Assessment of the potential for high-efficiency combined heat and power generation and efficient district heating and cooling for the Czech Republic

December 2015

CONTENTS

[The original text contained a glossary of abbreviations used in the Czech version, which is not relevant to the English text – translator's note.]

EXECUTIVE SUMMARY

Over the last two decades gradual changes have occurred in the Czech Republic energy sector in the fuel base and in technologies. A decline may be noted in the use of solid and liquid fuel (domestic coal and heating oils), with a contrasting increase in the use of nuclear energy (for electricity generation), natural gas (for individual heat generation and small CHP) and of renewable energy sources. It is realistic to assume that these trends will continue.

There has also been a significant reduction in heat consumption, because of rationalisation of generation, distribution and especially consumption, of heat. And although the potential for heat savings on the consumption side is not yet exhausted, the declining trend has already slowed noticeably.

The consumption of heat for heating, hot water heating and for technical purposes (with the exception of process heat) reached 445 PJ in 2013. The demand outlook for heat given in this report reflects on the one hand anticipated Czech economic growth in the industry and services sector and growth in the number of households, and on the other, a continuing trend towards energy savings, which should balance pressure on the growth in heat demand. The forecast result is a relative stagnation caused by a combination of growth in the economy, or more precisely in the number of households and energy savings in all these sectors.

From a generation standpoint, 2/3 of the heat is generated at an individual level and the remainder centrally. In central generation approximately 3/4 is from combined heat and power (CHP) and 1/4 is represented by generation for heat alone. The dominant fuel in individual heat generation and in central heating plants is natural gas. By way of contrast, the dominant fuels in combined heat and power are bituminous coal and brown coal, mainly of domestic origin. Current the combined cycle generates approx. 11 to 12 TWh of electricity. Most of this generation is achieved in older coal facilities with steam turbines. In terms of operation support, in 2014 53 % of the total CHP was designated high-efficiency CHP.

In respect of the scale of CHP use the current situation in the Czech Republic is favourable. CHP sources and heat supply systems have a long tradition in the Czech Republic, the relevant technologies are available, there is sufficient operational experience and know-how for the preparation and implementation of new high-efficiency CHP projects.

The potential for developing high-efficiency CHP has been identified in particular for smaller sources with power outputs at the level of single MWe. It will probably consist of increasing the number of micro-cogeneration units[1], small[2] and medium-sized CHP sources based on natural gas. A growth in high-efficiency CHP can also be assumed in the use of biomass, biogas stations (including drawing heat from existing sources) and in the development of the energy use of waste. Growth in these areas of high-efficiency CHP is however conditional upon maintaining stable economic stimuli for investors and source operators.

For large sources, only limited potential growth for high-efficiency CHP was identified. Heat from large sources such as heat plants, factory power stations but also the majority of power stations is currently largely applied at the generation point, or is transferred to the consumer using a heat supply network (HSN). In an HSN with large sources this is likely to be a change of the fuel base (co-combustion of renewable energy sources (RES) or alternative fuels) or an improvement in CHP parameters (achievement of greater efficiency or primary energy savings) resulting from reconstruction of a source. However in large sources one should not ignore the risk of a possible reduction in electricity generation from high-efficiency CHP. Current trends in the energy markets (and their consequences in the form of a reduction in the wholesale price of electricity) may cause a slowdown in high-efficiency CHP electricity generation at large sources and a shift to a partially heat-plant operating regime. The majority of large heat sources in the Czech Republic use solid fossil fuels. The retention of the existing level of electricity generation from high-efficiency CHP is therefore also threatened by the tightening of environmental requirements and the expected growth in the cost of CO_2 permits.

The general objectives of national energy policy and territorial energy policies declare support for the maintenance and development of high-efficiency CHP. Specific measures in the form of the setting up of primary legislation and implementing regulations represent a basis for applying the energy and

[1] Under Directive 2012/27/EU a micro-cogeneration unit is a CHP unit with a maximum capacity of up to 50 kWe.
[2] Under Directive 2012/27/EU a small capacity CHP unit is a CHP unit with an installed capacity of up to 1 MWe.

environmental benefits of high efficiency CHP. With respect to the development of a suitable economic and legislative environment for the further development of high-efficiency CHP and efficient systems for district heating in the Czech Republic, this report recommends further suitable measures which should be implemented as soon as possible.

These analyses of consumption savings of primary energy and the wider social benefit show the benefits of maintaining existing sources and developing new sources with high-efficiency CHP. In terms of the scale of new sources with high efficiency CHP, it is recommended on the basis of a cost benefit analysis working within a development corridor for the “CHP” scenario, the assumptions for which up to 2025 include:

Maintaining the existing scale of efficient HSNs and efficient sources with high-efficiency CHP

The development of small- and medium-sized sources burning gas fuels, supplemented by the development of sources using RSE or alternative fuels (by 2025 a total of 350 MWe of new sources of electricity capacity).

The achieved positive results for the “CHP” scenario represent a wider social view of the operation of existing and the development of new sources with high-efficiency CHP. The market price of electricity does not provide high-efficiency CHP operators with compensation for the additional costs associated with the energy savings and emissions savings arising through combined electricity and heat generation. In order to achieve the development of high-efficiency CHP under the “CHP” scenario, which was evaluated through a cost benefit analysis (CBA) as being the socially most advantageous, it is therefore necessary to secure the retention of the support system for electricity from high-efficiency CHP, or to re-work the system with measures which will represent business environment stability in this energy sector.

1. Introduction

European Parliament and Council Directive 2012/27/EU, on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Directive 2012/27/EU), lays out in Art. 14 the following requirements:

- Para. 1: By 31 December 2015, Member States will conduct a comprehensive assessment of the potential for high-efficient combined heat and power generation and efficient district heating and cooling, which will contain the data laid out in Annex VIII of the Directive, and will notify the Commission thereof.
- Para. 3: For the purposes of the assessment in paragraph 1 Member States conduct a cost benefit analysis which relates to their territory in accordance with Part 1 of Annex IX and is based on climatic conditions, economic feasibility and technical suitability.

The present report "Assessment of the potential for high-efficiency combined heat and power generation and efficient district heating and cooling for the Czech Republic" is the discharge of the aforementioned requirements by the Czech Republic.

From a content and methodological standpoint the report meets the requirements of Directive 2012/27/EU and was prepared in accordance with the "Guidance Note on Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EC, and repealing Directives 2004/8/EC and 2006/32/EC; Article 14: Promotion of efficiency in heating and cooling" (SWD(2013) 449 final, of 6 November 2013).

The contents of the report are structured as follows:

- Chapter 2 contains information pursuant to Point a) of Annex VIII of Directive 2012/27/EU, i.e. a description of demand for heating and cooling
- Chapter 3 contains information pursuant to Point b) of Annex VIII of Directive 2012/27/EU i.e. a demand development forecast for heat over the next 10 years particularly in respect of demand growth related to buildings and individual industry sectors
- Chapter 4 contains the mapping materials pursuant to Point c) of Annex VIII of Directive 2012/27/EU
- Chapter 5 contains the information pursuant to Points d) to e) of Annex VIII of Directive 2012/27/EU, i.e.:
  - determining the demand for heating and cooling which might be satisfied by high efficiency combined heat and power generation, including micro-cogeneration in households, and by district heating and cooling.
  - determining the potential for further high-efficiency combined heat and power generation, using the reconstruction of existing, and the construction of new, generating facilities and industrial facilities or other equipment producing waste heat
- Chapter 6 contains information pursuant to Point f) of Annex VIII of Directive 2012/27/EU, i.e. determining the potential of the energy efficiency of district heating and cooling infrastructure
- Chapter 7 contains information pursuant to Point g) of Annex VIII of Directive 2012/27/EU, i.e. a description of the strategies, policies and measures to be adopted in the period up to 2020 and up to 2030 to use the potential indicated in Chapter 5.
- Chapter 8 contains information pursuant to Point h) of Annex VIII of Directive 2012/27/EU, i.e. data on the proportion of high-efficiency combined heat and power generation and on the potential determined and progress achieved under Directive 2004/8/EC
- Chapter 9 contains information pursuant to Point i) of Annex VIII of Directive 2012/27/EU, i.e. an estimate of the quantity of primary energy saved
- Chapter 10 contains information pursuant to Point j) of Annex VIII of Directive 2012/27/EU, i.e. making an estimate of possible state aid measures for heating and cooling
- Chapter 11 represents compliance with the requirement under Art. 14 (3) to conduct a cost benefit analysis which relates to their territory in accordance with Part 1 of Annex IX of Directive 2012/27/EU.

The report was prepared using Czech Ministry of Trade and Industry statistical data supplemented by data from the Energy Regulatory Office (ERO), the Czech Statistical Office (CSO), the Czech Meteorological Institute, Eurostat/IEA data and taking into account forecasts given in Czech Republic strategic documentation (the Czech State Energy Concept, the Czech National Action Plan for Energy from Renewable Sources[3], the Czech National Action Plan for Energy Efficiency and others).

[3] Unless stated otherwise, this is based on the National Renewable Energy Sources Action Plan dated 2015 submitted for interdepartmental comments.

2. Demand for heating and cooling and ways of meeting it

The objective of this part of the document is to provide information pursuant to Point a) of Annex VIII of Directive 2012/27/EU, i.e. a description of demand for heating and cooling.

The following data sources inter alia were used to analyse existing demand for heat and the methods for meeting it.

- Ministry of Trade and Industry information from statements for cca 1,500 companies
- Ministry of Trade and Industry information for household consumption
- CSO information on energy balances for cca 25 thousand companies
- Czech Met Office information on approx. 12,000 sources / 6.5 thousand companies
- ERO information on cca 2,400 price locations / 500 companies
- Information on natural gas distribution from approx. 220 thousand demand points and transfer points in households / 110 thousand in companies.

In view of the scope of the processed data it is not possible to provide information on long-term trends. For this material information was therefore processed for 2013, for which year complete data are available for all analysed consumption segments.

To supplement data statistics were also used from the ERO, CSO, Czech Met Office, Eurostat/IEA together with other supplementary materials[4]. The data collection and evaluation methodologies used for reporting heat generation and consumption, or more precisely CHP varies by organisation, which must be respected particularly when comparing the results given in this material with other documents.

2.1 Heat consumption

Heat consumption in the Czech Republic in 2013 was approximately 583 PJ[5]. A major part of this heat (124 PJ) was consumed in the form of process heat (consumption of fuels and energy directly in the furnaces and burners of production lines).

The balance of heat consumption can be divided between:

- own consumption of technical heat and heat for heating purposes and hot water, i.e. consumption directly at the point of generation without deliveries to third parties
- heat supplied to third parties, including all sales (not including generators' own consumption), i.e.
    - o supplies to HSN – district heating (licenced organisations)
    - o sales of heat as part of a licensed activity
    - o supplies of heat within a housing association, etc.
    - o supplies within a generator's site to other parties (non-licensed organisations, non-licensed activities); heat supplied during boiler operations to other parties, etc.
- losses and balance differences.

The breakdown of overall heat energy consumption in the Czech Republic in 2013 categorised as follows is given in the following figure.

[4] Unless otherwise stated, data from the Czech Ministry of Trade and Industry are used in this document.
[5] 2013 was slightly above average in temperature terms – the variance from the temperature standard was +0,4 °C (Source: Czech Met Office).

Figure 1 Heat energy balance in 2013

Own consumption of process heat	124 PJ
Own consumption of technical heat and heat for heating purposes and hot water	335 PJ
Heat supplied to third parties	110 PJ
Losses and balance differences	14 PJ
Gross heat generation	583 PJ

Source: Ministry of Trade and Industry

In terms of heat consumption categorised by individual sector (without considering own consumption of process heat), the greatest consumption in 2013 was by the households sector, approximately 189 PJ[6.] In the industrial sector[7] consumption was approximately 176 PJ of heat energy. The remaining 80 PJ of heat consumption was recorded in the services and transport sectors and within other unspecified consumption.

Centrally generated and supplied heat covers approximately 150 PJ of the annual total consumption of heat (445 PJ). Of this value approximately 110 PJ is made up of centrally generated heat supplied to third parties. The remaining 40 PJ of heat is made up of self-generation consumption (e.g. consumption within technical equipment in factory energy, also supplying central heat outside a factory; supply of heat from a domestic boiler within the boiler owner's building, excluding heat sales to other buildings, etc.). This heat is thereafter not included in statistics and outlooks for individual heat generation, and remains within the category of centrally generated heat (see Table 1).

Aggregate data on heat energy consumption divided by sector and by heat generation and supply method (centrally or individually generated heat) in 2013 are given in the following table.

Table 1 Heat energy consumption in 2013 by sector and delivery method

Sector	Consumption of centrally generated heat [PJ]	Consumption of individually generated heat [PJ] [8]	Heat consumption total [PJ]
Industry, agriculture and forestry	69	107	176
Households	54	135	189
Services, transport and others	27	53	80
Total	**150**	**295**	**445**

Source: MTI, CSO

2.2 Heat generation

With the exception of process heat and heat covering losses[9] the annual amount of heat generated in the Czech Republic is approximately 445 PJ of heat for heating purposes, hot water preparation and technical heat (heat energy used for technical purposes in industry).

Heat is generated centrally in sources delivering heat to HSN and concurrently for consumption at the point of generation or in individual sources in the sense of individual heat supplies (IHS). The ratio of heat generation between HSN and HIS is approximately 1:2. The calculated shares of the individual components of heat

[6] This value does not take into consideration process heat (heat generated outside heating or hot water preparation needs).

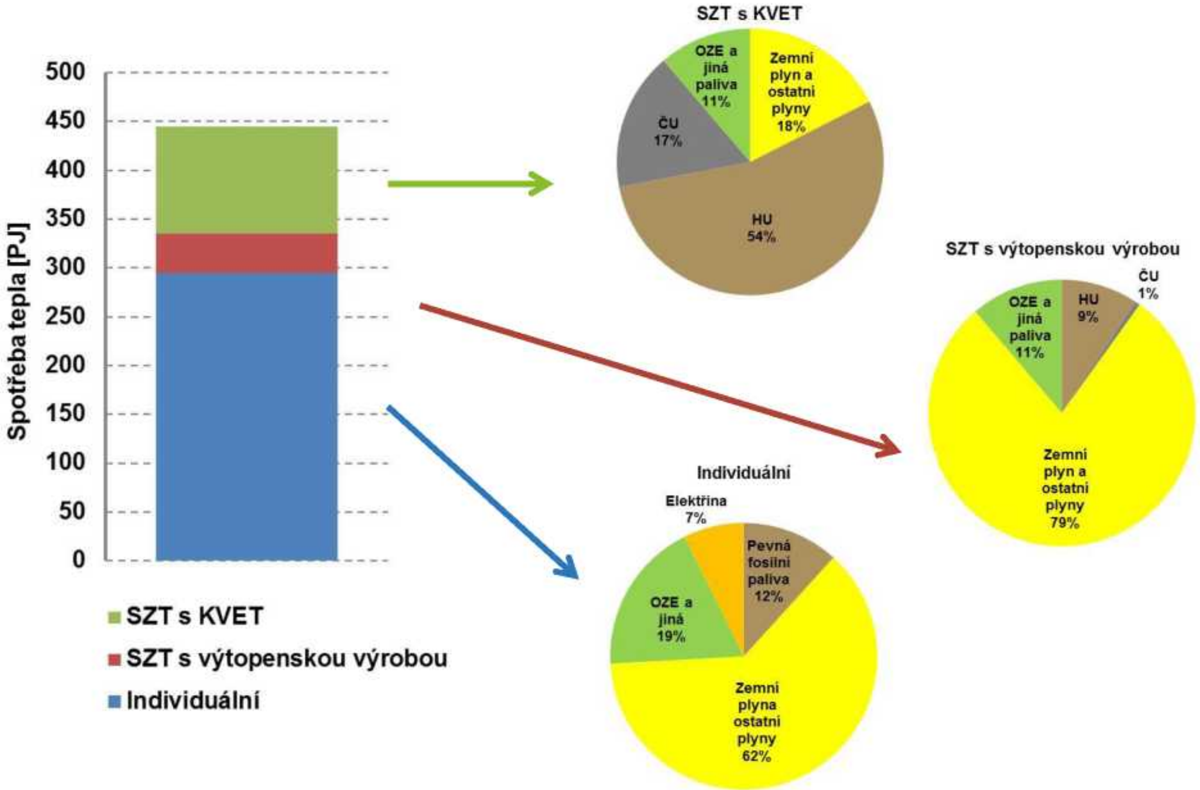
[7] The industrial sector includes mining and extraction, manufacturing industry, generation and distribution of electricity, gas, heat and cooled air, water supplies, activities relating to waste water, waste and land restoration, construction, with agriculture and forestry also included.

[8] More detailed information on the mix of individual generation and consumption is given in Chap. 5.

[9] Total annual gross generation of heat is approximately 580 PJ, of which approx.. 120 PJ is generated and consumed in the form of process heat and 15 PJ is attributed to losses and balancing differences. Process heat includes the direct injection of fuel or energy into metallurgical processes, into cement and lime production, into glass and ceramics production, and others. This is consumption of fuels and energy directly in the furnaces and burners of production lines.

generation are illustrated in the following graph.

Graph 1 Structure of heat generation in 2013



Source: MTI, CSO, Czech Heating Association

Key (left to right):
Spotřeba tepla: Heat consumption
SZT s KVET: HSN with CHP
SZT s výtopenskou výrobou: HSN with heat plant generation
Individuální: Individual
OZE a jiná (paliva): Renewable and other (fuels)
Elektřina: Electricity
Pevný fosilní paliva: Solid fossil fuels
Zemní plyn a ostatní plyny: Natural gas and other gases
HU: Brown coal
ČU: Bituminous coal

2.2.1. Central heat generation

There are currently approximately 2 thousand sources of centrally generated heat recorded. These are on the one hand heating plants supplying only heat, and on the other, power stations and heat plants delivering heat in a CHP regime. The proportion of heat generation by CHP approaches approximately 75 % of centrally generated heat.

