomass in Bulgaria is estimated at 3 615 ktoe, of which 550 ktoe is wood (Stoyanova M., Stefanov B., Takeva L., 2006)

Biomass – more efficient cleaner and diverse use following the sustainability criteria.

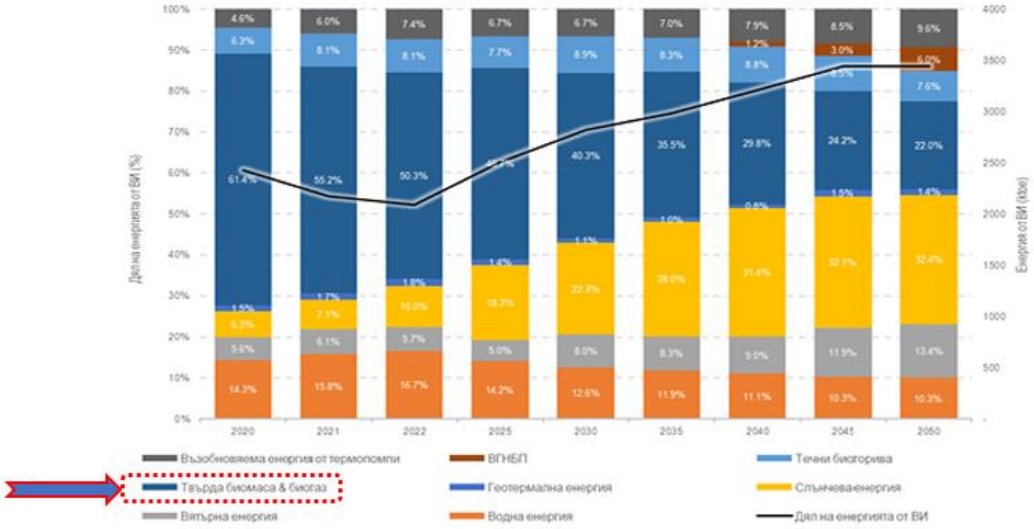


Figure 5: Indicative trend of renewable energy share in gross final energy consumption and shares of RES types in the period 2020-2050 (ME, MOEW, 2024)

Utilization of country RES potential

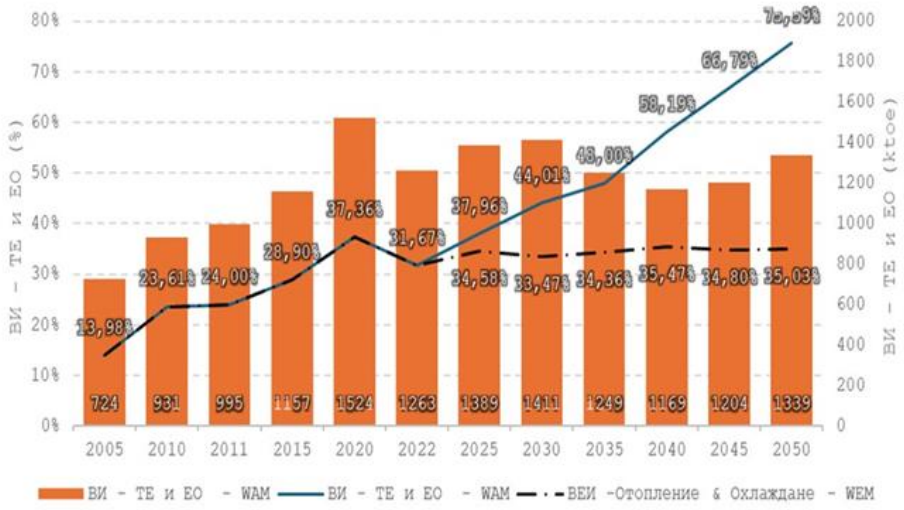
In 2022, Bulgaria occupied a position around the middle with a slightly less than 20% share of RES, being among the 17 countries in the European Union reporting shares below the EU average of 23.0%. However, in the period 2022-2030, the share of energy from renewable sources in gross final energy consumption will increase from 19.1% to 34.96%. A positive development is expected after 2030, and in 2050 the share of energy from renewable energy is expected to reach 35.4% (ME, MOEW 2024).

Renewables for heating and cooling

In terms of heating and cooling in Bulgaria, the share of RES (31.7%) is above the EU average (24.8% at the end of 2022) mainly due to the contribution of firewood.

The main trend in recent years is the sustainable growth in energy consumption from heat pumps (aerothermal and hydrothermal) in final consumption of heating and cooling energy, which in 2022 increased by 43% compared to 2017. At the same time a growing number of roof-based PV installations is also observed as an energy-saving measure, prescribed in building sector energy audits.

The current policies and measures (WEM) scenario in Bulgaria's Integrated Energy and Climate Plan (ME, MOEW 2024) are estimated to achieve an increase in the share of energy from renewable energy in the Heating and Cooling sector from 31.67% in 2022 to 33.47% in 2030, which is approximately 0.23 percentage points annually, which is lower than the requirements laid down in Directive (EU) 2023/2413. In long-term (2030-2050), the consumption of energy from renewable energy in the heat and cooling sector is expected to decrease in quantitative terms, and in 2050 it is expected to be 5% less than in 2030.



Source: Eurostat, SHARES; (B) EST model, E3-Modelling

Figure 6: Indicative trajectory for the share of RES in the gross final H&C energy consumption 2020-2050, WAM and WEM scenarios

3.4 Available support schemes

In 2015, the Council of Ministers adopted an **Energy Efficiency of Multi-Family Residential Buildings National Program** (Council of Ministers, 2015a). This program was open to all multi-family buildings, designed before April, 26, 1999, with three or more floors and at least six residential units. Eligible activities included energy efficiency improvements as recommended in energy audits, such as repair, modernization or replacement of heating

sources. The program was implemented across all 265 municipalities between 2015 and 2016, with a total budget of ca. BGN 2 billion. Despite some concerns about the success of the model adopted - 100% grant funding, unclear accountability regarding its impact, and instances of poor implementation - the Bulgarian government announced a **second phase of the program for the 2025-2029 period**.

In 2022, the Bulgarian government allocated €1.1 billion for the renovation of residential and public buildings, sourced from the National Recovery and Resilience Plan and the Operational Program "Development of the Regions" 2021–2027. These funds are intended for structural reinforcements, upgrades of heating and air conditioning systems, renewable energy installations, energy storage solutions, and integration of electric vehicle charging stations.

With an investment of EUR 879 million from the Recovery and Resilience Facility, the **Bulgaria's Recovery and Resilience Plan** (Council of Ministers, 2023) supports a comprehensive national scheme for energy efficiency renovation of residential, public and commercial buildings. Replacement of solid fuel (wood and coal) heating technologies is among the eligible measures.

The Operational Program "Development of the Regions" 2021-2027 (RDP) aims to create vibrant, economically strong and sustainable regions addressing negative demographic trends and regional disparities. The program provides funding through grants, financial instruments and budgetary guarantees (e.g. loan, debt, guaranty and equity investment). All urban municipalities in Bulgaria are eligible for funding under the RDP, with beneficiaries including governmental bodies, regional and local authorities, civil society (NGOs, employers' and trade union organisations, foundations), business, scientific community, associations of condominium owners.

Under Priority 1 – *Integrated urban development*, the ten large municipalities will receive support, with funding based on their territorial strategies (Municipal Integrated Development Plans) developed by municipal administrations. All other medium and smaller 40 urban municipalities will be supported under Priority 2 – *Integrated territorial development* of NUTS 2 regions. Both priorities foresee support of measures relating to energy efficiency and sustainable renovation of residential and public buildings, including student and school dormitories: awareness-raising campaigns and all types of EE measures in buildings, including structural (and seismic) reinforcement, heating and air-conditioning systems, integrated on-site renewable energy installations, electric vehicle charging equipment, digitalization of buildings, green infrastructure, etc.

Priority 4 – *Just transition* targets municipalities most affected by the energy transition, specifically Pernik, Kyustendil and Stara Zagora, as well as the ten municipalities in the Maritsa East coal basin. One of the supported measures includes improvement of energy efficiency in buildings (incl. RE heating) and promotion of energy communities and prosumers.

Operational Programme "Environment" 2021-2027 Bulgaria's Environment Programme 2021–2027 (Operational Programme "Environment") features a dedicated Priority Axis 5, titled "Air," which aims to improve ambient air quality through targeted interventions. At the heart of this priority is a large-scale initiative to replace outdated and polluting domestic heating systems—typically wood- and coal-fired stoves and boilers—with cleaner alternatives in residential households. The programme provides full grants to eligible households in selected municipalities to exchange their old heating appliances for modern, eco-friendly systems such as high-efficiency air-to-air heat pumps, pellet stoves, and other low-emission technologies. In return, beneficiaries are required to permanently decommission their old solid-fuel stoves, which are collected and scrapped to ensure they are not reused or resold.

This initiative is expected to support the transition of approximately 85,000 households from polluting heating methods to cleaner alternatives, significantly surpassing the 16,500 replacements carried out under the previous programming period (2014–2020). The replacement projects are being implemented in 21 municipalities identified as having persistently poor air quality due to high levels of particulate matter (PM_{10}), as recognized in an EU Court of Justice ruling against Bulgaria. These municipalities include Asenovgrad, Blagoevgrad, Burgas, Dimitrovgrad, Gorna Oryahovitsa, Haskovo, Kardzhali, Lovech, Montana, Nesebar, Pazardzhik, Pernik, Pleven, Plovdiv, Ruse, Shumen, Smolyan, Sofia (Stolichna Municipality), Veliko Tarnovo, Vidin, and Vratsa.

The total budget allocated for the heating replacement measure is BGN 610 million (approximately EUR 300 million) for the 2021–2027 period. Each municipality acts as both intermediary and project beneficiary, managing the programme at the local level. They are responsible for procuring appliances, hiring contractors for installation, managing outreach and household applications, and verifying that all eligibility criteria are met. Municipalities must also ensure the complete removal and dismantling of old heating devices and guarantee that new installations comply with all technical and environmental standards.

As of 2025, the “For Cleaner Air” heating replacement programme is well underway. The call for municipal project proposals was a one-time process, which closed in 2023, and is no longer open to new participants. All 21 selected municipalities have secured funding and have launched implementation phases, with household replacements actively taking place across the country.

The Energy Efficiency and Renewable Sources Fund (EERSF) established through the Energy Efficiency Act in 2004, functions as a lending institution, a credit guarantee facility and a consulting company. It provides technical assistance to Bulgarian enterprises, municipalities and private individuals in developing energy efficiency investment projects and then assists their financing, co-financing or plays the role of guarantor in front of other financing institutions. The financial resources of EERSF are being used to finance investments in (1) rehabilitation of buildings and (2) improvements to the heat source and distribution system.

In November 2024, the Ministry of Energy published a draft Indicative Work Program for the support of projects from the Modernization Fund for the period 2025-2026. The program proposes support for investments in RE heating and cooling (according to art. 10, para 2 (b) of Directive 2003/87/EU), with an indicative budget of EUR 310 mln., though further details are yet to be released.

In May 2023, the EU adopted Regulation (EU) 2023/955, establishing a Social Climate Fund as part of the Fit for 55 package. The fund will support measures and investments to reduce emissions in the road transport and building sectors, helping vulnerable households, micro-enterprises and transport users affected by the inclusion of GHG from these sectors in the EU Emissions Trading System. Each Member State should submit a Social Climate Plan by 30 June 2025, detailing how they will mitigate the impact of carbon pricing. Eligible measures include, among others, “building decarbonization, such as electrification of heating, cooling and cooking through access to affordable and energy-efficient systems” and “integrating renewable energy generation and storage, including through renewable energy communities, citizen energy communities and other active customers to promote self-consumption of renewable energy”. The fund allocates a maximum of €65 billion for the period from from 1 January 2026 to 31 December 2032. Member States must contribute at least 25% of the estimated total costs of their plans. The government of Bulgaria has defined the roles and responsibilities of the relevant bodies through an ordinance as of April 2025 but it remains unclear whether the country will provide the plan in time.

Energy and environmental projects will continue to be supported under the EEA Financial Mechanism/Norway Grants during the new 2021-2028 period (EEA Grants, 2025). The overall thematic priorities include: European green transition; Democracy, rule of law and human rights; and Social inclusion and resilience. The support for Bulgaria amounts to EUR 260 mln. The exact definition of priorities and allocation of the financial resources for Bulgaria are currently under negotiation but support for energy communities . In the previous programming period, the "*Renewable energy, energy efficiency, energy security*" program supported projects related to the use of geothermal energy for heating or for heating and cooling in state or municipally owned buildings, increasing energy efficiency in buildings and industry were supported.

3.5 GAP analysis

Policy and regulatory gaps

While the Integrated Energy and Climate Plan (NECP) 2021–2030 acknowledges the importance of integrating various energy sectors, it lacks comprehensive policies starting from the top level energy system integration perspective of heating and cooling. Moreover, Bulgaria does not have a dedicated national strategy for heating and cooling, which hampers coordinated efforts across different governance levels.

The transposition of key EU directives remains incomplete and disfunctional. The Renewable Energy Directive III (RED III) has not been fully transposed into national legislation, leading the European Commission to refer Bulgaria to the Court of Justice of the EU. Although the NECP sets a 44.01% renewable energy target for the heating and cooling sector by 2030, it lacks detailed measures for achieving the incremental annual increases mandated by RED III. Similarly, the revised Energy Efficiency Directive (EED) introduces new obligations, such as mandatory heating and cooling assessments and the development of municipal heating and cooling plans for municipalities with population over 45,000, which are still pending transposition. The revised Energy Performance of Buildings Directive (EPBD), which came into force on 28 May 2024, sets out more ambitious objectives, including zero-emission standards for new buildings and the phase-out of fossil fuel boilers by 2040. Bulgaria is currently in the process of transposing these provisions into national law.

Market and infrastructure barriers

Efficient and clean heating technologies - such as heat pumps, solar thermal collectors and efficient biomass boilers - are generally available but often come at high prices due to limited competition and even more so on system engineering where capacity and installation requirement are tailored to the customer. Additionally, there is a shortage of qualified installers, leading residents to often carry out installation works themselves, which can compromise system performance and safety. While some distributors offer installation services, others do not, further complicating the adoption of these technologies.

The liberalisation of the power market in Bulgaria is only partial, making it the last EU country with regulated energy market. This creates a two-way distortion: on one hand, it promotes the electrification of heating and cooling as electricity is relatively cheap and affordable; on the other, it disincentivizes the behavior that can help balance electricity use during peak demand. Moreover, the market is not oriented towards energy service companies (ESCOs), limiting opportunities for performance-based contracting and third-party financing.

Financial and consumer-level barriers

At the consumer level, several barriers hinder the replacement of heating systems. Environmental awareness among consumers is generally low, although it is improving,

especially in towns with high air pollution levels. However, awareness of health issues related to the direct use of gas at home and the climate footprint of gas remains limited. Gas is often labelled as the ultimate and no regret option for clean heating and the debate to phase out fossil-fuel boilers remains . Information about available technologies and funding is increasing due to the higher penetration of modern technologies, but there is a lack of one-stop-shops to provide comprehensive guidance.

The short investment horizon prevents households from appreciating the long-term benefits, such as increased comfort and improved energy security at the micro-level, of the clean and efficient technologies that require bigger upfront investment. The financial feasibility of replacement is affected by the lower price of inefficient fire stoves, as well as the relatively low price of coal briquettes and firewood. It remains uncertain when these types of technologies will be banned from the market and to what extend such bans would be enforced. Access to affordable financing is limited, with few opportunities to receive partial grants, sometimes combined with loans. The previously mentioned **Ordinance No. RD-07-5 for energy aid** (MLSP, 2008) has been criticized for creating a perverse incentive. By providing financial support without mandating or encouraging the adoption of energy-efficient heating solutions, it may inadvertently discourage investments in cleaner technologies. Beneficiaries might continue using inefficient and polluting heating fuels, such as wood and coal in substandard stoves, and electricity through inefficient appliances, as the assistance covers their costs, thereby undermining efforts to promote sustainable heating practices.

There is an absence of a regulatory framework that facilitates pilot projects, scaling mechanisms, or regulatory sandboxes tailored to H&C innovations. This gap restricts municipalities and energy providers from experimenting with or adopting advanced technologies such as industrial heat pumps, geothermal systems, low temperature district heating, or solar thermal collectors.

Financial support mechanisms for energy efficiency and renewable energy sources (RES) in residential and small and medium-sized enterprises (SMEs) sectors are characterized by intermittent funding cycles and administrative delays. Such inconsistencies erode stakeholder confidence and impede long-term planning. While the Energy Efficiency and Renewable Sources Fund (EERSF) offers some financial products, there is a lack of dedicated instruments specifically designed to support municipal-level H&C initiatives.

The integration of H&C considerations into municipal spatial and urban planning is limited. Although municipalities are mandated to develop energy efficiency and RES programs, these often lack specific requirements related to spatial mapping and planning for the H&C sector. Consequently, municipal programs tend to focus on publicly owned buildings and assets, with limited authority to implement measures in the private sector. This situation is compounded by insufficient technical support, limited financial resources, and inadequate access to quality data, all of which are necessary for effective H&C planning at the local level.

The relatively recent introduction of municipal programs for replacing old heating devices has yet to compensate for years of accumulated inaction. A significant shortcoming of the current public funding approach is its exclusive focus on energy poverty and the provision of 100% grants. This model leaves homeowners with no flexibility to influence the choice of technology or provider, and it prevents them from contributing additional funds to upgrade to higher-quality or more suitable heating solutions. As a result, it misses a key opportunity to engage and incentivize the middle class. Additionally, Bulgaria lacks tax incentives for green technologies, including in the heating and cooling sector. Measures such as reduced VAT on energy-efficient appliances—already adopted by several EU countries, including neighboring Romania—have not yet been considered.

There are currently no comprehensive plans for transitioning to fourth or fifth-generation district heating systems in Bulgaria. The existing district heating infrastructure, particularly in cities like Sofia, continues to rely heavily on fossil fuels, with limited integration of renewable energy sources. This reliance underscores the need for strategic planning and investment to modernize the H&C sector and align it with broader decarbonization goals.

4 Current H&C status in Croatia

4.1 H&C policy framework

National level

The Republic of Croatia has adopted several strategic documents relevant to the heating and cooling sector, with the most significant documents outlined below.

Heating and cooling, in accordance with the **Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050**[5], adopted pursuant to the Energy Act, play a key role in achieving decarbonisation and energy transition objectives. As the building sector - primarily through heating and cooling demands - accounts for a significant share of total final energy consumption, the transformation of this sector is of strategic importance. The main goals include improving energy efficiency, integrating renewable energy sources (RES), modernising thermal systems, and developing a supportive institutional and financial framework. The energy renovation of buildings is recognised as a cornerstone for reducing thermal energy demand, while the modernisation and development of efficient district heating and cooling systems are highlighted as key mechanisms of the energy transition. This approach enables greater integration of RES, utilisation of waste heat, reduction of technical losses, and enhanced supply reliability.

In the updated **Integrated National Energy and Climate Plan of the Republic of Croatia for the period 2021–2030**[6], the heating and cooling sector is recognised as one of the key areas for increasing the share of renewable energy sources and achieving climate targets. In accordance with the obligation under Directive (EU) 2018/2001, Croatia must ensure an annual increase in the share of renewable energy sources in heating and cooling of at least 1.3 percentage points, or 1.1 percentage points if waste heat is not utilised. The share of renewables in gross final energy consumption for heating and cooling amounted to 38.0% in 2021, while the target for 2030 has been set at 47.1%.

The **Energy Efficiency Programme for the Decarbonisation of the Energy Sector**[7] was adopted in November 2021, emphasising that heating and cooling in Croatia represent 70% of total final energy consumption in the household, services, and industry sectors. Furthermore, the Programme states that in the household sector, heating and cooling constitute as much as 80% of total final energy consumption; in the services sector approximately 60%; and in industry around 75%. It is also noted that thermal energy needs for heating and cooling in Croatia are only partially met through district heating systems (DHS). In the household sector, DHS represents 6.09% of total delivered energy for heating and cooling; in the services sector, this share is 6.99%; and in industry, 7.35%. The Programme includes proposed measures for improving the energy efficiency of district heating systems for the period up to 2030, as well as for the period from 2031 to 2050, along with investment estimates.

The **Long-Term Renovation Strategy of the National Building Stock until 2050**[8] is a key strategic document guiding the transformation of the existing building stock towards a highly energy-efficient and decarbonised state, in line with European and national climate and energy objectives. The primary goal is to identify and implement effective measures to support the long-term promotion of cost-effective, integrated renovation of the national building stock. The strategy foresees a gradual increase in the building renovation rate, starting from 1% in 2020,

[5] Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050
[6] Integrated National Energy and Climate Plan of the Republic of Croatia for the period 2021–2030
[7] Energy Efficiency Programme for the Decarbonisation of the Energy Sector
[8] Long-Term Renovation Strategy of the National Building Stock until 2050

with the objective of reaching an annual renovation rate of 4% by 2050. This renovation trajectory is aligned with the goal of reducing greenhouse gas emissions by 80% by 2050.

