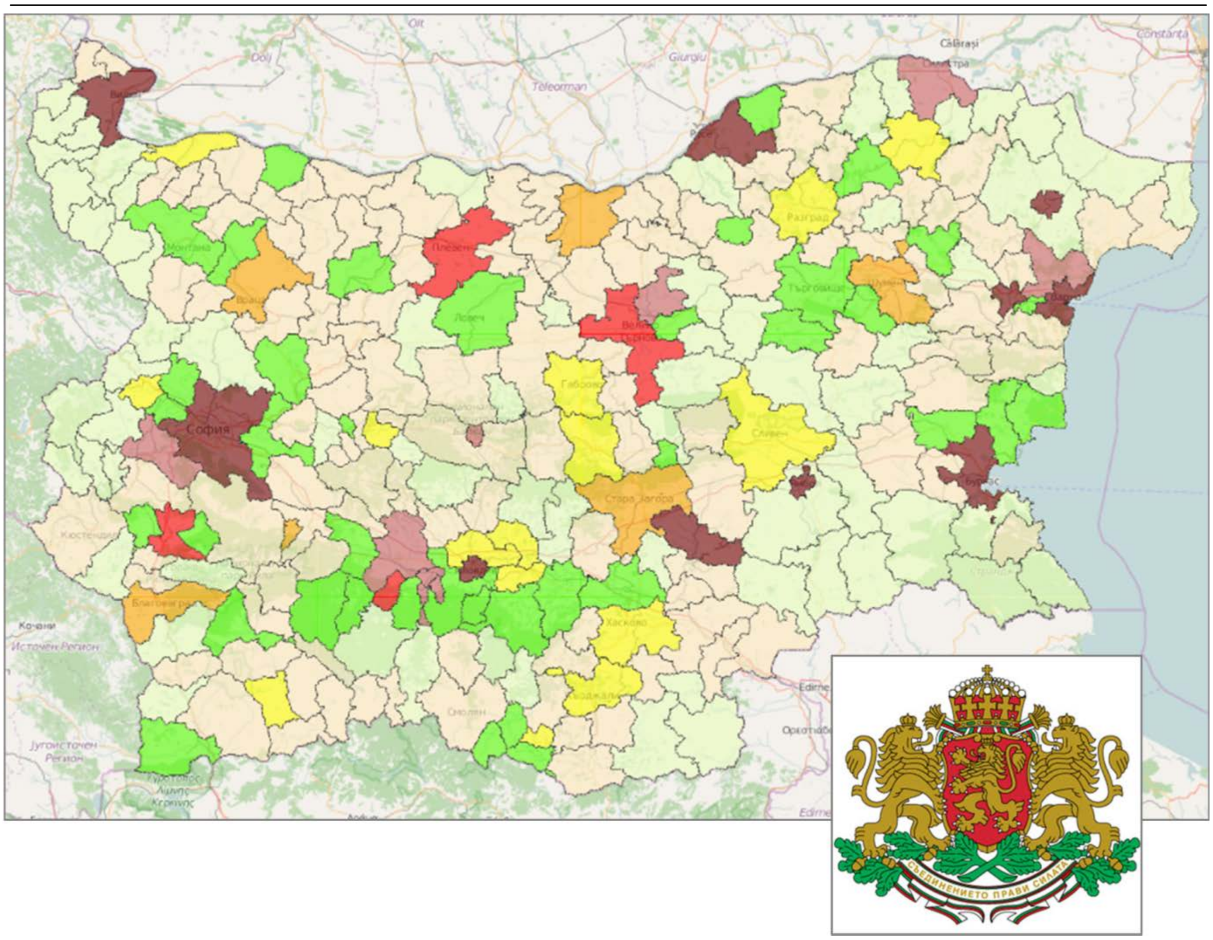
MINISTRY OF ENERGY

Comprehensive Assessment of the Potential for the Application of High-efficiency Cogeneration of Heat and Electricity and of Efficient District Heating and Cooling Systems in the Republic of Bulgaria



2016

Contents

This report is prepared in accordance with the obligation of all Member States of the European Union arising under Article 14(1) of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 *on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC („the Directive“).*

The report contains the results from the studies carried out to assess the potential of Bulgaria for the implementation of high efficiency cogeneration of energy for heating and cooling. Statistical information provided by the Ministry of Energy, the Energy and Water Regulatory Commission, the Sustainable Energy Development Agency, the National Statistical Institute, the National Institute of Meteorology and Hydrology (NIMH).

The information provided was used to develop, on the basis of the administrative map of Bulgaria, a *National Heat Map* which is available at the following address: http://maps.trimbul.com/bulgaria-heatmap/ and contains information about the consumption of energy for heating and about the technologies used to meet these needs in individual municipalities. It illustrates visually the areas with high heat consumption and respectively the location of the largest suppliers of heat using cogeneration.

1 INTRODUCTION

According to the provisions of Article 14, paragraph 1 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency (http://eur-lex.europa.eu/legal-content/BG/TXT/?qid=1463566841114&uri=CELEX:32012L0027), Member States shall carry out a comprehensive assessment of the national potential for the application of high-efficiency cogeneration and efficient district heating and cooling, containing the information set out in Annex VIII to the Directive. That information shall include:

a) a description of heating and cooling demand;

b) a forecast of how this demand will change over the next 10 years, taking into account in particular the evolution of demand in buildings and the different industry sectors;

c) a map of the national territory, identifying, while protecting commercially sensitive information:

i) heating and cooling demand points, including:

— municipalities and conurbations with a plot ratio of at least 0.3 and
— industrial zones with a total annual heating and cooling consumption of more than 20 GWh;

ii) existing and planned district heating and cooling infrastructure;

iii) potential heating and cooling supply points, including:

— electricity generation installations with a total annual electricity production of more than 20 GWh, and
— waste incineration plants,
— existing and planned cogeneration installations using technologies referred to in Part II of Annex I, as well as district heating installations;

d) identification of the heating and cooling demand that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration, and by district heating and cooling systems;

e) identification of the potential for additional high-efficiency cogeneration, including from the refurbishment of existing and the construction of new generation and industrial installations or other facilities generating waste heat;

f) identification of energy efficiency potentials of district heating and cooling infrastructure;

g) strategies, policies and measures that may be adopted up to 2020 and up to 2030 to realise the potential under point (e) in order to meet the demand under point (d), including, where appropriate, proposals to:

i) increase the share of cogeneration in heating and cooling production and in electricity production;

ii) develop efficient district heating and cooling infrastructure to accommodate the development of high-efficiency cogeneration and the use of heating and cooling from waste heat and renewable energy sources;

iii) encourage the locating of new thermal electricity generation installations and industrial plants producing waste heat at sites where a maximum amount of the available waste heat can be recovered to meet existing or forecast heat and cooling demand;

iv) encourage the locating of new residential zones or new industrial plants which consume heat in their production processes at sites where available waste heat, as identified in the comprehensive assessment, can contribute to meeting their heat and cooling demand. This could include proposals that support the clustering of a number of individual installations at the same location with a view to ensuring an optimal matching between demand for and supply of heat and cooling;

v) encourage the linking-up of thermal electricity generating installations, industrial plants producing waste heat, waste incineration plants and other waste-to-energy plants to the local district heating or cooling network;

vi) encourage the linking-up of residential zones and industrial plants which consume heat in their production processes to the local district heating or cooling network;

h) the share of high-efficiency cogeneration and the potential established and progress achieved under Directive 2004/8/EC;

i) an estimate of the primary energy to be saved;

j) an estimate of public support measures for heating and cooling, if any, with the annual budget and identification of the potential aid element. This is without prejudice to the need for a separate notification of the public support schemes for a State aid assessment.

1.1 Goals of the study

The aim of the study is to present the results of the comprehensive assessment of the potential for using high-efficiency cogeneration and efficient district heating and cooling systems according to the requirements of the Directive.

1.2 Limitations and assumptions

The results in the report largely depend both on the quality and the accuracy of the information required for developing the heat map and the forecast model, as well as on the assumptions made. The information received and used from state and municipal institutions has not been verified independently for accuracy and any findings or recommendations made in this report are subject to this reservation.

1.3 Results

This report:

— Presents a comprehensive assessment of the national potential of Bulgaria for the application of high-efficiency cogeneration and efficient district heating and cooling systems as required by Article 14(1) of Directive 2012/27/EU;

— It contains a National Heat Map of the territory of the Republic of Bulgaria as described in point 4 of this Report. The map corresponds to the requirements of point 1 c) of Annex VIII to the Directive.

2 DESCRIPTION OF HEATING AND COOLING DEMAND IN BULGARIA

Under Directive 2012/27/EU of the European Parliament of 25 October 2012, Member States carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration, the energy consumption situation, an analysis of high-efficiency cogeneration, and an assessment of the costs and benefits of using efficient heating and cooling systems, more specifically systems using high-efficiency cogeneration. The term “efficient heating and cooling” means a heating and cooling option that, compared to a baseline scenario reflecting a business-as-usual situation, measurably reduces the input of primary energy needed to supply one unit of delivered energy within the boundaries of the relevant system.

The Eurostat database contains data identical to those published as part of the national statistics, but does not provide specific information relevant to the elaboration of the balance of heat at national level and its territorial distribution according to consumption. The net generation of heat should be taken into account when estimating the useful heat demand in terms of assessing the potential for development of cogeneration. That value should be treated as the required heat that determines the need for development of high efficiency cogeneration.

2.1 Heat demand

The following tables provide information on current energy consumption for heating and cooling in Bulgaria based on information from 2014.

Table 2.1 presents information about the generated heat delivered to the following six groups of consumers:

— District heating installations;

— Large industrial consumers;

— Other industrial consumers;

— Households that are not connected to district heating;

— Consumers from the public sector and the services sector that are not connected to district heating;

— Other consumers from the industrial sector that are not connected to district heating;

The supply of heating energy for the first three groups of consumers is divided into heating from high-efficiency cogeneration and heating from district heating plants (DHP). Table 2.1 presents information about the 28 districts in the country, the basic input data being presented at municipal level.

The correlation of the results in Table 2.1 provides information on the percentage of heat produced by thermal power plants. A total of 13,410 GWh heat was produced and supplied by thermal power plants to consumers in 2014 which accounts for 36.4% of the total heat consumption in the country. About 78.6% of the demand for heat in the household sector is met by heating homes with electricity, solid fuels (coal and wood), liquid fuels and natural gas.

Table 2.1 Consumption of heating by types of customers in 28 districts of Bulgaria – 2014

District	District heating from high-efficiency cogeneration	District heating from DHP	Large industrial consumers from high-efficiency cogeneration	Large industrial consumers from DHP	Other industrial consumers from high-efficiency cogeneration	Other industrial consumers from DHP	Households that are not connected to district heating	Public sector and services that are not connected to district heating	Other industrial consumers that are not connected to district heating	Total supplied heat
	GWh/year	GWh/ye	GWh/year	GWh/ye	GWh/year	GWh/ye	GWh/yea	GWh/ye	GWh/yea	GWh/year
Blagoevgr	0	0	0	0	8	0	945	51	205	1,209
Burgas	74	56	415	102	0	0	984	62	269	1,963
Varna	44	14	3,415	116	2	15	1,219	26	308	5,159
Veliko	13	6	376	16	0	0	713	42	161	1,329
Vidin	0	0	1,104	33	0	0	305	12	61	1,515
Vratsa	17	62	0	0	0	52	522	23	114	789
Gabrovo	18	4	0	0	0	5	309	26	76	438
Dobrich	0	0	0	0	0	0	534	48	119	701
Kardzhali	0	0	0	0	0	0	453	28	99	581
Kyustendi	0	0	0	0	0	0	409	16	83	508
Lovech	0	0	0	0	12	0	461	42	87	602
Montana	0	0	0	0	0	0	474	23	91	588
Pazardzhi	0	0	51	0	0	0	818	44	173	1,087
Pernik	117	48	43	0	0	23	281	26	83	620
Pleven	176	4	0	0	0	38	594	31	166	1,008
Plovdiv	165	24	23	0	39	61	1,657	98	439	2,507
Razgrad	13	12	0	0	1	7	381	22	77	513
Ruse	78	102	7	0	0	62	528	37	148	962
Silistra	0	0	0	0	0	0	390	18	75	482

Sliven	50	34	0	0	0	17	461	22	125	709
Smolyan	0	0	0	0	0	0	423	29	74	526
Sofia city	2,265	1,314	0	0	2	897	812	426	856	6,573
Sofia	0	0	0	0	7	1	863	74	155	1,100
Stara	0	0	1,674	56	0	7	895	43	212	2,888
Targovish	0	0	0	0	0	0	343	14	76	432
Haskovo	0	0	0	0	0	0	690	29	155	874
Shumen	0	0	0	0	0	0	532	60	115	706
Yambol	0	0	0	0	6	5	352	10	82	455
Total for	3,031	1,681	7,108	324	77	1,189	17,349	1,383	4,683	36,824

The contribution of renewable energy sources (RES) to the total heat production is very small, but with a continuous upward trend. The production of energy from biomass by plants in district heating companies in Ruse, Veliko Tarnovo, Burgas, Bansko, Ihtiman, has a more substantial share in the production of heat from RES.

Solar energy is mainly used to heat water for hot domestic water (HDW) through photothermal conversion in the domestic sector and in the hotel industry. This technology is used for hot water for domestic use and in the industry.

Heat pumps are quickly introduced in small industrial enterprises and in the domestic sector for production of heat. Water-to-water heat pumps with electricity capacity of over 20 kW are used in the industry sector and in hotels. Air-to-air heat pumps with a capacity of up to 5 kW are used in the domestic sector for heating homes and offices, while single-family and multi-family houses use air-to-air or water-to-water heat pumps with an electricity capacity from 5 to 30 kW.

2.2 Cooling demand

Presently, no official data has been collected on cooling and air conditioning demand in Bulgaria. The cooling for large customers is generated almost exclusively by compressors and the significant increase in electricity consumption during the summer months points to the fact that the demand for cooling increases. Energy demand for cooling large-volume buildings requiring long hours of work is an essential part of the total energy consumption. For example, the demand for large business buildings is 37%, for the hotel sector 38%, for office buildings 56%. In case the cooling requirements are met through absorption or adsorption thermal installations the potential for development of cogeneration for heating and cooling could be increased.

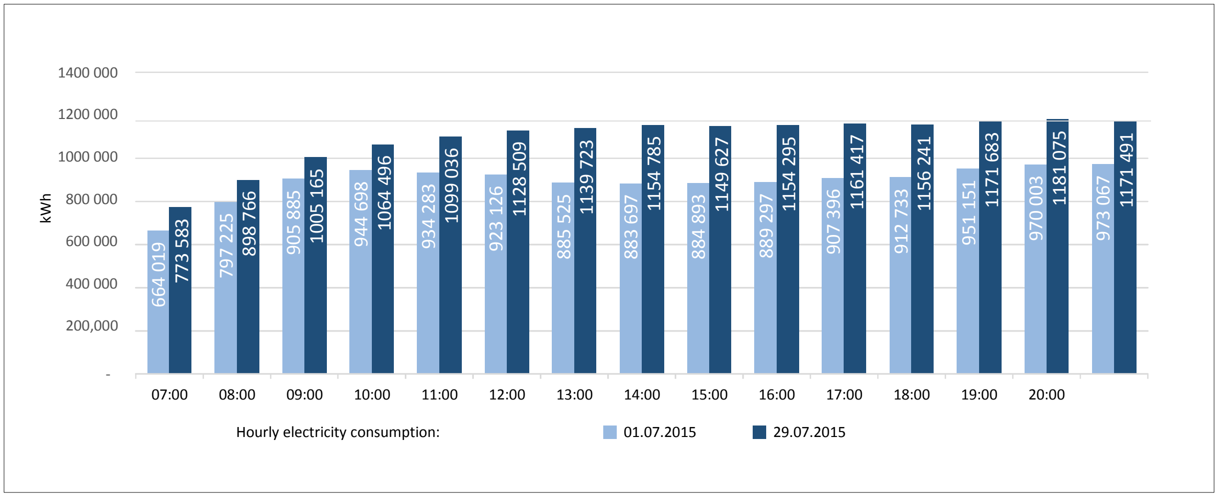
A typical example of high-efficiency generation of energy for heating and cooling is the installation of EVN Bulgaria Toplofikatsia in Plovdiv. In July 2013, EVN Bulgaria Toplofikatsia supplied and installed an absorption refrigerator as part of the first project in Bulgaria for cooling through the district heating systems. The first client of the project is the administrative building of Plovdiv Municipality - Trakia Area, in the city of Plovdiv. The absorption refrigerator converts the heat energy into cooling energy and powers the existing air-conditioning system of the building with cooling energy. As of 2016, chillers for cooling with a total capacity of 6 MW have been installed in the city of Plovdiv, while besides the administrative building of the Municipality of Plovdiv, clients of EVN Bulgaria Toplofikatsia supplied through the heat transmission network with coolant network water with a temperature of 85^{o}C, are also Trimontium Ramada Hotel, the new sports hall and a business building.

Efficient individual heating and cooling is another possibility for heating and cooling residential and office premises. Unlike efficient district heating and cooling where the amount of primary energy comes from non-renewable energy sources, the use of air-conditioning systems with heat pumps allows for the primary energy from non-renewable sources to be decreased by using instead energy from renewable sources such as temperature of the ambient environment, ground water and shallow earth wells. Thus the energy for heating and cooling produced within the rated capacity of the plant has reduced primary energy consumption and no costs for transmission and redistribution are incurred. In this case, the data of the energy consumed for cooling is based on the increased electricity consumption during the hot summer days, taking into account the average monthly temperatures, the cooling performance and the regional cooling degree days.

To illustrate that approach, the hourly electricity consumption for July 2015 in three energy distributors - CEZ, EVN and Zlatni Pyasatsi, was studied. That data is correlated with the average value of the maximum measured temperatures in the weather stations located in the respective regions. The hourly consumption of electricity for the lowest maximum temperature day and the hottest day is compared. The selected days are business days.

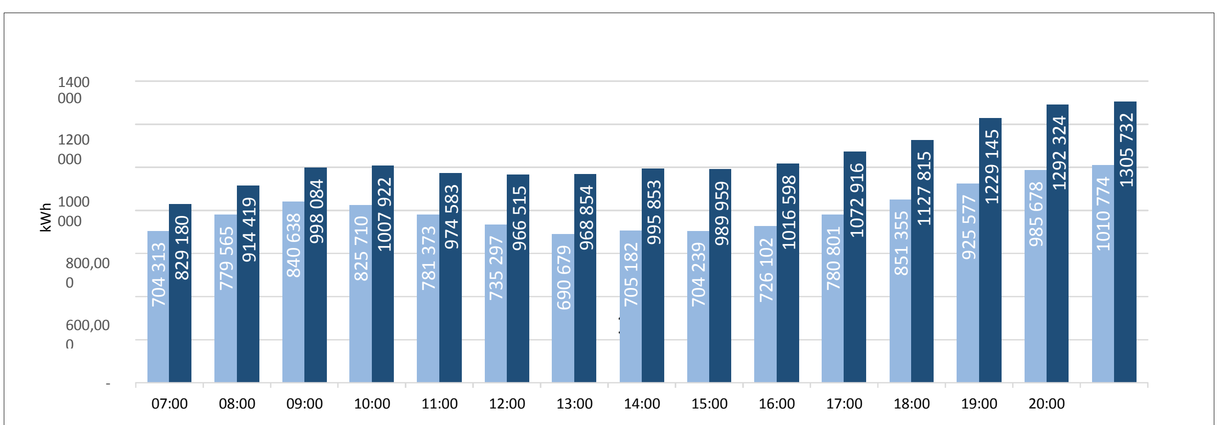
Chart 2.1 presents the hourly consumption of electricity for 01.07.2015, on which date the average value of the highest measured temperatures was 26^{o}C, and for 29.07.2015 when the maximum temperature was 35.7°C. During the hottest day, the aggregate consumption of electricity in the interval 7 - 21 h is 22% higher compared to the consumption on 01.07.2015, which was the coolest day in that month. At 14 h on the hot day, the consumption of electricity was 31% higher due to the need for cooling.

