MINISTRY OF ENERGY

A comprehensive assessment of the potential for high-efficiency cogeneration and for effective district heating and cooling systems in the Republic of Bulgaria

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LIST OF ABBREVIATIONS

CBA	Cost-benefit analysis
AUER	Sustainable Energy Development Agency
GDP	Gross Domestic Product
DHW	Domestic hot water
RES	Renewable energy sources
HE CHP	High-efficiency combined heat and electricity generation
RS	Renewable sources
WPP	Wind power plant
EED	Energy Efficiency Directive
EE	Energy efficiency
EC	European Commission
EU	European Union
ESM	Energy saving measures
KEVR	Energy and Water Regulatory Commission
FEC	Final Energy Consumption
FEI	Final Energy Intensity
mVETs	Small hydro-power plant
ME	Ministry of Energy
NEK	National Electricity Company
NEEAP	National Energy Efficiency Action Plan / the Plan
NSI	National Statistical Institute
NKS	National Coordination Strategy
HP	Heating plant
PSHPP	Pumped-storage hydro power plant
PEC	Primary energy consumption
GHG	Greenhouse gases
EU ETS	EU Emission Trading Scheme
HDN	Heat distribution network
HE CHPP	High-efficiency combined heat and power plants [cogeneration plants]
FETS	Photovoltaic power plant

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UNITS OF MEASUREMENT

y	Year
kg	Kilogram
BGN	Bulgarian Lev
m^3	Cubic meter
t	Tonnes
ha	Hectares
$gCO_2eq.$	grams of carbon dioxide equivalent
GWh	Gigawatt hour
MJ	Megajoule
MW	Megawatt
MWh	Megawatt hour
ktoe	Kilo tonne of oil equivalent
kW	Kilowatt
kWh	Kilowatt hour
toe	tonnes of oil equivalent

GENERAL ENERGY COEFFICIENTS

To	**TJ**	**Gkal**	**Mtoe**	**Mbtu**	**GWh**
From	Multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gkal	4.1868×10^{-3}	1	10^{7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	107	1	3.968×10^{7}	11 630
GWh	3.6	860	8.6×10^{-5}	3 412	1

MAIN DEFINITIONS

Gross domestic energy consumption	a performance indicator calculated by subtracting international marine bunkering from gross available energy. Under the new methodology (in force from the reporting year 2017) the indicator includes ambient heat.
Energy dependence	shows the extent to which an economy depends on imports in order to meet its energy needs. The indicator is calculated by dividing net imports by gross available energy.
Energy intensity	shows the amount of energy needed to produce a unit of gross domestic product. The indicator is calculated as the ratio of gross available energy (in tonnes of oil equivalent) to GDP in thousands of euros at 2010 prices and in thousands of BGN, United States dollars and euros at 2015 prices.
Final Energy Consumption	covers all energy supplied to the end user for all energy needs. It includes fuel consumption for the heat produced by the plant that is not sold but used for the operations of the relevant enterprise.
Useful energy	all energy required by the end-users in the form of heat and cold after all the steps of energy conversion have taken place in the heating and cooling equipment.
Primary energy	is energy as extracted from nature, i.e. energy that has not undergone conversion, such as coal (only refined output is taken into account), crude oil, natural gas, nuclear energy, energy from renewable sources (hydro, wind, solar, geothermal power and ambient heat), biomass, biogas, liquid biofuels and non-renewable fuels. According to the latest update of the methodology, from the beginning of 2019 the indicator also includes primary heat production. The latter is obtained by estimating the quantities of power and heat produced from the heat accompanying chemical processes on the one hand and production process efficiency on the other.
District heating plants	generate exclusively heat for sale
Total supplied energy	a performance indicator calculated as: primary energy production + recovered and recycled products + import-export + stock change – international sea bunkering – international flights. Represents the amount of energy needed to meet domestic consumption in Bulgaria. For by-products derived from conversion processes, the total energy supplied may be negative.

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This document has been drawn up with a view to ensuring compliance with the obligation of all Member States of the European Union under Article 14 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, and in particular Article 22 thereof, taking into account that Directive 2012/27/EU establishes the framework and content for comprehensive assessments of the potential for efficient heating and cooling by Member States. Articles 22 and 23(2) of Directive 2012/27/EU empower the Commission to adopt delegated acts with a view to adapting the requirements stipulated in Annexes VIII and IX. On this basis, Commission Delegated Regulation (EU) 2019/826 of 4 March 2019 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and of the Council on the content of comprehensive assessments of the potential for efficient heating and cooling[1] and Commission Recommendation (EU) 2019/1659 of 25 September 2019 on the content of the comprehensive assessment of the potential for efficient heating and cooling under Article 14 of Directive 2012/27/EU were adopted.

The document contains a comprehensive assessment of the potential for the use of high-efficiency cogeneration and for effective district heating and cooling systems in Bulgaria. The assessment constitutes a technical and economic methodology that aims to identify potential by means of a cost-benefit analysis on the basis of the data obtained and studies carried out. The document has further been compiled on the basis of information provided by the Ministry of Energy, the Energy and Water Regulatory Commission, the Agency for Sustainable Energy Development, the National Statistical Institute and other public sources.

The assessment is updated every five years at the request of the European Commission. The preparatory work carried out for the purpose of the analysis is closely linked to the planning and reporting arrangements provided for in Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (Governance Regulation) and builds on the previous assessment.

The National Heat Map (NHM) has been updated on the basis of a summary of the information provided. The NHM is based on the administrative division map of Bulgaria and contains information about the consumption of energy for heating and cooling and on the technologies needed to meet demand in the individual provinces and municipalities. It provides a visual representation of areas with high heat consumption and the location of major heat suppliers.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0826

INTRODUCTION

Article 14 of Directive 2012/27/EU on energy efficiency primarily aims to identify the potential for energy efficiency improvement through cogeneration, district heating and cooling and the use of sources of surplus heat. This Directive is a stepping stone towards achieving the goal of making Europe a low-carbon [economy] by 2050 in line with the Paris Agreement signed on 22 April 2016 and ratified by the European Union on 5 October 2016. According to [recital] 1 of the Directive, energy efficiency is a valuable means to address the triple challenge that Europe faces of improving the Union's security of supply and energy independence, mitigating climate change and achieving a better economic balance.
The requirements for Member States comprise three main elements:
1) identifying technical potential;
2) conducting a cost-benefit analysis of available options;
3) taking adequate measures to ensure the development of cost-effective potentials.

In 2018, as part of the Clean Energy for All Europeans package, a new amendment to the Energy Efficiency Directive (2018/2002) was agreed to update the policy framework for the period up to 2030 and beyond.

In order to deliver on this commitment, the EU has set the following binding climate and energy targets for 2030:

- reduce greenhouse gas (GHG) emissions by at least 40 % compared to 1990;
- increase energy efficiency (EE) up to at least 32.5 %;
- increase the share of renewable energy sources (RES) up to at least 32 % of gross final energy consumption in the EU;
- achieve a level of at least 15 % of interconnectivity between the electricity systems of Member States.

The overall assessment considers, on an integrated basis, the feasibility of meeting national heating and cooling needs in an energy-efficient manner.

Efficient heating and cooling primarily involves the use of heat from cogeneration and renewable energy sources, recovery of waste heat from industrial processes to meet heating and cooling demand and, more generally, the entire range of heating and cooling options that enable primary energy savings as compared to the baseline scenario. This is a holistic concept that covers all heating and cooling options in line with the general definition of energy efficiency set out in the Directive.

The results of the scenarios analysed have been used to identify points where waste heat is available and determine how these can be used in order to provide heat to urban agglomerations through the networks of district heating plants, as the cost-benefit analysis indicates that substantial economic, social and environmental benefits can be derived from choosing this specific method for generating energy-efficient heat.

Where cost-effective potential is identified, adequate measures should be taken to develop efficient district heating and cooling infrastructure and/or accommodate the development of high-efficiency cogeneration and the use of heating and cooling from waste heat and renewable energy sources, as required by Article 14(4) of the Directive.

1 OVERVIEW OF HEATING AND COOLING

In accordance with Directive 2012/27/EU of the European Parliament, as amended by the Energy Efficiency Directive (2018/2002), Member States carry out and notify to the Commission a comprehensive assessment of the potential for high-efficiency cogeneration, [to determine] the status of energy consumption and [conduct] an analysis of high-efficiency cogeneration and assess the costs and benefits of using efficient heating and cooling systems, in particular high-efficiency cogeneration.

The term ‘efficient heating and cooling’ is to be understood as a heating and cooling option that, compared to a baseline technology reflecting a business-as-usual situation, measurably reduces the input of primary energy needed to supply one unit of delivered energy within a relevant system boundary.

The potential for the use of cogeneration as a measure to save energy is currently underused in the Member States. The promotion of high-efficiency cogeneration based on useful heat demand is a priority for Member States, given the potential benefits of cogeneration with regard to saving primary energy and reducing emissions, in particular those of greenhouse gases. In addition, efficient use of energy by cogeneration can also have a positive contribution to the security of energy supply and boost the competitiveness of the European Union and its Member States.

Although the consumption of energy for heating and cooling in Bulgaria has increased moderately over the last decade, the persisting effect of Covid-19 is likely to suppress growth in demand. A moderate increase or a decrease in demand is expected, reflecting improved energy efficiency, modest economic growth and the retreat of current energy-intensive industries.

The initiatives undertaken in light of the implementation of energy-efficiency measures in the residential and industry sectors and the development of hydrogen transmission networks to be financed under Bulgaria’s Plan under the Recovery and Resilience Facility, as well as the construction of a combined heat and power plant with RDF-fuel recovery at the Sofia district heating plant (Toplofikatsiya Sofia), which has the largest share in heat supply, could potentially lead to an increase in the production and consumption of energy for heating and cooling by high-efficiency cogeneration plants.

1.1 Energy requirements for heating and cooling

An assessment of the analysis of useful energy was conducted for the period up to 2019 (NSI, 2019) to estimate end-use sectoral demand for useful energy for heating and cooling. For this purpose, the manufacturing (industry) sector, public and private services and other economic sectors aggregated under the heading Services, as well as private households, defined as Residential sector, were assessed[2]. Figure 1 below shows the generation of useful energy for heating and cooling in Bulgaria. The chart clearly shows that in the last 10 years final energy consumption in the industry sector decreased by 64 % compared to 2007 (according to figures for 2019) and that these levels have remained relatively stable. By 2019, final energy consumption in the services sector had increased by 71 % compared to 2007. Final energy consumption in the household sector is characterised by cyclical fluctuations driven by various economic and social factors. In 2019, consumption increased by 4 % compared to 2007. However, in 2019 the sector registered a decrease by 7 % compared to 2017.

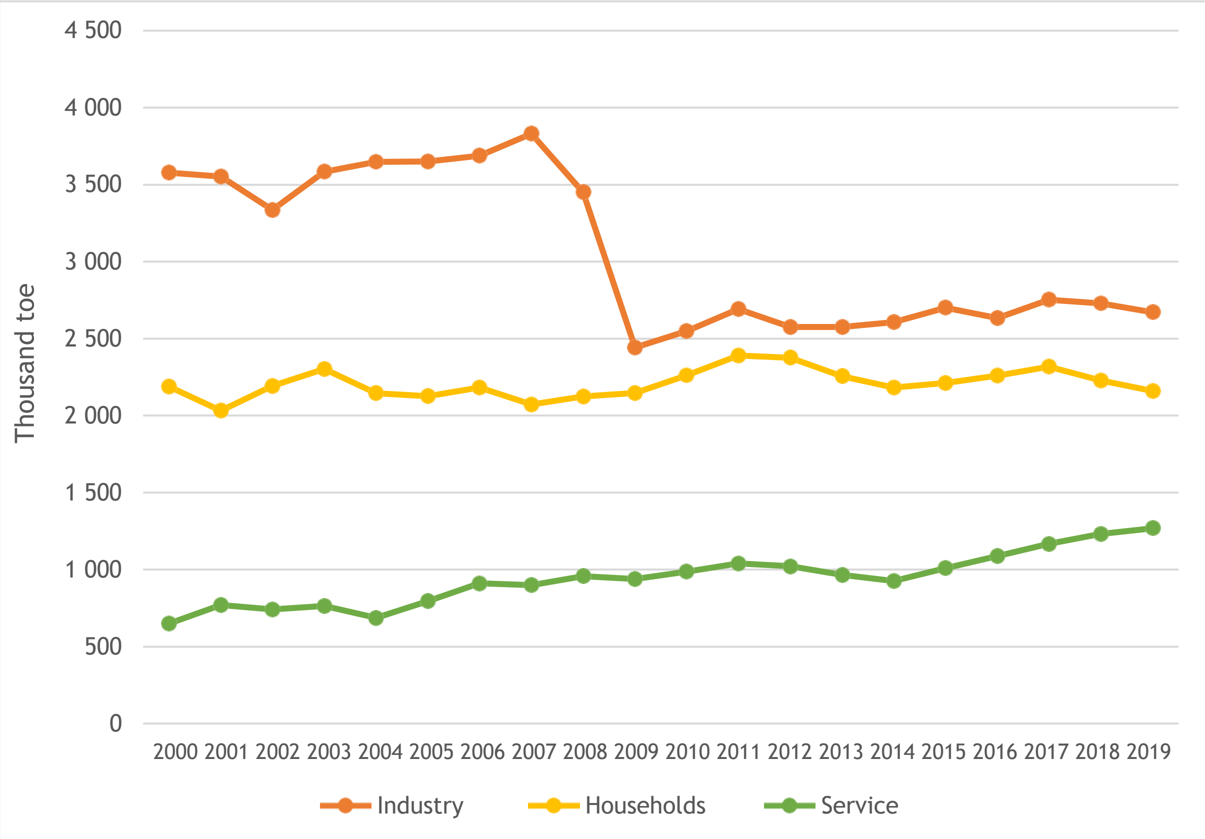


Figure 1. Final energy consumption by sector[3] Source: National Statistical Institute.

In order to simplify the reporting for the purpose of a comprehensive assessment of the potential for efficient energy supply for heating and cooling, the European Commission has provided a template and recommended its use (Commission Recommendation (EU) 2019/1659 of 25 September 2019). When current energy supply for heating and cooling is reported using this template, a distinction is made between on-site and off-site energy, each category being further divided

2 The terms residential, domestic and households can be considered synonymous.

3 To calculate the indicator according to the definition, the NSI uses gross domestic consumption data based on actual reported energy quantities. There are differences between NSI and Eurostat data as Eurostat's calculations rely on gross domestic consumption data in which nuclear power generation is calculated using an average coefficient for the entire European Union.

by sector (residential, services, industry and other sectors). Within each sector, a distinction is made between fossil fuels and renewables.

Current supply of energy for heating and cooling to end-use sectors (GWh/year) is broken down by technology and method of generation, i.e. from fossil fuels or renewable sources. A distinction is also made between on-site and off-site sources of energy. According to point 2(a) of Annex VIII to the Energy Efficiency Directive (EED), the most recent available data in GWh per year must be reported. This is why the figures and values in the analysis are reported as at 2019. The estimation of annual heating and cooling demand as useful energy and the quantification of final energy consumption by sector are shown in Tables 1 and 2, respectively.

The energy required by end-users in the form of heat and cold after all stages of energy conversion in heating and cooling equipment has been estimated by sector ('industry'), ('services'), and private households ('household/residential'). In each of the three sectors defined, the areas of useful energy production that are relevant to heating and cooling, notably 'space heating and air-conditioning', 'HE CHP' and 'heating boilers') have been taken into account.

The residential sector and most of the services sector comprise a large number of small and medium-sized consumers dispersed over the entire territory of a municipality or another territorial unit. Their energy demand is primarily for space heating/cooling and is thus determined by the building area that requires heating and/or cooling.

The industrial sector usually consists of a small number of large heat consumers, whose demand is determined by industrial processes.

'Other sectors' includes those sectors with a standalone share of demand for energy for heating/cooling of at least 5 % of total national demand for useful energy for heating and cooling.

To estimate the energy supplied for heating and cooling, data from the 2019 Energy Balance of the National Statistical Institute, information provided by the Ministry of Energy, data available in the public registers kept by the KEVR, AUEER, and data provided by 13 district heating utilities were used.

Table 1. Assessment of energy consumption for heating and cooling

2019 Energy provided on-site			**Unit**	**Value**
Residential sector	Fossil fuel sources	Heating boilers	GWh/year	**929.86**
		Other technologies	GWh/year	**5 210.02**
		HE CHP	GWh/year	
	Renewable energy sources	Heating boilers	GWh/y	**2 002.68**
		HE CHP	GWh/y	
		Heat pumps	GWh/y	
		Other technologies	GWh/year	**6 135.43**
Services sector	Sources of fossil fuels	Heating boilers	GWh/y	**1 158.26**
		Other technologies	GWh/y	**5 252.73**
		HE CHP	GWh/y	
	Renewable energy sources	Boilers	GWh/year	**1 297.17**
		HE CHP	GWh/y	
		Heat pumps	GWh/y	**1 340.80**
		Other technologies	GWh/y	**175.91**
Industry sector	Fossil fuel sources	Heating boilers	GWh/y	8 166.7
		Other technologies	GWh/y	1 966.17
		HE CHP	GWh/y	3 510.82
	Renewable energy sources	Heating boilers	GWh/y	1 787.37
		HE CHP	GWh/y	1 095.71
		Heat pumps	GWh/y	
		Other technologies	GWh/y	
Other sectors	Fossil fuel sources	Heating boilers	GWh/y	
		Other technologies	GWh/y	
		HE CHP	GWh/y	
	Renewable energy sources	Heating boilers	GWh/y	
		HE CHP	GWh/y	
		Heat pumps	GWh/y	
		Other technologies	GWh/y	

(Sources: own analyses based on 2019 NSI data on final energy consumption by sector)

Table 2. Assessment of energy consumption for heating and cooling

Energy supplied off-site			Unit	Value
Residential sector	Sources of fossil fuels	Heating boilers	GWh/y	**1 125.17**
		Other technologies	GWh/year	
		HE CHP	GWh/y	**1 754.32**
	Renewable energy sources	Heating boilers	GWh/y	**29.44**
		HE CHP	GWh/y	**668.45**
		Heat pumps	GWh/y	
		Other technologies	GWh/y	
Services sector	Fossil fuel sources	Heating boilers	GWh/y	**441.14**
		Other technologies	GWh/y	
		HE CHP	GWh/year	**687.81**
	Renewable energy sources	Heating boilers	GWh/y	**11.54**
		HE CHP	GWh/y	**262.08**
		Heat pumps	GWh/y	
		Other technologies	GWh/y	
Industry sector	Fossil fuel sources	Heating boilers	GWh/y	**374.25**
		Other technologies	GWh/year	
		HE CHP	GWh/y	583.51
	Renewable energy sources	Heating boilers	GWh/y	9.79
		HE CHP	GWh/year	222.34
		Heat pumps	GWh/y	
		Other technologies	GWh/y	
Other sectors	Fossil fuel sources	Boilers	GWh/y	
		Other technologies	GWh/year	
		HE CHP	GWh/y	
	Renewable energy sources	Heating boilers	GWh/year	
		HE CHP	GWh/year	
		Heat pumps	GWh/y	
		Other technologies	GWh/y	

(Sources: own analyses based on 2019 NSI data on final energy consumption by sector)

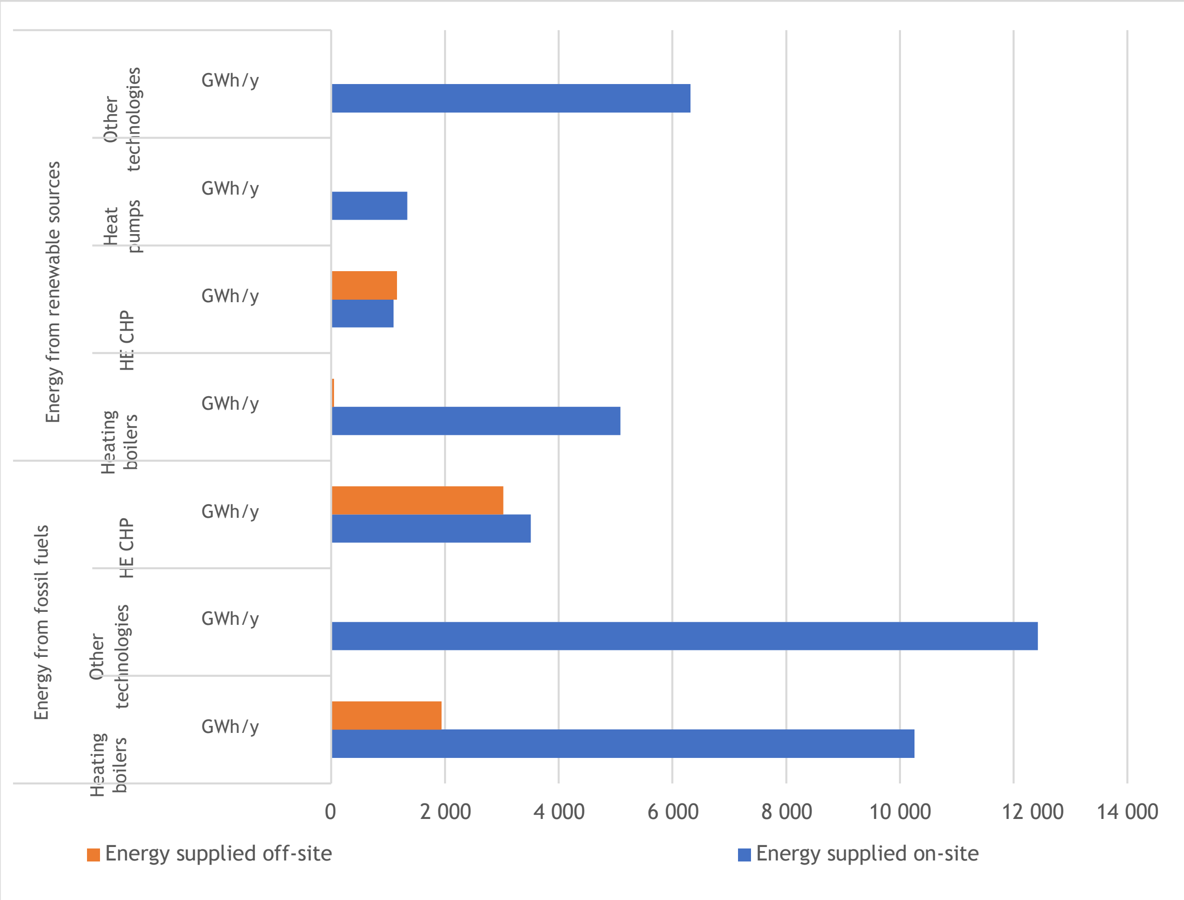


Figure 2. Consumption of energy for heating and cooling in all sectors

The assessment of the current supply of energy for heating and cooling involves combining different data sets, data down- and up-processing and applying assumptions and hypotheses:

- **Household sector:**

According to national statistical data, final energy consumption (FEC) in the household sector stands at 25 119.64 GWh/y. Total consumption of energy for heating and cooling, following sectoral FEC conversion on the basis of the assumptions set out below, is estimated at 17 855.4 GWh/y.

The following algorithm was used to allocate the energy provided for heating and cooling from on-site and off-site sources:

- In the context of other technologies, the same sources include the consumption of electricity and fossil fuels (coal). Under the ‘other technologies’ heading, ‘fossil fuel sources’ refers to the consumption of electricity for air-to-air conditioning systems, electric stoves, electric boilers and local heating installations burning fossil fuels (coal).
- In order to assess the use of renewable energy in the sector, data on the use of biomass

and solar thermal energy has been used. The underlying assumption is that 25 % of energy from biomass and all energy from natural gas is supplied by local heating installations. The resulting figures [for] boilers fired by non-renewable and renewable sources are set out in the table below. The figures for renewable energy reflect the values for heat generated by solar collectors and 75 % of energy generated from biomass and consumed through the use of other technologies.

- The assumption for ‘high efficiency CHP’ and energy provided on site is that this type of energy is used directly and exclusively in the industrial sector and is therefore not distributed in the household sector.

According to NSI data for 2019, energy for heating and cooling provided off-site stands at 6 170 GWh and is allocated to the household sector on the basis of the following calculations and assumptions:

- The total amount of energy for heating and cooling
  from ‘high efficiency CHP’ and boilers supplied off-site stood at 10 777 GWh/y. The amount of heat supplied by district heating installations (boilers) was estimated to be 1 992 GWh/y. The share of energy for heating and cooling supplied by heating boilers has been determined using the ratio between the total off-site energy used and the energy supplied by district heating plants (boilers). The same ratio has been used to calculate the quantity of energy for heating and cooling supplied by high-efficiency cogeneration plants and boilers.
- Renewable energy has been distributed according to the share of total energy consumed and the share of renewable energy used is shown in Figure 3. The remaining energy is allocated to the corresponding consumption from non-renewable sources.
- For HE CHP, the values were obtained by subtracting the energy consumption of heating boilers from total energy consumption off-site and using the result in the charts showing renewable and non-renewable HE CHP according to the share distribution of fuels used as shown in Figure 3 (Source: NSI).

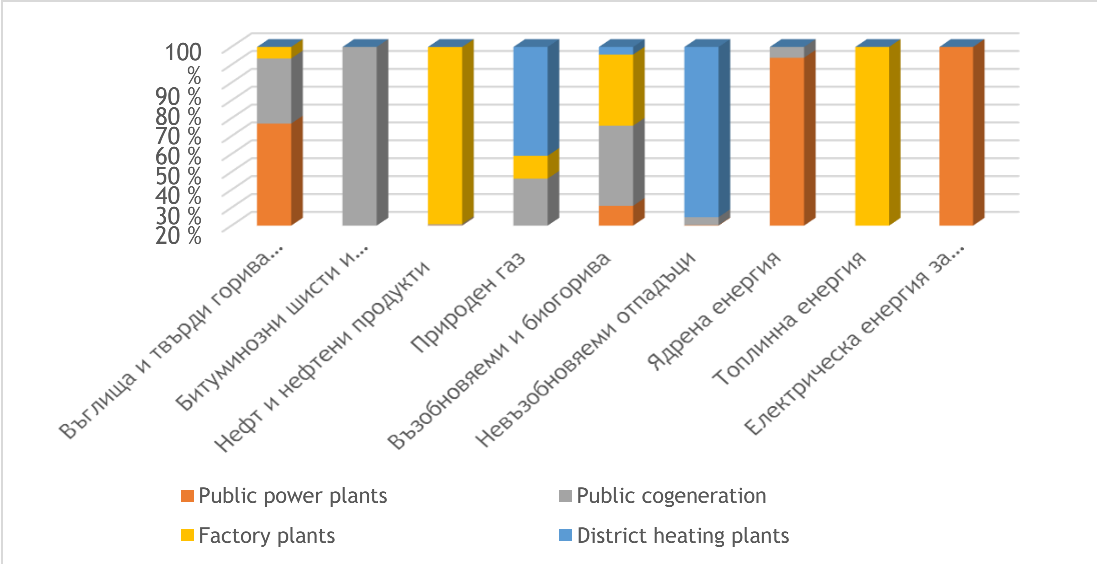


Figure 3. Structure of the energy inputs for conversion at power and heating plants[4]

Въглища и твърди горива	Coal and fossil fuels
Битуминозни шисти и …	Bituminous slate and …
Нефт и нефтени продукти	Oil and petroleum products
Природен газ	Natural gas
Възобновяеми и биогорива	Renewables and biofuels
Невъзнобновяеми отпадъци	Non-recoverable waste
Ядрена енергия	Nuclear power
Топлинна енергия	Thermal energy
Електрическа енергия за …	Electricity for …

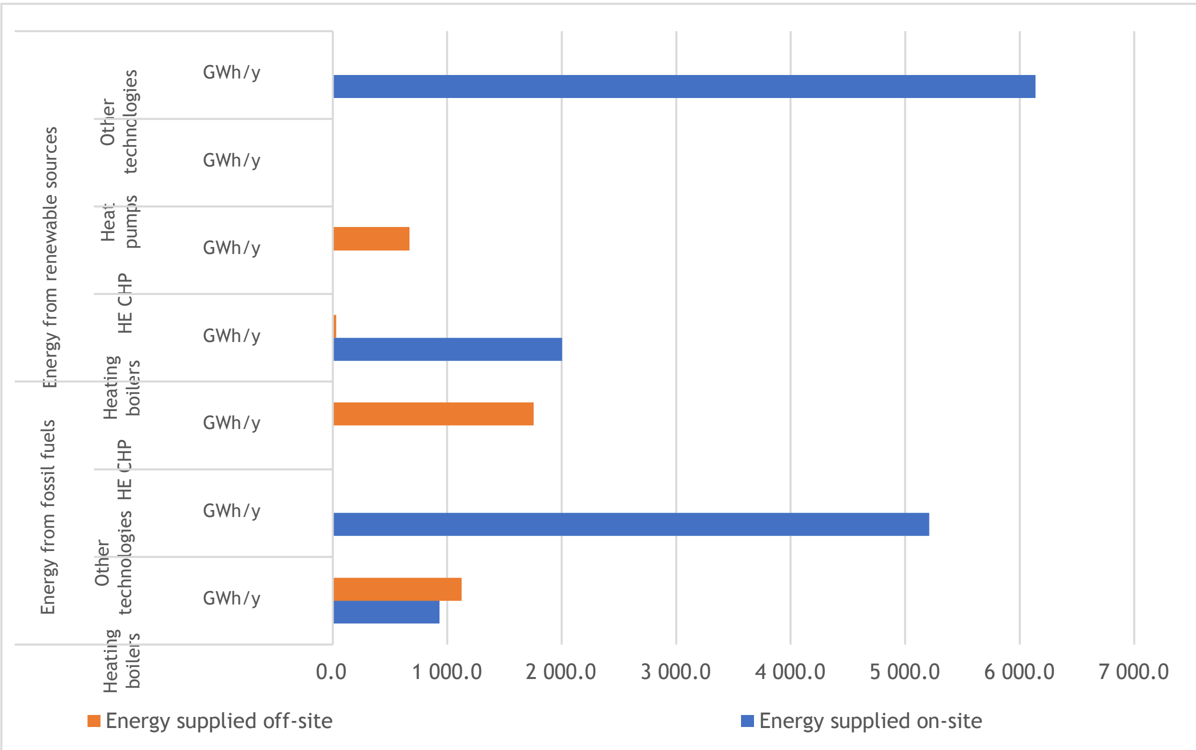


Figure 4. Consumption of energy for residential heating and cooling

4 Factory thermal power plants — their main activity is electricity generation or the combined production of power and heat, wholly or partly as autoproduction and an ancillary activity that supports their main operation (NSI).

- **Services sector**

According to national statistical data, final energy consumption (FEC) in the services sector stands at 14 746.84 GWh/y. Total consumption of energy for heating and cooling, calculated following sectoral FEC conversion on the basis of the assumptions set out below, is estimated at 10 627.4 GWh/y.

The following algorithm has been used to allocate the energy from on-site and off-site sources:

- According to an expert estimate, energy for heating and cooling accounts for 60 % of final energy consumption in the electricity sector. This energy has been allocated to energy provided on-site by other technologies. Electricity consumption for heating and cooling in the sector is almost fully dominated by air-to-air conditioning systems.
- Due to the insignificant use of solid fossil fuels, their share has not been taken into account in the analysis.
- In order to calculate the use of renewable energy in the sector, national statistical data on the reported consumption of biomass, solar, thermal energy, heat pumps consumption have been taken into account.
- An assumption has been made that all energy from natural gas, solid biomass and biogas is converted through heating boilers (local heating installations). The resulting figures are set out in the column entitled 'Energy from non-renewable and renewable sources converted by boilers' of the table. The figures for energy from renewable sources in the other technologies [column] constitute the resulting values for energy provided on site by solar collectors for DHW.
- It has been assumed that high-efficiency cogeneration for on-site energy consumption is currently not used in the sector.

NSI data contain information about off-site energy consumption. This is allocated within the sector using a methodology that is similar to that applied in the residential sector and already described.

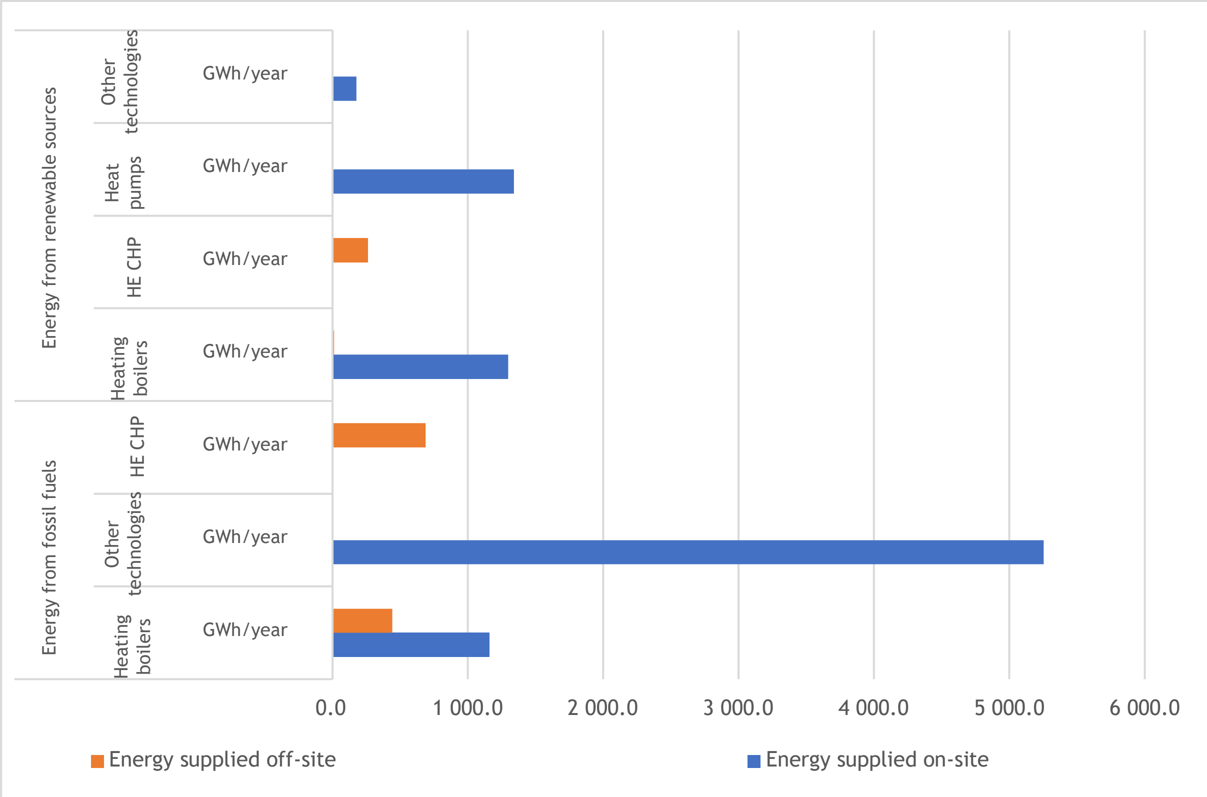


Figure 5. Consumption of energy for heating and cooling in the services sector

- **Industry sector**

According to national statistical data final energy consumption (FEC) in the industry sector stands at 31 085.83 GWh/y.

An assumption has been made that all energy from coal, natural gas, biomass and biofuels included in FEC in the sector is used for heating and cooling. The amount of energy produced by the HE CHP is allocated to renewable and non-renewable technologies according to the share distribution of energy from coal, natural gas biomass and biofuels in the mix for public cogeneration plants. The relevant data is shown in Figure 3. In order to determine the energy generated by using other technologies and provided on site for heating and cooling on the basis of national statistical data, only the electricity used has been included the category of ‘other technologies’. Due to the unavailability of specific data, an assumption has been made that 10 % of all final electricity consumption in the sector can be attributed to heating and cooling. Oil/petroleum products and waste heat from chemical and other processes have not been taken into account in this analysis as they do not have an impact on the sector. A further assumption has been made that the entire consumption of energy from fossil (non-renewable) fuels, gas and biomass and biofuels is recovered mainly in individual boilers. Fuels have been categorised as non-renewable and renewable depending on the technologies used. Total final consumption of energy for heating and cooling, following sectoral FEC conversion on the basis of the assumptions set out below, is estimated at 17 716.52 GWh/y.

- NSI data contains information about off-site energy consumption, which is allocated within the sector using a methodology that is similar to that applied in the residential sector and already described.