Pursuant to the Building Act, the **Energy Renovation Programme for Multi-Apartment Buildings for the period until 2030**[9] was adopted in December 2021. This Programme constitutes a key strategic document aimed at improving the energy performance of multi-apartment buildings, which make up approximately 35% of the total residential building stock and about 27% of the overall building stock in the Republic of Croatia. Approximately 32% of the total delivered energy in the household sector is attributed to multi-apartment buildings, with around 80% of that energy used to meet thermal needs - namely space heating and cooling, as well as domestic hot water preparation.

The **Energy Renovation Programme for Public Sector Buildings for the period until 2030**[10] was adopted in March 2022, pursuant to the Building Act. It represents a key strategic document that defines the goals, measures, and activities aimed at improving the energy performance of public sector buildings in the Republic of Croatia. An analysis of the current state indicates that the total primary energy consumption for thermal needs - namely heating, cooling, ventilation, domestic hot water preparation, and lighting - for 16,099,527 m² of public sector buildings prior to renovation amounts to 3,593 GWh annually, resulting in 602,804 tonnes of CO_2 emissions. The delivered energy required to meet the energy needs of these buildings totals 2,621 GWh per year.

In March 2023, pursuant to the Act on the Exploration and Exploitation of Hydrocarbons, the **Geothermal Potential Development Plan in the Republic of Croatia until 2030**[11] was adopted. The objective of the Plan is to promote the development and utilisation of geothermal energy as a domestic renewable energy source, particularly for heating and cooling purposes, thereby contributing to the decarbonisation of the energy sector and the improvement of energy efficiency. Croatia - especially the Pannonian Basin region - possesses significant geothermal potential. The temperature gradient in this area is 60% higher than the European average, enabling the broad application of geothermal energy in heating and cooling systems.

Municipal planning and local initiatives

When it comes to strategic documents at the local level, the City of Rijeka has, in recent years, developed several important documents aimed at achieving decarbonisation within its territory. A more detailed overview of two key documents is provided below.

The **Development Plan of the City of Rijeka for the period 2021–2027**[12] is a strategic document that guides the city's development towards sustainability, resilience, and digitalization. The document includes measures defined in the Sustainable Energy and Climate Action Plan (SECAP) previously developed by the City of Rijeka. One of the measures identified in this strategic document is the enhancement of district heating system efficiency through the renovation, reconstruction, and upgrade of the district heating infrastructure in Rijeka. The aim is to further improve the system's energy efficiency, increase the share of renewable energy sources, and enhance the quality of heating services provided to end users.

In 2020, the City of Rijeka prepared a **Sustainable Energy and Climate Action Plan (SECAP)**[13] for the period up to 2030, which will serve as the foundation for a series of three-year and annual Energy Efficiency Action Plans that the City is required to develop and

[9] Energy Renovation Programme for Multi-Apartment Buildings for the period until 2030
[10] Energy Renovation Programme for Public Sector Buildings for the period until 2030
[11] Geothermal Potential Development Plan in the Republic of Croatia until 2030
[12] Development Plan of the City of Rijeka for the period 2021–2027
[13] Sustainable Energy and Climate Action Plan (SECAP)

implement under national regulations. SECAP is a strategic document that outlines 24 measures aimed at improving energy efficiency and mitigating climate change. The mitigation measures implemented by 2030 are expected to result in a 47.32% reduction in CO_2 emissions compared to the baseline year of 2008. In the building sector, 15 measures have been selected. In addition to the already initiated integrated energy renovation of public, residential, and commercial buildings, plans include increased deployment of renewable energy sources for electricity production, the replacement of existing fossil fuel-based heating systems with renewable alternatives, improved efficiency of district heating, and a range of non-technical measures focused on education and public awareness.

The **Implementation Programme of the City of Rijeka for the 2021–2025 term**[14] is a key strategic planning document that defines the city's development priorities and measures. In the context of building renovation and the heating and cooling sector, the programme emphasizes energy efficiency, the use of renewable energy sources, and infrastructure modernization. The programme recognizes the need to renovate the existing building stock, with a particular focus on improving energy performance. Planned measures include the energy renovation of public buildings, the modernization of the district heating system, the integration of renewable energy sources, and the promotion of energy-efficient technologies.

A notable local initiative is the signing of a **Cooperation Agreement on the Development of Smart Energy Decarbonisation Systems** between Primorje-Gorski Kotar County, the City of Rijeka, and the Faculty of Engineering at the University of Rijeka. The agreement was signed in 2023 with the aim of creating a CO_2 neutral area at the local and regional self-government levels and achieving a long-term reduction in dependence on imported energy sources. The initiative promotes strategic energy planning with objectives that include the decarbonisation of the energy sector, sustainable use of domestic natural energy resources, efficient energy use, and reduction of the environmental impact of fossil fuel consumption. (www.rijeka.hr)

4.2 Legislative framework

National legislation

The **Building Act**[15] regulates the design, construction, use, and maintenance of buildings, as well as the implementation of administrative and other related procedures, with the aim of ensuring spatial protection and development in accordance with regulations governing spatial planning, and of meeting the essential requirements for buildings and other conditions prescribed for construction works. The Act defines the term "technical building system" as the technical equipment of a building or an independent functional unit within a building intended for space heating, space cooling, ventilation, air conditioning, domestic hot water preparation, built-in lighting, building automation and control, on-site electricity generation, or any combination thereof, including systems that use energy from renewable sources.

The **Spatial Planning Act**[16] regulates the spatial planning system, including its objectives, principles, and stakeholders; the monitoring of the spatial situation and developments within the spatial planning domain; planning requirements; the adoption of the Spatial Development Strategy of the Republic of Croatia; spatial plans, including their preparation and adoption procedures; the implementation of spatial plans; the regulation of building land; property law instruments related to the regulation of building land; and oversight.

[14] Implementation Programme of the City of Rijeka for the 2021–2025 term
[15] Building Act
[16] Spatial Planning Act

The **Energy Act**[17] constitutes the fundamental legal framework for regulating the energy sector, including energy production, distribution, and supply. Although it does not contain detailed provisions specific to heating and cooling, the Heat Energy Market Act and the Energy Efficiency Act complement this framework with a particular focus on these aspects.

The **Heat Energy Market Act**[18] regulates measures to ensure the secure and reliable supply of heat energy, the operation of thermal systems for the utilisation of heat energy for heating and cooling, the conditions for obtaining concessions for the distribution of heat energy and the construction of distribution networks, as well as the rules and measures for the safe and reliable performance of heat energy production, distribution, and supply within thermal systems. It also prescribes measures aimed at achieving energy efficiency in thermal systems. Article 5, paragraph 9 of the Act stipulates that local self-government units with a population exceeding 35,000 must develop heating and cooling plans.

The **Energy Efficiency Act**[19] constitutes the fundamental legal framework of the Republic of Croatia for promoting the efficient use of energy, including in the heating and cooling sector. This Act defines efficient heating and cooling as a system that, compared to a baseline scenario reflecting standard practice, measurably reduces the consumption of primary energy required to supply one unit of delivered energy within the relevant system boundary cost-effectively. This is determined following a cost-benefit analysis as prescribed by the legislation governing the heat energy market, and considering the energy required for extraction, conversion, transmission, and distribution.

The **Renewable Energy Sources and High-Efficiency Cogeneration Act**[20] establishes the legal framework for promoting renewable energy sources and high-efficiency cogeneration. The objective of the Act is to encourage sustainable energy production and consumption, reduce greenhouse gas emissions, and improve energy efficiency, including within the heating and cooling sector. The Act promotes the integration of renewable energy sources into heating and cooling systems. It recognises the importance of developing and modernising district heating and cooling systems based on renewable energy sources and high-efficiency cogeneration.

The **Act on the Exploration and Exploitation of Hydrocarbons**[21] regulates the exploration and exploitation of hydrocarbons and geothermal waters for energy purposes, including heating and cooling.

Key regulations

The key implementing regulations in the Republic of Croatia governing the heating and cooling sector are as follows:

- Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings
- Ordinance on Energy Audits of Buildings and Energy Certification
- Ordinance on the Energy Savings Monitoring, Measurement and Verification System
- General Conditions for the Supply of Heat Energy
- General Conditions for the Delivery of Heat Energy
- Network Rules for Heat Energy Distribution
- Methodology for Determining Tariff Item Amounts for Heat Energy Distribution
- Methodology for Determining Tariff Item Amounts for Heat Energy Production

[17] Energy Act
[18] Heat Energy Market Act
[19] Energy Efficiency Act
[20] Act on Renewable Energy Sources and High-Efficiency Cogeneration
[21] Act on the Exploration and Exploitation of Hydrocarbons

- Decision on the Manner and Procedure for Maintaining Separate Accounts of Energy Entities
- Methodology for Determining the Connection Fee to the Heat Distribution Network and for Increasing Connection Capacity

Government and regulatory authorities

The **Ministry of the Economy** (www.mingo.gov.hr) performs administrative, professional, and other tasks related to the development and enhancement of the competitiveness of the Croatian economy, industrial policy, the promotion of innovation and new technologies, as well as the stimulation of entrepreneurship and crafts. In the field of energy, the Ministry places particular emphasis on ensuring energy security and a reliable energy supply, as well as on improving energy infrastructure in line with the needs of economic development. The Ministry of the Economy plays a key role in the development and regulation of the heating and cooling sector through research and development of geothermal energy, modernization of thermotechnical systems, implementation of energy efficiency programs, and regulation of the thermal energy market.

The **Ministry of Physical Planning, Construction and State Assets** (www.mpgi.gov.hr) is responsible for matters related to spatial planning, construction, housing, and the management of state assets in the Republic of Croatia. Within its scope of responsibilities, the Ministry plays a key role in promoting energy efficiency in the building sector, particularly in the heating and cooling segment. The Ministry implements policies and programs aimed at increasing the energy efficiency of buildings, including energy renovation programs for single-family homes and multi-residential buildings, which involve measures such as improving thermal insulation and modernizing heating and cooling systems. It also manages the building energy certification system and promotes the construction and renovation of buildings in accordance with nearly zero-energy standards.

The **Ministry of Environmental Protection and Green Transition** (www.mzozt.gov.hr) of the Republic of Croatia is responsible for the preservation of natural resources, environmental and nature protection, as well as the promotion of sustainable development and climate change adaptation. Its scope of responsibilities includes tasks related to the protection of air, soil, and water, waste management, climate change mitigation, water management, and marine protection. In the context of heating and cooling, plays a key role through the implementation of measures and strategies aimed at reducing greenhouse gas emissions. This includes promoting energy efficiency in heating and cooling systems and the transition to renewable energy sources, as well as the use of resources from the Modernisation Fund, the Innovation Fund, and the Environmental Protection and Energy Efficiency Fund. These initiatives support the modernization of heating and cooling systems and involve collaboration with other institutions in financing projects that contribute to reduced energy consumption in the heating and cooling sector.

The **Ministry of Finance** (www.mfin.gov.hr) is responsible for the preparation and implementation of the Government's fiscal policy, with the aim of contributing to stable economic growth, increased prosperity, and improved quality of life and employment for all Croatian citizens. One of the Ministry's most important tasks is the preparation of the state budget and the management of budget revenues and expenditures, i.e., taxpayer funds. Although the Ministry of Finance does not directly manage the heating and cooling sector, it plays a key role in financing and supporting energy efficiency and green transition projects. Through state aid and budgetary resources, the Ministry enables the implementation of

programs that include the modernization of heating and cooling systems, improvements in energy efficiency, and the use of renewable energy sources.

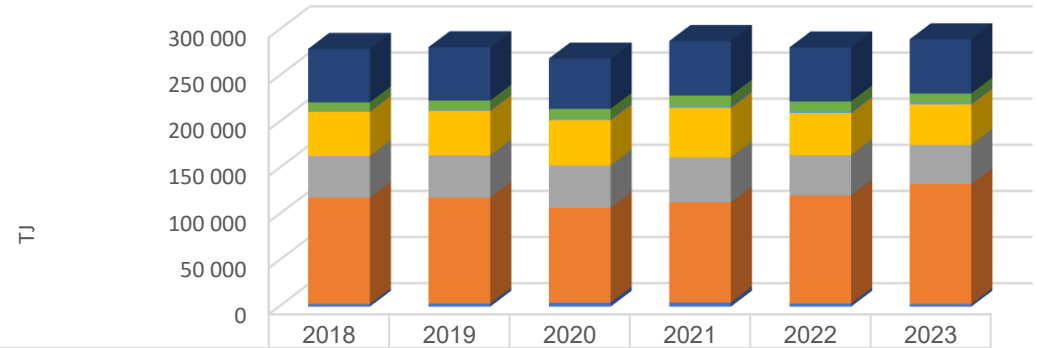
The **Croatian Energy Regulatory Agency** (www.hera.hr) is an independent public institution established under the Energy Activities Regulation Act. It operates as the national regulator of the energy sector, with the aim of ensuring the security, reliability, and transparency of the energy market in the Republic of Croatia. Agency reports to the Croatian Parliament, and its operations are managed by a Management Board appointed by the Parliament. In the heating and cooling sector, HERA plays a key regulatory role through the regulation of the district heating sector, the promotion of the use of renewable energy sources, and the monitoring of the thermal energy market.

The **Environmental Protection and Energy Efficiency Fund** (www.fzoeu.hr) is a key institution in Croatia for financing and implementing projects focused on environmental protection, energy efficiency, and the use of renewable energy sources. It manages funds from both national sources and EU funding mechanisms. FZOEU plays a significant role in the modernization of heating and cooling systems through activities such as the energy renovation of single-family homes, programs for energy-poor households, co-financing of photovoltaic power plants, and the promotion of energy efficiency in public buildings.

4.3 Final energy consumption

4.3.1 Utilized fuels and technologies

Croatia's final energy consumption has shown modest but consistent growth in recent years, increasing at an average annual rate of 0.7% between 2018 and 2023. In 2023, total final energy consumption reached 289.915 TJ, marking a 3.1% increase compared to the previous year. This growth was driven primarily by a notable rise in petroleum product consumption, which surged by 11,1% in 2023 and now accounts for 44.8% of total final energy use—the highest share among all energy sources (Figure 7).



	2018	2019	2020	2021	2022	2023
Electricity	57 921	57 862	54 474	59 054	58 481	58 730
Steam and hot water	9 454	10 015	10 597	11 442	10 607	9 813
Non-renew. waste	818	1 129	1 630	1 892	1 935	2 070
Renewables and biofuels	48 061	48 246	49 165	53 740	45 748	43 939
Natural gas	45 049	45 829	46 060	48 699	43 885	42 535
Petroleum products	115 303	114 797	102 691	108 658	117 052	130 012
Coal and coke	2 882	3 436	4 395	4 558	3 382	2 817

Figure 7: Final energy consumption per fuel in Croatia (Source: author's own processing based on data from Energy in Croatia 2023)

Electricity is the second most significant energy source, representing 20,3% of final consumption in 2023. Its use has remained relatively stable over the period, with only minor fluctuations and a negligible overall increase of 0,3% since 2018. Renewables and biofuels, while still a key component of Croatia's energy mix, have experienced a downward trend, falling by 1,8% over the five-year period and by 4% in 2023 alone. Their share in final energy consumption now stands at 15,2%. This decline is notable given Croatia's strategic goals to increase the use of renewables.

Natural gas consumption has also decreased, with a 1,1% drop since 2018 and a 3,1% reduction in 2023, now accounting for 14,7% of the total. The reduction in gas use may reflect both efficiency improvements and shifts in the industrial and residential sectors.

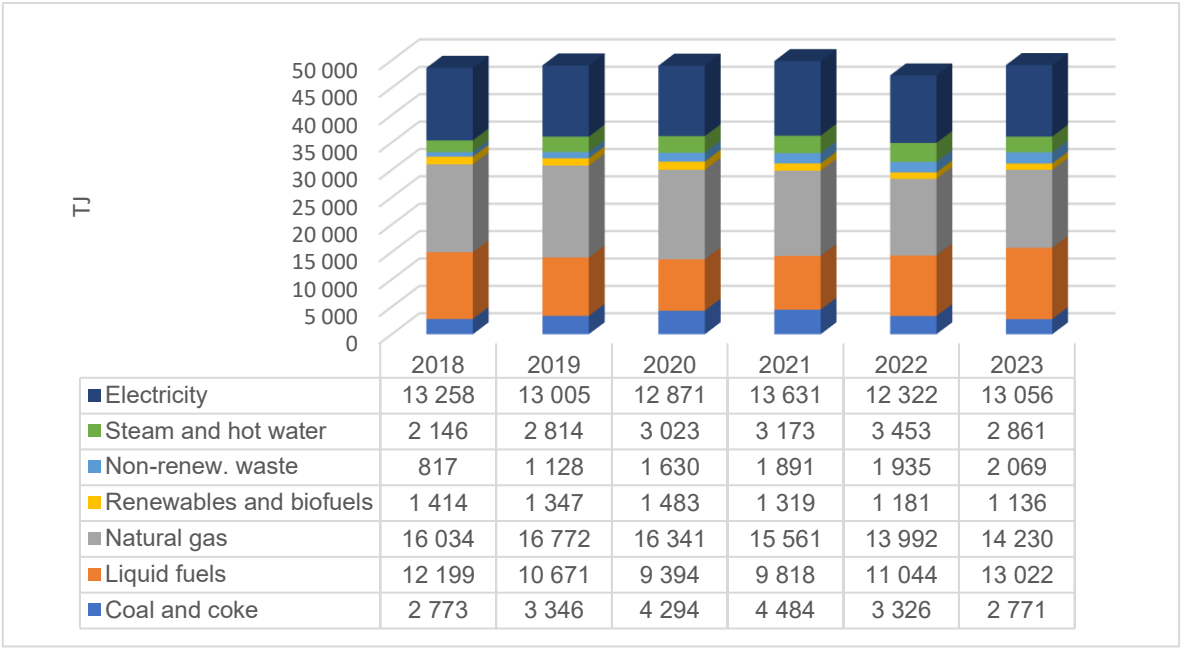
Coal and coke, once a more prominent part of the Croatian energy mix, have seen a marked decline—falling by 0,5% annually on average and dropping by 16,7% in 2023 alone. This trend is in line with national and EU-level decarbonization policies and the gradual phase-out of coal in favor of cleaner alternatives.

Non-renewable waste, though still a minor component at less than 1% of the total, has shown the fastest growth rate, increasing by 20,4% over the five-year period. This reflects broader efforts to utilize waste-to-energy technologies, although its overall impact on the energy mix remains limited.

Finally, the use of steam and hot water, which is closely linked to district heating systems, has remained broadly stable, with only a slight increase of 0,7% since 2018 and a 7,5% decrease in 2023. This stability suggests that while district heating remains an important element of Croatia's energy infrastructure, there has been limited expansion or modernization in recent years.

Industry sector

In the industry sector, the final energy consumption increased at an average annual rate of 0,2 per cent from 2018 until 2023. In 2023, energy consumption in the industry increased by 4 per cent compared to the previous year. Figure 8 presents trends in the consumption of energy forms within the total final energy consumption in industry in the period from 2018 to 2023. In the stated period, the shares of liquid fuels, non-renewable waste, steam and hot water increased. In contrast, the shares of natural gas, renewable sources and electricity decreased, and shares of coal and coke remained unchanged.



	2018	2019	2020	2021	2022	2023
Electricity	13 258	13 005	12 871	13 631	12 322	13 056
Steam and hot water	2 146	2 814	3 023	3 173	3 453	2 861
Non-renew. waste	817	1 128	1 630	1 891	1 935	2 069
Renewables and biofuels	1 414	1 347	1 483	1 319	1 181	1 136
Natural gas	16 034	16 772	16 341	15 561	13 992	14 230
Liquid fuels	12 199	10 671	9 394	9 818	11 044	13 022
Coal and coke	2 773	3 346	4 294	4 484	3 326	2 771

Figure 8: Final energy consumption in the industry by energy form (Source: author's own processing based on data from Energy in Croatia 2023)

Natural gas (29,0%), electricity (26,6%) and liquid fuels (26,5%) were the major energy sources in the industry final energy consumption.

Out of a total of 49.148 TJ of final energy consumed in the industry sector, 52%, or 25,563 TJ, is used for heating, cooling, and domestic hot water. The largest share of energy is consumed for heating in the production processes, accounting for as much as 87,3%. The rest is used for space heating and domestic hot water preparation (7,6%), cooling in the production processes (3,6%), and space cooling (1,5%) as shown in Figure 9.