In the Czech Republic approximately 150 PJ of heat is centrally generated annually. Of this value approximately 110 PJ is supplied to third parties. The remaining heat is made up of self-generation consumption (e.g. consumption within technical equipment in factory energy, also supplying central heat outside a factory; supply of heat from a domestic boiler with the boiler owner's building, excluding heat sales to other buildings, etc.).

From the perspective of the present document, of relevance is the division of centrally generated and supplied heat into heat generated using CHP and heat generated in a separate generation regime. While the quantity of heat generated in CHP in recent years correlates to temperature trends and reflects the impact of energy savings (according to the CSO from 2000 to 2013 heat from CHP declined by 17 %) for heating plants a more significant decrease in heat generated is observed (according to the CSO from 2000 to 2013 heat from heating plants declined by 37 %).

Concerning the fuel mix for heat generated using CHP, the dominant fuel is brown coal, which makes up more half the fuel consumed. For heat generated in the separate generation regime, the dominant fuel is natural gas, which covers 79 % of the fuel consumption for this generation. The percentage consumption shares for individual fuel types when generating heat in CHP and in heat plant generation are given in the following table.

Table 2 Share of fuels with central heat generation in CHP plants and heating plants

Fuel	**Share for CHP [%]**	**Share for heating plant generation [%]**
Brown coal	54	9
Anthracite	17	1
Natural gas and other gases	18	79
Renewable sources and other fuels	11	11

Source: MTI, CSO

The following table gives the structure of CHP plants as at 31st December 2014. It is clear from the table that most of the installed capacity relates to steam power stations with installed capacity over 5 MWe, namely 9,915.6 MWe. The heat installed capacity of these sources makes up more than 88 % of total heating installed capacity of CHP plants. As stated later in Chapter 10.2.1., almost 75 % of electricity from CHP comes directly from sources with an installed capacity over 5 MWe.

Table 3 Structure of CHP plants (December 2014)

Plant Capacity	Technology	Total installed elec. capacity [MWe]	Total installed heat capacity [MWe]
<= 1 MW_e (incl.)	Steam-powered power stations	13.0	537.4
	Gas turbine power stations	0.0	0.0
	Gas combustion	296.6	341.9
	Total	**309.6**	**879.4**
From 1 MW_e to 5 MW_e (incl.)	Steam-powered power stations	82.8	1266.9
	Gas turbine power stations	0.0	0.0
	Gas combustion	239.0	283.4
	Total	**321.8**	**1550.3**
over 5 MW_e	Steam-powered power stations	9 792.2	18 080.0
	Gas turbine power stations	118.0	119.9
	Gas combustion	5.4	7.9
	Total	**9 915.6**	**18 207.8**
Total	Steam-powered power stations	9 888.0	19884.4
	Gas turbine power stations	118.0	119.9
	Gas combustion	541.0	633.1
	Total	**10 547.0**	**20 637.4**

Source: ERO

2.2.2. Individual heat generation

Individual heat generation occurs in individual plants, which may be furnaces for solid, liquid or gaseous fuels, heat pumps, solar panels and others. Some 295 PJ of heat are generated annually on an individual basis in the Czech Republic, of which 45 % consists of individual heat generation and subsequent consumption in households. The remaining quantity of individual heat generation then comes from industry and services. Only a minor part of individually generated heat is produced using CHP.

Concerning fuels used in households, the most used is natural gas (60 % of households), following by the group of households burning coals, coke, or briquettes, with a share of just under 15 %. Approximately 13 % of households burn biomass as the primary fuel for generating heat. Electricity has a 12 % share.

As in households the most used fuel in the industry and service sectors for individual heat generation is natural gas, with an approximate share of 63 %. A summary of the share of individual fuel types is given in this table:

Table 4 Share of fuels for individual heat generation

Fuel	Share of fuel in households [%]	Share of fuel in industry and services [%]
Natural gas	60	63
Solid fossil fuels	15	9
Electricity	12	2
Biomass and other	13	26

Source: MTI, CSO, Czech Heating Association

2.3. Consumption of cooling

In view of the prevailing climatic conditions cooling is not especially developed in the Czech Republic. It is used typically in administrative buildings and service buildings, or more particularly, in industrial applications where there is a requirement to maintain a stable temperature.

Neither the manufacturers nor consumers of cooling have any reporting duties currently, and the precise volume of supply/consumption of cooling is therefore not known. Although individual cooling generation and systems for supplying cooling exist in the Czech Republic, the demand for cooling is not statistically evaluated.

In most cases these are individual cooling sources for use in a building where the heat transfer medium is generated. There are also applications of so-called tri-generation, that is joint generation of electricity, heat and cooling (usually on the basis of combustion motor technology).

As far as HSN are concerned, for the most part this is a combination of district distribution of hot water/steam and absorption cooling, where heat is used as the input energy for generating cooling. Cooling is thus supplied to industrial companies, to users in the services area or for example to mining companies. In relation to technology the supply of cooling is included in heat generation. It is estimated that central deliveries of cooling in the Czech Republic achieve a level of approximately 300 to 400 TJ p.a.

3. Demand forecast for heating and cooling

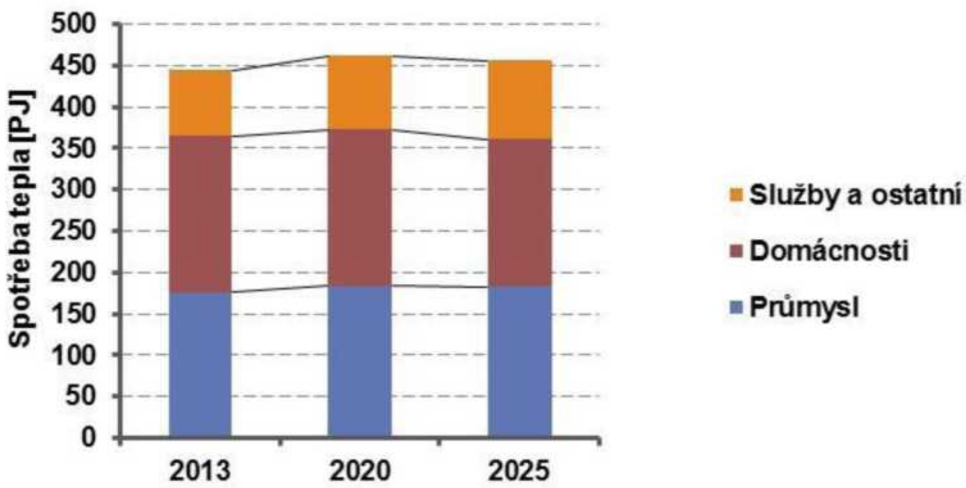
The objective of this part of the document is to provide information pursuant to Point a) of Annex VIII of Directive 2012/27/EU, i.e. a description of demand for heating over the next 10 years particularly in relation to demand development, for heat consumption in buildings and an individual industrial sectors.

The demand outlook for heat reflects anticipated Czech economic growth in individual sectors. The Czech Republic anticipates continuing economic growth and gradual convergence with the developed countries of Europe. However in some sectors there may be structural changes with a gradual decline in favour particularly of the services sector. In industrial production the most significant output growth is expected in manufacturing industry. In contrast, a decline should occur in mining and raw materials extraction. In aggregate, industrial sectors can expect an output increase by 2025 of up to 40 % (in constant prices in comparison with the 2013 reference year). In services growth is anticipated in essence in all sectors (in total for all sectors of more than 50 % in comparison with 2013). Further, the forecast assumes a continuation of the growth trend in the number of households. In line with economic growth there should be a gradual increase in the demand for heat, in technological processes, in process consumption for industry, as well as in end use.

However the forecasts assume a continuing trend towards energy savings, which should even out the pressure for a growth in demand for heat. In industry this represents a reduction of measured heat consumption per unit of output by an average of 25 %, in service sectors by up to 27 % (using a comparison with the reference year of 2013 and forecasts for 2025). For the population it is assumed that the continuing trend in economy measures will lead to a reduction in consumption in existing buildings of 10 %. The forecast result is a relative stagnation caused by a combination of relative growth in industrial sectors and purchasing power, equipping and number of households and energy savings in all these sectors.

For all sectors heat consumption is given without process heat (process heat is described in greater detail in Chapter 2) or losses.

Graph 2 Heat consumption outlook



Key (left to right):
Spotřeba tepla: Heat consumption
Služby a ostatní: Services and other
Domácnosti: Households
Průmysl: Industry

Outlook for heat consumption divided by sector and by supply method is also given in the following table[5].

Table 5 Heat consumption outlook [PJ]

Sector	2013	2020	2025
Industry, agriculture and forestry	176	184	183
Households	189	189	179
Services, transport and others	80	89	94
Total	**445**	**462**	**456**

4. Country maps related to heating and cooling

The objective of this part of the document is to provide information pursuant to Point c) of Annex VIII of Directive 2012/27/EU, i.e. to prepare maps of the Czech Republic which while retaining confidentiality on information of a sensitive nature, give:

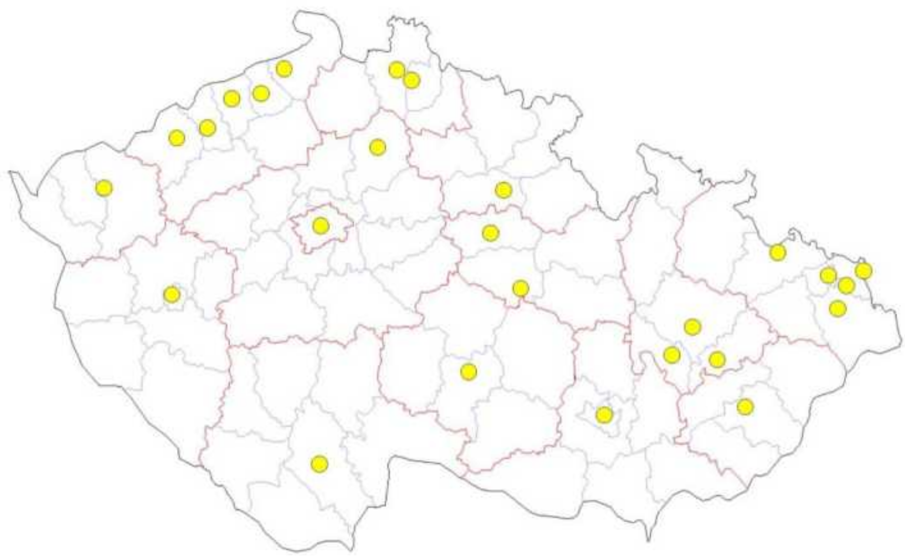
- Demand locations for heating and cooling
  - towns and suburbs
  - industrial zones
- existing and currently planned infrastructure for district heating and cooling
- possible supply points for heating and cooling
  - electricity generation facilities
  - waste incinerators
  - existing and currently planned CHP facilities and facilities for district heating

4.1 Demand locations for heating and cooling

4.1.1 Towns and suburbs

Categorisation of towns and suburbs by the "plot ratio > 0.3" indicator is not available for the Czech Republic. The following map therefore gives the most important municipalities in the Czech Republic – the statutory cities (Prague, Plzeň, Liberec, Brno, Ostrava, České Budějovice, Havířov, Hradec Králové, Karlovy Vary, Olomouc, Opava, Pardubice, Ústí nad Labem, Zlín, Jihlava, Kladno, Most, Karviná, Mladá Boleslav, Teplice, Děčín, Frýdek-Místek, Chomutov, Přerov, Jablonec nad Nisou, Prostějov).

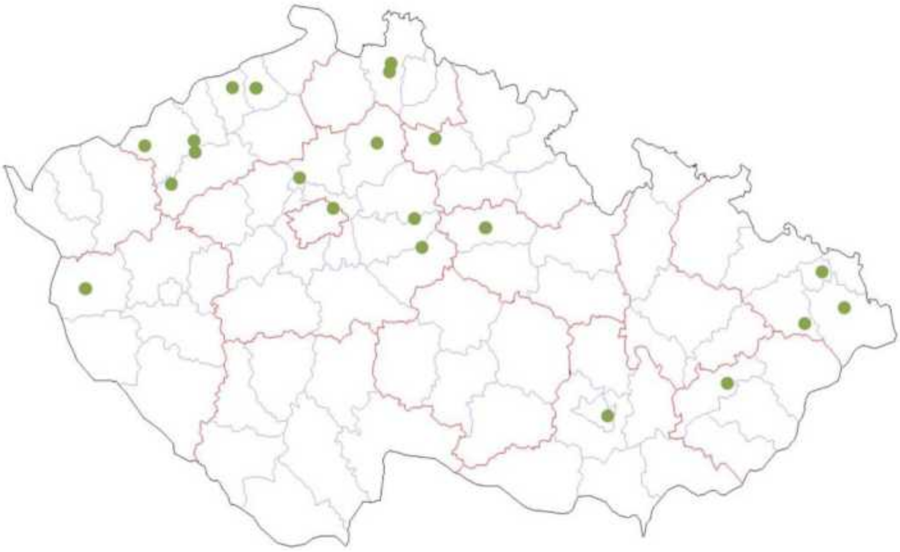
Figure 2 Map of the statutory cities of the Czech Republic



4.1.2. Industrial zones

Categorisation of industrial zones by heat consumption is not conducted in the Czech Republic. The following map gives industrial zones with an area in use of greater than 50 ha (Kolín-Ovčáry, Ostrava - Mošnov, Most Joseph, Holešov, Žatec - Triangle, Nošovice, Kutná Hora - Na Rovinách, Liberec Jih-Doubí, Bor Logistics Park, Mladá Boleslav - East, Kozomín - Úžice, Klášterec n.O. ind. park VERNE, Jičín – Industrial Zones I, II, III, Černovická terasa, Industriální park Krupka, Trade and Industry Zone Liberec North - Růžodol, Ostrava - Hrabová, Pardubice - Free Zone + Staré Čívice, Podbořany - Alpka, Business Site Vlčovice, Ústí nad Labem - Severní Předlice, VGP Park Horní Počernice).

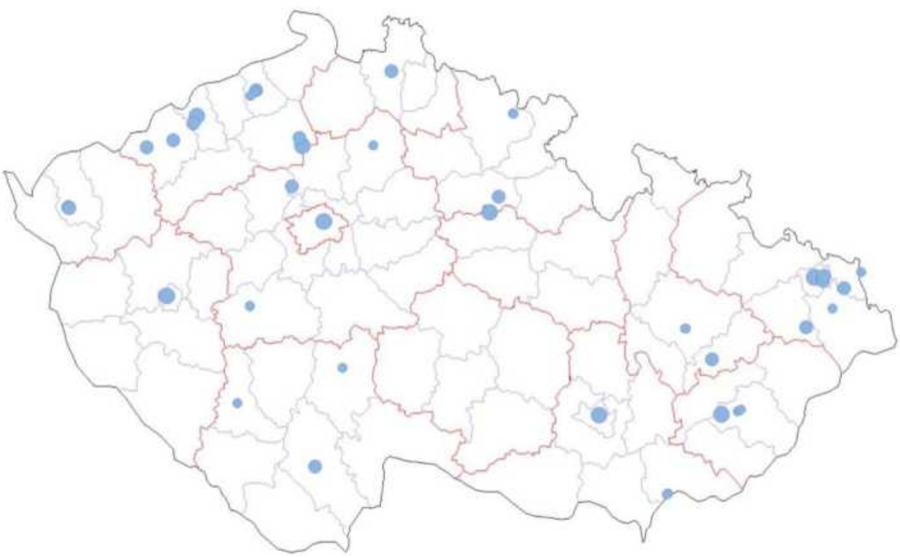
Figure 3 Map of industrial zones



4.2 Infrastructure for district heating and cooling

The following map shows the most important HSNs in the Czech Republic, for illustration systems with a transmission capacity in excess of 200 MWt were chosen (Hodonín, Trutnov, Tisová, Prunéřov, Ostrava Vítkovice, Plzeň, České Budějovice, feed from Mělníka and distributors in Prague, Strakonice, Ústí nad Labem, Ostrava, Karviná, Havířov, Olomouc, Přerov, Frýdek Místek, Ústí nad Labem, Zlín, Liberec, Brno, Hradec Králové, Mladá Boleslav, Příbram, Ostrava, Tábor, Olomouc, Štětí, Chomutov, Hodonín, Vítkovice, Ústí nad Labem, Litvínov, Zlín, Plzeň, Opatovice, Kralupy nad Vltavou, Most - Komořany, Kopřivnice, Otrokovice). Only the extraction of heat from the Temelín nuclear power station may currently be considered as more extensive currently planned infrastructure for district heating. In view of the fact that the development of high-efficiency CHP is mainly being planned for smaller plants, there will not be a need to construct extensive infrastructure projects for district heating.

Figure 4 Infrastructure map for district heating

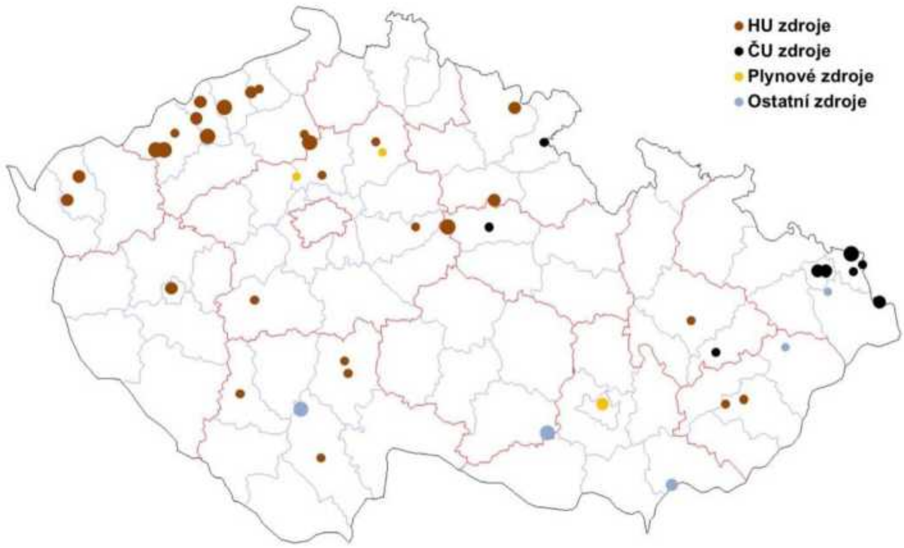


4.3 Supply points for heating and cooling

4.3.1 Electricity generating plants

The following map shows the largest existing sources in the Czech Republic with generation in excess of 20GWh/yr. where CHP is already in use or where these sources are suitable for the use of CHP technology (Ledvice, Mělník, Chvaletice, Tušimice, Počerady, Poříčí, Prunéřov, Tisová, Trmice, Kladno, Zlín, Opatovice, Vřesová, Chomutov, Plzeňská energetika, Plzeňská teplárenská, České Budějovice, Olomouc, Kolín, Komořany, Příbram, Strakonice, Tábor, Ústí nad Labem, Štětí, Otrokovice, Planá n.L., Neratovice, Mladá Boleslav, Litvínov, Dětmarovice, Třebovice, Karviná, ČSA-Karviná, Přerov, Ostrava-Přívoz, Náchod, Třinec, Synthesia Pardubice, ArcelorMittal Ostrava, Vítkovice, Brno, Kralupy nad Vltavou, Dobrovice, Hodonín, Biocel Paskov, Valašské Meziříčí, Temelín, Dukovany).