Chart 2.1 Hourly consumption of electricity, 01.07.2015 and 29.07.2015 (CEZ)



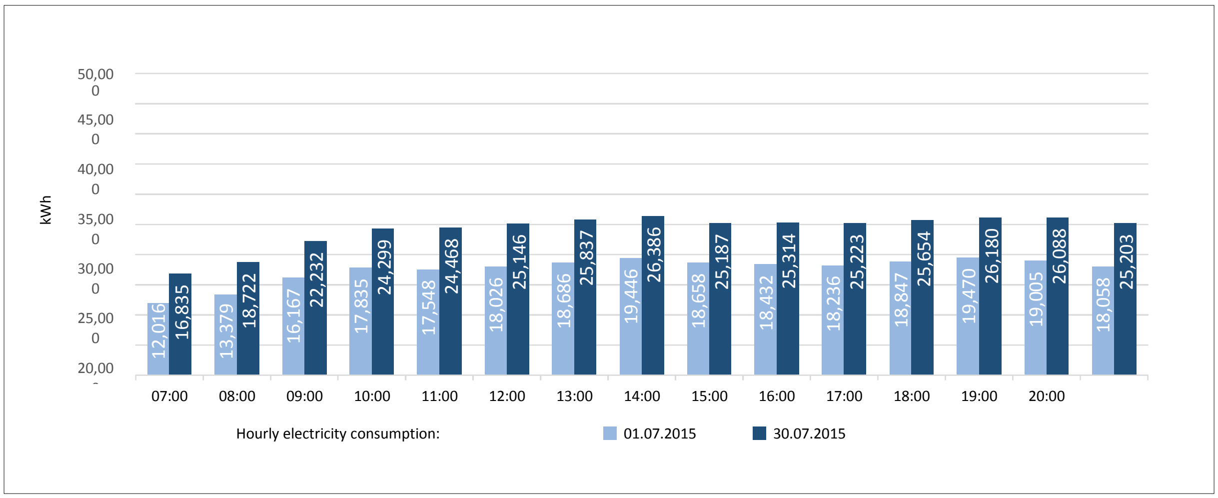
The electricity consumption situation at EVN is worth noting. The region served by EVN encompasses the South Bulgarian climatic subarea. In this climatic area on 30.07.2015 the average value of the highest measured temperatures was 38.2°C and the temperature on the coolest day - 01.07.2015, was 26.6°C. Chart 2.2 shows the hourly consumption of electricity on these two days. During the hottest day, the aggregate consumption of electricity in the interval 7 - 21 h was 30% higher compared to the consumption on 01.07.2015. At 14 h on the hot day, the consumption of electricity was 41% higher as a result of the need for cooling.

Chart 2.2 Hourly consumption of electricity, 01.07. and 30.07.2015 (EVN)



A typical example comes from Zlatni Pyasatsi energy distributor. It serves the region of the Black Sea climatic subarea. In this climatic area, on 26.07.2015 the average value of the highest measured temperatures was 33°C and the temperature on the coolest day - 01.07.2015, was 26.5°C. Chart 2.3 shows the hourly consumption of electricity on these two days. During the hottest day, the aggregate consumption of electricity in the interval 7 - 21 h was 28.5% higher compared to the consumption on 01.07.2015. At 14 h on 26.07.2015, the consumption of electricity was 37% higher as a result of the need for cooling.

Chart 2.3 Hourly consumption of electricity, 01.07. and 26.07.2015 (Zlatni Pyasatsi)



These examples show that the cooling energy is based on the consumed electricity. Small air-conditioning systems with air-to-air heat pumps are widely used.

The cooling performance (MWh/square meter) is determined on the basis of the rules for designing air conditioning systems or on the basis of the actual results of the process monitoring.

Table 2.2 presents an evaluation of cooling energy for the district cities of the 28 districts of Bulgaria. *Note:* The information is based on assumptions about the amount of energy used for cooling at national level as attributed to the district cities according to their population.

Table 2.1 Cooling consumption in the 28 districts of Bulgaria – 2014

District city	Cooling consumption
	GWh/year
Blagoevgrad	3.1
Burgas	8.4
Varna	13.8
Veliko Tarnovo	3.5
Vidin	2.4
Vratsa	2.8
Gabrovo	2.5
Dobrich	3.5
Kardzhali	2.7
Kyustendil	2.3
Lovech	1.9
Montana	2.0
Pazardzhik	4.5
Pernik	3.7
Pleven	5.0
Plovdiv	13.7
Razgrad	2.0
Ruse	6.6
Silistra	1.9
Sliven	4.9
Smolyan	1.6
Sofia city	52.7
Stara Zagora	6.4
Targovishte	2.2
Haskovo	3.6
Shumen	3.6
Yambol	2.9
Total for the country	164.0

More detailed geographical information relating to the number of buildings for each group of consumers and the space cooled is required for the development of a more detailed and exhaustive map of the energy used for cooling.

2.3 Consumption of heat by types of consumers

The end users of heat can be divided into 6 groups:

- Industrial sector:
- Domestic sector including the residential buildings from all settlements;
- Public sector and services - administrative buildings, schools, kindergartens, universities, cultural institutions, municipal buildings and hotels;
- Agrarian sector;
- Other consumers - small consumers in the commercial sector, small businesses and workshops.

2.3.1 Consumption of heat in the industry

Table 2.3 presents information on the industrial consumption of heat from high-efficiency cogeneration and district heating plants (DHP) by districts.

Table 2.3 Industrial consumption of heat generated by high-efficiency cogeneration and DHP - 2014

District	Large industrial consumers from high-efficiency cogeneration	Large industrial consumers from DHP	Other industrial consumers from high-efficiency cogeneration	Other industrial consumers from DHP	Total industrial consumption from high-efficiency cogeneration and DHP
	GWh/year	GWh/year	GWh/year	GWh/year	GWh/year
Blagoevgrad	0	0	8	0	8
Burgas	415	102	0	0	517
Varna	3,415	116	2	15	3,548
Veliko Tarnovo	376	16	0	0	392
Vidin	1,104	33	0	0	1,137
Vratsa	0	0	0	52	52

Gabrovo	0	0	0	5	5
Dobrich	0	0	0	0	0
Kardzhali	0	0	0	0	0
Kyustendil	0	0	0	0	0
Lovech	0	0	12	0	12
Montana	0	0	0	0	0
Pazardzhik	51	0	0	0	51
Pernik	43	0	0	23	66
Pleven	0	0	0	38	38
Plovdiv	23	0	39	61	123
Razgrad	0	0	1	7	8
Ruse	7	0	0	62	69
Silistra	0	0	0	0	0
Sliven	0	0	0	17	17
Smolyan	0	0	0	0	0
Sofia city	0	0	2	897	899
Sofia province	0	0	7	1	8
Stara Zagora	1,674	56	0	7	1,737
Targovishte	0	0	0	0	0
Haskovo	0	0	0	0	0
Shumen	0	0	0	0	0
Yambol	0	0	6	5	11
Total for the	7,108	324	77	1,189	8,698

2.3.2 Consumption of heat in residences and households that are connected to district heating

Table 2.4 presents information on the consumption of heat by households from high-efficiency generation and DHP by districts.

Table 2.4 Consumption of heat from high-efficiency cogeneration and district heating plants - 2014

District	District heating from high-efficiency cogeneration	District heating from DHP	Total consumption by consumers from high-efficiency cogeneration and DHP
	GWh/year	GWh/year	GWh/year
Blagoevgrad	0	0	0
Burgas	74	56	131
Varna	44	14	58
Veliko Tarnovo	13	6	19
Vidin	0	0	0
Vratsa	17	62	79
Gabrovo	18	4	22
Dobrich	0	0	0
Kardzhali	0	0	0
Kyustendil	0	0	0
Lovech	0	0	0
Montana	0	0	0
Pazardzhik	0	0	0
Pernik	117	48	165
Pleven	176	4	180
Plovdiv	165	24	189
Razgrad	13	12	25
Ruse	78	102	180
Silistra	0	0	0
Sliven	50	34	85
Smolyan	0	0	0
Sofia province	2,265	1,314	3,580
Sofia city	0	0	0
Stara Zagora	0	0	0
Targovishte	0	0	0
Haskovo	0	0	0

Shumen	0	0	0
Yambol	0	0	0
Total for the country	3,031	1,681	4,712

2.3.3 Consumption of heat in residences and households that are not connected to district heating

As can be seen from the information provided in table 2.1, in 2014 in Bulgaria the annual consumption of heat by household consumers that are not connected to district heating was 17 349 GWh.

Since there is no systematized information on the amount of heat consumption of households that are not connected to district heating in the different areas of the country, the assessment is made on the basis of the *values of the energy consumption indicators and the energy performance of buildings set out in Ordinance № E-RD-04-2 of 22.01.2016* by calculating the specific annual costs for heat depending on the nature of the settlement and the building stock.

According to section 5.2 of this study the settlements are grouped in the following categories:

- Municipalities with district heating;
- Municipalities with a population of more than 50 thousand residents;
- Municipalities with a population between 10 and 50 thousand residents;
- Municipalities with a population between 5 and 10 thousand residents;
- Municipalities with a population of less than 5 thousand residents.

The data from the national programme for refurbishment of the housing stock shows that the average occupancy of a dwelling in Bulgaria is 2.3–2.4 people, depending on the number of storeys of the building. Therefore, the NSI data about the population of municipalities as of 31.12.2014 and an average coefficient of occupancy of 2.4 residents of a dwelling are used to determine the average number of dwellings in the small municipalities from categories 3 to 5. Given the social structure of the population in small towns, it is assumed that the average heated area per dwelling does not exceed 30 m^2. That area, multiplied by the total specific energy consumption (kWh/m^2 consumed energy - specific rated consumption for heating of 1 m^2), yields the normalized annual consumption of heat per year (kWh/year) for an average dwelling. This is the method of calculating the consumption in dwellings that are not connected to district heating and which are not known to have received an energy certificate by the Sustainable Energy Development Agency (SEDA).

Ordinance № E-RD-04-2 of 22 January 2016 introduced an integrated indicator which is the specific annual energy consumption measured in kWh/m^2 per year.

The scale of energy consumption by type of categories of buildings is as follows:

1. Residential buildings under Annex 6 of the ordinance

Class	EPmin, kWh/m^2	EPmax kWh/m^2	RESIDENTIAL BUILDINGS
A+	<	48	A+
A	48	95	A
B	96	190	B
C	191	240	C
D	241	290	D
E	291	363	E
F	364	435	F
G	>	435	G

where: EPmin and EPmax are respectively the minimum and the maximum numeric value of the limits of the respective class.

The integrated indicator of annual energy consumption in kWh/m^2 per year for each building is calculated using the methodology under article 5, paragraph 3 of the ordinance. The allocation of a building to a class of energy consumption from A+ to G is achieved by comparing the value of the integrated energy indicator “specific annual consumption of energy” in kWh/m^2 with the numerical values of the limits of the classes from the scale of consumption classes according to the following condition:

$EPmin \le EP \le EPmax$

The consumption scale is based on the integrated indicator for specific energy consumption in kWh/m^2 per year. EP is the total specific consumption of energy for heating, cooling, ventilation, hot water, lighting and electrical appliances.

According to European statistics, about 65% of the fuels are used for heating, 15% - for hot water, 15% is the consumption of electricity for appliances and 5% for cooking food.

Therefore, the specific energy consumption for heating may be set at 65% of the integrated indicator for specific energy consumption EP in kWh/m^2 per year.
The following categorization of the building stock is used in order to determine the heat consumed by dwellings that are not connected to district heating:

- Class C: new buildings built according to the energy efficiency requirements;
- Class D: buildings built until 1990;
- Class E: buildings for which EP ≤ Epmax;
- For F class buildings: 1.25 EPmax<EP ≤ 1.5 Epmax;
- For G class buildings: EP > 1.5 Epmax.

Municipalities with fewer than 5 000 residents are village type settlements. The buildings were built mainly before 1960 and do not meet the minimum requirements of energy efficiency. They may be considered as category G with a specific annual heating consumption of 422 kWh/m^2.

Municipalities with 5–10 thousand residents have mainly urban type single-family buildings allocated to category F. The annual specific heating consumption figure applied is 351 kWh/m^2.

Municipalities with 10–50 thousand residents also have buildings with 3–4 storeys in their building stock which meet some energy efficiency requirements. Therefore, the building stock is included in category E and a specific annual heating consumption figure of 260 kWh/m^2 is applied.

Municipalities with more than 50 thousand residents also have residential buildings heated by a district heating system, as well as buildings with more than two storeys built after 1975. The building stock which is not connected to a district heating system is considered to be classified as category E with an integrated indicator of specific annual energy consumption of 290 kWh/m^2, which is equal to the minimum value for that category. The specific annual heat consumption figure applied is 188 kWh/m^2 (65% of 290 kWh/m^2).

Municipalities with district heating and more than 100 thousand residents have buildings that use local or individual heating for single-family or co-owned buildings. Some of them are renovated but have not undergone an energy audit. For buildings that are not connected to district heating, it is accepted that the integrated indicator of specific annual energy consumption is 250 kWh/m^2 (category D) and respectively the specific annual heat consumption is 163 kWh/m^2.

2.3.4 Consumption of heat in the public sector/services

The annual consumption of heat in Bulgaria in 2014 in the public sector and in the services sector by consumers that are not connected to district heating was 1 383 GWh. The assessment was made by municipalities and on the basis of information for 2014 provided by SEDA.

2.3.5 Consumption of heat in the agricultural sector

Table 2.5 provides information on heat consumption in the agricultural sector.

Table 2.5 Consumption of heat by enterprises in the agricultural sector - 2014

Name	Municipality	Unified Classification of Administrative-Territorial and Territorial Units (UCATTU)	Annual heat consumption
			GWh/year
Alt Co AD	Kresna	14492	8.18
Oranzherii Gimel II OOD	Levski	43236	11.70
Oranzherii Gimel I 200 AD	Zvanichevo village	55155	28.80
Oranzherii Gimel I 500 AD	Zvanichevo village	55155	22.30
Private Agricultural Producer Rumyana Velichkova	Trudovets village	05815	7.30
Oranzherii Petrov Dol OOD	Petrov Dol village	58503	1.90
Total			80.18

As of the end of 2014, Bulgaria also had several (9) high-efficiency cogeneration installations operating on biogas. The heat produced by them is used mainly in livestock farms and greenhouses, while the electricity is used for own needs, with the surplus amount being fed into the electricity distribution network. The installations have a total capacity of 13.5 MW with a range of installed capacities from 250 kWh to 5 000 kWh. The amount of electricity generated in 2014 was 30 000 MWh. The main sources of biogas are agricultural products - corn silage, manure, greenhouse waste, etc.

3 FORECAST CHANGE IN HEATING AND COOLING DEMAND OVER THE NEXT 10 YEARS

The Directive requires Member States to make an estimate of the demand for heating and cooling that could be met by high-efficiency cogeneration over the next 10 years.

According to estimates (baseline scenario) of the Directorate General for Energy (DG ENERGY), the Member States are expected to build another 116 GW of cogeneration capacity (net) by 2030, representing 26% of total investment in TPPs. Half of that investment will be spent on building gas-fired power plants, 11% on coal-fired power plants, 9% on oil-fired power plants and 27% on biomass power plants.

As regards the structure of resources, the future development of cogeneration is expected to have the following characteristics:

- speedy introduction of biomass;
- continuing dominant presence of gas-fired power stations;
- decreased use of petroleum products and coal.

After taking into account the decommissioning of old capacity, cogeneration capacity will increase by 170 MW by 2030. Regarding the structure of consumption, while in 2005 19% of capacity was intended for industrial activities, this share will exceed 40% in 2030.

Table 3.1 Forecast change in heating and cooling demand in Bulgaria over the next 10 years

		2010	2015	2020	2025
Total heating	TWh	37.39	36.82	39.19	33.09
Index (2010 = 1)	*1 000*	1.00	0.98	1.05	0.88
Total cooling	TWh	0.08	0.16	0.33	0.49
Index (2010 = 1)	*1 000*	1.00	2.00	4.00	6.00

The forecast demand figures for heating and cooling energy are based on the Energy Strategy of the Republic of Bulgaria up to 2020.

4 NATIONAL HEAT MAP

Part of the comprehensive assessment is the National Heat Map of the territory of the Republic of Bulgaria - http://maps.trimbul.com/bulgaria-heatmap/. The density of consumption (MWh/year/km^2) at municipality level is determined on the basis of the available information on the levels of annual heating consumption and is broken down over the following sectors:

— Heating supplied to district heating plants (in this case the district heating plants are included as consumers and not as a source of heating);

— Heating delivered to customers other than district heating plants:
  - Large industrial consumers (over 20 GWh) of energy for low temperature heating;
  - Small industrial consumers of energy for low temperature heating;
  - Households;
  - Public sector and services (administrative and public buildings, hospitals, schools and kindergartens, theatres, universities, etc.);
  - Other consumers (commercial sector, workshops, etc.).

Chart 4.1 Density of energy used for heating by districts (MWh/year/km^2)

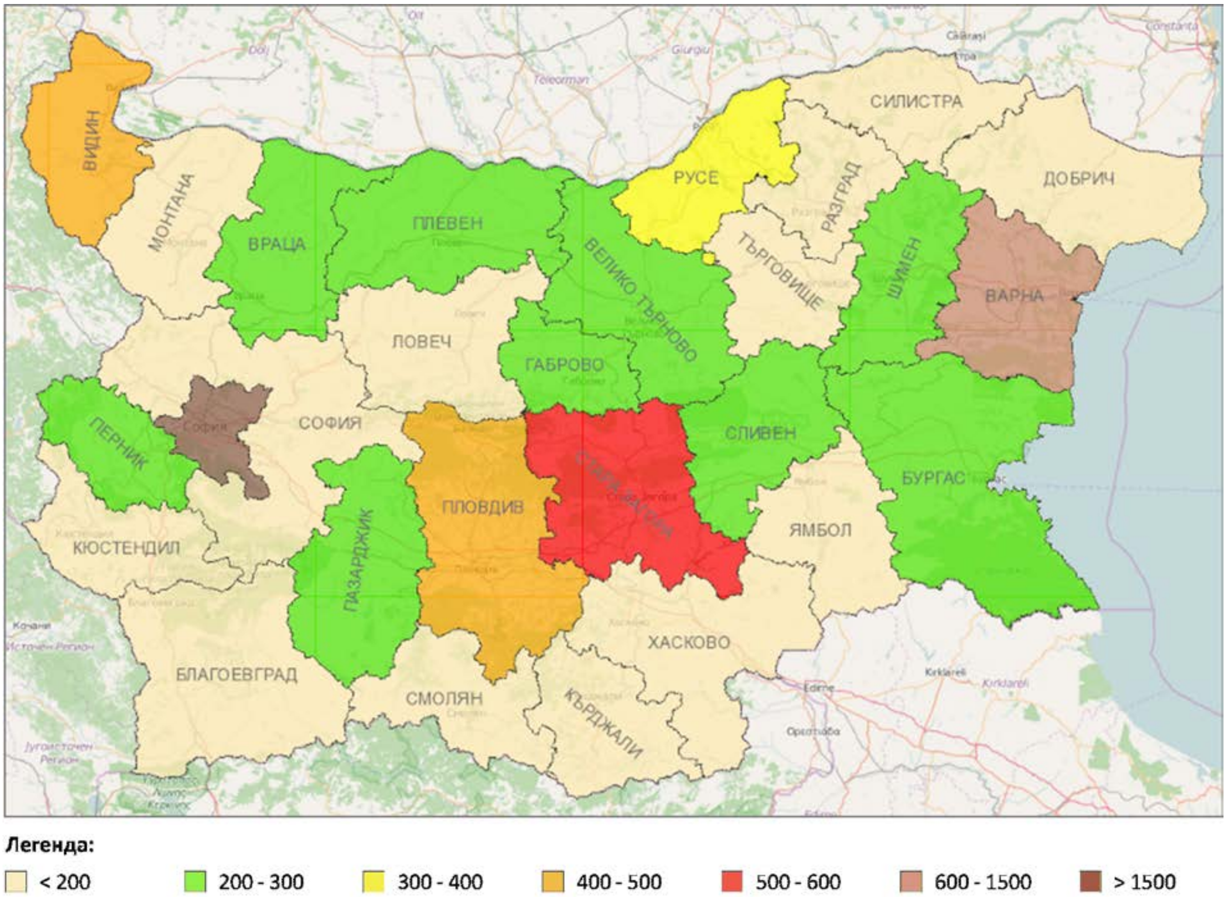


Chart 4.1 illustrates the layer of the heat map of the territory of Bulgaria with the boundaries of the 28 districts. The colour illustrating the heat density in MWh/year/km^2 shows the average value of heat consumption in the respective district. When the scale of the map is changed, the view is changed from district level to municipality level and illustrates the average energy consumption of each municipality (chart 4.2).