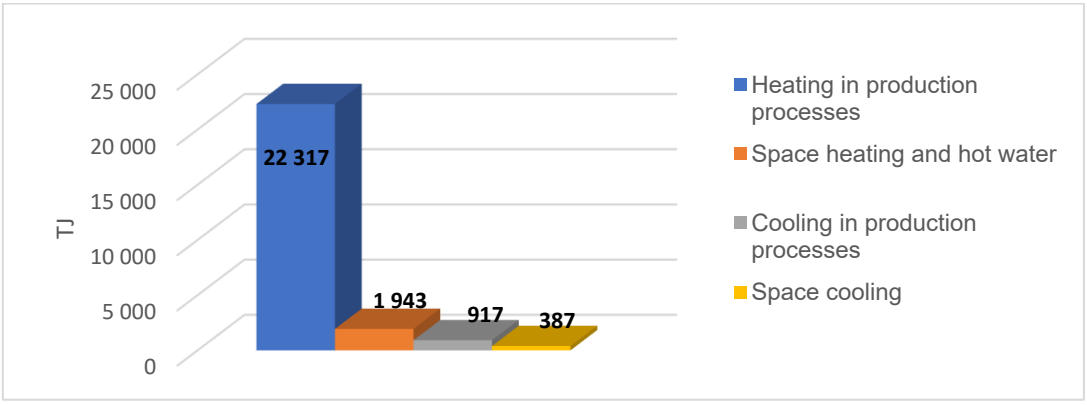


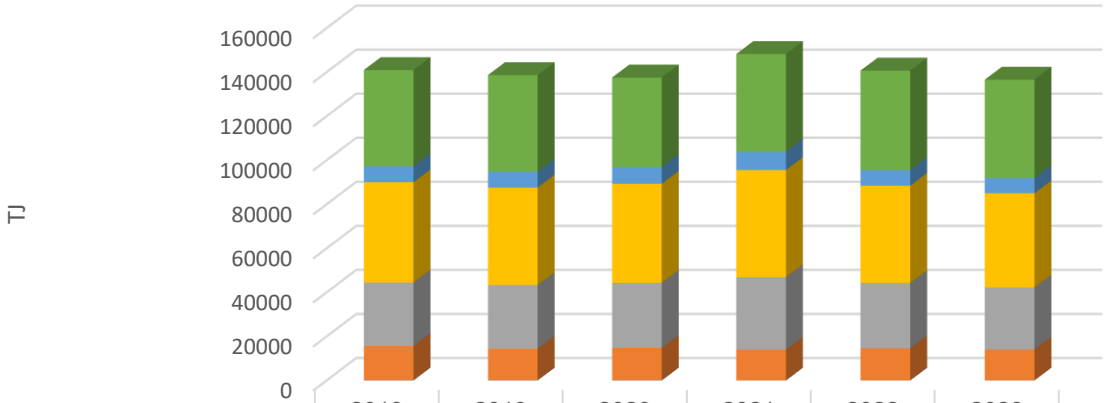
Figure 9: Final energy consumption in the industry sector for heating and cooling (Source: author's own processing based on data from EIHP)

In the industrial sector, a variety of systems are employed to provide both heating and cooling, depending on technological requirements, the type of production, and the availability of energy sources. The most commonly used systems for thermal energy production include boilers fueled by natural gas, fuel oil, or biomass, electric heaters, heat pumps, and district heating. According to available data, 12% of the total final energy used for heating and cooling in industry comes from district heating systems. The remaining share of thermal energy demand is most often met by on-site production in industrial boiler rooms. The predominant energy sources in these systems are natural gas and liquid fuels, while the share of renewable energy

sources such as biomass and geothermal energyis gradually increasing. For cooling needs, the industrial sector primarily relies on electrically powered cooling systems, with centralized chillers and local air conditioning units being the most widely used technologies.

Other sectors

Energy consumption in other sectors includes the energy consumed in households, services, agriculture, and fishing. Figure 10 presents trends in energy consumption in other sectors from 2018 until 2023.



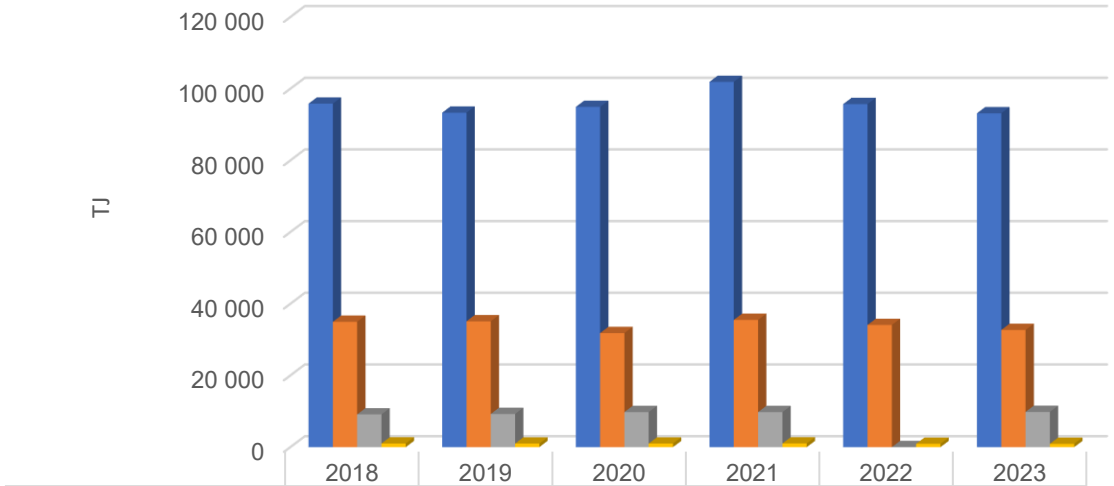
	2018	2019	2020	2021	2022	2023
Electricity	43 647	43 874	40 659	44 399	45 120	44 619
Steam and hot water	7 307	7 200	7 574	8 269	7 154	6 952
Renewables and biofuels	45 517	44 278	44 938	48 602	44 132	42 790
Natural gas	28 838	28 890	29 589	32 970	29 740	28 183
Petroleum products	15 541	14 314	14 691	13 922	14 507	13 985
Coal and coke	109	116	100	74	56	46

Figure 10: Final energy consumption in the other sectors by energy form (Source: author's own processing based on data from Energy in Croatia 2023)

From 2018 until 2023, energy consumption in other sectors decreased at an average annual rate of 0,6 per cent. In 2023, other sectors' overall annual energy consumption decreased by 2,9 per cent compared to the previous year.

Electricity (32,7%), renewables and biofuels (31,3%) and natural gas (20,6%) were the major energy sources in the other sectors final energy consumption.

Since the energy consumption in other sectors includes the energy consumed in households, services, agriculture, and fishing, Figure 11 presents energy consumption by specific subsectors from 2018 until 2023.



	2018	2019	2020	2021	2022	2023
Households	95 834	93 311	94 938	101 907	95 717	93 136
Services	34 979	35 113	31 827	35 508	34 090	32 697
Agriculture and forestry	9 129	9 252	9 784	9 791	9,971	9 823
Fishing	1 017	995	1004	1029	931	918

Figure 11: Final energy consumption in other sectors by subsectors (Source: author's own processing based on data from Energy in Croatia 2023)

The shares of specific subsectors in other sectors' total energy consumption in 2023 is shown in Figure 12. Households consistently account for the largest share of final energy consumption within the general consumption sector, representing 68% of total consumption followed by Services with a share of 24%.

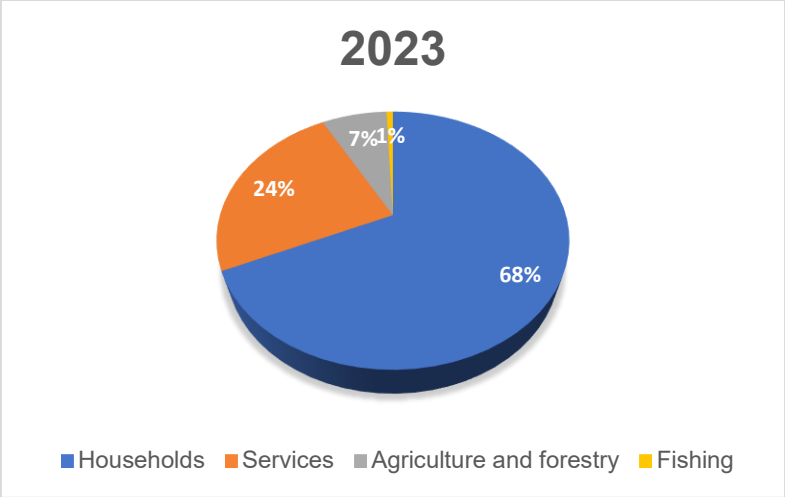


Figure 12: Final energy consumption in other sectors by subsectors (Source: author's own processing based on data from Energy in Croatia 2023)

Out of a total of 93.136 TJ of final energy consumed **in the household subsector**, 80%, or 74.509 TJ, is used for heating, cooling, and domestic hot water. The largest share of energy is consumed for space heating, accounting for as much as 81%. The rest is used for domestic hot water preparation (18%) and space cooling (1%) as shown in Figure 13.

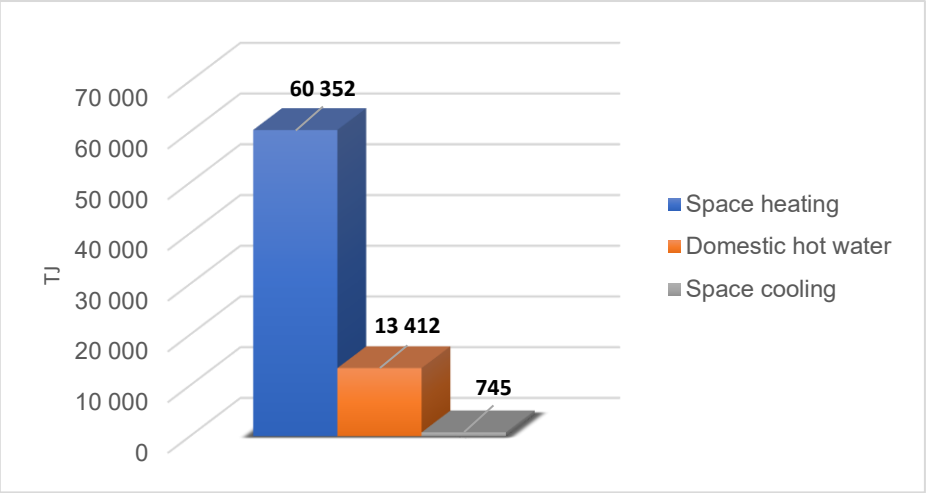


Figure 13: Final energy consumption in the households subsector for heating and cooling (Source: author's own processing based on data from EIHP)

In Croatian households, a variety of systems and energy sources are used for space heating, domestic hot water (DHW) preparation, and space cooling. The structure of final energy consumption for these purposes is as follows: 52% from renewable energy sources (RES), predominantly firewood in rural areas, 24% from natural gas, 11% from electricity, 6% from district heating, and the remainder from other sources as shown in Figure 14.

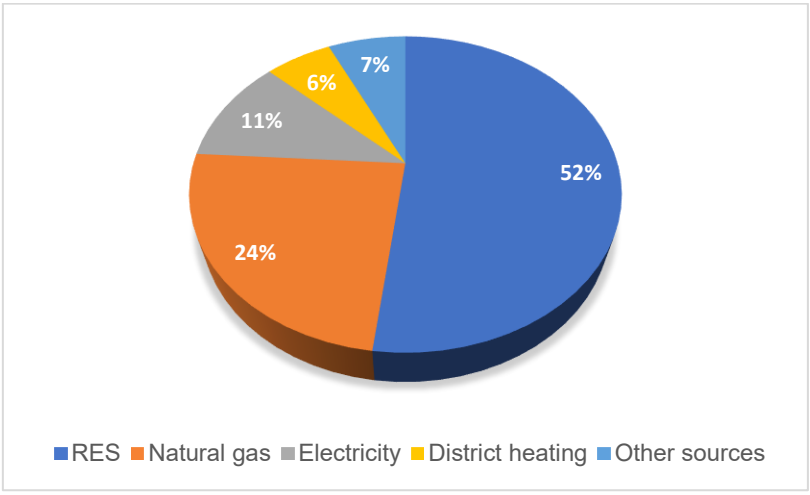


Figure 14: Energy sources for heating and cooling in the household subsector (Source: author's own processing based on data from EIHP)

Renewable Energy Sources (RES) account for the largest share—52% of final energy for heating and DHW comes from RES, primarily in the form of firewood burned in traditional stoves and boilers, especially in rural regions. Although this method utilizes a renewable source, it is often inefficient and environmentally unfriendly due to low combustion efficiency and significant local air pollution.

Natural Gas is used for 24% of household heating and DHW needs. Most commonly, households use gas boilers and individual gas heating systems, which are standard in urban areas and apartment buildings. Natural gas provides relatively efficient and convenient heating, especially where gas infrastructure is well developed. Electricity covers 11% of energy consumption for heating, DHW and space cooling.

Electricity is used for electric radiators, convectors, underfloor heating, water heaters (boilers), local air conditioning units and increasingly for heat pumps, which are gaining popularity due to their high efficiency and dual heating/cooling capability.

District Heating supplies 6% of household thermal energy needs. This system is most prevalent in larger cities such as Zagreb, Karlovac, Rijeka, Osijek, Sisak, Slavonski Brod, Vukovar, Velika Gorica, Zaprešić and Samobor where centralized heating networks are established. District heating enables the delivery of heat from centralized sources (such as cogeneration plants in Zagreb, Rijeka, Sisak and Osijek or heating plants) to end users combining different energy sources such as natural gas or biomass.

Other Energy Sources (such as liquefied petroleum gas, heating oil, coal, etc.) make up the remaining share and are mainly used in areas without gas networks or district heating networks.

For space cooling, Croatian households predominantly use electric air conditioning units (split and multi-split systems), which provide efficient cooling and can also be used for heating during transitional seasons. Although energy consumption for cooling still represents around 1% of total final energy use in the household sector, it is steadily increasing, particularly in coastal and urban areas due to climate change and rising living standards.

In the services sector, the share of energy used for space heating, cooling, and domestic hot water preparation in total final energy consumption is significantly lower than in the household sector, amounting to 56%, or 18.310 TJ out of a total of 32.697 TJ. The largest share of energy is used for space heating, accounting for as much as 72%. The rest is used for domestic hot water preparation (13%) and space cooling (15%) as shown in Figure 15.

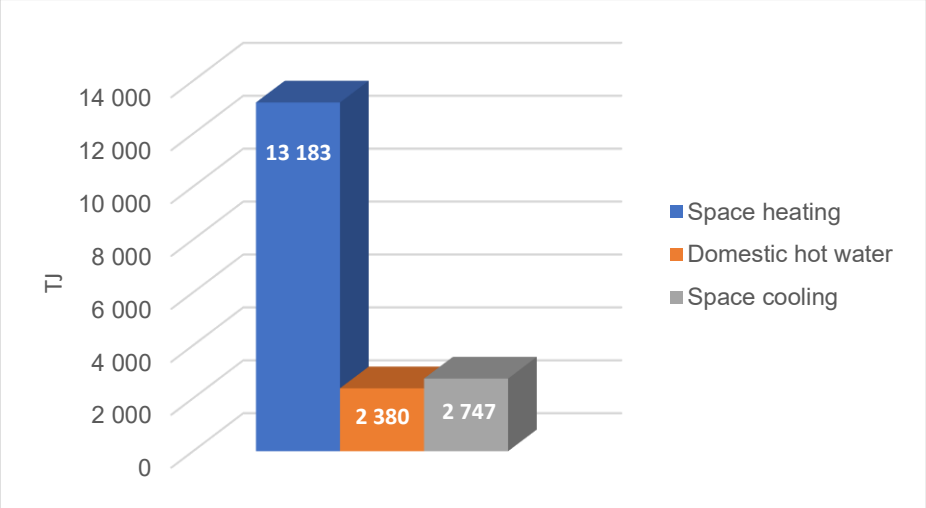


Figure 15: Final energy consumption in the services subsector for heating and cooling (Source: author's own processing based on data from EIHP)

In the Croatian services sector, the structure of final energy consumption for space heating, domestic hot water (DHW) preparation, and space cooling differs significantly from that of the household sector. The majority of energy demand in services is met by natural gas (44%), electricity (27%), and district heating (14%), while the share of renewable energy sources (RES) is negligible and included under "other sources" as shown in Figure 16.

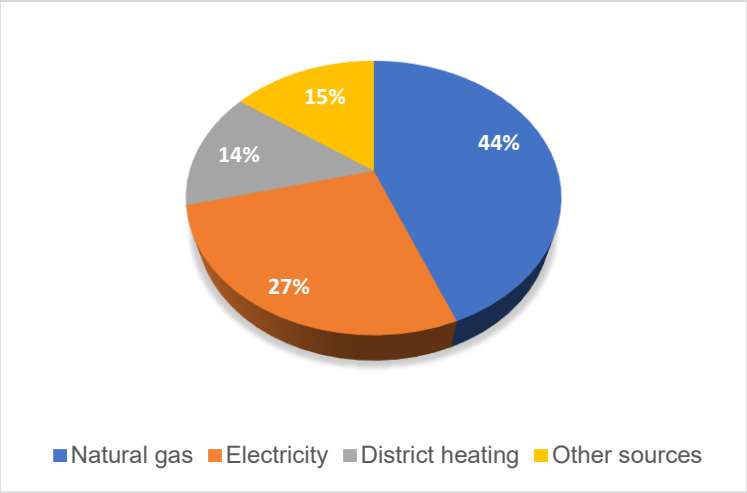


Figure 16: Energy sources for heating and cooling in the services subsector (Source: author's own processing based on data from EIHP)

Natural Gas is the primary energy source for heating and DHW in the services sector, accounting for approximately 44% of final energy consumption for space heating and DHW. Natural gas is predominantly used in central heating systems, including gas boilers and, in some cases, combined heat and power (CHP) plants within larger commercial or institutional buildings. Its widespread availability and relatively stable pricing make it the preferred choice for many service sector facilities.

Electricity constitutes about 27% of the sector's heating, cooling and DHW needs. Electricity is mainly used for space heating (through electric boilers, radiators, and heat pumps), DHW preparation (electric water heaters), and, most notably, for space cooling. Air conditioning systems—both centralized and decentralized (split and multi-split units)—are widely deployed in office buildings, hotels, and public institutions, making electricity the dominant energy source for cooling needs.

District Heating supplies roughly 14% of the subsector's energy needs. This system is most prevalent in urban centers with developed district heating networks, such as Zagreb, Rijeka, and Osijek. District heating is typically based on natural gas as the primary fuel and, to a lesser extent, on heat produced in cogeneration plants. It is mainly used for space heating and, in some cases, for DHW preparation in larger buildings. This system is most prevalent in larger cities such as Zagreb, Karlovac, Rijeka, Osijek, Sisak, Slavonski Brod, Vukovar, Velika Gorica, Zaprešić and Samobor where centralized heating networks are established. District heating enables the delivery of heat from centralized sources (such as cogeneration plants in Zagreb, Rijeka, Sisak and Osijek or heating plants) to end users combining different energy sources such as natural gas or biomass.

Other Energy Sources, including heating oil, liquefied petroleum gas (LPG), and a negligible share of renewables (such as solar thermal or biomass), together account for the remaining 15% of final energy consumption. The use of RES in the services sector is mostly limited to projects or specific applications, such as solar collectors for DHW in hotels or sports facilities.

Planned consumption trends until 2030

Croatia's updated National Energy and Climate Plan (NECP) projects a 15,7% reduction in total final energy consumption by 20230, declining from 6,98 Mtoe in 2021 to 5,88 Mtoe in 2030, as shown in Figure 17.

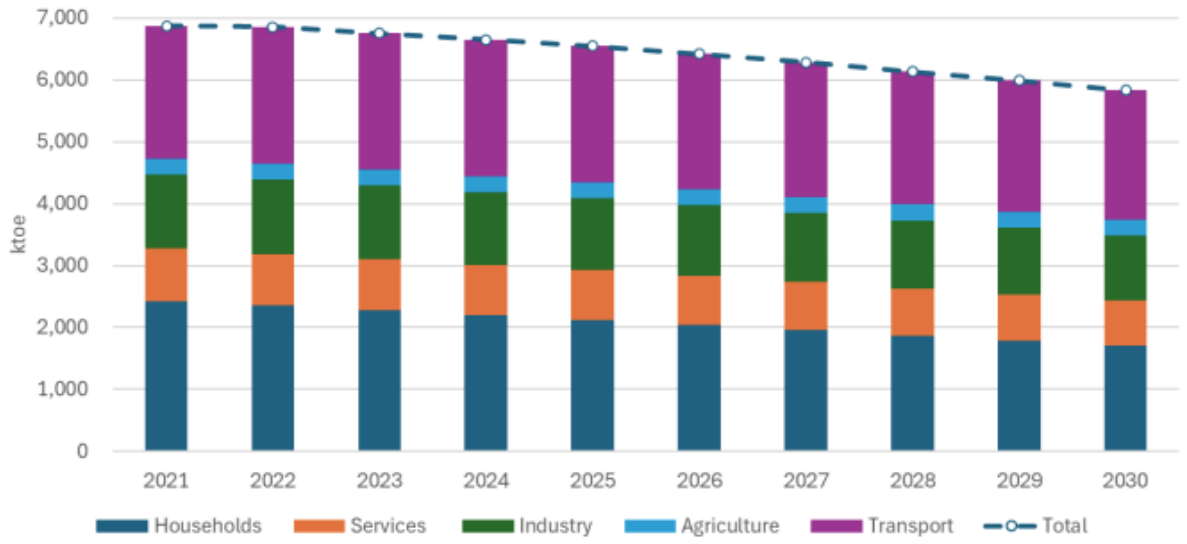


Figure 17: Projection of final energy consumption according to energy sectors (Source: NECP)

This trajectory aligns with EU decarbonization goals and Croatia's commitment to reduce greenhouse gas emissions by 62% in ETS sectors and 16.7% in non-ETS sectors by 2030. The decline reflects policies targeting energy efficiency, renewable energy adoption, and sectoral reforms.