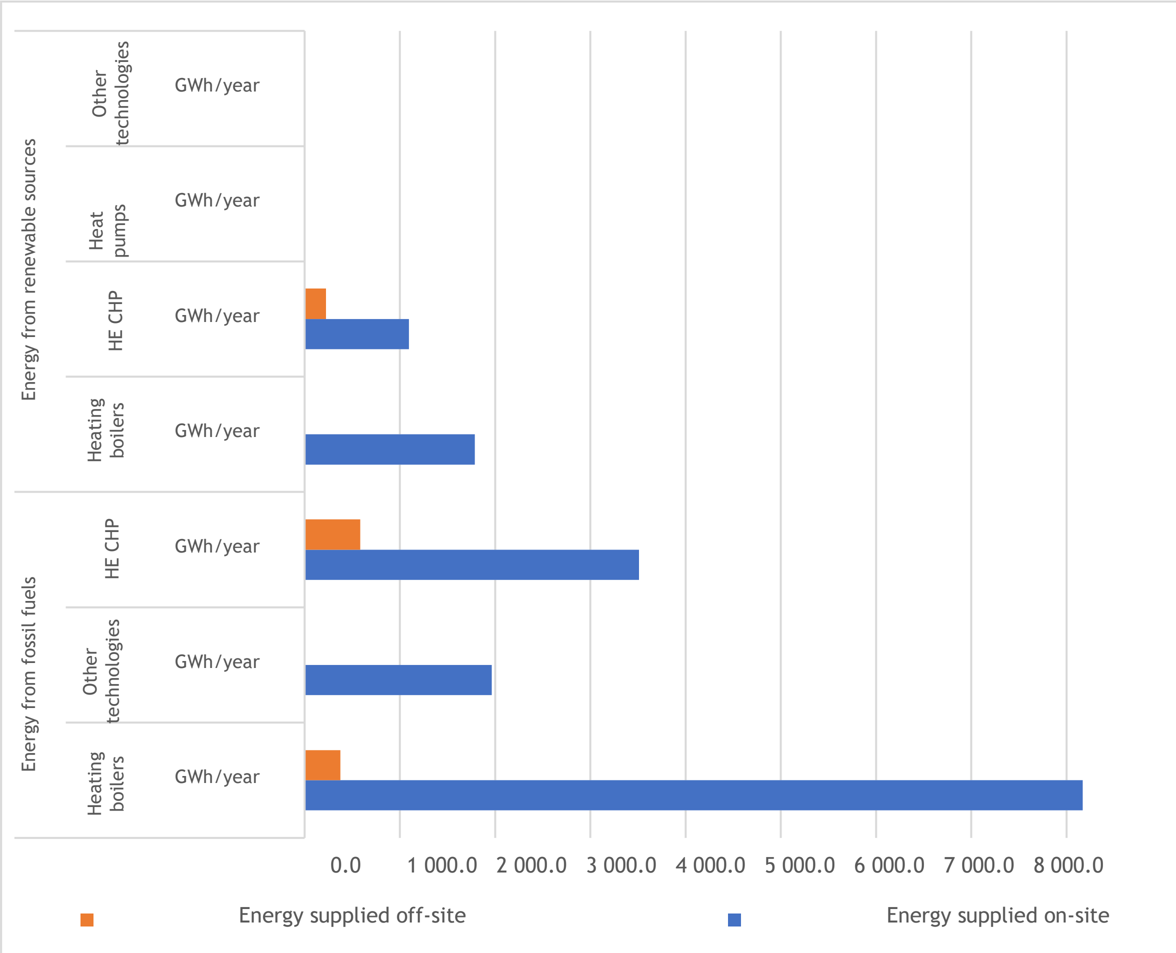


Figure 6. Consumption of energy for heating and cooling in the industry sector

The main technologies used to supply energy for heating and cooling in the three sectors and their percentage distribution are shown in the figure below. Other technologies have the largest share of 41 % and heat pumps have the smallest share of 3 %. Energy for heating from HE CHP has a share of 19 % of the total energy supplied for heating and cooling and that from boilers has a share of 37 %.

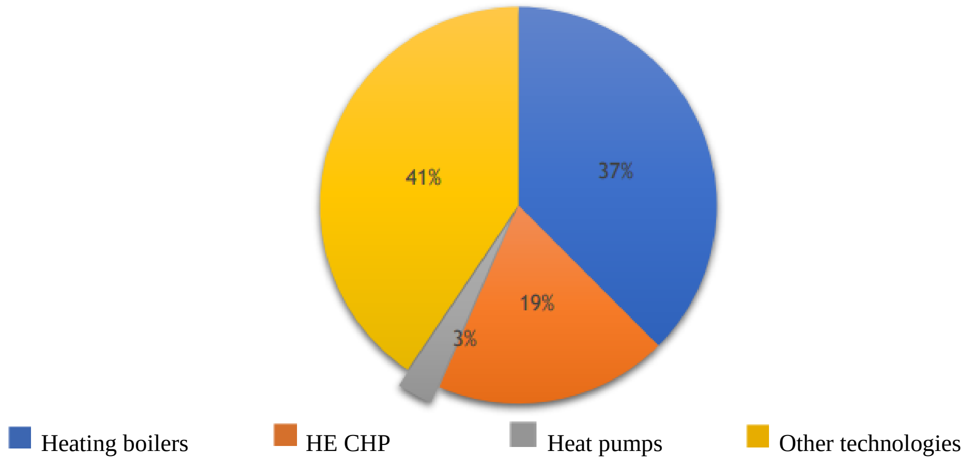


Figure 7. Percentage distribution of the technologies used to supply energy for heating and cooling

For the sectors concerned, fossil energy sources for heating and cooling provided on-site and off-site have a share of 59.6 % and 10.7%, respectively (Figure 8). The share of RES (33 %) is distributed as follows: 29.9 % of energy provided on-site and 2.6 % of energy provided off-site. This shows that the main sources of heat and cold are fossil fuels provided on-site by individual systems.

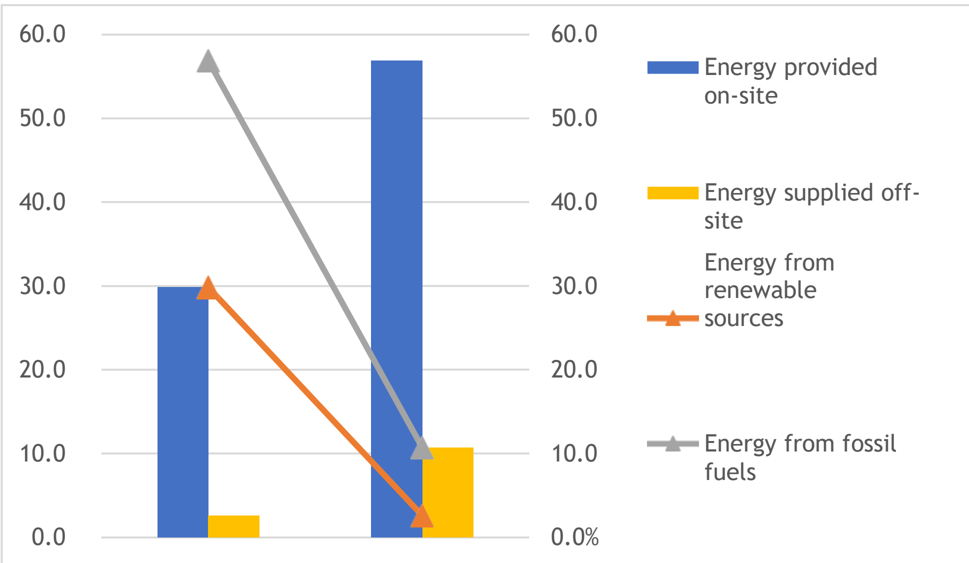


Figure 8. Percentage distribution of supplied energy and its source

The residential sector has the largest share of energy consumption for heating and cooling in FEC (38 %), followed by the industrial and services sectors with a share of 39 % and 23 % respectively (Figure 9).

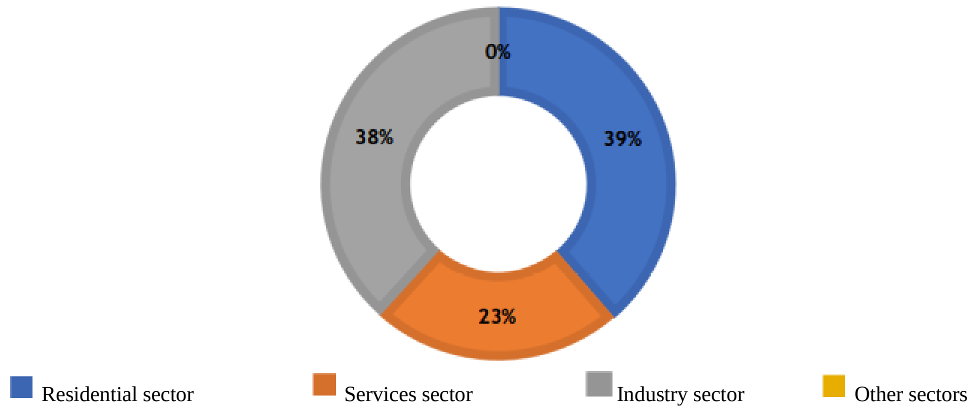


Figure 9. Structure of final energy consumption for heating and cooling by sector

1.2 Energy requirements for cooling

The energy requirements for cooling large buildings that operate continuously for extended periods of time have the largest share of total energy costs. Large consumers generate the energy they need to meet their cooling requirements through the exclusive use of compressor plants, and the significant increase in electricity consumption during the summer highlights the fact that demand is on the increase. For example, according to an expert estimate large commercial buildings, the hotel industry and office buildings have a share of 37 %, 38 % and 56 %, respectively. The use of absorption or adsorption thermal storage systems to meet cooling demand can help increase the potential for the development of combined generation of energy for heating and cooling.

For example, in July 2013 EVN Bulgaria Toplofikatsiya delivered and installed an absorption device as an element of the first project for cooling through district heating in Bulgaria. The first to benefit from the project was the administrative building of Plovdiv Municipality in the Trakia[5] municipal district in Plovdiv. In order to implement the technology, an absorption device and a water-cooling tower were installed in the selected building. This equipment converts the energy for heating supplied by the network into energy for cooling. In 2016, chillers with a total capacity of 6 MW were installed in Plovdiv. In addition to the administrative building of Plovdiv Municipality, EVN Bulgaria Toplofikatsiya now provides the same service to several other customers connected to its heat transmission network, which utilises water that is recycled through the system at a temperature of 85^{0}C. These are the Trimontsium Ramada Hotel, the Kolodrum Sports Hall and the Holiday Inn Hotel.

5 https://www.evn.bg/Business/Heating/CoolingCoGen.aspx

There has been no further development since 2019 and the project remains a pilot initiative. EVN Bulgaria Toplofikatsiya does not provide information about the consumption of heat for cooling under a separate heading in its reports.

Another good example of highly efficient generation of energy for heating and cooling is the trigeneration system installed at Kogen Zagore OOD, Yastrebovo village.

Efficient individual heating and cooling is another option for residential and office spaces. In contrast to efficient district heating and cooling, where the amount of primary energy is derived from non-renewable sources, the use of air conditioning systems with heat pumps allows the amount of primary energy from non-renewable sources to be reduced at the expense of using energy from renewable sources such as ambient temperature, groundwater and shallow boreholes. The energy for heating and cooling thus produced by the installed capacity of the plant has lower primary energy consumption and no transmission and redistribution costs.
In order to estimate the theoretical demand for energy for cooling, the Hotmaps modelling tool (https://www.hotmaps.eu/map) has been used. Data indicates that the theoretical energy demand for cooling (in the household and services sectors) in Bulgaria is 4 969.65 GWh/y. The actual consumption of energy for heating and cooling in residential buildings is significantly lower than both statutory and projected demand, which can be attributed mainly to social and economic factors.

According to the NSI (2019), the final consumption of energy for household cooling stood at 119.5 GWh. The most common method of cooling involves the use of small air-conditioning systems with air-to-air heat pumps. Electricity consumption during the summer provides a clear picture of their widespread use as shown in Figure 10 below.

Table 3. Electricity consumption during the summer

Date	**2.7.2019**	**3.7.2019**	**14.7.2019**	**15.7.2019**
Air temperature °C	**25.1 °C**	**25.1 °C**	**16.6 °C**	**17.9 °C**
Energy consumption between 8.00 a.m. and 8.00 p.m. in MWh	**55 554**	**56 056**	**45 573**	**47 866**
Energy consumption between 00.00 and 8.00 a.m. in MWh	**29 976**	**30 601**	**25 483**	**27 311**
Calendar day	**working**	**working**	**non-working**	**working**

*Data is available at https://www.entsoe.eu/data/power-stats/ и https://www.stringmeteo.com/synop/temp_month.php

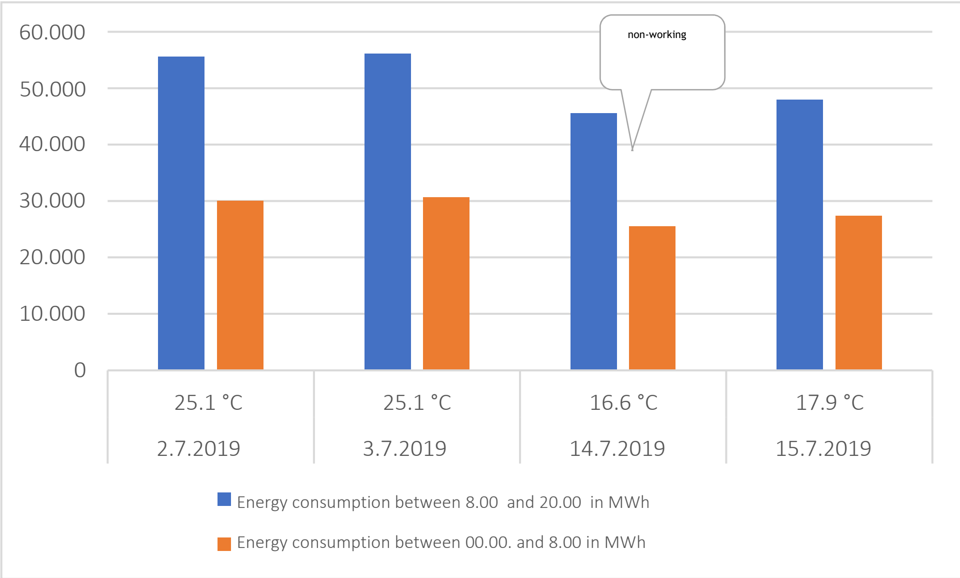


Figure 10. Electricity consumption during the summer in MWh

A comparison of electricity consumption on the days with the highest and lowest temperature in July 2019 (based on official Entsoe and Stringmeteo data) shows deviations from normal electricity consumption in the range of 15 % to 18 % between 8.00 a.m. and 8.00 p.m. Although the deviations in national electricity consumption data for the days concerned may be due to other reasons, the correlation between air temperature and the consumption of electricity for cooling is evident.

1.3 Energy requirements for heating and cooling by sector

Data on energy produced on-site and energy consumed off-site (Tables 1 and 2) has been used in order to provide an overview of current supply of energy for heating and cooling, estimate the useful energy and quantify final energy consumption in GWh per year by sector.

1.3.1 Consumption of energy for heating and cooling in the households sector

Energy consumption for heating and cooling is estimated at 17 855.4 GWh/y (Tables 1 and 2), or 38 % of FEC in the sector. Figure 11 shows that 80 % of the energy consumption is covered by energy generated on site.

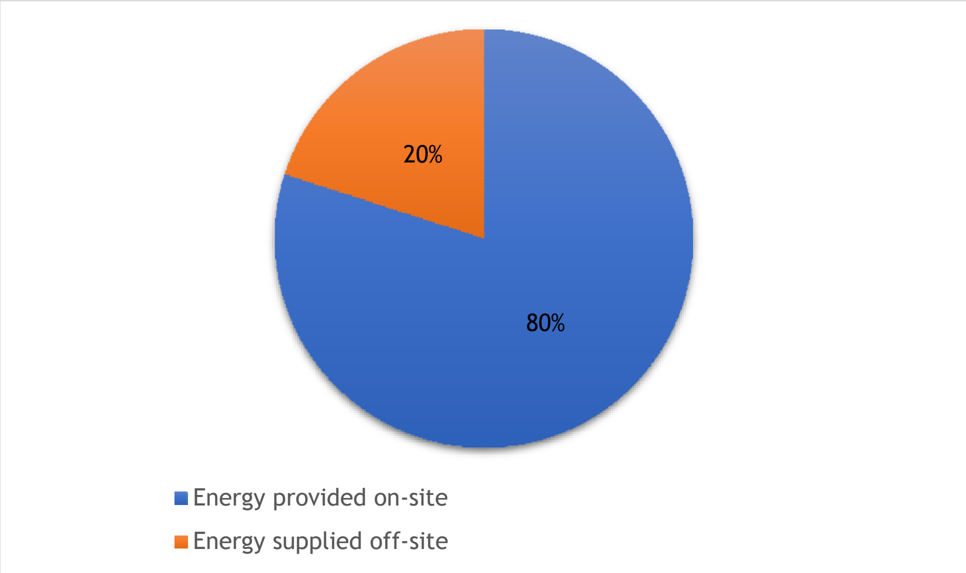


Figure 11. Percentage distribution of energy for heating and cooling in the residential sector, by place of supply

A breakdown of the energy mix in the residential sector by site where energy is provided is shown in Figure 12. Heat from HE CHP, which comprises 72 % of energy from fossil fuels and 28 % of energy from RES, is supplied off-site.

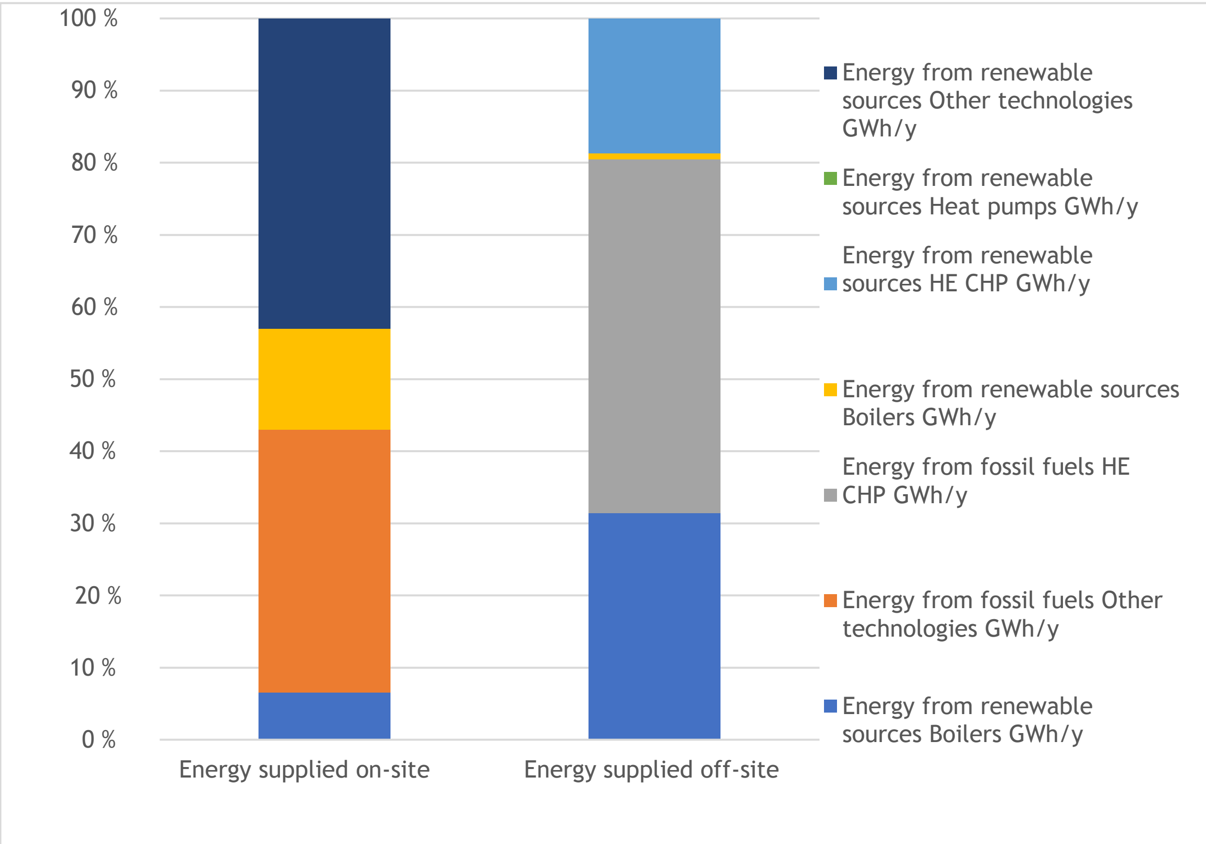


Figure 12. Consumption of energy for heating and cooling in the residential sector, by place of supply

Other technologies used for energy carrier conversion into useful energy for heating and cooling intended for consumers have a share of 63 % (Figure 13). Boilers in the household sector have a share of 23 % and (HE) CHP have a share of 14 %.

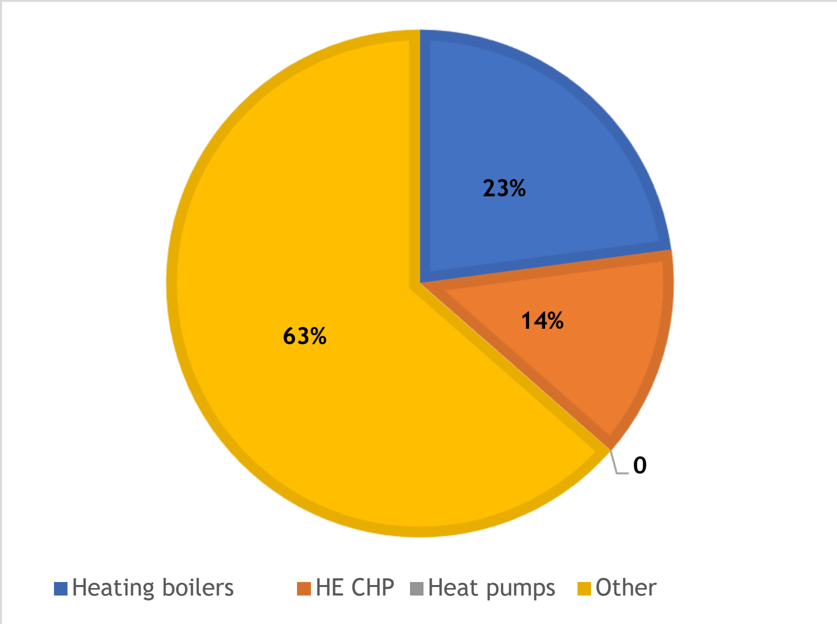


Figure 13. Percentage distribution of technologies for the supply of energy for heating and cooling in the residential sector

The data set out in Tables 1 and Table 2 allows an estimate to be made of the energy used for heating and cooling in the sector. According to this estimate, the shares of energy from renewables and energy fossil fuels are almost equal (Figure 14).

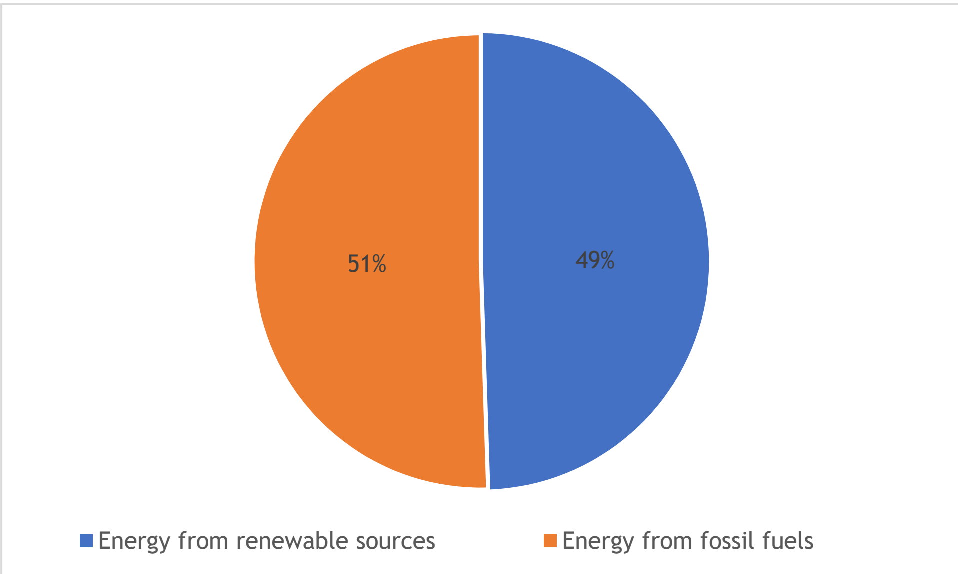


Figure 14. Percentage distribution of energy for heating and cooling in the residential sector, by source

The assessment in the housing sector is based on the conclusions set out in the long-term national strategy to support the renewal of the national building stock of residential and non-residential buildings with a horizon until 2050, which specifies the requirements for the energy performance and energy consumption of buildings. Buildings with poor energy performance (classes E, F and G) account for 91 % of unrenovated housing stock: class G (with primary energy consumption > 435 kWh/m2/year) – 18 %; class F (with primary energy consumption in the range of 364 kWh/m2/year to 435 kWh/m^2/year) – 34 %; and class E (with primary energy consumption in the range of 291 kWh/m^2/year to 363 kWh/m^2/year) – 39 %.

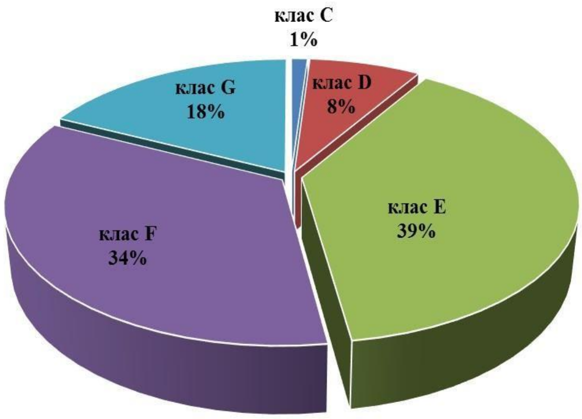


Figure 15. Percentage distribution of the energy consumption of unrenovated residential buildings placed in use before 2010 (2018 analysis)[6]

The analysis set out in the long-term national strategy to support the renovation of the national building stock of residential and non-residential buildings with a horizon until 2050 shows that the actual consumption of energy for heating is approximately twice as low as that required to reach statutory microclimate parameters in existing buildings in their current state, i.e. before renovation. This is mostly attributable to unoccupied housing units (with a share of more than 20 % of all housing units in occupied buildings), unheated common areas in residential buildings and low average temperatures maintained in conditioned spaces. This specificity of residential building stock in Bulgaria is the result of the demographic situation in the country, disparities in the territorial distribution of the population and the depopulation of some areas.

1.3.2 Consumption of energy for heating and cooling in the services sector

Consumption of energy for heating and cooling is estimated at 10 627.4 GWh/y (Tables 1 and 2), or 23 % of FEC in the sector. Figure 16 shows that 87 % of the energy for heating and cooling is supplied on-site and 13 % is supplied off-site. Other technologies

6 Source: Long-term national strategy to support the renovation of the national residential and non-residential building stock with a horizon until 2050

used for the conversion of energy carriers into useful energy for consumers have a share of 51 % (Figure 18). Boilers used for heating have the smallest share (6 %) and the share of HE CHP is 9 %.

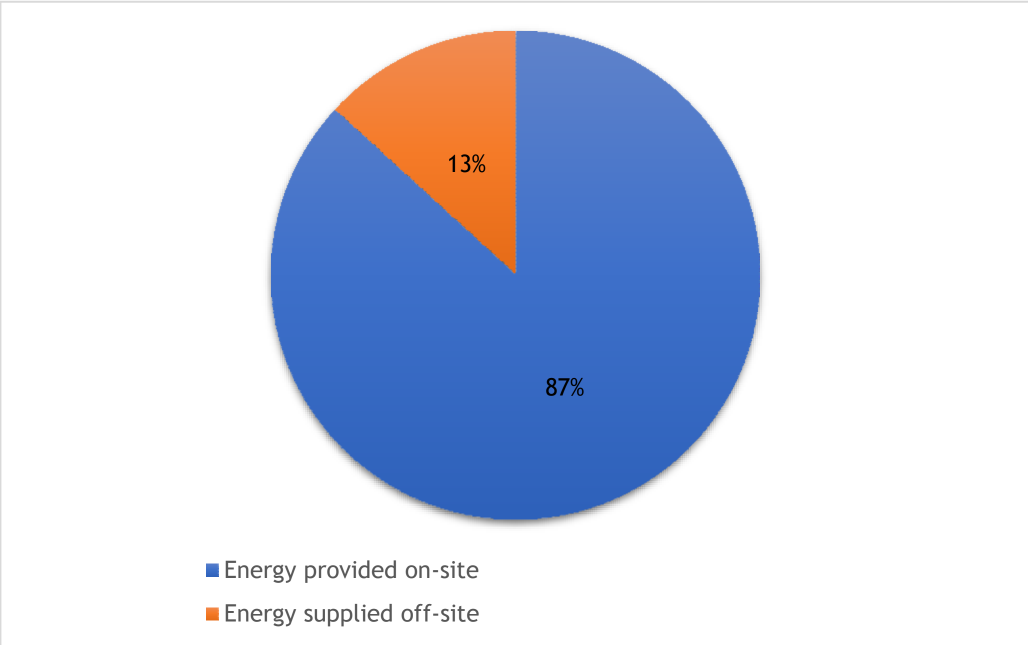


Figure 16. Percentage distribution of energy in the services sector, by place of supply

A breakdown of the energy mix in the services sector by place of supply is set out in Figure 17. Energy from HE CHP, which comprises 72 % of energy from fossil fuels and 28 % of energy from RES, is supplied off-site.

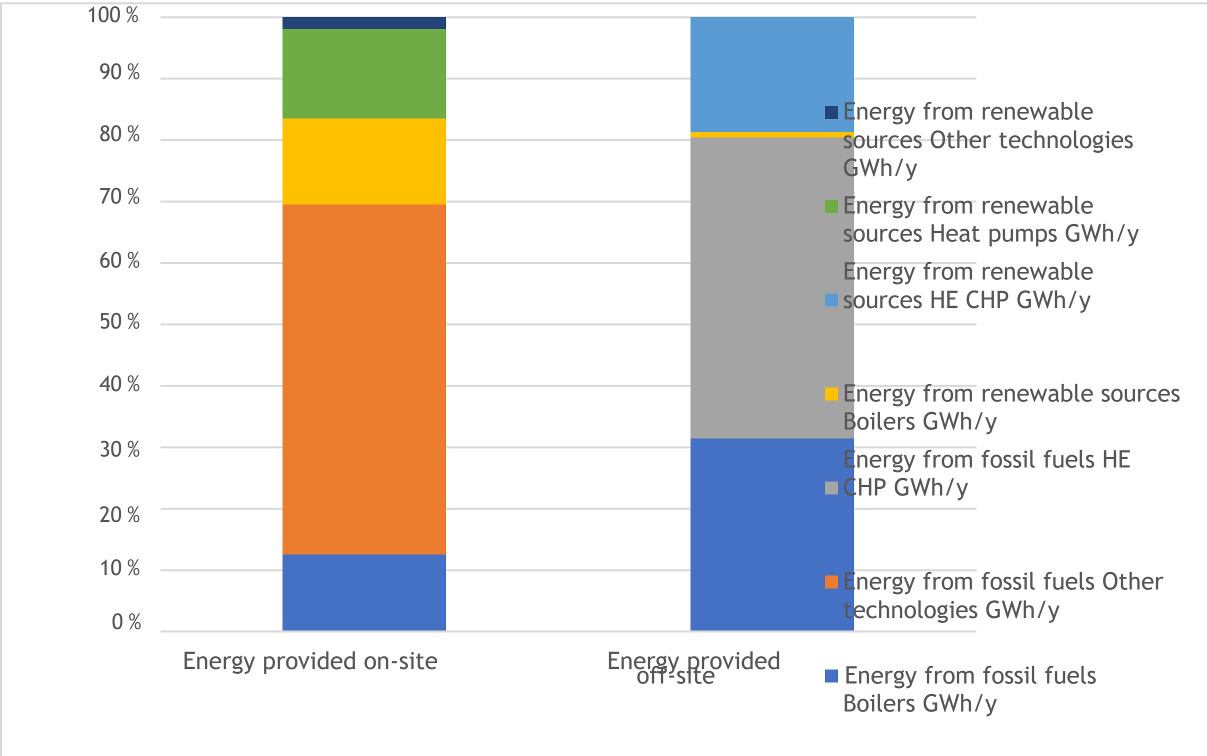


Figure 17. Consumption of energy for heating and cooling in the services sector, by place of supply

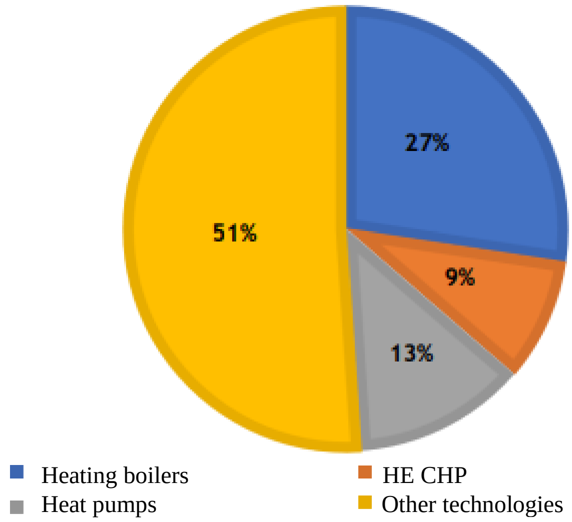


Figure 18. Percentage distribution of technologies for the supply of energy for heating and cooling in the services sector

According to the estimate of energy used for heating and cooling in the sector based on the data set out in Tables 1 and Table 2, the shares of energy from renewables and fossil fuels are 29 % and 71 %, respectively (Figure 19).

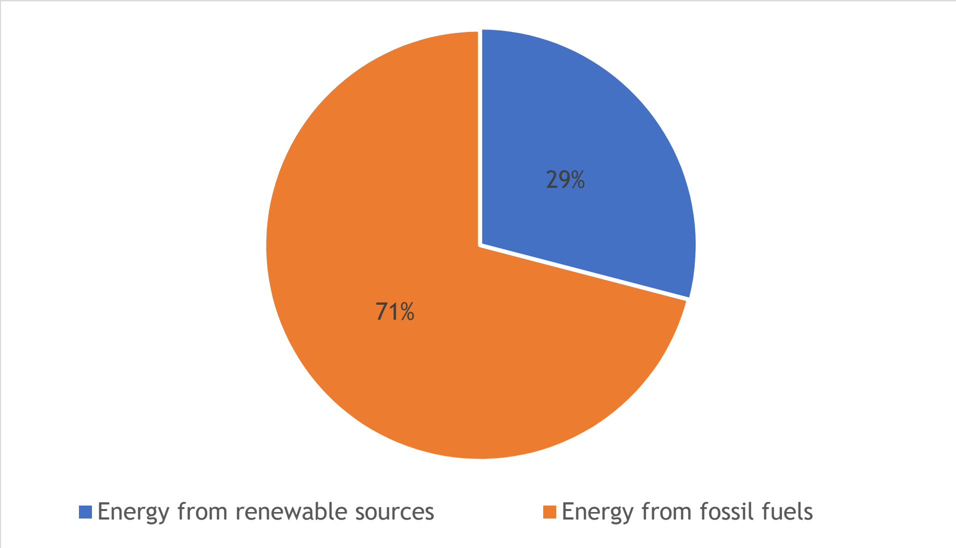


Figure 19. Percentage distribution of energy sources for heating and cooling in the services sector

1.3.3 Consumption of energy for heating and cooling by sector in the industry sector

Energy consumption for heating and cooling is estimated at 177 126.5 GWh/y (Tables 1 and 2), or 38 % of FEC in the sector. Figure 20 shows that 93 % of the energy consumption covered by energy generated on-site and 7 % — by energy supplied off-site. The boilers used for energy carrier conversion into useful energy for consumers have a share of 58 % (Figure 29). Other technologies have the smallest share (11 %) and the share of HE CHP is 31 %.

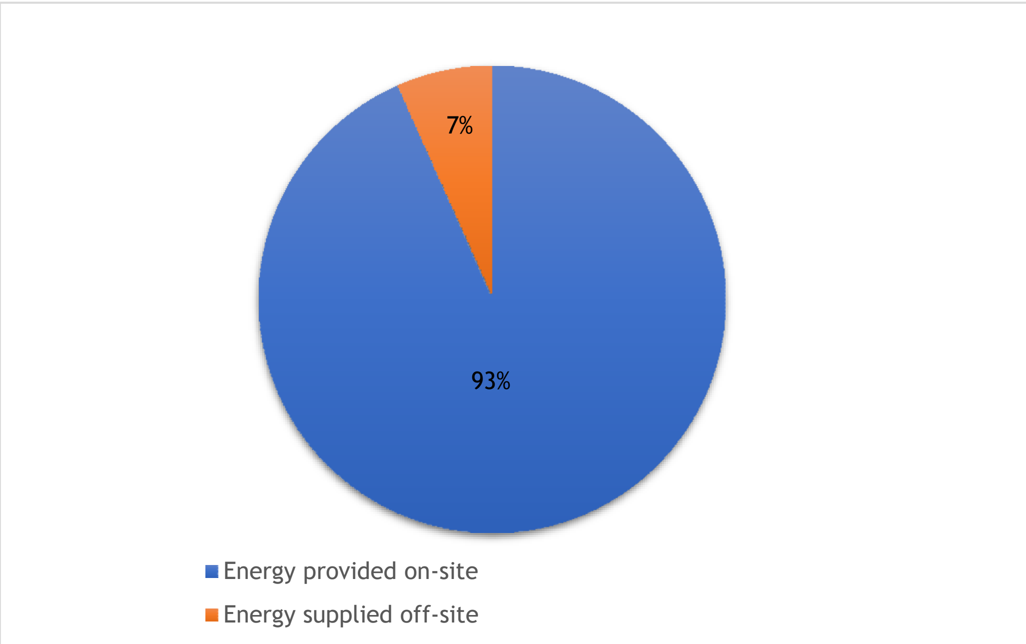


Figure 20. Percentage distribution of energy in the industry sector, by place of supply

A breakdown of the energy mix in the industry sector by place of supply is shown in Figure 21. Energy from HE CHP, which comprises 24% of energy from fossil fuels and 6 % of energy from RES, is supplied both on-site and off-site.