Figure 5 Electricity generating plants with technology permitting CHP



Key:
HU zdroje: Brown coal sources
ČU zdroje: Bituminous coal sources
Plynové zdroje: Gas sources
Ostatní zdroje: Other sources

The majority of heat generating plants in the Czech Republic with generation in excess of 20 GWh/yr. allow for heat supplies in the CHP regime, or more precisely are certified for electricity originating from high-efficiency CHP (excluding the power stations at Počerady, Mělník III, PPC Vřesová and Dukovany). At another 19 sources with generation in excess of 20 GWh/yr., CHP is not feasible (these are hydro, photovoltaic and wind power stations). Other sources are nuclear power stations and sources making predominant use of biomass and secondary sources.

4.3.2 Waste incinerators

The following map shows the 3 existing municipal waste incinerators in the Czech Republic (Prague, Brno, Liberec, with a total annual consumption of cca 650 thousand tonnes of waste) and the most significant industrial waste incinerator in Ostrava (consumption cca 20 thousand tonnes of waste).

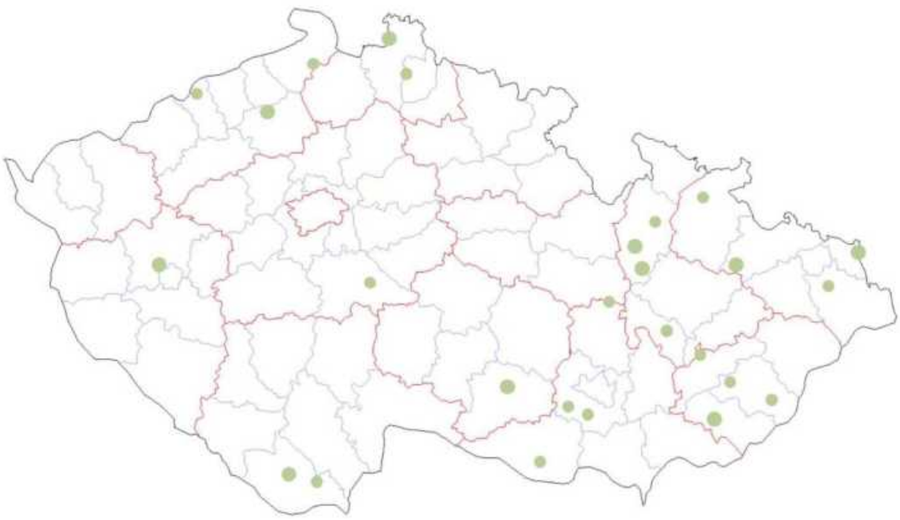
Figure 6 Map of waste incinerators

The Czech Republic also operates a further 23 minor incinerators of industrial/hazardous/medical waste with a minimum potential for energy use of waste. Currently an incinerator with a capacity of 100 thousand tonnes is under construction at Chotíkov near Plzeň.

4.3.3 Facilities with CHP and heating plant currently being planned

The following map is based on issued authorisations to build electricity generating plants, and depicts planned electricity generating plants with technology allowing for CHP (for the purposes of illustration sources with a planned electricity capacity in excess of 2 MWe have been chosen).

Figure 7 Planned CHP facilities



Plans to construct heating plants are not centrally recorded in the Czech Republic.

5 Development potential for CHP and district heating facilities

The objective of this part of the document is to provide information pursuant to Points d) and e) of Annex VIII of Directive 2012/27/EU, i.e.:

determining the demand for heating and cooling which might be satisfied by high-efficiency combined heat and power generation, including micro-cogeneration in households, and by district heating and cooling.

determining the potential for further high-efficiency CHP, using the reconstruction of existing, and the construction of new generating facilities and industrial facilities or other equipment producing waste heat

From the perspective of the methodology there is therefore commentary on the current status and expected development for individual types of heat generation, with the aim of determining the development potential for high-efficiency CHP and district heat, or more precisely the potential for meeting demand using these facilities.

In respect of types of generation and supply of heat, this chapter is divided into:

central and individual heat sources

CHP sources and separate heat generation sources.

In centralised heat generation, most sources in the Czech Republic are CHP, while for individual heating the sources are those with independent (separate, heating plant) heat generation.

The main aim of this chapter is to set out the potential of the individual heat generation technologies, or more precisely, of district heating, having regard to the overall demand for heat given in Chapter 3.

5.1 Sources in centralised heating systems

Sources supplying heat to district heating systems in the Czech Republic can overall be divided into several groups:

- Large CHP sources using solid fossil fuels – brown coal and bituminous coal, possibly in combination with other fuels (sources with steam boilers and backpressure or condensation extraction turbines)
- Large CHP sources using gaseous or liquid fossil fuels – natural gas and technical gases, or heating oil (sources with steam boilers and backpressure or condensation extraction turbines or gas turbines supplying heat).
- Smaller CHP sources using natural gas (co-generation units with combustion motors)
- Smaller CHP source using biomass and alternative fuels (biomass sources with steam turbines or with an ORC, biogas stations with combustion motors, waste incinerators with steam turbines).
- Nuclear power stations
- Sources making use of chemical and waste heat
- Heating boilers using fossil or other fuels

Central source supply the district heating system with approximately 110 PJ of heat p.a. in the form of warm or hot water or steam. A further part of the heat in the case of central sources is consumed directly at the point of generation. Over the long term central sources maintain a ratio of approximately 3:1 between CHP heat and heat from boilers (with a slightly rising trend in favour of CHP).

5.1.1 Large CHP sources using solid brown

Electricity generation and heat from brown coal developed in the Czech Republic in the second half of the 20th C linked to the availability of high-quality domestic brown coal from the North Bohemian and Sokolov brown-coal basins. For this reason brown coal is also the dominant fuel in the Czech Republic for CHP and represents approximately half of the supply of district heat. This fuel is used particularly in sources in areas favourably close to the brown-coal basins, i.e. in the regions of north, west, south and central Bohemia.

The supply of district CHP heat at approximately 50 PJ/yr. is secured by more than 45 sources with a total installed electricity capacity of approximately 9 GWe (40 % of the installed electricity capacity of the Czech Republic). In some sources, brown coal is co-combusted with other fuels – biomass, bituminous coal, or alternative fuels. These are heating plants and factory power statins, but supplies of heat are also provided by the majority of power stations. CHP sources using brown coal therefore also contribute significantly to the operation of the electricity grid.

The potential for supplies of heat from brown-coal CHP sources is to a large extent exhausted in the Czech Republic. Any further significant development of new sources and increases in heat supplies are not therefore to be expected (district heating systems have already been introduced in place of CHP from brown coal). Operators of existing sources will have to come to terms with the requirements for reducing pollutant emissions and the impact on generating costs of purchasing CO_2 emissions permits. There is also a risk for this type of source from the falling wholesale prices of electricity, which reduce the economic effectiveness of CHP; in the marginal case these can cause a shift from heating plant to boiler generation of heat. One of the aims of the Czech Republic energy concept is therefore to maintain at as a high a level as possible the level of district heating systems connected to high-efficiency CHP sources making efficient use of domestic brown coal.

Heat generation on this type of source will in future match an increase in energy efficiency on the consumption side. With the exception of a reduction in heat consumption there also exists the potential for increasing energy efficiency on the part of sources and HSN. For sources this is usually a matter of boilers or turbine reconstruction to parameters which better match the current level of heat supply. For (transmission) systems it is a case of a shift from steam-water systems to hot water. Nevertheless achieving this potential is difficult, having regard to the financial and technical demands of the related measures. In the outlook up to 2025 a decline is assumed in generation from brown coal with an anticipated increase in the consumption of other fuels. The trend in heat generation from brown-coal CHP sources is one of gentle decline, in view of the aforementioned assumptions.

5.1.2 Large CHP sources using bituminous coal

Bituminous coal is another important source for CHP and supplies of district heat. It has a share of approximately 15 % of the supplies of district heat from CHP. All large sources using bituminous coal are operated as CHP (heat plants, factory power stations, and one electricity power station). This fuel is used particularly in north Moravia, Silesia and in east Bohemia.

Most sources are currently undergoing “greening” in connection with the requirements of Directive 2010/75/EU. Retention of this type of source is expected, on the assumption of a decline in heat generation linked to a reduction in heat consumption. Bituminous coal sources are also threatened by the decline economic efficiency of CHP and similar risks of a shift to heating boiler generation apply to them, as in the case of brown coal. Further significant development of the use of bituminous coal for CHP related supply of district heat is not therefore to be expected (district heating systems have already been introduced in generation locations).

The expected trend up to 2025 in heat generation from bituminous coal CHP sources is one of gentle decline.

5.1.3 Large CHP sources using gaseous or liquid fuels

CHP sources using gaseous or liquid fuels have a share of approximately 15 % to 20 % of the supplies of district heat from CHP. From a fuels perspective with the exception of natural gas, technical gases from mining and chemical generation are used; the trend in the use of liquid fuels is one of decline.

From the perspective of source types, these are heat plants or factory power stations, with a predominance of the use of steam boilers with turbines (gas turbine cycles have yet to achieve wider use in the Czech Republic).

For the future, one cannot assume any development in this type of source (the use of natural gas in large CHP sources is not economically effective in the Czech Republic and the implementation of natural gas is likely to be at the level of smaller CHP plants). In the outlook up to 2025 one may assume stagnation or a slight decline in heat generation from this technology.

5.1.4 Biomass CHP sources

In large CHP sources, biomass is used for co-combustion with solid fossil fuels (the extent of use is however limited by the technical possibilities of the combustion equipment on the one hand, and by support for the use of biomass on the other), as well as independently.

With the exception of large sources co-incinerating biomass, heat in the Czech Republic is supplied by approximately 25 smaller co-generation biomass sources with a total capacity of cca. 80 MWe. There exists the potential for developing this technology in locations which have existing central heating boiler generation of heat. The limiting conditions for this development are the availability of biomass at the future generation location and the ability to obtain support for new sources.

Under the renewable sources NAP, growth of 4.5 PJ is assumed up to 2020 for heat generation from biomass outside households (co-combustion of renewable and non-renewable sources and independent combustion). Excluding the potential for growth of co-combustion of biomass in large sources, one may assume the commissioning of several smaller CHP generators making independent use of biomass (installed capacity of 10-15 MWe, or more precisely 20-30 MWt. Assuming the use of heat capacity at the level of 3 thousand hrs./yr. this represents a potential growth in the annual supply of heat from new biomass sources of 0.3 PJ by 2025).

5.1.5 Biogas CHP plants

The main growth in biogas plants in the Czech Republic occurred mainly from 2008 to 2013. In the Czech Republic there are at present in operation more than 570 biogas plants with a total installed capacity of approximately 370 MWe. Of this number, 70 % are made up of agricultural biogas plants, the remainder are units located at wastewater treatment plants (approximately 20 %) and at landfill sites (10 %).

The heat produced during operation of a combustion engine is partially used to maintain fermentation (cca. 20 %). For the balance of the generated heat there is not however in most cases accessible demand - usually as a result of the greater distance of the CHP unit from potential heat consumers. One of the activities being supported under the Operational Programmes up to 2020 is therefore support for transporting heat away from biogas plants.

Under the renewable sources NAP, growth of 36 MWe is assumed up to 2020 for biogas plants and an increase in heat generation of 1,3 PJ. Of the order of 5 to 10 % of existing biogas plants have the potential to have heat transported away, usually substituting for existing smaller heating boilers. Assuming the use of heat capacity at the level of 3 thousand hrs./yr. this represents a potential growth in the supply of new heat from existing and new biogas plants of 2 PJ by 2025).

5.1.6 CHP waste incinerators

The Czech Republic has in operation 3 municipal waste incinerators with a total annual capacity of cca. 650 thousand tonnes of municipal waste. All of these are equipped with CHP technology:

- ZEVO Malešice (heat supplied for distribution and consumption within the City of Prague).
- SAKO Brno (heat supplied for distribution and consumption within the City of Brno).
- Termizo (heat supplied for distribution and consumption within the City of Liberec).

Another municipal waste incinerator is currently in the construction phase – ZEVO Chotíkov, again using high-efficiency CHP technology and taking heat for distribution and consumption in the City of Plzeň.

In the Czech Republic there are also 5 cement plants which can accommodate the co-combustion of waste (Králův Dvůr, Čížkovice, Prachovice, Mokrá, Hranice) Annually these use approximately 340 thousand tonnes of normally hazardous/industrial waste. The independently generated heat in these cases is use as energy in the form of process heat.

The Czech Republic also operates a further 24 minor incinerators of industrial/hazardous/medical waste with an annual consumption of approximately 80 thousand tonnes.

According to Ministry of the Environment figures the Czech Republic as a whole produces approximately 5 mill. tonnes of municipal waste per annum. In accordance with the waste management plans, by 2024 there should be a limitation on landfill of mixed municipal waste, which also represents potential for growth in incinerators. Projects in preparation nevertheless currently come up against problems with economic feasibility arising from the very low charges for landfill disposal of mixed municipal waste and protracted permitting procedures. A new Waste Act, currently being worked on by the Ministry of the Environment, should bring about an increase in charges for landfill disposal of mixed municipal waste.

In the case of the growth of the energy use of waste, this will largely be CHP plant – for larger sources with condensation extraction turbines, for smaller sources with steam reduction. As an alternative or concurrently, following verification of operational experience, there may be development of pyrolytic or plasma gasification.

Under the renewable sources NAP, growth of 0.3 PJ is assumed up to 2020 for heat from the biodegradable part of municipal waste. In the Czech Republic the potential for energy use is approximately 1.4 tonnes of municipal waste. Assuming the energy use of all available fuel, the estimated potential is for growth in the electricity capacity of incinerators from 2016 to 2030 up to 30 MWe and for annual heat supplies of 3 PJ/yr.

5.1.7 Nuclear power stations

For both of the Czech nuclear power stations there are plans to transport heat for heating purposes. The situation is made more complex particularly because of the significant distance from larger population centres where the heat might be used.

Temelín nuclear power station

Heat is currently supplied from the Temelín nuclear power station to the town of Týn nad Vltavou to the volume of cca 0.2 PJ/yr. A significant plan is the construction currently under consideration of a hot water feed from the power station to České Budějovice. The length of the feed from the power station to the transfer point for the district heating system would be approximately 25 km and the expected quantity of heat supplied approximately 1.0 to 1.5 PJ/yr. The feed could thus cover approximately half the consumption needs of household customers. The plan has reached the stage of having a land planning decision issued.

For the existing generator and distributor of heat for České Budějovice, this plan is somewhat complicated. In terms of generation the potential reduction in supplies would mean a reduction in CHP efficiency, but at the same time it would be essential to leave in place a sufficient capacity reserve to cover unplanned outages of Temelín blocks, or breakdowns on the feeder line. At the same time bringing in heat in hot water form would require reconstruction of the heat mains.

Dukovany nuclear power station

At the present time, heat from the Dukovany nuclear power station is only used at the power station site. A plan exists to transport heat to the City of Brno approximately 40 km away, including supplying several smaller municipalities along the feeder route. Construction itself would be complicated, two rivers would need to be crossed and several tunnels constructed. These conditions cause a higher level of specific investment and from an economic efficiency standpoint the project is feasible only on the basis of heat off-take of approximately 4 PJ/yr.

This requirement for the quantity of heat supplied would in essence mean replacing the entire base load of district heating in Brno (including the municipal waster incinerator and other existing gas CHP plants). At the same time there would be a need to maintain a sufficient capacity reserve to cover outages. At the same time there is no current resolution for the renovation of the Dukovany power station, which attains its original projected service life in 2015-2017.

The option to construct a feed from the Dukovany power station can thus be considered a theoretical one, and the potential of this possible source is likely to remain unused.

5.1.8 Waste and chemical heat

The use of waste or chemical heat is currently recorded at the level of 5 to 7 PJ/yr. and is used for consumption at the point of generation and for heat supplies to the district heating system. It may be assumed that in manufacturing industry there exists the potential to increase the proportion of use of consumed process heat (the consumption of heat reaches 100 PJ/yr.). For this reason support activities under the Operational Programmes also include the use of waste energy in manufacturing processes, or more precisely, increasing the energy efficiency of manufacturing and technical processes.

5.1.9 Small and medium-sized natural gas CHP plants

In the Czech Republic there are at present in operation approximately 300 natural gas CHP plants with capacities from 50 kWe to 5 MWe with a total installed capacity of approximately 220 MWe. In this are of high-efficiency CHP the possibility exists up to 2025 of significant growth, particularly as a result of the shift from existing heating boiler generation and the addition of plants in new buildings. An assumption for the growth of this technology is the retention of existing support schemes.

The REZZO database (Register of Emissions and Sources of Atmospheric Pollution) was the starting point for estimating the potential for high-efficiency CHP in the area of existing heating boiler generation. From this database were chosen those sources using natural gas (i.e. the location has this fuel available) without installed CHP, which do not produce process heat. The growth potential was then derived from these values:

- micro-cogeneration (see Chap. 5.2.5)
- small and medium-sized sources with high-efficiency CHP (see following table).