The industrial sector's final energy consumption is projected to decrease by 14.3% (from 1.190 ktoe in 2021 to 1.020 ktoe in 2030). This reduction aligns with Croatia's NECP focus on modernizing industrial processes and integrating energy efficiency measures, such as waste heat recovery and electrification of production lines. The shift toward renewable energy sources (RES), particularly biomass and solar thermal energy, contributes to this trend. The NECP emphasizes the role of high-efficiency cogeneration and the Modernisation Fund's investments in renewable projects, which aim to reduce emissions while maintaining industrial competitiveness.

Households remain the largest energy consumers, but final energy use is projected to drop by 29.9% (from 2,410 ktoe in 2021 to 1,690 ktoe in 2030). This decline is attributed to Croatia's Long-Term Renovation Strategy, which aims to increase building renovation rates from 0.7% to 3% annually by 2030 transitioning buildings to near-zero energy (nZEB) or zero energy (ZEB) standards. Key measures include thermal insulation upgrades, window replacements, and the adoption of efficient heating systems.

Final energy consumption in services is expected to decline by 19.1% (from 890 ktoe in 2021 to 720 ktoe in 2030). This reduction is driven by building retrofits (public and commercial), solar PV integration, and the transition to district heating systems in urban centers like Zagreb and Rijeka. The NECP highlights the role of nearly zero-energy buildings (nZEB) standards, prioritization of solar PV integration in public facilities (e.g., schools, hospitals) and expansion of district heating networks in urban areas to serve municipal buildings.

4.3.2 Building stock data

Croatia's building stock is characterised by a high proportion of energy-inefficient buildings, with a large share constructed prior to the introduction of mandatory thermal protection standards. The Long-term renovation strategy of the national building stock by 2050 provides

the most comprehensive and structured overview of the national building stock, which forms the foundation for all future decarbonisation and renovation measures.

The total floor area of all buildings is estimated at around 220 million square metres (2020.), with residential buildings accounting for 74% of the total and non-residential buildings 26%. Within the residential sector, single-family houses dominate, making up approximately 86% of the stock by number, while multi-family buildings represent only 6%.

A defining feature of Croatia´s building stock is its age distribution. As shown in Figure 18, the majority of residential buildings were constructed before 1987, the year in which thermal insulation standards became mandatory in Croatia. The largest share of floor area is found in buildings constructed between 1941 and 1970, followed by the periods 1971-1987 and 1988-2005. Buildings constructed after 2010, which are typically subject to stricter energy efficiency and nZEB, account for minor share of the total stock.

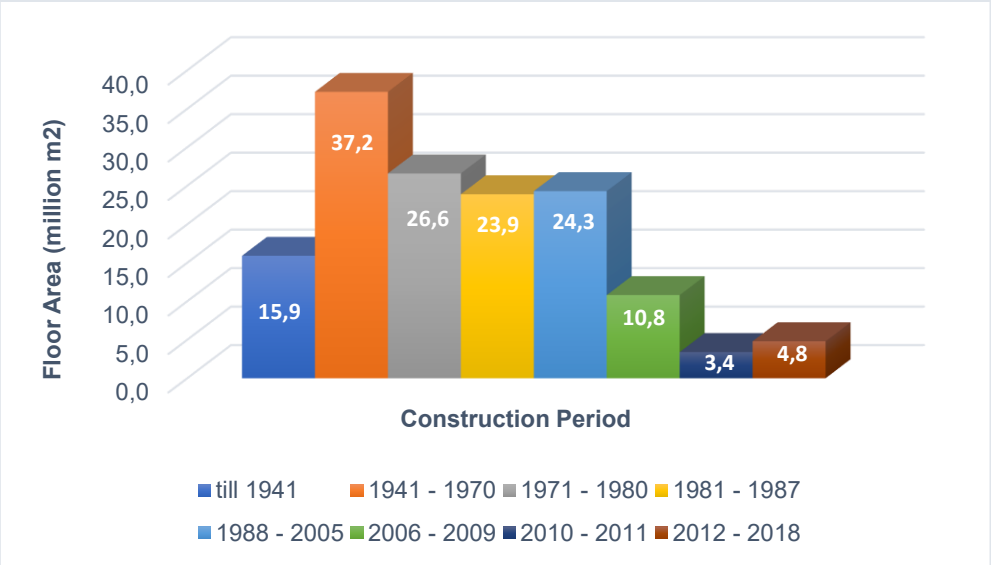


Figure 18: Total floor area of residential buildings in Croatia by construction period (Source: author's own processing based on data from Long-term renovation strategy of the national building stock by 2050)

The non-residential building sector, comprising both public and commercial buildings, has an estimated floor area of approximately 57 milion m^2. As shown in Figure 19, the largest share of these buildings was also constructed during the 1941-1970 and 1988-2005 periods. These buildings, particulary public infrastructure such as schools, hospitals and administrative buildings, often suffer from outdated heating systems and inefficient thermal envelopes.

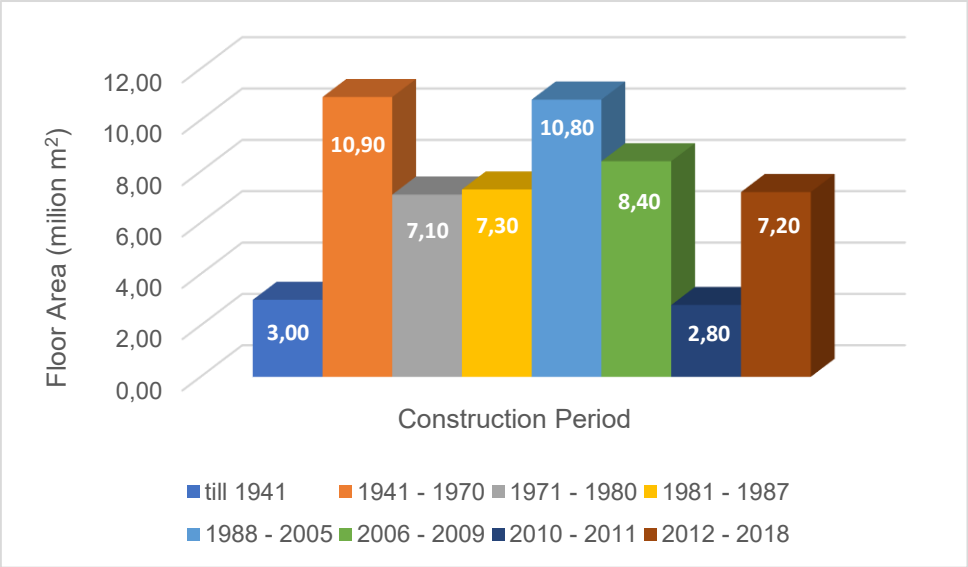


Figure 19: Total floor area of non-residential buildings in Croatia by construction period (Source: author's own processing based on data from Long-term renovation strategy of the national building stock by 2050)

Energy performance data from energy performance certificates (EPC) confirms that majority of Croatian buildings are classified in energy classes D, E or F, indicating poor thermal insulation and outdated installations. The average specific energy consumption for existing buildings is estimated at 150-200 kWh/m2/year, with pre-1987 buildings often exceeding this range substantially.

The annual deep renovation rate remains relatively low, estimated at under 1%, which is below the 3% target set in the Long-Term Renovation Strategy for 2030. In addition to the physical inefficiencies of the building stock, several non-technical barriers persist, including limited access to financing, administrative complexity, and low awareness among building owners, particularly in the residential sector.

Overall, the structure of the Croatian building stock reflects a concentration of energy-inefficient buildings constructed before 2005, especially prior to 1987. While more recent construction complies with higher energy standards, the majority of buildings in use today were built under much less demanding regulations and represent the main segment in need of renovation.

4.3.3 Energy efficiency related data for building stock

In addition to the structural characteristics and age distribution of the national building stock, an important aspect of energy performance is the actual efficiency of building service systems. These include heating, cooling, domestic hot water (DHW) generation, and lighting systems, all of which influence overall energy use in operational conditions.

One of the most relevant indicators for evaluating system performance is the ratio between delivered and required energy. This metric expresses how much energy is actually supplied to a building compared to what would theoretically be needed to maintain standard comfort and functionality. It takes into account losses in energy generation, distribution, control, and end-use, and thus reflects the real world effectiveness of building systems.

According to the Long-Term Renovation Strategy of the National Building Stock by 2050, data presented in Figure 20, a clear correlation can be observed between the construction period of buildings and the efficiency of their technical systems. Buildings constructed before 1980 typically exhibit average delivered-to-required energy ratios between 1.20 and 1.30, which

indicates that 20% to 30% more energy is consumed than theoretically needed. These higher values reflect outdated system configurations, inefficient control mechanisms, and insufficient insulation or thermal zoning.

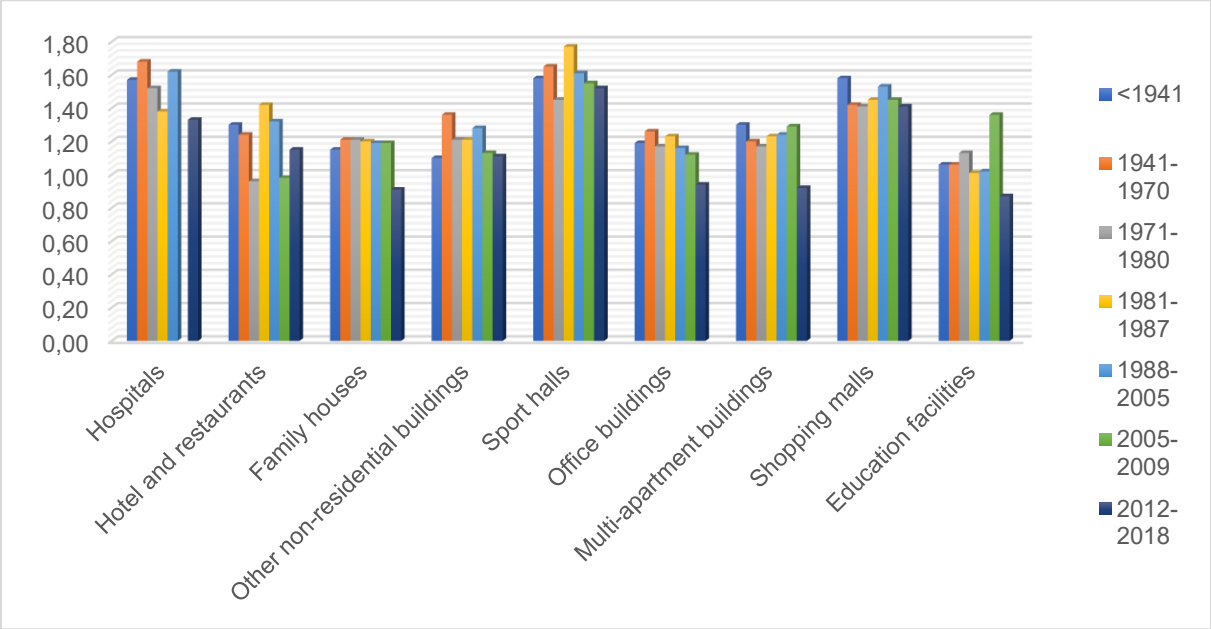


Figure 20: Ratio of total delivered energy to energy required for heating and cooling in various building types throughout different construction periods (Source: author's own processing based on data from Long-term renovation strategy of the national building stock by 2050)

On the other hand, buildings constructed after 2012 show a marked improvement, with average ratios below 1.00 in most categories. This suggests that newer buildings are equipped with more efficient systems, better performing building envelopes, and increasingly incorporate renewable and low energy technologies. For example, educational facilities, office buildings and family houses constructed in the most recent period demonstrate ratios in the range of 0.87 to 0.91, indicating near-optimal system operation.

These findings underscore that building age is a significant factor influencing the performance of technical systems. While regulatory advancements and improved construction practices are driving steady improvements in new buildings, a substantial share of the existing stock continues to operate with inefficient systems, particularly those constructed prior to 2005. Renovating these systems remains one of the most effective and impactful measures for improving energy performance and reducing consumption in the building sector.

4.3.4 RES potential and utilization for heating and cooling

A central pillar of Croatia's energy strategy is the accelerated integration of renewable energy sources (RES) into its national energy mix. Among the key metrics for tracking progress is the share of RES in final energy consumption for heating and cooling, a critical sector accounting for over 40% of Croatia's total energy demand.

The Integrated National Energy and Climate Plan (NECP) outlines ambitious indicative targets for RES adoption. For the heating and cooling sector, Croatia aims to achieve a 47,1% renewable energy share by 2030, representing a 9,1 percentage point increase compared to 2021 levels (Figure 21Figure 21). This target aligns with EU decarbonization goals and reflects Croatia's focus on leveraging its solar, geothermal, and biomass resources to reduce dependence on fossil fuels in residential and industrial thermal applications.

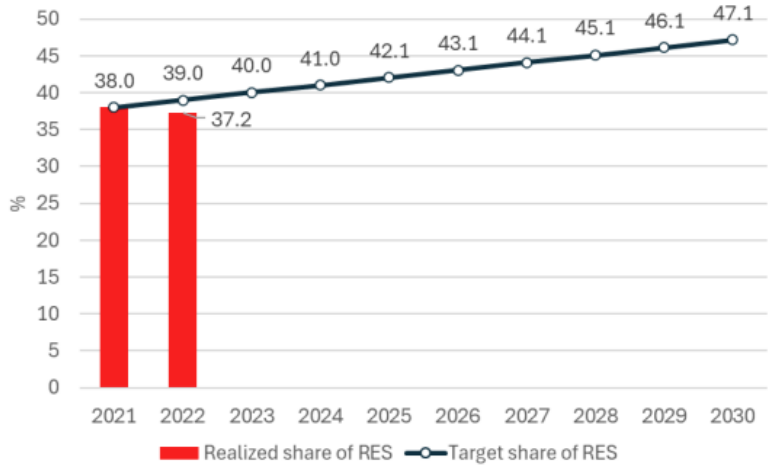
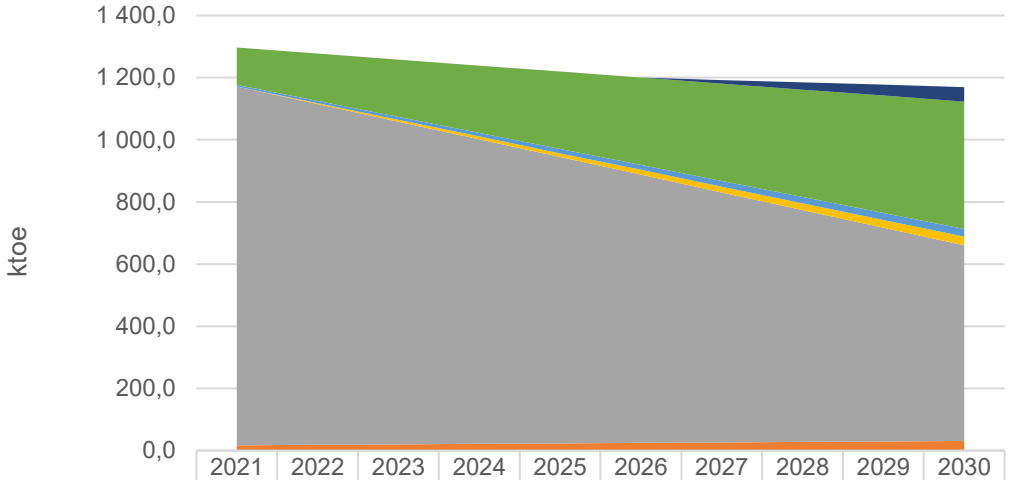


Figure 21: Indicative trajectory of RES share in heating and cooling (Source: NECP)

Estimated trajectories of renewable energy technologies that are planned to be used to achieve indicative trajectory of RES share in heating and cooling from 2021 to 2030, are shown in Figure 22.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hydrogen	0,0	0,0	0,0	0,0	0,0	0,0	11,7	23,3	35,0	46,6
RES Heat*	120,6	152,7	184,8	216,9	249,1	281,2	313,3	345,4	377,5	409,6
Geothermal energy	5,0	7,2	9,3	11,5	13,7	15,9	18,1	20,3	22,5	24,7
Gaseous and liquid biofuels	0,0	3,1	6,2	9,2	12,3	15,4	18,5	21,6	24,7	27,7
Solid biomass	1 154,4	1 096,1	1 037,8	979,5	921,2	863,0	804,7	746,4	688,1	629,8
Solar energy	17,1	18,6	20,2	21,7	23,2	24,8	26,3	27,9	29,4	31,0

**RES Heat includes heat produced from renewable energy sources in public heating plants, boiler rooms, industrial heating plants and heat pumps.*

Figure 22: Estimated contribution of RES technologies in H&C sector (source: author's own processing based on data from NECP)

Solid biomass will remain the dominant RES technology but is projected to decrease dramatically from 1,154.4 ktoe (89% of RES H&C) in 2021 to 629.8 ktoe (54% of RES H&C) in 2030 - a 45% reduction. This decline reflects Croatia's strategy to address sustainability concerns and air pollution from inefficient wood-burning stoves, particularly in rural areas where 52% of households rely on traditional biomass.

RES Heat, representing RES in public heating plants, boiler rooms, industrial heating plants and heat pumps, shows the most dramatic expansion from 120.6 ktoe in 2021 to 409.6 ktoe in 2030 - a 240% increase (primarily heat pumps). This technology will become the second-largest RES contributor (35% of total RES H&C by 2030). The tripling of RES heat capacity supports Croatia's electrification strategy and building renovation programs (ENU-3 and ENU-4), particularly targeting the replacement of fossil fuel heating systems and inefficient biomass stoves.

Solar thermal energy grows modestly from 17.1 ktoe to 31.0 ktoe (81% increase), representing the smallest but consistent contribution. Given Croatia's excellent solar potential (1,200-1,600 kWh/m² annually), this growth appears conservative and suggests significant untapped potential for solar heating applications, particularly in the residential and services sectors.

Geothermal energy increases from 5.0 ktoe to 24.7 ktoe (394% increase), though remaining relatively small in absolute terms. Croatia has identified 1 GW of geothermal potential in the Pannonian Basin, indicating this trajectory represents only initial development of the available resource, with substantial potential for future expansion in district heating systems.

Biofuels emerge from zero to 27.7 ktoe by 2030, reflecting the development of biogas and biomethane production from agricultural and municipal waste. This aligns with Croatia's circular economy objectives and represents efficient utilization of waste streams.

Hydrogen appears as a new technology starting in 2027 (11.7 ktoe) and reaching 46.6 ktoe by 2030. This represents Croatia's commitment to green hydrogen development as part of the EU's hydrogen strategy, likely focusing on industrial applications and high-temperature heating processes where direct electrification is challenging.

4.4 Available support schemes

National energy renovation programmes for buildings in the Republic of Croatia represent targeted support mechanisms implemented by the Government of the Republic of Croatia through the Environmental Protection and Energy Efficiency Fund, co-financed from national and European sources. These programmes are structured according to building typology and are aimed at implementing energy renovation measures, with a particular focus on improving heating and cooling systems and reducing energy consumption.

Further information on the programmes is provided below:

- **Programme for single-family houses** – active from 2014 to 2020, with grant coverage of up to 80% of investment costs in 2015 and up to 60% in 2020 and 2021. A new programme for the 2021–2030 period has been announced but has not yet been formally adopted.
- **Programme for multi-apartment buildings** – launched in 2016, financed through a combination of EPEEF funds (up to 40%) and the European Structural and Investment Funds (up to 60%). The revised programme for the 2021–2030 period has been officially adopted.
- **Programme for public buildings** – initially implemented exclusively through the ESCO model between 2014 and 2020, with direct grants introduced in 2016. The programme has been extended and aligned with national renovation objectives for the 2021–2030 period.
- **Programme for cultural heritage buildings** – in effect until 2030, supports the energy renovation of protected buildings of cultural and historical significance. In accordance with conservation guidelines, the programme enables energy efficiency measures that do not compromise protected elements, including thermal insulation, installation of

efficient heating and cooling systems, and the use of renewable energy sources where technically and visually acceptable.

Currently, various sources of funding for energy renovation of buildings are available to beneficiaries, including non-repayable grants from national and European funds, as well as commercial financing options such as favourable loans and market-based investment models.

A detailed overview of available financing options is presented below.

The **Urban Development Fund** (Urban Development Fund | HBOR) is a financial instrument implemented by the Croatian Bank for Reconstruction and Development (HBOR), with funding provided by the European Regional Development Fund (ERDF) and HBOR. In accordance with state aid regulations, the Fund finances investments by local and regional self-government units, as well as companies, institutions, agencies, and other legal entities owned by them or by the Republic of Croatia. The purpose of the loans is to finance investment projects (investments in fixed assets - tangible and intangible) by public sector entities in mixed commercial-public infrastructure, i.e., investments that, alongside a public component, also contain a commercial element involving revenue generation from service charges. These investments aim to promote environmental protection projects, energy efficiency, and the use of renewable energy sources, as well as the development of multipurpose, sports, tourism, socio-cultural, business, and similar infrastructure, and residential infrastructure exclusively intended for rental housing. All investments must comply with the “Do No Significant Harm” principle. Loans may be approved with the possibility of partial principal forgiveness of the ERDF-funded portion (up to a maximum of 50% of the total loan amount), subject to the fulfillment of predefined criteria.