Chart 4.2 Density of energy used for heating by municipalities (MWh/year/km^2)

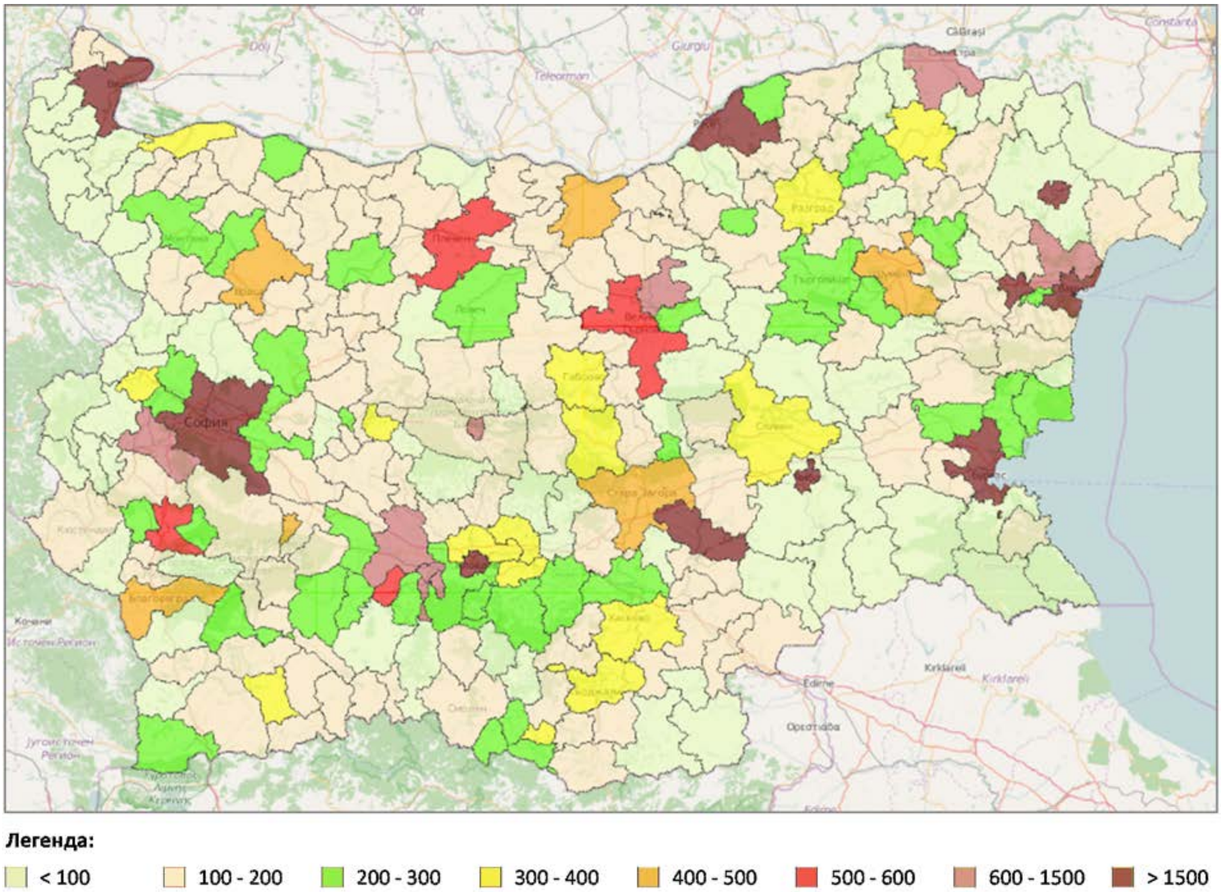


Chart 4.2 illustrates the layer of the heat map of the territory of Bulgaria with the boundaries of the 265 municipalities according to the territorial-administrative division. The colour illustrating the heat density in MWh/year/km^2 shows the average value of heat consumption in the respective municipality.

Chart 4.3 Density of energy used for heating by areas of Sofia, Plovdiv and Varna (MWh/year/km^2)

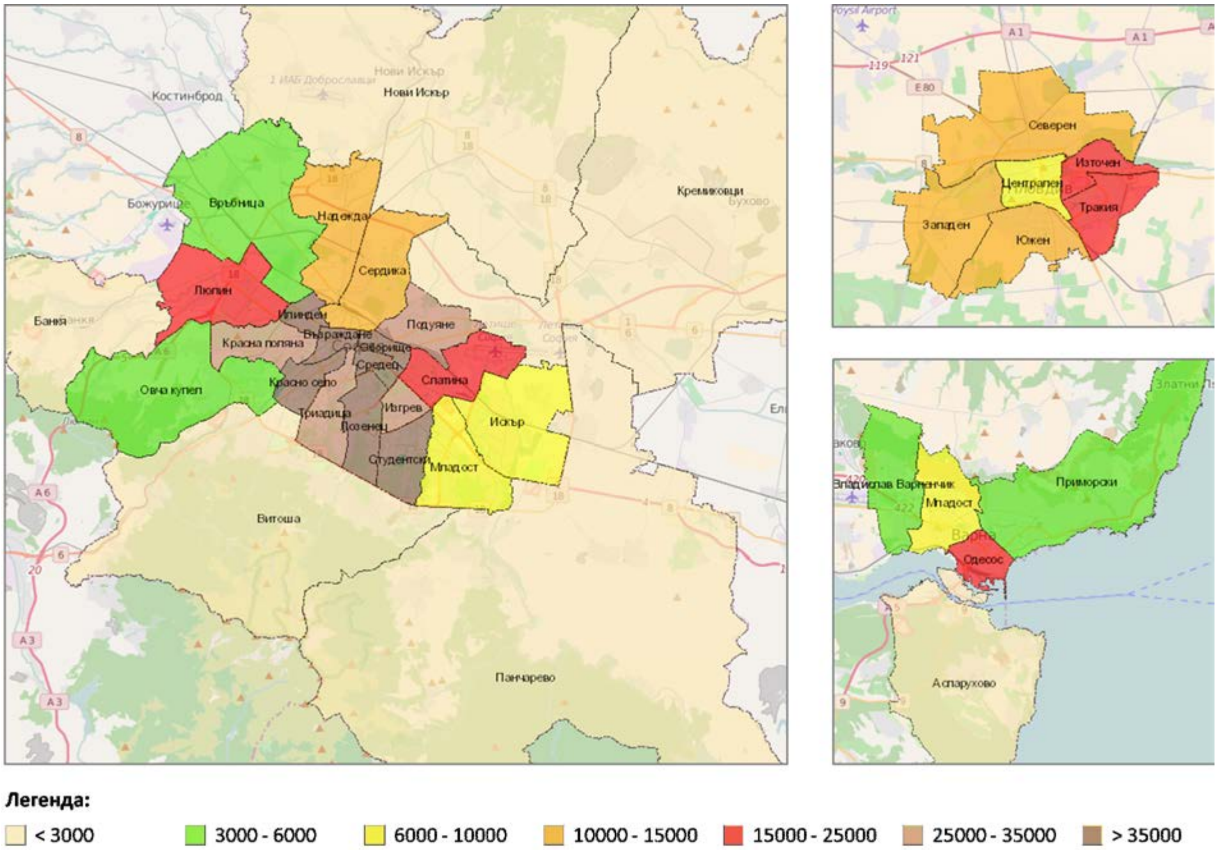
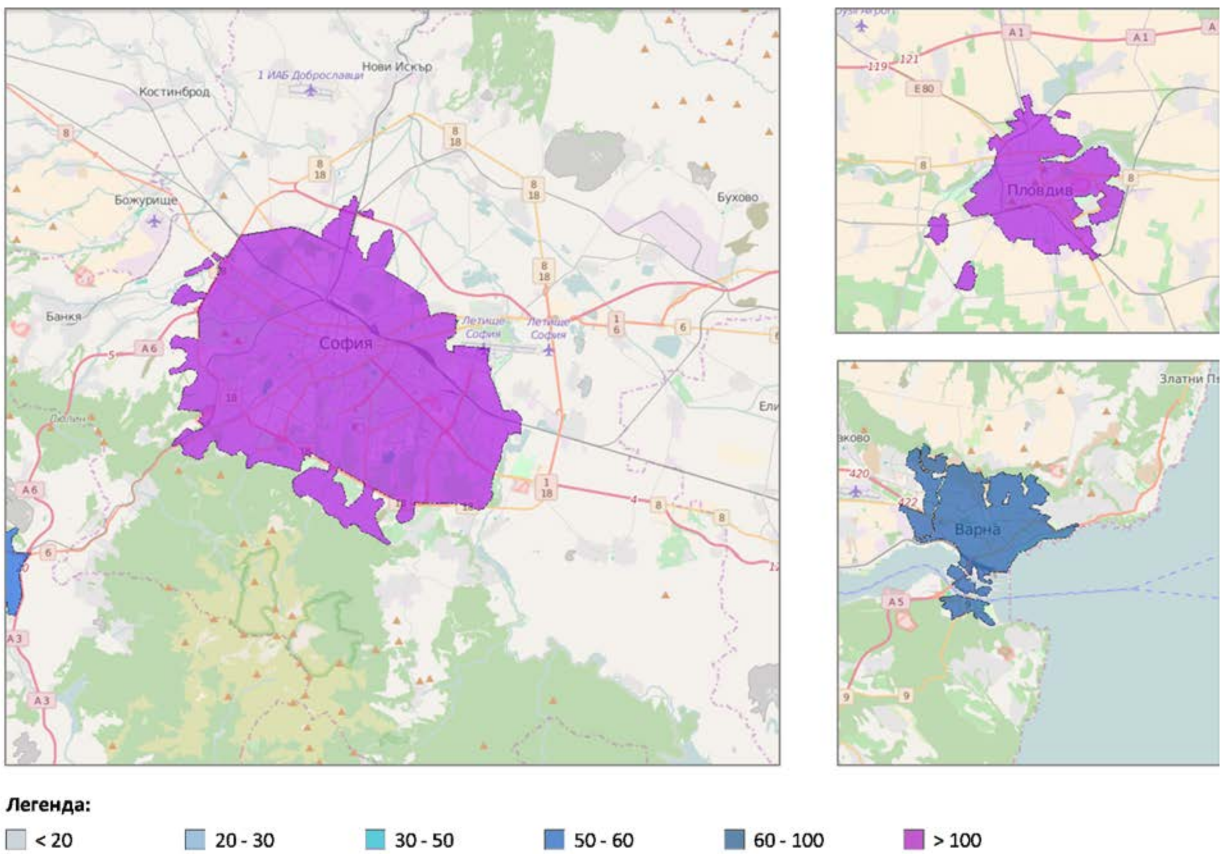


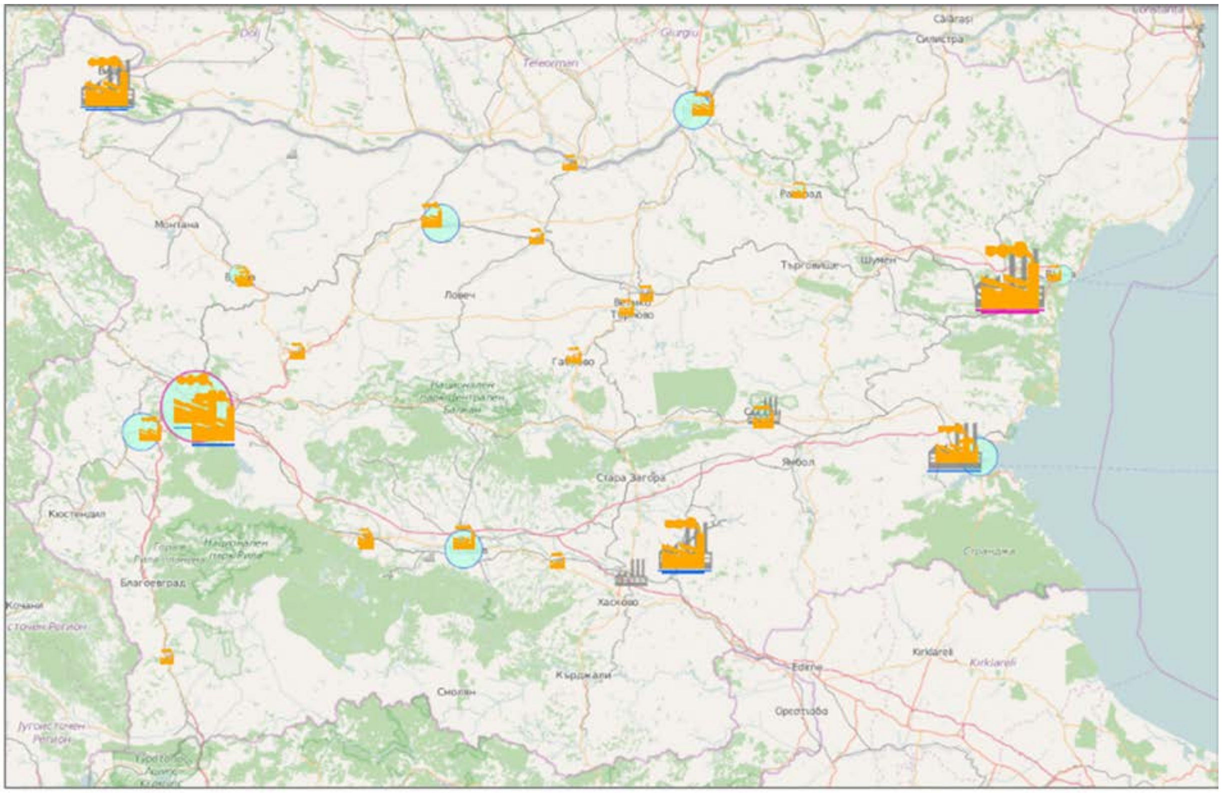
Chart 4.3 illustrates the layer of the heat map of the territory of Bulgaria with the boundaries of the 24 areas of the city of Sofia, the 6 areas of the city of Plovdiv and the 5 areas of the city of Varna according to the territorial-administrative division. The colour illustrating the heat density in MWh/year/km^2 shows the average value of heat consumption in the respective area.

Chart 4.4 Density of energy used for cooling (MWh/year/km^2)



The information on energy used for cooling in MWh/year/km^2 is presented for the district cities based on population. The assumptions of the amount of cooling energy used by one person are made on the basis of the average values in other EU states.

Chart 4.5 District heating plants, large industrial consumers of heat and thermal power plants



Легенда:

ТЕЦ над 20GWh   Топлофикации над 20GWh   Предприятия над 20GWh

In addition to the information on the density of the heat consumed at municipality level, the heat map contains also information on the following individual installations:

— District heating networks;

— Large industrial consumers of heat (more than 20 GWh/year);

— Thermal power plants.

These installations, along with the thermal power plants and the waste incineration plants, are the potential sources that can supply heat to district heating systems.

A table containing information on the selected installation is visualized with a click on the marker indicating the relevant district heating network, thermal power plant or large consumer of heat.

5 DESCRIPTION OF THE METHODOLOGY USED

The purpose of the first stage of the evaluation is to obtain the information needed as input data for analysing the costs and benefits of the different energy-efficient heating and cooling systems, including cogeneration and technologies based solely on heat generated from renewable energy sources that could meet the individual (decentralized) demand for heating/cooling, or the district heating systems designed to meet the demand for heating/cooling by using different types of fuel and technologies.

The technical potential of each of these solutions represents the projected heating/cooling potential of the facility that will be installed, wherever possible, regardless of the associated costs and benefits, without the need to make significant investments in supporting infrastructure such as, for example, a new district heating or gas network. Every solution should be assessed and included in the cost and benefit analysis as explained in more detail in Chapter 7. However, it is necessary to first define terms such as "social cost effectiveness" and "net present value" (NPV).

5.1 Determination of social cost effectiveness and net present value (NPV)

The term "social cost effectiveness" refers to the costs and benefits for society as a whole and not to the assessment of profitability or other aspects. When determining the social net present value (NPV), cash flows are discounted at the social rate of time preferences which is lower than the standard rate of commercial discount and reflects the preferences of society as a whole for the current return, and not as future revenues. When determining the social net present value, external factors such as costs to improve air quality and costs associated with carbon dioxide emissions are also taken into account.

5.2 Segmentation of individual demand for heating/cooling

To ensure a correct and reliable estimate of the potential for individual and network solutions, the different thermal loads are divided into 300 areas, including 265 municipalities, 24 administrative districts in Sofia, 6 administrative districts in Plovdiv and 5 administrative districts in Varna.

These areas are segmented in the following categories:

— Municipalities with district heating;
— Municipalities with a population of more than 50 thousand;
— Municipalities with a population between 10 and 50 thousand;
— Municipalities with a population between 5 and 10 thousand;
— Municipalities with a population of less than 5 thousand.

The following breakdown is applied in assessing consumers: dispersed consumers and point consumers.

Dispersed consumers - this group consists of a large number of small users on whom it is neither practical, nor necessary to collect and use personal data, for example in the case of individual houses or auxiliary buildings. These consumers will be treated as dispersed energy consumers because their energy consumption is related mainly to heating/cooling of their floor space. The data collected about their consumption and other characteristics are allocated to areas with higher demand and are used in the comprehensive assessment.

Point consumers - these are large individual energy consumers, mainly industrial or agricultural, on which there are individualized data. Their heat consumption is influenced primarily by the needs of the industrial processes concerned. Point consumers are included in the comprehensive assessment as individual points of demand for heating/cooling or are grouped as areas of demand. This category also includes large tourist complexes that are outside localities and are not included in the 300 surveyed areas.

The potential for high-efficiency cogeneration with additional heat is modelled for the first three categories of municipalities because the heat loads involved are significant and data are available on heat consumption. It should also be noted that there are no accurate data for the consumption of heat by individual buildings. For that reason, such data are modelled as average values for buildings of a particular type and according to the type of fuel currently used for heating.

5.3 Identification of high-efficiency options for heating/cooling

It is possible to use a number of potential technologies for high-efficiency heating and cooling both for district heating networks and for individual consumers of heating or cooling. According to this analysis, high-efficiency cogeneration and heat pumps are the two key technologies with potential for cost savings.

5.3.1 Existing technology

The model examines existing technology that could, according to the assessment, be replaced by a more efficient technology before the end of its service life.

5.3.2 Baseline technology

A technology that serves as an alternative, against which all possible high-efficiency technologies are compared. As explained in section 5.4.1, natural gas is assumed to be the primary heating fuel, where available, and coal is used where there is no gas available. Where high-efficiency cogeneration is deployed, with additional heat being produced by boilers, the assumption is that the boilers may be replaced with gas installations to increase the efficiency of cogeneration.

5.3.3 Determination of heat-demand system boundaries

The following parameters that define requirements such as heat load and heat density per unit area, district-heating-network transmission capability and limit length are used to determine the boundaries of systems:

— Density of buildings: ratio between the floor area and the surface area of given district;
— Heat density: amount of useful heat demand related to a unit area of a given district for one year;
— Linear heat density of transmission: amount of useful heat demand related to a unit length of a pipeline route;

— Additional parameter: total amount of heating/cooling demand within the boundaries of the system.