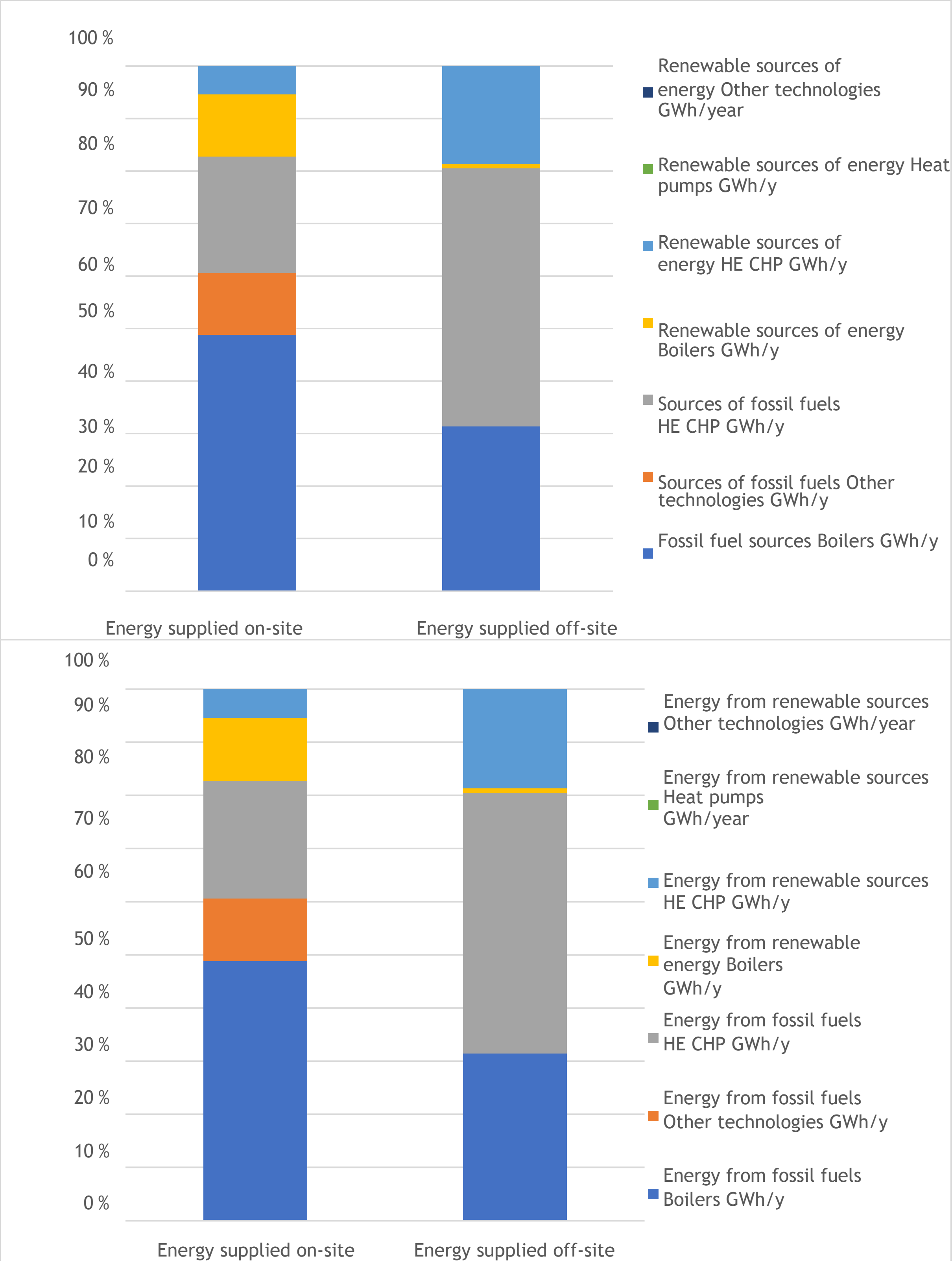


Figure 21. Consumption of energy for heating and cooling in the industry sector, by place of supply

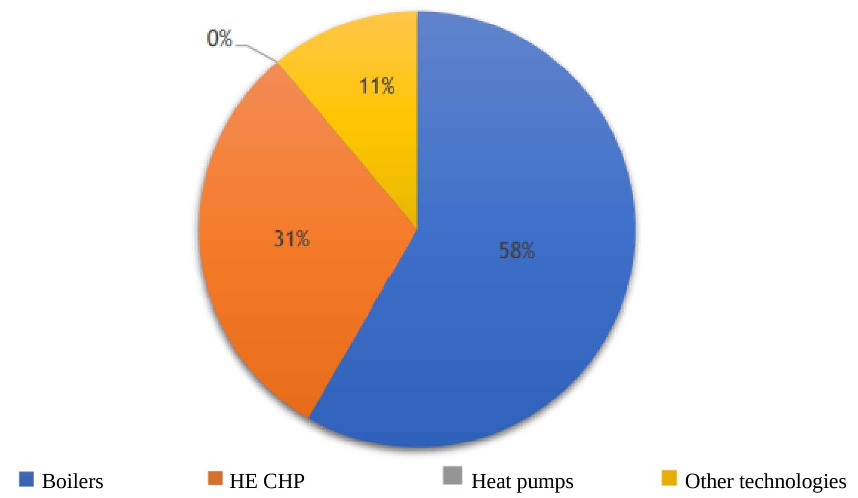


Figure 22. Percentage distribution of technologies for the supply of energy for heating and cooling in the industry sector

According to the estimate of energy used for heating and cooling in the sector based on the data set out in Tables 1 and Table 2, the shares of energy from renewables and fossil fuels are 18% and 82 % respectively (Figure 23).

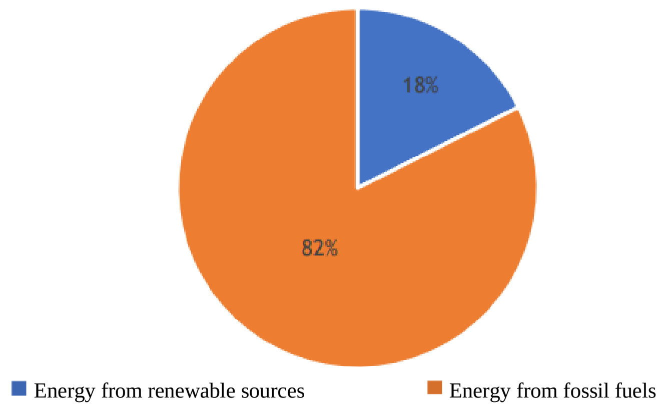


Figure 23. Percentage distribution of energy for heating and cooling in the industry sector, by source

1.4 Consumption of energy for heating and cooling by district heating plants

District heating plants are a socially and economically viable solution and have a share of 13 % in total energy consumption for heating and cooling in the sectors concerned.

The following table sets out a summary of the energy for heating and cooling supplied by district heating networks, taking into account existing technical solutions.

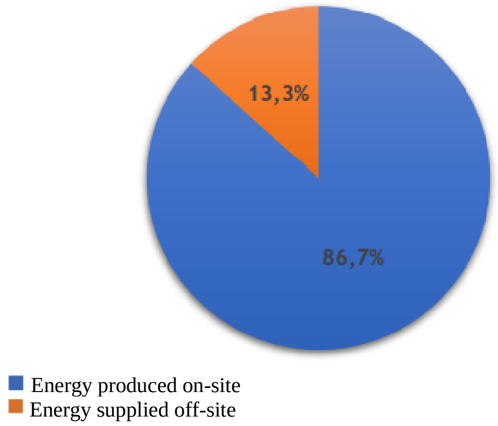


Figure 24. Percentage distribution of energy, by place of supply

The shares of energy supplied by district heating plants to consumers are as follows: 58 % to the household sector, 23 % to the services sector; and 19 % to the industry sector.

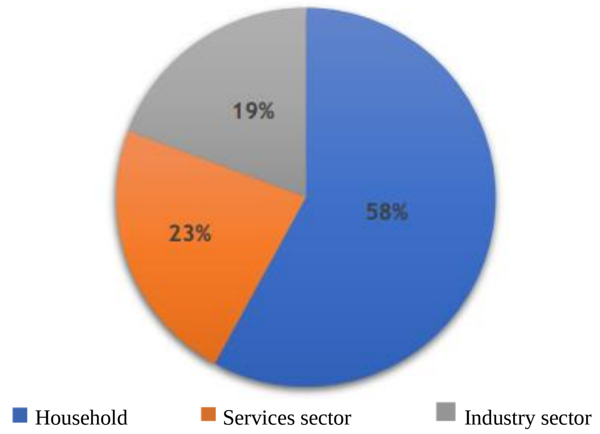


Figure 25. Percentage distribution of energy for heating and cooling from district heating plants, by sector

Table 4. Assessment of the [final energy] consumption (FEC) for heating and cooling of district heating networks

	Efficient district heating networks[7]	**Efficient district heating networks**	**Inefficient district heating networks**	**Inefficient district heating networks**
	2018	**2019**	**2018**	**2019**
Energy for heating supplied to clients of district heating plants (GWh/y), incl. for:	**4 024.17**	**4 206.11**	**1 666.94**	**1 246.39**
Industrial plants	**597.50**	**756.67**	**13.89**	**10.28**
Enterprises in the sectors of transport, agriculture/forestry and fishing	**11.94**	**11.11**	**5.56**	**4.17**
Service sector businesses	**894.17**	**819.72**	**399.17**	**296.11**
Household clients	**2 520.56**	**2 618.61**	**1 248.33**	**935.83**
Number of district heating networks	**32**	**33**	**9**	**9**
Length of district heating networks in km	**2 331**	**2 439**	**764**	**676**
Number of clients	**405 016**	**464 844**	**199 138**	**174 143**
Losses in district heating networks (GWh/y)	**1 821.67**	**1 922.78**		

Source: NSI

According to data, in 2019 the district heating network expanded by approximately 4.5 % compared to 2018 and the number of newly connected clients increased by 13 %.

Table 5 sets out a list of district heating utilities in Bulgaria and the geographic boundaries of their respective networks.

Table 5. District heating networks within the geographical boundary in 2019

No	**District heating utility**	**Geographical boundaries of the network**	**Installed capacity MWth**
1	TOPLOFIKATSIYA SOFIA EAD	Sofia	4 186
2	EVN BALGARIA TOPLOFIKATSIYA EAD	Plovdiv	297
3	TOPLOFIKATSIYA PLEVEN EAD	Pleven	655.85
4	TOPLOFIKATSIYA VRATSA EAD	Vratsa	134
5	TOPLOFIKATSIYA BURGAS EAD	Burgas	390
6	VEOLIA ENERGY VARNA EAD	Varna	47
7	TOPLOFIKATSIYA VT EAD	Veliko Tarnovo	173
8	TOPLOFIKATSIYA RAZGRAD AD	Razgrad	4.8
9	TOPLOFIKATSIYA PERNIK EAD	Pernik	105
10	TOPLOFIKATSIYA SLIVEN EAD	Sliven	484.8

[7] Efficient district heating and cooling networks means district heating or cooling systems utilising at least 50 per cent renewable energy, 50 per cent waste heat, 75 per cent cogenerated heat or 50 per cent of a combination of such energy and heat.

11	TOPLOFIKATSIYA GABROVO EAD	Gabrovo	89
12	TOPLOFIKATSIYA RUSE EAD	Ruse	624
13	BRIKEL EAD	Galabovo	510

Source: Data provided by the Ministry of Energy of the Republic of Bulgaria and the KEVR[8]

All district heating utilities providing central heating in 13 cities in Bulgaria, except the Sofia District Heating (*Toplofikatsiya*) EAD, which supplies 71 % of the total energy for heating and cooling to consumers and is fully owned by the metropolitan municipality, are privately-owned.

The table below shows the net installed capacity, combined heat and power plants and plants using recovered heat from chemical or other processes in the production of energy for heating and cooling in Bulgaria in 2019. The installed capacity of the plants is 5 441 MWth and the net heat output supplied to the network – 7 376 GWh.

Table 6. Existing technologies in district heating networks

Capacity and output	**2018**				**2019**			
Plant technology supplying heat to the network	**Installed net heat capacity in MWt**	**Net production of heat supplied to the grid in GWh**			**Installed net heat capacity in MWt**	**Net production of heat supplied to the network in GWh**		
		Total	**Hot water**	**Steam**		**Total**	**Hot water**	**Steam**
Cogeneration plants using non-renewable fuels	2 075	**4 973**	**4 299**	**674**	**1 835**	**5 237**	**4 588**	**649**
Cogeneration plants using renewable fuels	109	**223**	**204**	**19**	**149**	**307**	**298**	**8**
Cogeneration plants using geothermal or solar energy	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Cogeneration plants using heat recovered from chemical or other processes	-	**-**	-	-	-	**-**	-	-
Plants producing exclusively heat and utilising non-renewable fuels**	3 179	**2 192**	**2 192**	-	**3 146**	**1 677**	**1 677**	-
Heat-only installations	74	**69**	**69**	-	**79**	**80**	**80**	-

8 https://www.dker.bg/uploads/reshenia/2020/res_i8_1_032_20.pdf; https://www.dker.bg/uploads/_CGCalendar/2021/rep_brikel_Izm_lic_2021.pdf

using renewable sources*								
Heat-only installations using electricity (electric boilers)	-	**-**	-	-	-	**-**	-	-
Heat-only installations using geothermal, ambient or solar energy	-	**-**	-	-	-	**-**	-	-
Installations recovering heat from chemical and other processes	232	**56**	**56**	**0**	**232**	**76**	**76**	**0**
TOTAL	**5 669**	**7 513**	**6 821**	**693**	**5 441**	**7 376**	**6 718**	**658**
*** incl. reduction heat (heat released before the electricity generator)**								

Source: NSI

The development of high-efficiency cogeneration improves environmental protection and contributes, above all, to the efficiency of electricity generation, thereby improving the efficiency of the use of primary energy carriers.

Information about the progress of heating utilities towards the achievement of their individual energy savings targets for the period 2017-2019 as at 31 March 2020 is set out in the table below. A general failure to achieve the individual targets set is observed.

Table 7. Progress achieved by obligated parties in terms of fulfilling the individual targets for the period 2017-2020

NAME OF OBLIGATED PARTY	**INDIVIDUAL ENERGY SAVINGS TARGET FOR 2017**		**PROVEN ENERGY SAVINGS 2017**		**UNDERACHIEVEMENT 2017**		**INDIVIDUAL ENERGY SAVINGS TARGET FOR 2018**		**PROVEN ENERGY SAVINGS 2018**		**UNDERACHIEVEMENT 2018**		**INDIVIDUAL ENERGY SAVINGS TARGET FOR 2019**		**PROVEN ENERGY SAVINGS 2019**		**UNDERACHIEVEMENT 2019**		**INDIVIDUAL ENERGY SAVINGS TARGET FOR 2020**		**CUMULATIVE UNDERACHIEVEMENT 2020** *(Column 6*4+Column 9*3+ Column 10*2+Column 13)*	
	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh	ktoe	GWh
TOPLOFIKATSIYA BURGAS EAD	0.098	1.144	0.000	0.000	0.098	1.144	0.151	1.758	0.000	0.000	0.151	1.758	0.102	1.188	0.000	0.000	0.102	1.188	0.125	1.452	1.176	13.679
TOPLOFIKATSIYA VRATSA EAD	0.058	0.679	0.000	0.000	0.058	0.679	0.088	1.023	0.000	0.000	0.088	1.023	0.060	0.695	0.000	0.000	0.060	0.695	0.073	0.855	0.691	8.031
TOPLOFIKATSIYA PERNIK EAD	0.435	5.065	0.000	0.000	0.435	5.065	0.606	7.052	0.000	0.000	0.606	7.052	0.426	4.959	0.000	0.000	0.426	4.959	0.549	6.390	4.963	57.721
TOPLOFIKATSIYA PLEVEN EAD	0.170	1.978	0.000	0.000	0.170	1.978	0.267	3.100	0.000	0.000	0.267	3.100	0.175	2.034	0.000	0.000	0.175	2.034	0.212	2.465	2.042	23.744
EVN BULGARIA TOPLOFIKATSIYA EAD	0.150	1.743	0.000	0.000	0.150	1.743	0.234	2.726	0.000	0.000	0.234	2.726	0.158	1.840	0.000	0.000	0.158	1.840	0.199	2.312	1.818	21.141
TOPLOFIKATSIYA RUSE EAD	0.234	2.724	0.000	0.000	0.234	2.724	0.352	4.089	0.000	0.000	0.352	4.089	0.230	2.674	0.000	0.000	0.230	2.674	0.345	4.010	2.796	32.522
TOPLOFIKATSIYA SLIVEN EAD	0.134	1.555	0.000	0.000	0.134	1.555	0.245	2.846	0.000	0.000	0.245	2.846	0.177	2.062	0.000	0.000	0.177	2.062	0.252	2.928	1.875	21.807
TOPLOFIKATSIYA SOFIA EAD	2.692	31.305	0.000	3.142	2.422	28.163	4.135	48.095	0.000	0.000	4.135	48.095	2.767	32.180	0.000	0.000	2.767	32.180	3.627	42.180	31.254	363.481
VEOLIA ENERGY VARNA EAD	0.043	0.497	0.043	0.497	0.000	0.000	0.070	0.819	0.070	0.819	0.000	0.000	0.047	0.552	0.047	0.552	0.000	0.000	0.062	0.719	0.062	0.719
TPP GORNA ORYAHOVITSA EAD	0.064	0.747	0.064	0.745	0.000	0.002	0.100	1.168	0.100	1.168	0.000	0.000	0.050	0.578	0.000	0.000	0.050	0.578	0.155	1.805	0.255	2.963
TOPLOFIKATSIYA VT AD	0.015	0.170	0.000	0.000	0.015	0.170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.682
TOPLOFIKATSIYA GABROVO EAD	0.015	0.170	0.000	0.000	0.015	0.170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.058	0.678
TOPLOFIKATSIYA PETRICH	0.015	0.173	0.000	0.000	0.015	0.173	0.022	0.260	0.000	0.000	0.022	0.260	0.017	0.196	0.000	0.000	0.017	0.196	0.023	0.265	0.183	2.131
TOPLOFIKATSIYA RAZGRAD EAD	0.017	0.203	0.000	0.000	0.017	0.203	0.028	0.325	0.000	0.000	0.028	0.325	0.018	0.208	0.000	0.000	0.018	0.208	0.022	0.250	0.211	2.455

Source: AUER

According to applicable legislation, the public electricity supplier NEK EAD, respectively the final suppliers EVN Bulgaria Elektrosnabdyavane EAD, CEZ ELEKTRO BULGARIA and ENERGO PRO Prodazhbi AD are obliged to purchase the entire quantity of electricity produced by HE CHP registered with a monthly certificate of origin from the producers connected to the respective grid at preferential prices, with the exception of the electricity necessary to ensure the operational reliability of the main plant facilities and produced in excess of the quantity of electricity from cogeneration and the quantities which the producer uses for its own needs and for its own consumption or has reserved under concluded contracts for participation in the balancing market, or the electricity which is supplied to and consumed by non-household customers other than entities financed by the public budget and which the producer with a predominant heat load for business needs supplies with heat.

The quantities of electricity from high-efficiency cogeneration of heat and electricity are purchased up to those determined by a decision of the Energy and Water Regulatory Commission on setting individual prices for each installation.

The national policy for support of high-efficiency combined heat and power generation is governed by the Energy Act, the Regulation on determining the quantity of electricity produced from combined heat and power generation and the Regulation on the issuance of certificates of origin for electricity produced from renewable energy sources and/or via cogeneration.

The share of the installed net capacity of cogeneration plants using non-renewable fuels increased by 2 % in 2019 compared to 2018, and that of plants using renewable fuels increased by 1 % in 2019 (Figure 26). This indicates that a gradual replacement of technologies with ones that are more efficient has commenced, but also that there is a decline in demand for heating energy supplied by district heating plants.

In 2019, a total of 2 762 200 electronic certificates of origin were issued to the companies that applied for such certificates and electricity from high-efficiency cogeneration in the same year stood at 2 762 200 MWh. In 2020, a total of 2 736 895 electronic certificates of origin were issued and transferred in respect of electricity produced by combined heat and power plants, which corresponds to the electricity produced from high-efficiency cogeneration (2 736 895 MWh). This represents a decrease by 25 305 certificates (less than 1 %) compared to the number of certificates issued in 2019.

As at the end of 2019, 36 high-efficiency, low-capacity cogeneration plants using biomass and agricultural waste were constructed and commissioned in Bulgaria. The heat generated by these plants is mainly used in livestock farms and greenhouses and electricity is used on an autoproduction basis, with residual quantities sold to the electricity grid. In 2019, biomass installations connected to the electricity grid and distribution networks in Bulgaria had an electricity output of 82 754 MWhe in 2019 (according to KEVR data – https://www.dker.bg/uploads/2020/EWRC_report_EC_2020.pdf) . Agricultural products (corn silage, manure, greenhouse waste, etc.) made up the bulk of energy sources used for the production of biogas at biomass plants.

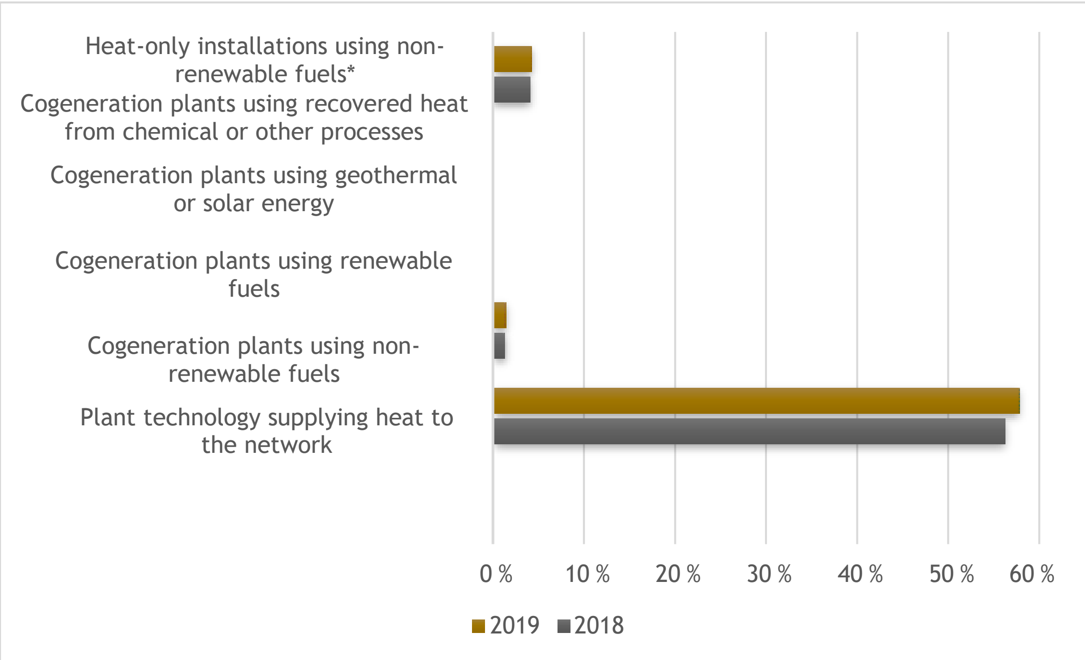


Figure 26. Distribution per type of cogeneration plant

Figure 27 clearly shows that the net installed thermal input (MW) decreased by 4 % in 2019 compared to 2018, and that the net thermal output supplied to the network (GWh) also decreased by 2 % in the same period.

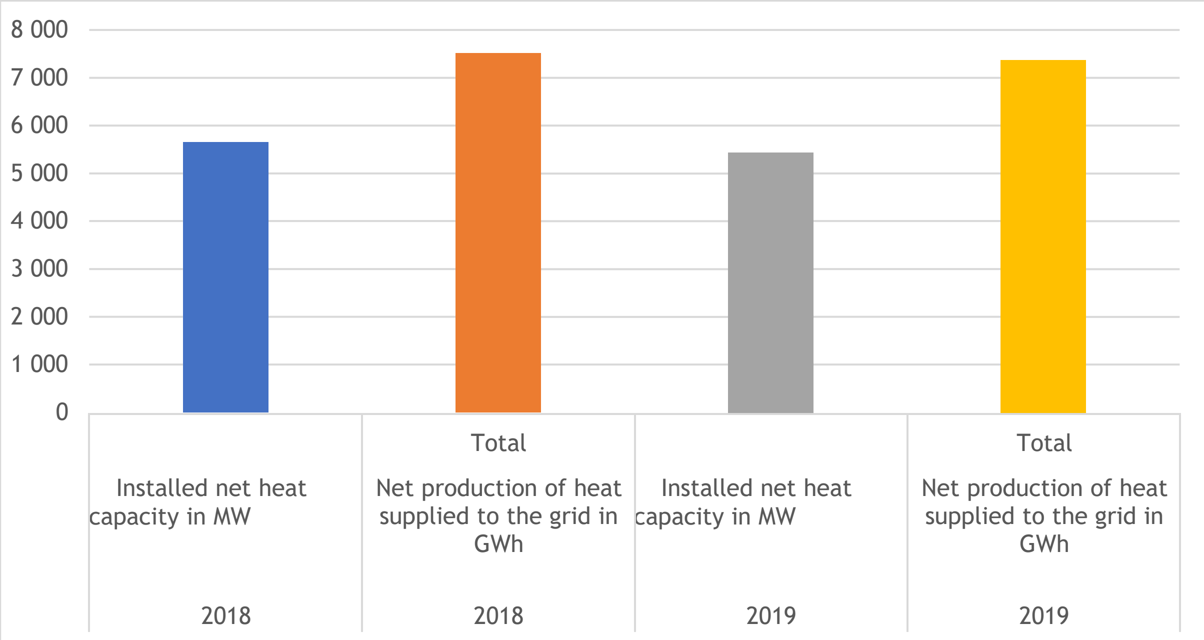


Figure 27. Net production of heat supplied to the grid

The output of energy for heating and cooling and the capacity of cogeneration plants is shown in Table 8.

Table 8. Electricity and heat generation and capacity of cogeneration plants for 2019

1: CHP output and capacity of cogeneration plants with efficiency >= 75 %				
Type of cycle	Maximum capacity	Output	Fuel input	Heat
	Heat	Gross useful energy for heating		
	Net			
	MWt	GWh/y	GWh/y	Number
Combined cycle gas turbine with heat recovery (η total >= 80 %)	443	665.05	1 496.23	2
Gas turbine with recovery boiler	-	-	-	-
Internal combustion engine with waste heat recovery	88	423.92	1 034.81	42
Steam counterbalanced turbine	1 705	4 911.50	7 290.86	12
Condensing steam turbine	1 589	3 638. 62	6 091.04	14
Other	-	-	-	-
Sub-TOTAL	3 825	9 639.10	15 912.94	70
2: CHP output and capacity of cogeneration plants with efficiency < 75 %				
Type of cycle			Fuel input	Heat
	Heat	Gross useful energy for heating		
	Net			
	MWt	GWh/y	GWh/y	Number
Combined cycle gas turbine with heat recovery (η total < 80 %)	-	-	-	-
Gas turbine with recovery boiler	-	-	-	-

Internal combustion engine with waste heat recovery	-	-	-	-
Steam counterbalanced turbine	-	-	-	-
Condensing steam turbine (η total < 80 %	262	377.81	688.11	2
Other	-	-	-	
Sub-TOTAL	262	377.81	688.11	2
TOTAL	4 087	10 016.91	16 601.05	72

- no case

Source: NSI

The table shows that the number of facilities with efficiency that is equal to or greater than 75 % have a dominant share, with 63 % of all facilities comprising an internal combustion engine with waste heat recovery.

According to NSI data for 2019, the fuel consumption of district heating utilities using current technologies is equivalent to 16 601.05 GWh/y. The percentage distribution of the relevant fuels is shown in Figure 28. Natural and manufactured gas have a share of 42 % and brown, lignite and other solid coal fuels account have the second largest share of 24 %. Solid biomass accounts for 17 % of fuel inputs, followed by other liquid fuels with a share of 16 %. Industrial waste and biogas have a share of less than 1 % of the fuel inputs used by cogeneration plants.

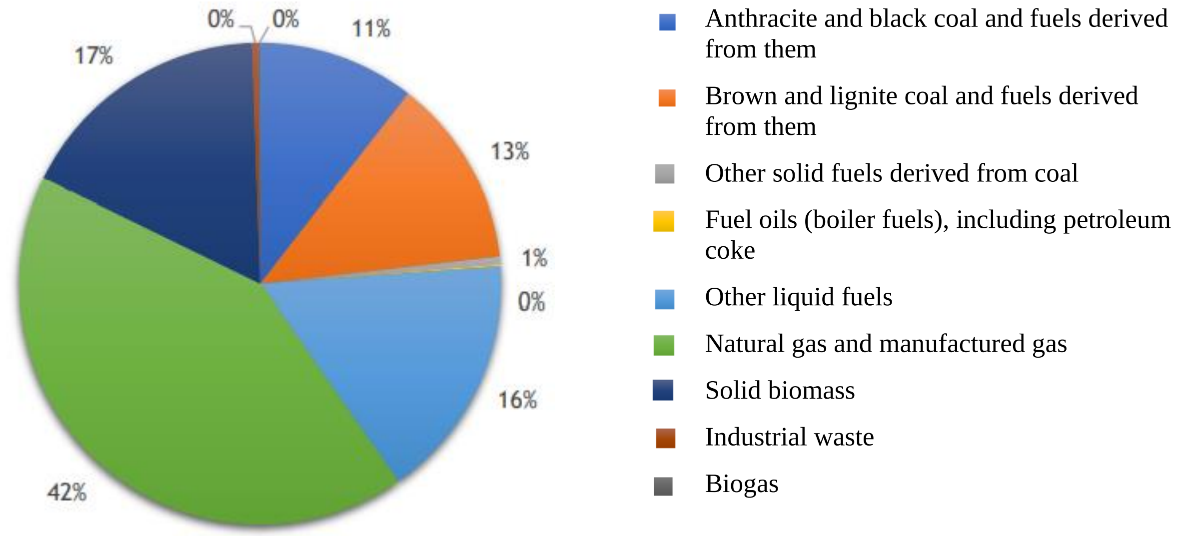


Figure 28. Cogeneration plants fuel input for 2019

Most district heating companies which until 10 to 15 years ago operated as heat-only plants, have made significant investments and installed gas engines and gas turbine modules for the purpose of electricity generation. Gas engines have been installed or hot water boilers have been replaced in factory thermal power plants (ZTETs) and in dozens of greenhouses. In 2019, the thermal energy produced in Bulgaria by ZTETs and (thermal) district heating plants (TPP) stood at 14.382 TWh.

The NSI data set out above indicate that thermal power plants (TPP) have the largest relative share of 54.0 %, followed by factory thermal power plants (ZTETs) with a share of 45 %, and nuclear power plants (NPP) with a share of 1 %.

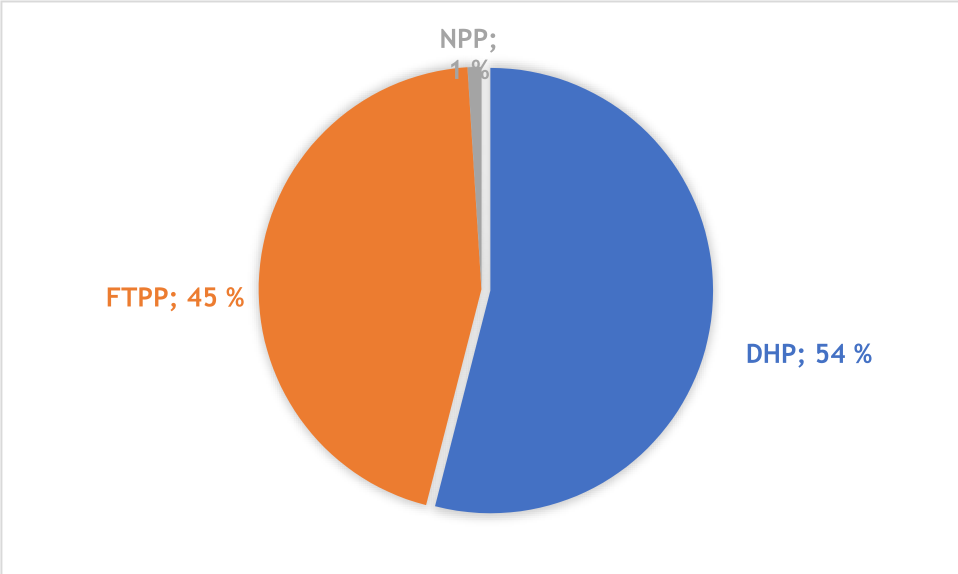


Figure 29. Relative share of heat per plant

1.5 Plants generating heat or waste cold and their potential for heating and cooling, in GWh per year

Traditionally, waste heat from electricity generation in the industry sector has been an important source for heat supply in terms of a strategic energy system approach. Research indicates that large quantities of energy are wasted as a result of failure to integrate these strategic sources of heat into energy policies, relying instead on the use of expensive forms of energy, such as [that derived from] natural gas, to meet energy needs for low-value heating[9]. Strategic sources like the ones above can be:

– heat generation installations that can supply or can be retrofitted to supply waste heat with a total thermal input of over 50 MW;
– CHP plants using the technologies referred to in Part II of Annex I to Directive 2003/87/EC, with an aggregate thermal input of more than 20 MW;
– waste incineration plants;
– installations for energy from renewable sources with a total thermal input of more than 20 MW other than installations for energy for heating or cooling utilising renewable sources;
– industrial installations with a total thermal input of more than 20 MW capable of supplying waste heat.

[9] ReUseHeat. ReUseHeat 2019. https://www.reuseheat.eu/ (accessed February 1, 2019).

Much of the waste heat from flue gas utilisation in heat recovery plants is already being utilised. Currently, the installed waste heat recovery capacity in the industry sector is 232 MW and heat recovery stands at 76 GWh/y. The utilisation of the technical potential for waste heat from the industrial (chemical, paper, etc.) sector will largely depend on individual technical, economic and regulatory conditions in the future.

The analysis of the thermal power plants with capacity for supply or potential for retrofitting for the purpose of supplying waste heat takes into account the design of the future waste incineration plant (RDF) to be constructed at the Sofia district heating plant.

Table 9. Cumulative potential for electricity production from waste heat[10]

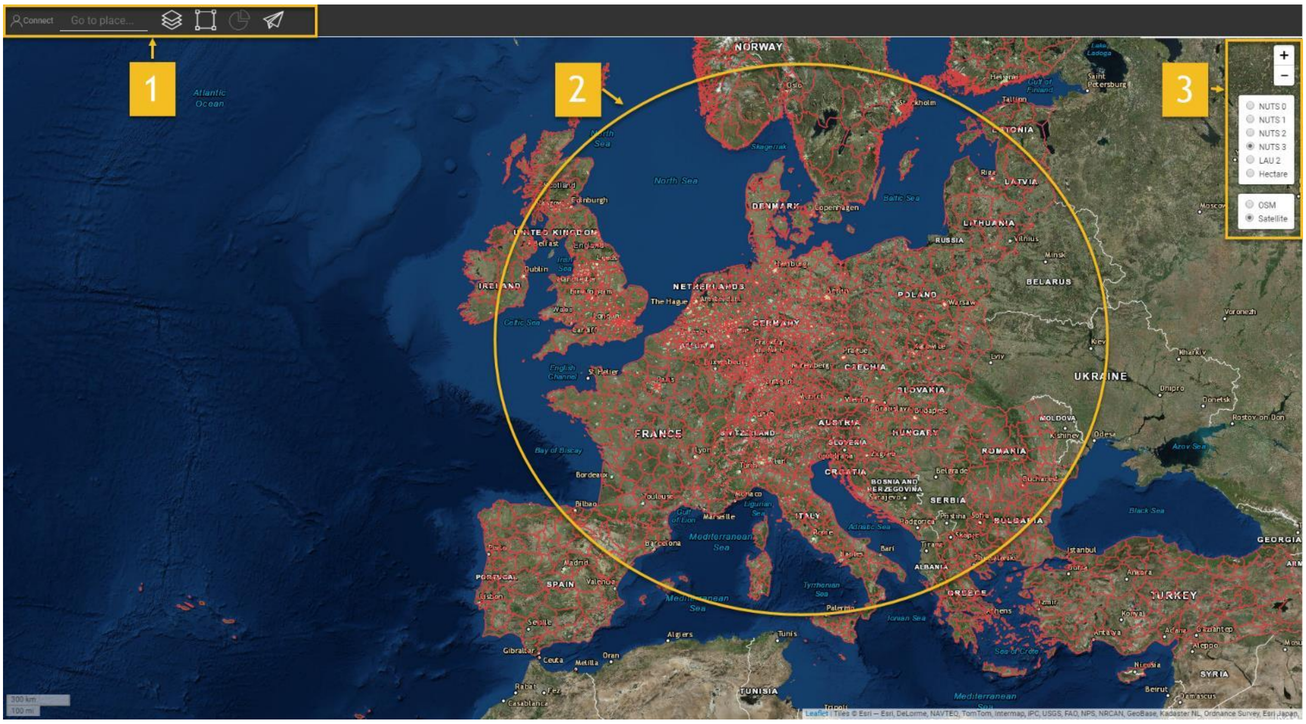
	Threshold	Unit	Value
Heat production installations	50 MW	GWh/y	-
HE CHP	20 MW	GWh/y	-
Waste incineration plants	-	GWh/year	464
Plants using renewable sources	20 MW	GWh/year	-
Industrial plants	20 MW	GWh/year	-

1.6 National Heating Map

Bulgaria's heating map has been upgraded using the European Hotmaps tool, introduced in September 2020. As a result of this assessment, data about district heating companies and installations, as well as large heat producers in the industry sector, has been integrated into the Hotmaps database.