The **Competitiveness and Cohesion Programme 2021–2027** (Competitiveness and Cohesion Programme 2021-2027) sets out the objectives and priorities for the effective use of the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) for the 2021–2027 period. The main goal of the supported interventions is to strengthen the economy, support the digital and green transition, promote digitalisation for citizens and businesses, improve connectivity and mobility across the Republic of Croatia, and enhance the quality of life for the population. The Programme defines six priorities, two of which fall under the policy objective A Greener Europe. For these specific priorities - Promoting energy efficiency and renewable energy sources; climate change adaptation, risk prevention, environmental protection and resource sustainability and Development of sustainable intermodal urban mobility as part of the transition to a low-carbon economy - a total financial allocation of nearly €2,3 billion has been designated.

The **National Recovery and Resilience Plan 2021–2026** (National Recovery and Resilience Plan 2021- 2026) is financed through the Recovery and Resilience Facility, under which the Republic of Croatia has been allocated nearly €10 billion. The Plan defines several subcomponents related to the green transition that impact the heating and cooling sector - enhancing competitiveness and the green transition of the economy, energy transition for a sustainable economy, and building decarbonisation. A total of 12% of the financial allocation is earmarked for the building renovation initiative.

In the 2021–2027 financial period, a total of €681.275 million has been allocated for sustainable urban development measures through the **Integrated Territorial Investments** (ITI) mechanism (ITI mechanism), within the framework of the Integrated Territorial Programme 2021–2027, which represents 13.05% of the ERDF allocation Eligible investment areas for cities under the Integrated Territorial Investments through the ITI mechanism include investments in entrepreneurship, green, clean, smart and sustainable urban mobility, brownfield sites, cultural heritage and tourism, green infrastructure and natural heritage,

multipurpose infrastructure and public spaces, pilot projects at the level of city districts and neighborhoods, district heating (for phased projects), and energy efficiency (as a horizontal requirement). The implementation of the ITI mechanism is carried out in 22 cities that have established their respective urban areas.

The **Modernisation Fund** (Modernisation Fund) is a European Union financing instrument established under Directive (EU) 2018/410 to support investments aligned with climate and energy goals by 2030. Aimed at accelerating the energy transition in lower-income Member States, the Modernisation Fund offers 10 countries the opportunity to access non-repayable grants to promote modernization investments in the electricity sector, as well as in other energy systems, in addition to other European funding instruments. The Fund is financed through the sale of 2% of the total quantity of emission allowances available on the market during the 2021–2030 period, along with the sale of a portion of emission allowances that may be additionally transferred from the total volume of allowances intended for auctioning, allocated for solidarity and growth purposes. Croatia is entitled to 3.14% of the Fund, amounting to 14.6 million emission allowances.

The **European Economic Area (EEA) and Norway Financial Mechanism** (EEA Grants) is available to the Republic of Croatia for the period 2021–2028, with topics relevant to the heating and cooling sector addressed under the broader priority of the Green Transition. The Green Transition programme area focuses on reducing greenhouse gas emissions, increasing energy efficiency, and promoting the use of renewable energy sources. Within this framework, projects involving the modernization of heating and cooling systems - including the transition to renewable energy sources and improvements in energy efficiency - may be eligible for funding (programming for the Republic of Croatia is currently underway).

Commercial banks in Croatia play a key role in financing heating and cooling projects, particularly those focused on energy efficiency and the use of renewable energy sources. Their offerings include a range of financial instruments tailored to the needs of both businesses and citizens. For example, banks provide financial support for projects involving the installation of high-efficiency heating and cooling systems, such as heat pumps and solar thermal collectors. These programs often combine non-repayable grants with favorable loan conditions, thereby reducing the financial burden on end users.

4.5 GAP analysis

Policy and regulatory gaps

The heating and cooling sector in the Republic of Croatia has been identified as a key element in achieving both national and EU-level decarbonisation targets, enhancing energy efficiency, and integrating renewable energy sources (RES). However, significant implementation challenges persist despite this sector's strategic relevance.

Local and regional self-government units play a pivotal role in executing energy policies and implementing energy renovation initiatives. Yet, these entities often lack the necessary administrative and technical capacity, which severely constrains effective planning and execution. This is particularly evident in energy planning—closely tied to spatial planning—which can either limit fossil fuel use or enable the integration of renewable alternatives. These capacity limitations also hinder the promotion of district heating and cooling systems as viable decarbonisation strategies for densely populated urban areas.

In terms of individual heating and cooling systems, the existing regulatory framework mandates the inclusion of a specified RES share in all new buildings and in those undergoing energy

renovation, which is most commonly met through the deployment of technologies such as heat pumps.

Despite this obligation, the current rate of energy renovation is insufficient to meet strategic targets. This shortfall is primarily due to inconsistent and inadequately funded co-financing mechanisms. Moreover, alternative financing models—such as public-private partnerships, concession schemes, and market-based incentives—are constrained by regulatory uncertainties, limited legal guarantees, and unclear long-term profitability for investors.

There is no unified national framework—whether legislative or based on best practices—that integrates urban planning with energy planning, despite this being fundamental to sustainable infrastructure development. The absence of such coordination leads to fragmented infrastructure planning, such as new residential areas being developed without adequate access to district heating or electricity networks. As a result, fragmented and individualised solutions are often pursued, delaying decarbonisation and creating hidden challenges for future stakeholders.

Furthermore, the legislative framework lacks ambition and foresight in accommodating emerging technologies and concepts in heating and cooling. Key opportunities—such as consumer-producer aggregation (prosumers), thermal energy storage, and the integration of heating and cooling systems into balancing markets or electricity system flexibility—remain underutilised or unrecognised within existing regulations.

While heat production is technically classified as a market activity, once a producer meets over 60% of a system's demand, the activity is redefined as a public service and becomes subject to regulated tariffs. Heat distribution is legally defined as a public service delivered via concession, whereas heat supply remains a market activity requiring licenses and consumer contracts. Despite the formal liberalisation of the heat market, in practice, heat production prices remain heavily regulated.

The expansion of district heating networks is further hindered by limited planning. The current legal framework places the burden of connection costs on end users, discouraging new or renovated buildings from connecting to these networks. Consequently, individual systems are often favored over district heating options.

Compounding the issue, heat substations are typically owned by building owners rather than district heating operators. This fragmented ownership complicates the integration of RES, the reduction of operational temperatures, and the upgrading of existing systems.

Although Croatia has adopted a strategic framework for geothermal energy development, practical implementation is slowed by complex permitting procedures, limited data accessibility, and the absence of supporting infrastructure for integrating geothermal sources into existing networks.

Aligning national legislation with the EU acquis remains a persistent challenge, requiring coordinated institutional efforts, systemic reforms, and significant capacity-building among all stakeholders.

Technical challenges

Croatia's heating and cooling sector faces substantial technical barriers in transitioning to a decarbonised and energy-efficient system that aligns with EU directives. While national targets for RES integration and greenhouse gas reductions are ambitious, outdated infrastructure and limited system readiness remain critical obstacles.

Multi-apartment buildings are often equipped with obsolete heating systems and insufficient thermal insulation, resulting in excessive energy consumption and high operational temperatures. This undermines decarbonisation goals, especially in buildings using individual heating systems. Additionally, co-owners frequently show limited interest in modernisation investments, impeding the energy transition. The same situation applies to single-family homes, reflecting the broader challenge posed by an ageing building stock.

District heating systems are still predominantly reliant on natural gas, with RES contributing only marginally. Key technical barriers include incompatibility between existing infrastructure and RES technologies, challenges in adapting systems to low-temperature operations, and a lack of digitalisation and automation. Moreover, promising renewable heat sources often lie outside urban areas or far from existing networks, requiring costly infrastructure extensions.

Although approximately 64% of heat distribution networks have been modernised, unreconstructed sections continue to experience high heat losses. Additionally, substations—which are essential for enabling low-temperature operation—are rarely included in energy renovation programs and are usually not owned by the operators.

The current extent of district heating networks does not cover all urban areas, limiting opportunities for new customer connections. A growing and underestimated challenge is the increasing electrification of heating and cooling systems. This shift places additional pressure on an already outdated and inefficient electricity distribution grid, particularly in urban areas.

This situation creates a high risk of insufficient connection capacity—both for individual heat pumps and large-scale units for district heating. Addressing this issue will require the establishment of new technical standards and substantial investments in electricity infrastructure, particularly in cable networks. Such upgrades require not only considerable financial resources but also extended design and construction timelines.

An additional technical barrier is the lack of digital solutions and limited progress in digital transformation across all related sectors. This restricts the development of modern approaches to consumption and production monitoring, flexibility services, and broader RES integration.

Finally, due to its geographic and demographic profile, Croatia constitutes a relatively small market within the EU. This makes it less attractive for technology providers, complicating the implementation and scaling of RES-based solutions.

Financial challenges

Decarbonising individual heating systems—particularly within households—faces a significant funding gap. Existing co-financing schemes are underfunded and limited in scope and frequency, restricting their effectiveness. This applies equally to multi-apartment buildings. Affordable financing options from commercial banks or ESCOs remain scarce, further constraining implementation due to the high upfront investment costs.

District heating operators face structural financial vulnerabilities. Operating under the public service framework subjects both generation and distribution to regulated tariffs, resulting in revenues that often do not cover actual costs. Consequently, district heating becomes less financially attractive compared to individual solutions.

To meet EU decarbonisation milestones for 2035 and 2050, operators must invest in new generation facilities based on RES and waste heat. However, their weak financial standing and lack of creditworthiness limit access to necessary financing, significantly hindering the implementation of required investments.

Most financial programs supporting renovation and decarbonisation—including energy renovations and new RES integration in district heating systems—rely almost exclusively on EU funds. This dependency, shaped over years, has created a perception that EU funding is both indispensable and prestigious. Coupled with outdated and inflexible project eligibility requirements (e.g., requiring final design documentation), this results in unsustainable reliance on external funding. Homeowners, apartment associations, and even public sector entities often delay implementation for years while awaiting suitable co-financing opportunities—despite already investing in costly project documentation.

Other identified challenges

A lack of reliable, accessible data—on building stock, energy consumption, network losses, and system performance—hampers informed policy planning and implementation across all levels, from municipalities to system operators and potential investors. Often, stakeholders fail to cooperate or share information during the development of plans and strategies. This extends the strategic planning process and undermines the accuracy of needs assessments and investment projections.

Regulatory uncertainty remains a major deterrent for market participants. Delays in transposing EU directives into national legislation, limited stakeholder involvement in these processes, and slow adoption of secondary legal acts all contribute to unclear and unstable investment conditions. As a result, private banks often classify these investments as high-risk, leading to unfavorable capital costs.

There is also a marked shortage of qualified professionals for the design, implementation, and maintenance of RES-based and digitalised heating and cooling systems—both at individual and centralised levels. In such a scenario, operational expenses (OPEX) frequently become an additional barrier to implementing decarbonisation measures.

Finally, insufficient public awareness and community engagement regarding the benefits of decarbonisation severely limit participation in energy renovation programs, connection to district heating systems, and willingness to invest private capital.

5 Current H&C status in Greece

5.1 H&C policy framework

Greece has implemented several strategic plans and initiatives to address heating and cooling within its broader energy and climate policies towards reaching climate neutrality by 2050. The main strategic plan of the country is the National Energy and Climate Plan (NECP) introduced by the Regulation on the governance of the Energy Union and Climate Action (EU) 2018/1999, agreed as part of the Clean energy for all Europeans package. Other strategic plans that relate to heating and cooling are the comprehensive assessment for heating and cooling in line with Article 25 of the Energy Efficiency Directive, as well as the Long Term Renovation Strategy.

Greece drafted its first NECP in 2019, while an update was completed in 2024, setting its strategic priorities and alignment with European Union goals of the fit for 55 package. According to the updated **National Energy and Climate Plan (NECP[22])** of August 2024, heating and cooling plays a key role in reaching the country's overall targets. Additionally, NECP sets a specific target of reaching 52.6% RES share in gross final consumption for heating and cooling by 2030 and 84.1% in 2050. Towards this goal contributes both the promotion of efficient heating and cooling systems in combination with the upgrading of the building envelope, as well as the increased use of RES, with technologies, such as heat pumps and solar thermal. It is also envisaged, albeit with a small share, a contribution from district heating networks from RES, mainly utilizing geothermal energy, biomass and renewable gases.

Complementary to the NECP, there is the comprehensive assessment for heating and cooling, in line with Article 25 of the recast Energy Efficiency Directive, which should be carried out every 5 years. Greece has submitted the first **comprehensive assessment of the potential for efficient heating and cooling** to the European Commission in 2016, while an updated version was provided in 2021. This strategic evaluation addressed, on an integrated basis, the possibility of meeting the heating and cooling needs at a nationwide level in an energy-efficient manner. It includes a mapping of current and future heating and cooling demand, both for centralized systems like district heating and decentralized or stand-alone options. It identifies cost-effective opportunities and outlines measures to support the development of efficient infrastructure, ensuring all heating and cooling options are considered in national energy planning. The latest available comprehensive assessment of 2021 is currently being updated according to the provisions of Article 25 of Directive (EU) 2023/1791 and Annex X and is planned to be finalized by the end of the second quarter of 2025.

Furthermore, Greece's **Long-Term Renovation Strategy (LTRS)**, established under Article 2a of Law No. 4122/2013, outlines a comprehensive approach to enhancing the energy efficiency of the country's building stock, with a particular focus on heating and cooling systems. A key provision mandates that all new buildings must cover at least 60% of their annual hot water demand through solar thermal installations, unless alternative renewable energy sources are utilized (Article 6, Paragraph 3 of Law No. 4122/2013; KENAK Article 8, Paragraph 3.1.3). Additionally, from 2021 onwards, all new constructions are required to be nearly zero-energy buildings (nZEBs), as stipulated in Article 9 of the same Law.

Ministry of Environment and Energy has also mandated (Law 4342/2015, Art. 7, par. 12) that Regional Authorities and Mayors are responsible for preparing an Energy Efficiency Action Plan for their buildings (called "SEAK"). This Action Plan had to be submitted to the Ministry of

[22] https://commission.europa.eu/publications/greece-final-updated-necp-2021-2030-submitted-2025_en

Environment and Energy by the end of 2022 and should be updated every 4 years. It gives an overview of the building stock under the responsibility of the regional authority and prioritizes these buildings with regard to the need for actions to improve their energy efficiency. It also contains a techno-economic analysis of building energy upgrade interventions, setting a target and a plan to achieve the energy saving target. SEAKs are prerequisites for the inclusion of local authorities in financial programs for the energy upgrading of their buildings that refer to them. Additionally to that, regional authorities from 1/1/2025 are also responsible for conducting a Local Plan for the reduction of Emissions (called "DHSME") and then updating it every 5 years. This local plan has a wider scope of application than SEAK, dealing besides buildings with all municipal facilities as well as municipal fleet. These plans are also considered as prerequisites for the inclusion of local authorities in financial programs.

It worth mentioning that Greece has also a **National Strategy for Adaptation to Climate Change**, endorsed by the Parliament in August 2016, which defines goals, principles, and priorities for climate adaptation in Greece. It includes potential adaptation measures for sectors significantly affected by climate change, such as energy, where heating and cooling are pertinent. The strategy serves as a guiding document for developing regional adaptation action plans, ensuring that local measures align with national objectives.

Moreover, the **National Recovery and Resilience Plan Greece 2.0** encourages investments facilitating Greece's green and digital transition. It encompasses 106 investment initiatives and 68 reforms, with grants totaling €17.77 billion and loans of €12.73 billion. The plan aims to support sustainable recovery and growth, aligning with Greece's National Recovery and Resilience Plan, and is backed by resources from the Recovery and Resilience Facility. Investments focus on urban revitalization, sustainable transport, energy efficiency, and renewable energy, directly impacting heating and cooling sectors by promoting energy-efficient buildings and the integration of renewable energy sources.

Finally, it is worth noting that the pilot municipality of Veria has already prepared a **Sustainable Energy and Climate Action Plan (SECAP)** since September 2017, under the EU Initiative Covenant of Mayors[23], which focuses on municipal buildings and facilities, residential buildings, local electricity, sustainable transport and public awareness activities. More specifically, it includes energy efficiency measures in public buildings and awareness campaigns for public employees, schools and citizens, aiming to increase the use of public transportation and bicycles and to reduce the conventional energy consumption. Moreover, it describes efforts to increase the use of renewables (especially solar photovoltaics) in buildings and open spaces as well as the promotion of more efficient municipal public lighting. The municipality of Veria has also prepared its Energy Efficiency Action Plan for buildings (SEAK) since September 2024 and its Local Plan for the reduction of Emissions (DHSME) within 2025.

5.2 Legislative framework

In Greece, several Laws and regulatory frameworks govern heating and cooling, primarily aligned with EU Directives aimed at energy efficiency, renewable energy, and emissions reduction. An overview of the most important Laws and their relevant articles is analysed below.

More specifically, **Law 4122/2013** is a pivotal Greek legislation that transposed the Directive 2010/31/EU on the energy performance of buildings into national law. This Law establishes a comprehensive framework aimed at enhancing the energy efficiency of buildings in Greece, with specific provisions related to heating and cooling systems. Article 14 mandates regular

[23] The Covenant of Mayors is a European co-operation movement involving local and regional authorities. Signatories of the Covenant of Mayors voluntarily commit to increasing energy efficiency and the use of renewable energy sources on their territories.

inspections of heating systems with an effective rated output of over 20 kW, emphasizes the assessment of system efficiency and appropriate sizing compared to heating requirements and aims to optimize energy performance and reduce consumption. Article 15 requires periodic inspections of air-conditioning systems with an effective rated output exceeding 12 kW, focuses on evaluating system efficiency and ensuring proper sizing relative to cooling demands and seeks to enhance energy efficiency and minimize operational costs. Additionally, Article 16 stipulates that detailed reports should be prepared following inspections conducted under Articles 14 and 15. These reports should include findings on system performance and recommendations for improvements or upgrades, while Article 16 ensures transparency and provides building owners with actionable insights to enhance system efficiency.

Moreover, **Law 4342/2015** is the transposition Law of EED into Greek legislation. This Law introduces several measures aimed at enhancing energy efficiency, particularly in the areas of heating and cooling. Article 7 mandates that, starting from January 1, 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by the central government must be renovated annually to meet at least the minimum energy performance requirements. Also, Article 9 is noted for establishing the Energy Efficiency Obligation Scheme, which may encompass aspects related to efficient heating and cooling. In addition, Article 15 refers to heating and cooling issues, implementing Article 14 of the EU EED, which focuses on promoting efficiency in heating and cooling systems. Article 15 requires the preparation of a comprehensive assessment of the potential for high-efficiency cogeneration and efficient district heating and cooling, while ensures public support for heating and cooling systems (like cogeneration or district heating), complying with EU state aid rules. Article 22 mandates the implementation of regular energy audits for large-scale heating and cooling installations. The audits are intended to ensure compliance with energy performance standards and to identify opportunities for further efficiency improvements. In addition, Article 30 establishes a framework for the certification and training of professionals involved in the design, installation, and maintenance of heating and cooling systems.

Furthermore, **Law 5037/2023** is a recent legislative act in Greece that, among others, transposed Directive 2018/2001 and Directive 2019/944 and amended Law 3468/2006. In this Law, Renewable Energy Communities and Citizens Energy Communities are defined and their operation is established. Article 83 introduces a framework for incorporating energy from renewable sources into district heating and cooling networks or for constructing new infrastructure if there is significant potential of production of heating and cooling from large biomass, solar, ambient and geothermal energy units, as well as from waste heat and cooling.

In terms of buildings, there is the Greek Regulation on the **Energy Performance of Buildings** (named **KENAK**), which was updated in July 2017 and sets the standards for the energy performance classification of new constructed and existing buildings. Also, in the national plan for increasing nearly zero-energy buildings (nZEBs), issued in August 2018, the definition of nZEBs is given, requiring new buildings to meet at least Energy Class A and existing buildings to reach at least Energy Class B+.

Moreover, Greece's **National Climate Law** (Law 4936/2022, A' 105), enacted in May 2022, establishes a comprehensive framework aimed at achieving climate neutrality by 2050. This legislation sets intermediate targets, including a 55% reduction in net greenhouse gas emissions by 2030 and an 80% reduction by 2040. In the context of heating and cooling, the Law introduces specific measures to enhance energy efficiency and reduce emissions in the building sector:

- **Phase-out of oil boilers**: Article 17 of the Climate Law mandates the discontinuation of oil-based heating systems in areas served by natural gas networks by 2025, promoting the adoption of cleaner alternatives, such as heat pumps.

- **Solar thermal installations**: Existing regulations require that at least 60% of the annual hot water demand in new buildings be met through solar thermal systems, unless alternative renewable energy sources are utilized.
- **Nearly zero-energy buildings**: From 2021 onwards, all new buildings are required to be nearly zero-energy buildings, significantly reducing the energy consumption associated with heating and cooling.

It is worth noting that the EU Member States, including Greece, are required to transpose the recast EED provisions into national law by 11 October 2025, while the EU Member States, including Greece, are required to transpose the amended RED provisions into national law by 21 May 2025.