A proper breakdown of heating energy demand by district requires the use of diverse information. Data sets related to land register, housing development, social status of households and the use of assumptions for each model need to be combined for that purpose.

The processing of existing information points to an insufficiency in the case of most towns and cities with a district heating system, or to the fact that the existing district heating network has reached its maximum expansion because of a decrease in the number of residents and a temporary end to the construction of new housing. Sofia City is a typical example in that respect.

Areas with basic heat demand:

A. Industrial zones, for example:

— Industrial area Bozhurishte - in the area of the town of Bozhurishte there is an industrial zone including several large production companies and there is a potential for its expansion, with its natural needs for heating and cooling energy. The potential consumers around this area include also the tens of large enterprises in the sphere of services and the commercial centres built around the highway to Kalotina and to the west from the ring road of Sofia (e.g. METRO-Zapad, BAUMAX, AIKO, TECHNOMARKET, SCHENKER, the showrooms of Citroen, Audi, Toyota and others) that are within a radius of about 0.5-1.5 km from the industrial area. Additional points of heating demand can be the multi-storey residential buildings in the centre of Bozhurishte.

  The potential to meet the heating demand can be defined in two ways:

  - Construction of a new cogeneration plant with a capacity satisfying the current consumers (the consumers listed above) and the future consumers (when the industrial zone is expanded) with an appropriate heat transmission network (HTN). The future cogeneration plant and the HTN can be built with larger capacities than the real and farther projected load based on the possibility to sell the excess heat to Toplofikatsia Sofia (after conclusion of mutually beneficial agreements) and a connection can be constructed between the new HTN and the existing network of

Toplofikatsia Sofia (powered by Heating Plant Lyulin) which has two main pipelines just 2 km from the industrial zone.

- The heat load of the industrial zone will be fed through an extension of the HTN of Toplofikatsia Sofia (from DHP Lyulin) to the west (in view of the nearby main heat transmission pipelines) and reconstruction of Heating Plant Lyulin and construction of cogeneration capacities.

B. Distanced commercial centres that cannot be connected to the district heating network, for example:

— The area around Mall Sofia Ring and Ikea. Both sites are consumers of heating and cooling energy all year round, using electricity. Other buildings in the sphere of services are to be built next to these two large consumers. The construction of a local high-efficiency cogeneration plant may become an alternative scenario in the future.

C. Residential areas with concentrated household heat load due to high-rise residential buildings that are not connected to a district heating network (DHN):

— Residential quarter Manastirski Livadi - potential options:
    - Building a local high-efficiency cogeneration plant and the respective local HTN
    - Connecting a new HTN to the existing HTN of Toplofikatsia Sofia which extends as far as the neighbouring residential quarter of Borovo, after reconstruction of the transmission possibility of the existing HTN and construction of cogeneration capacities in the heat source - DHP Zemlyane.

— Residential quarter Malinova Dolina - potential options:
    - Building a local high-efficiency cogeneration plant and the respective local HTN
    - Connecting a new HTN to the existing HTN of Toplofikatsia Sofia which extends as far as the nearby residential quarter of Mladost IV, after reconstruction of the transmission possibility of the existing HTN and intensification of the cogeneration capacities in the heat source thermal power plant (TPP) Sofia Iztok.

5.3.4 Different options for high-efficiency heating

The following high-efficiency technologies were considered:

A. Individual possibilities for heat production

- High-efficiency cogeneration based on natural gas (microcogeneration, piston engines, gas turbines, steam turbines and combined gas turbines) with additional heat that is generated by gas boilers;
- High efficiency cogeneration (steam turbines) where the heat is generated by a coal-fired power plant;
- High efficiency cogeneration (steam turbines) where the heat is generated by a biomass-fired thermal power plant;
- Air-to-air, air-to-water or water-to-water heat pumps. Where necessary, these options will be available to the existing local heating networks in schools and residential buildings that are not connected currently to district heating.

B. Possibilities for supply connected to new district heating networks

Where appropriate, such new networks can deliver heat to buildings in the public sector and in the services sector as well as to residential buildings that are not currently connected to district heating systems.

5.4 Applicability of high-efficiency heating/cooling options

Not all of the above options are applicable to all sectors. It is assumed that air-to-air heat pumps and photothermal conversion of solar energy are not suitable for industrial or district heating because of the low temperature of the generated heat and the need for large amounts of heat. For the purposes of assessing the social net present value (NPV) of the high-efficiency individual or district heating solution, it is assumed that the underlying technology will be applied in segments unsuitable for high-efficiency heating technologies. It is also assumed that high-efficiency cogeneration on the basis of natural gas is a suitable option only where the high-efficiency cogeneration or gas boilers have been chosen as a basic technology, as described in Section 5.4.1. Furthermore, it is assumed that the district heating networks are not suitable for the industry because of the high temperature of the heat which is required by most of the industrial manufacturers. The information on heat production and consumption by the industry clearly shows that a number of factory plants can provide both high-temperature heat to the industry, and low temperature heat to the district heating networks. In this case, it would be possible to increase the amount of heat generated by factories' thermal stations and to increase the supply of heat to the existing networks.

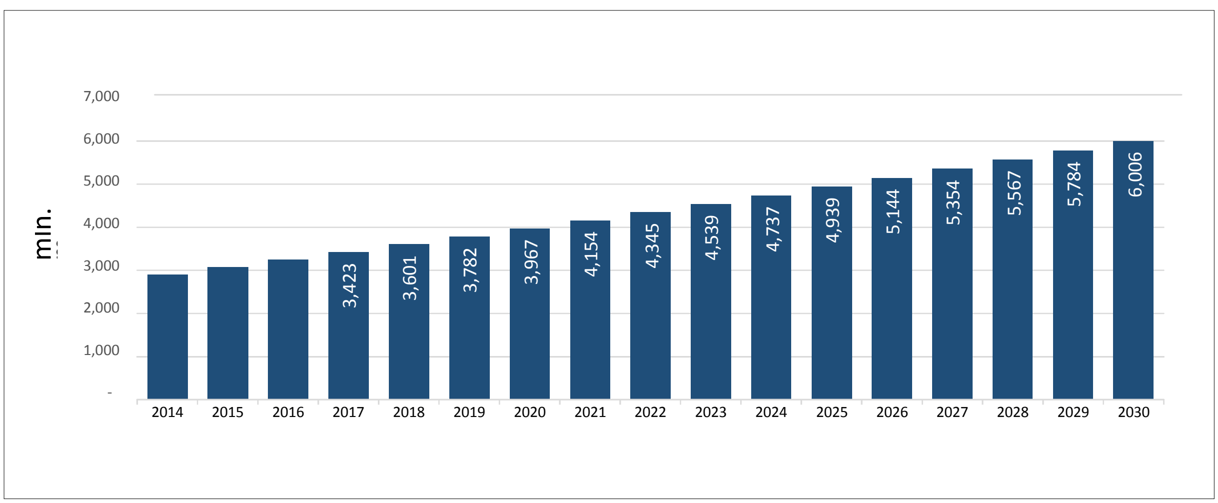
5.4.1 Availability of natural gas and its impact on the technical options

Prospects for the demand of natural gas in Bulgaria for the period 2014-2030:

The forecast for the demand for natural gas in Bulgaria was developed by analysing historical data for the development of the economy and the relationship between the GDP growth and energy demand. The forecast is based on the following assumptions:

- Increase of the share of natural gas in the energy mix - from 13% at the beginning of the period to 27% at the end of the period;
- Growth in primary energy consumption (PEC) from 17 to 22 million tons of oil equivalent;
- GDP growth is around 2% per year;
- Closing down facilities in the nuclear energy sector;
- Replacement of the energy from the closed nuclear and thermal power plants for production of electricity using natural gas.

Chart 5.1 Forecast for the consumption of natural gas in Bulgaria



It is expected that in 2030 the consumption of natural gas in Bulgaria will slightly exceed 6 billion m^3.

At the background of such development of the natural gas market by 2030, the average natural gas consumption per capita in the country will reach 860 cubic meters/person, which is commensurate with the EU average.

With the availability of natural gas, it is assumed that high-efficiency cogeneration with natural gas would be an appropriate solution only for areas that are supplied with natural gas. The data on the current availability of natural gas in each municipality and the expected extension of the gas transmission network were laid down in the model. On that basis, the analysis takes into account that natural gas is currently available in approximately 175 municipalities (zones) from a total of 300 municipalities (zones), and that number is expected to grow to 260 areas by 2025.

The following three options can be used in the determination of the basic scenario for development of district heating systems under the assumption of a "business as usual" scenario:

A. If it is assumed that the fuel used remains unchanged, i.e. coal-fired boilers will be replaced by new plants for high efficiency cogeneration.

B. If it is assumed that all boilers will be replaced with gas boilers in places supplied with natural gas.

C. If it is assumed that all boilers will be replaced with gas boilers in places where natural gas will be available in 2019.

5.5 Summary of heating/cooling options

Table 5.1 Possible heating/cooling options

Type of facilities	Main technology	Option 1 (Individual high-efficiency gas-based cogeneration)	Option 2 (Individual high-efficiency coal-based cogeneration)	Option 3 (Individual high-efficiency biomass-based cogeneration)	Option 4 (Individual heat pumps)	Option 5 (New district heating networks with high-efficiency gas-based cogeneration)	Option 6 (New district heating networks with high-efficiency coal-based cogeneration)	Option 7 (New district heating networks with high-efficiency biomass-based cogeneration)	Option 8 (Solar and geothermal energy including the main source)
175 areas with central gas supply by 2016									
Industry/ Existing district heating and networks	Individual gas-fired boilers	Individual high efficiency gas-based cogeneration with additional supply of heat from boilers	Individual high efficiency coal-based cogeneration with additional supply of heat from boilers	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Schools/ kindergartens (not connected to district heating and networks)	Individual gas-fired boilers	Individual high efficiency gas-based cogeneration with additional supply of heat from boilers	Individual high efficiency coal-based cogeneration with additional supply of heat from boilers	Not applicable	Individual heat pumps	New district heating networks with high efficiency gas-based cogeneration	Not applicable	Not applicable	Solar collectors with individual gas-fired boilers
Residential buildings (not connected to district heating networks)	Existing system for heating and type of fuel	Gas-based microcogeneration where gas is available	Not applicable	Not applicable	Individual heat pumps		Not applicable	Not applicable	Solar collectors with existing system for heating and type of fuel

Type of facilities	Main technology	Option 1 (Individual high-efficiency gas-based cogeneration)	Option 2 (Individual high-efficiency coal-based cogeneration)	Option 3 (Individual high-efficiency biomass-based cogeneration)	Option 4 (Individual heat pumps)	Option 5 (New district heating networks with high-efficiency gas-based cogeneration)	Option 6 (New district heating networks with high-efficiency coal-based cogeneration)	Option 7 (New district heating networks with high-efficiency biomass-based cogeneration)	Option 8 (Solar and geothermal energy including the main source)
125 areas without central gas supply by 2016									
Industry/Existing district heating networks	Individual high-efficiency coal-fired boilers	Not applicable	Individual high-efficiency coal-based cogeneration with additional supply of heat from boilers	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Schools/kindergartens (not connected to district heating networks)	Individual high-efficiency coal-fired boilers	Not applicable	Individual high-efficiency coal-based cogeneration with additional supply of heat from boilers	Not applicable	Individual heat pumps	Not applicable	New district heating networks with high-efficiency coal-based cogeneration with additional supply of heat from boilers	Not applicable	Solar collectors with individual coal-fired boilers
Residential buildings (not connected to district heating networks)	Currently used fuel	Not applicable	Not applicable	Not applicable	Individual heat pumps	Not applicable	Not applicable	Not applicable	Solar collectors with the existing heating system and type of fuel

5.6 Description of the technical assessment model and a cost and benefit assessment model

The functions of the model are as follows:

1. For each zone category 1, 2 and 3 described in Section 5.1, the model is used to calculate the required power in case of a basic technology and individual options for high-efficiency cogeneration based on gas, coal and biomass, heat pumps and solar thermal energy.
2. For each of the 19 municipalities, the model is used for the calculation of the total consumption of heat for residential buildings and buildings in the services sector that are presently not connected to district heating networks and the possibility to build district heating and cooling through high-efficiency cogeneration based on natural gas, biomass or coal.
3. The model allows for calculation of the capital costs and the annual maintenance costs of individual solutions and district heating networks.
4. The model is used to calculate the annual production of heat and electricity and the amount of fuel for each variant for heating, taking into account the need of additional supply of heat from boilers.
5. The model is used to calculate the discounted cash flows and the present value (PV) between 2015 and 2044 for all primary options and individual potentials for high-efficiency heating of the zones of categories 1, 2 and 3, taking into account the capital costs, the maintenance costs, the long-term instability of fuel prices, the external costs, and the social discount rate.
6. For each category of municipalities under point 5.2, the model identifies the most efficient heating option from a social and economic point of view (the one with the highest PV value). In some cases, the identified option is the main option.
7. For each municipality, the total present value (PV) for the best combination of individual solutions for heating of buildings in the public sector that are not currently connected to the district heating network is compared to the present value (PV) for new district heating networks based on gas, coal and biomass.
8. The total generated heat and electricity and the annual production and the number of facilities are summarized on the basis of the criteria for selection of the most socially and economically advantageous combination of individual and new solutions for heating in each municipality.
9. The base present value (PV) is subtracted from the PV for each high-efficiency solution in order to calculate the net present value (NPV) for each of the high-efficiency options and then it is summarized using the same rules.

Table 5.2 Technical assumptions and estimate of the heating technology costs

Type of plant	Fuel	Technique	Power				Heat to electricity coefficient	Minimal power	Efficiency in condensing mode	Efficiency in cogeneration mode	Efficiency	Satisfying heat demand (the difference is covered only by boilers)	Consumption parameter (electricity/heat)	Capital costs BGN/kW=A x MWe^n		Maintenance costs			Operating expenses	Average service life
														A	n	Power variables	Constants	Production variables		
			electricity		heat			heat			heat									
description	description	description	kWₑ	kWₑ	kWₜ	kWₜ	dimensionless	kWₜ	%	%	%	%	dimensionless	BGN/kW	dimensionless	BGN/kW/year	BGN/year	BGN/MWh	BGN/MWh	years
Microgeneration	Gas	Stirling engine	1		12	-	11.83	0.01	6.0%	6.0%	71.0%	100.0%	Electricity	2 435.26	-	-	-	20.05	48.94	15
High-efficiency cogeneration	Gas	Gas piston engine	5		12	-	2.33	0.01	22.3%	22.3%	52.0%	63.4%	Electricity	1 655.90	-	-	-	6.26	15.32	15
High-efficiency cogeneration	Gas	Gas piston engine	13		30	-	2.33	0.03	22.3%	22.3%	52.0%	63.4%	Electricity	1 873.30	-	-	-	6.26	15.32	15
High-efficiency cogeneration	Gas	Gas piston engine	13	50	30	117	2.33	0.03	22.3%	22.3%	52.0%	63.4%	Electricity	468.27	(0.1500)	-	-	6.26	15.32	15
High-efficiency cogeneration	Gas	Gas piston engine	50	100	75	150	1.50	0.08	31.7%	31.7%	47.7%	63.4%	Electricity	455.34	(0.1500)	-	-	6.09	14.78	15
High-efficiency cogeneration	Gas	Gas piston engine	100	200	131	262	1.31	0.13	33.8%	33.8%	44.2%	63.4%	Electricity	455.34	(0.1500)	-	-	6.09	14.78	15
High-efficiency cogeneration	Gas	Gas piston engine	200	1 000	240	1 200	1.20	0.24	38.0%	38.0%	45.6%	63.4%	Electricity	455.34	(0.1500)	-	-	6.09	14.78	15
High-efficiency cogeneration	Gas	Gas piston engine	1,000	4,000	1,600	6,400	1.60	1.60	30.0%	30.0%	48.0%	63.4%	Electricity	455.34	(0.1500)	-	-	4.83	11.73	20
High-efficiency cogeneration	Gas	Small gas turbines	4 000	7 000	6 400	11 200	1.60	6.40	30.0%	30.0%	48.0%	63.4%	Electricity	814.68	(0.2300)	-	-	4.55	11.05	20
High-efficiency cogeneration	Gas	Small gas turbines	7 000	25 000	8 400	30 000	1.20	8.40	30.0%	30.0%	36.0%	63.4%	Electricity	814.68	(0.2300)	-	-	4.05	9.82	20
High-efficiency cogeneration	Gas	Large gas turbines	25 000	40 000	30 000	48 000	1.20	30.00	35.0%	35.0%	42.0%	63.4%	Electricity	814.68	(0.2300)	-	-	4.05	9.82	20
High-efficiency cogeneration	Gas	Gas turbines – comb.	40,000	200,000	30,400	152,000	0.76	30.40	45.1%	38.6%	29.3%	63.4%	Electricity	637.43	(0.1000)	-	-	3.03	7.37	20
High-efficiency cogeneration	Gas	Gas turbines – comb.	200,000		152,000	-	0.76	152.00	45.1%	38.6%	29.3%	63.4%	Electricity	374.34	-	-	-	3.03	7.37	20
High-efficiency cogeneration	Coal	Steam turbines and	1,000	10,000	3,000	30,000	3.00	3.00	31.0%	18.6%	55.8%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
High-efficiency cogeneration	Coal	Steam turbines and	10,000	25,000	30,000	75,000	3.00	30.00	31.0%	18.6%	55.8%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
High-efficiency cogeneration	Coal	Steam turbines and	25,000		75,000	-	3.00	75.00	33.0%	19.8%	59.4%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
High-efficiency cogeneration	Biomass	Steam turbines and	1,000	10,000	3,000	30,000	3.00	3.00	31.0%	18.6%	55.8%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
High-efficiency cogeneration	Biomass	Steam turbines and	10,000	25,000	30,000	75,000	3.00	30.00	31.0%	18.6%	55.8%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
High-efficiency cogeneration	Biomass	Steam turbines and	25,000		75,000	-	3.00	75.00	33.0%	19.8%	59.4%	63.4%	Electricity	1 571.66	-	-	-	10.12	24.56	20
Heat-only plant	Gas	Boiler			20		not applicable	-	not applicable	not applicable	84.6%	100.0%	Heat	72.24	-	4.33	-	-	-	15
Heat-only plant	Gas	Boiler			20	180	not applicable	0.02	not applicable	not applicable	84.6%	100.0%	Heat	44.77	-	1.44	-	-	-	20
Heat-only plant	Gas	Boiler			180	3,600	not applicable	0.18	not applicable	not applicable	81.0%	100.0%	Heat	31.39	-	0.48	-	-	-	20
Heat-only plant	Gas	Boiler			3,600	100,000	not applicable	3.60	not applicable	not applicable	81.0%	100.0%	Heat	22.85	-	0.48	-	-	-	20
Heat-only plant	Gas	Boiler			100,000		not applicable	100.00	not applicable	not applicable	81.0%	100.0%	Heat	14.54	-	0.48	-	-	-	20
Heat-only plant	Coal	Boiler			8		not applicable	0.01	not applicable	not applicable	80.8%	100.0%	Heat	423.49	-	9.09	-	-	-	20
Heat-only plant	Coal	Boiler			20		not applicable	0.02	not applicable	not applicable	80.8%	100.0%	Heat	315.49	-	9.57	-	-	-	20
Heat-only plant	Coal	Boiler			20	180	not applicable	0.02	not applicable	not applicable	77.0%	100.0%	Heat	288.48	-	3.24	-	-	-	20
Heat-only plant	Coal	Boiler			180	1,000	not applicable	0.18	not applicable	not applicable	77.0%	100.0%	Heat	225.71	-	9.72	-	-	-	20
Heat-only plant	Coal	Boiler			1,000	5,000	not applicable	1 000.00 0	not applicable	not applicable	77.0%	100.0%	Heat	205.63	-	8.97	-	-	-	20
Heat-only plant	Coal	Boiler			5 000		not applicable	5 000.00 0	not applicable	not applicable	77.0%	100.0%	Heat	157.40	-	6.97	-	-	-	20
Heat-only plant	Fuel oil	Boiler			20		not applicable	-	not applicable	not applicable	84.6%	100.0%	Heat	78.70	-	2.31	-	-	-	15
Heating with electricity	Electricity	Boiler			10	23	not applicable	-	not applicable	not applicable	90.0%	100.0%	Heat	84.24	-	-	-	-	-	15
Ovens	Coal	Boiler			8		not applicable	0.01	not applicable	not applicable	70.0%	100.0%	Heat	423.49	-	9.09	-	-	-	20
Ovens	Coal	Boiler			20		not applicable	0.02	not applicable	not applicable	70.0%	100.0%	Heat	299.79	-	9.09	-	-	-	20
Heat pumps	Electricity	Heat pump			6		not applicable	0.01	not applicable	not applicable	300.0%	100.0%	Heat	596.82	-	4.17	-	-	-	20
Heat pumps	Electricity	Heat pump			10		not applicable	0.01	not applicable	not applicable	300.0%	100.0%	Heat	541.66	-	2.50	-	-	-	20
Heat pumps	Electricity	Heat pump			20		not applicable	0.02	not applicable	not applicable	300.0%	100.0%	Heat	445.19	-	1.25	-	-	-	20
Heat pumps	Electricity	Heat pump			50		not applicable	0.05	not applicable	not applicable	320.0%	100.0%	Heat	388.41	-	8.86	-	-	-	20
Heat pumps	Electricity	Heat pump			300		not applicable	0.30	not applicable	not applicable	320.0%	100.0%	Heat	276.25	-	2.01	-	-	-	20
Solar collectors	None	Flat plate collectors			1	5		0.00	not applicable	not applicable	not applicable	10.3%	Heat	669.28	-	18.46	-	-	-	20
Solar collectors	None	Flat plate collectors			5	10		0.01	not applicable	not applicable	not applicable	10.3%	Heat	669.28	-	18.46	-	-	-	20
Solar collectors	None	Flat plate collectors			10	20		0.01	not applicable	not applicable	not applicable	10.3%	Heat	576.97	-	9.23	-	-	-	20
Solar collectors	None	Flat plate collectors			20	32		0.02	not applicable	not applicable	not applicable	8.1%	Heat	576.97	-	9.23	-	-	-	20
Solar collectors	None	Flat plate collectors			32			0.03	not applicable	not applicable	not applicable	8.1%	Heat	369.26	-	3.46	-	-	-	20

6 ANALYSIS OF THE NATIONAL POTENTIAL FOR THE APPLICATION OF HIGH-EFFICIENCY COGENERATION AND ALTERNATIVES

The available national technical potential for applying high-efficiency cogeneration is determined on the basis of the actual annual heat consumption for 2014.