Table 6 Technical growth potential for small and medium-sized co-generation up to 2025

Category [kW_e]	50-200	200-1,000	>1,000	Total
Estimated potential - Elec. capacity [MWe]	210	360	260	830
Estimate potential – Heat generation [PJ]	2,5	6,8	4,3	13,7

With the exception of the usual supply of heat from co-generation units in the form of water or steam there is now also demand for co-generation units to supply process heat in industrial applications (e.g. for drying a range of raw and other materials).

5.1.10 Central heating boilers

The predominant fuel for central heating boilers is natural gas supplemented by solid fuels (particularly biomass and fossil fuels). Generation from heating boilers attains 40 PJ/yr. This area of heat generation represents significant potential for the growth of combined generation, particularly in the form of the installation of CHP units with piston motors (see Chaps. 5.1.9 and 5.2.5), as a replacement/supplement for existing heating boilers. A further trend in this area will probably be a decline in the use of solid fossil fuels as a consequence of environmental demands on these combustion sources.

5.2 Individual heating

5.2.1 Gas boilers

Natural gas is the most important fuel for individual heating and also has the highest share in overall heat consumption in the Czech Republic. Natural gas is used for heating by approximately 1.4 mill. households (approximately 35 % of the total number of households, or more precisely 60 % of individually heated households). Similarly, in the industrial and services sectors there is an almost 2/3 share for the dominant technology of individual heat generation. At the same time this is a possible substitute for the supply of heat from HSN. This dominant position is likely to remain in place into the future. Only for a minor number of own generators may one assume a shift from using natural gas burned in boilers to using micro-cogeneration/minor CHP or gas heat pumps.

5.2.2 Boilers using solid fossil fuels.

Solid fossil fuels (brown and bituminous coal, coke, briquettes) represent the cheapest form of individual heating and are used currently by approximately 0.35 households. In the industrial and services sectors they have an almost 1/10 share of individual heat generation. In the light of support for exchanging individual fossil-fuel boilers in households (replacing with lower emissions boilers) one may expect a reduction in the share of this heat generation technology. This fuel is used largely as a result of its low price. As substitutes may be used biomass or other modern technologies (heat pumps, solar collectors, etc., in the case of larger sources, CHP units may be a substitute).

5.2.3 Biomass boilers

Biomass (word, wooden briquettes or pellets) is used in individual heating particularly in locations where natural gas is not available or where it is cost effective for the user to make use of this fuel. Biomass is used as the primary source of heat by approximately 0.3 mill. households (and as a supplementary source of heat by a further 0.5 mill. households). In the future a slight rise in the share of biomass in individual heating may be expected. Under the renewable sources NAP, growth of 4.5 PJ is assumed up to 2020 for heat generation from biomass in households.

5.2.4 Electric boilers and heat pumps

Electricity is normally used for heating in family homes in locations where natural gas is not available. Currently electricity is used in approximately 0.3 mill. households. In future one may assume an increase in the use of electric heat pumps, both for new builds and for conversions from the original use of electric boilers or other fuels with lower ease of handling (coal, biomass). Under the renewable sources NAP, growth of 8.3 PJ is assumed up to 2020 for heat generation from heat pumps.

5.2.5 Micro-cogeneration

Micro-cogeneration, with capacities of the order of unit kW or tens of kW, is not for the moment too widespread (of the order of 200 units with a total electricity capacity of 5 MWe). In future one may assume a gentle increase in this technology (predominantly based on burning natural gas) in places where to date only single generation has applied, but also in places where heat is being used for the first time.

Installation of high-efficiency CHP can be assumed particularly for service buildings, residential blocks with higher capacities of gas heating, and in smaller quantities also in family houses. Installation of high-efficiency CHP in apartments (probably a combination of a gas boiler with a Stirling motor with a capacity of cca 1 kWe) will be minimal.

From the perspective of micro-cogeneration growth, based on analyses of the database of small pollution sources and household natural gas consumption, the potential growth is estimated at up to 150 MWe up to 2025, with expected heat supply from CHP of up to 5.0 PJ.

5.3 Summary of the potential for individual heat generation technologies.

The following table summaries the assumptions for growth/decline in the individual heat generation technologies. The trend up to 2025 for central heat generation should be a decline in heat boiler heat generation with an anticipated replacement by small and medium-sized CHP units, supplemented by extraction of heat from suitably located biogas plants. Any other significant growth in large sources with high-efficiency CHP is not anticipated, but there may be a substitution of the fuels used for CHP (e.g. municipal waste, nuclear fuel, biomass in place of fossil fuels). For large sources with high-efficiency CHP there is also the risk of a decline in electricity generation from CHP as a result of an accumulation of economically unfavourable factors (lower grid electricity prices, imposition of permits, environmental requirements, etc.) For individual sources growth in the application of modern technologies is expected (e.g. of heat pumps, solar collectors), together with the growth of micro-cogeneration (up to 50 kWe) and small co-generation (up to 1 MWe), particularly in administrative buildings, service buildings or in industrial applications.

Table 7 Growth trends in the individual heat generation technologies

Technology	Current situation	Trend	Potential heat generation trend for the Czech Republic up to 2025	Commentary
Large CHP sources using brown coal	= ½ of CHP heat in Czech Republic	↘	None (economy measure on the consumption side balanced by the growth in new consumers)	Slight decline (warming); partial shift to other fuels
Large CHP sources using bituminous coal	= 1/6 of CHP heat in Czech Republic	↘	None (economy measure on the consumption side balanced by the growth in new consumers)	Slight decline (warming); partial shift to other fuels
Large CHP sources using gaseous or liquid fuels	= 1/6 of CHP heat in Czech Republic	→	None (economy measure on the consumption side balanced by the growth in new consumers)	Stagnation or slight decline (warming)
Biomass CHP sources	= 80 MW_e normally CHP	↗	0.3 PJ for smaller sources (incl. co-combustion with coal up to 4.5 PJ)	Use of biomass for co-combustion and slight growth in smaller CHP plants
Biogas CHP plants	= 370 MW_e, heat not normally used	↗	2 PJ (extraction of heat from existing biogas plants and new biogas always with CHP)	Slight growth of new sources and extraction of heat from existing
CHP waste incinerators	3 municipal waste incinerators in Czech Republic (all CHP)	↗	3 PJ	Growth in municipal waste incinerators in line with plans for waste management
Nuclear power stations	Heat not used in any significant way	↗	1.5 PJ	Potential for extracting heat from Temelín power station
Waste and chemical heat	Heat normally exploited at point of origin	↗	Not quantified	Potential in form of exploitation of process heat
Small and medium-sized CHP plants using gaseous fuels	= 220 MWe normally CHP	↗	13.7 PJ	Growth in form of replacement of heating boilers or in new consumption locations
Central heating boilers	= ¼ of central heat generation	↘	None (unless heat plants limit CHP because of inefficient electricity generation)	Decline in boilers using solid fossil fuels and natural gas
Individual gas boilers	= 60 % of individual heating	→	Not quantified But may represent the easiest replacement for central source.	Stagnation, possibly slight shift to applying gas heat pumps
Individual solid fossil fuel boilers	= 10-15 % of individual heating	↘	None	In spite of current support for exchange of boilers a decline is expected in the use of solid fuels
Individual biomass boilers	= 10-15 % of individual heating	→	4.5 PJ by 2020	Stagnation (pellet boilers in new buildings vs. shift to other fuels in existing)
Individual electric boilers and heat pumps	= 10-15 % of individual heating	↗	For new consumption, potential for heat pumps (8.3 PJ by 2020)	Significant growth of electric heat pumps, particularly to the detriment of electric boilers.
Micro-cogeneration	= 200 cases (5 MW_e)	↗	5 PJ	Growth in the form of supplementary separate heat generation

6. Potential for energy efficiency in the district heating and cooling infrastructure

The aim of this part of the document is to provide information pursuant to Point f) of Annex VIII of Directive 2012/27/EU, i.e. determining the potential for energy efficiency in the district heating and cooling infrastructure.

The HSNs in the Czech Republic include approximately 2,000 recorded heat sources, of which 1,800 sources with a capacity exceeding 5 MWt. Of 4.1 million households 1.6 million are supplied by district heating, approximately 40 % The total length of heat networks totals some 10 thousand kilometres.

Loss statistics in HSN mains conducted by the CSO indicate an increase in pro-rata losses (total losses in relation to total heat supplied) from 9 % in 2004 to 10.8 % in 2013.

The rising trend in pro rata losses in recent years is caused by ageing of the infrastructure and a reduction in heat off-take with a retention of loss levels. In general the most significant potential for reducing losses in mains consists of converting from steam-water networks to hot water.

In view of the length of the heat networks and the fact that almost 15 % of them are still steam-water (1,458 km, to be exact), there is great potential for heat savings in this area of distribution. The old steam-water networks are characterised by losses which are five times greater than those for hot water networks. The average values for pro rata annual losses in both types of heat mains have the following values:

- Steam mains 7.35 – 9.80 GJ/m
- Hot water mains 1.61 – 2.00 GJ/m

If we consider only steam mains without technical operations, i.e. without so-called “big chemistry” and technical operations, the total length of steam mains used for district heat supply is 1,129 km, of which it is estimated that cca. 900 km is in need of reconstruction. For the reduction being considered for pro rata losses achieved by replacing steam mains averaging 5.74 GJ/m per year, the overall expected annual energy savings can be quantified at approximately 5.2 PJ. This would mean an increase in distribution efficiency for heat energy roughly of 1/3.

Costs for the complete conversion of steam mains to hot water can be estimated at between 21 and 28 mill. CZK/km (total costs for reconstruction in green spaces and by roads/railways, including turnouts). This means total costs for reconstruction of all steam networks designated for reconstruction at a level of 19 to 24 bn. CZK

Implementation of mains conversion from steam to hot water is nevertheless technically quite difficult, because these mains are as a rule to be found in densely built-up areas. And in spite of the positive effects in energy savings, similar projects are not economically worthwhile in terms of investor return. For this reason for the following period, reconstruction of systems aimed at loss reduction is the subject of investment support from operational programmes.

6.1 Efficient heat and cooling supply systems in the Czech Republic

In Directive *2012/27/EU, Art. 2 (41), efficient district heating is defined as a* “a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat”. Currently no records are maintained in the *Czech Republic for efficient district heating and cooling systems, and thus no corresponding statistics are available which relate to this segment.*

The only relevant data source which can be used for these purposes is the list of HSNs with a greater than 50 % share of heat energy generated from renewable sources, which is recorded and published by the ERO under Section 25 (5) of Act No 165/2012, on supported energy sources and a change to certain laws, as amended. Records for other types of efficient HSNs are being prepared.

In 2014 a total of 94 HSNs were recorded where more than half the heat energy came from renewable energy sources. The average proportion of heat from renewable energy sources in these systems was 92.5 % A total of 57 systems showed a proportion of heat from renewable energy sources of 100 %

Act No 165/2012 instructs the ERO to record and publish a summary of efficient HSNs. This should happen for the first time by 30 April 2016 at the latest. Subsequently it will be possible to start [?] in relation to these systems.

7. Strategies, policies and measures

The aim of this part of the documents is to provide information pursuant to Point g) of Annex of Directive 2012/27/EU, i.e. a description of the strategies, policies and measures to be adopted in the period up to 2020 and up to 2030 to use the potential indicated in Chapter 5.

The description is formally divided up into existing and proposed strategies, policies and measures.

7.1 Existing strategies, policies and measures

The basic document for sustainable development is the Strategic Framework for Sustainable Development for the Czech Republic approved by government resolution No. 37 of 11 January 2010. Within Priority 2.2: Securing the energy security of the state and increasing the energy and raw materials efficiency of the economy, Objective 3 is set out: Support sustainable energy. The objective is particularly:

- *to increase energy efficiency when converting primary energy sources with the concurrent optimum use of renewable energy sources*
- *to increase energy savings in the individual sectors of the national economy and at the final consumer and*
- *to support the use of efficient and environmentally friendly technologies (e.g. BAT)*

The resources for meeting this objective include inter alia the aforementioned maximum concern for the environment, which will be primarily based on and effective and environmentally friendly structure of renewable source use and on the generation methods for electricity and heat energy.

This document is also followed by the Czech Republic State Environment Policy for 2012-2020 dated 2012 and the State Energy Concept from 2015, giving more specific objectives and measures, as well as action plans for individual areas such as, for example, the Biomass Action Plan for the Czech Republic for 2012-2020, the National Action Plan for Renewable Energy Sources (2012), the National Action Plan for Smart Networks and the National Action Plan for Energy Efficiency.

The following specific measures follow on from current legislation and it assumed that they will be in force at least until 2020.

7.1.1 Increasing the proportion of CHP

Strategic documents

Czech State Environmental Policy 2012-2020

Within the topic of Climate Protection and Atmosphere Quality Improvement, under Priority 2.1 Reduction of greenhouse gas emissions and limiting the negative impact of climatic changes Objective 2.3.3 is set out: Securing the commitment to increase energy efficiency by 2020. The measures to achieve this objective include: “Support an increase in the proportion of CHP”.

State Energy Concept

Under the State Energy Concept, one of the strategic objectives is by 2040 to cover at least 60 % of heat energy supplies from HSN by CHP generation (p. 43).

The following objective is stated within the strategy up to 2040 for electrical and heat energy sectors:

PII.5. Moving the majority of heating boilers across to high-efficiency CHP generation wherever this is economically feasible.

The key basic input assumptions, so-called axioms, which are always respected when implementing the State Energy Concept, include directing brown coal primarily into CHP and sources with the highest efficiency (p. 43).

The main objectives for heat generation and supply (Chap. 5.4) include:

D.3. Secure a gradual shift towards CHP generation combined with efficient use of heat pumps on all heating boilers.

The component objectives for energy conversion efficiency include:

Fb.3. A shift towards high-efficiency CHP in all heat supply systems.

The component objectives for natural gas sources include:

Ae.2. Create the conditions for developing micro co-generation sources and their intelligent integration into networks with priority use of electricity for own use.

The component objectives for secondary sources of energy and waste include:

Ag.4. Support CHP energy generation from biogas plants using as fuel biodegradable waste from the usable parts of municipal and agricultural waste and food industry waste.

Czech Biomass Action Plan for 2012-2020

In Chapter 6.2 Conclusions and Recommendations, the document gives the following recommendation: *Support the priority use of biomass for CHP with the highest possible heat energy share and thereby achievement of high efficient of biomass energy conversion (minimum 60 % – 70 %).* There is a further recommendation to set current support policies so that motivate investors towards higher energy efficiency (CHP equipment, boilers) to achieve a higher level of use of available heat.

NREAP

The NREAP in the wording of its 2012 update assumes a growth in electricity from CHP from renewable energy sources from 3,457 GWh in 2013 to 4,502 GWh in 2020. It should of course be pointed out that this growth will to a large extent be achieved at the expense of CHP from fossil fuels, particularly from brown coal and that this, then, is not a net increase in electricity generation from CHP in the Czech Republic. An update of the NREAP is currently being undertaken. This update assumes growth in electricity generation from CHP from renewable energy sources from 4,685 GWh in 2015 to 5,129 GWh in 2020.

National Action Plan for Smart Networks

In Chapter 5.3 Development of other energy areas in the Czech Republic, it is stated that the future significance of heat sources is also to be expected in greater involvement in the provision of services at transmission system level, as well as at distribution system level. The regulatory abilities of CHP sources can be extended using installation of equipment for electricity consumption (electric boilers) and heat accumulators. Into the future the primary role for heating plants will be heat supplies, with their role in the future consisting also of expanding the support services offered and securing electricity supplies in the event of a system grid emergency and its break-up into off-grid operations.

Specific Measures

The Czech Republic has introduced investment and operational support from electricity generation from high-efficiency CHP, described further in Chap. 10.

Under Act No 165/2012 distribution system operators and transmission system operators must give priority to connecting plants generating electricity from CHP on their defined territory.

Fuel used for CHP electricity generation is, under Act No 261/2007, as later amended, and in accordance with Directive 2003/96/EC exempt from gas tax and solid fuel tax.

The construction of an electricity plant with a total installed capacity of 1 MW or greater, under Act No 458/2000, on the Conditions for Business and State Administration in the Energy Industries and a change to certain laws (the Energy Act), as amended, is possible only on the basis of a granted state authorisation to build an electricity plan, which is awarded by the Ministry of Trade and Industry. The Ministry will not issue an authorisation if the planned electricity plant is not in accordance with an energy assessment to secure high-efficiency CHP under the Act on Energy Management.

Under Act No 406/2000, on Energy Management, as amended (the Energy Management Act), a building contractor or? of an energy system must from 1 July 2015 arrange an energy assessment to assess the costs and benefits of arranging high-efficiency CHP in the event of construction of a new electricity plan or the substantial reconstruction of an existing electricity plant with total heat capacity over 20 MW with the exception of electricity plans to be operated for less than 1500 hours a year and nuclear power plants.

Under Act No 406/2000, the regions and the City of Prague must prepare territorial energy concepts, which set out the objectives and principles for energy management within a region, the City of Prague, its city districts or municipalities. The territorial energy concept contains defined and expected areas or corridors for construction projects of public interest to develop the energy economy, while taking account of the potential to use efficient heating and cooling systems, particularly if they make use of high-efficiency CHP and heating and cooling using renewable energy sources where it is appropriate. The territorial development concept is the basis for preparing the Territorial Development Principles or the territorial plan.

7.1.2 HSN Infrastructure Development

State Energy Concept

The key basic input assumptions, so-called axioms, which are always respected when implementing the State Energy Concept, include priority retention of effective systems of supplying heat energy (in both economic and energy terms) (p. 43).

Heat supplies must be secured using current HSN wherever it is economically appropriate, on the assumption that the environmental impact and other externalities are appropriately reflected in input prices for central and non-central sources (p.46).

The following requirement is stated within the strategy up to 2040:

PI.9. Renewal, transformation and stabilisation of heat supply networks based to a distinctive degree on domestic sources (nuclear, coal, renewable energy sources, secondary sources) supplemented by natural gas. The use of the storage capability of the heating systems in possible combination with heat pumps.