5.3 Final energy consumption

In Greece, final energy consumption in the industrial sector followed an almost downward trend over 2014-2023, reaching about 2.5 Mtoe in 2023, compared to 3.1 Mtoe in 2014. Electricity (40%) and oil (30%) were the fuels that contributed substantially to the country's final energy consumption, followed by natural gas (23%), as shown in Figure 23.

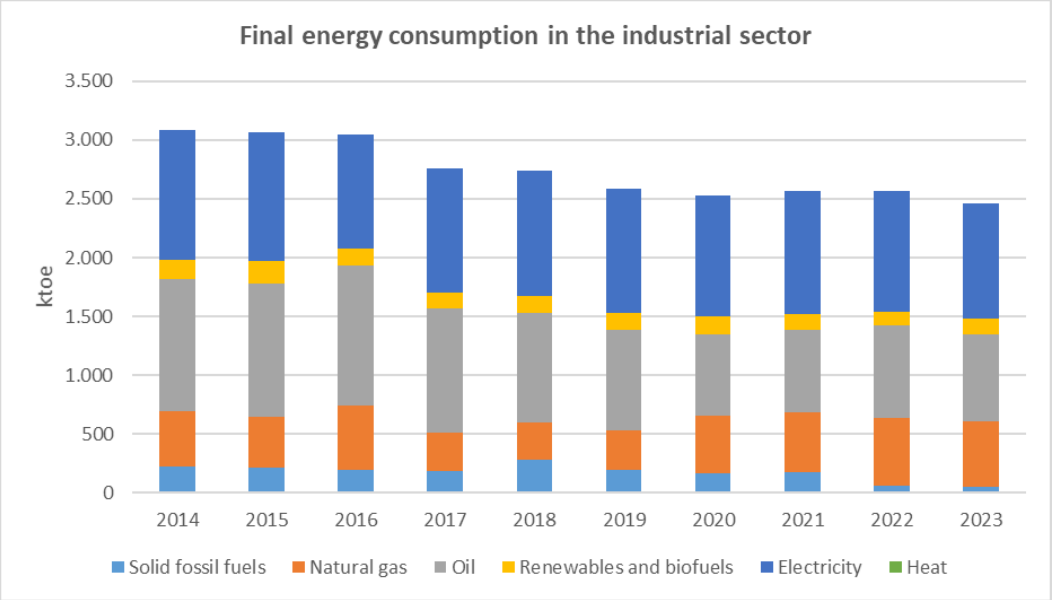


Figure 23: Final energy consumption per fuel in Greece's industrial sector, 2014-2023

In the tertiary sector, final energy consumption increased by 23% in 2023 at 2.1 Mtoe, compared to 2014 levels. Electricity (69%) was the major fuel that contributed significantly to the country's final energy consumption, followed mainly by renewables and biofuels (19%), as shown in Figure 24.

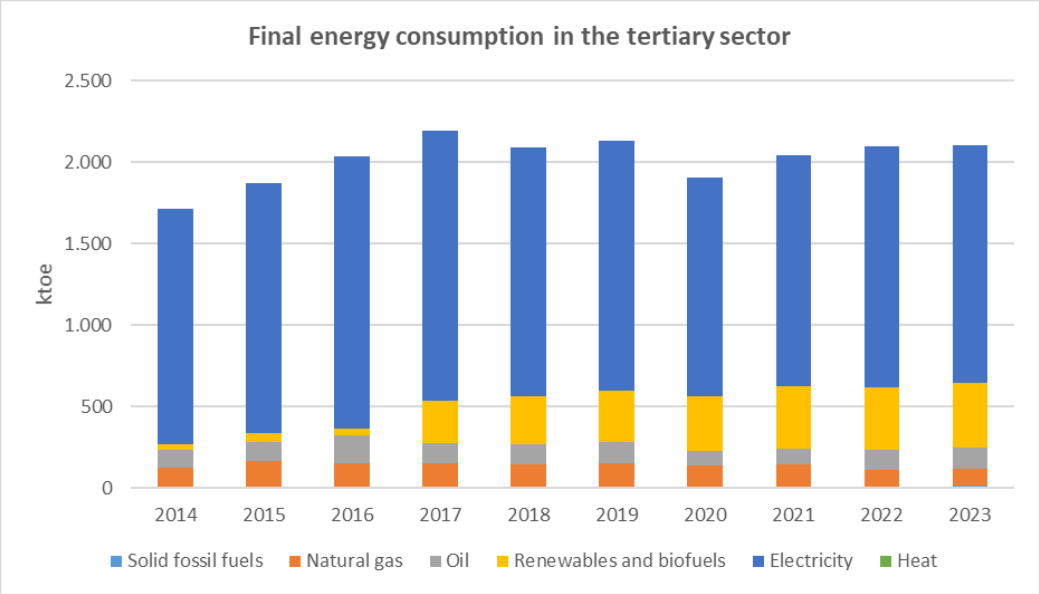


Figure 24: Final energy consumption per fuel in Greece's tertiary sector, 2014-2023

In the residential sector, more fuels contributed to Greece's final energy consumption, which decreased only by 2% in 2023 (at about 3.8 Mtoe), compared to 2014 levels. More specifically, electricity (35%) was again the major fuel, followed by renewables and biofuels (31%), oil (24%) and natural gas (10%).

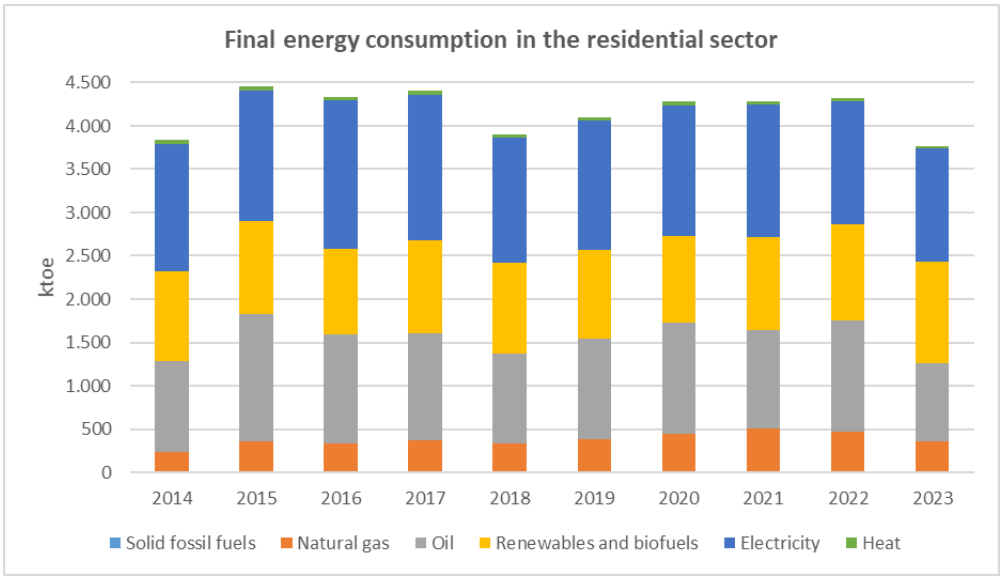


Figure 25: Final energy consumption per fuel in Greece's residential sector, 2014-2023

The agriculture and forestry sector was contributed less in the country's final energy consumption, standing at 275 ktoe in 2023, a 8% rise, compared to 2014 levels. Once again, electricity (65%) was the main energy technology used in this sector, while oil (17%) and renewables and biofuels (11%) played also an important role.

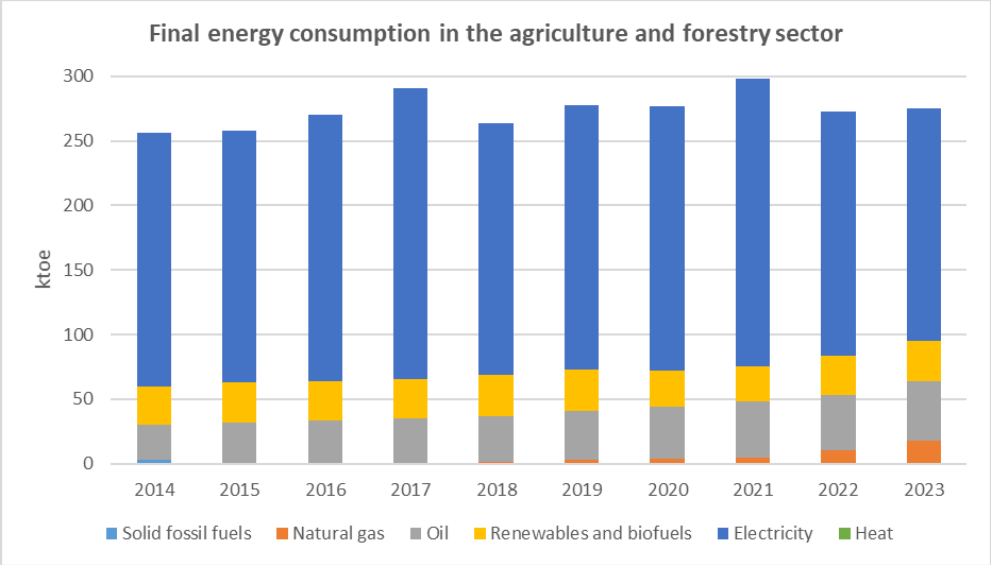


Figure 26: Final energy consumption per fuel in Greece's agriculture and forestry sector, 2014-2023

The previous analysis showed the various fuels that are used in the main sectors in Greece, taking into consideration that heating and cooling is not used in the transport sector. It is worth noting that there is a lack of data in terms of heating and cooling in tertiary and industrial sectors. For that reason, only the final energy consumption per fuel in the residential sector is analysed below.

In Greece's **residential** sector, the final energy consumption in space heating stood at 2.45 Mtoe in 2022, compared to 2.72 Mtoe in 2015. Oil and petroleum products contributed 47% to the final energy consumption in terms of space heating in 2022, followed by renewables and biofuels (30%), primary solid biofuels (26%) and natural gas (18%), while heat pumps contributed only 4%.

Space cooling is much less developed than space heating in Greece, reaching 0.152 Mtoe in 2022, compared to 0.139 Mtoe in 2015, with electricity contributing fully in terms of space cooling. Water heating corresponded to 0.657 Mtoe in 2022, compared to 0.497 Mtoe in 2015. Renewables and biofuels (50%) and solar thermal (47%) were the fuels with highest contribution in the final energy consumption in 2022 in terms of water heating, followed by electricity (34%) and oil and petroleum products (11%).

Similarly, the final energy consumption in cooking reached 0.272 Mtoe in 2022, compared to 0.251 Mtoe in 2015, while electricity (74%) and oil and petroleum products (23%) were the fuels that mainly used in cooking. It is worth noting that 0.748 Mtoe were consumed from lighting and electrical appliances in 2022, less than the consumption of 0.739 Mtoe in 2015, with electricity being the only fuel that was contributed.

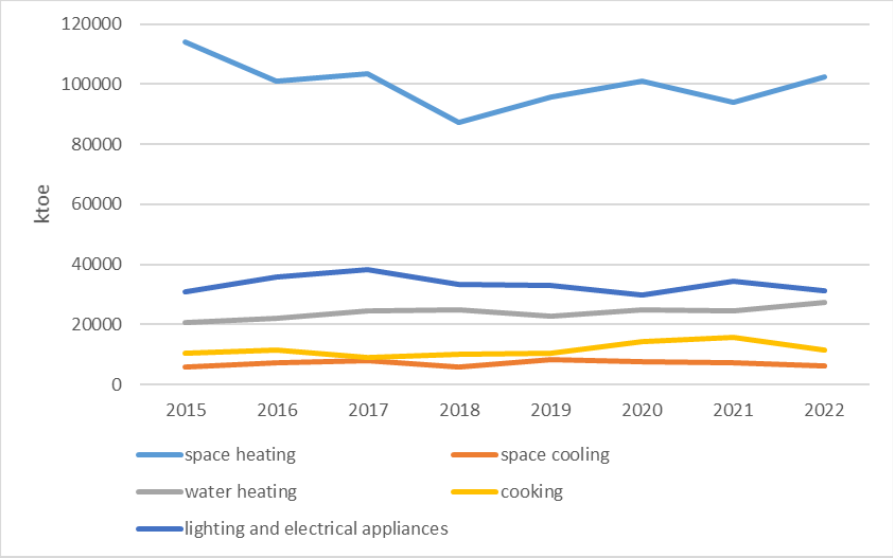


Figure 27: Final energy consumption for heating and cooling per use in Greece's residential sector, 2015-2022

From 2014 to 2023, renewable heating and cooling increased from 1,426.8 ktoe to 1,768.1 ktoe and from 28% to 36% of total heating and cooling demand.

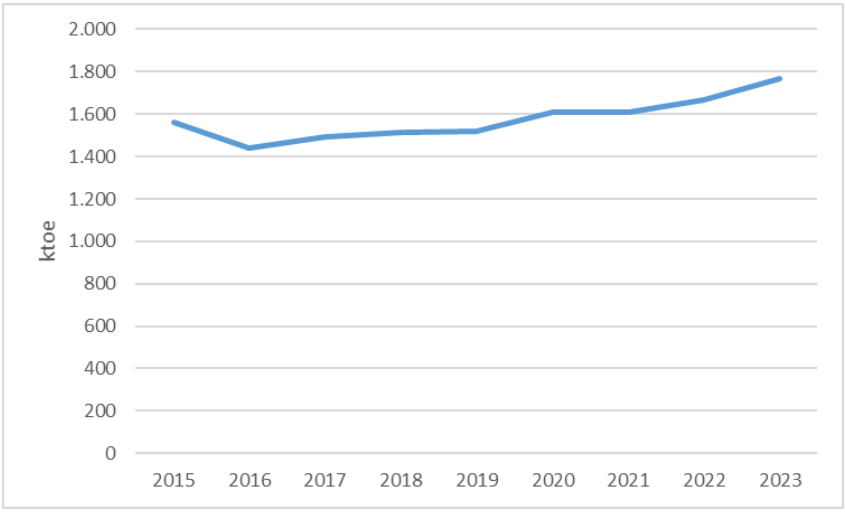


Figure 28: Use of renewables and biofuels for heating and cooling in Greece, 2015-2023

According to the updated NECP of August 2024, final energy consumption in the residential sector decreases by 2% in 2030 and by 12% in 2050, compared to 2022 (Figure 29), reaching 4.2 Mtoe in 2030 and 3.8 Mtoe in 2050. Electricity and bioenergy hold the largest shares, with 40% and 20% respectively, in total final consumption in the residential sector in 2030. The use of natural gas is maintained at the same levels (marginal increase to 12% share in 2030 from 11% in 2022), substituting part of the consumption of oil for heating, leading to a reduction in the share from 30% in 2022 to 7% in 2030. Substantial is also the increase in the use of heat pumps in 2030, compared to 2022, as assumed by the rise in the use of ambient heat (260% increase in 2030 compared to 2022). The same trend continues until 2050 as a result of the electrification of the residential sector with the elimination of heating oil and the significant reduction of natural gas.

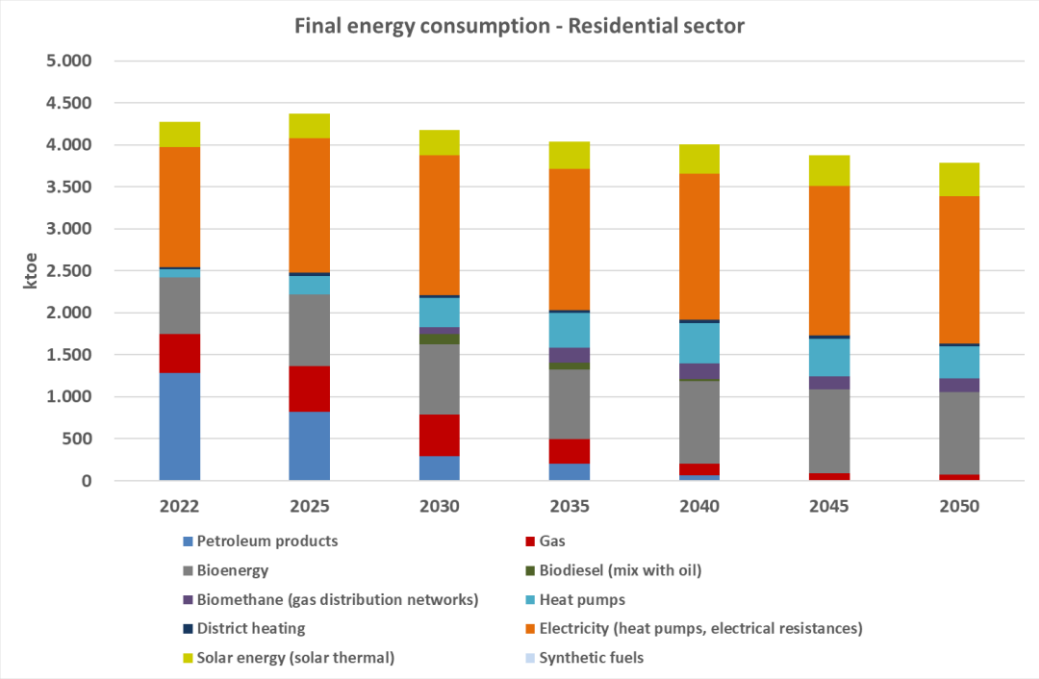


Figure 29: Final energy consumption per fuel in Greece's residential sector, 2022-2050

In the tertiary sector, an increase in final energy consumption of 12% is achieved in 2030 (2.33 Mtoe) and 30% in 2050 (2.70 Mtoe), compared to 2022 (2.08 Mtoe) (Figure 30). At the technology level, the penetration of heat pumps dominates with a share in final energy consumption of 21% in 2030 compared to 17% in 2022. Electricity consumption is also particularly high, maintaining a share of 66% in 2030, slightly reduced compared to 2022 (71%).

The contribution of natural gas remains unchanged at 5% in the period 2022-2030, while the significant increase in biodiesel, biomethane and bioenergy leads in turn to a reduction in the contribution of petroleum products from a share of 6% in 2022 to 3% in 2030 in terms of final energy consumption in the tertiary sector. The same trend is maintained until 2050, with electricity and ambient heat being the main energy products for covering the thermal needs of the tertiary sector.

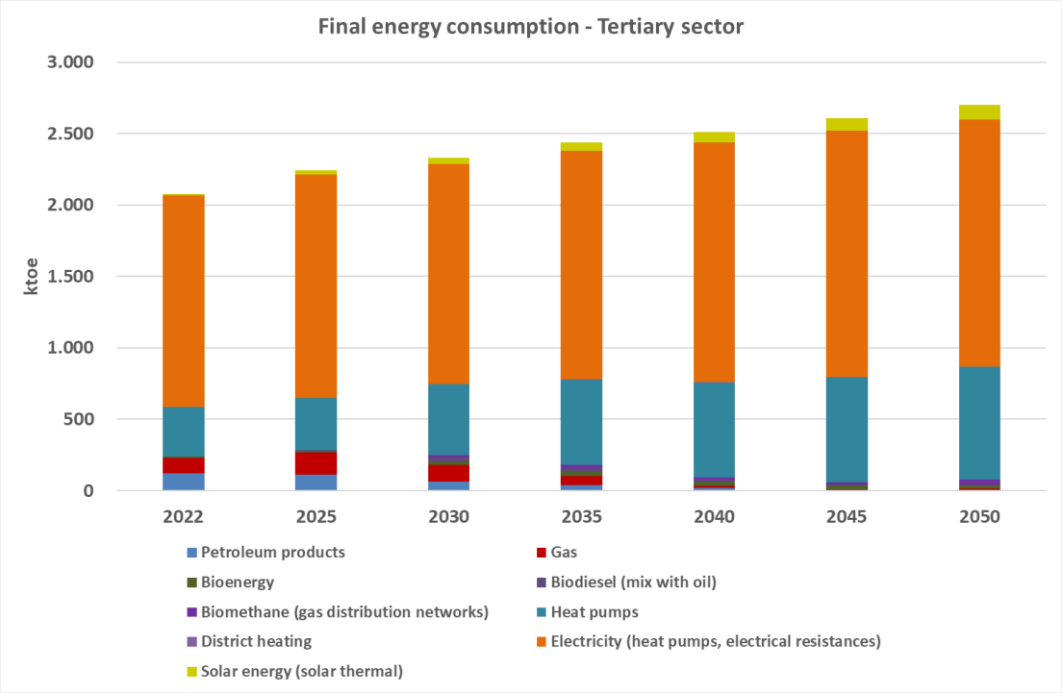


Figure 30: Final energy consumption per fuel in Greece's tertiary sector, 2022-2050

In the industrial sector, a mild decrease in final energy consumption is recorded during the period 2022-2050 (Figure 31). More specifically, there is an overall decrease in energy consumption by 14% in 2030 and by 26% in 2050, compared to 2022. The dominant energy product in the industrial sector is electricity, the contribution of which increases from a share of around 40% in 2022 to a share of 46% in 2030 and a share of 72% in 2050 of total final energy consumption. Petroleum products and natural gas make a relatively significant contribution, which is however constantly decreasing, while the use of bioenergy is increasing, as shown by the doubling of energy consumption in 2050, compared to 2022.