The first step is to identify the existing capacities of high-efficiency cogeneration from Section 2 in order to compare them with the existing heating and cooling needs.

The above leads also to an assessment of the possibility to replace the existing cogeneration capacities with new high-efficiency cogeneration in order to satisfy the annual heat consumption by the industry and the district heating networks which are, according to the available information, the only sectors with cogeneration on the spot. The possibilities of using gas, coal and biomass are assessed separately because of the different heat-to-electricity ratio and the different service life.

The next step is to calculate the technical potential to introduce new high-efficiency cogeneration that will provide heat to the existing district heating networks, industrial plants, buildings in the public and the private sectors that do not yet have a cogeneration system. These calculations are made for two different scenarios:

— first scenario - where a district heating network is available;

— second scenario - includes installation of new district heating networks that will deliver heating to public and residential buildings which are not connected to district heating.

The results of these calculations are presented below.

6.1 Existing capacity for high-efficient cogeneration

Table 6.1 Existing capacity for high-efficient cogeneration

Parameter	Capacity for production of electricity from high efficiency cogeneration (MWe)
Total rated capacity for electricity generation (MWe)	13,563
Installed electrical capacity of large power plants and combined heat and power (CHP) plants (GWh/year)	8,585
Installed electrical capacity of a CHP plant with certified high-efficiency generation (MWe)	814

Most of the capacities installed in the power plants are suited also for the production of heat (63%), i.e. they can operate in cogeneration mode, but only 814 MWe of their capacity for heat generation may be defined as high-efficiency cogeneration.

6.2 Technical condition in 2014

The following tables show the total heat demand in the country and the maximum potential for heat generation, taking into account different technical solutions. The assessment of the heat load accommodation through building new district heating networks includes the total heating costs of buildings in the public and in the household sectors that are not connected to district heating, but are localized on a small area to avoid major investment costs. If there is an available district heating network, the heat generated by high-efficiency cogeneration plants is assessed after taking into account the transmission losses.

The municipalities where local regional high-efficiency cogeneration plants for heating and cooling can be built are determined on the basis of audits of the heating demand in the municipalities (see Section 2) and the results from the economic modelling. The analysis takes into account also the type of fuel depending on the local conditions of its availability and supply.

Assessments whether the investments in new heating networks will increase the technical potential for using high-efficiency cogeneration can be made after comparing the potential for high-efficiency cogeneration and the need to build new district heating networks for the local regional systems providing heat to the public and the residential sectors.

Table 6.2 Technical condition for heat generation in high-efficiency cogeneration plants in 2014

Technical condition for heat generation GWh/year	Share by sectors and district heating networks				TOTAL
	Existing district heating networks	Industry	Public sector and services that are not connected to district heating	Individual heating in residential buildings not connected to district heating	
Total demand for heat	4,712	8,698	6,065	17,349	36,824
Breakdown: cogeneration with additional heat from boilers					
Share of high-efficiency	64%	83%			
Share of boilers	36%	17%			
Total production, gross	5,830	8,698	6,065	17,349	37,941
Places with existing cogeneration	3,750	7,185	-	-	10,935
High-efficiency gas-based cogeneration with additional heat from	2,572	5,964			8,535

High-efficiency coal-based cogeneration with additional heat from	1,178	1,221			2,399
Places without existing cogeneration	2,080	1,512	6,065	17,349	27,007
Generation of heat from gas-fired boilers	2,045	-			2,045
Generation of heat from coal-fired boilers	-	-			-
Generation of heat from biomass-fired boilers	35	-			35
Gas-based	-	-			-
Heat pumps	-	-			-
Solar and geothermal installations with additional heat from boilers	-	-			-

6.3 Technical potentials in 2025

In table 6.3, the total demand for heat for 2025 is in line with the forecast GDP growth of Bulgaria, as well as with the expected decrease of the energy intensity in the same period. Respectively, the gross production of heat envisages reduction of the heat transmission losses from slightly over 23% in 2014 to 10% in 2025 for the existing district heating networks or from a total of 7% in 2014 to 5% in 2025.

The potential for new high-efficiency cogeneration capacities is assessed on the basis of the population not connected to district heating and the climatic indicators of the regions where such population is concentrated. Upon the application of the following criteria:

— population above 42,000, and

— heat consumption of over 10 GWh per year,

it was established that the potential for new high-efficiency cogeneration capacities covers approximately 50% of the population in the country not connected to district heating, i.e. 19 settlements.

The average heat load is determined (on the basis of the average length of the heating season and the share of heating energy - a coefficient of ß=0.9 is accepted) after calculating the heat supplied to those settlements. The total heat load, including the losses, is estimated taking into account the load for domestic hot water (DHW) and applying the expected heat transmission losses. The average minimum and the average ambient temperatures show the peak heat load of the respective settlements.

The change of the GDP and the energy intensity are taken into consideration in the calculation of that potential.

The net present value is calculated for every potential new high-efficiency cogeneration capacity taking into account the following:

- the required electrical and thermal power to meet the basic heat load;
- the operating hours;
- the installation life-cycle;
- the fixed and variable costs;
- the capital costs needed to build the plant;
- the type of fuel.

The appropriate technology is selected on the basis of the highest net present value and the area where the facility is to be located (usually representing a condition for access to different fuels).

Accordingly, the amount of heat generated by the new facilities is to be included into new local regional networks. It is planned to build additional high-efficiency capacities based on gas in the places with existing cogeneration and the difference to the peak load is to be covered by boilers. Gas-fired boilers are to be installed in the places without existing cogeneration.

Thus the envisaged capacities are to replace the inefficient ones in the public sector and in the services sector that are not connected to district heating.

Table 6.3 Technical potential for heat generation in new high-efficiency cogeneration plants and alternatives by 2025

Technical potential for heat generation GWh/year	Share by sectors and district heating networks					TOTAL
	Existing district heating networks	Industry	Public sector and services that are not connected to district heating	Individual heating in residential buildings not connected to district heating	New district heating networks - local and extensions	
Total demand for heat	5,967	11,013	6,642	21,967	1,038	46,627
Breakdown: cogeneration with additional heat from boilers						
Share of high-efficiency cogeneration	64%	83%			100%	
Share of boilers	36%	17%			0%	
Total production, gross	6,563	11,123	6,538	21,967	1,142	47,334
Places with existing cogeneration	4,221	9,189	-	-	993	14,404
High-efficiency gas-based cogeneration with additional heat from boilers	2,895	7,627			993	11,515
High-efficiency coal-based cogeneration with additional heat from boilers	1,326	1,562			-	2,888
Places without existing cogeneration	2,342	1,934	6,538	21,967	149	32,930
Generation of heat from gas-fired boilers	2,302	-	6,538		149	8,989
Generation of heat from coal-fired boilers	-	-				-
Generation of heat from biomass-fired boilers	39	-				39
Gas-based microcogeneration	-	-				-
Alternative high-efficiency solutions						
Heat pumps			6,538			
Solar and geothermal installations with additional heat from boilers						

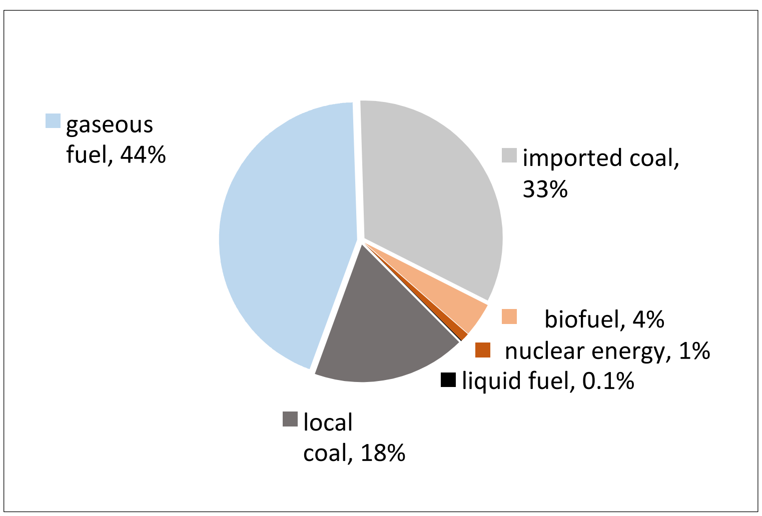
Licences for the activity of district heating have been issued by the Energy and Water Regulatory Commission (EWRC) to more than 20 regional district heating companies. Other licenses have been issued to thermal power plants belonging to the assets of chemical, metallurgical, food processing, petrochemical and textile industrial enterprises. Most of the companies have facilities for cogeneration of electricity and heat and hold a license to sell electricity in a combined way at preferential prices approved by EWRC.

All district heating companies providing district heating in 12 major cities of the country, except for Toplofikatsia Sofia AD (servicing over 70% of all users of heating and being 100% municipal property), are privately owned.

In 2014, the total amount of heat generated by heating power plants (HPP), factory thermal power plants (FTPP) and nuclear power plants (NPP) is 15 TWh, which is 0.8% less compared to 2013. In structural terms, the largest amount is produced by FTPP - 56%, followed by HPP - 43%, and NPP - 1%.

The gaseous fuels have the largest share of all fuels used in the production of heat - 44%, followed by imported coal - 33%, local coal - 18%, and biofuels - 4%. The other fuels have an insignificant share.

Chart 6.1 Structure of the energy sources used for heat production (2014), % based on a thousand tons oil equivalent



The share of imported energy sources for heat production is 76% and that of local sources - 24% (nuclear energy is accounted for as a local energy source).

The total final heat consumption in the country in 2014 amounts to 12.4 TWh, which is 0.1% less than in 2013. In the structure of heat consumption, non-household (industrial and commercial) consumers have the largest share - 67%, followed by household consumers - 28%, and non-household budget consumers - 5%.

The district heating in 12 major cities of the country is provided by cogeneration plants producing heat and electricity.

They produced 6.6 TWh heat in 2014.

The final consumption of heat produced by these plants is 4.8 TWh where 73.0% of that energy is for household consumers, 14.7% - for non-household (industrial and commercial) consumers, and 12.3% - for non-household budget consumers.

6.4 Primary energy production

The production of primary energy in the country accounts for around 60% of the gross domestic energy consumption with a relatively invariable structure in recent years and with dynamics determined by the consumption (NSI data).

Chart 6.2 Production of primary energy and gross domestic energy consumption (1000 toe)

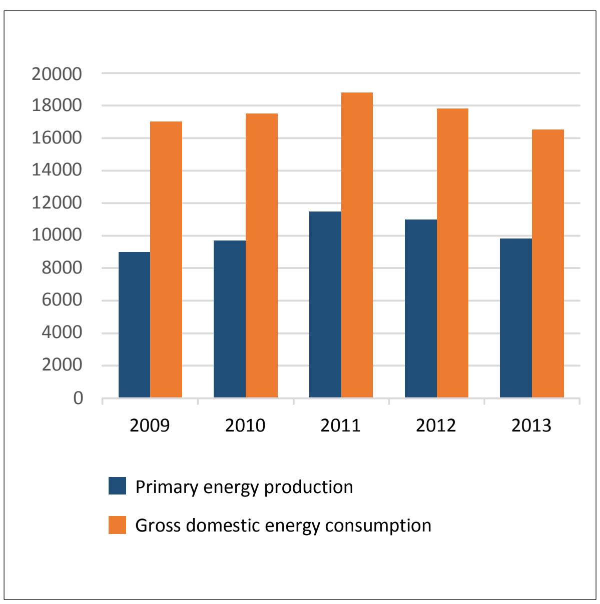
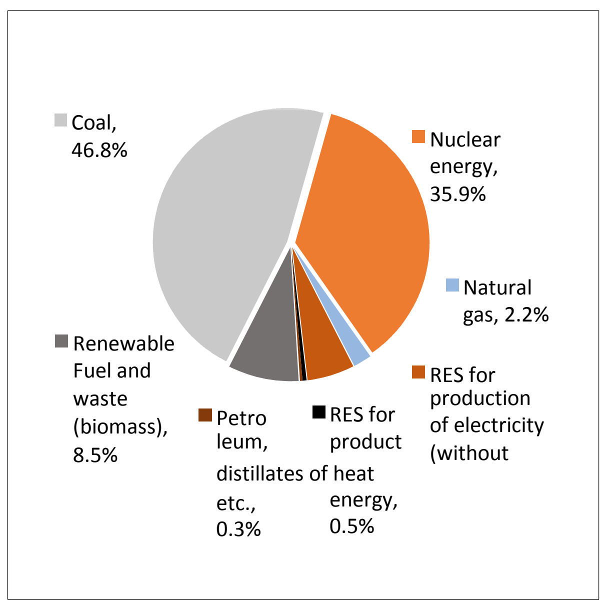


Chart 6.3 Structure of primary energy production (2013)



6.5 Energy transformation

About 2/3 of the fuel and energy are used by plants for generation of electricity and heat, approximately 1/3 - by refineries for production of oil products, and an insignificant amount - by briquette factories, blast furnaces and coking enterprises. The energy produced as a result of the transformation is about 60% of the transformation input.

Chart 6.4 Primary energy used for transformation, 1000 toe

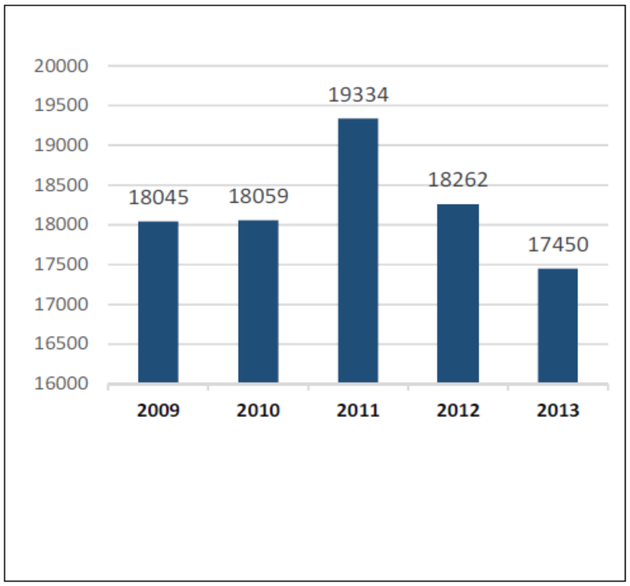
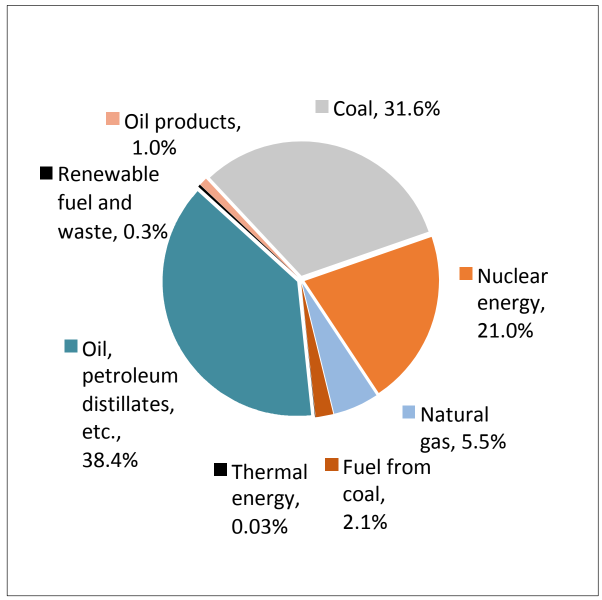


Chart 6.5 Fuel and energy transformation input (2013)



6.6 Final energy consumption

The energy available for final consumption is used for non-energy consumption (mainly by the chemical industry) and for energy consumption.

Chart 6.6 Structure of final energy consumption (2013)

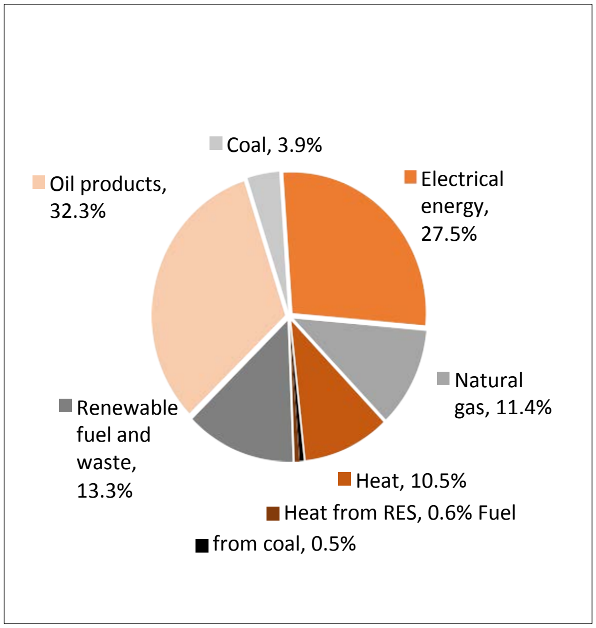
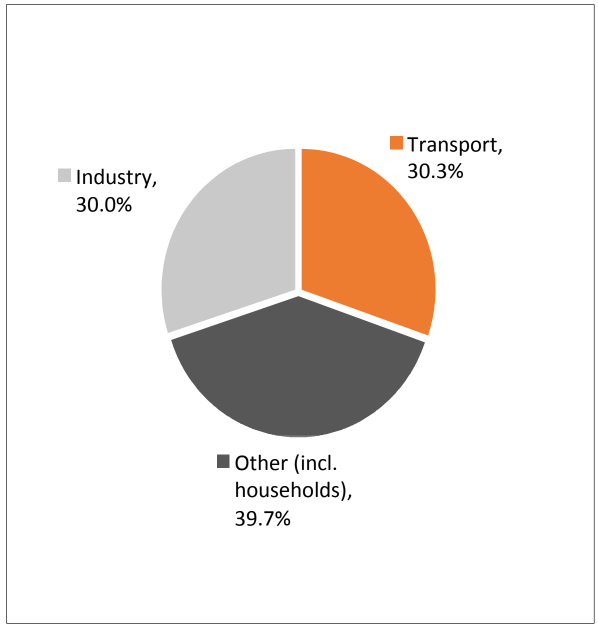


Chart 6.7 Final energy consumption by sectors (2013)



The potential for production of heat in new cogeneration installations can be achieved primarily through:

1. Transition from separate heat production to high-efficiency cogeneration of electricity and heat

The highest potential in that respect exists in Sofia where the share of separate heat production in Toplofikatsia Sofia is about 37% of the total heat produced by utilising the capacity of the company. There have been preliminary studies for the construction of gas-steam cogeneration plants for heat and electricity in the two large heating plants of the company, with a total electrical capacity of 96 MWe and a total heat capacity of 100 MWt. The total energy efficiency of the plant is expected to be 85% and the savings of natural gas - more than 20% compared to the separate production of heat and electricity.