Hotmaps relies on a GIS-based graphical user interface. A map of Europe is shown on the homepage. By default, the EU-28 heat density map and the boundaries of NUTS 2 regions are displayed. In addition to these two maps, some tools and buttons can be seen in the GUI. These are displayed as follows:

10 https://www.dker.bg/uploads/reshenia/2019/res_s-2_19.pdf

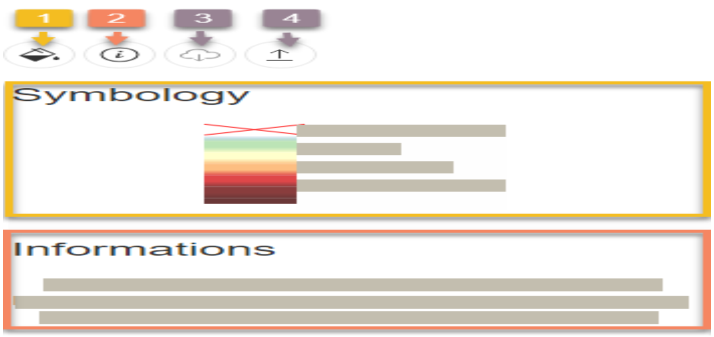


Hotmaps homepage:

Parts of the user interface are shown here:

1. toolbar in the top left corner;
2. the map itself;
3. some tools to change the style (territorial range) of the map.
4. At the top right is a link to [the Hotmaps Wiki](), which is a guide to using the tool and its features.

Pressing the  button opens a sidebar with different layer types on the left-hand side of the screen. Each layer has a set of tools as shown below:



1. displays the symbol properties for the layer (Legend) tab;
2. displays the information tab;
3. Download the default dataset;
4. Select a layer

The following raster layers are displayed:

- **17 x Buildings layer**

  - Heat density map (total/residential/non-residential)
  - Cooling density map (total/residential/non-residential)
  - Gross area (total/residential/non-residential)
  - Building volumes (total/residential/non-residential)
- **1 x Population layer**
  - Total population
- **3 x Renewable energy sources**
  - Solar radiation on building footprint
  - Wind potential 50 m
  - Forest residues
- **5 x climate layers:**
  - Temperature
  - Cooling degree days
  - Heating degree days
  - Solar radiation
  - Wind speed The following

vector layers are visible:

- 4 x industial layers
- Industrial emissions
- Excess heat from industry
- Name of company within industrial site perimeter
- Industrial site sub-sector

- 6 x Renewable energy sources
- Waste water treatment plants Capacity
- Capacity of wastewater treatment plants
- Crop residue
- Organic waste from animal husbandry
- Potential of geothermal energy
- Municipal solid waste

- 1 x Solar power layer
- Average CO_2 emissions by country

In order to accurately define the territorial scope of the search data, the Nomenclature of Territorial Units for Statistics zones at NUTS 1, 2, 3 and LAU 2 levels can be displayed in greater detail using the buttons in the top right corner of the heat map modelled using the hotmaps.eu/map tool. It is also possible to survey specific areas, neighbourhoods, selected plots when by using ‘selection tools' when hectares are used to define the territorial range. The visualisation is available in two versions: 'OSM' and 'Satellite'.

The heat map also contains a 'Calculations' module, and the instruction section of the Hotmaps Wiki platform also contains a training section on performing various calculations.

1.6.1 Areas of demand for heating and cooling

On the basis of the analysis referred to in point 1, consumption density at the level of provinces has been determined according to Bulgaria's administrative division on the basis of the information available about the annual levels of consumption of energy for heating and cooling.

The colour that indicates heat density stands for the average value of heat consumption for the respective province in different sectors. The screenshots represent the average heat consumption for the cities of Sofia, Plovdiv and Varna. An average sample from the heat map visualises the current state of energy for heating and cooling used as a total figure for the household and service sectors and then separately for the energy used for heating in the household and service sectors. These are represented as images in Figures 30 to 38.

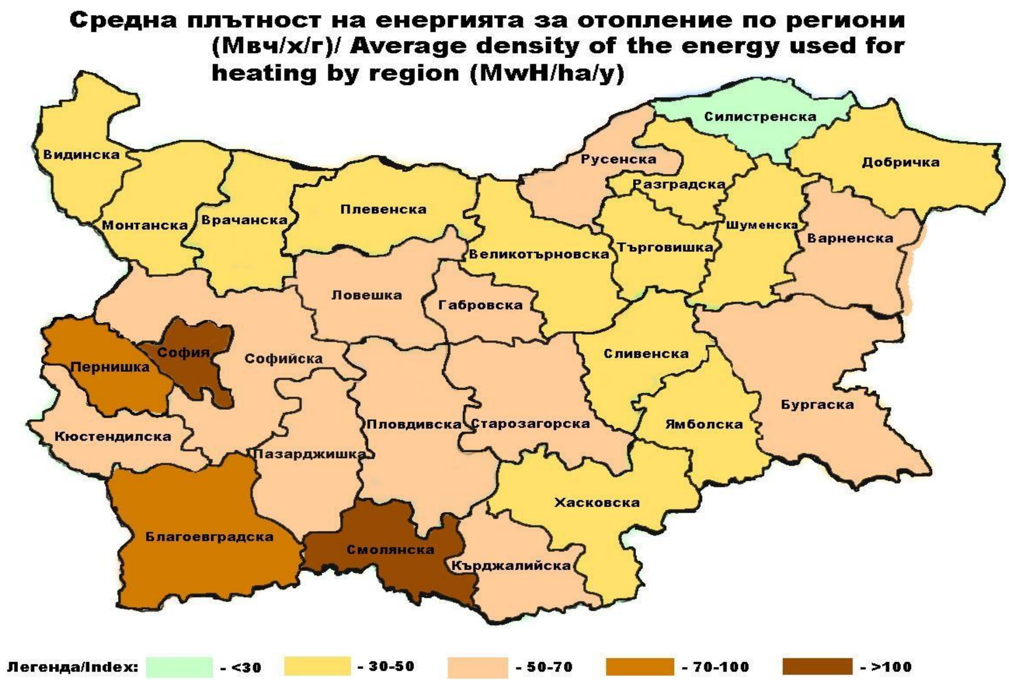


Figure 30 Average density of energy used for heating by province (GWh/year)

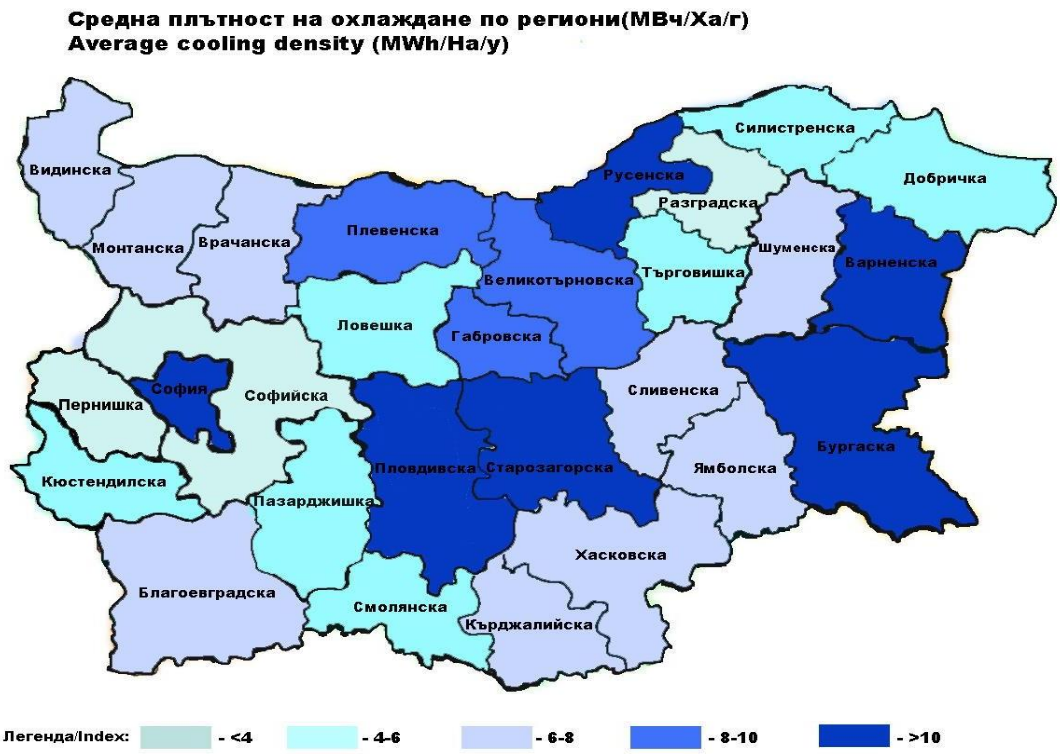


Figure 31. Average density of energy used for cooling by province (GWh/year)

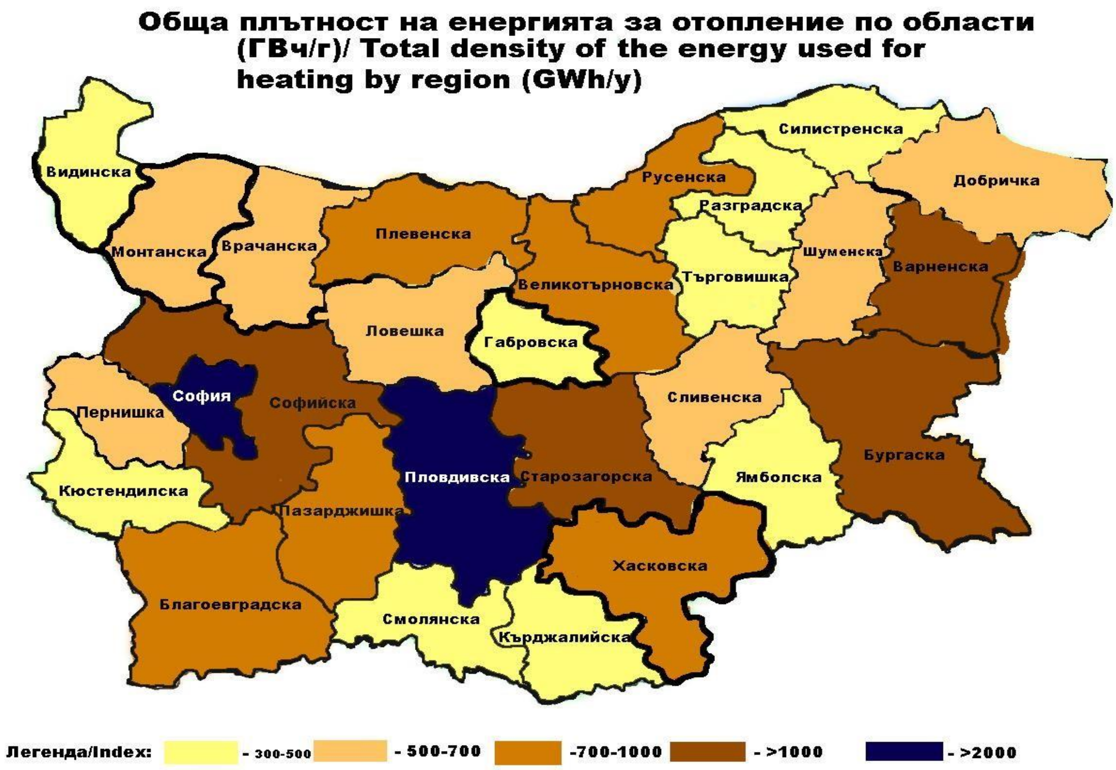


Figure 32. Total density of energy used for heating by province (GWh/year)

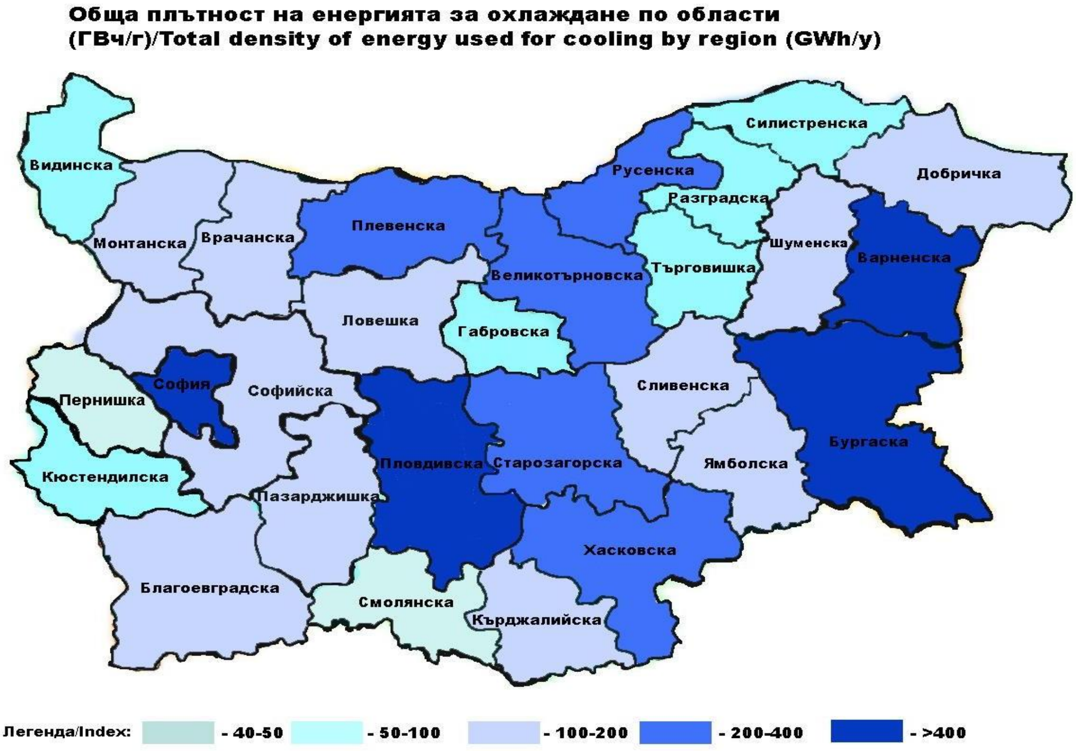


Figure 33. Total density of energy used for cooling by province (GWh/year)

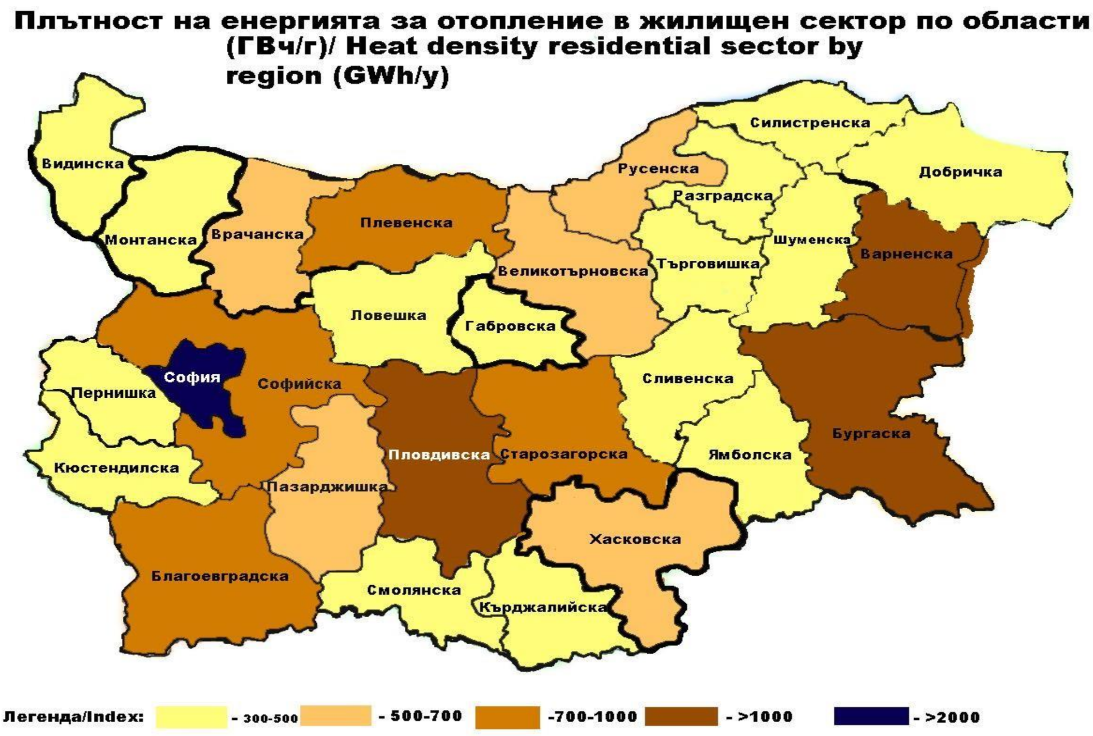


Figure 34. Density of energy used for heating in the residential sector by province (GWh/year)

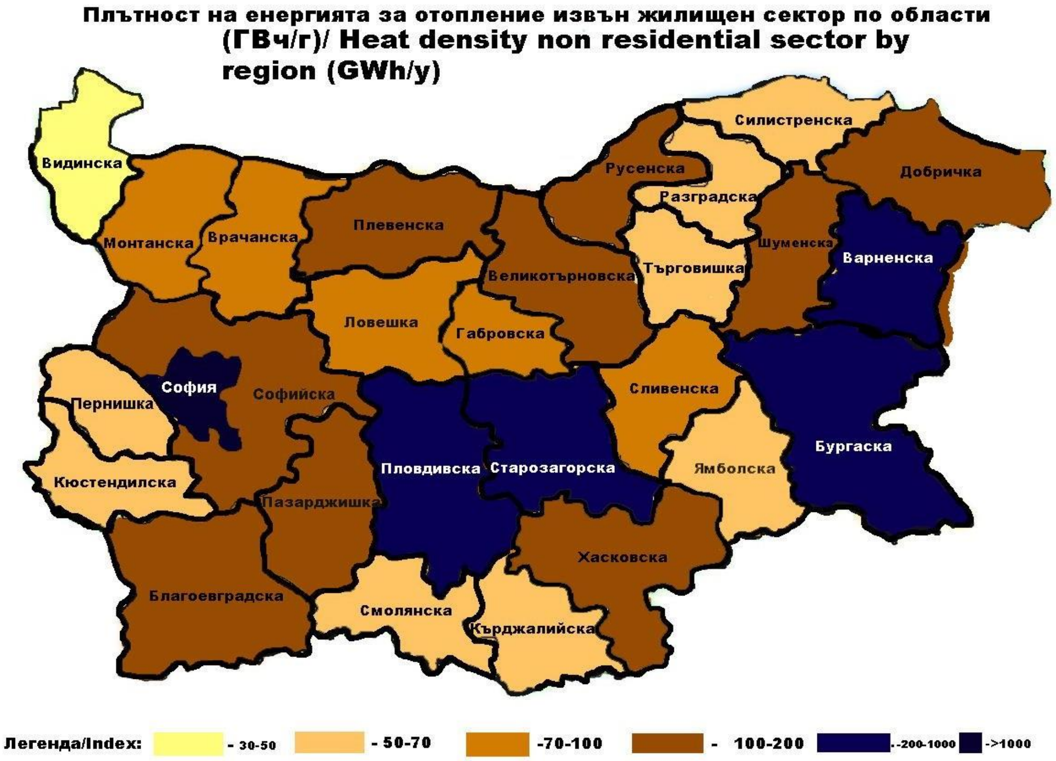
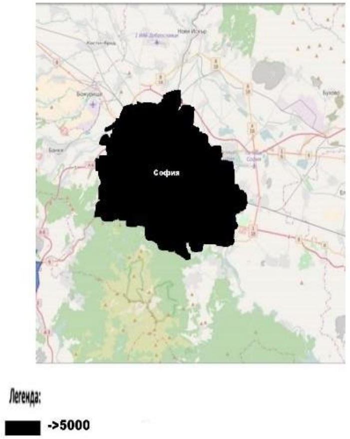


Figure 35. Density of energy used for heating in the "services sector by province (GWh/year)



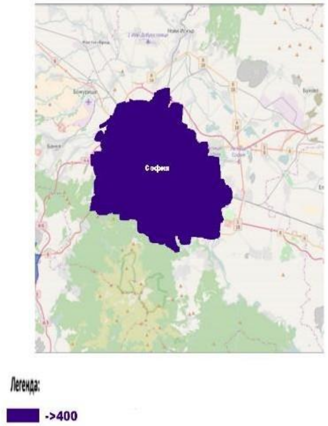
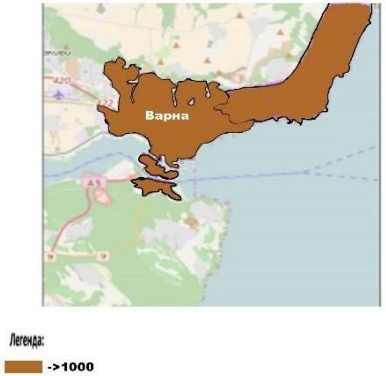


Figure 36. Density of energy used for heating (in black) and cooling (in blue) in Sofia (GWh/year)

Figure 37. Density of energy used for heating (in brown) and cooling (in purple) in Plovdiv (GWh/year)



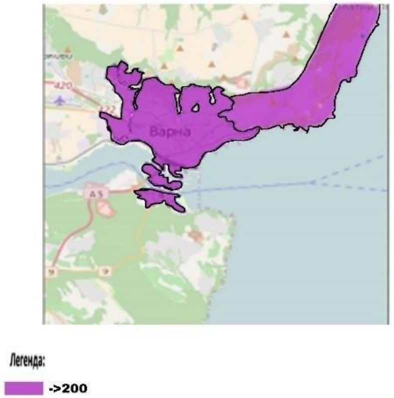


Figure 38. Density of energy used for heating (in brown) and cooling (in purple) in Varna (GWh/year)

For all other territorial units, the values for heat demand and theoretical energy demand for cooling can be derived from the hotmaps.eu tool under the classification of territorial units for statistics in Bulgaria (NUTS).

1.6.2 Existing energy supply points for heating and cooling

The following have been classified as large energy producers and consumers: district heating utilities, district heating plants, large industrial heat consumers, etc. Information about companies in the industrial sector is available at: www.hotmaps.eu/map, layer Industry by selecting Industrial site company name/Industrial site subsector and data on district heating plants in the Heating utilities layer, login with the username: bghotmap@abv.bg and password: BGhotmaps.

1.7 Projected heating and cooling demand

The projected demand for energy for heating and cooling has been calculated on the basis of projections of thermal energy consumption, taking into account key macroeconomic indicators — demographics, GDP and additional factors, such as ambient temperatures, implementation of EE measures in the services and household sectors, intensity of the economy, degree and rate of technology substitution, the projections set out in the 2016 baseline scenario of Directorate-General for Energy (https://ec.europa.eu/info/departments/energy_bg), the Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030, and the long-term national strategy to support the renovation of the national building stock of residential and non-residential buildings by 2050.

The trends in projected demand for energy for heating and cooling (in GWh) have a time horizon of 30 years and, more specifically take into account the projections for the next 10 years.

The projected curves for renewable energy that Bulgaria plans to use in order to match the overall and sectoral renewable energy curves for the period 2020-2030, including the expected total gross final energy consumption for each technology and sector in million toe, are shown in Figure 39, disaggregated by technology.

The data shows that the final consumption of energy for heating and cooling in Bulgaria is expected to have decreased by 2 % by 2030 compared to 2020 on account of the additional energy efficiency improvement measures and policies planned, which will have a positive impact on the losses in district heating (from 2 229 GWh in 2020 to 1 574 GWh in 2030). With regard to the renewable energy mix, further development of solar installations has been planned. These are expected to generate 347 GWh of thermal energy in 2030. The main renewable source of energy for heating and cooling used in Bulgaria is biomass on account of the development of cogeneration plants (expected to increase from 4 GWh in 2020 to 2 497 GWh in 2030), and the use of of biodegradable waste, with geothermal sources and heat pumps also expected to register a small increase over the period.[11]

Table 10. Projected technology curves for renewable energy for the period 2020-2030, ktoe — sector energy for heating and cooling[12]

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biomass	1 109	1 163	1 217	1 270	1 324	1 378	1 404	1 430	1 456	1 482	1 508
Solar energy	**23**	**23**	**24**	**25**	**26**	**26**	**27**	**28**	**28**	**29**	**30**
Geothermal energy	35	35	35	36	36	36	36	36	36	36	35
Heat pumps	**98**	**101**	**104**	**108**	**111**	**114**	**116**	**117**	**119**	**120**	**122**
Gross final consumption of energy for heating and cooling from RES	1 264	1 322	1 381	1 439	1 497	1 555	1 583	1 611	1 639	1 667	1 695
Gross final consumption of energy for heating and energy for cooling	**4 069**	**4 072**	**4 074**	**4 076**	**4 078**	**4 080**	**4 060**	**4 039**	**4 019**	**3 999**	**3 978**
RES – energy for heating and cooling	31.07	32.48	33.89	35.3	36.71	38.11	38.99	39.88	40.78	41.68	42.6

Source: Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030

Taking into account the requirements laid down in Article 1 of Directive (EU) 2018/2001 of the European Parliament [and of the Council], the projected indicative annual increase in the share of energy from RES between 2020 and 2030 is 1.15 percentage points (calculated as the difference between the share of energy from RES between 2020 and 2030, divided by the number of years).

11 Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030
12 RES – energy for heating and cooling, % – Share of energy for heating and cooling in gross final consumption of energy for heating and cooling.

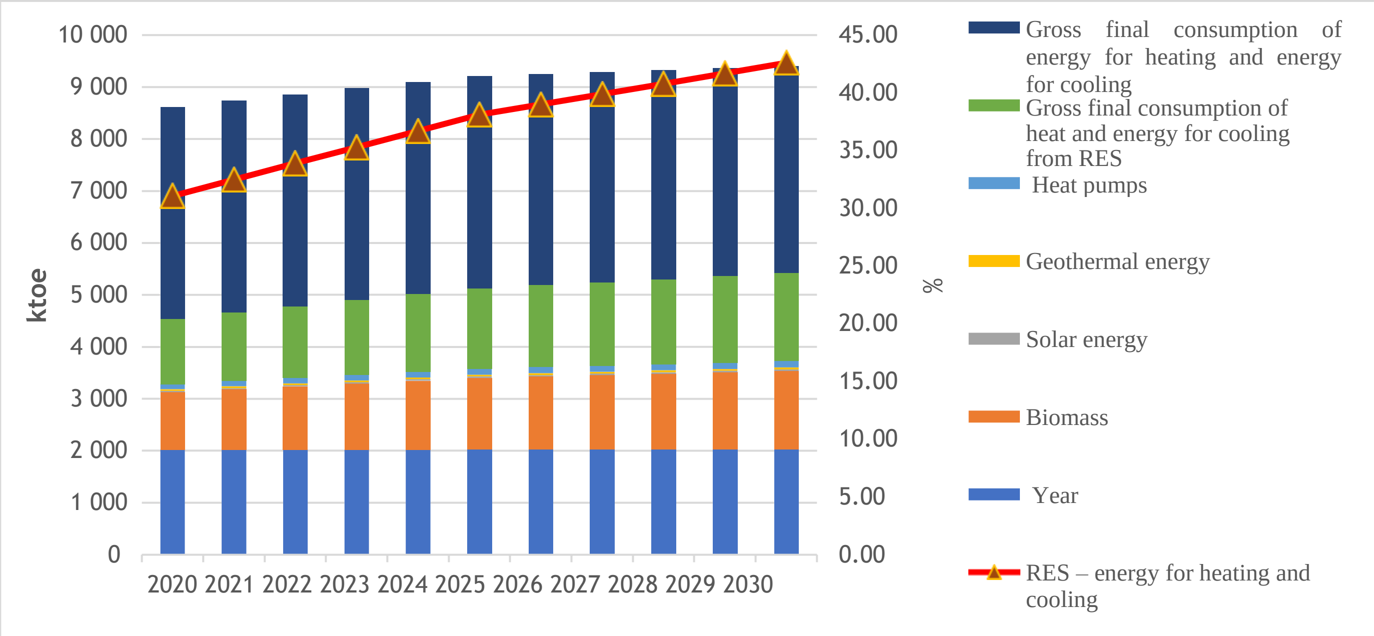


Figure 39. Projected technology curves for renewable energy for the period 2020-2030, ktoe — energy for heating and cooling sector

Projected evolution of the main exogenous factors with an influence on the development of the energy system, i.e. GDP and population growth.
The main development curves for Bulgaria until 2050 are developed in the 2016 baseline scenario of DG ENER.

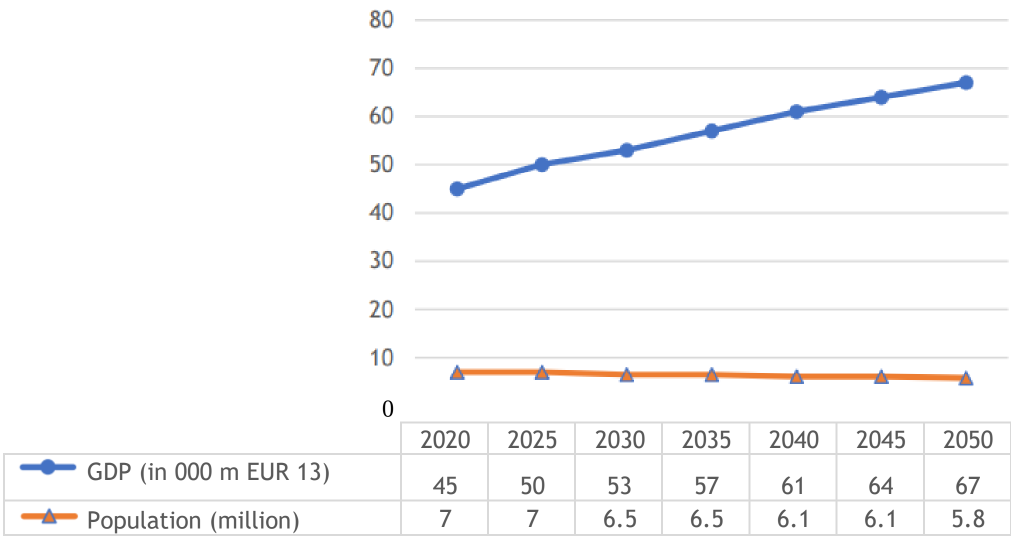


Figure 40. Key demographic and economic indicators

Although Bulgaria's population is expected to decline to 5.8 million people in 2050, GDP is projected to increase, reaching EUR 67 [bn] in 2050.

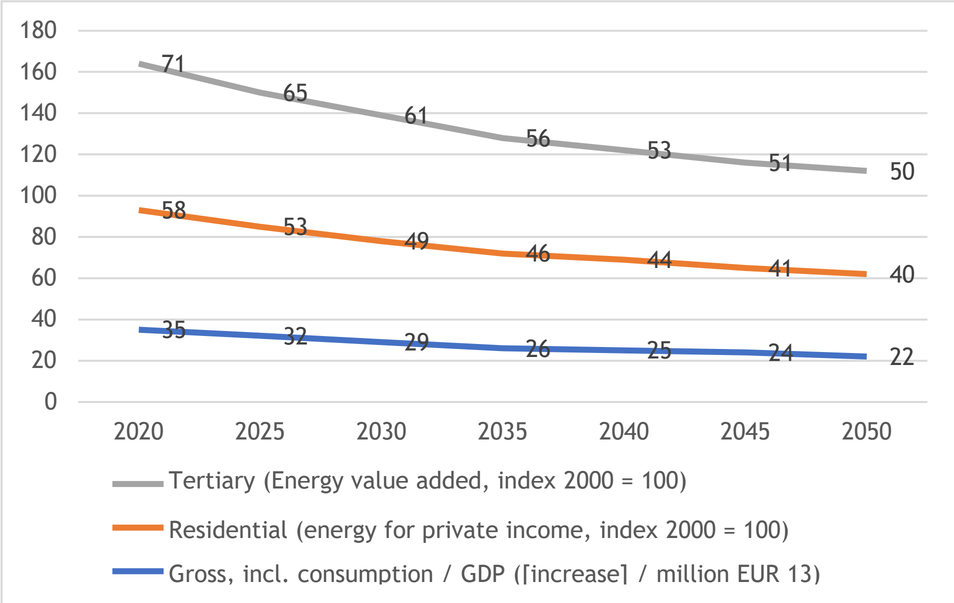


Figure 41. Final energy intensity by sector

Bulgaria has significantly reduced its final energy intensity on account of changes in economic structure coupled with energy efficiency policies and measures implemented in all sectors of the economy. In the period 2020-2050, it will stay on course, continuing to lower final energy intensity, with a projected average annual rate of decrease of approximately (-33 %).

Energy intensity has decreased in all sectors, with the largest [projected] decrease in the industry sector by 37 % compared to 2020.

Taking into account existing measures and policies, the table below sets out the projections for gross domestic consumption (by fuel and energy type), FEC (by fuel and energy sector) and non-energy consumption for the period 2020-2050.

According to this scenario, installed cogeneration capacity in Bulgaria is expected to decrease by about 11 % compared to current levels. The main fuels used for heat generation will be solid fuels, gas and RDF. According to the scenario, fuels derived from oil will remain in use until 2030, albeit in minimal quantities. The scenario does not envisage the construction of hydrogen and geothermal district heating plants. By 2050, the share of the installed capacity of plants fired by solid fuels is projected to gradually decrease by more than 50 % compared to current levels and the share of the installed capacity of gas-fired plants is set to increase by nearly 62 % compared to current levels. The installed capacity of plants utilising waste fuel is expected to increase significantly, marking a twofold increase in 2030 and fourfold one by 2050 compared to current installed heat generation capacity.

Table 11. Projected installed capacity for heat and electricity generation in the Republic of Bulgaria

Generating capacity MWe	2020	2025	2030	2035	2040	2045	2050
Thermal output	**5 782**	**4 726**	**4 536**	**3 924**	**3 267**	**3 323**	**3 874**
of which cogeneration units	1 704	1 653	1 518	1 143	1 016	1 140	1 146
of which CCS[13] units	**0**	**0**	**0**	**0**	**0**	**0**	**990**
Solid fuels	4 819	3 501	3 391	2 379	1 799	1 590	2 179
Gaseous fuels	**910**	**1 129**	**1 043**	**1 433**	**1 271**	**1 517**	**1 478**
Petroleum products	2	2	2	0	0	0	0
Waste — RDF biomass	**51**	**94**	**101**	**112**	**197**	**216**	**217**
Hydrogen installations	0	0	0	0	0	0	0
Geothermal heat	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: Directorate-General for Energy (DG ENER)[14]

Despite a gradual decline in installed capacity by nearly 19 % in 2030 compared to current levels and a declining population, hardly any change in final energy consumption in Bulgaria is projected to occur.

Table 12. Fuels expected to be used in heat generation

Year	2020	2025	2030	2035	2040	2045	2050
Fuel input for heat generation (GWhe)	5 904	5 128	4 789	4 964	4 533	3 127	3 671
Solid fuels	**5 223**	**4 344**	**4 083**	**3 648**	**3 142**	**1 938**	**2 689**
Oil (including refinery oil)	17	17	0	0	0	0	0
Gas (including derivative gases)	**627**	**658**	**605**	**1 086**	**1 059**	**853**	**632**
Biomass from waste	38	110	101	214	332	337	350
Geothermal heat	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hydrogen — methanol	0	0	0	0	0	0	0

Source: Directorate-General for Energy (DG ENER)

13 CCS – Carbon capture and storage
14 https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

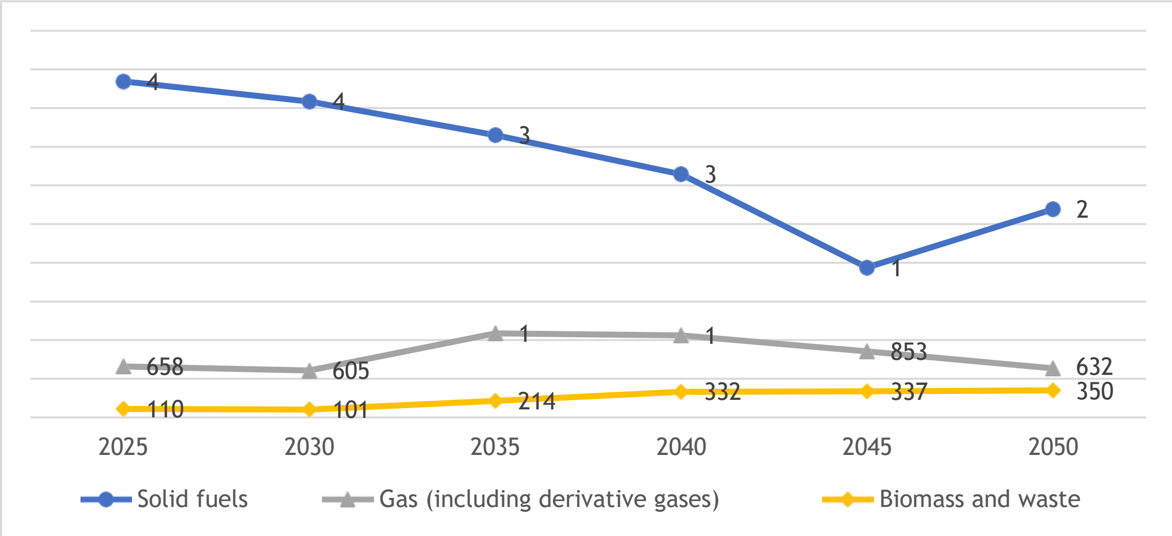


Figure 42. Fuel input for heat generation (GWhe)

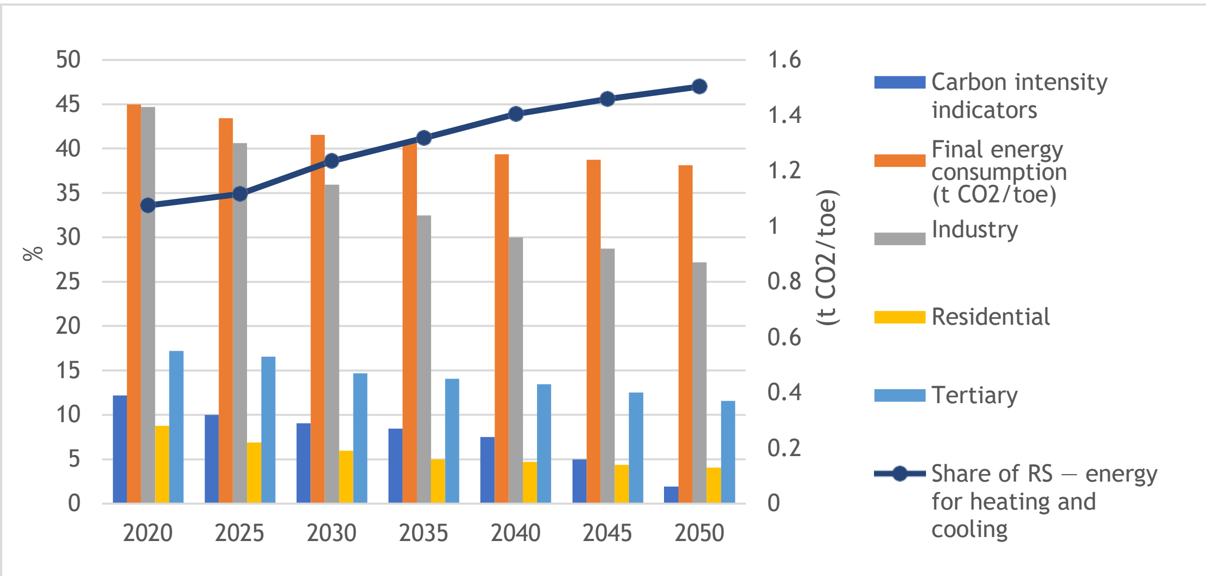


Figure 43. Projected carbon intensity indicators by sector

A summary and overview of the demand for energy for heating and cooling by sector is set out in Table 13.