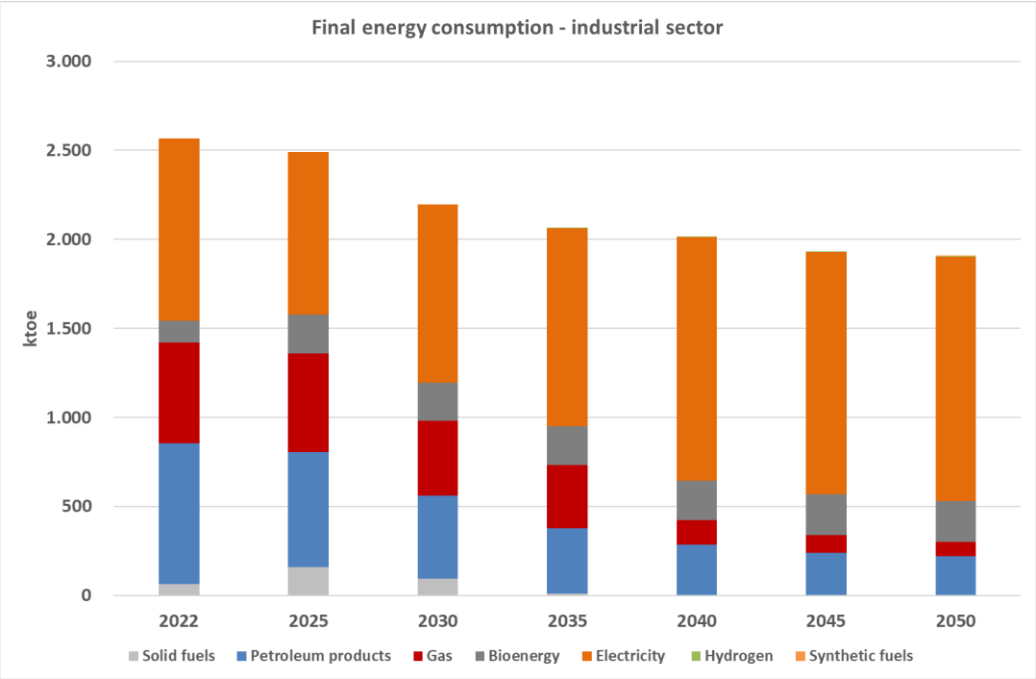


Figure 31: Final energy consumption per fuel in Greece's industrial sector, 2022-2050

In the agricultural sector, a significant increase in final energy consumption is achieved in the period 2022-2050 (29% increase), mainly due to the increased use of electricity and bioenergy. However, final energy consumption stabilizes after 2025 at the level of 340-350 ktoe. Electricity use decreases over 2030-2050 (5.8% decrease in 2050, compared to 2030). Correspondingly, bioenergy use increases significantly both in 2030 (49% increase, compared to 2022) and in 2050 (169% increase, compared to 2022). Finally, the consumption of petroleum products decreases significantly over 2022-2050.

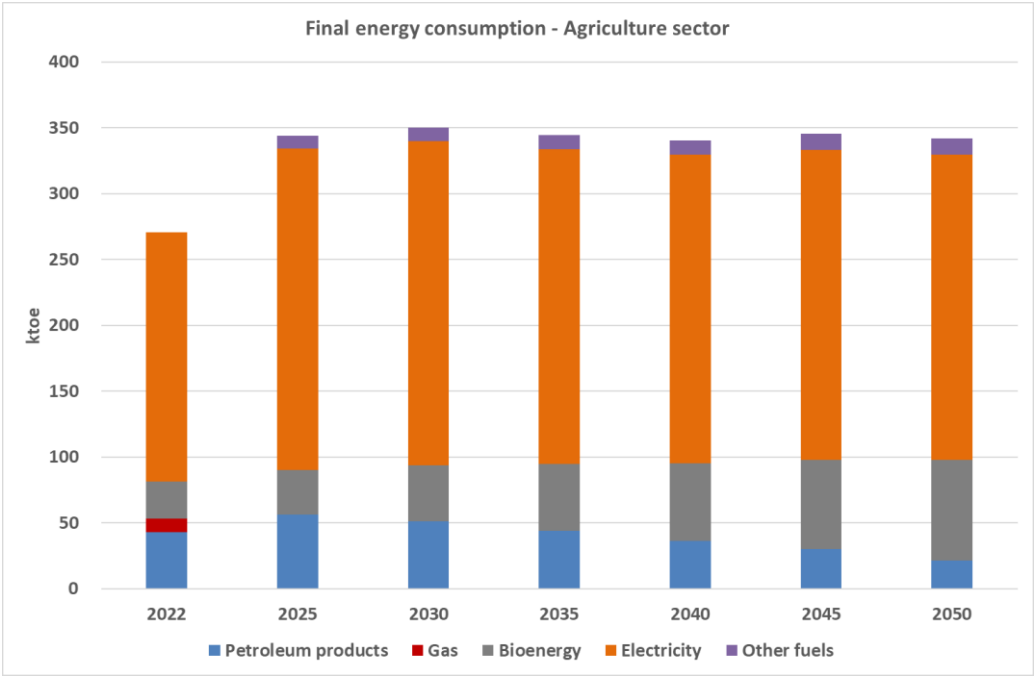


Figure 32: Final energy consumption per fuel in Greece's agriculture sector, 2022-2050

According to the updated NECP of August 2024, the binding target for the development of RES for heating and cooling in Greece is set at 52.6% for 2030. Heat pumps will mainly contribute to achieving this target, since they use electricity, ambient heat and thermal solar systems. There is no provision for expanding the use of biomass for combustion in city buildings to avoid burdening atmospheric air pollution by particles. In any case, the use of biomass will remain at current levels, ensuring its efficient utilization.

The RES share in gross final energy consumption for heating and cooling in Greece is expected to reach 39.8% in 2025, 75.2% in 2040 and 84.1% in 2050.

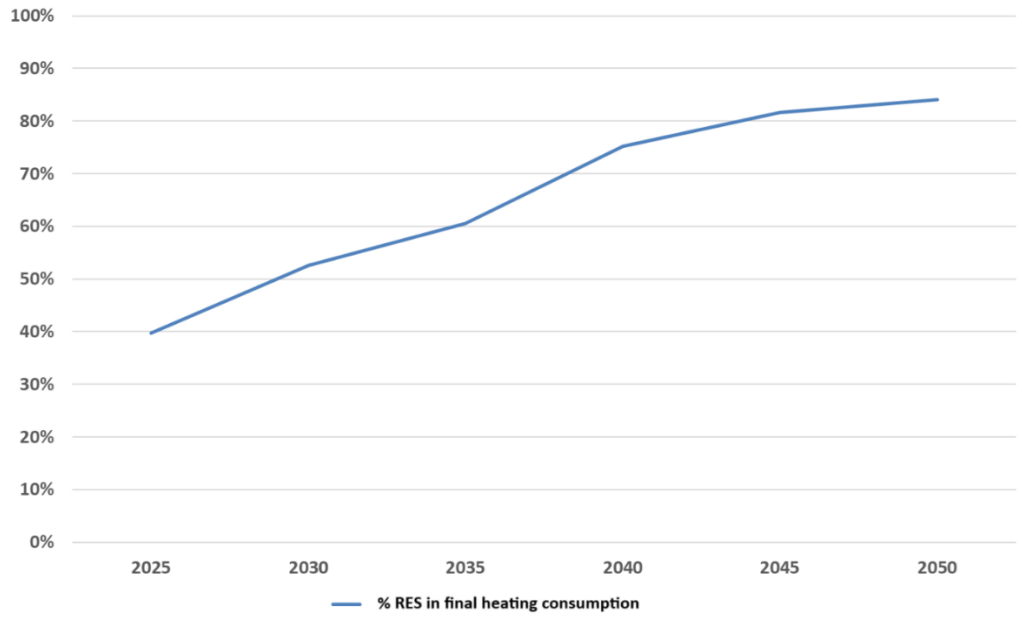


Figure 33: RES penetration in final energy consumption for heating and cooling in Greece

In buildings, 60% of Greece's building stock belongs to the lowest energy categories (E-G) and more than half was built before 1980, therefore lacking thermal insulation. There is also a significant discrepancy between the national built environment and the EU average, as shown in the shares of low-performance buildings. These buildings usually have significantly lower resilience to rising energy costs as well as extreme weather events due to climate change that are already taking place in Greece (e.g. floods, heat waves).

The increase in the renovation rate of the building stock will play a key role in the evolution of final energy consumption in the residential sector (Figure 34). More specifically, the annual renovation rate of residential buildings in the period 2025-2030 will amount to 68 thousand renovations. Correspondingly, in the period 2031-2040 the annual renovation rate will decrease to 64 thousand renovations, while a significant increase is expected in the period 2041-2050 to 83 thousand for the decarbonization of the residential sector.

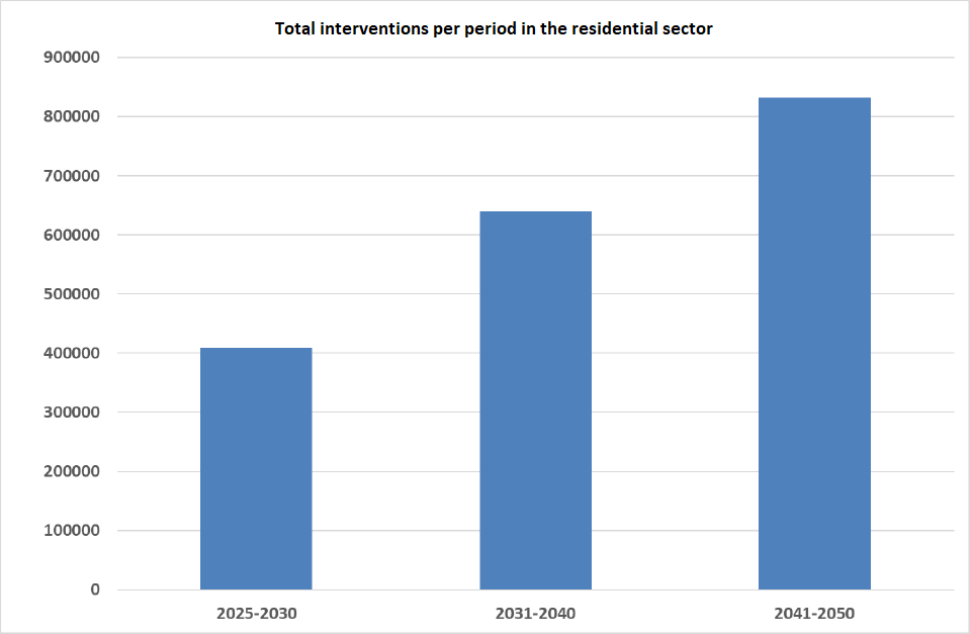


Figure 34: Total interventions per period in the residential sector by 2050

According to the 2017 Monitoring Report of the Sustainable Energy and Climate Action Plan (SECAP) of the municipality of Veria[24], the latest available aggregated data for final energy consumption in the area is for 2012 and its breakdown is shown in Table 4.

Table 4: Final energy consumption per sector and per fuel in the municipality of Veria, 2012

Consumption type	Electricity	Heating oil	Diesel oil	Gas oil	LPG	Biomass	Total
A. Buildings and Facilities							
Municipal buildings/facilities	6.660	3.938					10.598
Residential buildings	103.820	142.885	0	0	0	18.102	264.807
Buildings of the tertiary sector	83.198	464			155		83.817
Industries	30.188						30.188
Municipal lighting	7.860						7.860
Subtotal for buildings	**231.726**	**147.287**	**0**	**0**	**155**	**18.102**	**397.270**
B. Transport							
Private vehicles			142.132	107.206			249.338
Public transport			4.384				4.384
Municipal fleet			2.210	278	14		2.502
Subtotal for transport			**148.726**	**107.484**	**14**		**256.224**
C. Agriculture/Livestock farming							
Irrigation	19.410						19.410
Plant and animal production			9.722				9.722
Subtotal for agriculture/livestock farming	**19.410**		**9.722**				**29.132**
TOTAL	**251.136**	**147.287**	**158.448**	**107.484**	**169**	**18.102**	**682.626**

[24] ETAM (2017), 2017 Monitoring Report of the Sustainable Energy and Climate Action Plan (SECAP) of the municipality of Veria,

5.4 Available support schemes

Greece has implemented various support schemes and financing instruments to promote efficient heating and cooling solutions. These initiatives, existing and propoped, aim to enhance energy efficiency, reduce greenhouse gas emissions, and align with European Union directives.

The **existing support schemes** can be summarized as follows:

- The government has announced in January 2025 a new €223.2 million support programme, known as **"Change heating system and water heater"**, to facilitate the use of green heating systems for households, such as rooftop solar heaters and heat pumps. It takes place under the RePowerEU policy initiative and the National Recovery and Resilience Plan Greece 2.0. They are financed from the EU's NextGenerationEU package for economic recovery from the COVID-19 pandemic. The programme supports the purchase of new solar heaters for domestic hot water, covering 50% to 60%, depending on the applicant's income. Eligible costs for heat pumps amount to 50%, while installation works are also covered with 50% to 60%.
- Greece, over the last years, has a dedicated programme, known as **"SAVE at Home"**, aimed at improving energy efficiency in primary residences (detached houses and individual apartments) and providing subsidies of 50%-100% of the investment cost. Beneficiaries can also benefit from a low interest-free loan to cover their own contribution. Eligible interventions are interventions such as replacing window frames, installing or upgrading thermal insulation, modernizing heating and cooling systems, adopting RES-powered hot water systems, and integrating smart home energy management and storage solutions. The most recent cycle of this programme was launched in January 2025 with a budget of €434 million. A strategic change in this last cycle is that the eligible interventions for heating systems and domestic hot water include only RES options (e.g. air to water heat pumps, geothermal heat pumps, biomass boilers, solar thermal collectors), while fossil fuel based systems are excluded.

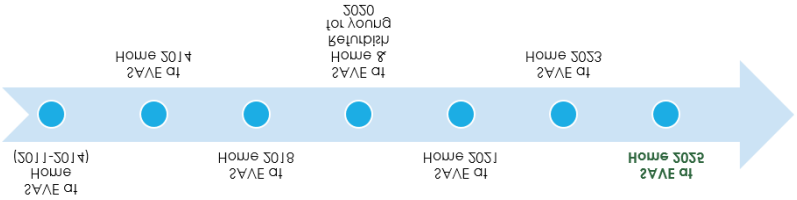


Figure 35: Various cycles of SAVE at Home programme, 2011-2025

- The **Electra** programme, launched in 2020, aims to improve the energy efficiency of public buildings. The programme is funded from 2022 to 2026 with €500 million by the Deposit and Load Fund of the European Investment Bank, €170 million from the EU Recovery and Resilience Facility, and €250 million in private investments. The programme includes public buildings with an energy class between C and H that have not yet undergone radical renovation. The programme finances the renovation of the whole building, aimed to improve energy efficiency and reach class B and reduce energy demand by 30%, with the mandatory appointment of an energy manager. Financed interventions include replacing windows, modernising heating and cooling systems, and installing renewables and electricity storage. The programme encourages the participation of energy service companies to perform the renovation works. Up to 50% of eligible renovation costs can be funded through the programme,

while there are non-repayable grants covering part of the investment. In addition, there are favorable loans (through the Deposit and Loan Fund and EIB) to cover remaining project costs as well as the option for energy service companies (ESCOs) to participate through energy performance contracts (EPCs).

- The **"Upgrade my house"** programme, with a budget of €300 million, for the provision of interest-free loans for energy interventions in dwellings (main or non-rented secondary) of natural persons, without income criteria. The eligible investments include thermal insulation (internal/external), construction of a green roof, installation of energy-efficient frames, solar water heater. external permanent shading systems, a heating-cooling system using exclusively renewable energy sources or a high-efficiency combined heat and power system, thermostatic regulation systems. energy storage system (accumulators) from renewable energy sources and photovoltaic stations. The maximum amount of funding is 50% of the project budget of the application and in any case cannot exceed the amount of €500,000.
- **Income Tax Deductions**: Tax deduction for expenses related to services for the energy, operational and aesthetic upgrading of buildings (Article 39B of Law 4172/2013 (Government Gazette A', 167/23.07.2013)), as well as tax depreciation of companies (Article 24 of Law 4172/2013 (Government Gazette A', 167/23.07.2013)). These incentives encourage both individuals and companies to adopt sustainable energy solutions.
- **Development Law Incentives**: The 2016 Development Law offers investment subsidies and tax breaks for renewable heating and cooling projects undertaken by private enterprises or social cooperatives. Subsidies can cover 30%-65% of relevant investment costs, depending on the project's nature and the size of the enterprise.

There are also the **proposed support schemes**, as analysed in Greece's updated NECP of August 2024, which are summarized in Table 5.

Table 5: Proposed support schemes in Greece's updated NECP

Policy measure	Objective	Affected sector	Measure category
Promotion of RES, storage systems and fuel production from RES	Reduction of GHG emissions apart from ETS	Electricity Generation Heating-Cooling Transport Sector	Regulatory, Technical, Economic measure
Reduction of fluorinated gas emissions	Reduction of GHG emissions apart from ETS	Industrial processes Refrigeration, air conditioning, fire protection systems	Regulatory measure
Development of environmental markets through the use of Guarantees of Origin for the production of RES projects	Increase in electricity production from RES Increase in RES for heating-cooling Increase in RES in transport	Electricity Generation Heating-Cooling Transport Sector	Regulatory, Economic measure
Support for the development of RES energy projects (with or without storage systems by Renewable Energy Communities and Citizen Energy Communities through the use of specialized financial tools	Increase in electricity production from RES	Electricity generation	Increase in electricity production from RES
Design of interconnections based on the optimal utilization of RES potential	Increase in electricity production from RES	Electricity generation	Technical measure

Policy measure	Objective	Affected sector	Measure category
and the enhancement of green electricity exports	Increase in RES for heating-cooling		
Promotion of RES installation in buildings	Increase in electricity production from RES Increase in RES for heating-cooling	Electricity generation Heating-Cooling in buildings	Economic measure
Setting minimum RES participation limits and removing obstacles to installing RES and storage systems in buildings	Increase in electricity production from RES Increase in RES for heating-cooling	Electricity generation Heating-Cooling in buildings	Regulatory measure
Promotion of efficient heating and cooling systems using RES	Increase in RES for heating and cooling	Heating-Cooling in all consumption sectors	Technical, Economic measure
Support and implementation of optimal environmental and energy-efficient bioenergy applications	Increase in RES for heating and cooling	Heating-Cooling in all consumption sectors	Economic measure

More specifically, programmes for the installation of photovoltaic systems with a storage system for self-production will be strengthened with the aim of producing electricity from renewable sources to cover thermal - cooling needs through heat pumps and reducing energy costs for consumers. In addition, the installation of hybrid RES systems (such as solar thermal with heat pumps, photovoltaic with heat pumps, solar thermal with biomass, solar thermal with geothermal energy) will be encouraged, based on the principle of technological neutrality.

The promotion of the use of bioenergy to meet the heating and cooling needs of households and industries is an important step towards reducing dependence on conventional energy sources and reducing greenhouse gas emissions. Greece has a great potential for the development of bioenergy, as it has rich natural resources and alternative energy sources that can be exploited. In any case, the exploitation of bioenergy will be carried out through modern and energy-efficient boilers and heating systems, ensuring compliance with the provisions of the applicable environmental legislation.

The use of RES systems for heating and cooling (mainly heat pumps and solar thermal systems) will be enhanced through the combined use of different policy measures in full compliance with the provisions of the comprehensive assessment for the promotion of efficient heating and cooling, which will be appropriately revised based on the new energy saving and RES targets. The updated comprehensive assessment for heating and cooling will be prepared in accordance with the provisions of Article 25 of Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency, applying the “Energy Efficiency First” Principle.

5.5 GAP analysis

The promotion of efficient heating and cooling options in Greece faces several challenges and barriers. These obstacles stem from policy gaps, economic constraints, infrastructure limitations, and public awareness issues. Below are the main challenges:

1. **Economic & Financial Barriers**

- **High Initial Investment Costs** – Energy-efficient systems (e.g., heat pumps, geothermal, solar thermal) require high upfront costs, deterring adoption, despite long-term savings.

- **Inadequate Financial Incentives & Subsidies** – While some government programmes exist, funding is insufficent to satisfy the demand, while many households and businesses struggle to access subsidies or low-interest loans.
- **Energy Poverty** – A significant portion of the population cannot afford heating and cooling upgrades, especially in rural and lower-income areas.

2. **Policy & Regulatory Barriers**

- **Complex & Bureaucratic Procedures** – Obtaining permits for renewable energy systems (e.g., geothermal, district heating) is time-consuming and complicated, discouraging investment.
- **Delays in the implementation of energy efficiency policies and measures** – Deviation have been observed compared to the implementation plan of the NECP for the energy efficiency policies and measures to attain the energy efficiency targets.

3. **Technical & Infrastructure Barriers**

- **Aging Building Stock** – Many Greek buildings, especially in cities, lack proper insulation and efficient HVAC systems, making retrofitting costly and complex.
- **Limited District Heating Infrastructure** – Unlike other European countries, district heating is underdeveloped, with most systems concentrated in Northern Greece.
- **Grid Limitations for Electrification** – Increased adoption of electric heating (e.g., heat pumps) strains the electricity grid, requiring significant upgrades.