There are also separate plans to build unit plants with gas-piston internal combustion engines for cogeneration of heat and electricity in the six district heating plants of the company, with a total electric capacity of 24 MW_e, a heat capacity of 24 MW_t and thermal batteries with a total capacity of about 8000 m^3.

2. Transition from Rankine steam cycle to cogeneration gas steam cycle

There is a possibility to expand the potential for cogeneration at Toplofikatisa Sofia.

A gas steam plant for cogeneration of heat and electricity with an electric capacity of 95-105 MWe and a thermal capacity of 80-95 MW_t is envisaged for one of the two thermal power plants of Toplofikatsia Sofia – TPP “Sofia-Iztok”.

The implementation of such a system involves the construction of:

— gas turbine with a waste heat boiler with an electric capacity of 65-75 MW_e;

— anti-pressure steam turbine with a condensing boiler with an electric capacity of 30 MW_e and a thermal capacity of 80-95 MW_t

(The Programme for technological renovation of Toplofikatsia Sofia EAD envisages the reconstruction of turbogenerator TG 3 of TPP Sofia Iztok and the transition from a condensation turbine to an anti-pressure turbine with a condensing boiler.)

The plant will operate 8400 h/year; the required investment is BGN 107,000,000, of which:

— BGN 98,000,000 for the gas turbine and the waste heat boiler;
  — BGN 9,000,000 for the reconstruction of TG 3.

The total energy efficiency of the plant is expected to be 85% and the savings of natural gas - 29.27 % compared to the separate production of heat and electricity.

3. Intensification and expansion of existing cogeneration

The following is integrated in the business plans of a number of companies:

— Intensification of the existing cogeneration through construction of gas-steam plant units with gas piston engines with a total rated capacity of 80-98 MW_e and 70-90 MW_t, with investments of about BGN 103,300,000.

— Expansion of the existing cogeneration through the construction of units with gas piston engines with a total rated capacity of 35MW_e and 37MW_t, with investments of about BGN 33,000,000.

The total energy efficiency of the plant is expected to be 85% and the savings of natural gas - more than 20% compared to the separate production of heat and electricity.

Potential to use waste

The investment programme of Toplofikatsia Sofia EAD and Sofia Municipality envisages design and building of a cogeneration plant with utilization of refuse derived fuel (RDF) in Sofia by 2020. Toplofikatsia Sofia intends to use modified solid fuel derived from waste (RDF) in order to change the fuel base for production of energy by replacing natural gas, switching to renewable sources of fuel and increasing the efficiency of heat generation. With the building of one of the sites for the existing heat sources of the cogeneration installation using RDF, some of the used basic fuel - natural gas used at Toplofikatsia Sofia EAD, will be replaced by RDF - a modified solid fuel from waste, thus the production of energy in TPP Sofia will become less dependent on imported gas. The new installation for utilization of RDF for energy purposes is an important part of the strategy of Toplofikatsia Sofia for the development and stabilization of the production capacity for generating heat in Sofia. The thermal power plant using RDF will replace some of the old facilities in Toplofikatsia Sofia producing heat (some of them are more than 50 years old) with new modern facilities that meet the requirements of the European directives for highly efficient and environmentally friendly production of energy. The implementation of the project will decrease the dependence of Toplofikatsia Sofia on imported gas - i.e. the fuel base will be partially diversified. The plant for RDF utilization will reduce the emissions of CH_4 and CO_2 emissions from municipal solid waste, while the fuel component available in the waste will be utilized for the cogeneration.

The capacity of the plant has the following parameters:

- Obtained amount of modified solid fuels RDF - 180,000 t/y, 22.5 t/h;
- Produced electricity - 20 MWe;
- Produced heat - 58 MWt (with condensation of flue gases);
- Operation of the plant - 8,000 h.

In case no modified solid fuels (RDF) are available as a result of the processing of municipal waste with a calorific value of 13 GJ/t, the plant will be able to utilize alternative fuels, such as: low grade RDF - with low calorific value; low grade / fresh biomass with low calorific value; sludge (dehydrated, 10% dry matter, maximum 10% of the total mass).

The plan of the heat and electricity cogeneration plant envisages that based on the processing of 22,5 t/h RDF fuel with a calorific value of 13 GJ/t, the plant will generate a thermal capacity of about 81 MW. The expected nominal result of the obtained electric output of the steam turbine is 20 MWe, while the net electrical output is expected to be 19.5 MWe. About 50 MWt thermal power is expected to be generated as a result of the use of the waste steam in a condensing boiler and 5÷8 MWt in addition from the condensing of flue gases, i.e. a total of about 58 MWt. If the plant operates 8000 hours around the nominal design point and therefore processes 180,000 tons of RDF, an annual production of about 156 GWh electricity a year (19.5 MWe x 8,000 h) can be expected. The plant needs extra power that is estimated to be 95 kWh per ton of RDF or approximately 17 GWh for 180,000 tons. Hence, the maximum net generation of electricity is expected to be approximately 139 GWh. The main technological plan includes:

— steam generator (boiler with grate combustion) that burns RDF fuel or biomass and generates steam with pressure of 60 bar and a temperature of 425°C.

— anti-pressure steam turbine with a condensing boiler with electric capacity of 20 MW_e and thermal capacity of 58 MW_t.

The plant will operate more than 8,000 h/year; the required investment is BGN 130,000,000. The total energy efficiency of the plant is expected to be about 70% and the savings of natural gas - 29.86% compared to the separate production of heat and electricity.

The building of a plant for utilization of the energy from RDF in one of the heat sources of Toplofikatsia Sofia EAD has the following goals:

— maximum utilization of energy from RDF fuel produced from the municipal waste of the city of Sofia;

— diversification of fuel base for power generation at Toplofikatsia Sofia - replacement of natural gas with RDF;

— improving the energy efficiency in energy production by replacing obsolete generating capacities with new high-efficiency cogeneration capacities using the existing infrastructure in the heat sources of Toplofikatsia Sofia to a maximum extent;

— reduction of greenhouse gas emissions per unit of energy;

— reduction of production costs per unit of energy and possible reduction of the cost of the generated energy.

The implementation of the investment intention to build a plant for RDF recovery, considered the final closing stage of the development of an "Integrated system of facilities for treatment of municipal waste of Sofia Municipality", is of particular importance for the population of the city of Sofia. Besides providing a lasting solution to the existing environmental problems of the capital city, the construction of the plant will have an impact on the resolving of the social and economic issues related to providing good heating at affordable prices for the population and will eliminate the costs of Sofia Municipality for the transportation of RDF for incineration at the cement plants in the town of Devnya.

The project for building a cogeneration plant in the city of Sofia utilizing RDF will have a positive social and socio-economic impact on the population of the city of Sofia and Sofia Municipality.

The implementation of the project will open about 35 jobs for the period of operation of the facility.

The total investments needed for the implementation of the individual projects is BGN 549,100,000, while the investment funding laid down in the business plans of the district heating companies by 2019 is BGN 174,999,000; part of this amount is intended for rehabilitation of the heat transmission network.

It should be taken into account that the calculation is made mainly on the basis of information provided by the district heating companies a few years ago.

The following table shows the forecast results for the expansion of the cogeneration of electricity and heat in the district heating companies:

Table 6.4: Forecast results for the expansion of the cogeneration of electricity and heat in the district heating companies

	Units	2010	2014	2025
Electricity	GWh/year	1,887	2,758.9	3,683.4
Heat	GWh/year	7,160	6,449.6	7,347
Fuel energy	GWh/year	11,308	11,009	13,788
Electricity/heat	-	0.263	0.428	0.501
Fuel savings	%	10	10	20
Fuel coal	%	12	19	10
Fuel natural gas	%	88	81	90
Energy saved from the fuel	GWh/year	1,256.3	1,428.8	3,447
CO_2 emission factor - coal	t CO_2/MWh	0.439	0.439	0.439
CO_2 emission factor - natural gas	t CO_2/MWh	0.247	0.247	0.247
CO_2 emission factor - mix	t CO_2/MWh	0.270	0.270	0.266
CO_2 emission savings	103 t CO_2/year	339.2	385.8	916.9
CO_2 emission savings compared to 2010	103 t CO_2/year		46.6	577.7
CO_2 emission savings compared to 2014	103 t CO_2/year			531.1

The total potential for building high-efficiency cogeneration capacities for heat and electricity in district heating by 2025 is 355 MW_e, of which 235 MW_e will constitute new capacities and 120 MW_e - replacement capacities.

7 COST AND BENEFIT ANALYSIS AND SOCIO-ECONOMIC POTENTIAL FOR HIGH-EFFICIENCY COGENERATION OF ENERGY

The cost and benefit analysis and the socio-economic potential of the high-efficiency cogeneration have been assessed in terms of the possibilities for replacement over the next 30 years of the existing capacities for production of heat using high-efficiency technologies on the basis of the net present value, taking into account the following elements:

- technical potential based on the current consumption of heat and the increase/decrease of the consumption of heat in the period 2014–2046;
- financial costs and benefits of these technologies for the whole country;

— the effects of reducing carbon emissions and improving air quality, expressed in monetary value.

Furthermore, the additional potential for development of cogeneration production lies in the fact that as a result of the creation of new systems, the heat that is currently generated by thermal power plants can be produced by high-efficiency cogeneration facilities.

The heat that is currently produced from cogeneration with primary fuel coal can also be seen as additional potential for developing high-efficiency cogeneration systems. The replacement of these systems with gas with a significantly higher cogeneration factor will not increase the heat produced by the cogeneration but will increase the amount of the generated electricity. The existing cogeneration systems with low coefficient of cogeneration such as coal-based systems with steam turbines can also be seen as having potential for development of the production of electricity from cogeneration. Additional potential can be provided on the basis of the waste heat generated by waste incineration plants, large industrial installations and other facilities generating waste heat. The utilization of that heat is technically feasible.

The additional potential of individual homes and buildings that are not connected to district heating is practically equal to their total consumption as it is accepted that currently individual houses do not use cogeneration systems.

7.1 Results

The results of the cost and benefit analysis at national level are summarized in the following tables and present the ratio of the generated heat, the possibilities for production of electricity from high-efficiency cogeneration and the most social cost-efficient combination of high-efficiency technologies for district heating networks. The assessment of the potential for use of high-efficiency cogeneration of heat is based on the current annual heat consumption. The introduction of high-efficiency technologies would be justified from a social and economic point of view over the next 10 years if the existing heating systems are replaced where there are technical and market possibilities. As regards the technical potential of district heating systems, the heat generated by the thermal power plants is presented by taking into account the losses during the transmission process.

High-efficiency cogeneration is a socially and economically feasible solution capable of providing nearly 32.5% of the total national consumption of heat (2.4% supplied by new district heating networks). New district heating networks mean a possibility to build regional local plants that will meet the energy needs for heating and cooling of administrative buildings and the neighbouring buildings located in the city centres of municipalities with more than 20,000 residents. These are cities that are supplied with gas but do not have district heating. That group includes 19 municipalities that are potential consumers of high-efficiency cogeneration of heat.

Table 7.1. below presents the socio-economic potential for heat production by 2025 and Table 7.2 presents the same data as a percentage of the total consumption of heat.

The total amount in the horizontal rows corresponds to the values in column "Total" and represents the distribution of the values in column "Total" of the consumption and the production in the respective sectors:

I. Existing district heating networks;
II. Industry;
III. Public sector and services that are not connected to district heating;
IV. Individual heating in residential buildings not connected to district heating; and
V. New district heating networks - local and extensions.

The first vertical column shows different and possible technologies for generation of heat. The rows of each column contain values of the amount of energy that could be produced using a technology from the relevant row of the first column. The assessment is based on technical and economic considerations. In the column for each sector, some values are repeated because they show possibilities for alternative technological solutions (i.e. the total amount in the column is not informative).

The consumption data shows that high-efficiency cogeneration accounts for 35% of the total heat consumption which indicates a theoretical potential for introduction of high-efficiency solutions for the remaining 65%. Almost the entire high-efficiency cogeneration (93%) is concentrated in two sectors: I. "Existing district heating networks" and II. "Industry". The potential for building high-efficiency solutions to meet the needs of sector III "Public sector and services that are not connected to district heating" and IV. "Individual heating in residential buildings not connected to district heating" is clearly seen. It is not possible to build and/or recommend high-efficiency solutions for every place. Due to economic, technical or purely social reasons, we believe that nearly 42% of the consumption of sector IV. "Individual heating in residential buildings not connected to district heating" will keep being provided by conventional heat production solutions.

Data about the generation required to meet the heat demand is presented together with the transmission losses in the networks, where applicable, for example the heat transmission losses for consumers/producers of heat in the industrial sector were considered insignificant, i.e. the heat producer is located next to the consumer, and therefore the losses are reported as zero. The same is valid for sector “Public sector and services that are not connected to district heating” and for sector “Individual heating in residential buildings not connected to district heating”. Optimized losses of 10% are accepted with regard to the sector of new district heating networks - local and extended (compared to approximately 23% for 2014).

The forecasts of consumption and respectively production take into account the changes in the GDP, the reduction of the energy intensity and the optimization of heat transmission losses.

It is envisaged that new district heating networks - local and extensions, are to meet the demand of the buildings in the public and services sectors that are not connected to district heating, i.e. the new district heating capacities and networks will replace partially the existing methods of heating by introducing high-efficiency cogeneration solutions.

The distribution of the heat load provided by heat pumps in sector “Individual heating of residential buildings not connected to district heating” is based on the distribution of the population in cities/villages, the percentage of the population living below the poverty threshold and defining its economic situation as acceptable (approximately 20%) and the applied correction for that part of the population that is supplied with gas. The factor that the use of solid fuel boilers is strongly limited in multi-storey residential buildings is also taken into account. The same reason - concentration of population in multi-storey buildings, is a limiting factor also for the feasibility of installation of solar collectors, further hampered by the need to transform the existing installations for domestic hot water. The remaining required heat load is ensured by conventional solutions (heating with gas, solid fuel, electricity, etc.), estimated on the basis of the current distribution and the statistics, Bulgaria’s energy strategy, and the population distribution in settlements determining the access to gas and solid fuel, as well as to biomass.

Table 7.1. Evaluation of the technical potential for heat generation in GWh/year

Technical potential for heat generation GWh/year	Share by sectors and district heating networks					TOTAL
	Existing district heating networks	Industry	Public sector and services that are not connected to district heating	Individual heating in residential buildings not connected to district heating	New district heating networks - local and extensions	
Total heat demand	5,967	11,013	6,642	21,967	1,038	46,627
High-efficiency cogeneration with additional heat from boilers	6,301	8,867	-	-	1,142	16,311
High-efficiency cogeneration	6,301	8,862	-	-	1,046	16,210
- additional heat from boilers	-	5	-	-	96	102
Total production, gross	6,563	11,123	6,538	21,967	1,142	47,334
Places with existing cogeneration	4,221	9,189	-	-	960	14,371
High-efficiency gas-based cogeneration	2,895	7,660	-	-	158	10,714
- additional heat from boilers		3			32	35
High-efficiency coal-based cogeneration with heat from boilers	1,326	1,185	-	-	-	2,511
- additional heat from boilers					-	-
Generation of heat from biomass-fired boilers					748	748
- additional heat from boilers					22	22
Places without existing cogeneration	2,342	1,934	6,538	21,967	182	32,963
Generation of heat from gas-fired boilers	2,045	17	-		69	2,131
- additional heat from boilers		2			19	22
Generation of heat from coal-fired boilers					-	-
- additional heat from boilers					-	-
Generation of heat from biomass-fired boilers	35				71	106
- additional heat from boilers					22	22
Gas-based microcogeneration					-	-
- additional heat from boilers					-	-
Alternative high-efficiency solutions				2,405		2,405
Heat pumps				2,185		2,185
Solar and geothermal installations with additional heat from boilers				220		220
Conventional solutions for production of heat only				19,563		19,563
Gas-fired heat plants				6,590		6,590
Coal-fired heat plants				7,030		7,030
Heat plants using electricity				3,966		3,966
Heat plants using another energy source				1,977		1,977

Table 7.2 Evaluation of the technical potential for heat generation as a percentage

Technical potential for heat generation GWh/year	Share by sectors and district heating networks					TOTAL
	Existing district heating networks	Industry	Public sector and services that are not connected to district heating	Individual heating in residential buildings not connected to district heating	New district heating networks - local and extensions	
Total heat demand	12.8%	23.6%	14.2%	47.1%	2.2%	100.0%
High-efficiency cogeneration with additional heat from boilers	38.6%	54.4%	0.0%	0.0%	7.0%	35.0%
High-efficiency cogeneration	13.5%	19.0%	0.0%	0.0%	2.2%	34.8%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
Total production, gross	13.9%	23.5%	13.8%	46.4%	2.4%	100.0%
Places with existing cogeneration	9.1%	19.7%	0.0%	0.0%	2.1%	30.8%
High-efficiency gas-based cogeneration	6.2%	16.4%	0.0%	0.0%	0.3%	23.0%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
High-efficiency coal-based cogeneration with heat from boilers	2.8%	2.5%	0.0%	0.0%	0.0%	5.4%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Generation of heat from biomass-fired boilers	0.0%	0.0%	0.0%	0.0%	1.6%	1.6%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Places without existing cogeneration	5.0%	4.1%	14.0%	47.1%	0.4%	70.7%
Generation of heat from gas-fired boilers	4.4%	0.0%	0.0%	0.0%	0.1%	4.6%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Generation of heat from coal-fired boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Generation of heat from biomass-fired boilers	0.1%	0.0%	0.0%	0.0%	0.2%	0.2%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Gas-based microcogeneration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
- additional heat from boilers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Alternative high-efficiency solutions	0.0%	0.0%	0.0%	5.2%	0.0%	5.2%
Heat pumps	0.0%	0.0%	0.0%	4.7%	0.0%	4.7%
Solar and geothermal installations with additional heat from boilers	0.0%	0.0%	0.0%	0.5%	0.0%	0.5%
Conventional solutions for production of heat only	0.0%	0.0%	0.0%	42.0%	0.0%	42.0%
Gas-fired heat plants	0.0%	0.0%	0.0%	14.1%	0.0%	14.1%
Coal-fired heat plants	0.0%	0.0%	0.0%	15.1%	0.0%	15.1%
Heat plants using electricity	0.0%	0.0%	0.0%	8.5%	0.0%	8.5%
Heat plants using another energy source	0.0%	0.0%	0.0%	4.2%	0.0%	4.2%

7.2 Effects

More than 60% of the consumed heat in the country is used by consumers not connected to district heating. The construction of high-efficiency solutions covering some of the demand in buildings in sector “Public sector and services not connected to district heating” is expected to lead to savings of 52,000 t CO_2 a year and a generation of 367 GWh electricity that will replace some of the electricity produced on the basis of conventional methods. One possibility is to use the potential of high-efficiency solutions such as gas piston engines, small to large gas turbines with open or closed cycles, steam turbines using biomass as fuel, heat pumps, etc.