Demand for useful energy for heating and cooling in Bulgaria is expected to decrease by 2 % in 2030 compared to 2019 and by 4 % in 2050 compared to 2020.

*Table 13. Current and projected energy demand for heating and cooling in Bulgaria in the next 10 to 30 years**

			Year						
		Unit	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Demand for heat, final energy consumption	Residential sector	GWh/y	**17 855.37**						
	Services sector	GWh/y	**10 627.44**						
	Industry sector	GWh/y	**17 912.20**						

	Other sectors	GWh/year							
Demand for heat, useful energy	Residential sector	GWh/y	**13 956.52**	**13 556.16**	**13 841.66**	**13 884.00**	**14 284.85**	**14 720.72**	**15 192.38**
	Services sector	GWh/year	**10 093.20**	**10 277.26**	**10 076.70**	**10 196.21**	**10 328.37**	**10 473.57**	**10 666.84**
	Industry sector	GWh/year	**15 620.05**	**16 200.69**	**16 728.82**	**17 169.60**	**17 722.61**	**18 301.19**	**18 906.30**

**The development of the forecast until 2050 is based on the baseline scenario.*

In order to estimate the final consumption of thermal energy, the current analysis of national statistical data set out in Bulgaria's total energy balance for 2019 has been used. For this purpose, the total quantities of energy in all categories of the energy mix that form an element of final consumption by fuel have been converted into useful energy. Data has not been disaggregated to indicate final demand for energy for cooling. The current and projected demand for useful energy for heating and cooling is reported on the basis of information about final energy consumption and the useful energy value of the fuels in the mix. For geothermal energy and heat pumps a factor of 3.5 has been used. According to point 1.1 above the table does not contain data about other sectors (agriculture).

1.8 Share of energy from renewable sources and from waste heat or cold in the final energy consumption of the district heating and cooling sector

In 2019, the contribution of RES to the consumption of energy for heating and cooling had a share of 35.5 %. This constitutes an increase by 19 % as compared to 2015 as shown in Figure 44.

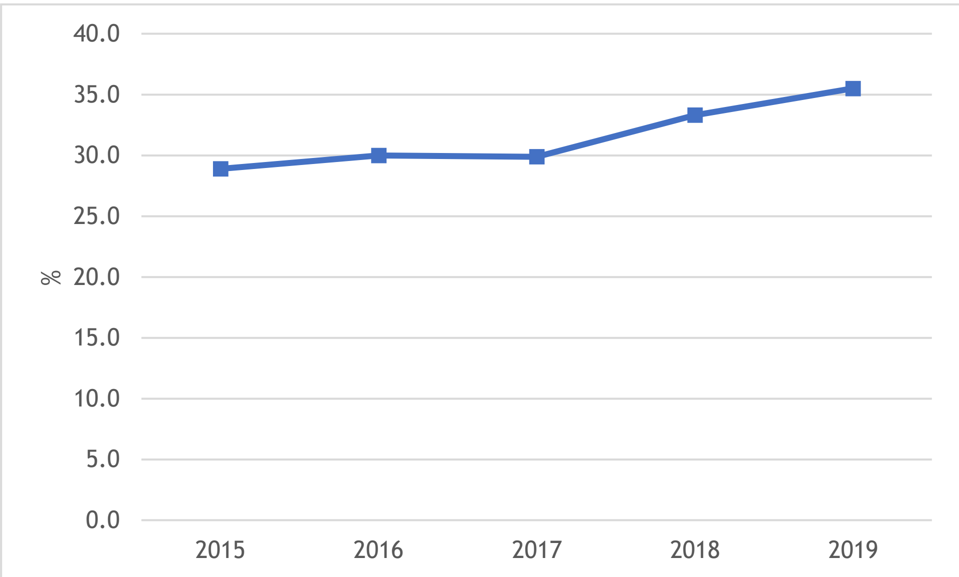


Figure 44. Share of renewable energy for heating and cooling, %

Source: NSI

According to national statistical data, energy from RES (biofuels) has a share of 2.55 % in district heating installations, gas being the main fuel used with a share of 94 %. For public CHP plants, the share of RES in 2019 stood at 26.75 %. The share of renewable energy in final energy consumption of the district heating and cooling sector is shown in Figure 45.

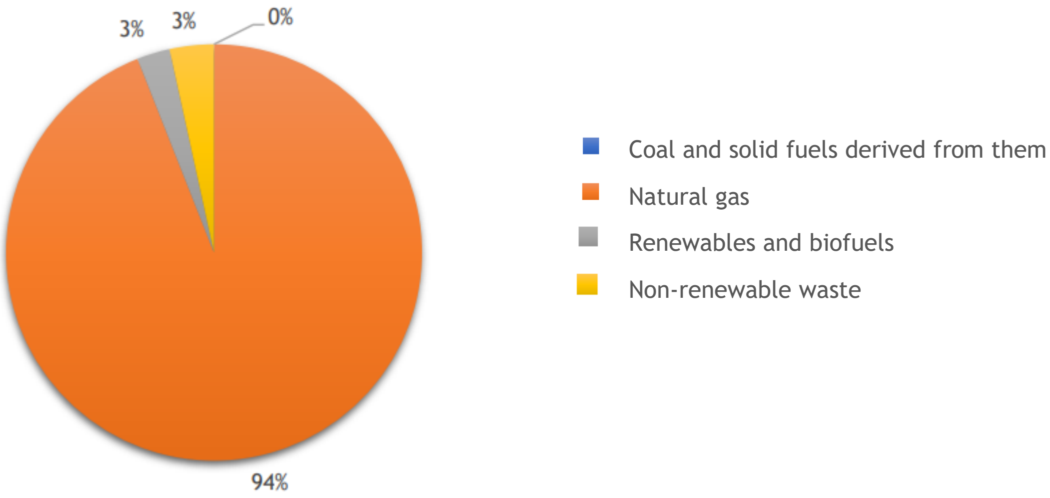


Figure 45. Share of carbon emissions from renewable sources in final energy consumption by the district heating plants and cooling systems sector

The share of RES in final energy consumption of the district heating and cooling sector according to the series of average values for the period shown is 2.9 %.

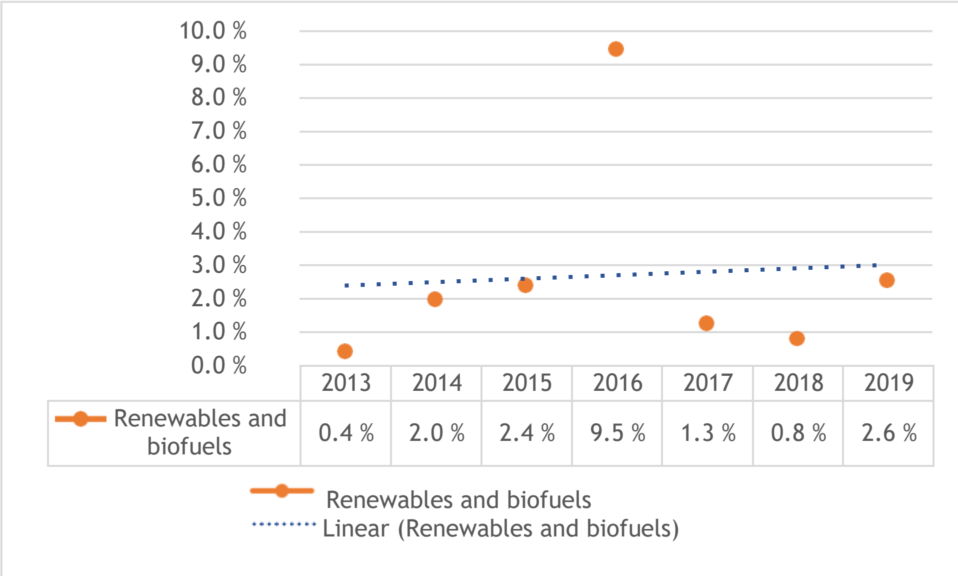


Figure 46. Share of carbon emissions from renewable sources in final energy consumption by the district heating plants and cooling systems sector in the period 2013-2019

2 GOALS, STRATEGIES, MEASURES AND POLICIES

2.1 Role of efficient heating and cooling in long-term GHG emission reduction and overview of existing policies

District heating companies currently supply 13 % of total national consumption of heat. The share of traditional district heating in the household and services sectors is estimated at 17.4 %. In the next 10 years, the share of consumers connected to traditional district heating is expected to marginally increase while final consumption is expected to decrease on account of the improved energy performance of buildings.

Consumers not connected to district heating currently have a share of nearly 87 % of the final consumption of energy for heating and cooling in Bulgaria.

The capacity of electricity and heat cogeneration plants in the next five-year period is shown in Figure 47. There has been an increase in electricity and heat generation by CHP with efficiency that is equal to or greater than 75 %.

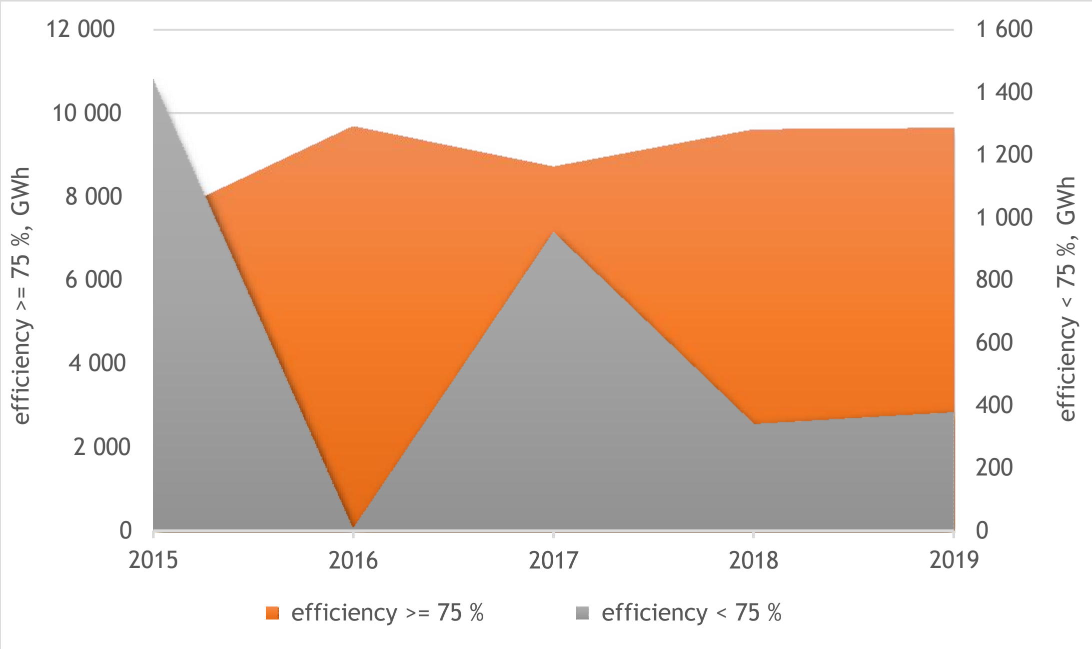


Figure 47. Electricity and heat generation and capacity of cogeneration plants

The potential for heat generation in new CHP power plants can by and large be harnessed through a shift from separate heat generation to high-efficiency cogeneration; a shift from the Rankine steam cycle to combined gas-steam cycle; the use of fuel from processed waste; and the development of micro- and mini-CHP.

Correlation analysis has been used to calculate Pearson's coefficient, which shows the correlation between production data and the year of production ($R^2 = 0.988$). The value indicates a strong correlation and a high degree of confidence in the linear model.

A production trend equation in the form of the linear function $y = 242.13x + 8861.4$ has been defined, where x is the sequence number of the year and y is the electricity and heat production in GWh for that year. The figure 12 791.52 GWh has been calculated on the basis of the resulting linear equation, indicating potential for a 22 % increase in electricity and heat generation by HE CHP by 2030 compared to 2019. The data is shown in Figure 48. The data is shown in Figure 48.

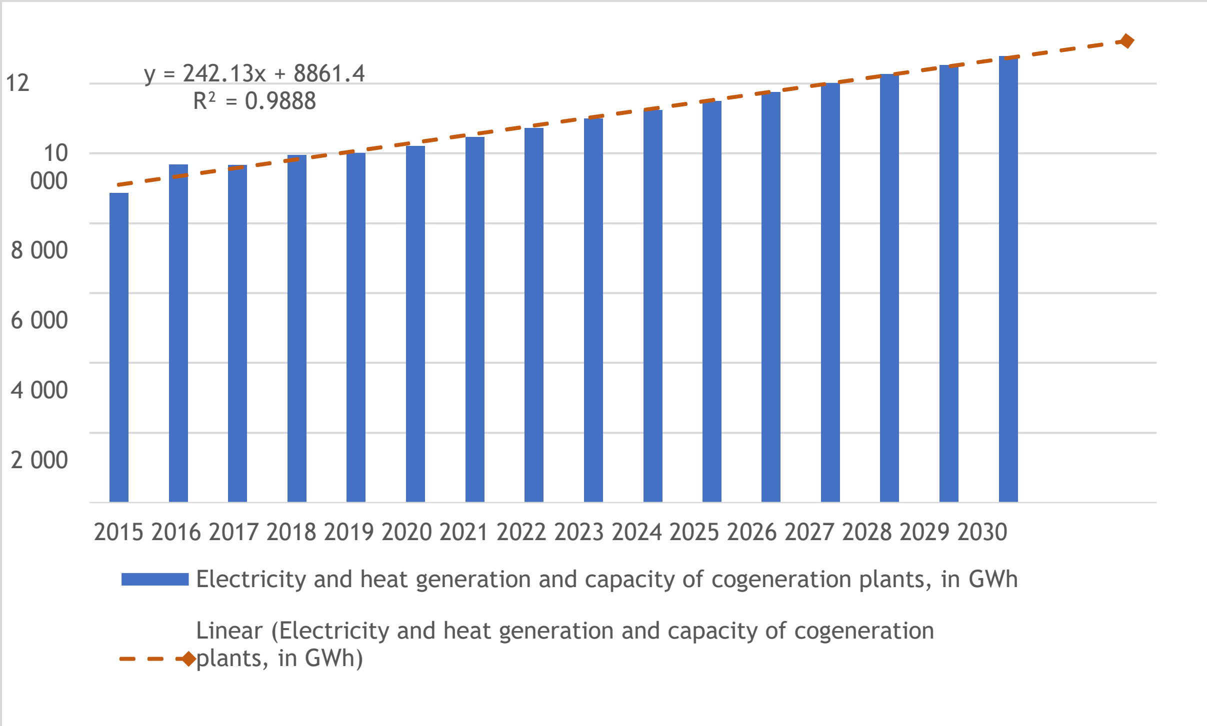


Figure 48. Potential for heat generation in new cogeneration plants

Successfully tapping existing potential will largely depend on the policies and measures implemented with a view to achieving the ultimate goal of sector decarbonisation by 2050.

2.2 Overview of existing policies and measures

There are plans to limit support for electricity produced from RES through preferential prices and replace it with support for electricity produced by facilities with a total installed capacity of less than 0.5 MW. Specific measures to promote the production of energy for heating and cooling and gas from RES are laid down in the Renewable Energy Sources Act (ZEVI), including provisions on support for and implementation of projects for the construction of heat transmission networks in agglomerations that meet the requirements for a self-contained territorial unit, where the supply of energy for heating from renewable sources is economically justified. Support for and implementation of projects for the construction of small, decentralised heating and/or cooling systems; connection of facilities for the generation of energy for heating from RES to the heating network and purchase by heat transmission companies of heat from other producers.

The progress achieved towards the priority set in the Energy Strategy for the development and expansion of household gasification in Bulgaria is estimated at 5 %. The use of electricity in final consumption has led to a threefold increase in primary energy costs compared to the environmentally-friendly alternative of direct use of natural gas. This means that the substitution of electricity by natural gas for heating and domestic use will contribute to the achievement of triple savings of primary energy and should therefore be seen as an option for increasing energy efficiency.

In order to create incentives that will increase the level of household gasification in Bulgaria, the Ministry of Energy has implemented the project *Energy Efficiency Measures for End Users of Natural Gas* (DESIREE), funded by a grant in the amount of EUR 10.9 million from the Kozloduy International Fund. The aim is to give a boost to household gasification by supporting the initial investment of approximately 10 000 households wishing to connect to the existing gas distribution network (support covers a fixed fee in the amount of 30 % of the eligible investment and 100 % of the connection fee, but not more than EUR 1 000 per household for systems with high-efficiency boilers and not more than EUR 1 200 per household for systems with condensing boilers).

A description of the measures taken in 2017 and 2018 and/or planned at national level to promote the use of energy from renewable sources, taking into account the indicative trajectory for achieving the national targets for energy from renewable sources, respectively the reduction of greenhouse gas emissions in the heating and cooling sector according to the National Renewable Energy Action Plan (Article 22(1)(a) of Directive 2009/28/EC) is set out in Bulgaria's Fifth National Report on progress achieved in the promotion and use of energy from renewable sources[15].
An assessment of the implementation of the national energy efficiency measures is set out in the 2019 Annual Report on the implementation of the National Energy Efficiency Action Plan for the period 2014-2020 [16]. The measures in the area of HE CPE are set out in Table 14.

Table 14. Measures supporting the achievement of the national high-efficiency heating and cooling targets for long-term reduction of greenhouse gas emissions

Name and reference of the measure	Type of measure	Intended outcome	Target group and/or activity	Start and end dates of the measure
Support scheme for the generation of energy for heating and cooling in the industry sector	Financial, regulatory	Behavioural change, installed capacity (MW/year), energy produced (ktoe)	Investors, final consumers, public administration	During the reporting period, the production of thermal energy from RES was supported under Operational Programmes and Programme BG04 Energy Efficiency and Renewable Energy, financed under the Financial Mechanism of the European Economic Area 2009-2014.

15 https://www.me.government.bg/files/useruploads/files/vp_espuer_2017.pdf, Table 2

16 https://www.seea.government.bg/documents/Otchet_NPDEE_2019_22.07.2020.pdf, Chapter 5

Support scheme for the generation of heat from RES in residential and public buildings	Financial. regulatory	Behavioural change, installed capacity (MW/year), energy produced (ktoe)	Investors, final consumers, public administration	The measure is permanent. No deadline. National programme for energy efficiency of multifamily residential buildings was adopted by Decree No 18 of 2.2.2015.
Programme for financial incentives for the use of local heating	Financial	ktoe	Investors	2013 — permanent. No deadline.
Tax incentives for investment in the production of electricity from RES for the household sector	Financial	ktoe	Final consumers	The measure was introduced in 2009 with the Local Taxes and Fees Act (ZMDT). According to Article 24(1)(18) and (19) of the ZMDT buildings that meet the statutory requirements and implement measures for RES recovery for the purpose of autoproduction are exempt from taxes for the period specified by law. No deadline.
Developing assessment procedures that require mandatory labelling of biomass incineration equipment	Regulatory, financial	ktoe	Energy suppliers	The measure was introduced in 2011 Labelling is governed by the provisions laid down in the Technical Requirements for Products Act in connection with the requirements for eco-design.

Source: Fifth National Report on progress in the promotion and use of energy from renewable sources

2.2.1 Decarbonisation dimension

Existing and planned measures have a major contribution to decarbonisation in the energy sector as the main source of greenhouse gas (GHG) emissions. The following points of relevance to the sector of heating and cooling have been identified in the Integrated Energy and Climate Plan of the Republic of Bulgaria for the period 2021-2030:

- Upgrade of cogeneration plants and central heating boilers with natural gas turbines;
- Reduction of losses in heat networks;
- Fuel switching from coal to natural gas;
- Increase of high-efficiency cogeneration;
- Increase of the share of energy for heating and cooling from renewable energy sources;

Aggregated policies and measures for the households and public sectors

- Gas supply to households;

- Installation of solar collectors;
- Implementation of the measures set out in the National Programme for Accelerated Gasification (NPAG) in Bulgaria;
- Refurbishment (renovation) of public and State-owned buildings (with a total area of more than 250 square metres) up to a specified annual percentage following the entry into force of the Energy Efficiency Directive;
- Introduction of a mandatory energy efficiency scheme (lowering fuel and energy consumption in final energy consumption);
- Accelerating the date of entry into force of Regulation 2015/1185 and mandatory accelerated phase-out of traditional polluting heating appliances (solid fuel stoves) in line with the National Air Pollution Control Programme 2020-2030;
- Introducing a fuel quality standard for coal (at national level), surrogate measures to reduce the moisture content of firewood used in municipalities that do not meet air quality criteria for PM10 and, potentially, of a standard for the maximum moisture content of firewood, in line with the National Air Pollution Control Program 20202-030;
- Households affected by the mandatory phase-out of traditional stoves in transition to heating reliant on natural gas (reconnection and new connections), central heating (reconnection and new connections), or the use of eco-design-compliant space heaters) in line with the National Air Pollution Control Program 2020-2030.

The use of fuels other than conventional fuels for primary energy production should be linked to the implementation of the following measures:

- Conducting and adopting a national analysis of the potential for sustainable biomass from all sectors (including but not limited to forestry and agriculture) and sustainability criteria, taking into account the sustainability criteria set out in Directive (EU) 2018/2001;

In order to stimulate the use of renewable energy for heating and cooling, the Renewable Energy Act promotes the generation of energy for heating and cooling from renewable sources by means of:

- support for and implementation of projects for the construction of heat transmission networks in agglomerations that meet the requirements for a self-contained territorial unit, where the supply of energy for heating from RES is economically justified and an investment project has been submitted;

- support for and implementation of projects for the construction of small, decentralised heating and/or cooling systems;

- facilitation of the connection of heating plants utilising RES to the heat transmission network and purchase by the heat transmission company of the energy for heating generated by other heat producers, where technically possible and economically feasible. Directive 2010/31/EU requires that new buildings occupied or owned by public authorities meet the standard for near-zero energy efficiency after 31.12.2018 and that all new buildings meet the same standard after 21.12.2020.

The Renewable Energy, Energy Efficiency and Energy Security Programme, financed by the Financial Mechanism of the European Economic Area and having a total budget of nearly EUR 33 million will finance projects relating to the improvement of energy efficiency and the use of energy from renewable sources. These measures are expected to be implemented through projects for the generation of electricity and heat and energy for cooling from renewable sources of 46 000 MWh/year and result in annual CO_2 emission reductions of 54 280 tCO_2.[17]

The heating and cooling sector has the largest contribution to the achievement of the target for the share of RES in Bulgaria's gross final energy consumption. In 2019, biomass had the largest share (88.4 %) in the consumption of renewable energy in the sector. The use of geothermal and solar energy for heating is still underdeveloped and in 2019 the shares of these renewable sources in gross final consumption of renewable energy for heating and cooling stood at 2.6 % and 1.9 %, respectively. In 2019, the use of renewable municipal solid waste (36.3 ktoe) for heat generation was recorded. The use of energy from heat pumps, which increased nearly two and a half times between 2010 and 2019 can be pointed out as a positive trend.

The projected GHG emissions for the energy sector shown in Table 15 are based on an analysis of the changes in Bulgaria's energy balance expected to occur by 2030 as a result of the implementation of existing measures, which Bulgaria has planned and provided as underlying assumptions[18].

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[17] Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030
[18] Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030

Table 15. Projected emissions in the energy sector, ktoe CO2

Emissions	**2015**	**2020**	**2025**	**2030**
Total CO2 emissions	47 251.45	46 601.55	45 693.02	39 989.60

2.2.2 *Dimension Energy efficiency*

The energy savings achieved lower demand for imported conventional fuels and thus have a positive influence on the decrease of trade balance deficit. It should be noted that many of the measures set out in the NEEAP can only be properly assessed after the end of the respective period of implementation, meaning that the actual impact of the NEEAP is expected to be greater than reported here. National law requires EE audits and performance optimisation in respect of heating systems with hot-water boilers and air-conditioning systems in buildings.

Table 16. Achievement of the national target for energy savings for the period 2014-2019

	GWh/y	**ktoe**
National target 2014-2020	8 325.6	716
2019 achievement	1 128.1	97.02
2014-2019 achievement	7 295.2	624.5
Target achievement rate for the period 2014-2019, %	87.6	

Source: 2019 National report on the implementation of the National Energy Efficiency Plan 2014-2019

Assessment of the energy efficiency improvement measures set out in the National Energy Efficiency Action Plan in 2019 updated information about the main measures contributing to the achievement of the national energy efficiency target (in accordance with Annex 4 to the NEEAP and the Additional requirements stipulated in Article 24(1), Annex XIV, Part 1(b) of Directive 2012/27/EU)[19] is set out in Table 17.

Table 17. Assessment of the energy efficiency improvement measures set out in the NEEAP in 2019

Measure	**Energy savings, GWh**	**CO_2 emission savings $ktCO_2/y$**
Energy efficiency obligation scheme	40.91	

[19] Progress report on the implementation of the policies and measures for the renovation of building stock in the Republic of Bulgaria, ANNEX 1

Mandatory energy efficiency management in enterprises and industrial systems	283.7	77.08
Mandatory energy performance audits for EE and certification of buildings	57.1	21.8
Energy performance audits of enterprises and industrial systems	201.4	73.13
Obligation of government and local government bodies to draw up their own energy efficiency improvement programmes and mandatory EE management in public buildings	83.8	33.7
Financing of projects for the introduction of energy-saving technologies and energy from renewable sources under the Operational Programme Innovation and Competitiveness 2014-2020, measure Increasing renewable energy production — geothermal and hydro power	46	3.96
Procedure BGI6RFOP002 – 3.002 Increasing energy efficiency in large enterprises – an alternative measure to meet the National Cumulative Energy target for energy efficiency	50.79	34.8
Energy Efficiency and Renewable Sources Fund	3.361	
Programme for the accreditation of the energy efficiency of homes	6.15	4.2
National programme for energy efficiency of multifamily residential buildings	100.7	35

With regard to heating and cooling, long-term national energy efficiency targets include prioritisation of the uptake of high-efficiency cooling and heating, the introduction of innovative technologies using geothermal, hydrothermal and solar energy, and the use of waste heat and cold.

The achievement of the energy efficiency targets set is strategically linked to building stock renovation and priority will be given to energy efficiency combined with the use of renewable energy sources in the buildings sector.

In order to stimulate the wider uptake and continued annual increase in the use of renewable energy in the heating and cooling sector, priority will be given to the use of high-efficiency heating and cooling installations, the introduction of innovative technologies using geothermal, hydrothermal and solar energy, and the utilisation of waste heat and cold.

The use of biomass for district and local heat generation will increase subject to the requirements of Article 28(2) to (7) and (10) of Directive (EU) 2018/2001 (Figure 49).

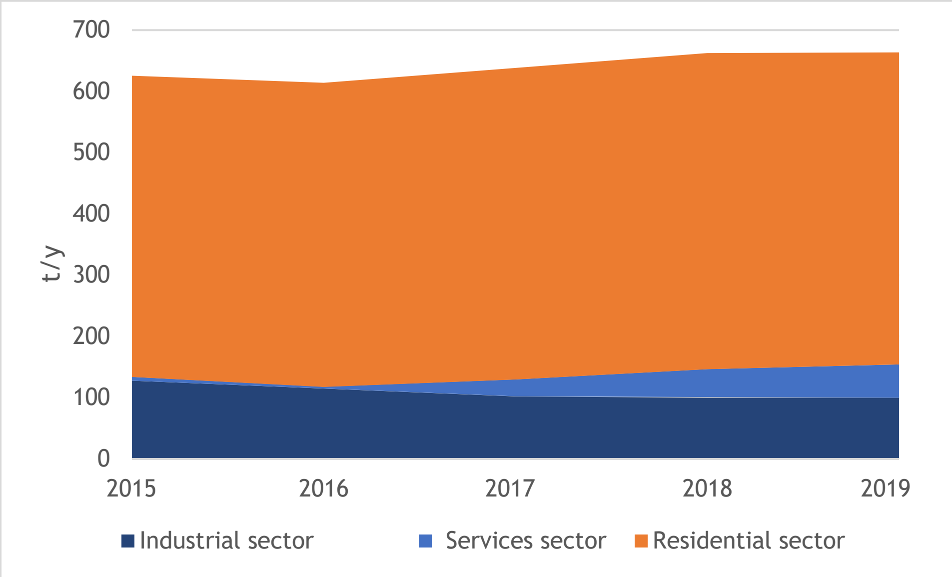

Figure 49. Share of carbon emissions from renewable sources (biomass) in final energy consumption by sector Source: NSI

In order to support the achievement of the national energy efficiency (EE) target by 31 December 2030, an energy savings obligation scheme will be introduced, as well as alternative measures to ensure that the overall cumulative end-use energy savings target is achieved for the period from 1 January 2021 to 31 December 2030.

The estimated new annual energy savings in final energy consumption achieved through EE Obligation schemes and alternative measures under Articles 7a and 7b of Directive 2012/27/EU, broken down by year, are as follows:

Table 18[20].

[20] Integrated Energy and Climate Plan of the Republic of Bulgaria 2021 – 2030

Table 18. Distribution of the overall cumulative target for the period 2021-2030 by year, ktoe

Breakdown by year	Obligations scheme measures	Alternative energy saving	
		Operational Programme Environment and Operational Programme Innovations and Competitiveness	National Mechanism for Energy Efficiency Financing (NMFEE)
2021- 2022	11.07 ktoe/y	11.31 ktoe/y	46.8 ktoe/y
2023- 2024	11.85 ktoe/y	12.12 ktoe/y	50.1 ktoe/y
2025-2030	14.72 ktoe/y	15.03 ktoe/y	62.3 ktoe/y
Expected cumulative savings in final consumption	697.21 ktoe	712.32 ktoe	2 948.02 ktoe

2.2.3 Energy security dimension

The objectives set with a view to ensuring the security of energy supply, i.e. a continuous and adequate supply of energy from all sources to all consumers, can be achieved through[21]:

- energy supply diversification;
- increasing the flexibility of the national energy system;
- addressing constrained or interrupted supply of a particular energy source, for the purpose of improving the resilience of regional and national energy systems, including a timeframe for when the objectives should be met;
- improving network and information security (cybersecurity);
- harnessing the potential of renewable energy sources as a local resource that reduces dependence on imports, improves security of energy supply and eases environmental obligations.

2.2.4 Internal energy market dimension

The basic principles of price regulation on the domestic energy market are stipulated in the Energy Act (ZE) and the methods for price regulation, the rules for price formation or determination and modification, the procedure for the provision of information, submission of price proposals and price approval are governed by applicable bylaw (dedicated regulations).
Pursuant to Article 21(8) of the Energy Act (ZE), the Commission for Energy and Water Regulation (KEVR or the Commission) regulates prices in the cases provided for in the ZE. According to Article 30(1)(3) and (4) of the ZE, the prices at which producers sell thermal

[21] Integrated Energy and Climate Plan of the Republic of Bulgaria 2021 – 2030

energy to transmission undertakings and customers directly connected to the network used by the heat transmission undertaking to supply heat to customers are subject to regulation by the KEVR. According to Article 33(1) of the ZE, the KEVR sets preferential prices for the sale of electricity produced by high-efficiency cogeneration by the combined heat and electricity plants mentioned in Article 1 of the ZE. The preferential price for electricity produced by high-efficiency cogeneration by the combined heat and electricity plants mentioned in paragraph 1 is determined in accordance with Article 33(3) of the ZE, namely on the basis of individual production costs plus a premium determined by the KEVR per producer group and according to the criteria set out in Article 24 of Regulation No 1 of 14 March 2017 on the regulation of electricity prices (NRTsEE). According to Article 33(5) of the ZE, acting on a proposal of the respective heat supply undertaking, the KEVR sets a preferential price for the heat intended for the association[22] referred to in Article 151(1) of the ZE and for the supplier[23] referred to Article 149a of the ZE.

The prices subject to regulation are calculated by the energy undertakings in accordance with the requirements laid down in the ZE, the implementing regulations thereto and KEVR's guidelines on price formation.

According to the latest amendments to the ZE, the public supplier, respectively final suppliers, are obliged to purchase from producers with plants with total installed electric capacity of less than 500 kW and connected to the respective grid, the entire quantity of electricity from high-efficiency cogeneration for which a monthly certificate of origin is available at preferential prices determined in accordance with the respective regulation referred to in Article 3, with certain exceptions described in Article 162(1). The quantities of electricity from high-efficiency cogeneration are purchased up to the quantities determined by the decision of the Commission on setting a preferential price. In addition to the preferential price, the producer may also sell electricity to the final supplier at a price equal to the arithmetic average price for surplus electricity on the balancing market for the month concerned.

A preferential price and/or premium for electricity from high-efficiency cogeneration produced from an existing or new plant is granted following an auction conducted by the Commission. The conditions and procedure for conducting an auction and the criteria for determining the preferential price and/or premium are set out in Article 163e of the ZE. According to these:

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22 Customers of thermal energy in building with a condominium management regime may establish an association with which the heat undertaking concludes a contract for the sale of the heat used by customers in the building.

23 Customers of thermal energy in a building with a condominium management regime may purchase heat from a supplier selected with the written consent of the owners of at least two-thirds of the properties situated in the building with a condominium regime. Heat suppliers are legal entities registered as traders in accordance with national law.

The KEVR holds auctions for the supply of electricity at preferential tariffs and/or premiums from existing or new high-efficiency combined heat and power plants on the following conditions:
1. existing capacity for high-efficiency combined heat and power generation has been decommissioned;
2. the assistance granted must not result in the budget of the scheme for support of the production of electricity from high-efficiency cogeneration by way of preferential tariffs and/or premiums approved by the European Commission being exceeded;
3. preferential tariffs and/or premiums for energy have not been set before the auction.

Auctions are not conducted in the following cases:

1. installing replacement capacity or undertaking a retrofit or an upgrade, which require commissioning within the meaning of the Spatial Development Act, at a plant belonging to a producer to which a preferential price and/or premium has been granted;
2. where the Minister for Energy demonstrates to the European Commission that only one or a limited number of projects or sites are likely to be eligible.

The conditions and procedure for organising auctions and the criteria for setting preferential tariffs and/or premiums are stipulated in a regulation adopted by KEVR in accordance with the Guidelines on State aid for environmental protection and energy 2014-2020.

In the event that no auction is held, the support granted must not lead to an exceedance of the budget approved by the European Commission under the scheme for support via feed-in tariff and/or premiums for the production of electricity from high-efficiency cogeneration.

According to Article 162a, the Electricity System Security Fund pays, by way of compensation, a premium to producers with plants with total installed electrical capacity of 500 kW and more for the entire quantity of electricity from high-efficiency cogeneration registered with a monthly certificate of origin, except for the quantity of electricity necessary to ensure the operational reliability of the main facilities, produced in excess of the quantity of electricity from cogeneration, autoproduction quantities within the meaning of Article 119(1) or the quantities with which the producer participates in the balancing energy market or uses to cover consumption by non-household customers other than budget entities whom the producer with predominant heat load for business purposes supplies with heat. Electricity from high-efficiency cogeneration is compensated up to the quantities determined by the decision of the Commission on setting a preferential price.

The origin of the energy and the basis for granting preferential prices to producers is proven by a certificate of origin – an electronic document issued in respect of 1 MWh of electricity per producer for the net production of electricity measured at the exit of the plant and fed into the electricity grid, subject to the requirements for accuracy, reliability and non-forgery. The content of the certificate is described in Article 163b of the ZE. The certificate of origin is issued at the request of the producer of electricity from high-efficiency cogeneration and is used as proof that the electricity and heat produced are from high-efficiency cogeneration. Only one certificate of origin may be issued per unit of electricity produced from high-efficiency cogeneration, which is valid for 12 months from the production of the unit concerned.

The Commission recognises the certificates of origin issued by the competent authorities in other Member States of the European Union and in the States parties to the Agreement on the European Economic Area. Certificates of origin for electricity produced from high-efficiency cogeneration are issued, transferred and revoked electronically. The conditions and procedure for the issuance, transfer and revocation of certificates of origin for electricity from cogeneration are stipulated in a regulation adopted by the KEVR.

2.2.5 Dimension research, innovation and competitiveness

Bulgaria has set the following targets in the area of research, innovation and competitiveness:

- achieving the targets set out in the 2030 Clean Energy for All package of the EU and developing a low-carbon economy in the long term;
- supporting local industries in the adoption of low-carbon technologies and the public, administrative and household sectors in the use of new high-efficiency energy-saving technologies;
- building smart grids for automated control of electricity systems, both on the supplier’s side and on the consumer’s side, in order to ensure the highest quality electricity supply to consumers and renewable energy utilisation to the maximum degree. The ultimate aim is to upgrade and automate existing electricity networks.