4. **Market & Industry Challenges**

- **Dependence on Fossil Fuels** – Greece still relies on **natural gas and heating oil**, slowing the transition to renewables.
- **Shortage of Skilled Professionals** – There is **a lack of trained technicians and engineers** for installing and maintaining modern heating and cooling systems.
- **Limited Availability of High-Efficiency Technologies** – Advanced technologies like geothermal heating and district cooling are **not widely available** across the country.

5. **Social & Behavioral Barriers**

- **Low Public Awareness** – Many households and businesses lack knowledge about energy-efficient heating and cooling options and their long-term benefits.
- **Cultural Preferences for Traditional Heating** – In many areas, firewood and oil heating are deeply ingrained habits, making it difficult to shift to modern solutions.
- **Reluctance to Invest in Energy Renovations** – Property owners, especially in multi-family buildings, often hesitate to invest in collective heating system upgrades due to cost-sharing disputes.

6. **Climate & Geographical Barriers**

- **Diverse Climate Conditions** – Greece has varied climatic zones, making it challenging to implement a one-size-fits-all heating and cooling strategy.

- **Mountainous-Specific Challenges** – The transition of mountainous areas to efficient heating/cooling is challenging due to the more expensive and logistically difficult.

6 Synopsis and comparative analysis

The CHAMP project supports municipalities in Bulgaria, Greece and Croatia in aligning with EU directives requiring local heating and cooling (H&C) plans. The project assesses policies, technologies, energy consumption, and gaps in the three countries to promote clean energy transitions. All three countries are governed by updated EU legislation: Renewable Energy Directive (RED), the Energy Efficiency Directive (EED), and the Energy Performance of Buildings Directive (EPBD). These directives push for annual increases in renewable energy use, comprehensive H&C assessments, and energy-efficient renovations.

Bulgaria lacks a dedicated national H&C strategy, though its NECP sets a 44% RES share target for H&C by 2030. Municipalities often rely on legacy infrastructure, and planning has traditionally focused on public buildings. Recent shifts target household heating via air quality programs. Electricity and firewood dominate household heating in Bulgaria. District heating exists in 12 towns but is mostly fossil-fuel based. Heat pumps are expanding but still limited. Firewood remains prevalent, especially in rural regions, often with inefficient systems. In addition, Bulgaria faces regulatory gaps, including partial transposition of EU directives and limited municipal planning mandates. Market barriers include poor consumer awareness, installation challenges, and insufficient incentives for mid-income households.

Similarly, Croatia's NECP emphasizes H&C decarbonization, with a 2030 RES target of 47.1% in H&C. District heating plays a minor role but modernization and integration of geothermal and solar energy are key strategic goals. Croatia relies heavily on individual gas and wood-fired systems, with electricity use rising. District heating is limited to a few urban areas. Cooling demand is increasing, primarily met through electricity-driven air conditioning. Barriers include low energy renovation rates, limited geothermal use despite potential, and fragmented implementation of renovation strategies. Regulatory delays and modest progress in modernizing district heating limit impact.

Greece's NECP targets 52.6% RES share in H&C by 2030. The municipality of Veria is representative of peri-urban areas with mixed building stock. Greece emphasizes electrification and energy renovations, particularly through EU-funded programs. Electric heaters, split air conditioners, and oil boilers dominate, while district heating is underdeveloped. Heat pump adoption is rising, supported by renovation funding. Solar thermal energy is widespread, especially for domestic hot water. Main challenges include fragmented data, slow implementation of municipal plans, and weak enforcement of building codes. Planning often overlooks rural and older urban areas, and one-stop shops for consumer guidance are underdeveloped.

Croatia shows stronger integration of H&C in strategic documents, with clear investment frameworks. Greece leads in solar thermal use and electrification, while Bulgaria stands out in leveraging air quality legislation to influence heating choices. In all three countries, residential heating dominates energy use. Bulgaria has the highest use of firewood, Croatia retains gas dominance, and Greece uses electric- and oil-based systems. Cooling is growing faster in Croatia and Greece due to climatic conditions. All three countries face high upfront costs for efficient systems, limited installed capacity, and fragmented supply chains. Installation quality varies, and consumer trust and technical support services remain underdeveloped.

Moreover, Bulgaria and Croatia operate aging district heating systems that are not yet adapted for low-temperature, renewable-based operation. Greece lacks such infrastructure, relying on decentralized solutions. Bulgaria provides extensive support to vulnerable households through targeted grants, but lacks engagement mechanisms for the middle class.

Greece leads in solar potential utilization, Croatia shows promise in geothermal development, while Bulgaria has abundant biomass and geothermal capacity, much of which remains untapped or inefficiently used. Municipal-level data remains inconsistent across all three countries, impeding proper planning. Bulgaria is somewhat ahead in using census-based energy data, but all countries need better digital tools and centralized databases.

None of the countries fully meets the planning and transposition obligations under the revised EED and RED III. Bulgaria lags in directive transposition and district heating modernization, while Croatia and Greece need to accelerate local plan adoption.

To close gaps, all three countries must improve municipal planning capacity, transposition of EU laws, consumer engagement, and financing accessibility. Focused investments in low-carbon district heating for Bulgaria and Croatia and decentralized electrification for Greece are key to long-term decarbonization.

References

ETAM (2017), 2017 Monitoring Report of the Sustainable Energy and Climate Action Plan (SECAP) of the municipality of Veria

CINEA. (2025). Bulgarian municipalities working together to improve air quality - LIFE IP CLEAN AIR project. Reference: LIFE17 IPE/BG/000012. Co-funded by EC, CINEA. 2018-2025. https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE17-IPE-BG-000012/bulgarian-municipalities-working-together-to-improve-air-quality

Council of Ministers. (1996). Clean Ambient Air Act. In force since 29.06.1996, last amendment SG, issue 41 of 10.05.2024. https://lex.bg/laws/ldoc/2133875712

Council of Ministers. (2003). Energy Act. Last amendments SG issue 26, 27.03.2025. https://lex.bg/laws/ldoc/2135475623

Council of Ministers. (2011). Energy from Renewable Sources Act. Last amendments SG issue 14 of 18.02.2025. https://lex.bg/bg/laws/ldoc/2135728864

Council of Ministers. (2015). Energy Efficiency Act. Last amendments SG issue 86 of 13.10.2023. https://seea.government.bg/documents/ZAKON_za_energijnata_efektivnost.pdf

Council of Ministers. (2015a). Energy Efficiency of Multi-Family Residential Buildings National Programme. Adopted by Ordinance No. 18 of 02.02.2015 of the CoM. https://www.mrrb.bg/en/energy-efficiency/energy-efficiency-of-multi-family-residential-buildings-national-programme/

Council of Ministers. (2020). Ordinance on the Requirements for the Quality of Solid Fuels Used for Domestic Heating, the Conditions, Procedure and Method for Their Control. Adopted by Decision No. 22 of 17.02.2020 of the Council of Ministers, last amendments SG issue 105 of 19.12.2023. https://www.damtn.government.bg/wp-content/uploads/naredbi/naredba_za_iziskvaniyata_za_kachestvoto_na_tvardite_goriva.pdf

Council of Ministers. (2021). Long-Term National Strategy for Supporting the Renovation of the National Building Stock of Residential and Non-Residential Buildings by 2050. Adopted by the Decision No. 8 of 27.01.2021. https://www.seea.government.bg/documents/bg_ltrs_2020_en_version.pdf

Council of Ministers. (2023). Updated National Recovery and Resilience Plan. December 2023. https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/bulgarias-recovery-and-resilience-plan_en

DG-ENERGY. (2024). EU Building Stock Observatory. Published by EC, Directorate-General for Energy, updated on 04.12.2024. https://data.europa.eu/data/datasets/building-stock-observatory?locale=en

EEA Grants. (2025). Start of the negotiations between Bulgaria and the Donor Countries on the new period of the EEA and Norway Grants. Published on 18.02.2025. https://www.eeagrants.bg/en/news/launch-of-negotiations

European Commission (2025). Heating and cooling. https://energy.ec.europa.eu/topics/energy-efficiency/heating-and-cooling_en

Eurostat. (2024). Energy use in EU households in 2022 lowest since 2016. Article published on 05.06.2024. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240605-2

Eurostat. (2025). Disaggregated final energy consumption in households - quantities. Last update: 14.05.2025. https://ec.europa.eu/eurostat/databrowser/view/nrg_d_hhq/default/table?lang=en&category=nrg.nrg_quant.nrg_quanta.nrg_d

Eurostat. (2025a). Final energy consumption in households by type of fuel. Last update: 03.05.2025. https://ec.europa.eu/eurostat/databrowser/view/ten00125/default/table?lang=en

EWRC. (2005). Methodology for determining admissible amounts of technological costs of heat energy at transmission of heat. Energy and Water Regulatory Commission. Adopted by protocol Decision No. 139/20.10.2005, p. 1. https://www.dker.bg/files/DOWNLOAD/methodology_2.pdf

EWRC. (2012). Methodology for determining admissible technological costs in transmission, distribution and storage of natural gas. Energy and Water Regulatory Commission. Adopted by protocol Decision No. 117/16.07.2012. https://www.dker.bg/files/DOWNLOAD/metodika_thnol_razh_%2012.pdf

IME. (2024). Regional Profiles. Pernik District. Institute for Market Economics. https://www.regionalprofiles.bg/var/docs/2024_EN_RP/11_Pernik.pdf

ME. (2007). Ordinance №16-334 of 6 April 2007 on Heat Supply. Ministry of Energy. Last amendments SG issue 60 of 7.7.2020. https://lex.bg/laws/ldoc/2135550456

ME. (2023). Draft Sustainable Energy Development Strategy of the Republic of Bulgaria 2030/2050. Ministry of Energy. https://www.parliament.bg/pub/cW/20200909030007%D0%A1%D1%82%D1%80%D0%B0%D1%82%D0%B5%D0%B3%D0%B8%D1%8F%20%D0%B7%D0%B0%20%D1%83%D1%81%D1%82%D0%BE%D0%B9%D1%87%D0%B8%D0%B2%D0%BE%20%D0%B5%D0%BD%D0%B5%D1%80%D0%B3%D0%B8%D0%B9%D0%BD%D0%BE%20%D1%80%D0%B0%D0%B7%D0%B2%D0%B8%D1%82%D0%B8%D0%B5%20%D0%BD%D0%B0%20%D0%A0%20%D0%91%D1%8A%D0%BB%D0%B3%D0%B0%D1%80%D0%B8%D1%8F%202030%20%D0%B3..pdf

ME, MOEW. (2024). Bulgaria - Final updated NECP 2021-2030 (submitted in 2025). Ministry of Energy, Ministry of Environment and Water. Published on 15.01.2025 by EC, Directorate-General for Communication. https://commission.europa.eu/document/download/a3370b6f-98f5-4402-acee-df1f2e505437_bg?filename=bulgaria-final-updated-necp-2021-2030-submitted-2025_bg.pdf

MH, MOEW. (2010). Ordinance No. 12 of 15 July 2010 on Limits for Sulphur Dioxide, Nitrogen Dioxide, Fine Particulate Matter, Led, Benzene, Carbon Monoxide and Ozone in the Ambient Air. Ministry of Health, Ministry of Environment and Water. Last amendments SG issue 79 of 8.10.2019. https://lex.bg/laws/ldoc/2135691821

Ministry of Economy of Croatia (2025). Integrated National Energy and Climate Plan for the Republic of Croatia for the Period 2021-2030. https://mzozt.gov.hr/UserDocsImages/KLIMA/NECP_Update%20_CRO_EN_FINAL.pdf

Ministry of Environment and Energy of Greece (2025). Greece - Final updated NECP 2021-2030 (submitted in 2025). https://commission.europa.eu/publications/greece-final-updated-necp-2021-2030-submitted-2025_en

MLSP. (2008). Ordinance No. RD-07-5 of 16 May 2008 on the Terms and Procedure for Allocation of Targeted Heating Assistance. Ministry of Labour and Social Politics. In force since 27.5.2008, last amendments SG issue 50 of 9.06.2023. https://lex.bg/laws/ldoc/2135588875

MOEW. (2022). Bulgaria's long-term climate change mitigation strategy by 2050. Ministry of Environment and Water. https://www.moew.government.bg/static/media/ups/articles/attachments/BG%20LTS%202050573839cd4d01854ef8b597881fde2256.pdf

NSI. (2023). Households in the Republic of Bulgaria as of September 7, 2021. National Statistical Institute. Press release, published on 22.06.2023. https://nsi.bg/en/content/20512/%D0%BF%D1%80%D0%B5%D1%81%D1%81%D1%8A%D0%BE%D0%B1%D1%89%D0%B5%D0%BD%D0%B8%D0%B5/households-republic-bulgaria-september-7-2021

NSI. (2025). Regions, districts and municipalities in the Republic of Bulgaria 2023. National Statistical Institute. Published at: 04.03.2025. https://nsi.bg/bg/content/22168/%D0%BF%D1%83%D0%B1%D0%BB%D0%B8%D0%BA%D0%B0%D1%86%D0%B8%D1%8F/%D1%80%D0%B0%D0%B9%D0%BE%D0%BD%D0%B8%D1%82%D0%B5-%D0%BE%D0%B1%D0%BB%D0%B0%D1%81%D1%82%D0%B8%D1%82%D0%B5-%D0%B8-%D0%BE%D0%B1%D1%89%D0%B8%D0%BD%D0%B8%D1%82%D0%B5-%D0%B2-%D1%80%D0%B5%D0%BF%D1%83%D0%B1%D0%BB%D0%B8%D0%BA%D0%B0-%D0%B1%D1%8A%D0%BB%D0%B3%D0%B0%D1%80%D0%B8%D1%8F-2023

NSI. (2025a). Population by districts, municipalities, place of residence and sex as of 31.12.2024. National Statistical Institute. Published on 29.04.2025. https://nsi.bg/bg/content/2975/%D0%BD%D0%B0%D1%81%D0%B5%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5-%D0%BF%D0%BE-%D0%BE%D0%B1%D0%BB%D0%B0%D1%81%D1%82%D0%B8-%D0%BE%D0%B1%D1%89%D0%B8%D0%BD%D0%B8-%D0%BC%D0%B5%D1%81%D1%82%D0%BE%D0%B6%D0%B8%D0%B2%D0%B5%D0%B5%D0%BD%D0%B5-%D0%B8-%D0%BF%D0%BE%D0%BB

NSI. (2025b). Regional statistics - Bulgaria. National Statistical Institute. Published on 18.02.2025. https://nsi.bg/en/content/14772/total

Official Journal of the European Union (2024). DIRECTIVE (EU) 2024/1275 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 April 2024 on the energy performance of buildings (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401275

Official Journal of the European Union (2023a). DIRECTIVE (EU) 2023/1791 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023L1791

Official Journal of the European Union (2023b). DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

Pernik Municipal Council. (2017). Updated Municipal Development Plan of the Municipality of Pernik 2014-2020. Adopted by the Decision No. 733/23.01.2018 of the Pernik Municipal Council. https://pernik.bg/wp-content/uploads/2020/10/%D0%90%D0%9A%D0%A2%D0%A3%D0%90%D0%9B%D0%98%D0%97%D0%90%D0%A6%D0%98%D0%AF-%D0%9D%D0%90-%D0%9E%D0%91%D0%A9%D0%98%D0%9D%D0%A1%D0%9A%D0%98-%D0%9F%D0%9B%D0%90%D0%9D-%D0%97%D0%90-%D0%A0%D0%90%D0%97%D0%92%D0%98%D0%A2%D0%98%D0%95-%D0%9D%D0%90-%D0%9E%D0%91%D0%A9%D0%98%D0%9D%D0%90-%D0%9F%D0%95%D0%A0%D0%9D%D0%98%D0%9A-2014-2020-%D0%93.-%D0%97%D0%90-%D0%9F%D0%95%D0%A0%D0%98%D0%9E%D0%94%D0%90-2017-2020-%D0%93..pdf

SEDA. (2025). Analysis of the state of energy efficiency in the country and annual progress on the implementation of policies and measures to improve energy efficiency in Bulgaria in 2024. Sustainable Energy Development Agency. Annual Report. March 2025. https://www.seea.government.bg/documents/Analiz_EE_za2024.pdf

Sofia. (2021). Complex Programme for Improving Ambient Air Quality of Sofia Municipality 2021-2026. Adopted by Decision 204/22.04.2021 of the Sofia Municipal Council. https://www.sofia.bg/documents/20121/1088172/2021-05-05-%D0%9F%D1%80%D0%B8%D0%BB.1.pdf/2835466e-f861-49c0-94f8-a5b9d61755a5

Sofia. (2023). Ordinance on the creation of zones with low emissions of harmful substances in the atmospheric air on the territory of the Metropolitan Municipality. Adopted by Decision 931 of Sofia Municipal Council, in force since 1.12.2023. https://sofia.obshtini.bg/doc/5053858

Stoyanova M., Stefanov B., Takeva L. (2006). Prospects for biomass use in Bulgaria in the context of the European Energy Strategy. The Journal of Management and Sustainable Development. Management and sustainable development 3-4/2006(15). https://jmsd.bg/files/articles/15/15-43_M_Stoyanova_Stefanov_Takeva.pdf

World Bank. (2018). Bulgaria National Program for Energy Efficiency in Residential Buildings; Program Design Report for the Second Phase. Report No: AUS0000388. July 2018. https://documents1.worldbank.org/curated/en/329851534930802672/pdf/Bulgaria-National-Residential-Energy-Efficiency-Program-Phase-2-Design-Report.pdf

City of Rijeka (2020.) Sustainable Energy and Climate Action Plan (SECAP) Informacija-o-provedbi-savjetovanja-s-javnošću-o-Nacrtu-prijedloga-akcijskog-plana-održivog-energetskog-razvoja-i-prilagodbe-klimatskim-promjenama-Grada-Rijeke-SECAP.pdf

City of Rijeka (2021.) Development Plan of the City of Rijeka for the period 2021. – 2027. Plan-razvoja-Grada-Rijeke-za-razdoblje-2021.-2027..pdf

City of Rijeka (2022.) Implementation Programme of the City of Rijeka for the 2021–2025 term Provedbeni-Program-Grada-Rijeke-za-mandatno-razdoblje-2021.-2025.-godine.pdf

City of Rijeka (2025.) Cooperation Agreement on the Development of Smart Energy Decarbonisation Systems Grad Rijeka potpisnik Sporazuma o suradnji na razvoju pametnih sustava za dekarbonizaciju energije – Grad Rijeka

Competitiveness and Cohesion Programme 2021–2027 (2024.) sfc2021-PRG-2021HR16FFPR001-2.1.pdf

Croatian Bank for Reconstruction and development Urban Development Fund | HBOR

Croatian Parliament (2012.) Energy Act Zakon o energiji - Zakon.hr

Croatian Parliament (2013.) Building Act Zakon o gradnji - Zakon.hr

Croatian Parliament (2013.) Heat Energy Market Act Zakon o tržištu toplinske energije - Zakon.hr

Croatian Parliament (2013.) Spatial Planning Act Zakon o prostornom uređenju - Zakon.hr

Croatian Parliament (2014.) Energy Efficiency Act Zakon o energetskoj učinkovitosti - Zakon.hr

Croatian Parliament (2018.) Act on the Exploration and Exploitation of Hydrocarbons Zakon o istraživanju i eksploataciji ugljikovodika - Zakon.hr

Croatian Parliament (2020.) Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 Strategija energetskog razvoja Republike Hrvatske do 2030. s pogledom na 2050. godinu

Croatian Parliament (2021.) Renewable Energy Sources and High-Efficiency Cogeneration Act Zakon o obnovljivim izvorima energije i visokoučinkovitoj kogeneraciji - Zakon.hr

Energy Efficiency Programme for the Decarbonisation of the Energy Sector (2021.) PROGRAM ENERGETSKE UČINKOVITOSTI ZA DEKARBONIZACIJU ENERGETSKOG SEKTORA.PDF

Energy Institute Hrvoje Požar (2024.) Energy in Croatia 2023 Energija-u-HR-2023_WEB_novo.pdf

Ministry of Physical Planning, Construction and State Assets (2021.) Energy Renovation Programme for Multi-Apartment Buildings for the period until 2030 Program_energetske_obnove_VS_zgrada_do_2030.pdf

Ministry of Physical Planning, Construction and State Assets (2022.) Energy Renovation Programme for Public Sector Buildings for the period until 2030 PROGRAM_EN_OBN_ZGRADA_JAVNOG_SEKTORA_do2030.pdf

European Economic Area (EEA) and Norway Financial Mechanism Programme areas and funds for the EEA and Norway Grants

Geothermal Potential Development Plan in the Republic of Croatia until 2030 (2023.) Plan razvoja geotermalnog potencijala Republike Hrvatske do 2030..pdf

Integrated Territorial Investments (ITI) ITU – Integrirana teritorijalna ulaganja – EU fondovi Hrvatska

Ministry of Physical Planning, Construction and State Assets (2020.) Long-Term Renovation Strategy of the National Building Stock until 2050 Revizija Dugoročne strategije za poticanje ulaganja u obnovu nacionalnog fonda zgrada Republike Hrvatske

National Recovery and Resilience Plan 2021–2026 (2025.) Revised Annex to the Council Implementing Decision amending the 28 July 2021 Decision on the Assessment of Croatias Recovery and Resilience Plan (EN), June 2025.pdf

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