7.3 A specific example of modelling of the socio-economic effect of Toplofikatsia Sofia

7.3.1 Description of the technical assessment model and a cost and benefit assessment model

A model of Toplofikatsia Sofia has been developed which is an aggregate of TPP and heating plants. The study focuses on the replacement of capacities in the heating plants with high-efficiency capacities and takes into account the plans for intensification of the high-efficiency capacities in the thermal power plants.

The model is structured as follows:

- A basic model of Toplofikatsia Sofia was developed on the basis of data from 2014. The technical data, the financial statements of the company and a number of macroeconomic indicators have been taken into account. Regarding the technical data: capacities (heat and electricity) are presented individually and as a summary:

Plant	Capacity	
	heat	electricity
TPP Sofia	810	70
TPP Sofia Iztok	1.253	156
DHP Zemlyane	536	
DHP Lyulin	512	
Temporary Heating Plant Suha Reka	32	
THP Hadzhi Dimitar	40	
THP Levski G.	40	
THP Orlandovtsi	4	
THP Ovcha Kupel 1	40	
THP Ovcha Kupel 2	40	
THP Inzhstroy	19	

The fuel mix and the technological losses and energy consumption for own needs have been taken into account. The staff has been analysed and gradual optimization has been envisaged.

- Assumptions have been made regarding the changes in the heat consumption and the heat consumption has been reflected in the forecast financial statements. The assumptions reflect changes in macro indicators (changes in the gross domestic product, inflation (for the country and for the EU), exchange rates) which in turn have been projected to periods of 5 or 7 years depending on the available forecasts. After that assumptions for smooth growth or maintaining the level of the indicators have been made.
- Different applicable high-efficiency solutions and the required capacity presented individually and summarized have been analysed on the basis of the changes in the heat load.

Plant	Power	
	heat	electricit
TPP Sofia	58	20
TPP Sofia Iztok	90	128
DHP Zemlyane	53	54
DHP Lyulin	53	54
Temporary Heating Plant Suha Reka	4	4
THP Hadzhi Dimitar	7	7
THP Levski G.	4	4
THP Orlandovtsi		
THP Ovcha Kupel 1	10	10
THP Ovcha Kupel 2	10	10
THP Inzhstroy	2	2

The heat capacity presented in the table has a substituting role, while the electricity capacity is additional, for example 53 MWt of the existing rated capacity of DHP Zemlyane is proposed to be replaced which will lead in turn to additional 54 MWe compared to the total rated capacity of Toplofikatsia Sofia EAD.

- The forecast financial statements report also the long-term instability of the fuel mix prices and the changes in the foreign currency rates. It is accepted that only the prices of fuels are changed but not their technical characteristics (e.g. calorific value). The net present value of the basic model has been calculated.
- The price of heat and electricity has been projected on the basis of the forecast financial statements and the regulator’s heat and electricity pricing requirements.
- The model allows for calculation of the capital expenses and the annual operating costs and the maintenance costs of individual solutions. No potential investments in heating networks have been taken into account.
- A model is developed for each plant where there is a possibility for replacement with

a high-efficiency solution to show how the operative date and the cash flows change after the commissioning of the new capacities. Thus the new net present value is compared to the basic one and if the new present value is higher than the basic value a high-efficiency solution is recommended.

An analysis of a high-efficiency solution for DHP Zemlyane is presented below. All presented changes are compared against the basic model of Toplofikatsia Sofia EAD.

Each new version of a high-efficiency solution is compared against the basic model that produces only heat. The new high-efficiency solutions will also produce electricity apart from heat. The table shows that the replacement of the thermal capacity of DHP Zemlyane with a high-efficiency solution would increase the production of electricity with 38.9% compared to the basic variant. It should be noted that the costs have different values due to the different technologies and specifications of the respective installation and the different type of fuel used. Because of the model used, the calculation of the price of the produced electricity - costs plus permitted rate of return, yields values very close to the change of the net present value compared to the basic variant.

The table shows that when only the turbine groups of a gas turbine and a steam turbine using biomass are compared, the steam turbine generates higher revenues but also higher costs which is reflected in the lower added value to the net present value.

DHP Zemlyane	Electricity	Revenues	Costs		NPV
			Repair and maintenance	Operative	
Combined Cycle Gas Turbine (CCGT)	38.9%	6.6%	6.1%	4.9%	4.6%
Steam turbine, fuel biomass	38.9%	8.7%	20.5%	16.3%	4.5%
Open cycle gas turbine (OCGT) - 3 pcs.	38.9%	6.6%	6.1%	4.9%	4.6%

- It is envisaged that each of the individual options will be commissioned in 2019, as the individual solutions for heating or temporary heating plants, or in 2020 for both thermal power plants.
- The model is used to calculate the discounted cash flows and the present value (PV) in the period between 2015 and 2044 for all primary options and individual potentials for high-efficiency solutions, taking into account the capital costs, the maintenance costs, the long-term instability of fuel prices, the external costs, and the social discount rate.
- For each option, the model identifies the most efficient heating production option from social and economic point of view (the one with the highest PV value). In some cases, the identified option is the sole option.

- The proposed solution for TPP Sofia was taken over from the investment intention of Sofia Municipality for the construction of a plant for incineration of refuse derived fuel (RDF).

7.3.2 Conclusions from the technical assessment model and cost and benefit assessment

The replacement with high-efficiency cogeneration technologies for production of heat and electricity in TPP Sofia, TPP Sofia Iztok, DHP Zemlyane, DHP Lyulin, DHP Suha Reka, THP Hadzhi Dimitar, THP Levski G., THP Orlandovtsi, THP Ovcha Kupel 1, THP Ovcha Kupel 2 and THP Inzhstroy adds to the net present value of Toplofikatsia Sofia between 0.5% to 8.33% on an individual basis compared to the basic model, i.e. each individual solution is seen as an independent and separate one. The execution of all assessed solutions would provide a cumulative effect of over 22%.

All envisaged high-efficiency cogeneration technologies operate with natural gas. In some cases there are optimal possibilities to use biomass or even coal as main fuel, however, in view of the location of the respective plants and their access to fuel, it is considered that natural gas would be the most efficient and the most environmentally friendly fuel.

The planned facilities are high-efficiency solutions such as combined cycle gas turbines (CCGT or OCGT) or gas piston engines.

8 IDENTIFICATION OF ENERGY EFFICIENCY POTENTIALS OF DISTRICT HEATING AND COOLING INFRASTRUCTURE

The potential for energy efficiency of the infrastructure of district heating and cooling consists in the rehabilitation of the heat networks and the replacement of outdated direct heating substations with modern highly automated high-efficiency indirect stations, which would decrease the losses in heat transmission and distribution and would reduce the emissions of CO_2.

The best practices involving the use of district heating facilities with pre-insulated pipes achieve reduction of heat losses up to 3%. A similar level of losses can be achieved for systems with a high power density. In the context of the national situation in the Republic of Bulgaria, it is accepted that the average power density of district heating system will allow for a reduction of the heat losses up to 10% when using the best available technology.

In order to reduce the losses to 10% (with current average losses of 23.7%) the district heating networks must be modernized so as to decrease the annual losses from 2.77 TJ/km to 1.17 TJ/km. Since the length of the heat transmission network (1,898 km) is closely related to the values of the heat transmission losses, it can be assumed that the requirement to reduce the losses per kilometre of the network down to 1.17 TJ/km should be applied to all heating systems in the country.

The potential as a result of the improvement of the energy efficiency of the heating systems is assessed at 1.6 TJ or 30.3% of the heat that is currently lost in the transportation of the heat carrier.

The total demand for cooling that can be satisfied by using absorption refrigerator facilities with heat provided by the system will increase over the next 10 years. According to the forecasts, in 2025 the demand for heat for cooling will increase to one third of the total demand for heat of large office buildings, administrative and hotel buildings. Such buildings are equipped with central ventilation (distribution cooling) systems, which means that they will use cooling systems with absorption units installed in district heating substations with cooling equipment (transformation of district heating substations into a heating and cooling substation). Most of the multi-family residential buildings are not equipped with cooling equipment of all dwellings and usually have no central ventilation system, so these buildings are not to be included in the technical potential for using heat for cooling.

9 MEASURES FOR DEVELOPMENT OF EFFICIENT HEATING AND COOLING INFRASTRUCTURE AND/OR FOR SUPPORT OF THE DEVELOPMENT OF HIGH-EFFICIENCY COGENERATION AND USE OF HEATING AND COOLING GENERATED ON THE BASIS OF WASTE HEAT AND RENEWABLE ENERGY SOURCES

9.1 Current Situation

9.1.1 High-efficiency cogeneration

The development of electricity production from high-efficiency cogeneration contributes to the better preservation of the environment and most of all to the increased efficiency of electricity generation, thus enhancing the efficient use of primary energy sources.

The mechanism for support of producers of electricity from high-efficiency cogeneration of heat and electricity was introduced in Bulgaria in 2007 with the approval of the relevant legislative changes to the Energy Act.

According to the existing legislation, the public electricity provider NEK EAD, respectively the end suppliers EVN, CEZ and Energo Pro, are obliged to purchase from producers connected to the network the whole amount of electricity from high-efficiency cogeneration of heat and electricity, registered with a monthly certificate of origin, at preferential prices, except for the amount of electricity required to ensure the operational reliability of the main facilities produced in excess of the amount of electricity from cogeneration and the amounts that the producer uses for its own needs or for which the producer has signed contract with which the producer participates in the balancing energy market, or which is consumed by non-household customers that do not receive budgetary support and which the producer with predominant heat load for business needs supplies with heat.

The amounts of electricity from high-efficiency cogeneration of heat and electricity are purchased up to the amounts determined with a decision of the Energy and Water Regulatory Commission for the determination of an individual price for the plants.

The national policy to promote high-efficiency cogeneration of heat and electricity is regulated in the Energy Act, the Ordinance on the determination of the amount of electricity produced by combined heat and electricity production systems, and the Ordinance on the issuance of certificates of origin for electricity obtained from renewable energy sources and/or by using cogeneration methods.

I. Energy Act

The Energy Act established a framework supporting and facilitating the development of heat and electricity cogeneration as a generally recognized form of efficient and environmentally responsible method of power production.

The main cogeneration promotion preferences laid down in the Energy Act are in the following areas:

- Purchase of the electricity produced by cogeneration plants;
- Pricing the electricity from cogeneration;
- Construction of cogeneration plants;
- Connection of cogeneration plants to the electricity transmission and distribution networks.

The incentives for the different areas are as follows:

1. Preferential terms of purchasing the electricity produced by cogeneration plants

The public supplier and accordingly the final suppliers of electricity are obliged to purchase all the electricity produced by heat and electricity cogeneration systems registered with a certificate of origin, except the volumes, which the producer uses for own purposes or for placement in the free electricity market.

2. Preferential terms of pricing the electricity produced by cogeneration plants

The preferential prices of cogenerated electricity produced by electricity and heat generation plants are determined on the basis of the individual production costs plus a margin determined by EWRC for the various producers on the basis of criteria laid down in the Price Regulation Ordinance issued under Art. 36(3) of the Energy Act.

The criteria used for determining the groups of producers and the respective margins are as follows:

- Prevailing use of the main heat load - for production purposes or for heat and HDW (hot domestic water);
- Type of fuel used;
- Cogeneration technology;
- Plant/installation capacity.

3. Preferences for construction of cogeneration plants

The Act contains a special provision, according to which if there is an established need for additional heat energy, all new plants rated 5 MW or more and using natural gas must implement the principle of combined generation of heat and electricity.

4. Connecting with all priority plants

- The transmission operator and all electricity distribution operators must connect with all priority plants that generate electricity using high-efficiency cogeneration systems with rated capacity up to 10 MW.
- The extension and reconstruction of the networks related with the connection of such plants is the responsibility of the transmission or distribution operator, as the case may be.
- To accomplish such extension/reconstruction of the networks, the transmission and/or distribution operator is entitled to apply for external financing.

II. ORDINANCE № RD-16-276/2008 on the determination of the amount of electricity produced by combined heat and electricity production systems

The main criteria for determination of the amount of cogenerated electricity and its recognition as high-efficiency electricity according to the ordinance are:

Ordinance № RD-16-267 is applied to cogeneration plants for heat and electricity and Article 2 lists the following types in separate points: point 1 - condensation turbine with adjustable steam bleeder; point 2 - steam turbine with back pressure; point 3 - gas turbine with a waste heat boiler; point 4 - internal combustion engine (ICE) with a utilizer; point 5 - combined cycle gas; point 6 - microturbines, Stirling engines, fuel cells, steam engines, organic Rankine cycles and combinations of the above listed systems. According to Article

4(1) of Ordinance № RD-16-267, the gross annual amount of cogenerated electricity produced by plants under Article 2 shall be considered equal to the gross annual production of electricity by the plant when the reported total annual energy efficiency of the use of the fuel is equal to or greater than: 75% for the plants under Article 2, points 2–4 and point 6; 80% or the plants under Article 2, points 1 and 5. Article 14(1) of the same ordinance states that the cogeneration of heat and electricity is highly efficient when it leads to annual fuel savings of at least 10% of the fuel required for the production of the same amount of heat and electricity separately, and paragraph 1 of the same article states that for plants with single electricity capacity up to 1 MW the criterion for high-efficiency production is annual fuel savings versus the fuel required for the production of the same amount of heat and electricity separately, without a requirement regarding the amount of fuel savings.

III. Ordinance on the issuance of certificates of origin for electricity obtained from renewable energy sources and/or by using cogeneration methods

Bulgaria has designated the Energy and Water Regulatory Commission (EWRC) to be the independent competent authority responsible for certifying the origin of electricity and for ensuring compliance with the criteria and rules for granting the certificates of origin.

The Energy and Water Regulatory Commission (EWRC) regulates the prices:

— at which the producers sell heat to the heat transmission company and to directly connected clients;
— at which the heat transmission companies sell heat to clients;
— for connection to the heat transmission networks;
— of the services provided to the clients, determined by the commission and related to the licence activity.

In connection with the determination of the prices, the energy companies submit to EWRC a detailed written justification of the costs proposed for approval. The proposal for approval of prices contains also information on the costs that are related to a non-regulated activity by type and value.

The commission sets a rate of return of the capital for the regulatory period which is equal to the forecast weighted average cost of the capital. The weighted average cost of the capital is the target rate of return of the debt and equity of the energy company, as determined by the commission, weighted according to the share of each of these sources of funding in a specific target structure of the capital.

9.2 Potential additional policies and measures

Article 14(2) of Directive 2012/27/EU states that:

“Member States shall adopt policies which encourage the due taking into account at local and regional levels of the potential of using efficient heating and cooling systems, in particular those using high-efficiency cogeneration. Account shall be taken of the potential for developing local and regional heat markets."

The developed policies and strategy must include the following aspects:

— taking measures for development of the infrastructure of efficient district heating and cooling systems in connection with the development of high-efficiency cogeneration and the use of waste heat and renewable energy sources for heating and cooling;
— initiatives for building new generating thermal power plants and industrial plants generating waste heat in areas where it is possible to utilize a maximum amount of waste heat in order to meet any existing and future demand for energy for heating or cooling;
— actions to encourage the construction of new residential areas and new industrial users of heat in areas where the comprehensive assessment of the potential for energy efficiency has identified waste heat that can be used to cover the existing heating and cooling demand. These actions may include proposals for concentration of a large number of individual plants in a particular area in order to ensure optimal balancing of demand and supply of energy for heating and cooling;
— actions to encourage the construction of new thermal power generation plants, industrial plants generating waste heat, plants for incineration of waste and other plants producing heat from waste and their connection to district heating systems for heating and cooling;
— actions to encourage processes where residential areas and industrial plants that consume heat in their production processes are connected to district heating systems for heating and cooling.

The document defining the policies and the strategy of the Bulgarian state in the field of energy is he Energy Strategy of Bulgaria until 2020

(http://www.mi.government.bg/files/useruploads/files/epsp/22_energy_strategy2020.pdf)

The Energy Strategy is a fundamental document of the national energy policy approved by the Council of Ministers and adopted by the National Assembly of the Republic of Bulgaria.

The Energy Strategy addresses the main challenges facing the Bulgarian energy sector at present, the primary, but not the only one, being the high energy intensity of the GDP - despite the positive improvement trend, the energy intensity of the national GDP in 2015 is 89% higher than the EU average (taking into account the purchasing power parity).

The energy savings is the measure that is best prepared for implementation and is a secure way to achieve the European goal of 20 percent reduction in greenhouse emission gases by

2020. In this regard, the efforts of the Bulgarian state will be aimed at improving the efficiency of electricity and heat production, decreasing the losses in transmission and distribution of energy, accelerating the use of more fuel-efficient vehicles and intensifying the use of public transport, improving in due time the energy performance of existing buildings and introducing more stringent energy standards for new buildings, including energy independent buildings, and a consistent tax policy for more efficient use of energy. Bulgaria will increase in practice its capacity to export energy with more than 1500 MW as a result of the increased energy efficiency of end users and in the energy sector and the increased share of directly used natural gas and renewable energy.

The decentralized production of energy from renewable energy resources or the use of solar, wind, geothermal energy, the energy of the environment through heat pumps and biomass, depending on the local potential and needs, is a sector with great prospects in the country. Thus all the costs associated with the connection to networks and energy transmission and distribution losses are avoided.

The government's priority is the development and expansion of domestic gas supply in the country. Increasing the percentage of households supplied with gas to 30% in 2020 and the replacement of the electricity used for heating with high-efficiency appliances using natural gas may save households more than one billion BGN for energy costs.

The preservation and development of district heating remains a priority and companies must be technically upgraded and financially stabilized. The methods for high-efficiency cogeneration of heat and electricity will be actively supported, with a focus on technologies using renewable energy sources, including waste biomass, plant and animal waste.

Power plants and district heating plants are the main source and emit more than 34 mln. tons of CO_2 per year. These energy companies are obliged to participate in the European Emissions Trading System for greenhouse gases. The scheme functions in accordance with the ‘polluter pays’ principle. Payment consists in purchasing allowances for emission of certain quantities of greenhouse gases in the production of electricity and heat and as a result of other production activities.

The aim of the scheme is to encourage the market development and distribution of low-carbon and high-efficiency technologies.

At the beginning of 2013, the third eight-year period of the European Emissions Trading System for greenhouse gases started. The fixed national emission ceilings have been removed and a common ceiling for the whole EU has been introduced that will be decreased linearly every year during the period until 2020 in line with the target of 21% reduction in emissions compared to the 2005 levels. The free allowances are to be allocated by the Member States on the basis of transitional rules for the harmonized free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC valid for the whole EU. The basic principle of the allocation is that the free allowances will be determined on the basis of pre-approved product indicators throughout the EU and not on the basis of the total historical emissions of each plant, as it was during the period 2008-2012. The indicators represent a threshold amount of free allowances that a plant can obtain per unit of output. The share of allowances that Member States will auction has been increased significantly. The 'polluter pays' principles has been preserved.

The obligation for plants to return annually an amount of allowances equal to their verified greenhouse gas emissions in the previous year has been preserved. There will be no free allocation of allowances to electricity producers and from 2013 electricity producers will be obliged to purchase all allowances they need. For countries with electricity sectors characterized by a high dependence on a single fossil fuel or by an unsatisfactory level of connectivity to the European electricity system, a provision is made for a derogation from this rule. Ten Member States, including Bulgaria, may apply for that derogation.

Greenhouse gas emission will be reduced in the following ways:

— Using less energy, i.e. improving the energy efficiency of energy production and consumption;
— Using cleaner energy, i.e. improving the energy mix by increasing the proportion of low emission energy;
— Rapid technological advances including introduction of new energy (clean coal) technologies.