The main objectives for heat generation and supply (Chap. 5.4) include:

D.1 Maintain over the long term the greatest possible economically sustainable scope of systems for supplying heat, having regard to their competitiveness, and to arrange comparison of the economic conditions of centralised and decentralised heat sources when paying for emissions and other externalities (carbon tax, permits, emissions).

D.5. Support the restructuring of energy and economically ineffective heat supply systems wherever there is an assumption of achieving higher energy efficiency, higher fuel usage flexibility and better parameters in terms of sustainable development.

D.6. Support the maximum use of heat from nuclear power stations for heating larger agglomerations near such sources. The following fall into consideration: Brno, Jihlava, Dukovany, České Budějovice, as well as others over the time horizon to 2030.

D.8. Support territorial development of heat supply networks where it is realistic and effective, with the aim of making use of the balance of heat capacity resulting from savings in buildings.

The component objectives for de-centralised heat generation include:

Dc.5. The preference for high-efficiency CHP

The main objectives for energy efficiency (Chap. 5.6) include:

F.6. Use of public aid funds (including part of the income from emission permit auctions) for measures aimed an increasing energy efficiency (e.g. in the reconstruction and development of HSNs).

The component objectives for energy conversion efficiency include:

Fb.4. Loss reduction in heat facility distribution systems

NREAP

The NREAP in paragraph 4.2.9 states that the current infrastructure for district heating and cooling is sufficient to achieve the objective for the share of renewable sources against gross domestic energy consumption in 2020. In current systems there is mainly a need to focus on their renewal and improving their economy (reduction of heat losses during distribution). New HSNs may come about mainly in smaller residential areas, where a suitable renewable energy source is available (particularly biomass or biogas) in sufficient quantity. An update of the NREAP is currently being undertaken.

Specific measures

The Czech Republic has introduced investment support for reconstruction and development of HSN infrastructure, described further in Chap. 10.

Reconstruction of HSNs was also included in the National Investment Plan pursuant to Art. 10c of Directive 2009/29/EC, amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community. HSM operators with co-generation source can thus obtain free of charge assigned permits in exchange for investing in the reconstruction of HSNs. But within investments included in the National Investment Plan it is forbidden to have support concurrent with grant-aided programmes.

Under Act No 406/2000, the regions and the City of Prague must prepare territorial energy concepts, which set out the objectives and principles for energy management within a region, the City of Prague, its city districts or municipalities. The territorial energy concept contains defined and expected areas or corridors for construction projects of public interest to develop the energy economy, while taking account of the potential to use efficient heating and cooling systems, particularly if they make use of high-efficiency CHP and heating and cooling using renewable energy sources where it is appropriate. The territorial development concept is the basis for preparing the Territorial Development Principles or the territorial plan.

7.1.3 Growth in use of waste heat and heat from renewable energy sources

State Energy Concept

Biomass is the only supplementary systemic renewable energy source which is available on a larger scale in the Czech Republic for the needs of the heating sector. Other forms of renewable sources are limited for heating sector purposes for technical and other (socio-environmental) reasons. The potential of geothermal energy is for the moment untested, but according to preliminary analyses may be significant. The use of geothermal energy is for the time being associated with high costs. Wind and water energy are not suitable for heating purposes and the use of solar energy does not have sufficient potential for centralised heating supplies. Growing importance is attached to the use of biogas, first of all in agriculture (p.16).

Under the State Energy Concept, one of the strategic objectives is by 2040 to cover at least 20 % of heat energy supplies from HSN generation from by renewable energy sources (p. 43).

The main objectives for heat generation and supply (Chap. 5.4) include:

D.2. To support the use of biomass, other renewable and secondary sources and the maximum use of waste in combination with other fuels for heat supply networks, particularly for medium and small-sized source and reasonable collection distances.

The component objects in the fuel base for HSN include:

Da.2 To support the shift particularly of medium and small-sized heat supply systems over to multi-fuel systems making use of locally available biomass, natural gas, as well as other fuel, where in particular natural gas will play the role of a stabilising and supplementary fuel.

The component objectives for secondary sources of energy and waste include:

Ag.2. To give priority support to direct (thermic) use of non-recyclable waste without prior treatment for co-generation heat supply systems in accordance with environmental protection, in particular atmospheric protection.

The optimal scenario for energy development up to 2040 as given in the State Energy Concept assumes a significant increase in the share of heat from renewable energy sources of heat supplies from HSNs.

Czech Biomass Action Plan for 2012-2020

In Chap. 6.3.2 Grant Policy, the document recommends supporting the renewal of the boiler base in the form of combustion sources for solid biomass in the household sector and in small HSN boilers.

NREAP

The NREAP assumes growth in heat generation from biomass outside households, the biodegradable part of solid municipal waster and other wastes, biogas and geothermal energy of approximately 6 PJ. It can be assumed that the major part of this growth will be secured using heat supply networks. An update of the NREAP is currently being undertaken.

Specific Measures

Generators generating heat from biomass, bioliquids, and geothermal energy have the right to operational support under Act No 165/2012. The support relates to facilities with a nominal heat capacity greater than 200 kW and is paid out in the form a green bonus against the market price of the heat supplied. As part of the amendment to Act No 165/2012, approved in 2015 by Act No 131/2015, heat support was also introduced from 1 January 2016 for generation of utility heat from biogas arising more than 70 % from farmyard fertilisers and by-products of animal husbandry or from biodegradable waste in heat plants with an installed electrical capacity of up to 500 kW. However claims for this support can begin only on completion of notification of this newly introduced support system to the European Commission.

The Czech Republic has also introduced investment support for the use of heat from renewable sources, described further in Chap. 10.

Act No 165/2012, also lays down the obligation to purchase heat generated from renewable sources and allowing connection of a heat plant to heat distribution facilities. The obligation to purchase relates only to such an amount of heat as will not threaten reliable and safe operation of the relevant heat supply network, or part thereof, or will not limit the use of renewable sources in another heat energy source connected to the heat distribution facility. The obligation to allow the connection of a heat plant and the purchase of heat does not arise if the heat generator is not a license holder for heat energy generation under the Energy Act, if the heat distribution facility is part of an efficient heat supply network, if it were to increase the total cost of heat acquisition for existing customers of a heat energy distribution license holder, or if the characteristics of the heat transfer medium do not match the parameters of the heat distribution system of the heat supply system at the connection point.

Heat supply networks with a proportion of heat from renewable sources greater than 50 % have, in Annex No 3 to Decree No 78/2013, on the energy efficiency of buildings, as amended by Decree No 230/2015, an established special factor for non-renewable primary energy, which is favourable reflected in the energy efficiency evaluation of buildings connected to a heat supply network with a high share of renewable energy sources.

Under Act No 406/2000, the regions and the City of Prague must prepare territorial energy concepts, which set out the objectives and principles for energy management within a region, the City of Prague, its city districts or municipalities. The territorial energy concept contains defined and expected areas or corridors for construction projects of public interest to develop the energy economy, while taking account of the potential to use efficient heating and cooling systems, particularly if they make use of high-efficiency CHP and heating and cooling using renewable energy sources where it is appropriate. The territorial development concept is the basis for preparing the Territorial Development Principles or the territorial plan.

7.1.4 Support for the location of heat plants and sources of waste heat in places of potential heat consumption

State Energy Concept

The component objectives for coal energy include:

Ad.2. New coal sources to be directed at high-efficiency and CHP generation with a minimum annual energy conversion efficiency of 60 % or efficiency in line with BAT, if higher.

Specific measures

The construction of an electricity plant with a total installed capacity of 1 MW or greater, under Act No 458/2000, as amended, is possible only on the basis of a granted state authorisation to build an electricity plan, which is awarded by the Ministry of Trade and Industry. The Ministry will not issue an authorisation if the planned electricity plant is not in accordance with an energy assessment to secure high-efficiency CHP under the Act on Energy Management.

Under Act No 406/2000, a building contractor or owner of an energy system must from 1 July 2015 arrange an energy assessment to assess the costs and benefits of arranging high-efficiency CHP in the event of construction of a new electricity plan or the substantial reconstruction of an existing electricity plant with total heat capacity over 20 MW with the exception of electricity plans to be operated for less than 1500 hours a year and nuclear power plants.

7.1.5 Support for the location of new consumption points in places with a supply of waste heat

Under Act No 406/2000, the regions and the City of Prague must prepare territorial energy concepts, which set out the objectives and principles for energy management within a region, the City of Prague, its city districts or municipalities. The territorial energy concept contains defined and expected areas or corridors for construction projects of public interest to develop the energy economy, while taking account of the potential to use efficient heating and cooling systems, particularly if they make use of high-efficiency CHP and heating and cooling using renewable energy sources where it is appropriate. The territorial development concept is the basis for preparing the Territorial Development Principles or the territorial plan.

7.1.6 Support for the connection of new heat sources to HSNs

Under Act No 406/2000, a building contractor or owner of an energy system must from 1 July 2015 arrange an energy assessment for:

- assessing the costs and benefits of using waste heat to satisfy the economically justified demand for heat, including CHP, and connection of equipment at the very least to a heat supply network located within 1000 metres of the heat source, in the case of construction of a new electricity plan or the substantial reconstruction of an existing electricity plant with total heat capacity over 20 MW producing waste heat at a useable temperature.
- assessing the costs and benefits of the use of waste heat off-take at least from industrial operations located within 500 meters of a heat distribution facility, in the case of the construction of, or the substantial reconstruction of, an existing heat supply network with sources with a total heat capacity over 20 MW.

This assessment is part of the documentation for issuing a land planning decision, and if a land planning decision is not needed, is part of the project documentation for issuing a construction permit, or part of the documentation for issuing a joint land planning decision and construction permit.

7.1.7 Support for the connection of new heat consumption points to HSNs

In accordance with Act No 235/2004 on Value Added Tax, as subsequently amended, heat is included in the lower VAT rate of 15 %

Under Act No 406/2000, the regions and the City of Prague must prepare territorial energy concepts, which set out the objectives and principles for energy management within a region, the City of Prague, its city districts or municipalities. The territorial energy concept contains defined and expected areas or corridors for construction projects of public interest to develop the energy economy, while taking account of the potential to use efficient heating and cooling systems, particularly if they make use of high-efficiency CHP and heating and cooling using renewable energy sources where it is appropriate. The territorial development concept is the basis for preparing the Territorial Development Principles or the territorial plan.

Pursuant to Act No 406/2000, a building contractor, housing association or building owner must, during the construction of new buildings or during a major change to an existing building with an energy source with installed heat generation capacity greater than 200 kW, arrange for an energy assessment to assess the technical, economic and environmental feasibility of alternative systems of energy supply, which also include heat supply networks. This assessment is part of the documentation for issuing a land planning decision, and if a land planning decision is not needed, is part of the project documentation for issuing a construction permit, or part of the documentation for issuing a joint land planning decision and construction permit. In the case of buildings with installed heat capacity of less than 200 kW, the law lays down an obligation to have a similar assessment performed for the building energy efficiency certificate.

Under Act No 201/2012 on atmospheric pollution as amended legal entities and individuals are obliged, if it is technically possible and economically acceptable, for new buildings and for changes to existing buildings to make use for heating of heat from a heat supply network or a source which is not a stationary atmospheric pollution source.

7.2 Newly proposed measures

As part of the preparation of this document further measures were proposed to support high-efficiency CHP and high-efficiency district heating and cooling in the Czech Republic.

1. Securing the continuation of operational support for high-efficiency CHP and heat from renewable energy sources, compatible with EU public aid rules for new equipment commissioned 2016 onwards and legislatively anchoring the support scheme in an appropriate manner.

   Justification: Czech legislation assumes the continuation of operational support for high-efficiency CHP and heat from renewable energy sources into future years. However there is a need to notify the support scheme at the European Commission and then conduct the adjustments essential to ensure its full compatibility with EU public support rules. In view of investor confidence there is a need to legislatively anchor the operational support in a way that creates suitable economic conditions for the growth of high-efficiency CHP and long-term predictability and stability of the business environment.

2. An increase in taxation of fossil fuel consumption in stationary sources excluding CHP in equipment not falling with the emissions trading system at a level matching the CO2 emissions price from the expected permit price

   Justification: The plan comes from the Czech State Environmental Policy for 2012-2020 and also from the National Emissions Reduction Programme. This increase in taxation of equipment for mono-generation of heat would increase the competitiveness of CHP.

3. As part of the update to the National Smart Networks Action Plan, evaluate the options for providing support services at the distribution system level (voltage regulation, regulation of idle capacity, short-circuit contribution, blackstart, off-grid operations, etc.).

   Justification: Heat plants with CHP generation could offer more support services at the distribution systems level, which could contribute to the return on the investment in their construction and modernisation.

4. Including the primary energy factor for efficient heat supply networks in the energy efficiency evaluation for buildings (amendment to Decree No 78/2013).

   Justification: Currently only a renewable energy sources share of greater than 50 % is included as a plus in the evaluation of the energy efficiency of buildings. Including of efficient heat supply networks would create a motivation for connecting new buildings in particular to these networks.

5. Accelerate and simplify the permitting processes for high-efficiency CHP facilities and for the construction and reconstruction of heat networks.

   Justification: The building of new high-efficiency CHP facilities and heat networks including reconstruction thereof, should not be unnecessarily burdened with excessive administration. At the same time, plan discussion times should be shortened and the scope for obstruction limited.

6. Set motivational economic conditions for the energy use of the municipal waste remaining after the sorting of recyclable items. Link possible public support to the use of heat.

   Justification: The current Waste Act assumes termination of municipal waste to landfill in 2024. In line with the hierarchy of waste handling there is therefore a need to create an economic environment for the use of remaining municipal waste, which would otherwise have to go to landfill. At the same time there is a need to have regard for the maximum possible use of its energy content. The key economic instrument here is the landfill payment, which should be significantly increased. This approach is in accordance with the Czech 2015-2024 Waste Management Plan and the Czech State Environmental Policy 2012-2020.

7. Securing corresponding funds to stimulate reconstruction and development of HSNs after 2020 using inter alia some of the funds from selling greenhouse gas emission permits and other support mechanisms.

   Justification: Under current ESIFs it will be possible to provide grants only up to 2023 and it is not currently clear whether this support will continue into the next programme period. It would nevertheless be appropriate to secure after that date adequate funds to support reconstructions and development of heat supply networks.

8. Share of high-efficiency combined heat and power generation and on potential determined and progress achieved under Directive 2004/8/EC

The objective of this part of the Document is to provide information pursuant to Point h) of Annex VIII of Directive 2004/8/ES, i.e. data on the share of high-efficiency combined heat and power generation and on the potential determined and progress achieved under Directive 2004/8/EC

Progress in supporting combined heat and power generation contained in the legislation is described in Chapters 7 and 10.A support system for electricity generation from high-efficiency CHP has been introduced using price regulation implemented by the ERO based on current energy legislation. CHP and district heating investment support projects appear in grant programmes. CHP sources and HSNs have tradition in the Czech Republic going back many years. In the future there will be development of high-efficiency CHP particularly at the level of small capacities, or more precisely small HSNs.

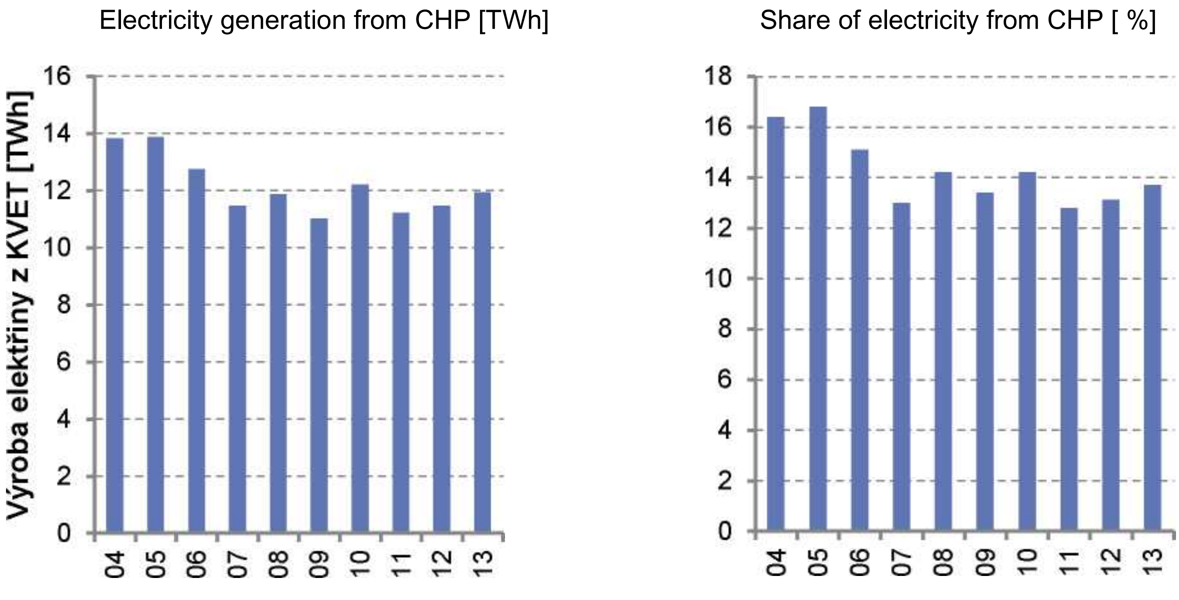
The following tables and graphs illustrate the results of statistical monitoring for CHP. Further data can be found in other parts of this document.

The following table and graphs give the growth of electricity generation from CHP and the CHP share of overall gross electricity generation. Electricity from high-efficiency CHP represents more than have of the overall generation of electricity from CHP, see Chap. 10.2.1.

Table 8 Growth in share of electricity generated from CHP

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gross electricity generation [TWh]	84.3	82.6	84.4	88.2	83.5	82.3	85.9	87.6	87.6	87.1
Electricity generation from CHP [TWh]	13.8	13.9	12.7	11.5	11.9	11.0	12.2	11.2	11.5	11.9
Electricity share from CHP [%]	**16.4**	**16.8**	**15.1**	**13.0**	**14.2**	**13.4**	**14.2**	**12.8**	**13.1**	**13.7**

Graph 3 Growth of electricity generation from CHP and the CHP share of electricity



The reducing generation of electricity and heat from CHP matches the decline in central generation of heat. However the share of heat from CHP has increased over the last few years (according to the CSO from 2004 to 2013 the share of supply heat in heat plants and power stations using solid fuels, nuclear power station, gas turbine cycles and CHP units with piston motors in relation to total central heat generation has risen from 70.5 % to 74.3 %).