3 ANALYSIS OF THE ECONOMIC POTENTIAL FOR EFFICIENCY IN HEATING AND COOLING

The analysis of the economic potential of heating and cooling technologies covers the entire territory of Bulgaria. It is based on a cost-benefit analysis (Article 14(3) EED) and uses the net present value (NPV) as an assessment criterion. It further identifies alternative scenarios for more efficient and renewable heating and cooling technologies – this involves constructing baseline and alternative scenarios for national heating and cooling systems.

3.1 Geographical and system boundaries

The geographical boundary covers the entire territory of Bulgaria — NUTS level 0. In order to precisely determine the potential for individual and network solutions, individual heat loads can be detailed for NUTS 1, 2, 3 and LAU 2 areas using the heat map modelling tool (hotmaps.eu/map).

Information about heat demand in the household and services sectors within the geographical boundary of the system is set out in Table 19.

Table 19. Demand for heat in the residential and services sectors

Profile of heating demand	
Heat demand	GWh
Heating Household sector	15 200
Hot water heating in the residential sector	4 760
Heating Services sector	10 000
Hot water heating in the services sector	3 470

The options for expanding the supply of energy for heating and cooling within the boundaries of the a given subsystem of a heating utility are examined in Table 20.

Table 20. Opportunities to expand the supply of energy for heating and cooling within and beyond network boundaries

Alternatives for expansion of the supply of energy for heating and cooling in the area of existing district heating plants	
Currently not connected to the network	**Connected to the network**
Industrial zones and technological parks	Business and technology centres existing and currently under construction

Remote shopping centres	Existing buildings and buildings currently under constriction in the services sector
Residential areas	Existing multi- and single-family buildings
	New multifamily residential buildings

The system boundaries concerned correspond to those specified in the heat transmission licence issued for the respective city/territory/area. A general observation that applies to all district heating utilities is that their heat transmission networks are not situated along the boundary of the entire system but cover only partially the territory specified in the licence.

The processing of available information indicates that existing district heating networks have almost reached their full expansion potential in view of declining population, the drop in investment in new housing stock, improved energy efficiency of existing building stock, relatively low income levels, high energy efficiency requirements for new buildings (e.g. near-zero energy efficiency) when investing in new buildings and other factors affecting the consumption of energy for heating and cooling.

The projected trajectory for the development of supply of energy for heating and cooling by district heating utilities indicates a decrease in energy supply by 2030, which warrants an assumption that the decrease in the supply of energy for heating and cooling against the improved energy efficiency of buildings in the services and household sectors and the higher energy efficiency of new technologies will exceed the need for an increase in energy for heating and cooling in the development of networks within the boundaries of existing sub-systems.

Table 21. Projected energy supply and demand for heating and cooling within the boundaries of subsystems

	Heat demand*		**Theoretical demand for energy for cooling***	**Heat demand**	**Energy supplied by heating utilities**		
	Household sector	Services sector		Household and services sector	2019	2025	2030
	GWh/y	**GWh/y**	**GWh/y**	**GWh/y**	**GWh/y**	**GWh/y**	**GWh/y**
For Bulgaria (NUTS 0)	**20 005.57**	**6 748.99**	**4 969.65**	**26 754.56**			
TOPLOFIKATSIYA SOFIA EAD	**3 291.10**	**2 638.61**	**415.72**	**5 929.71**	**3 541.00**	**3 449.32**	**3 190.62**
EVN BULGARIA TOPLOFIKATSIYA EAD	**847.51**	**232.76**	**262.6**	**1 080.27**	**196.06**	**204.45**	**211.41**
TOPLOFIKATSIYA PLEVEN EAD	**294.86**	**69.59**	**95.34**	**364.45**	**209.22**	**245.10**	**250.00**
TOPLOFIKATSIYA VRATSA EAD	**203.81**	**35.6**	**39.5**	**239.41**	**72.46**	**88.00**	**93.00**
TOPLOFIKATSIYA BURGAS EAD	**649.43**	**148.72**	**216.58**	**798.15**	**100.57**	**142.00**	**142.00**
VEOLIA ENERGY VARNA EAD	**882.15**	**314.01**	**269.94**	**1 196.16**	**60.40**	**61.80**	**64.50**
TOPLOFIKATSIYA VT EAD	**196.77**	**45.76**	**51.65**	**242.53**	**13.29**	**99.23**	**109.16**
TOPLOFIKATSIYA RAZGRAD AD	**89.99**	**23.65**	**25.03**	**113.64**	**21.00**	**24.00**	**24.00**

TOPLOFIKATSIYA PERNIK EAD	**304.3**	**38.34**	**27.14**	**342.64**	**26.55**	**26.55**	**26.55**
TOPLOFIKATSIYA SLIVEN EAD	**224.39**	**45.19**	**74.04**	**269.58**	**248.24**	**250.00**	**250.00**
TOPLOFIKATSIYA GABROVO EAD	**211.92**	**36.73**	**40.63**	**248.65**	**140.60**	**19.50**	**23.00**
TOPLOFIKATSIYA RUSE EAD	**420.44**	**114.46**	**132.64**	**534.90**	**340.07**	**332.00**	**332.00**
BRIKEL EAD	**19.2**	**3.25**	**8.79**	**22.45**	**14.21**	**13.63**	**13.63**

*Demand for heat and theoretical demand for heat for cooling have been estimated using the modelling instrument (Hotmaps.eu/map).

In order to demonstrate the possible future development of the network within the boundaries of a given subsystem Sofia has been used as an example. Three tentative zones with appropriate heat density have been identified.

A. Industrial zones

A list of the industrial zones and technological parks in Bulgaria is available on the website of the Bulgarian Agency for Innovations: https://www.investbg.government.bg/bg/destinations/severozapadni-industialni-zoni-36.html

An example of such an opportunity in Sofia is the Bozhurishte Industrial Zone situated in proximity to the town of the same name. An industrial zone has already been built in Bozhurishte where several large manufacturing companies operate, which has the potential to expand their demand for energy for heating and cooling. Potential users along the perimeter of the zone include dozens of a large service companies and shopping centres built along the motorway to Kalotina and the ring road to the west of Sofia within a radius of 0.5-1.5 km of the industrial zone. Additional heat demand points could be the multi-storey residential buildings in the centre of Bozhurishte. The demand for heat in the zone is estimated at 25.19 GWh/y and the theoretical demand for energy for cooling at 1.88 GWh/y.

B. Residential areas with concentrated domestic heat load resulting from high-rise residential development that are not connected to district heating networks (DHN)

The residential area Manastirki Livadi presents an opportunity in this regard.

In order to identify the options for the supply of energy for on-site heating and cooling within the geographical boundary, including the achievement of synergies within the boundaries of the systems of district heating utilities, the following options have been identified:

- Individual options for on-site heat generation[24]

[24] http://www.code2-project.eu/wp-content/uploads/D2.5-2014-12-micro-CHP-potential-analysis_final.pdf

– High-efficiency natural gas-based cogeneration (micro-generation, piston engines, gas turbines, steam turbines and combined-cycle gas turbines,) with supplemental heat provided by gas-fired boilers;
– High efficiency hydrogen-based cogeneration (micro and mini cogeneration – fuel cells – PEMFC, PAFC, SOFC);
– High-efficiency cogeneration (steam turbines) where heat is provided by a biomass-fired thermal plant;
– Air-to-air, air-to-water or water-to-water heat pumps with SCOP > 3.5 in heating mode.
– Construction of individual DHW installations, including the installation of hybrid solar panels.

- Supply options for the construction of new local district heating installations

Where appropriate, such new local networks can supply heat to buildings in the household and services sectors not currently connected to district heating systems.
– High-efficiency natural gas-based cogeneration (micro-generation, piston engines, gas turbines, steam turbines and combined-cycle gas turbines,) with supplemental heat provided by gas-fired boilers;
– High efficiency hydrogen-based cogeneration (cogeneration, fuel cells — PEMFC, PAFC, SOFC);
– High-efficiency cogeneration (steam turbines) where heat is provided by a biomass-fired thermal plant;
– Construction of a Solar CHP DHW system[25] — a system of interconnected thermal solar collectors combined with an energy storage system and gas/biomass boilers or the supply of supplementary heat via an absorption heat pump driven by the district heating system[26].High efficiency hydrogen-based cogeneration (micro- and mini-cogeneration — PEMFC, PAFC, SOFC fuel cells);

3.2 Identifying suitable technical solutions

A number of potential high-efficiency heating and cooling technologies can be used for both district heating networks and in the segment of energy for heating or cooling supplied to individual consumers.

[25] www.sdh.bg/2017/10/05/70
[26] bulgaria_sdh-analysis_2015.pdf

Fossil fuel-reliant basic technology to be used as a benchmark for all potential high-efficiency RES technologies using natural gas. Natural gas is assumed to be the primary heating fuel, where available in the baseline scenario, and biomass/biofuels where no gas is available. In the case of high efficiency CHP with additional heat produced by boilers, the replacement of boilers with gas/biomass (biofuel) plants to increase the efficiency of the CHP is acceptable.

The possible technical solutions for heating and cooling are set out in the tables below, divided into zones with/without central gas supply.

Table 22. Possible technical solutions for heating/cooling in areas with central gas supply

Type of equipment	Basic technology	Option 1 (Individual high-efficiency gas-fired cogeneration plants)	Option 2 (Individual high-efficiency biomass/RDF based cogeneration plants)	Option 3 (Individual heat pumps)	Option 4 (New district heating networks reliant on high-efficiency gas cogeneration)	Option 5 (New district heating networks reliant on high-efficiency biomass cogeneration)	Option 6 (Solar and geothermal energy, including the main source)
Industry/Existing heating networks	Individual gas boilers	Individual high-efficiency cogeneration of gas, with additional supply of heat from boilers	Individual high-efficiency biomass/RDF cogeneration	Not applicable	Not applicable	Not applicable	Solar collectors
Buildings services sector (not connected to district heating networks)	Individual gas boilers	Individual high-efficiency cogeneration of gas, with additional supply of heat from boilers	Not applicable	Individual heat pumps	New district heating networks reliant on high-efficiency gas cogeneration	Not applicable	Solar collectors with individual gas-fired boilers
Residential buildings (not connected to district heating networks)	Existing heating system and type of fuel	Micro-cogeneration of gas, where gas is available	Not applicable	Individual heat pumps	New district heating networks reliant on high-efficiency gas cogeneration	Not applicable	Solar collectors with existing heating system, and type of fuel

Table 23. Possible technical solutions for heating/cooling in areas without central gas supply

Type of equipment	Basic technology	Option 1 (Individual high-efficiency gas cogeneration)	Option 2 (Individual high-efficiency biomass/RDF cogeneration/fuel cells)	Option 3 (Individual heat pumps)	Option 4 (New district heating networks reliant on high-efficiency gas cogeneration)	Option 5 (New district heating networks reliant on high-efficiency biomass cogeneration)	Option 6 (Solar and geothermal energy, including the main source)
Industry/Existing networks	Individual high-efficiency coal-fired boilers	Not applicable	Individual high-efficiency cogeneration using biomass/RDF	Not applicable	Not applicable	Not applicable	Not applicable
Buildings services sector (not connected to district heating networks)	Individual high-efficient boilers fired by coal/boiler fuel	Not applicable	Micro-cogeneration using biomass/fuel cells	Individual heat pumps	Not applicable	Not applicable	Solar collectors with individual biomass-fired boilers
Residential buildings (not connected to district heating networks)	Type of fuel currently used	Not applicable	Micro-cogeneration using biomass/fuel cells	Individual heat pumps	Not applicable	Not applicable	Solar collectors with existing heating system and type of fuel

The choice of appropriate technical solutions for the supply of energy for heating and cooling within a system depends on a number of factors, including:

- the availability of resources;
- the characteristics of heat demand;
- the characteristics of the possible sources of energy for heating and cooling.

When selecting a replacement technology, the feasible technical solutions may be linked to a combination of options.

The technical potential of each solution represents the projected heating/cooling potential of the facility to be installed at a feasible site, regardless of the associated costs and benefits, without the need for significant investments in supporting infrastructure such as, for example, a new district heating or gas network.

The feasibility of technical solutions is sector-specific. It is assumed that air-to-air heat pumps and solar thermal energy conversion are not suitable for industrial or district heating due to the low temperature of generated heat and the need for large quantities of thermal energy.

The quantities of heat generated by the new facilities should therefore be connected to new local district heating networks. There are plans to upgrade existing CHPs with gas-fired replacement capacity, with the shortfall to peak load to be covered by boilers. In areas without existing CHP where gas is available, gas-fired boilers can be installed.

High-efficiency natural gas-based cogeneration is a feasible option only when high-efficiency cogeneration or gas-fired boilers are selected as the primary technology. It is assumed that district heating networks based on the use of energy from waste heat and cold from industrial production are unfeasible due to the high temperature of the heat needed in most industries and the location of the plants, which will require greater investment in the construction of new networks.

In light of the ultimate goal of achieving carbon neutrality, cogeneration has a significant role to play. One of the key aspects related to the heating and cooling sector is sectoral coupling. Sectoral coupling will ensure that electricity from renewable sources plays an increasingly important role and contributes to the goal of decarbonisation. It also brings synergies with the integration of a high proportion of renewables and is therefore seen as a key concept in the context of energy transition. Sectoral coupling also enhances the system resilience through higher redundancy, thereby strengthening the security of energy supply. It is therefore advisable that legislation on sectoral interconnection be improved to create a level playing field for the connection of different sectoral technologies. An example of sectoral interconnectivity is shown in Figure 50.

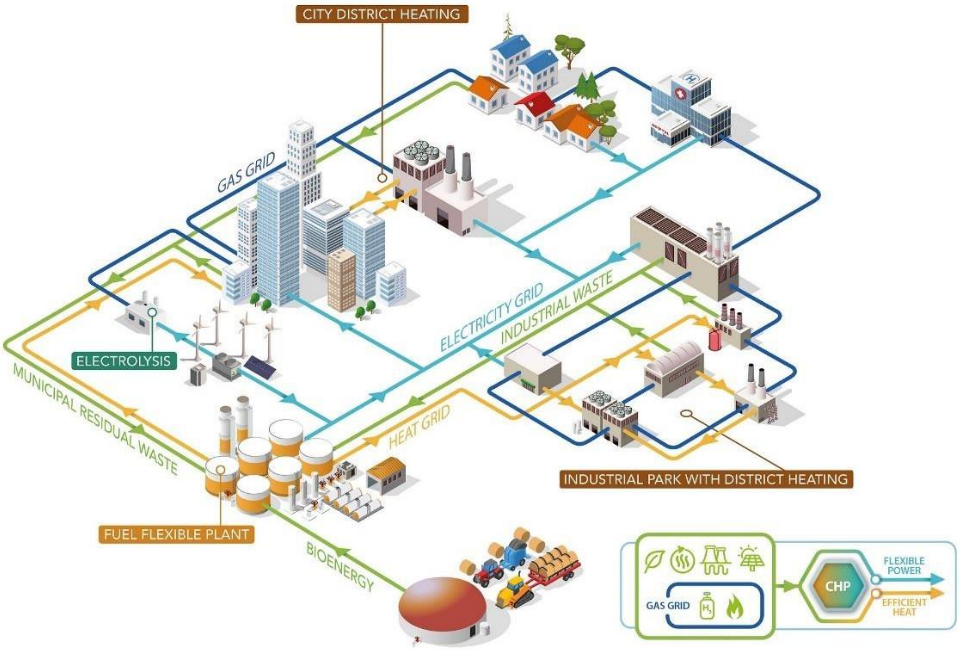

Figure 50. Alternative solution for CHP in a climate-neutral energy system[27]

3.3 Baseline scenario

The baseline scenario serves as a starting point for the analysis of the economic potential of heating and cooling technologies, taking into account existing policies at the time of this comprehensive assessment. The characteristics of the following national heating and cooling system elements have been taken into account:

- overview of heat consumers and their current energy consumption;
- current heat and cold supply sources;
- potential sources of energy for heating and cooling.

In the baseline scenario (with existing measures), an assumption has been made that no changes will occur in terms of measures that have already been implemented.

27 https://www.cogeneurope.eu/knowledge-centre/cogeneration-in-2050

- Methodology:

1. The structure of the technologies used has been defined by fuel used in current production of energy for heating and cooling in the sectors examined in this analysis.
2. The structure is broken down by sector, with the industry sector (HE CHP) divided into energy for heating and cooling produced from sources on-site (factory plants) and energy supplied off-site (district heating companies).
3. District heating plants (energy supplied off-site) have been examined in terms of the share of fuels [they use to supply energy] in the three sectors covered by the analysis.
4. Assumptions about the future structure of heating and cooling technologies have also been made on the basis of the rate of substitution of fuels and technologies under the current measures and policies.
5. The assessment of the future technology structure is based on the average lifetime of the relevant technology, assuming a lifetime of 20 years.
6. It has further been assumed that 1/20 of available facilities, classified by technology, will be annually replaced.

3.3.1 Current mix of heating and cooling supply technologies

The table below shows the current structure of heating and cooling technologies which, depending on the benefit-cost analysis, can be replaced by a more efficient technology before the end of its useful life.

Table 24. Current structure, technical assumptions and cost estimate per heating technology

Type installation	Fuel	Technology	Capacity		Capacity		Heat to electricity Electricity	coefficient minimum	Condensing efficiency mode	Cogeneration efficiency mode	Efficiency	Capacity to cover heating needs (the difference is to be covered by boilers	Cost parameter electricity / heat)	Average service life
			Electricity		heat			heat			heat			
			kWe	kWe	kWt	kWt	no measurement unit	kWt	%	%	%	%	no measurement unit	years
Micro-generation	Gas	Stirling engine	1	-	12	-	11.83	0.01	6.00 %	6.00 %	71.00	100.00 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	5	-	12	-	2.33	0.01	22.30 %	22.30 %	52.00	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	13	-	30	-	2.33	0.03	22.30%	22.30 %	52.00	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	13	50	30	117	2.33	0.03	22.30%	22.30%	52.00	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	50	100	75	150	1.5	0.08	31.70%	31.70 %	47.70	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	100	200	131	262	1.31	0.13	33.80%	33.80 %	44,20	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	200	1 000	240	1 200	1.2	0.24	38.00%	38.00 %	45.60	63.40 %	Electricity	15
High-efficiency cogeneration	Gas	Piston engine	1 000	4 000	1 600	6 400	1.6	1.6	30.00%	30.00 %	48.00	63.40 %	Electricity	20
High-efficiency cogeneration	**Gas**	**Other gas turbines**	4 000	7 000	6 400	11 200	1.6	6.4	30.00%	30.00 %	48.00	63.40 %	Electricity	20
High-efficiency cogeneration	Gas	Other gas turbines	7 000	25 000	8 400	30 000	1.2	8.4	30.00%	30.00 %	36.00	63.40 %	Electricity	20
High-efficiency cogeneration	**Gas**	**Large gas turbines**	25 000	40 000	30 000	48 000	1.2	30	35.00%	35.00 %	42.00	63.40 %	Electricity	20
High-efficiency cogeneration	Gas	Gas turbines - combined	40 000	200 000	30 400	152 000	0.76	30.4	45.10%	38.60 %	29.30	63.40 %	Electricity	20
High-efficiency cogeneration	**Gas**	**Gas turbines - combined**	200 000	-	152 000	-	0.76	152	45.10%	38.60 %	29.30	63.40 %	Electricity	20
High-efficiency cogeneration	Coal	Steam turbines	1 000	10 000	3 000	30 000	3	3	31.00%	18.60 %	55.80	63.40 %	Electricity	20
High-efficiency cogeneration	**Coal**	**Steam turbines**	10 000	25 000	30 000	75 000	3	30	31.00%	18.60 %	55.80	63.40 %	Electricity	20
High-efficiency cogeneration	Coal	Steam turbines and other vapour turbines	25 000	-	75 000	-	3	75	33.00%	19.80 %	59.40	63.40 %	Electricity	20
High-efficiency cogeneration	**Biomass**	**Steam turbines**	1 000	10 000	3 000	30 000	3	3	31.00%	18.60 %	55.80	63.40 %	Electricity	20
High-efficiency cogeneration	Biomass	Steam turbines and other vapour turbines	10 000	25 000	30 000	75 000	3	30	31.00%	18.60 %	55.80	63.40 %	Electricity	20
High-efficiency cogeneration	**Biomass**	**Steam turbines and other vapour turbines**	250 00	-	75 000	-	3	75	33.00 %	19.80 %	59.40	63.40 %	Electricity	20

Heating plant	Gas	Boiler	-	-	20		N/A	-	N/A	N/A	84.60	100.00%	Heat	15
Heating plant	**Gas**	**Boiler**	-	-	20	180	N/A	0.02	N/A	N/A	84.60	100.00%	Heat	20
Heating plant	Gas	Boiler	-	-	180	3 600	N/A	0.18	N/A	N/A	81.00	100.00 %	Heat	20
Heating plant	**Gas**	**Boiler**	-	-	3 600	100 000	N/A	3.6	N/A	N/A	81.00	100.00 %	Heat	20
Heating plant	Gas	Boiler	-	-	100 000	-	N/A	100	N/A	N/A	81.00	100.00 %	Heat	20
Heating plant	**Coal**	**Boiler**	-	-	8	-	N/A	0,01	N/A	N/A	80.80	100.00 %	Heat	20
Heating plant	Coal	Boiler	-	-	20	-	N/A	0.02	N/A	N/A	80.80	100.00 %	Heat	20
Heating plant	**Coal**	**Boiler**	-	-	20	180	N/A	0,02	N/A	N/A	77.00	100.00 %	Heat	20
Heating plant	Coal	Boiler	-	-	180	1 000	N/A	0.18	N/A	N/A	77.00	100.00 %	Heat	20
Heating plant	**Coal**	**Boiler**	-	-	1 000	5 000	N/A	1 000.00	N/A	N/A	77.00	100.00 %	Heat	20
Heating plant	Coal	Boiler	-	-	5 000	-	N/A	5 000. 00	N/A	N/A	77.00	100.00 %	Heat	20
Heating plant	**Heating oil**	**Boiler**	-	-	20	-	N/A	-	N/A	N/A	84.60	100.00 %	Heat	15
Heating using electricity	Electricity	Boiler	-	-	10	23	N/A	-	N/A	N/A	90.00	100.00 %	Heat	15
Furnaces	**Coal**	**Boiler**	-	-	8	-	N/A	0.01	N/A	N/A	70.00	100.00 %	Heat	20
Furnaces	Coal	Boiler	-	-	20	-	N/A	0.02	N/A	N/A	70,00	100.00 %	Heat	20
Heat pumps	**Electricity**	**Heat pump**	-	-	6	-	N/A	0.01	N/A	N/A	300.00	100.00 %	Heat	20
Heat pumps	Electricity	Heat pump	-	-	10	-	N/A	0.01	N/A	N/A	300.00	100.00 %	Heat	20
Heat pumps	**Electricity**	**Heat pump**	-	-	20	-	N/A	0.02	N/A	N/A	300.00	100.00 %	Heat	20
Heat pumps	Electricity	Heat pump	-	-	50	-	N/A	0.05	N/A	N/A	320.00	100.00 %	Heat	20
Heat pumps	**Electricity**	**Heat pump**	-	-	300	-	N/A	0.3	N/A	N/A	320.00	100.00 %	Heat	20
Solar collectors	none	Flat collectors	-	-	1	5	-	0	N/A	N/A	N/A	10.30 %	Heat	20
Solar collectors	**none**	**Flat collectors**	-	-	5	10	-	0.01	N/A	N/A	N/A	10.30 %	Heat	20
Solar collectors	none	Flat collectors	-	-	10	20	-	0.01	N/A	N/A	N/A	10.30 %	Heat	20
Solar collectors	**none**	**Flat collectors**	-	-	-	32	-	0.02	N/A	N/A	N/A	8.10 %	Heat	20
Solar collectors	none	Flat collectors	-	-	-	-	-	0.03	N/A	N/A	N/A	8.10 %	Heat	20

3.3.2 *Potential technical opportunities for the introduction of new mini and micro cogeneration systems for the provision of heating and cooling*

The cogeneration installations with a capacity between 5 kW and 50 kW belong to the categories of mini- and micro-cogeneration systems for energy for heating and cooling. Most are based on reciprocating engine technology (gas engines), but can also be based on gas turbines or fuel cells.

The power to heat ratio is approximately 1:2. The internal combustion engine (ICE) is the dominant technology used, but gas turbine and fuel cell are also feasible. Gas engines are spark-ignitable (Otto cycle) and either operate in near stoichiometric conditions allowing three-way catalysts to be used to reduce emissions, or are designed for fuel-poor operation. Examples of a few selected mini and micro-CHP systems with capacity of 5 kW to 50 kW are set out in Table 25. The electricity generation efficiency of small CHP systems with installed capacity between 5 and 50 kWe is typically between 25 % and 30%. The overall efficiency of these units is often between 85 % and 95 %. However, as a result of condensation overall efficiency may reach and even exceed 100 %.

Overall efficiency is defined as the sum of the electricity (kWh/h) and heat (kWh/h) generated in relation to fuel input (kWh/h) on the basis of heating value.

Table 25. Selected mini- and micro-CHP technologies available in Europe

Technology	Power (kW)	Electrical efficiency (%)	Efficiency
Gas engine (ICE)	5.5	27	88-99
Gas engine (ICE)	15	30	92
Gas engine (ICE)	18	32	96
Gas engine (ICE)	50	34	88
Gas turbine	28	25	-
PEMFC type fuel cell	up to 15 kW	37	60
SOFC type fuel cell**	up to 15 kW	33	60

*Proton Exchange Membrane Fuel Cell **Solid Oxide Fuel Cell

Systems comprising CHP installations often also comprise a thermal energy storage system and additional boilers. Heat storage has several purposes and boilers are used for heating when it exceeds the heat output of the cogeneration plant. In order to achieve optimal electricity generation efficiency and make the most of the investment, CHP plants should (where possible) operate at full load and for many hours each year.

28 https://www.pace-energy.eu/wp-content/uploads/2020/06/PACE-T1.4-Training-Documents-Module-1-Basics-FV.pdf

Cogeneration boilers in the power range of 5 kWe to 50 kWe operate on low-voltage power (400 VAC). The generated power can be used only internally within the connected building(s) or can be fully or partially exported to the grid, if tariffs are attractive and national regulations allow it. One of the options to maximise the number of operating hours per year is the inclusion of the production of energy for cooling (trigeneration or the production of electricity, heat and cold). This is a particularly suitable option in the services sector (office buildings, shopping centres and hospitals), which often need additional cooling. Energy for cooling can be generated by using the thermal energy from a CHP plant with an absorption chiller.

3.3.3 Availability of natural gas and implications for technical options

In 2020, natural gas consumption in Bulgaria stood at 31 337 GWh, which represents an increase of 2.86 % compared to consumption in 2019 (30 465 GWh)[29]. According to the 2019 NSI General Energy Balance, natural gas had a share of 13.13 % in primary energy consumption and a share of 12.96 % in final fuel and energy consumption. The share of natural gas in Bulgaria's energy balance is still lower than the EU average. However, it has the potential for significant and sustainable growth, given progress in gasification and the role of natural gas as a transition fuel towards the achievement of a low-carbon economy.

At the end of 2019, twenty-four companies in Bulgaria had a licence for natural gas distribution and natural gas supply and operated in 35 areas specified in the respective licences that covered 172 out of a total of 300 municipalities (zones). By 2030, the number of zones is expected to increase to 260. According to data provided by gas distribution companies, in 2019 they serviced a total of 119 745 customers, of which 93.7% were households. This represents an increase by 11 % compared to the previous year. There has been an increase by 12 % in households customers and by 5 % in non-residential clients.

In 2018, Bulgaria's energy dependence on natural gas supplies was exceedingly high (98.3 %).

Natural gas is a major natural resource and there is a potential to increase its share in Bulgaria's total energy consumption in coming years. Albeit the share of domestic gas supply in Bulgaria is currently very low compared to other EU Member States, it has been continuously increasing. Promoting gasification by expanding the gas transmission network to new areas and ensuring that a greater number of municipalities, distribution companies and consumers have access to natural gas supply is one of the priorities set out in Bulgaria's Energy Sector Strategy. Natural gas is at the heart of the EU's policy to reduce greenhouse gas emissions by 2030.

[29] Ten-Year Network Development Plan of BULGARTRANSGAZ EAD for the period 2021-2030.

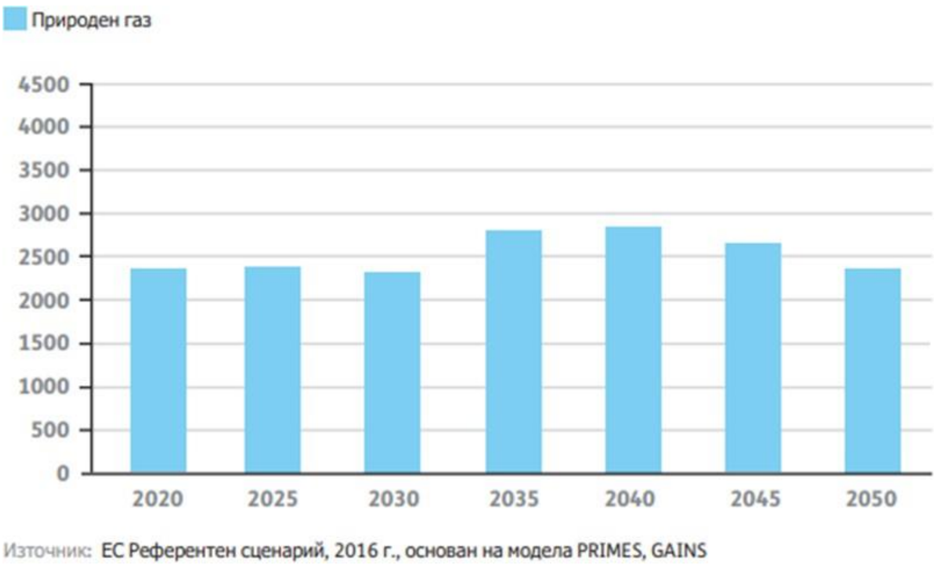

Figure 51. European Commission forecast for gross domestic gas consumption in Bulgaria (million m^3).

Considering existing energy efficiency policies, measures, and programs, Figure 52 below shows gross domestic consumption projections for the consumption of natural gas and FEC for the period 2020-2050.[30]

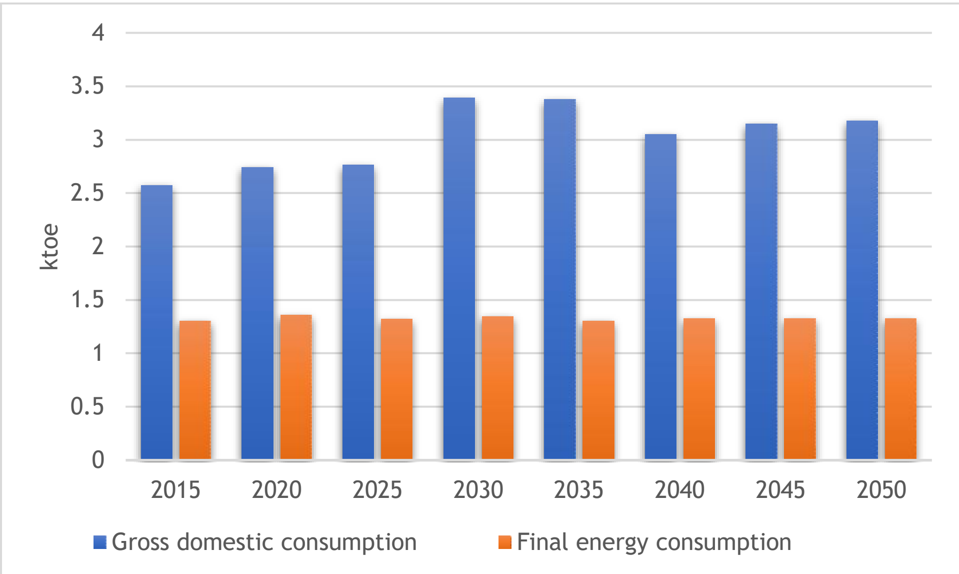

Figure 52. Forecasts of gross domestic consumption [and] projected non-energy consumption of natural gas for the period 2020-2050

Gas and hydrogen infrastructure[31] will also play a key role in decarbonisation and the achievement of carbon neutrality by 2050. EU policy is aimed at phasing out the use of coal and gradually

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30 The projection is based on the forecasts set out in the Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030.
31 https://www.bulgartransgaz.bg/files/useruploads/files/amd/TYNDP%202021/Draft%20BTG%20TYNDP%2021-30%20BG.pdf

increasing the use of alternative environmentally friendly energy carriers such as hydrogen. The draft National Recovery and Sustainability Plan includes a proposal for the construction of a new gas transmission infrastructure suitable for the transport of hydrogen and low-carbon gaseous fuels in Bulgaria's coal-mining regions.

3.3.4 Current structure of heating and cooling supply technologies

- Household sector

Homes in the household sector are mostly heated with electricity, solid fuels (unprocessed solid biomass, coal) and district heating and, to a lesser extent, liquid fuels, natural gas and solar collectors.

The main fuel conversion technologies used in the household sector to convert fuels into energy for heating and cooling are:

Air-air conditioning systems, low-power boilers using solid biomass or natural gas, appliances (stoves, fireplaces) for direct combustion of solid biomass, solar collectors (DHW modules), electric heaters, and electric hot water heaters. Cogeneration systems are not used in the sector.

The structure of technologies will remain relatively unchanged, with the use of non-environmentally friendly fuels, such as naphtha (liquid fuels), being gradually phased out in the baseline scenario. Air-air conditioning systems will remain the most commonly used technology to be replaced by similar appliances with SCOP = 3.5 or higher in the future. Electric water heaters will remain the primary technology for providing domestic hot water, supported by solar hot water systems in the future. The consumption of energy for heating and cooling will continue to decrease against an improvement of energy performance characteristics of buildings.

- Services sector

Buildings in the services sector are mostly heated with electricity, solid fuels (unprocessed and processed biomass) and district heating and, to a lesser extent, liquid fuels, natural gas and solar collectors.

The main fuel conversion technologies used in the heating and cooling sector are:

Air-air conditioning systems, small and medium-sized heating boiler installations using solid biomass or natural gas, solar collectors (DHW modules) and heat pumps. CHP systems supplying energy on-site are not used in the sector.

The structure of technologies will remain relatively unchanged as projected in the baseline scenario. Air-air conditioning systems will remain the most commonly used technology to be replaced by similar appliances with SCOP = 3.5 or higher in the future. Where natural gas is available, local heating systems will be based on gas-fired boilers, and where this is not the case, boilers using processed or unprocessed biomass for heating will be used. The consumption of energy for heating and cooling will continue to decrease against an improvement of energy performance characteristics of buildings.

- Industry sector

The industry sector is the most technologically advanced and uses predominantly boiler and cogeneration systems. Local heating systems using gas and solid biomass are also in use, albeit to a lesser extent, as are air-air conditioning systems and waste heat (used as an autoproduction option on site).
Turbo generators (TG) and Internal Combustion Engines (ICE) are the most commonly used technologies in high-efficiency cogeneration.

The larger factory heating plants Bulgaria are:

The **thermal power plant (TPP) of Brikel EAD**. which is designed for electricity and heat cogeneration. The TPP has six BKZ-210-140-FV steam drum generators (boiler units). Three units are in operation and three units operate in back-up mode in accordance with the terms of Integrated Permit (IP) No 40-H1/2011, updated by Decision No 40-H1-IO-A1/2013 of the IAOS under the jurisdiction of the Ministry of Environment and Water (MOSV). They operate as a collector scheme and can supply the installed turbine generators individually and together via a main steam collector. The units are designed to burn low-grade lignite coal. Four type VPT-50-130/4 turbines have been installed, rated at 50 MWe each, 3000 min-1, with 2 adjustable steam outlets for industrial and district heating. The district heating part of the plant consists of industrial steam boilers for the needs of the production of briquettes and the supply of energy for heating in Galabovo. The facilities were commissioned between 1960 and 1962.

TPP Deven – Solvay Sodi AD

The TPP comprises 5 coal-fired boilers operating on common feed and steam collectors and 7 cogeneration plants (consisting of 8 cogeneration units in total) grouped into three types as well as 6 cogeneration units for non-combined heat and power, notably reduction and cooling units (RCCU) and quick-release reduction and cooling units (QRCCU) that are steam fed from the common steam header of the boilers. The plant outlets for combined and non-combined power and heat generation are grouped in 3 6, 17 and 36 bar pressure collectors to meet the needs of thermal energy customers. The outlets of the cogeneration and non-combined heat and power plants are grouped in 3, 17 and 36 bar pressure collectors to meet the thermal energy needs of the customers.

<u>Cogeneration plants:</u>

- Plant Nos. 1 and 2 with turbine generators Nos 1 and 2 (TG1 and TG2, respectively) are fed with superheated steam from all power steam boilers through a common steam header. The turbines are condensing, with an industrial steam header and regenerative steam headers for feedwater heating.
- Plant Nos 4, 5, and 7 with turbine units Nos. 4, 5, and 7 (TG4, TG5, and TG7, respectively) are fed with superheated steam from all power steam boilers through a common steam header. The turbines are counterbalanced and do not have non-adjustable steam headers. They are connected to a secondary turbine generator (TG3), which is fed with 36 bar steam from a common header at the outlet of TG4, TG5 and TG7. The secondary turbine is counterbalanced and does not have non-regulated steam taps.
- Installations Nos 6 and 8 with turbine units Nos 6 and 8 (TG6 and TG8, respectively) are fed with superheated steam from all power steam boilers through a common steam header. The turbines are counterbalanced with an adjustable industrial steam header and have regenerative steam headers for feedwater heating.