Given the stabilizing role of local coal as a resource for electricity production, the state will support financially and institutionally the construction of power plants featuring technologies for carbon dioxide capture and storage using the schemes and mechanisms adopted at European level and following a balanced policy between the environmental legislation and the encouragement of local energy resources.

Presently in Bulgaria the potential of solid biomass, mainly as a fuel for heating households and public buildings, as well as the potential of hydropower in water power plants (WPP) are utilized in the most optimal way.

The production of electricity by wind and solar power plants is under rapid development, as is the use of solar energy for households' hot water needs.

According to the National Action Plan for renewable energy, the aggregate technical potential for energy production from renewable energy sources in Bulgaria is about 4500 ktoe annually.

Bulgaria has a policy targeted at building a national scheme of mechanisms to support the development of RES. The greatest support is provided to producers of electricity from renewable energy sources benefiting from:

- priority connection to the grid;
- guaranteed purchase of the produced electricity;
- guaranteed return through preferential prices of the produced electricity;
- loan facilities;
- facilitated administrative arrangements.

No other mechanisms are applied in practice besides the preferential pricing to encourage the development of RES. We have also noted that the mechanisms to support the production of energy from RES for heating and cooling needs are not sufficiently developed.

Some of the priorities in the support policies are:

- Facilitating the procedures for building small (domestic) RES energy capacities such as plants to utilize the solar potential for hot water, heating and/or electricity production, exploiting the potential of heat and geothermal energy, biomass, etc.;
- Extension beyond 2015 of the deadline for application of preferential purchase prices and for obligatory purchase of electricity produced from renewable sources, including where it is produced by cogeneration plants for heat and electricity operating with renewable sources.

10 ASSESSMENT OF THE PROGRESS MADE UNDER DIRECTIVE 2004/8/EC FOR INCREASING THE SHARE OF HIGH-EFFICIENCY COGENERATION IN THE GROSS DOMESTIC CONSUMPTION OF ELECTRICITY

High-efficiency cogeneration offers considerable potential to achieve energy savings in the EU, as the heat produced by power generation is not wasted but is used instead. This potential has not yet been fully realised. Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market (the CHP Directive or the Cogeneration Directive) aims to facilitate the installation and operation of cogeneration facilities in order to save energy and combat climate change. The CHP Directive should, in the short term, make it possible to consolidate existing cogeneration installations and promote new plants, and, in the longer term, create the necessary framework for high-efficiency cogeneration to reduce emissions.

Directive 2006/32/EC on energy end-use efficiency and energy services (the Energy Services Directive or the ESD) aims at making the end use of energy more economical and efficient by establishing indicative targets, incentives and the institutional, financial and legal frameworks needed to eliminate market barriers and imperfections which prevent efficient end use of energy. It also aims at creating conditions for the development and promotion of the energy services market, on one hand, and for the elaboration of energy saving programmes and other measures aimed at improving the energy end-use efficiency, on the other hand.

The Energy Services Directive applies to the distribution and retail sale of energy, the delivery of measures to improve end-use energy efficiency, with the exception of activities included in the EU Emissions Trading Scheme (ETS) and, to a certain extent, to the armed forces. It targets the retail sale, supply and distribution of extensive grid-based energy carriers, such as electricity and natural gas, as well as other types of energy such as district heating, heating oil, coal and lignite, forestry and agricultural energy products and transport fuels.

As of 5 June 2014, the ESD and the CHP Directive are almost fully revoked by Directive 201/27/EC on energy efficiency (“DEE”).

In accordance with Article 14(2) of the ESD, the Member States are required to prepare a second Energy Efficiency Action Plan (EEAP) and to notify it to the Commission no later than 30 June 2011.

In accordance with Article 10 of the CHP Directive, Member States are required to publish a report with the results of the analysis and evaluations carried out in relation to the guarantee of origin, to the national potential for high-efficiency cogeneration and to the existing legislative and regulatory framework related to cogeneration.

In accordance with Article 11 of the CHP Directive, the Commission is required to report periodically on the progress towards the CHP Directive's goals. In implementation of this requirement, the Commission has prepared a progress report on the implementation of Directive 2006/32/EC on energy end-use efficiency and energy services and the implementation of Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market from 08.01.2014.

According to the conclusions made in the report of 08.01.2014, the buildings have the largest individual share in relation to the energy savings potential in the EU and the improvement of their energy efficiency is the main objective of Member States. Almost all Member States report in their second Energy Efficiency Action Plans (EEAPs) measures for the new buildings and the existing buildings (residential and public buildings). The savings achieved by building regulations and actions make up a significant part of total national energy savings, while some include also earlier savings resulting from regulations implemented since 1995.

Some Member States include in their savings calculations of the effects of specific EU legislation on energy efficiency, such as the implementing regulations relating to Ecodesign and Energy labelling.

In terms of financing energy saving measures, the use of EU funds as well as revenues from the sale of Assigned Amount Units (AAUs) under the Kyoto Protocol are reported by a number of Member States. At the same time, efforts to increase the involvement of the private sector in the financing of energy efficiency improvements are on the rise throughout the EU.

The number of promising horizontal measures laid down in the second EEAPs has increased as compared to the first ones. Thus,, the energy savings obligations now form a key part of the efforts to promote energy savings. The Energy Services Companies (ESCOs) remain a further key area of financing energy efficiency in the EU. In view of that, a number of Member States point out the establishment of energy services model contracts and the introduction of legislation or the removal of legal barriers to ESCOs' access to energy services in the public sector. At the same time, as observed during the first reporting period, many of the measures notified with regards to ESCOs contain little detail about concrete actions to be undertaken.

The total end-use energy savings for 2010 declared by the Member States are approximately 59 Mtoe (million tonnes of oil equivalent). That value is about 35% higher than the total amount of the interim objectives for energy savings defined by the 27 Member States in their first EEAPs presented in 2008. The declared interim energy savings levels vary from 1.8% of the reference consumption in Lithuania to almost 9% in Germany and Sweden where the indicative target under the ESD for 2016 was actually achieved at the end of the interim stage.

Total final energy savings of around 132 Mtoe are projected for 2016, which goes way beyond the 9% indicative target of approximately 89 Mtoe. Spain and Germany forecast the highest levels of savings, while four Member States have indicated savings for 2016 below 9% of their reference energy consumption. When comparing the savings figures of the Member States however, it is important to consider the methods used to calculate the savings, rather than simply the declared and projected savings levels. Several different approaches have been used to quantify the savings. Accordingly, the numbers presented below in table 10.1 can only serve as a rough indicator of the actual EU saving impact.

As the above EU energy efficiency progress overview indicates, various positive developments occurred between the first and the second EEAPs under the ESD. The extensive use of the guidelines and the template provided by the Commission has contributed to the overall improved quality of the EEAPs. The second EEAPs indicate that there is still room for improvement of the information provided in the EEAPs as to specify whether and how Member States can reach the energy savings target.

Table 10.1: EEAP energy end-use saving targets and forecasts for 2016 and declared savings for 2010

	Target for energy end-use savings for 2010 (*equivalent to primary energy in italics*)		Stated energy end-use savings for 2010 (*equivalent to primary energy in italics*)		Projections for energy end-use savings for 2016 (*equivalent to primary energy in italics*)	
Member State	Mtoe	Percentage of the reference consumption	Mtoe	Percentage of the reference consumption	Mtoe	Percentage of the reference consumption
Austria	0.428	2.0 %	1.180	5.5 %	1.874	8.8 %
Belgium	0.789	3.0 %	1.301	4.9 %	2.985	11.4 %
Bulgaria*	0.209	3.0 %	0.305	4.4 %	1.066	15.3 %
Cyprus	*0.060*	3.3 %	*0.066*	3.6 %	*0.191*	10.4 %
Czech Republic	0.355	1.8 %	0.532	2.7 %	1.596	8.2 %
Denmark	0.449	3.0 %	0.664	4.4 %	1.285	8.6 %
Estonia	0.061	2.3 %	0.079	3.0 %	0.213	8.1 %
Finland	0.507	3.0 %	1.040	6.1 %	2.123	12.5 %
France	5.000	3.8 %	5.159	3.9 %	18.000	13.5 %
Germany	12.181	6.1 %	17.937	9.0 %	33.868	17.1 %
Greece	0.439	2.8 %	0.794	5.1 %	1.415	9.0 %
Hungary	0.152	1.0 %	0.293	1.9 %	1.371	9.0 %
Ireland	*0.559*	4.5 %	*0.523*	4.2 %	*1.576*	12.6 %
Italy	3.066	2.7 %	4.102	3.6 %	10.880	9.6 %
Latvia	0.006	0.2 %	0.294	8.8 %	0.299	9.0 %
Lithuania	0.054	1.5 %	0.067	1.8 %	0.341	9.4 %
Luxembourg	0.045	2.7 %	0.128	7.6 %	0.238	14.1 %
Hungary	0.011	3.0 %	0.014	3.8 %	0.033	9.0 %
Netherlands	0.978	2.0 %	*2.278*	4.7 %	*6.416*	13.1 %
Poland	1.021	2.0 %	3.037	5.9 %	5.779	11.3 %
Portugal	0.344	1.9 %	0.662	3.6 %	2.240	12.2 %
Romania	0.940	3.0 %	2.222	7.1 %	2.800	9.0 %
Slovakia	0.224	3.0 %	0.668	9.0 %	0.671	9.0 %
Slovenia	0.102	2.5 %	0.101	2.5 %	0.591	14.5 %
Spain	2.179	3.0 %	4.720	6.5 %	13.126	18.1 %
Sweden	2.003	6.3 %	2.846	9.0 %	4.626	14.6 %
United Kingdom	11.737	9.0 %	8.547	6.6 %	17.816	13.7 %

The 2016 figures for Bulgaria represent the total bottom-up savings given in the EEAP.

11 ESTIMATE OF THE PRIMARY ENERGY TO BE SAVED

11.1 Primary energy saved in cogeneration installations

Information on the electricity and heat generated in 2010, 2012 and 2014 and the primary energy savings of cogeneration plants is provided in the following table in compliance with Annex II of Directive 2012/27/EU of the European Parliament and of the Council.

Table 11.1 Generated electricity and heat and primary energy savings in cogeneration plants - MWh

	Name	Total electricity and heat	Fuel savings	Total electricity and heat	Fuel savings	Total electricity and heat	Fuel savings
		2010		2012		2014	
1	TPP Burgas, city of Burgas	269,894	53,606	235,641	52,394	257,245	58,720
2	TPP Lukoil Neftochim, town of Kameno	659,115	18,830	925,976	23,793	641,126	14,232
3	TPP Vladislav Varnenchik, city of Varna	116,498	29,476	125,452	29,751	136,278	32,425
4	TPP Gradska, city of Vratsa	85,153	17,455	92,097	19,158	89,617	18,472
5	Heating plant Mladost, city of Vratsa	-	-	27,780	7,459	29,600	7,791
6	Heating plant Razgrad, city of Razgrad	37,655	10,805	33,142	7,679	37,368	8,224
7	Heating plant Veliko Tarnovo, city of Veliko Tarnovo	48,132	9,238	46,109	9,170	40,865	8,735
8	Heating plant Kogeneratsionna tsentrala 6.66 MW, town of Parvomai	-	-	18,315	4,838	43,878	10,215
9	TPP Oranzheria 500 decares, village of Bratanitsa	-	-	1,465	321	44,645	9,569
10	TPP Oranzheria 200 decares, village of Bratanitsa	-	-	1,399	330	58,395	13,885
11	TPP Oranzheria Levski, town of Levski	-	-	-		23,528	5,172
12	TPP Oranzherii Kresna, town of Kresna	22,447	6,112	16,294	4,499	16,510	4,893
13	TPP Oranzherii Trudovets, village of Trudovets	11,324	2,711	20,962	5,264	14,471	3,639
14	TPP Unibel, city of Yambol	13,767	4,015	11,819	2,667	11,292	2,498
15	TPP Republika, city of Pernik	371,821	81,243	383,246	84,362	406,545	272,910
16	TPP Gabrovo, city of Gabrovo	45,046	4,039	41,501	6,578	39,247	8,985
17	TPP Pleven, city of Pleven	680,009	111,082	752,019	132,406	721,728	143,672
18	TPP Sofia, city of Sofia	1,574,848	132,949	1,557,588	123,925	1,390,030	79,848
19	TPP Sofia Iztok, city of Sofia	2,323,257	294,033	2,365,638	303,822	2,207,201	251,463
20	TPP Plovdiv Sever, city of Plovdiv	377,637	49,812	630,801	83,362	565,831	123,272
21	TPP to Brikel EAD, town of Galabovo	811,158	217,865	2,418,094	662,905	2,638,504	687,165
22	TPP Sliven, city of Sliven	234,127	93,170	307,697	124,730	321,759	153,965
23	TPP Ruse Iztok, city of Ruse	411,593	140,007	420,930	169,984	413,810	332,175
24	TPP Deven, town of Devnya	3,253,655	440,376	3,710,230	655,597	3,708,700	425,842
25	TPP Gorna Oryahovitsa, city of Gorna Oryahovitsa	58,542	24	113,185	5,366	91,274	11,303
26	TPP Svishtov, town of Svishtov	130,053	46,548	47,543	19,791	20,461	149,650
27	TPP Vidahim, city of Vidin	1,438,100	213,045	1,545,508	287,877	1,438,075	229,218
	Total	12,973,831	1,976,440	15,850,430	2,828,030	15,407,983	3,067,938

Table 11.2 Primary energy savings in cogeneration plants - reduction of carbon dioxide emissions (CO_2) MWh

	Name	Type of the main fuel	CO_2 emission coefficient - t CO_2/MWh	Fuel savings	Saved CO_2 emissions - tons	Fuel savings	Saved CO_2 emissions - tons	Fuel savings	Saved CO_2 emissions - tons
				2010		2012		2014	
1	TPP Burgas, city of Burgas	Natural gas	0.247	53,606	13,241	52,394	12,941	58,720	14,504
2	TPP Lukoil Neftochim, town of Kameno	Natural gas	0.247	18,830	4,651	23,793	5,877	14,232	3,515
3	TPP Vladislav Varnenchik, city of Varna	Natural gas	0.247	29,476	7,281	29,751	7,349	32,425	8,009
4	TPP Gradska, city of Vratsa	Natural gas	0.247	17,455	4,311	19,158	4,732	18,472	4,563
5	Heating plant Mladost, city of Vratsa	Natural gas	0.247	-	-	7,459	1,842	7,791	1,924
6	Heating plant Razgrad, city of Razgrad	Natural gas	0.247	10,805	2,669	7,679	1,897	8,224	2,031
7	Heating plant Veliko Tarnovo, city of Veliko Tarnovo	Natural gas	0.247	9,238	2,282	9,170	2,265	8,735	2,158
8	Heating plant Kogeneratsionna tsentrala 6.66 MW, town of Parvomai	Natural gas	0.247	-	-	4,838	1,195	10,215	2,523
9	TPP Oranzheria 500 decares, village of Bratanitsa	Natural gas	0.247	-	-	321	79	9,569	2,364
10	TPP Oranzheria 200 decares, village of Bratanitsa	Natural gas	0.247	-	-	330	81	13,885	3,430
11	TPP Oranzheria Levski, town of Levski	Natural gas	0.247	-	-		-	5,172	1,277
12	TPP Oranzherii Kresna, town of Kresna	Natural gas	0.247	6,112	1,510	4,499	1,111	4,893	1,209
13	TPP Oranzherii Trudovets, village of Trudovets	Natural gas	0.247	2,711	670	5,264	1,300	3,639	899
14	TPP Unibel, city of Yambol	Natural gas	0.247	4,015	992	2,667	659	2,498	617
15	TPP Republika, city of Pernik	Coal	0.439	81,243	35,666	84,362	37,035	272,910	119,808
16	TPP Gabrovo, city of Gabrovo	Coal	0.439	4,039	1,773	6,578	2,888	8,985	3,945
17	TPP Pleven, city of Pleven	Natural gas	0.247	111,082	27,437	132,406	32,704	143,672	35,487
18	TPP Sofia, city of Sofia	Natural gas	0.247	132,949	32,838	123,925	30,609	79,848	19,722
19	TPP Sofia Iztok, city of Sofia	Natural gas	0.247	294,033	72,626	303,822	75,044	251,463	62,111
20	TPP Plovdiv Sever, city of Plovdiv	Natural gas	0.247	49,812	12,304	83,362	20,590	123,272	30,448
21	TPP to Brikel EAD, town of Galabovo	Coal	0.439	217,865	95,643	662,905	291,015	687,165	301,665
22	TPP Sliven, city of Sliven	Coal	0.439	93,170	40,901	124,730	54,757	153,965	67,591
23	TPP Ruse Iztok, city of Ruse	Coal	0.439	140,007	61,463	169,984	74,623	332,175	145,825
24	TPP Deven, town of Devnya	Coal	0.439	440,376	193,325	655,597	287,807	425,842	186,945
25	TPP Gorna Oryahovitsa, city of Gorna Oryahovitsa	Natural gas	0.247	24	6	5,366	1,325	11,303	2,792
26	TPP Svishtov, town of Svishtov	Coal	0.439	46,548	20,435	19,791	8,688	149,650	65,697
27	TPP Vidahim, city of Vidin	Coal	0.439	213,045	93,527	287,877	126,378	229,218	100,627
	Total			1,976,440	725,549	2,828,030	1,084,794	3,067,938	1,191,684

Chart 11.1 Production of electricity and heat and fuel savings, MWh (2010-2014)

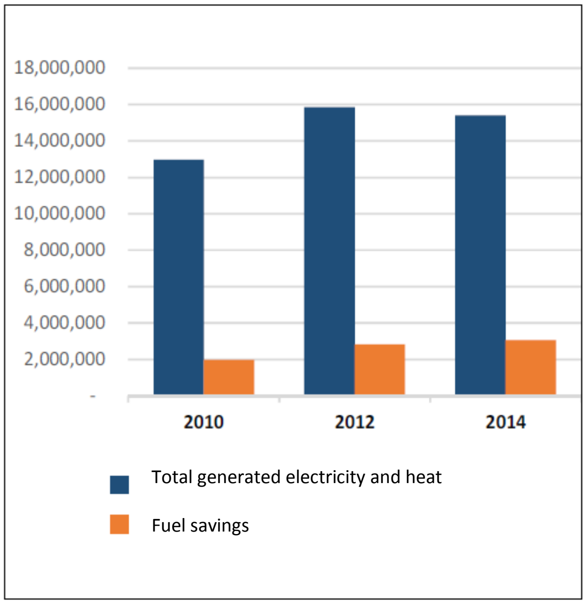
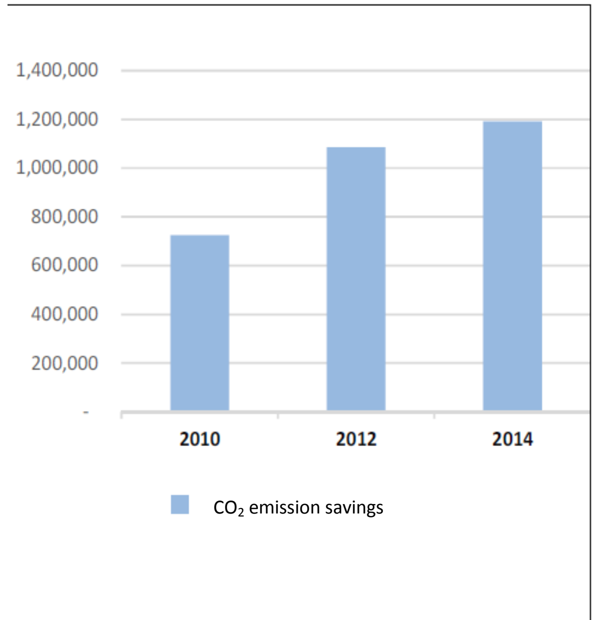


Chart 11.2 CO_2 emission savings, tons (2010–2014)



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