9. Estimate of the quantity of primary energy saved

The objective of this part of the document is to provide information pursuant to Point i) of Annex VIII of Directive 2012/27/EU, i.e. an estimate of the quantity of primary energy saved.

The estimate of primary energy saved was made only for all CHP electricity and heat (active HSNs are not currently fully documented for the Czech Republic). For this reason it is not possible to determine the potential for primary energy saving for active HSNs.

To calculate primary energy savings achieved through the use of CHP in the Czech Republic in 2013, CHP statistics prepared at the Ministry of Trade and Industry were used. The reporting methodology differs slightly from the CSO methodology used for reporting to the European Commission and Eurostat, and for this reason the values for gross electricity generation and utility heat from CHP also vary slightly.

The calculation of primary energy savings was performed in accordance with Annex II of Directive 2012/27/EU and Commission Implementing Decision 2011/877/EU). Harmonised reference efficiency values for separate heat generation were always used for the steam/water medium case. Harmonised reference efficiency values for separate electricity generation were always selected for a CHP unit commissioned in 2003 (see Directive 2012/27/EU, Annex 2, para. f, Point 3). The calculation concerns all electricity from CHP without removing electricity generation not tied to utility heat; it also includes plants which do not meet the criterion for high-efficiency CHP. In this sense the calculation must be regarded as very conservative (the calculated relative primary energy savings also take account of CHP which is not classified as high-efficiency). The statistical data were not available for an exact calculation of primary energy savings only for high-efficiency CHP.

In line with para. 11 of the Annex, a correction was also made for climatic conditions within the Czech Republic and the voltage level of plant connection.

The results for primary energy savings achieved are given in the following table. These are the results for all CHP, not just for high-efficiency CHP. Data for high-efficiency CHP are not unfortunately currently available in the scope required.

Table 9 Primary energy savings achieved from CHP in 2013

Fuel	Electricity CHP [GWh]	Utility heat [TJ]	Fuel input [TJ]	CHP efficiency [%]	Primary Energy Savings [TJ]
Biomass	747	7,642	15,395	67	5,679
Biogas	971	3,496	8,741	80	5,126
Bituminous coal	1,954	20,240	40,205	68	-365
Brown coal	5,630	66,339	116,537	74	11,911
Waste heat	25	296	730	53	-94
Oils	9	136	263	64	-31
Other liquid fuels	1	6	10	84	3
Other solid fuels	111	1,677	3,302	63	512
Other gases	868	8,199	19,559	58	-50
Natural gas	1,226	12,880	21,405	81	1,751
Total	**11,542**	**120,911**	**226,147**	**72**	**24,442**

Source: MPO

Primary energy savings associated with the estimated growth in high-efficiency CHP from 2016 to 2025 was analysed for three developing areas of CHP:

Individual heat generation using micro-cogeneration (IZT - micro-cogeneration)

Central heat generation in small and medium-sized CHP (SZT – Small and Medium CHP for gaseous fuels)

Central CHP heat generation from biomass and alternative fuels (SZT - renewable energy sources and other alternative fuels)

For “IZT - micro-cogeneration” and “SZT – Small and Medium CHP” for gaseous fuels, when calculating primary energy savings, harmonised reference efficiency values were used for separate heat generation for natural gas fuel and for the steam/hot water medium, under the Commission Implementing Decision of 19 December 2011, laying down the harmonised reference efficiency values for separate electricity and heat generation using European Parliament and Council Directive 2004/8/EC, repealing Commission Decision 2007/74/E. In the case of SZT -renewable energy sources and other alternative fuels the harmonised reference value used was that for separate heat generation for agricultural biomass and for the steam/water medium.

Harmonised reference efficiency values for separate electricity generation were selected for the same fuels as in the case of separate heat generation.

A correction was made for climatic conditions within the Czech Republic for an average temperature of 8 °C. The correction factor for voltage was for simplification taken in all cases to be equal to 0.945, corresponding to a voltage level of plant connection of 0.4 to 50 kV.

The results of the estimate of primary energy savings in individual years achieved thanks to new high-efficiency CHP electricity generation plants commissioned from 2016 to 2016 for the CHP and High CHP scenarios (see Chap 11 – CBA) are given in the following table.

Table 10 Estimate of primary energy savings achieved as a result of new high-efficiency CHP from 2016 to 2025

	Primary Energy Savings [PJ]									
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CHP scenario										
Ind. - micro-cogeneration	0.01	0.03	0.06	0.10	0.16	0.16	0.17	0.17	0.18	0.18
HSN – small and medium CHP	0.10	0.21	0.32	0.44	0.56	0.79	1.04	1.31	1.60	1.92
HSN – CHP - renewable energy sources and others	0.5	1.01	1.55	2.10	2.68	2.76	2.84	2.91	2.99	3.07
Total	**0.61**	**1.25**	**1.92**	**2.64**	**3.41**	**3.71**	**4.04**	**4.39**	**4.76**	**5.17**
High CHP scenario										
Ind. - micro-cogeneration	0.01	0.04	0.08	0.14	0.23	0.25	0.27	0.29	0.31	0.34
HSN – small and medium CHP	0.18	0.37	0.58	0.80	' 1.05	1.31	1.60	1.92	2.26	2.63
HSN – CHP - renewable energy sources and others	0.70	1.44	2.22	3.05	3.91	4.08	4.25	4.42	4.59	4.76
Total	**0.89**	**1.85**	**2.87**	**3.98**	**5.19**	**5.65**	**6.12**	**6.63**	**7.16**	**7.73**

The table below also gives an estimate of the cumulative primary energy savings both for individual growth areas, as well as for all technologies together. The table also gives the cumulative quantity of utility heat and electricity generated in new high-efficiency CHP plants from 2016 to 2025 together with the anticipated efficiency of these plants.

Table 11 Estimate of cumulative primary energy savings achieved as a result of new high-efficiency CHP from 2016 to 2025

Technology	**Utility heat [PJ]**	**Electricity CHP [GWh]**	**CHP efficiency [%]**	**Primary energy savings [PJ]**
CHP scenario				
Individual – micro-cogeneration	6.1	675.9	82.0	1.21
HSN – small/medium CHP	18.8	3,725.4	82.0	8.29
HSN – CHP – RSE and others	23.7	2,432.1	75.0	22.40
Total	**48.5**	**6,833.4**	**78.7**	**31.90**
High CHP scenario				
Individual – micro-cogeneration	9.8	1,091.4	82.0	1.96
HSN – small/medium CHP	28.8	5,708.8	82.0	12.70
HSN – CHP – RSE and others	35.3	3,628.7	75.0	33.43
Total	**73.9**	**10,428.9**	**79.2**	**48.08**

10. Public support measures for heating and cooling

The objective of this part of the document is to provide information pursuant to Point j) of Annex VIII of Directive 2012/27/EU, i.e. to perform an estimate of the possible public support measures for heating and cooling, with an annual budget and a definition of the element of possible support.

For clarity the chapter is divided into 2 sub-chapters – investment support and operational support.

10.1 Investment support programmes

Public investment support for high-efficiency CHP and district heating can currently be drawn from several programmes. These are on the one hand programmes increasing heat generation and distribution efficiency and on the other, programmes aimed at reducing heat consumption (including an improvement in individual heating efficiency).

10.1.1 Investment support programmes – heat generation and distribution

Investment support for projects increasing heat generation and distribution efficiency can be drawn from the Operational Programme Enterprise and Innovation for Competitiveness 2014 – 2020 (OP EIC) or from the Operational Programme Environment 2014 – 2020 (OPE).

The OP EIC which is financed from the European Regional Development Fund (ERDF) is divided into three priority axes, with Priority Axis 3 being relevant for the issue under consideration: Effective energy use, development of energy infrastructure and renewable energy sources, support for the introduction of new technologies in energy and secondary raw materials management (PO3) under which 1.2 bn EUR will be distributed by 2020.

PO3 contains six specific objectives (SO) of which the following SOs are relevant for the purposes of this study:

- SO 3.1: Increase share of renewable energy in gross final energy consumption in Czech Republic (Resource allocation: 53 mill. EUR)
- SO 3.2: Increase the energy efficiency of the business sector (Resource allocation: 746 mill. EUR)
- SO 3.4: Apply innovative low-carbon technologies in energy management and in the exploitation of secondary raw materials (Resource allocation: 37 mill. EUR)
- SO 3.5: Increase the efficiency of the heat supply networks (Resource allocation: 143 mill. EUR)

Within the aforementioned SOs individual grant programmes are opened continuously.

A further source of investment support for projects increasing heat generation and distribution efficiency is the Operational Programme Environment 2014 – 2020 (OPE). As in the case of OP EIC, OPE is divided into several priority axes. From the perspective of the present study these specific objectives are relevant in the following priority axes:

- Priority axis 2: Improving atmospheric quality in human settlements
    - Specific objective 2.2: Reduce emissions of stationary sources sharing in the exposure of the population to over-threshold concentrations of pollutants (Resource allocation: 95 mill. EUR)
- Priority axis 3: Waste and material flows, environmental burden and risks
    - Specific objective 3.2: “Increase the share of material and energy use of waste” – Activity 3.2.3 - Construction and modernisation of equipment for the energy use of waste and related infrastructure (Resource allocation: 55 mill. EUR)
- Priority axis 5: Energy savings
    - Specific objective 5.1: Reduce the energy demands of public buildings and increase share of renewable energy (Resource allocation: 510 mill. EUR)

The project financial resources falling under SO 5.1 may be drawn down only by the public sector, non-governmental non-profit organisations and churches and religious societies and their unions. Project financial resources falling under SOs 2.2 and 3.2 may be drawn down both by public sector bodies and by businesses, commercial companies, cooperatives and sole traders.

A further option for obtaining investment support are the programmes underwritten by the Czech Technology Agency (TA CR). These programmes are focused on applied research, experimental development and innovation, including generation and distribution of heat/cooling, including co-generation and tri-generation. Public tenders within these programmes are announced annually and the overall expenditure for the individual programmes is of the order of billions of Czech crowns. This support may be obtained both by research organisations and by industrial companies. While research organisations have the option to draw up to 100 % support, support for companies in the case of industrial research is of the order under the current Epsilon programme of 50 % to 80 % depending on the size of the company, and documentation of effective cooperation with a research organisation. The maximum financial support amount from public sources expended on a single project is limited to 3 mill. EUR.

10.1.2 Investment support programmes – consumption and individual heating aspect

Under the so-called "boiler grants" the Ministry of the Environment is planning by 2020 to exchange at least 80,000 obsolete household solid fuel boilers, of which there are over 350 thousand in use in the Czech Republic, according to the Ministry of the Environment. The Regions will be responsible for allocating the financial resources (totalling 9 bn CZK); they will apply for the money from OPE.

Within OPE support for the exchange of obsolete solid fuel boilers is based on Specific Objective 2.1: Reduce emissions from household local eating sharing in the exposure of the population to over-threshold concentrations of pollutants. Grants will be provided only for sources meeting the requirements of Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products and their implementing regulations. A subject of support allocated to individuals will be the acquisition or exchange of a heat pump, solid fuel boiler, gas condensation boiler, installation of solar-thermic systems for preheating or preparation of hot water and so-called micro-energy measures (e.g. insulation, window replacement, etc.).

A further programme, the aim of which is to improve environmental conditions by reducing the output of pollutants and greenhouse gases, energy savings at the point of consumption and stimulation of the Czech economy, together with other social benefits, is the programme entitled New Green Savings, financed from the Czech state budget. For this programme the Czech Republic has obtained funds through the sale of emissions permits (EUA) under Act No 383/2012, on the conditions for trading in greenhouse gas emissions permits, on the European market for emissions permits (EU ETS) in the third trading period 2013 - 2020. The programme focuses on two areas – family houses and apartment blocks.

In the case of family houses one may obtain a grant for reduction of the energy demands of existing family houses, the construction of family houses with very low energy demands and for efficient use of energy sources, which include inter alia grants for replacing non-environmentally friendly heat sources (burning, for example, coal, coke, coal briquettes or heavy fuel oil) with efficient environmentally friendly sources (for example, biomass boilers, heat pump or gas condensation boiler).

For apartment blocks in this area there is support for measures to reduce the energy demands of existing apartment blocks, such as:

- grants to insulate the exterior of a building – replacing windows and doors, insulating exterior walls, roofs, ceilings, floors
- to replace non-environmentally friendly heat sources (burning, for example, coal, coke, coal briquettes or heavy fuel oil) with efficient environmentally friendly sources (for example, biomass boilers, heat pump or gas condensation boiler)
- to replace electrical heating with heat pump systems
- to install solar thermal systems
- to install forced ventilation systems with heat won back from waste air
- measures may be implemented separately or in various combinations

Other important grant programmes focussed on reducing energy consumption also include the Operational Programme Environment (SO 5.2), the Integrated Regional Operational Programme 2014 - 2020, the Operational Programme Prague – Growth Pole, the PANEL programme, the JESSICA programme and the EFEKT programme.

10.2 Operational support for electricity from CHP and heat from renewable energy sources

10.2.1 Operational support for electricity from CHP

Support for electricity from high-efficiency CHP in the Czech Republic is part of the support system for generation of electricity and heat from renewable energy sources, high-efficiency CHP, secondary energy sources and individual electricity generation. From a legislative point of view, support for high-efficiency CHP is embodied in Act No 165/2012 and the related Decree on Electricity from high-efficiency CHP and electricity from secondary sources, laying down the quantity of electricity from CHP to which support relates.

The value of support for electricity from high-efficiency CHP is set annually in the ERO Price Ruling. 2014 has been selected to illustrate support for high-efficiency CHP; the following numbers for support paid out are available for this year. For 2014 operational support was paid out under Energy Regulatory Office Price Ruling 4/2013 dated 27 November 2013. Based on the Price Ruling there is then a calculation of the value of the green bonus for individual plants having regard to the location and size of the installed electricity capacity of the plant, the primary fuel used and the operating regime for the electricity generating plant.

The annual green bonus for CHP is made up of two rates – a basic rate and a supplementary rate, with the supplementary rate relating then only to the plant categories given in the Price Ruling. The basic rate is then divided up according to the total installed plant capacity, into plants with an installed capacity up to 5 MWe (incl.) and over 5 MWe.

In the case of sources with an installed capacity up to 5 MWe (incl.) the value of the basic rate is scaled according to the installed plant capacity and the operating hours.

Table 12 Basic rate for annual green bonus for electricity for a CHP plant with an installed capacity up to 5 MWe (incl.) for 2014

Line	Type of source supported	Installed plant capacity (kW)		Operating hours (h/yr.)	Green bonuses (CZK/MWh)
		from	to (incl.)		
700	CHP plant with the exception of plants claiming support under Point (1) and/or (2.1.) of the Price Ruling and with the exception of combustion of municipal waste	0	200	3000	1610
701		0	200	4400	1150
702		0	200	8400	220
703		200	1000	3000	1150
704		200	1000	4400	750
705		200	1000	8400	140
706		1000	5000	3000	800
707		1000	5000	4400	470
708		1000	5000	8400	45
709	CHP plant concurrently claiming support under Point (1) and/or (2.1.) of the Price Ruling and with the exception of combustion of municipal waste	0	5000	8400	45

In the case of sources with an installed capacity in excess of 5 MWe, account is taken of the installed plant capacity, the primary energy savings and the energy generation efficiency.

Table 13 Basic rate for annual green bonus for electricity, for a CHP electricity generation plant with a total installed capacity of CHP units in excess of 5 MWe for 2014

Line	Type of source supported	Installed plant capacity (kW)		Primary energy savings (%)		Energy generation efficiency (%)		Green bonuses (CZK/MWh)
		from	to (incl.)	from	to (incl.)	from	to (incl.)	
750	CHP plant	5000	-	10	15	-	-	45
751		5000	-	15	-	-	45	60
752		5000	-	15	-	45	75	140
753		5000	-	15	-	75	-	200
754	New or modernised CHP plant	5000	-	15	-	45	-	200

Plants defined in the Price Ruling are also entitled to obtain the supplementary rate of annual green bonus. There are two of these supplementary rates – Supplementary rate I to the basic annual green bonus rate for all electricity from high-efficiency CHP and Supplementary rate II to the basic annual green bonus rate for electricity from high-efficiency CHP based on biomass.

Table 14 Supplementary rate I to the basic annual green bonus rate for all electricity from high-efficiency CHP for 2014

Line	Type of source supported	Commissioning Date		Installed plant capacity (kW)		Biomass category and use process	Green bonuses (CZK/MWh)
		from	to (incl.)	from	to (incl.)		
770	Electricity generation burning only biomass	1.1.2013	31.12.2013	0	5000	O	100
771		1.1.2014	31.12.2014	0	5000	O	455
772	Electricity generation burning (separately) gas from the gasification of solid biomass	1.1.2013	31.12.2013	0	2500	O	455
773		1.1.2014	31.12.2014	0	2500	O	755
774	Electricity generation burning biogas in a biogas station	1.1.2013	31.12.2013	0	2500	AF	455
775	New electricity generation burning biogas in a biogas station meeting the condition in Point (3.5.2.)	1.1.2014	31.12.2014	0	550	AF	900
776	Plant burning degassing or coal mine gas	1.1.2013	31.12.2014	0	5000	-	455
777	Electricity generation through combustion of municipal waster or co-combustion of municipal waste and other energy sources	-	31.12.2012	0	5000	-	155
778	Electricity generation burning (separately) natural gas	-	31.12.2014	0	5000	-	455

Supplementary rate I covers all electricity generated from high-efficiency CHP.