The **company Svilotsel EAD** (TPP Svishtov AD) is a biomass/biofuel plant. The following main facilities for combined production of electricity and heat are installed:

- Four TP-47 steam turbine generators —STG1, STG2, STG3 and STG4), which were commissioned in 1971, each with nominal steam output of 220 t/h, minimum steam production 170 t/h, nominal: superheated steam pressure 10 MPa, superheated steam temperature 540°C, feed water temperature 215°C, design fuel is coal (fuel oil — reserve fuel).
- Three PT-60/90/13/1,2 turbine generators — TG1 and TG2 are with turbine type, commissioned in 1971 and 1972, respectively, each with rated power of 60 MW, steam input consumption — 402 t/h, steam input pressure — 9 MPa; steam pressure of the steam header for industrial needs — 1.3 MPa, steam consumption of the steam header for industrial needs — 200 t/h, maximum consumption — 250 t/h, steam pressure in the steam header for heating needs — 0.12 MPa, steam consumption in the steam header for heating needs 120 t/h, and with an electric generator type TVF-60-2 with 6.3 kV voltage generator.
- TG3 — SST-600 condensing steam turbine (non-adjustable) with rated electrical power 58.00 MW. The SGen5- 100A-2P power generator is manufactured by Siemens, Czech Republic.

Lukoil Neftohim Burgas AD is a natural gas-fired power plant with an installed electrical capacity of 257 MWe, and installed thermal capacity of 960 MWt. The following main facilities are in operation at the thermal power plant:

- two BKZ 160-100-GM power steam generators — EPG2 and EPG3, commissioned in 1964 and 1965, respectively, with nominal steam output of 160 t/h, design fuel — fuel oil and natural gas;
- four BKZ 320-140-GM power steam generators — EPG7, EPG8, EPG9 and EPG12, commissioned in 1970, 1971, 1971 and 2000, respectively, with nominal steam output of 320 t/h, design fuel — fuel oil (for EPG7, EPG8 and EPG9) and fuel oil and natural gas for EPG12.
- two BKZ 320-140-GM7C power steam generators — EPG10 and EPG11, put into operation in 1979 and 1983, respectively, with nominal steam output of 320 t/h, design fuel — fuel oil and natural gas;
- turbine generators: TG1 — type PT 25-90/10M, commissioned in 2001; TG2 — type P12-90/10, commissioned in 1964; TG3 — type PT 65/75-130/13, commissioned in 2005; TG4 — type PT 60-130/13, commissioned in 1968; TG5 — type P50-130-1, commissioned in 1971 and TG6 — type P50-130-1, commissioned in 1982.
- EPG9, EPG10 and EPG11 were decommissioned in 2020.

District heating utilities

The main fuels used in CHP plants are coal (brown, black), biofuel, natural gas and in minor quantities fuel oil and gas oil (reserve fuel).

According to the NSI data, natural gas had the largest share of the fuels used in district heating plants in 2019 (94 %) (Figure 45).

The largest district heating company in Bulgaria is Toplofikatsiya Sofia EAD. It supplies 71 % of the total quantity of energy for heating from thermal power plants within the geographical territory.

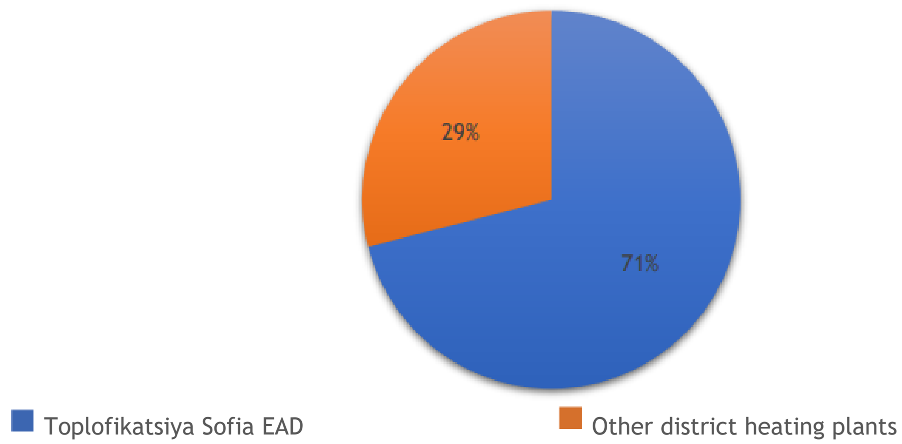


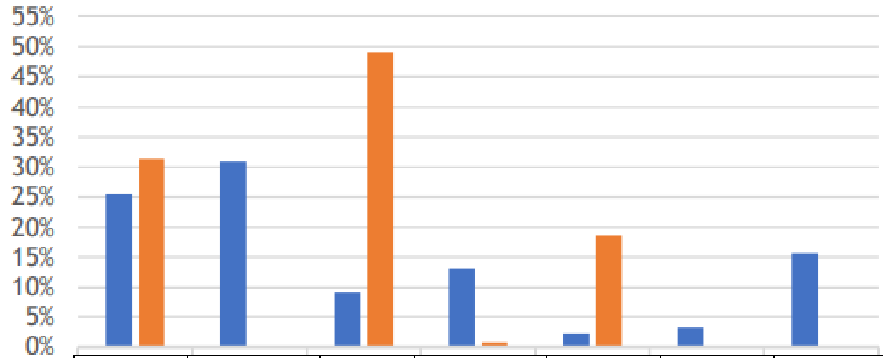
Figure 53. Share of district heating plants in Bulgaria

Table 26. CHP plants for combined production of electricity and heat per technology and year of commissioning

NAME	INSTALLATIONS												
	Technology	**Year of commissioning**	**Technology**	**Year of commissioning**	**Technology**	**Year of commissioning**	**Technology**	**Year of commissioning**	**Technology**	**Year of commissioning**	**Technology**	**Year of commissioning**	**Main fuel**
Toplofikatsiya Razgrad EAD	ICE	2009											Natural gas
Toplofikatsiya – VT AD	ICE	2007											Natural gas
Toplofikatsiya Vratsa EAD	ICE	2005	ICE	2005									Natural gas
Toplofikatsiya Vratsa EAD	ICE	2012											Natural gas
Toplofikatsiya – Burgas EAD	ICE	2007	ICE	2007	ICE	2007	ICE	2007	ICE	2007	ICE	2007	Natural gas
Veolia Energy Varna EAD	ICE	2005	ICE	2005	ICE	2009	ICE	2009	ICE	2015			Natural gas
Toplofikatsiya — Gabrovo EAD	Gas turbine	1978											Biofuel
Toplofikatsiya — Pernik EAD	Gas turbine	1993	Gas turbine	1958	Gas turbine	1966							Brown coal
Toplofikatsiya — Pleven EAD	Combined steam-gas cycles (CSGC)	2008											Natural gas
Toplofikatsiya Sofia EAD TPP Sofia	Gas turbine	2015	Gas turbine	2015									Natural gas
Toplofikatsiya Sofia EAD TPP Sofia East	Gas turbine	1964	Gas turbine	1964	Gas turbine	2019	Gas turbine	1988					Natural gas
EVN Bulgaria Toplofikatsiya EAD	CSGC	2011	Gas turbine	1976									Natural gas
Brikel EAD	Gas turbine	1960	Gas turbine	1961	Gas turbine	1961	Gas turbine	1962					Lignite coal
Toplofikatsiya — Sliven EAD	Gas turbine	1970											Brown coal / biofuel

Toplofikatsiya Rus EAD	Gas turbine	1985	Gas turbine	1984									Imported coal /Biofuel

Source: KEVR



	Heating boilers	Other technologies	HE CHP	Heating boilers	HE CHP	Heat pumps	Other technologies
	Sources of fossil fuels			Renewable energy sources			
Energy supplied on-site	25%	31%	9%	13%	2%	3%	16%
Energy supplied off-site	31%	0%	49%	1%	19%	0%	0%

Energy supplied on-site   Energy supplied off site of consumption

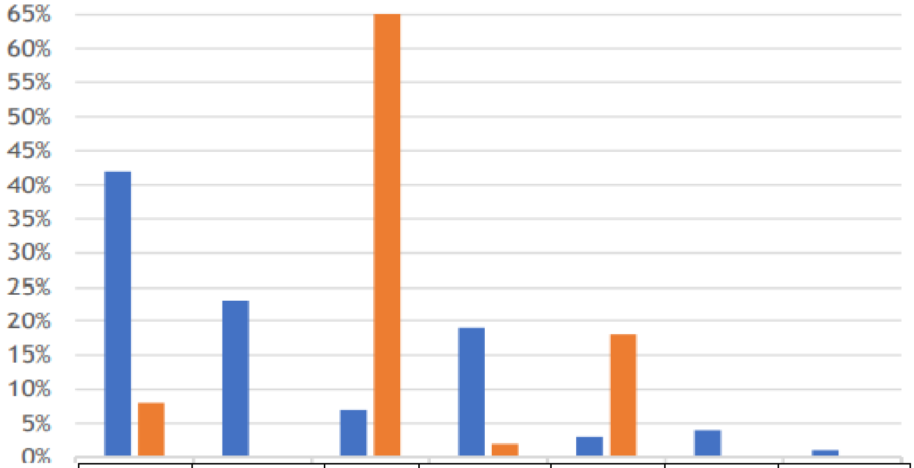
Figure 54. Structure of current technologies 2019

The baseline scenario is underlined by the assumption of continued maintenance of installed cogeneration capacity and an increase in the technical capacity of existing cogeneration installations for heating and cooling by replacing them with new technological equipment with improved technical characteristics, along with the departure of some heating boilers from the technology mix. The main change in the structure of technologies for plants supplying energy for heating and cooling off-site arises from the change in the future structure of the production capacities of the Sofia district heating utility (Toplofikatsiya EAD). A decrease in demand for useful energy for heating and cooling in the household and services sectors due to improved energy performance of buildings. Entry of RDF fuels in district heating.

3.3.2 Future mix of heating and cooling supply technologies and their replacement rate

The future mix of heating and cooling supply technologies has been estimated by taking the fuel mix in the final year and then determining the technology mix for that year and all years in between, assuming different evolution trajectories depending on how the technologies involved. By combining this information with the heating and cooling demand forecasts, a forecast of the structure of technologies throughout the period has been made. The assumptions relating to the future structure of heating and cooling technologies are based on the rate of replacement technologies at the end of the lifetime of current heat generation equipment.

The structure of technologies within the baseline scenario is shown in the figure below.



	Sources of fossil fuels: Heating boilers	Sources of fossil fuels: Other technologies	Sources of fossil fuels: HE CHP	Renewable energy sources: Heating boilers	Renewable energy sources: HE CHP	Renewable energy sources: Heat pumps	Renewable energy sources: Other technologies
Energy supplied on-site	42%	23%	7%	19%	3%	4%	1%
Energy supplied off-site	8%		72%	2%	18%		

Energy supplied on-site Energy supplied off site of consumption

Figure 55. Structure of technologies in baseline scenario 2030

Based on the methodology used, the structure of the technologies by fuel is shown in Figure 56.

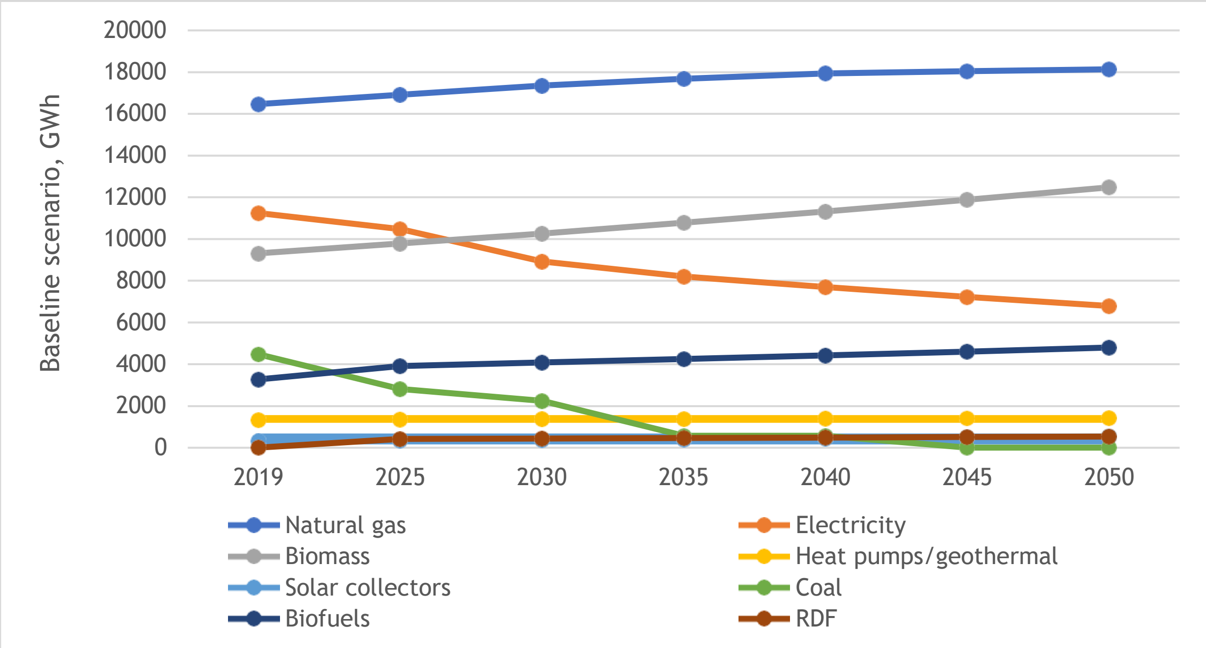


Figure 56. Structure of technologies by fuel in baseline scenario

The baseline scenario reflects the assumption that technologies will be substituted at a rate of 1/20 each year under current measures and policies. The rate of decrease in final energy consumption for heating and cooling is low, driven by Bulgaria's economic development indicators.

3.4 Alternative scenario

The alternative scenario shows the development of final energy consumption for heating and cooling, where final energy consumption is maintained. However, the implementation of new measures and policies may result in greater synergies and a higher share of renewable energy.

The alternative scenario has been examined on the basis of the baseline scenario methodology with the following assumptions:

- The baseline and alternative scenarios rely on the same assumption for the level of final consumption of energy for heating and cooling;
- Accelerated phase-out of non-renewable solid fuels from the energy mix, assuming that technology substitution will take place at a rate of 1/10 per year;
- Gradual replacement of natural gas as a transit fuel used during the period of transition to a low-carbon economy by 2050 by fuel mixtures of renewable biogas and/or green hydrogen;
- Increase in the share of energy supplied from waste in district and decentralised district heating systems;
- Increase in the share of energy for heating and cooling from RES to reach the final high level decarbonisation target.

Based on the methodology used Alternative scenario, the structure of the technologies by fuel is shown in Figure 57.

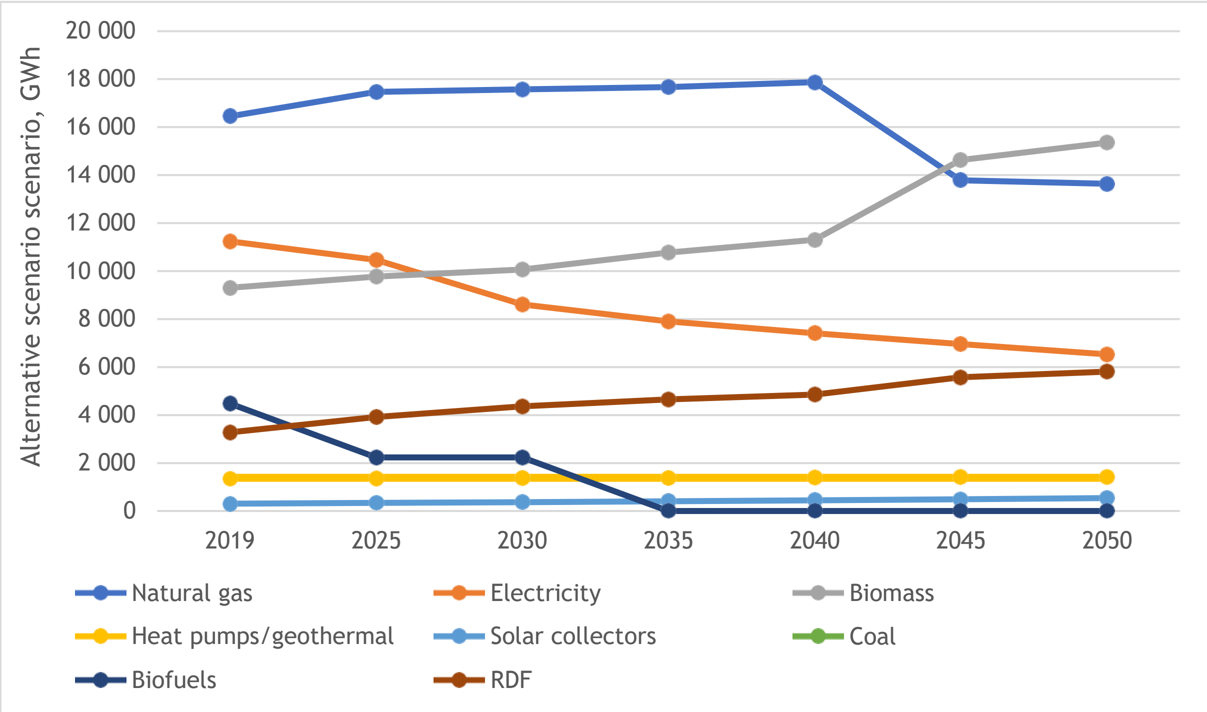


Figure 57. Structure of technologies by fuel in baseline scenario

Modelling under the two scenarios is based on the same macroeconomic indicators for gross domestic product (GDP), GDP per capita, population projections and the CBA.

In the baseline scenario (with existing measures), an assumption has been made that no changes will occur in terms of measures that have already been implemented. Under the baseline scenario, a share of 44 % of renewable energy will be achieved by 2050. In the alternative scenario, which shows the development of final energy consumption, a share of at least 55 % of renewable energy in heating and cooling will be achieved by 2050. It is stressed that the alternative scenario is not aligned with current measures and policies. The alternative scenario should therefore be considered to be based on the assumption that natural gas will also be provided by renewable gas mixtures (including green hydrogen) and that the decrease in demand for energy on account of building stock renovation and new construction with near-zero consumption will be sufficient to achieve a high level of decarbonisation.

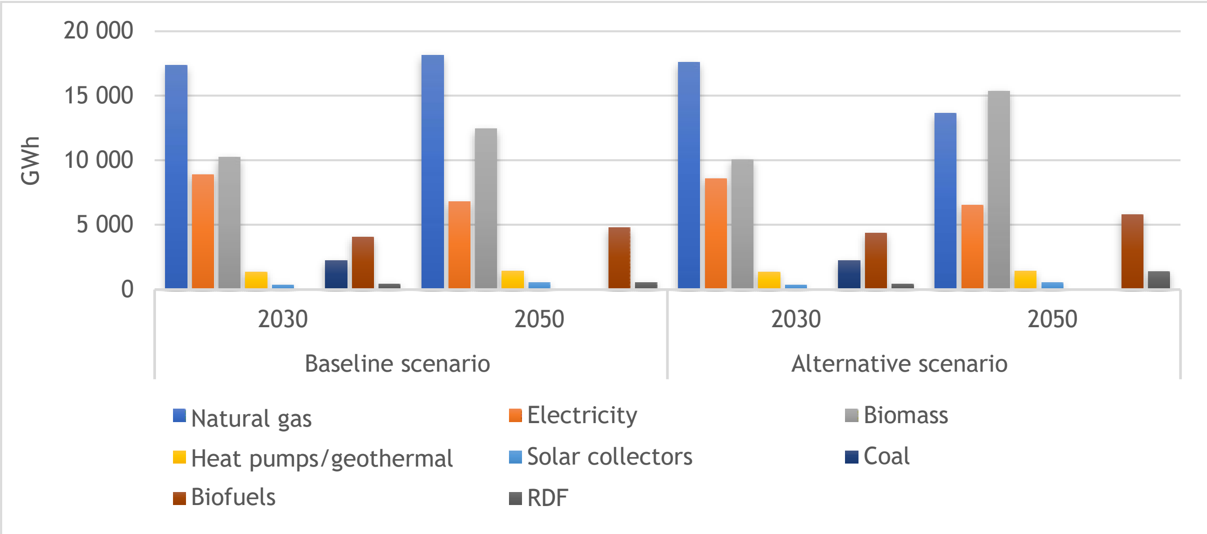


Figure 58. Structure of technologies by fuel in baseline and alternative scenario

The assessment of the environmental impact of additional CHP capacity in the alternative scenario should take into account the environmental effect of changes in electricity production.

GHG emission values can vary over time due to changes in various parameters (e.g. population density, total pollutant load of the air). Changes in technological design, respectively changes in the energy mix, also have an impact on external environmental costs.

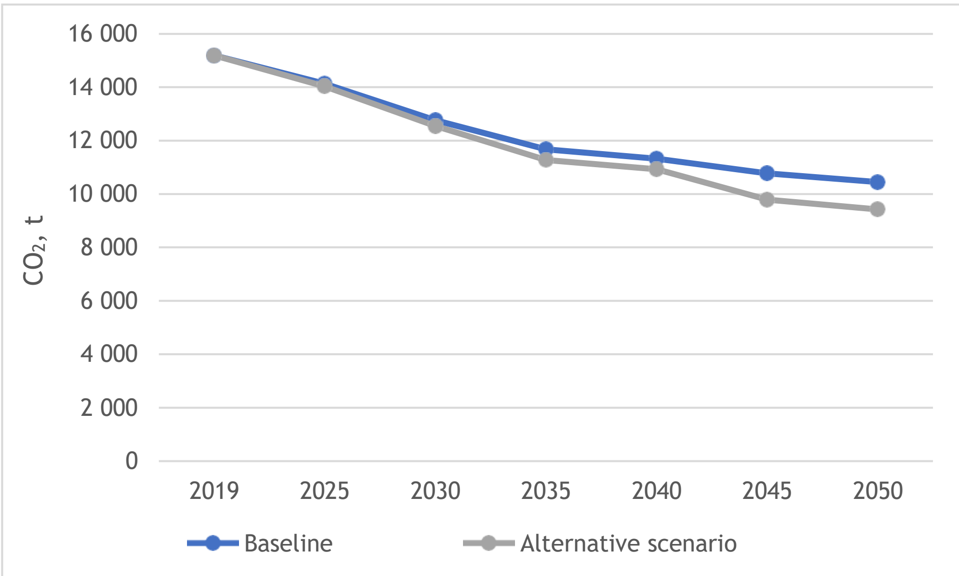


Figure 59. CO_2 t emissions for baseline and alternative scenarios

3.5 Economic potential

The analysis of the economic potential of efficient heat supply has been conducted in the following four steps:

1. Identification of areas where district heating could be of interest based on the estimated cost of heat distribution according to heat density.
2. Clustering areas with similar characteristics and compiling a typology by heat density.
3. Estimation of the possible fuels used.
4. Calculation of the cost of supplying heat from a new district heating network based on a different technology in the areas and under the market conditions identified.
5. Identification of the economic potential for efficient district heating and combined heat and power generation by comparing investment-related costs, variable and fixed costs of supplying district heating in the model cities identified.
6. The total potential within the geographic boundary has been calculated separately. The difference between the total potential and currently utilised potential is equal to the economic potential of extending existing and building new district heating networks. The economic potential has been estimated based on the Hotmaps tool. Both economic and financial analyses rely on the use of the net present value as an assessment criterion. An identified minimum heat density of 12 GWh/year has been used as a basis for the calculations.

On account of the predominant share of heat demand, the analysis of economic potential covers only heat supply.

3.6 Forecast of economic potential at national level

According to Article 127 of the ZE, thermal energy generation takes place at combined heat and power plants, heating plants, waste heat recovery plants and installations using renewable sources.

Where heat demand exists, new gas-fired cogeneration plants with a capacity of more than 5 MW are constructed for the combined production of electricity and heat. This does not apply in the case of technical reconstruction or construction of replacement facilities in order to ensure the fulfilment of obligations for continued heat supply. This limits the current potential for the implementation of high-efficiency cogeneration and efficient district heating and cooling systems.

The economic potential should be assessed in light of the overall EU policy for the achievement of full decarbonisation by 2050. Two of the options to achieve this objective are the use of indigenous renewable resources and the development of cogeneration capacities based on indigenous RES. The introduction of high-efficiency technologies would be socially and economically viable over the next 10 to 30 years, if current technologies are replaced and fossil fuels are substituted by renewables, particularly in the light of continually increasing prices of CO_2 emissions.

The development of new district heating networks, both local and extensions to existing ones, in order to meet the needs of buildings in the domestic and service sectors that are not connected to district heating depends on whether new policies and measures will be put in place as existing plants have exhausted their capacity for expansion under current policies and measures. One of the possibilities is to exploit the potential of highly efficient technical solutions, such as gas reciprocating engines or combined gas and steam cycles in the replacement of technologies in large power plants. Use of small to large open- or closed-cycle gas turbines, biomass fired steam turbines, hydrogen cells, solar hot water plants, etc. in meeting own heat demand. The development of district heating systems should also be considered in light of local community (municipal) plans, the development of municipal infrastructure and the technical possibilities for building new district heating networks. The use of biogas and/or natural gas enriched with biogas/green hydrogen and biomass utilisation with a focus on biomass from agricultural waste and residues from industrial plants and households (RDF) holds a potential to increase the share of energy from RES in district heating and cooling systems. The implementation of new measures and policies that promote local district heating installations supplying one administrative and several residential buildings with heat supply from a mini-CHP system also holds a potential. The system can be combined with solar hybrid panels. The possible fuel options depending on the selected technical options could include biogas-enriched natural gas. The hydrogen fuel additive for the cogenerator could be produced on-site through electrolysis, with the necessary energy supplied from the power generated by the hybrid thermal/solar panels. Where gas is not available, micro-CHP can be based on processed biomass or fuel cells. Heat pumps are a solution for decentralised small users in the domestic and service sectors. New policies and measures in the area of sectoral interconnectivity will help tap the technical potential of renewable energy more fully. The energy efficiency potential of district heating and cooling infrastructure lies in the rehabilitation of heat transmission networks and the replacement of outdated district heating stations with modern high-efficiency automated indirect stations, which will reduce heat transmission and distribution losses and reduce

CO_2 emissions. The application of best practice solutions involving the use of pre-insulated pipes for district heating systems achieves heat loss reductions of up to 3 %. A similar level of loss [reduction] can be achieved for high-density power systems. In the context of prevailing conditions in Bulgaria, it is assumed that the average power density of district heating systems will allow heat loss reductions of up to 10 % t be achieved through the use of best available technology. The development of electricity production from high-efficiency cogeneration contributes to a decrease in the fuel used, the achievement of higher efficiency of electricity generation and better protection of the environment.

In order to assess the economic potential on the basis of RES, different scenarios for the rate of uptake by high efficiency combined-cycle plants have been examined, using the Hotmaps tool modules.

The potential for new high-efficiency cogeneration capacity in new district heating plants and networks has been estimated on the basis of the population not connected to heating networks and the energy demand density according to the heat map (Hotmaps.eu tool).

After applying the following criteria:

- Population of more than 42 000 inhabitants
- Heat consumption of more than 12 GWh per year,

it was established that 19 agglomerations offer potential for the construction of new high-efficiency cogeneration capacity.

The calculation module enabled an economic analysis of the feasibility of meeting the heat demand of a typical urban agglomeration (12 GWh/y)) to be performed. The input data used for the analysis is shown in Table 27.

Table 27. Conditions and input data for economic analysis

Total demand for heat	**12 GWh/y**	
Minimum heat density	MWh/(ha*y.)	14.23
Maximum heat density	MWh/(ha*y.)	649.28
Average heat density	MWh/(ha*y.)	244.81

The calculations were made using the DISTRICT HEATING PLANT module, developed as an element of the Hotmaps project financed by the Horizon 2020 programme[32].

[32] https://wiki.hotmaps.eu/en/CM-District-heating-supply-dispatch

Table 28. Assessment of the economic potential of a district heating plant

Thermal output capacity —	**CHP (5 MW)**
Thermal output capacity —	waste incineration plants — 5 MW
Thermal output capacity —	Heat pump (5 MW)
Thermal output capacity —	Solar heat — 5MW
Price of CO_2 emissions —	50 EUR/tCO_2)
interest rate —	0.05
Basic input data —	
thermal efficiency	CHP (0.6)
Electrical efficiency —	CHP (0.2)
thermal efficiency —	waste incineration plants — 0.6
Electrical efficiency —	waste incineration plants — 0.2
COP heat pump	3.5
thermal efficiency —	Solar heat — 1
CHP lifetime	20a
operation —	waste incineration plants — 20a
Heat pump lifetime	20a
operational lifetime — solar collector	20a
energy carrier — CHP —	biomass — 22EUR/MWh
energy carrier — waste incineration plants —	3EUR/MWh
energy carrier — heat pump —	100 EUR/MWh
energy carrier — solar heat —	0 EUR/MWh
emission factor — natural gas —	0.202tCO_2/MWh
emission factor — waste	0.114tCO_2/MWh
emission factor — radiation	0tCO_2/MWh
emission factor — electricity	0.819tCO_2/MWh
price of energy carrier — natural gas —	24EUR/MWh
price of energy carrier — waste	3EUR/MWh
price of energy carrier — biomass	22EUR/MWh
price of energy carrier — radiation	0 EUR/MWh
price of energy carrier — electricity	100 EUR/MWh)
fixed electricity price —	CHP (100 EUR/MWh)

The results obtained are set out in the table below.

Table 29. Results of the assessment of the economic potential for the construction of a new district heating plant

Fuel		**Biomass**	**Natural gas**	**RDF**	**Heat pumps**	**Solar collectors**
		CHP				
Total annual costs	EUR/y	1 170 000	1 380 000	2 000 000	794 000	622 000
Total income from electricity	EUR/y	153 000	405 000	153 000	0	0
Total heat output	MWh/year	12 000	12 000	12 000	12 000	1 2000
Total electricity output	MWh/year	4 000	4 050	4 000	0	0
Total investment costs	EUR/y	4 016 197.7 3	1 163 189	1 280 000	1 380 488	1 472 521
Total operation and Maintenance (O&M) costs	EUR/y	284 000	285 000	456 000	176 000	182 000
Total fuel costs	EUR/y	628 571	694 286	85 714	153 000	0
Total CO2 emission costs	EUR/y	43 000	205 000	114 000	164 000	0
Total costs	EUR/y	85 800	87 000	85 800	0	0
Total CO2 emissions	t/y	860	4 090	2 280	3 270	134
Total demand for heat	MWh/year	12 000	12 000	12 000	12 000	12 000
TOTAL final energy consumption	MWh/year	20 000	20 300	20 000	3 429	13 400
Maximum heat load	MW	4.52	4.52	4.52	4.52	4.52
Installed capacity	MW	5	5	5	5	5

The total central heating potential in GWh/y within the geographical boundary has also been derived using the Hotmaps tool. The estimated value is 10 673.4 GWh/y. The quantity of the potential already utilised, i.e. the potential within existing heating networks (6 169.85), should be subtracted from this figure. The available potential, calculated for agglomerations identified as fitting the profile, including 12 existing district heating networks with potential for expansion and 19 agglomerations with potential for the construction of new district heating networks, is 4 503.55 GWh/year.

The energy efficiency potential of existing district heating and cooling network infrastructure has been identified. It is available in the rehabilitation of the heat networks and the replacement of existing district heating stations with new modern smart plants. This will reduce heat transmission and distribution losses and contribute to the achievement of decarbonisation objectives in the sector.

In order to reduce losses to 10 % (with current average losses of 23.0 %), district heating networks should be upgraded so that annual losses be reduced from 2.77 TJ/km to 1.17 TJ/km. As the length of the heating network (3 095 km) is closely link to the value of heat losses during transmission, an assumption can be made that the requirement for loss reduction per km to 1.17 TJ/km should be applied to all district heating systems in Bulgaria.

The potential resulting from the improved energy efficiency of district heating systems is estimated at 1.6 TJ, which represents 42 % of the heat that is currently lost during heat transmission.

The potential for the development of renewable technologies which, in combination with the technological upgrade, rehabilitation and implementation of energy efficiency measures in existing district heating systems, will ensure the achievement of Bulgaria's objectives and commitments in line with the EU energy policies and priorities should also be noted. The table below sets out the economic potential of heating and cooling technologies for the period until 2030 under the baseline scenario.

Table 30. Estimated economic potential of efficient and renewable heating and cooling technologies

2030	**Baseline scenario**	**Alternative scenario**
	GWh/year	GWh/year
Industrial waste heat		
Industrial waste cold		
Waste incineration	438.90	438.90
HE CHP	400-600	1 900- 2 000
Renewable energy sources		
Geothermal energy		
Biomass	1 757.96	1 843.48
Solar thermal	63.69	63.69
Other RES		
Heat pumps	26.95	26.95
2050	**Baseline scenario**	**Alternative scenario**
	GWh/year	GWh/year
Industrial waste heat		
Industrial waste cold		
Waste incineration	533.49	1387.06
HE CHP	500 -700	1 950- 2 200
Renewable energy sources		

Geothermal energy		
Biomass	3 581.84	4 690.90
Solar thermal	234.01	234.01
Other RES		
Heat pumps	82.49	82.49
Reduction of heat losses from existing district heating and cooling networks	1 111. 66	

3.7 Model relevant to the baseline scenario

The model has been examined independently as it is relevant to the largest district heating company in the sector and its development will have an impact on the performance of the entire sector.

3.7.1 Model for Sofia district heating, comprising a set of CHP and heating plants

The scenario considered, which involves modelling of the social and economic effect of the Sofia district heating plan (Toplofikatsiya Sofia), has been accepted as relevant to the baseline scenario. A cost-benefit analysis has been performed in order to identify the most cost-effective heating or cooling solution relative to the defined baseline scenario for the sub-system within the geographical boundary for planning purposes. A model has been developed for Toplofikatsiya Sofia, which comprises a combination of CHP and heating plants. The focus of the analysis is the replacement of current heating plant capacity with high-efficiency capacity, taking into account the plans to intensify high-efficiency capacity at CHPs.

The model is structured as follows:

A baseline model for Toplofikatsiya Sofia has been developed using data for 2019. Technical data, the development programme until 2024, the company's financial statements and a number of macroeconomic indicators have been taken into account. As of 2019, Toplofikatsiya Sofia has 4.186 MWt of installed capacity for heat generation and 238 MWe of capacity for electricity generation and operates a network with a length of more than 1 007 km, comprising approximately 17 300 indirect subscriber stations (SS). The heat load connected to Sofia's transmission network is estimated to be approximately 5 840 MW in total. It is satisfied by 4 separate heating districts (HD):

- HD Sofia — with a heat load of 1 334 MW and DHW load of 293 MW;
- HD Sofia East — with a heat load of 1 737 MW and DHW load of 581 MW;
- HD Zemlyane — with a heat load of 905 MW and DHW load of 295 MW;
- HD Lyulin — with a heat load of 487 MW and DHW load of 206 MW.

- The Ovcha Kupel 1 CHP plant is designed for the production of thermal energy for the needs of the Ovcha Kupel residential area. It comprises 6 boilers with a thermal output of 8.70 MW each, operating with natural gas as the main fuel and fuel oil as emergency fuel.

- CHP Ovcha Kupel 2is designed for the production of thermal energy for the needs of the Ovcha Kupel residential area. It comprises 6 boilers with a thermal output of 8.70 MW each, operating with natural gas as the main fuel and fuel oil as emergency fuel.
- The Hadzhi Dimitar CHP plant is designed for the production of thermal energy for the needs of the Hadzhi Dimitar residential area. It comprises an old boiler house with 3 boilers, each with a thermal output 4.36 MW, and a new boiler house with 4 boilers, each with heat output 8.70 MW, operating on natural gas and fuel oil as emergency fuel, as well as 2 steam boilers with a steam output of 1.6 t/h, one of which is not in operation.
- The Suha Reka CHP plant is designed for the production of thermal energy for the needs of the Suha Reka residential area. It comprises 4 boilers, each with a thermal output of 8.70 MW, operating with natural gas as the main fuel and fuel oil as emergency fuel., as well as 2 steam boilers with a steam output of 0.4 t/h. Boilers 1, 3 and 4 use natural gas as the main fuel and boiler 2 uses natural gas as the main fuel and fuel oil as reserve fuel.
- The Levski G CHP plant is designed for the production of thermal energy for the needs of the Levski G residential area. It comprises 6 boilers, each with a thermal output of 8.70, operating with natural gas as the main fuel and fuel oil as emergency fuel, as well as 2 steam boilers with a steam output of 1.6 t/h.
- The Orlandovtsi CHP plant is designed for the production of thermal energy for the needs of the Orlandovtsi residential area. It comprises 1 water boiler with a thermal output of 4.66 MW, operating with industrial fuel oil as the main fuel of the plant and supplied by tank trucks.
- The Inzhstroy CHP plant is designed for the production of thermal energy for the needs of the Zaharna Fabrika residential area. It comprises 3 water boilers, two of which with a thermal output of 8.70 MW and the third with a thermal output of 2.30 MW.

The table below sets out data on the electrical and heat capacity of Toplofikatsiya Sofia:

Table 31. Capacities are shown on a stand-alone basis[33]

Plant/Source of heat	Electrical Power	Heat output
	MW	MW
TPP Sofia	72	1 323
TPP Sofia East	166.8	1 464
Zemlyane heating plant	0	581
Lyulin heating plant	0	581

33 https://www.dker.bg/uploads/_CGCalendar/2020/rep_TFsf_ud_lic_072020.pdf

Residential complex Hadzhi Dimitar,	0	46.8
CHP Levski G	0	43.6
CHP Suha Reka	0	35
CHP Orlandovtsi	0	5
CHP Ovcha Kupel 1	0	43.6
CHP Ovcha Kupel 2	0	43.6
CHP Inzhstroy	0	19.7
TOTAL	239	4 186

Assumptions of a change in heat consumption have been made, which are reflected in the company's forecasts. These reflect projected changes in macro indicators (GDP, inflation (domestic and at EU level, exchange rates) over the next 5-year or 7 year-period, depending on available forecasts. The indicators are expected to gradual increase or follow a flat curve after this period.