Table 15 Supplementary rate II to the basic annual green bonus rate for all electricity from high-efficiency CHP based on biomass for 2014

Line	Type of source supported	Biomass category and use process	Green bonuses (CZK/MWh)
780	Co-combustion of biomass and a non-renewable energy source	S1	940
781		S2	520
782		P1	940
783		P2	520

Supplementary rate II covers electricity from high-efficiency CHP based on biomass for 2014.

The following table gives the total amount of support paid out for electricity generated in high-efficiency CHP in 2014 divided by the individual lines of the ERO Price Ruling, together with the total quantity of electricity support and plants supported.

Table 16 Support paid out, quantity of electricity and number of plants divided by the basis and supplementary rates for annual green bonus in 2014

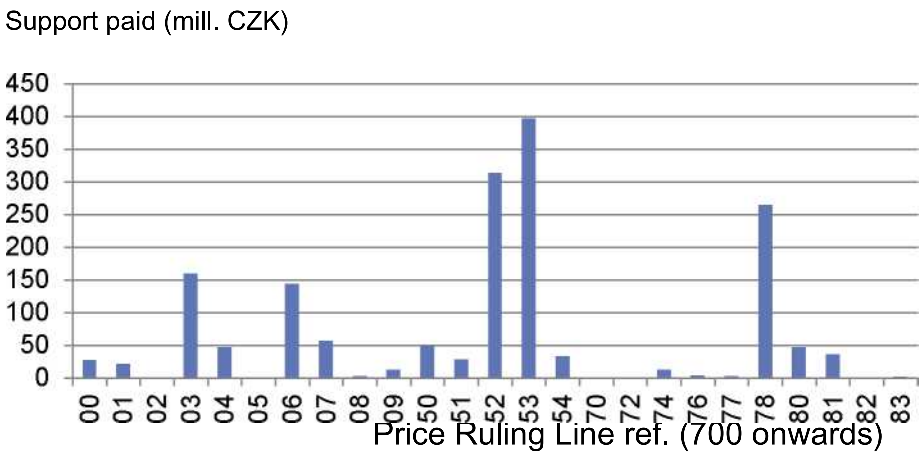
Line	Support (mill. CZK)	Quantity (GWh)	No of plants (-)
700	27,5	17,1	158
701	21,7	18,9	85
702	1,1	5,1	31
703	159,3	138,7	173
704	46,4	61,8	62
705	0,4	2,7	6
706	144,1	180,2	54
707	56,1	119,8	29
708	2,9	65,3	6
709	12,4	276,1	169
750	48,5	1077,8	44
751	28,2	470,0	42
752	314,0	2243,0	42
753	397,1	1985,6	17
754	33,4	167,2	6
770	0,5	5,3	3
772	0,2	0,4	2
774	12,5	27,5	38
776	3,6	7,9	2
777	2,5	16,4	1
778	264,6	582,1	579
780	46,5	49,5	10
781	35,7	68,7	10
782	0,0	0,0	1
783	1,4	2,6	2
Total	1660,8	-	-

Source: Short-term electricity market

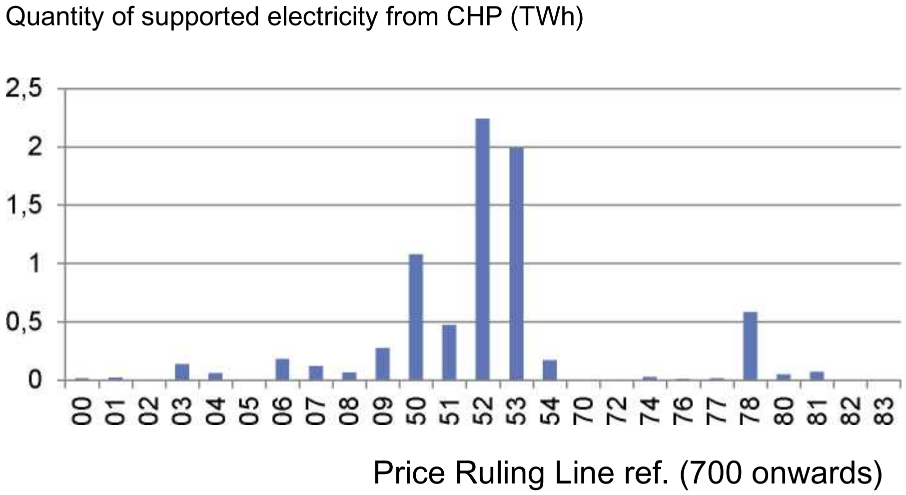
The quantities of electricity and numbers of plants cannot be totalled, since the operating units drawing down green bonus consisting of basis and one of the supplementary rates would counted twice.

For clarity the following graphs depict graphically all the monitored values.

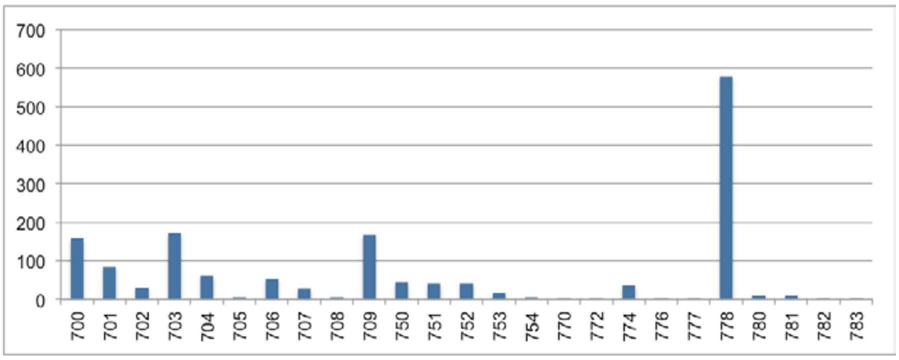
Graph 4 Value of support paid out by ERO Price Ruling line in 2014



Graph 5 Quantity of supported electricity from high-efficiency CHP by ERO Price Ruling line in 2014



Graph 6 Number of supported plants generating electricity from high-efficiency CHP by ERO Price Ruling line in 2014



Source: Short-term electricity market

In 2014 in total there was support in the form of green bonus for 6,802 GWh of electricity from high-efficiency CHP, corresponding to 53 % of the total gross electricity generation from CHP in the Czech Republic (12,830 GWh).

Plants with installed capacity less than 5 MWe (incl.) in 2014 generated a total of 3,269 GWh of electricity, of which 922 GWh, i.e. 28.2 % was supported by green bonus. Plants with installed capacity in excess of 5 MWe in 2014 achieved a total of 9,561 GWh of electricity, of which 5,908 GWh, i.e. 61.8 % was supported by green bonus.

The total value of public support for electricity from high-efficiency CHP generated in 2014 reached the amount of 1,661 mill. CZK Of this amount 760 mill. CZK was for sources with an installed capacity of less than 5 MWe (incl.) and 901 mill CZK for plants with installed capacity in excess of 5 MWe.

For clarity all the aforementioned values are given in the following table. For comparison values for 2013 are also given; that year was climatically slightly above average (annual deviation from normal temperature: +0.4 °C), and in that year the quantity of electricity from high-efficiency CHP (supported generation) was set using the original methodology.

From 2013 onwards there has been a change in the methodology for setting the quantity of electricity from high-efficiency CHP for large sources. Moreover 2014 was markedly warmer than the preceding year.

These influences caused a reduction in the quantity of supported electricity for these sources of approx. 20 %, viz. following the table.

Table 17 Generation, supported generation and support paid out for plants generating electricity from high-efficiency CHP in 2013 and 2014

	Total generation (GWh)		Supported generation (GWh)		Support paid (mill. CZK)	
	2013	2014	2013	2014	2013	2014
Plants up to 5 MWe (incl.)	...	3,269	989	886	680	760
Plants in excess of 5 MWe	...	9,561	7,370	5,943	1,293	901
Total	**11,965**	**12,830**	**8,359**	**6,829**	**1,973**	**1,661**

Source: ERO, Ministry of Trade and Industry, Short-term electricity market

In 2014, supported generation by plants generating electricity from high-efficiency CHP with an installed capacity in excess of 5 MWe was approximately 6.5 times greater than for plants up to 5 MWe. Differences in the value of financial support are no longer so noticeable (CHP plants up to 5 MWe draw down substantially higher average support per MWh generated).

In 2014 plants burning biogas were paid support for electricity from high-efficiency CHP to the value of 12.5 million CZK, with the quantity of electricity supported reaching 27.5 GWh.

A basic difference between 2014 and 2013 is the option to obtain a supplementary rate for the green bonus for plants burning (separately) natural gas (Line 778 of the ERO Price Ruling, see above). As can be seen from the table referred to, in 2014, 582.1 GWh of electricity was supported using this supplementary rate. All this electricity, whose total paid-out support has reached 264.6 mill. CZK, was generated in plants with an installed capacity of up to 5 MWe.

Graph 7 Share of high-efficiency CHP support by size of source

Support paid for electricity from high-efficiency CHP in 2014 by source size	Quantity of electricity from high-efficiency CHP in 2014 by source size
Plants up to 5 MWe (incl.): 46 %	Plants up to 5 MWe (incl.): 13 %
Plants in excess of 5 MWe: 54 %	Plants in excess of 5 MWe: 87 %

Source: Short-term electricity market

Currently the Czech Republic has 1109 registered generating plants with a total installed capacity of 10,604.3 MW, which have a claim to operational support in the form of green bonus for electricity from high-efficiency CHP. As fuel, most of these sources use biogas (187) and biomass (96) and “other sources” (755), which includes natural gas, bituminous coal and brown coal, that is, fuels for which there is no support for renewable or secondary sources.

Since 2013 practically all sources in operation are of the “other sources” type. Sources burning biomass include both straight combustion of biomass and co-combustion of biomass and a non-renewable source in the case of large power stations or heat plants.

Table 18 Generating sources with the option to claim support for electricity from high-efficiency CHP

	2012		2013		2014		6/2015	
Type of generating source/fuel	Number	P installed (MW)	Number	P installed (MW)	Number	P installed (MW)	Number	P installed (MW)
Biogas	134	79,1	187	100,2	187	100,2	187	100,2
Biomass	79	3 128,9	93	3 181,3	96	3 183,4	96	3 183,4
Degassing	9	15,5	11	18,3	11	18,3	11	18,3
Mine gas	17	22,4	17	22,4	17	22,4	17	22,4
Secondary sources	16	579,5	19	581,3	21	585,1	21	585,1
Landfill and sludge gases	21	12,9	21	12,9	22	13,2	22	13,2
Other sources	561	6 576,9	637	6 602,8	711	6 665,2	755	6 681,7
Total	**837**	**10 415,0**	**985**	**10 519,1**	**1 065**	**10 587,8**	**1 109**	**10 604,3**

Source: Short-term electricity market

10.2.2 Operational support for heat from renewable energy sources

In the Czech Republic, operational support for heat from renewable energy sources is provided through the green bonus. The green bonus for heat from renewable energy sources is provided only under the annual green bonus regime to the value of 50 CZK/GJ, is defined in Section 26 Act No 165/2012, which also lays down that support for heat in the form of operational support for heat within a single heat plant can be combined with support for hear in the form of investment support for heat. Under Section 24 (4) of Act No 165/2012 heat generated from supported biomass may claim operational support; this biomass is the subject of electricity support under Section 4 (5) a) of Act No 165/2012, or heat generated from bio-liquids meeting the sustainability criteria set out by the implementing regulation in heat plants with a nominal heat capacity greater than 200 kW or heat generated from geothermal energy in facilities with a nominal heat capacity greater than 200 kW.

The following basic conditions must also be met in order to obtain operational support for heat from renewable energy sources:

- the generator must be a licence holder for heat generation
- the nominal heat capacity of the heat plant must be greater than 200 kW
- the heat generated must be supplied into a HSN
- the heat must be generated in facilities which meet the minimum energy use efficiency set out in Decree No 441/2012, setting the minimum energy use efficiency for electricity and heat generation.

This operational support does not apply to heat from biogas stations, co-combustion of renewable and non-renewable sources, or other sources. In 2014, 1,017 GWh (3,661 TJ) of heat were supported by support for heat from renewable energy sources. The total value support paid out was 183.1 mill. CZK

As part of the amendment to Act No 165/2012, approved in 2015 by Act No 131/2015, heat support was also introduced from 1 January 2016 for generation of utility heat from biogas arising more than 70 % from farmyard manure and by-products of animal husbandry or from biodegradable waste in heat plants with an installed electrical capacity of up to 500 kW. However claims for this support can begin only on completion of notification of this newly introduced support system to the European Commission.

11. Cost benefit analysis

Art.14 (3) of the Energy Efficiency Directive requires the conduct of a cost benefit analysis which relates to their territory in accordance with Part 1 of Annex IX and is based on climatic conditions, economic feasibility and technical suitability. A CBA permits the discovery of the most efficient solutions in terms of sources and costs, with the aim of meeting needs in the supply of heating and cooling. The aim of the analysis is to be: "facilitating the determination and implementation of the most efficient solutions in terms of sources and costs, with the aim of meeting needs in the supply of heating and cooling".

A CBA is performed particularly for the analysis of the costs and benefits of high-efficiency CHP from a society-wide perspective and does not take into account any public support provided.

An assessment of potential for cooling was not performed in view of the absence of any base data. As stated in the preceding chapters, the Czech Republic does not maintain records on the generation of cooling and its distribution. The options for securing such data and preparing a similar analysis for cooling will be considered in later updates of this Report.

11.1 Description of the cost benefit analysis methodology for high-efficiency co-generation of heat and electricity

The objective was to establish incremental costs and benefits to meet demand for heat in 2025 for individual variants.

The CBA approach was as follows:

1) Defining the structure of heat generation/supply for 2016-2025 in the baseline scenario.
2) Defining the structure of heat generation/supply for 2016-2025 in alternative "CHP" and "High CHP" scenarios. The scenarios reflect the different percentage degree of fulfilment of the technical potential.
3) Quantification of the incremental costs/benefits of the alternative scenarios compared to the baseline scenario.
4) Identification of the most suitable scenario.
5) Sensitivity analysis.

During the preparation of the CBA a scenario was considered with a minimum generation of electricity from CHP, approximately at the level of own electricity consumption. This scenario would of course show negative benefits compared to the baseline scenario, and was therefore not worked up during preparation of the present study and is not included in this study.

For scenario comparison purposes, in all scenarios the same quantity of electricity supplied and heat consumed in the Czech Republic is assumed. Increasing electricity generation from CHP reduces the quantity of electricity by condensation without supplying useful heat and also independent heat generation. In scenarios with a higher level of electricity from high-efficiency CHP, saved fuel costs and saved costs for externalities are thus taken into account in comparison with separate generation of electricity and heat.

For the CBA the methodology prepared in accordance with the requirements of Part 1 of Annex IX of EU Directive 2012/27/EU was used. The basic principles are given in the following table.

Table 19 CBA preparation approach

Steps/aspects pursuant to Annex IX	Inclusion in methodology
a) Settling system limits and geographical limits	Entire Czech Republic
b) Integrated approach to supply and demand variants	The current status and anticipated growth of heat supply and demand reflect all available technologies, information and trends, which are available. Information for cooling is not monitored in the Czech Republic

c) Creation of baseline level	A baseline scenario was defined which reflects the assumption of the non-existence of economic stimuli for investors to implement and operate CHP sources. In Chapter 5 the technical potential of new high-efficiency CHP electricity generators was established; this will serve as the basis for establishing alternative scenarios.
d) Determining alternative scenarios	Alternative scenarios represent variants of the percentage fulfilment of technical potential of high-efficiency CHP
e) Method for calculating net benefits	The NPV method will be used. The discounted incremental costs/benefits of the alternative scenarios will be compared to the baseline scenario.
f) Price calculation and forecast and other estimates for economic analysis.	Available forecasts (national and international) will be used.
g) Economic analysis: listing of effects	For the purposes of this CBA a conservative approach was chosen (minimise number of expert estimates; do not quantify costs and benefits which cannot be documented with relevant documentation, etc.), and therefore: The following are included and quantified: • anticipated investment and operating costs associated with covering the demand for heat • fuel costs and externalities saved for separate electricity generation, when replaced by co-generation of electricity • additional costs (or savings) related to emissions of pollutants. • savings related to cost savings on the transmission and distribution of electricity and the distribution of heat (consumption at the point of generation). For the reasons given here, the following are not included: • energy costs and savings arising from improved flexibility of energy supplies which are difficult to quantify in the conditions of the Czech Republic and have been ignored for the purposes of this study. • savings arising from limiting investment in infrastructure, since no high impact is assumed on the CBA, inter alia because of the cost of extraction • costs/benefits related to job creation – these benefits are very difficult to quantify and no significant change in the number of jobs across the individual variants for heat sourcing is anticipated. • benefits arising from any increased in electricity supply reliability due to installation of high-efficiency CHP, since these are very difficult to quantify in the conditions of the Czech Republic and no significant impact on the results of the CBA is anticipated.
h) Sensitivity analysis	The most significant factors are identified which have an impact on the CBA results (change in NPV).

11.1.1 Approach to evaluating the benefits of alternative variants

The baseline scenario considers electricity generated using separate electricity generation without heat output (not CHP) from brown coal at 32.5 % efficiency, hereinafter denoted condensation electricity.

Cost savings on fuel for condensation electricity not generated represent fuels costs which need not be incurred, because the corresponding amount of electricity is generated using combined heat and power generation in high-efficiency CHP sources (the relevant fuel costs for CHP sources are included in the costs of the alternative variant in question).

CO_2 savings for condensation electricity not generated represent emission permit costs which need not be incurred, because the corresponding amount of electricity is generated using combined heat and power generation in high-efficiency CHP sources (the relevant permit costs for CHP sources are included in the costs of the alternative variant in question).

Emissions (So, NO_x, solid pollutants) savings for condensation electricity not generated represent an evaluation of emissions which need not be emitted, because the corresponding amount of electricity is generated using combined heat and power generation in high-efficiency

CHP sources (the relevant evaluation of emissions from CHP sources are included in the costs of the alternative variant in question).