- Fuel mix and process losses and captive energy consumption have been taken into account. An analysis of staffing needs has been conducted and gradual optimisation has been planned.
- The different applicable high-efficiency solutions have been analysed on the basis of heat load variation assumptions and a summary of the capacity required is set out in summary below:

The company's development model for the period 2020-2024 envisages the upgrade of all sources of heat with the installation of cogeneration plants. Following the upgrade and installation of new high-efficiency cogeneration installations, the company's installed capacity for electricity generation will increase from 261 MWe to 561 MWe, and the installed capacity for heat generation will be maintained, with the new installations serving as replacement capacity for existing water boiler units.

The planned upgrade of the power plants includes the construction of new cogeneration installations: TPP Sofia with installed capacity of 59 MWe and 50 MWt, TPP Sofia Iztok with installed capacity of 137 MWe and 114 MWt, TPP Zemlyane with installed capacity of 42 MWe and 35 MWt, TPP Lyulin with installed capacity of 42 MWe and 35 MWt and the CHP plants with a capacity of 20 MWe and 20 MWt.
The total capacity of the new plants is 300 MWe and 254 MWt, with an expected investment of approximately EUR 200 000.

The upgrade of heat sources with cogeneration plants will doubtlessly deliver benefits such as:

- Improved reliability and quality of energy supply;
- Increase of the quantity of electricity generated by operation of the facilities in combined-cycle mode;

- Fuel savings from cogeneration, approximately 148 751 000 nm^3 of natural gas saved (compared to separate power generation);

- Lower greenhouse gas emissions, CO_2 savings and, savings from the purchase of allowances at regional level (compared to coal-fired power generation);

In order to ensure the necessary technological and financial sustainability of the company, the model envisages:

The introduction of high-efficiency technological plants to increase overall plant efficiency from 83.4 % to 86.3 %. This will increase the ratio of gross electricity generation to total energy output of the facilities from 18.40 % to 55 %.

- The projected financial statements also take into account the long-term volatility of fuel mix prices as well as changes in exchange rates. An assumption has been made that only fuel prices will change, but not their technical characteristics (e.g. calorific value). The net present value for the baseline model has been calculated.
- On the basis of the projected financial statements and the regulatory body's requirements for heat and power pricing, heat and electricity prices have also been estimated.
- The model allows capital expenditure and annual operating costs to be calculated as well as maintenance costs associated with individual solutions.
- For each of the constituent plants of Toplofikatsiya Sofia AD, where a possibility exists for the replacement of existing facilities with high-efficiency solutions, a model has been elaborated to predict changes in operational data and cash flows following the commissioning of the new facilities. The resulting new net present value is compared to that calculated under the baseline scenario and, where the former value is greater than the latter, the installation of a high-efficiency solution is recommended.

3.7.2 Conclusions from the technical assessment model and the cost-benefit evaluation of the Sofia Heating District Plant

Replacement of existing technologies with high-efficiency combined heat and power solutions at TPP Sofia, TPP Sofia Iztok TPP Zemlyane, TPP Lyulin, TPP Suha Reka, TPP Hadzhi Dimitar, TPP Levski G., TPP Orlandovtsi, TPP Ovcha Kupel 1, TPP Ovcha Kupel 2 and TPP Inzhstroy.

The upgrade will increase the current net value of Toplofikatsiya Sofia between 0.5 % to 8.33 % for each of the individual facilities as compared to the baseline model, i.e. each unique individual solution is considered on a stand-alone basis. The implementation of all assessed solutions will produce a cumulative effect of more than 22 %.

In some cases, there are optimal possibilities to use biomass or even coal as the main fuel. However, given the location of the plants and their access to fuels, the natural gas (mixtures of hydrogen and natural gas) is considered to be the most efficient and environmentally-friendly solution.

Each of the planned capacities involves a high-efficiency solution, such as combined-cycle gas turbines (CCGT or OSGT) or gas piston engines.

3.7.3 Forecast development of the heat load for Sofia

Preparation is under way for further development of company's heating network on the basis of Sofia's master plan and letters and applications received from investors and developers interested in connecting future buildings to the heating network. The analysis of these applications shows a trend of continuously increasing interest in construction in the south-east parts of Sofia, and more specifically the following municipal districts:

- Lozenets, Vitosha residential area, Hladilnika Vitosha Research and Industrial Zone (NPZ), Filip Kutev Street, between Cherni Vrah Boulevard and Srebarna Street;
- Iskar, Druzhba residential area, Druzhba – obikolna area, between Tsvetan Lazarov Boulevard, Christopher Columbus Boulevard, Konstantin Kostenechki Street and Obikolna Street;
- Studentski, Vitosha residential area, Vitosha TPP Simeonovo, the area between Simeonovsko Shose Boulevard, Hristo Vakarelski Street and 21 Vek Street in th direction of Simeonovsko Shose Boulevard;
- Manastirski Livadi — Zapad residential area;
- Manastirski Livadi — Iztok residential area;
- Lyulin — Tsentar area;
- Buxton residential area;
- Ovcha Kupel 1 and 2 residential areas;
- Ovcha Kupel residential area up to Gornobanski Boulevard;
- Slavia residential area to the west of Vladayska River;
- Pavlovo up to Nikola Petkov [Boulevard];
- Buxton residential area above Vihren Street.

In view of the plans for the development of the individual neighbourhoods, the company will strategically develop its network in the residential areas Malinova Dolina 1, 2, 3, 4, 5 and 6, including the area between Tsar Boris III Blvd., Simeonovsko shose Blvd., Kirkor Azaryan Street, the Ring Road and Suhata Reka river.

The heat loads associated with the development of Sofia by 2030 and the total projected heat load for each of the four district heating areas is expected to be as follows:

Table 32. Projected heat load per heating area as at 2030

Heating district	Forecast heat load
Sofia	125 MW
Sofia East	225 MW
Zemlyane	90 MW
Lyulin	25 W

The projections are based on an expert assessment conducted after an analysis of the company's investment programme, Sofia's master plan and letters and applications received from investors and developers interested in connecting future buildings to the heating network.

3.7.4 *Waste recovery potential*

The use of modified solid fuels derived from waste (RDF) in order to change the power generation fuel base by replacing natural gas, switching to renewable fuels and increasing the efficiency of heat generation. According to the investment programme of Toplofikatsiya Sofia EAD and the Metropolitan Municipality

an RDF (refuse derived fuel) waste recovery plant in Sofia will be designed and constructed in Sofia by 2024. The new RDF incineration plant will replace facilities that have already been dismantled and decommissioned (removed from the company's licence). The current generation capacities at the Sofia CHP will remain in operation. RDF waste recovery will lead to the partial substitution of natural gas, the main fuel used by Toplofikatsiya Sofia, with modified RDF (a refused-derived solid fuel).

Waste potential utilisation for heat generation will result in:

✓ Power generation by thermal power plants that is independent from imported gas to a greater degree and fuel base diversification.

✓ Development and stabilisation of Sofia's heat generation capacity.

✓ Replacement of some of the old heat generating capacity (some more than fifty years old) with new modern facilities that meet the requirements for efficient and environmentally-friendly power generation laid down in EU directives.

✓ Reduction of CH4 and CO2 emissions from municipal solid waste utilising the fuel component in waste for cogeneration.

✓ Recovery of Sofia's municipal waste.

- ✓ Reduction power generation unit costs and possible decrease of the price of energy.
- ✓ Improved energy efficiency of power generation through the replacement of outdated generation capacity with new, high-efficiency combined heat and power capacity, making optimal use of available infrastructure at the level of heat sources.

Increased electricity generation and the consequent decrease in imports and the use of natural gas will result in additional environmental benefits, supporting the development of a competitive low-carbon economy.

Table 33. Technological data of RDF plant

Technology/project	System
Type of furnace and boiler and energy system	• Grate stoker furnace with horizontal steam boiler and combined heat and power production. • Steam parameters: 425°C at 60 bar • Production capacity (gross) 21 MW Production capacity (net): 19 MW • Heat generation (with condensation) 55 MW • Heat storage capacity: 230 MWh
Flue gas treatment	• Semi-dry flue gas treatment with scrubber after DeNOX condensation system: SNCR
Waste treatment	• Nominal processing capacity: 22.5 t/h at 13 GJ/t = 81.3 MW • Planned annual treatment 180 000 tonnes (at 13 GJ/y) • Incineration heat variations: 10-16 GJ/t • Fuel processing variations 15.8-27 tonnes per hour
Capacity of the facility	• 180 000 RDF t/y (22,5 t/hour);
Production capacity	• 58 MWt of heat and • 20 MWe of electricity, • providing electricity for the needs of 30 000 households • providing heat for the needs of 40 000 households

Operational lifetime of the facility	• 26 years from the date of commissioning

Source: KEVR

In its business plan for the period 2020-2024, Toplofikatsiya Sofia EAD envisages the construction of an RDF plant, as well as cogeneration modules for electricity and heat generation. A total of five (5) gas turbines with a total electrical capacity of 223.9 MWe, three (3) steam turbines with a total capacity of 39.5 MWe and five (5) gas turbine engines (GBE) are planned to be commissioned at Ovcha Kupel-2 CHP,
Hadzhi Dimitar CHP and the Levski G CHP. These will have a total capacity of 20.5 MWe. The planned investments are detailed in Table 34.

Table 34. Planned investment activities with their estimated annual values for the period 2020-2024

Investment activities	**2020**	**2021**	**2022**	**2023**	**2024**	Total for the period
RDF incineration plant	**64 351 611**	**79 097 026**	**164 668 934**	**0**	**0**	**308 117 570**
Investment in cogeneration plants	**1 920 000**	**80 756 020**	**165 854 775**	**113 008 846**	**0**	**361 539 642**
Upgrade/replacement of equipment	**208 585 781**	**37 817 440**	**2 668 241**	**5 867 490**	**5 867 490**	**80 806 441**
Heat transmission networks upgrade	**26 830 083**	**13 500 000**	**13 500 000**	**13 500 000**	**13 500 000**	**80 830 083**
Total costs:	**121 687 474**	**211 170 486**	**346 691 950**	**132 376 336**	**19 367 490**	**831 293 736**

Source: KEVR

The price framework for the period until 2024 of Toplofikatsiya Sofia EAD is set out in the table below:

Table 35. Projected prices of heat and electricity

	Indicators	**Measure**	**2020**	**2021**	**2022**	**2023**	**2024**
1	Preferential price granted to power plant, excluding VAT	BGN/MWh	239.15	231.27	243.19	247.67	260.73
2	Single-component price of heat with hot water carrier, excluding VAT	BGN/MWh	66.94	67.83	70.15	69,68	71.42

Source: KEVR

Table 36. Projected prices of CO2 emissions

	Indicators	Measure	2020	2021	2022	2023	2024
1	Price of CO_2	EUR/tonne	27	29	31	33	35

Source: KEVR

In connection with the KEVR decision on application of the rate of return on capital method for companies in the heat and electricity sector and pursuant to Article 1, second sentence of the ZE, Guidelines for determination of the prices of heat and electricity from cogeneration when regulated on the basis of the rate of return on capital method have been developed and adopted by the Decision detailed in point 8 of Minutes No 95 of 25.5.2015 of the KEVR (the RoR Guidelines).

The rules governing price regulation on the basis of the rate of return on capital method are set out in the ZE and Regulation No 5 of 23.1.2014 on regulation of the prices of heat and electricity (NRTsEE).

According to Article 3(2)(1) of the NRTsTE and the NRTsEE, this is the method by which the KEVR, having conducted a regulatory review, approves the prices and requisite annual earnings of energy undertakings for a regulatory period of at least tone year. A subsequent regulatory review is carried out pursuant to a decision of the KEVR or upon an application submitted by an energy undertaking in the event of material discrepancies between the approved and reported elements of the requisite earnings.

The projected revenues for the period 2020-2024 have been determined on the basis of the company's projections regarding its generation programme and the prices of heat and electricity for each year of the business plan, calculated using pricing models based on the rate of return on capital method and in line with projected costs. Revenues are determined on the basis of a feed-in tariff for electricity generated exclusively by HE CHP.

3.8 Cost-benefit analysis

- Functions of the model

1 The model is used to compare a baseline high-efficiency cogeneration technology based on natural gas, biomass, RDF and a district heating installation based on solar thermal energy on the basis of the technologies currently in use within the geographical boundary.

2 The model is based on the total heat demand for a target urban area with a heat demand of 12 GWh/year and is applicable for consumers not currently connected to district heating networks. It is used to assess, on the basis of the net present value, the feasibility of building high-efficiency cogeneration plants for district heating and cooling based utilising natural gas, biomass or RDF.

3 The model calculates the internal rate of return (IRR) and net present value (NPV) for all primary and individual high-efficiency heating and cooling options, taking into account capital expenditure, maintenance costs, long-term fuel price volatility, environmental costs, external costs and the social discount rate.

4 The model identifies the most socially and economically efficient heating option (the option with the highest NPV).

5 The total net present value (NPV) for the best combination of solutions, notably to build a new district heating network, is compared to the present value (PV) for building new district heating networks.

6 Information about the total quantity of heat and electricity generated, as well as the annual output and number of installations, has been summarised on the basis the criterion the most socially and economically efficient combination of new heating solutions for new district heating networks.

The NPV for each potential new high-efficiency CHP installation was calculated using the following assumptions:

- Technical life of the investment – 20 years;
- Discount factor – 5 %;
- The model assumes that the heat line has a load factor of 80 %, which is equivalent to operating at full capacity for 7 008 hours per year;
- The heat loss in heat distribution from the source to consumers is assumed to be 10 %;
- Maintenance and operating costs are calculated individually for each system.
- The prices used in the economic analysis reflect social and economic costs and benefits.
- External costs, such as environmental and health impacts, have been estimated, including as part of the sensitivity analysis.

– Basic input data for the done:
– Costs
- Capital expenditure
  The capital costs for heating and cooling are identical as those set out in the financial analysis.
- Operation and maintenance costs
  The operational and maintenance costs associated with the supply of energy for heating and cooling are the same as those set out in the financial analysis.
- Fuel (and electricity) costs.

Fuel and electricity costs are the same as those set out in the financial analysis.

- External environmental and health factors.

The process of power generation has various environmental impacts as a consequence of pollution emissions, land use and resource consumption (fuel, water, etc.). Environmental assessment methods are generally underlined by an 'impact pathway evaluation' approach, which aims to model the cause-effect relationships — from induced pressures on the environment (e.g. emissions) to the impacts on different groups — by assessing changes in the quality of the environment. Once these impacts have been evaluated in physical units, the damage or value of the impacts used is estimated by applying economic valuation methods.

Carbon prices are thus an important factor in the analysis. The average (auction) price of reported CO_2 emission allowances for the regulatory/price period from 1 July 2018 to 30 June 2019 is 21.24 EUR/tonne (41.54 BGN/tonne) according to the European Energy Exchange data. In connection with this, an average auction price (Auction Price) for CO_2 allowances from the Primary Market Auctions held on the European Energy Exchange for the period between 1 July 2018 and 30 June 2019 in the amount of EUR 21.24 EUR/tonne of CO_2 (41.54 BGN/tonne of CO_2) has been adopted for the purpose of heat pricing in the sector. The BGN equivalent is calculated on the basis of the fixed rate of exchange of the Bulgarian National Bank (BGN 1.95583 = EUR 1.00). The calculated price above does not take into account the reported prices of CO_2 allowance achieved in the German and Polish auctions or those for airline operators. As the regulatory/price period from 1 July 2018 to 30 June 2019 covers six-month periods of two calendar years, data from the EUA Primary Market Auction Report 2018 and the EUA Primary Market Auction Report 2019 has been used, which is publicly available on the website of the European Energy Exchange at: https://www.eex.com/en/market-data/environmentalmarkets/eua-primary-auction-spot-download.[34]

The choice of a solution should not only take into account current emission prices, but allow for possible extreme increases in the future. For this reason, two alternatives — a low emission price and an extreme emission price — have been developed calculated.

The entire environmental assessment process is conducted on a project-by-project basis by applying the requirements laid down in

[34] The data corresponds to the official data from the approved business plan of Toplofikatsiya Sofia EAD, subject to updating in line with the current exchange prices.

environmental legislation (e.g. for Environmental Impact Assessments (EIA) to each project.

- Benefits
- Business incentives;
- Decrease in the use of imported fossil fuels;
- Predictable costs for users;
- Reducing the emissions of CO_2, sulphur/nitrogen oxides and particulate matter;
- Creating temporary and permanent jobs;
- Improving the quality of ambient air;
- Independence of heating and cooling from weather and road conditions.

The cost-benefit analysis and the social and economic potential for high-efficiency cogeneration have been assessed in terms of their potential to replace existing heat generation capacity in the next 10 years with high-efficiency technologies on a net present value basis, taking into account the following elements:

- Technical potential based on current heat consumption and the increase/decrease in heat consumption between 2020 and 2050;
- Financial costs and benefits of the technologies for the entire country;
- The effects of reducing carbon dioxide emissions and improving air quality, expressed in monetary terms.

The penetration of new heat storage systems offers an additional potential for the development of cogeneration as it will make it possible for the heat currently provided by heating boilers to be generated from renewable sources.

The heat currently generated by coal-fired CHP can also be viewed as offering additional potential for the construction of high-efficiency cogeneration. Although the replacement of these installations with gas-fired systems with a significantly higher combined production factor will not increase the heat produced by cogeneration, it will increase the amount of electricity produced. Waste incineration (RDF) plants also offer additional potential.

A cost-benefit analysis (CBA) is conducted for each specific project with a total heat input of more than 20 MW. The cost-benefit analysis and the analysis of the national potential for high-efficiency cogeneration referred to in Article 4(2)(11) of the ZE are provided for in a regulation issued by the Minister for Energy.

The development of investment projects involves a cost-benefit analysis conducted in accordance with the Regulation referred to in Article 163 of the ZE for installations with a total heat input capacity of more than 20 MW in the following cases:

1 Planning a new thermal power plant to assess the costs and benefits of designing a plant to operate as a high-efficiency cogeneration installation;

2 significant retrofitting of a thermal power plant to assess the costs and benefits of retrofitting the plant as a high efficiency cogeneration installation;

3 significant retrofitting of an industrial plant generating waste heat at a useful temperature in order to enable waste heat utilisation to meet an economically viable demand, including through cogeneration, and by connecting that plant to a district heating or cooling network;

4 planning of a new district heating and cooling network. In the case of an existing district heating or cooling network, a new energy production installation or a significant retrofit of an existing installation are planned in order to enable waste heat recovery from adjacent industrial installations.

The geographical boundaries delineate a suitable and clearly defined area of a certain type at the level of municipalities/urban areas and 19 towns without an existing district heating system have been identified.

Additional identification, using the Hotmaps tool, of urban areas that meet the requirement for heat density of at least 12 GWh/y within the 12 towns in which district heating plants operate without the towns being connected to the respective heating networks.

The cost-benefit analysis takes into account all relevant centralised or decentralised generation resources available within system and geographic boundaries, including the technologies examined individually and the fuels used, as well as the trends and characteristics of demand for energy for heating and cooling.

Economic potential calculations have been used as model input data. The additional assumptions made are set out in in Table 37.

Table 37. Model calculation assumptions

Electricity price	**EUR/MWh**	**100**
Heat price	EUR/MWh	43.5
Heat premium	EUR/MWh	45
CO_2 price	EUR/tCO_2	50
Extreme CO_2 price	EUR/tCO2	150
Fuel price	Increase +	30 %

The results of the conducted analysis are set out in Table 38.

Table 38. Results of the analysis

NPV models			**CHP**			
NPV model (5 % discount factor)	NPV/IRR	Biomass	Natural gas	Natural gas/8 % green hydrogen	RDF	Solar collectors
NPV CO_2 price — EUR 50, without premium per MWh of electricity	NPV:	957 879.17	-1 205 346.18	1 367 013.54	2 548 391.02	3 440 082.70
	IRR:	13 %	1 %	17 %	24 %	27 %
NPV CO_2 price — EUR 50, with premium* EUR 45 per MWh of electricity	NPV:	3 201 077.03	1 065 891.65	3 638 251.37	4 791 588.88	3 440 082.70
	IRR:	30 %	8 %	33 %	38 %	27 %
NPV CO_2 price — 150 EUR, without premium per MWh electricity	NPV:	-113 870. 92	-6 302 390.21	-3 322 266.97	-292 992.94	3 273 089.08
	IRR:	4 %	#NUM!	#NUM!	2 %	26 %
NPV CO_2 price — 150 EUR, with premium* EUR 45 per MWh of electricity	NPV:	2 129 326.94	-4 031 152.38	-1 051 029.14	1 950 204.92	3 273 089.08
	IRR:	0.22	#NUM!	-0.14	0.20	0.26
NPV model (5 % discount factor) 30 % for high fuel prices						
NPV CO_2 price — EUR 50, without premium per MWh of electricity+ 30 % for high fuel prices	NPV:	-1 392 137.64	-3 801 046.57	-1 436 342.88	2 227 934.18	3 440 082.70
	IRR:	#NUM!	-17 %	#NUM!	22 %	27 %
NPV CO_2 price — EUR 50, with premium* EUR 45 per MWh of electricity, + 30 % for high fuel prices	NPV:	851 060.22	-1 529 808.73	834 894.96	4 471 132.04	3 440 082.70
	IRR:	13 %	0 %	12 %	36 %	27 %
NPV CO_2 price — 150 EUR, without premium per MWh of electricity + 30 % for higher fuel prices	NPV:	-2 463 887.73	-8 898 090.60	-6 125 623.38	-613 449.78	3 273 089.08
	IRR:	#NUM!	#NUM!	#NUM!	-2 %	26 %
NPV CO_2 price — 150 EUR, with premium* EUR 45 per MWh of electricity + 30 % for higher fuel prices	NPV:	-220 689.86	-6 626 852.76	-3 854 385.55	1 629 748.08	3 273 089.08
	IRR:	3 %	#NUM!	#NUM!	18 %	26 %
NPV model (discount rate 8 %)						
NPV CO_2 price — EUR 50, without premium per MWh of electricity	NPV:	507 859.659	-1 801 714.579	830 189.4384	1 7361 34.884	2 397 793.09
	IRR:	13 %	1 %	17 %	24 %	27 %
NPV CO_2 price — EUR 50, with premium* EUR 45 per MWh of electricity	NPV:	2 275 126.192	-12 357.21404	2 619 546.803	3 503 401.417	2 397 793.09
	IRR:	30 %	8 %	33 %	38 %	27 %
NPV CO_2 price — 150 EUR, without	NPV:	-336 501.018	-5 817 336.869	-2 864 183.068	-502 402.7253	2 266 229.915

premium per MWh of electricity	IRR:	4 %	#NUM!	#NUM!	2 %	26 %
	NPV:	1 430 765.515	-4 027 979.504	-1 074 825.703	1 264 863.808	2 266 229.91 5
NPV CO_2 price — 150 EUR, with premium* EUR 45 per MWh electricity	IRR:	22 %	#NUM!	-14 %	20 %	26 %
NPV model (8 % discount rate) 30 % for high fuel prices						
NPV CO_2 price — EUR 50, without premium per MWh of electricity+ 30 % for high fuel prices	NPV:	-1343562. 424	- 3 846 694.425	-1 378 388.795	1 483 668.236	2 397 793.09
	IRR:	#NUM!	-17 %	#NUM!	22 %	27 %
NPV CO_2 price — EUR 50, with premium* EUR 45 per MWh of electricity, + 30 % for high fuel prices	NPV:	423 704.1098	-2 057 337.06	410 968.57	3 250 934.769	2 397 793.09
	IRR:	13 %	0 %	12 %	36 %	27 %
NPV CO_2 price — 150 EUR, without premium per MWh of electricity + 30 % for higher fuel prices	NPV:	- 2 187 923.101	- 7 862 316.714	-5 072 761.301	-754 869.373	2 266 229.91 5
	IRR:	#NUM!	#NUM!	#NUM!	-2 %	26 %
NPV CO_2 price — 150 EUR, with premium* EUR 45 per MWh of electricity + 30 % for higher fuel prices	NPV:	-420 656.5672	- 6 072 959.349	- 328 3403.936	1 012 397.16	2 266 229.91 5
	IRR:	3 %	#NUM!	#NUM!	18 %	26 %

*Article 33a (New in SG No 38/2018, in force from 1.7.2018) (1) (amended in SG Nos 41/2019, in force as from 1.7.2019, and 9/2021, in force as from 2.2.2021) The KEVR shall determine the amount of the premiums paid for the electricity produced by high-efficiency combined heat and power plants with total installed capacity of 500 kW and more.

The economic potential of the different options for efficient heating and cooling is strongly dependent on future framework conditions such as energy prices, CO_2 prices, and whether external costs or the costs of connecting to district heating are taken into account. In order to clarify this, a large number of scenarios have been developed. The cities that offer potential for district heating for the scenarios concerned have been identified geographically. An assumption was made that for heat demand below
12 GWh/year the construction of new district heating networks is not economically justified. A further assumption is that the calculations made for new district heating plants will also be applicable to existing networks with insufficient capacity to meet demand greater than 10 GWh/year, where expanding the network is technically feasible.

The underlying assumption of the study is that the ultimate goal is to achieve partial or full climate neutrality by 2050. Therefore, the assumption for 2050 is that, among other things, the entire demand for natural gas will be met by mixtures of natural gas (bio-gas) and green hydrogen.

These conditions warrant the following conclusions:

- Decarbonisation in the sector of heating and cooling in Bulgaria is achievable but only under certain substantive assumptions and framework conditions, such as major efforts to renovate buildings, simultaneous decarbonisation of electricity generation and successful synergies of traditional district heating with on-site CHP in the domestic and services sectors.
- The development of district heating systems in the 19 areas identified for possible construction of CHP plants should be examined in light of the plans of the local municipalities, the development of urban infrastructure and the associated technical feasibility of building district heating networks.
- The share of district heating in the future will depend primarily on the degree of connection that can be achieved within the 12 district heating areas, which in turn has a strong link to the regulatory conditions for energy planning. Depending on the achievable rate of connection, the economic potential of district heating is estimated to be in the range of 3 % to more than 10 %. The reduction of energy losses within existing networks to a minimum and the economic tolerability of final energy prices for individual user groups will have an important impact on the speed of connection to heating networks.
- A very high level of decarbonisation, or full decarbonisation, is only achievable on the assumption that the electricity to be supplied in the future is generated from renewable sources.

The following conclusions can be drawn in respect of the technological mix of fuels used to provide district heating:

- The assumptions set out in this study indicate that natural gas, including mixtures of natural gas and biogas/hydrogen, are not an economically viable solution for sector decarbonisation in light of increased GHG prices.
- In the future, biomass may become a substantial resource for heat generation both in terms of on-site use and in district heating. Biomass plants appear to retain their cost-effectiveness under certain conditions even under the scenarios envisaging an extreme increase in the price of emissions.
- Heat pumps and geothermal sources have been rejected at the level of technical options and have not been considered in the analysis.
- The use of waste heat from industrial plants has likewise not been considered in the CBA on account of the low proportion of heat it can provide at national level and the low uptake achieved to date.
- The development of large cogeneration plants is constrained by the regulatory framework. Nevertheless, the development of small CHP plants creates an opportunity for the achievement of cross-sectoral synergies.

- Large-scale solar thermal systems may represent an economically reasonable option on the condition that synergies with cogeneration systems are achieved.
- The use of large heat storage systems has been demonstrated to have a significant contribution to the economic performance of the heating network. At the same time, considerable uncertainty exists as to the costs involved, which also depend on the systems' exact location.

The analysis of models, including in this study, is always fraught with uncertainty. On the one hand, uncertainty arises from possible developments in terms of costs. On the other hand, further uncertainty arises from technological development and the efficiency expected to be achieved in the future along with the relevant technological characteristics. This also shows that the interplay of different renewable district heating technologies in the mix, even when using heat storage systems, is complex and highly dependent on the expected demand for energy for heating and cooling. Expected heat demand in turn strongly depends on the measures for building renovation, and on the achievable levels of connection of new users. As these factors cannot be predicted in the long term, a continuous adaptive planning process is needed on the part of heating network operators and through modification of measures and policies.

3.9 Sensitivity analysis

Sensitivity analysis has been conducted to examine the impact of the most critical and uncertain variables on the results obtained.

As the results are very sensitive to fuel prices, a sensitivity analysis has been conducted in a scenario of a +30 % increase of the prices of all fossil fuels, electricity and solid biomass.

The discount rate is another important factor that affects all results. The application of a discount rate of 8 % (instead of 5 %) in this sensitivity analysis clearly shows that:

- Scenarios that include high efficiency technologies or renewable energy sources (solar) benefit from fuel price increases, so the economic NPV and therefore the economic potential is higher. However, for most solutions, the economic potential (in terms of energy) is unaffected as it was already at maximum level in terms of technical potential in the baseline scenario.
- In contrast to the above, technologies that are more capital intensive with low variable costs (on account of their greater efficiency) compared to those in the baseline scenario, are negatively affected by an increase of the discount rate as their NPV decreases. This is the case for solar thermal plants.

4 POTENTIAL NEW STRATEGIES, MEASURES AND POLICIES

In line with the Delegated Regulation (EU) 2019/826 of the European Commission, this section sets out an overview of ‘new legislative and other strategic measures to exploit the economic potential identified in accordance with the above’.

As the economic potential of district heating is in line with climate targets, the achievement of a higher share of renewable energy in district heating systems should be pursued. Therefore, all network operators should be required to have a plan to increase the efficiency of their existing network, which they should detail how ta higher share of RES by 2030 will be achieved.

As part of this exercise, network operators should describe the necessary measures they plan to take and quantify the expected greenhouse gas (GHG) savings. Efficiency plans should form the basis for the gradual renewal of networks, taking into account planning at municipal level. An exception to this obligation should be provided for operators of local heating networks based on power generated exclusively from renewable energy sources.

New legislative and non-legislative policy measures directly related to the heating and cooling sector are addressed in the following policy documents:

- Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030
- Long-term National Strategy to support the renovation of the national residential and non-residential building stock by 2050,
- National Air Pollution Control Programme 2020-2030,
- Recovery and Sustainability Plan for Bulgaria (V 0.3).

Existing and additional policies and measures will be implemented to achieve the national target of 27.09 % share of RES in gross final energy consumption by 2030. The policies and measures take into account the priorities and guidelines of the new energy and climate policy of the EU and are in line with the experience and results of the policies and measures implemented in the area of RES energy production and consumption to date. The aim is to achieve cost-effective development of RES as an important part of the Union’s decarbonisation policy by 2030.

Barriers to the use of renewable energy, district heating and gas can be identified and acted upon, together with relevant industry organisations. A reassessment of the regulatory framework could be initiated to encourage the use of cleaner or lower emission sources of heating compared to solid fuels.

Policies and measures can be applied to the production of HE CHP to:

- Ensure the development of high-efficiency combined heat and power, along with considering new measures and policies to promote the recovery of energy for heating for cooling;
- District heating companies embracing the opportunities to upgrade existing facilities and heat transmission networks through the derogation provided for in Article 10c and the Modernisation Fund and referred to in Article 10d of Directive 2018/410/EU;[35]
- Use of environmentally-friendly fuels for power generation by existing district heating utilities and in the construction of new plants, including fuel switching, use of energy from renewable sources, waste heat and cold;
- Providing incentives for the construction of local district heating and cooling systems in urban agglomerations, as well as the use of micro-CHP units installed in residential buildings;
- Connecting new consumers of energy for heating and/or cooling to existing heating networks;
- Continuing the reduction of losses in heat transmission and distribution;
- Ensuring the connection of producers of energy for heating and cooling from RES to the existing heat transmission networks and purchasing of the energy generated by other producers by the heat supply company, where this is technically feasible and economically viable.
- Improve policies and measures for the achievement of optimal cross-sectoral connectivity.

The potential measures outlined above are supported by the investment intentions of heating utilities in Bulgaria, such as:

- construction of photovoltaic parks for clean electricity generation;
- construction of electrolysis plants in which hydrogen is produced from the electricity generated in a photovoltaic plant by water electrolysis;

[35] https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX%3A32018L0410

- Construction of oxygen stations enabling the storage of the oxygen produced in water electrolysis. The oxygen stations are planned to be used as an oxidant in boiler gasifiers;
- Construction of gas turbines with an electricity generator as an element of combined-cycle power generation. The gas turbines are envisaged to run on a mixture of natural gas and hydrogen, which will reduce the amount of carbon dioxide generated;
- The use of boiler heaters with the aim of increasing the potential of the heat obtained at the outlet of the gas turbine by burning an additional quantity of natural gas, syngas or biogas to raise efficiency.

The new investments foreseen in the NEEAP 2030 are focused exclusively on renewables and are expected to attract EUR 2.2 billion between 2026 and 2030. The new renewable capacity to be built over the next decade will be dominated by solar power, whose capacity will increase from 7 % in 2018 to just over a third of the energy mix by 2030.The big jump in the construction of new green capacity after 2030 will come in response to the declining share of coal plants and the lack of sufficient natural gas projects. Bulgaria’s Partnership Agreement for the programming period 2021-2027 sets out the Member State’s strategy and priorities for implementing the Cohesion Policy and the Common Fisheries Policy, as well as the framework for the management of EU funds over the programming period 2021-2027. According to the draft document, in the next programming period, EU-funded investments will take place under all five policy objectives of the Union. As part of the procedures under the different operational programmes, applicants for funding should describe the measures necessary for implementation and quantify expected greenhouse gas (GHG) savings.

The implementation the plans should form the basis for the renovation and upgrade of district heating facilities, the construction of new ones and the introduction of RES in the heating and cooling sector, taking into account planning at municipal level.

5 SOURCES OF INFORMATION

1. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 г.http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:BG:PDF;
2. Energy Sector Act - http://lex.bg/laws/ldoc/2135475623;
3. Regulation No E-RD-16-427 of 2.9.2015 laying down the criteria for comprehensive assessment, the cost-benefit analysis and the analysis of the national potential for high-efficiency cogeneration — http://www.eneffect.bg/ee-infocenters/Legislation/Aktualizacia_Jan_2016/Nar%20E-RD- 16427-cogen.pdf;
4. Regulation No RD-16-276 of 19.3.2008 of the Ministry of Energy on determining the quantity of electricity produced from combined heat and power generation; https://www.me.government.bg/bg/library/naredba-rd-16-267- ot19-mart-2008-g-za-opredelyane-na-kolichestvoto-el-energiya-proizvedena-ot-kom-301- c78m260-1.html;
5. Regulation No RD-16-996 of 31.10.2007 of the Ministry of Energy on the content, structure, conditions and procedures for the submission of information by enterprises operating in the extractive industry and the sectors of processing and trading in fuels, conversion. transmission, distribution and trade in energy and natural gas for the purposes of energy forecasting and planning;
6. Methodological guidelines for conducting a comprehensive assessment of the national potential for high-efficiency cogeneration of the Ministry of Energy — https://www.me.government.bg/files/useruploads/files/ukazaniq_16.12.pdf;
7. REGULATION No E-RD-04-2 of 22.1.2016 on energy consumption indicators and energy performance of buildings — http://seea.government.bg/documents/NAREDBA_ERD042_ot_22012016.pdf;
8. REGULATION No 7 of 15.12.2004 on heat conservation and energy savings in buildings of the Ministry of Regional Development and Public Works;
9. REGULATION No E-RD-04-2 of 22.1.2016 on energy consumption indicators and the energy performance of buildings;
10. Fifth national report on progress in the promotion and use of energy from renewable sources https://www.me.government.bg/bg/themes/peti- nacionalen-doklad-za-napredaka-v-nasarchavaneto-i-izpolzvaneto-na-energiyata-ot- vazobnovyaemi-iztochnici-2140-1546.html;
11. Integrated Energy and Climate Plan of the Republic of Bulgaria 2020-2030 https://www.me.government.bg/files/useruploads/files/national_energy_and_climate_plan_bulgaria_clear_22.02.20.pdf;
12. Long-term National Strategy to support the renovation of the national residential and non-residential building stock by 2050
13. REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL 2019 assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the Energy Efficiency Directive as required by Article 24(3) of the Energy Efficiency Directive 2012/27/EU

https://eur-lex.europa.eu/legal-content/BG/TXT/?uri=CELEX:52020DC0326;
14. KEVR reports to the European Commission for 2018 and 2019;
15. Ministry of Economy Bulletin on the state of play and development of the Bulgarian energy sector in 2019 https://www.me.government.bg/files/useruploads/files/buletinenergy2018-04.06.2019-finish.pdf
16. Reports of heating utilities
17. National Statistical Institute (NSI) (http://www.nsi.bg/) ;
18. Sustainable Energy Development Agency (AUER) (http://www.seea.government.bg/bg/);
19. Energy and Water Regulation Commission (KEVR) (http://www.dker.bg/);
20. Ministry of Energy (ME) (https://www.me.government.bg/bg);
21. Electricity System Operator EAD (http://www.tso.bg/);
22. Ministry of Economy (MI) (https://www.mi.government.bg/bg);
23. Ministry of Environment and Water (MOSV) (http://www.moew.government.bg/);
24. Executive Agency for the Environment (IAOS) (https://eea.government.bg/);
25. National Institute for Meteorology and Hydrology of the Bulgarian Academy of Sciences (http://www.meteo.bg/);
26. BULGARGAZ AD (http://www.bulgargaz.bg/);
27. Overgas Inc. AD