Quantification of savings on the transmission and distribution of electricity are based on the assumption that 50 % of electricity generated in newly installed high-efficiency CHP sources is consumed at the generation point, thereby avoiding the technical network losses of 8 % of this electricity. The remaining 50 % of the electricity is consumed in distribution networks and no technical losses are thereby incurred (particularly in the absence of transmission from central sources) at the level of 2 % of this electricity. This electricity is valued at the electricity market price (for 2016, the EEX base lifted by 10 %; later years inflation indexed). The savings also include an evaluation of externalities (SOx, NOx, solid pollutants)

11.2 Description of basic assumptions

The change in operating costs (OPEX) includes in particular a change in fuel costs, a change in personnel costs and maintenance costs for newly commissioned sources. It also reflects the fuel costs/savings dependent on CHP/heat plant generation in a CHP unit.

The change in investment costs (CAPEX) represents a change in investment costs because of the need to implement sources to cover demand for heat. The change in CAPEX also reflects the change in the structure of sources in the individual variants.

For the NPV calculation, the evaluation considered a contribution to cover fixed costs, reflecting the anticipated 20 year lifetime of sources, so that the matching costs and benefits of the individual variants could be appropriately assessed. This means that the 2016 – 2025 evaluation considered only the matching portion of investment costs at 1/20 for each operating year for a specific CHP unit.

The model considers a number of parameters and assumptions. The table gives an overview of the basic CBA input parameters.

Table 20 Selected CBA input parameters

Parameter	Value considered for CBA	Note
Inflation	2 %	ČNB inflation target
Efficiency	By type of source, fuel and operations method	Conservative approach chosen
Period evaluated	2016 - 2025	For investment costs, depreciation at the rate of 1/20 for each year evaluated was used for NPV calculation.
Discount rate	6.94 %	Set using WACC for the IV regulatory period for distribution and transmission of electricity[10], increased by 0.5 %
NOx valuation	CZK 32,000/t	Rate set on the basis of unit costs for limiting pollutant emissions Set in line with the explanatory report to Act No 201/2012 on atmospheric protection
SO_2 valuation	CZK 16,000/t	
Solid pollution valuation	CZK 97,000/t	
CO_2 valuation	CZK 229 - 715/t	By anticipated permit price for the individual years.
Investment costs for new micro-cogeneration	CZK 45 mill/MWe	
Average investment cost for new small and medium-sized high-efficiency CHP plants using gaseous fuels	CZK 31 mill/MWe	Average reflecting various size levels for CHP units.
CZK/EUR exchange rate	27 CZK/EUR	

[10] The post-tax value was used, which is lower than the nominal value set for the relevant organisations in the electrical energy sector.

11.2.1 CO_2 valuation

CO_2 emissions were valued at the expected price of an emissions permit. In 2016 the CBA assumes a price of 8.5 EUR, in 2020 a price of 16.5 EUR and in 2025 a price of 26.5 EUR. In view of the possible volatility of these parameters the sensitivity of NPV to the growth of this parameter is given at the end of this chapter.

11.2.2 Emissions valuation (SO_x, NO_x, solid pollutants)

Emissions valuation is an area where there is a clear variability of the valuation depending on the approach adopted. In principle there are two basic approaches to valuation:

a) Valuation based on setting costs for emissions restrictions, i.e. what costs must be incurred to prevent the generation of a particular volume of emissions.

b) A valuation based on an evaluation of the consequences arising from emissions (on health, the environment, etc.).

For CBA purposes variant a) was chosen, where a valuation in line with the explanatory report to Act No 201/2012, on atmospheric protection, was used. In view of the broad range of values for the valuation a sensitivity analysis was prepared, which also reflects the high emissions valuations calculated during the CASES project[11] (on average 14x higher than the values considered in the CBA).

11.3 Description of the baseline level – “Baseline Scenario”

This scenario is based on a situation where no operation support for high-efficiency CHP exists, and therefore there is not substantial economic stimulus for investors to implement and operate these kinds of sources.

Assumptions:

- Minimum to zero growth in micro-cogeneration because of lack of economic effectiveness.
- Minimum to zero growth in high-efficiency CHP in small and medium-sized sources because of lack of economic effectiveness.
- To meet demand for heat, there is growth in boiler heat generation, particularly using natural gas, both centrally and individually.
- For existing sources there will be usage changes in order to meet demand for heat.
- Reduction in electricity generation from high-efficiency CHP.

If development were to be in line with the assumptions in this scenario, it might threaten the Czech Republic’ compliance with its European obligations on energy savings and increased use of renewable sources and high-efficiency CHP.

Covering demand for heat under this scenario is indicated by the following table.

[11] http://www.feem-proiect.net/cases/index.php

Table 21 Heat generation in the baseline scenario [%]

	2013	2020	2025
Individual	**66.3**	**67.0**	**67.2**
Micro-cogeneration	*0.0*	*0.0*	*0.0*
Electric boilers and heat pumps	*4.8*	*6.1*	*6.2*
Solid fuel boilers (coal)	*7.8*	*7.5*	*7.2*
Renewable energy sources and other alternative fuels	*12.3*	*13.1*	*13.3*
Gas boilers	*41.4*	*40.4*	*40.5*
Heat supply networks	**33.7**	**33.0**	**32.8**
Heat supply networks – Heat plants total	**9.0**	**10.2**	**11.3**
Heat plants on bituminous coal	*0.1*	*0.1*	*0.2*
Heat plants on brown coal	*0.8*	*1.2*	*1.4*
Heat plants on renewable energy sources and other alternative fuels	*1.0*	*1.0*	*0.9*
Heat plants on gaseous fuels	*7.1*	*7.9*	*8.9*
Heat supply networks – CHP total	**24.7**	**22.8**	**21.5**
Nuclear power stations	*0.0*	*0.0*	*0.4*
Small and medium-sized CHP plants using gaseous fuels[12]	*0.9*	*0.9*	*0.9*
Major CHP on gaseous fuels (PPC, boilers and TG)	*3.5*	*3.1*	*3.2*
CHP on bituminous coal	*4.2*	*3.8*	*3.4*
CHP on brown coal	*13.3*	*12.4*	*11.1*
CHP on renewable energy sources and other alternative fuels	*2.7*	*2.5*	*2.5*
Total	**100.0**	**100.0**	**100.0**

11.4 Evaluation of alternative scenarios

Technical potential of new CHP

The basis for establishing alternative scenarios is the technical potential of new high-efficiency CHP plants. The technical potential for the growth in individual technologies was set out in Chap. 5.

[12] Within this category, in all variants there may also be sources which do not supply to HSN and make use of generated heat and electricity for their own use, but by their size and the nature of their operations fit in this category rather than in the micro-cogeneration category.

11.4.1. “CHP” scenario

Represents a lower degree of fulfilment of the technical potential.

<u>**“CHP” scenario:**</u>

- ***33 MWe of newly commissioned micro-cogeneration sources, generating more than 101 GWh of electricity and 0.91 PJ of heat in 2025.***
- ***227 MW_e of newly commissioned small and medium—sized CHP on gaseous fuels, generating more than 862 GWh of electricity and 4.35 PJ of heat in 2025.***
- ***62 MW_e of newly commissioned CHP on renewable energy sources and other alternative fuels, generating more than 332 GWh of electricity and 3.25 PJ of heat in 2025.***

Covering demand for heat under this scenario is indicated by the following table.

Table 22 Heat generation in the “CHP” scenario [%]

	2013	2020	2025
Individual	**66.3**	**66.7**	**67.0**
Micro-cogeneration	***0.0***	***0.2***	***0.2***
Electric boilers and heat pumps	***4.8***	***6.1***	***6.2***
Solid fuel boilers (coal)	***7.8***	***7.5***	***7.2***
Renewable energy sources and other alternative fuels	***12.3***	***13.1***	***13.3***
Gas boilers	***41.4***	***39.9***	***40.1***
Heat supply networks	**33.7**	**33.3**	**33.0**
Heat supply networks – Heat plants total	**9.0**	**8.5**	**8.3**
Heat plants on bituminous coal	***0.1***	***0.1***	***0.0***
Heat plants on brown coal	***0.8***	***0.5***	***0.4***
Heat plants on renewable energy sources and other alternative fuels	***1.0***	***1.6***	***1.6***
Heat plants on gaseous fuels	***7.1***	***6.2***	***6.2***
Heat supply networks – CHP total	**24.7**	**24.8**	**24.8**
Nuclear power stations	***0.0***	***0.0***	***0.4***
Small and medium-sized CHP plants using gaseous fuels[13]	***0.9***	***1.2***	***1.9***
Major CHP on gaseous fuels (PPC, boilers and TG)	***3.5***	***3.4***	***3.1***
CHP on bituminous coal	***4.2***	***4.0***	***3.8***
CHP on brown coal	***13.3***	***12.7***	***11.9***
CHP on renewable energy sources and other alternative fuels	***2.7***	***3.4***	***3.6***
Total	**100.0**	**100.0**	**100.0**

<u>Assumptions:</u>

- Medium to high growth in micro-cogeneration
- Medium to high growth in small and medium-sized CHP
- Decline in heat-plant generation of heat (replaced by CHP).
- For existing sources there will be usage changes in order to meet demand for heat.

[13] Within this category, in all variants there may also be sources which do not supply to HSN and make use of generated heat and electricity for their own use, but by their size and the nature of their operations fit in this category rather than in the micro-cogeneration category.

- Electricity generation from high-efficiency CHP will grow.

The “CHP” scenario represents the following incremental changes when compared to the “Baseline Scenario”

- For the 2016 – 2025 evaluation period, Total Costs (OPEX, contribution to fixed costs in the value of depreciation, CO2 and SOx, NOx, solid pollutant emissions) when compared to the baseline scenario, higher by 43.11 bn CZK.
- For the 2016 – 2025 evaluation period, Total Benefits (fuel cost savings for condensation electricity not generated, emissions saving for condensation electricity not generated, transmission and distribution cost savings), compared to the baseline case, higher by 71.59 bn CZK.

The “CHP” scenario is therefore cheaper by 28.48 bn CZK than the “baseline scenario” for the 2016 – 2025 evaluation period. Calculated to net present value the additional savings under the “CHP” scenario are 19.28 bn CZK Meeting the demand for heat up to 2025 is thus under the “CHP” scenario cheaper from a society-side point of view and thus more favourable than the baseline scenario.

The following table gives the calculation results.

Table 23 Incremental costs and benefits of the “CHP” scenario compared to the “Baseline Scenario”

Parameter (bn CZK)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	al
Contribution to CAPEX	0.04	0.10	0.17	0.25	0.36	0.40	0.44	0.49	0.54	0.60	3.41
OPEX	2.52	2.54	2.73	3.00	3.38	3.59	3.83	4.06	4.33	4.63	34.62
CO2	0.16	0.18	0.19	0.21	0.21	0.26	0.31	0.36	0.42	0.49	2.80
Externalities (SOx, NOx, solid pollutant emissions)	0.21	0.22	0.19	0.21	0.22	0.24	0.25	0.26	0.24	0.25	2.28
Total costs	**2.93**	**3.04**	**3.29**	**3.67**	**4.18**	**4.49**	**4.83**	**5.17**	**5.53**	**5.97**	**43.11**
Cost savings on fuel for condensation electricity not generated	3.01	3.15	3.31	3.48	3.67	3.81	3.95	4.11	4.28	4.47	37.24
CO_2 savings for condensation electricity not generated	1.25	1.59	1.95	2.34	2.75	3.13	3.53	3.95	4.40	4.86	29.76
Emissions (SOx, NOx, solid pollutants)) savings for condensation electricity not generated	0.39	0.40	0.41	0.42	0.23	0.23	0.23	0.24	0.24	0.25	3.05
Electricity transmission and distribution cost	0.10	0.10	0.12	0.13	0.15	0.16	0.17	0.19	0.20	0.22	1.54

savings, including externalities											
Total Benefits	**4.75**	**5.25**	**5.79**	**6.37**	**6.79**	**7.33**	**7.89**	**8.49**	**9.13**	**9.80**	**71.59**
Benefits - costs	**1.82**	**2.21**	**2.50**	**2.70**	**2.61**	**2.84**	**3.06**	**3.32**	**3.59**	**3.83**	**28.48**
Benefits – costs (NPV)	**1.70**	**1.93**	**2.04**	**2.06**	**1.86**	**1.90**	**1.92**	**1.94**	**1.96**	**1.96**	**19.28**

11.4.2 "High CHP" scenario

Represents a high degree of fulfilment of the technical potential.

"High CHP" scenario:

- ***63 MWe of newly commissioned micro-cogeneration sources, generating more than 187 GWh of electricity and 1.7 PJ of heat in 2025.***
- ***311 MW_e of newly commissioned small and medium—sized CHP on gaseous fuels, generating more than 1183 GWh of electricity and 5.96 PJ of heat in 2025.***
- ***108 MWe of newly commissioned CHP on renewable energy sources and other alternative fuels, generating more than 517 GWh of electricity and 5.03 PJ of heat in 2025.***

Covering demand for heat under this scenario is indicated by the following table.

Table 24 Heat generation in the "High CHP" scenario [%]

	2013	2020	2025
Individual	**66.3**	**66.8**	**67.0**
Micro-cogeneration	*0.0*	*0.3*	*0.4*
Electric boilers and heat pumps	*4.8*	*6.1*	*6.2*
Solid fuel boilers (coal)	*7.8*	*7.5*	*7.2*
Renewable energy sources and other alternative fuels	*12.3*	*13.1*	*13.3*
Gas boilers	*41.4*	*39.8*	*39.9*
Heat supply networks	**33.7**	**33.2**	**33.0**
Heat supply networks – Heat plants total	**9.0**	**7.8**	**7.1**
Heat plants on bituminous coal	*0.1*	*0.1*	*0.0*
Heat plants on brown coal	*0.8*	*0.5*	*0.4*
Heat plants on renewable energy sources and other	*1.0*	*1.0*	*0.9*
Heat plants on gaseous fuels	*7.1*	*6.2*	*5.7*
Heat supply networks – CHP total	**24.7**	**25.4**	**25.9**
Nuclear power stations	*0.0*	*0.0*	*0.4*
Small and medium-sized CHP plants using gaseous fuels[14]	*0.9*	*1.5*	*2.3*
Major CHP on gaseous fuels (PPC, boilers and TG)	*3.5*	*3.4*	*3.4*
CHP on bituminous coal	*4.2*	*4.0*	*3.8*
CHP on brown coal	*13.3*	*12.7*	*11.9*
CHP on renewable energy sources and other alternative	*2.7*	*3.8*	*4.1*
Total	**100.0**	**100.0**	**100.0**

Assumptions:

- High growth in micro-cogeneration
- High growth in small and medium-sized CHP
- Decline in heat-plant generation of heat (replaced by CHP).
- For existing sources there will be usage changes in order to meet demand for heat.
- Electricity generation from high-efficiency CHP will grow significantly.

The "High CHP" scenario represents the following incremental changes when compared to the "Baseline Scenario"

- For the 2016 – 2025 evaluation period, Total Costs (OPEX, contribution to fixed costs in the value

[14] Within this category, in all variants there may also be sources which do not supply to HSN and make use of generated heat and electricity for their own use, but by their size and the nature of their operations fit in this category rather than in the micro-cogeneration category.

In terms of heat consumption categorised by individual sector (without considering own consumption of process heat), the greatest consumption in 2013 was by the households sector, approximately 189 PJ6.

of depreciation, and externalities caused by emissions) when compared to the baseline scenario, higher by 67.18 bn CZK.

- For the 2016 – 2025 evaluation period, Total Benefits (fuel cost savings for condensation electricity not generated, emissions saving for condensation electricity not generated, transmission and distribution cost savings), compared to the baseline case, higher by 78.31 bn CZK.

The “High CHP” scenario is therefore cheaper by 11.13 bn CZK than the “baseline scenario” for the 2016 – 2025 evaluation period. Calculated to net present value the additional savings under the “High CHP” scenario are 7.60 bn CZK Meeting the demand for heat up to 2025 is thus under the “High CHP” scenario cheaper from a society-side point of view and thus more favourable than the baseline scenario. However, compared to the “CHP” scenario the benefits from this scenario are lower, mainly because of a different mix of sources, higher average costs for energy in fuel and high investment costs (particularly for micro-cogeneration).

The following table gives the calculation results.

Table 25 Incremental costs and benefits of the "High CHP" scenario compared to the "Baseline Scenario"

Parameter (bn CZK)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total
Contribution to CAPEX	0.07	0.17	0.29	0.43	0.61	0.69	0.76	0.85	0.94	1.04	5.85
OPEX	3.37	3.61	3.98	4.49	5.21	5.50	5.84	6.22	6.65	7.14	52.02
CO2	0.30	0.35	0.41	0.47	0.53	0.61	0.70	0.80	0.90	1.01	6.08
Externalities (SOx, NOx, solid pollutant emissions)	0.33	0.34	0.28	0.30	0.31	0.32	0.34	0.35	0.32	0.33	3.23
Total costs	**4.07**	**4.47**	**4.96**	**5.69**	**6.66**	**7.13**	**7.64**	**8.22**	**8.81**	**9.52**	**67.18**
Cost savings on fuel for condensation electricity not generated	3.10	3.29	3.49	3.73	3.99	4.17	4.37	4.58	4.81	5.05	40.57
CO2 savings on fuel for condensation electricity not generated	1.29	1.66	2.06	2.50	2.98	3.43	3.90	4.41	4.94	5.50	32.67
Emissions (SOx, NOx, solid pollutants)) savings for condensation electricity not generated	0.40	0.42	0.43	0.45	0.25	0.25	0.26	0.27	0.27	0.28	3.28
Electricity transmission and distribution cost savings, including externalities	0.10	0.11	0.13	0.15	0.17	0.18	0.20	0.22	0.25	0.27	1.78
Total Benefits	**4.89**	**5.47**	**6.12**	**6.83**	**7.39**	**8.04**	**8.74**	**9.48**	**10.26**	**11.11**	**78.31**
Benefits - costs	**0.82**	**1.00**	**1.15**	**1.14**	**0.73**	**0.91**	**1.09**	**1.26**	**1.45**	**1.58**	**11.13**
Benefits – costs (NPV)	**0.76**	**0.87**	**0.94**	**0.87**	**0.52**	**0.61**	**0.68**	**0.73**	**0.79**	**0.81**	**7.60**

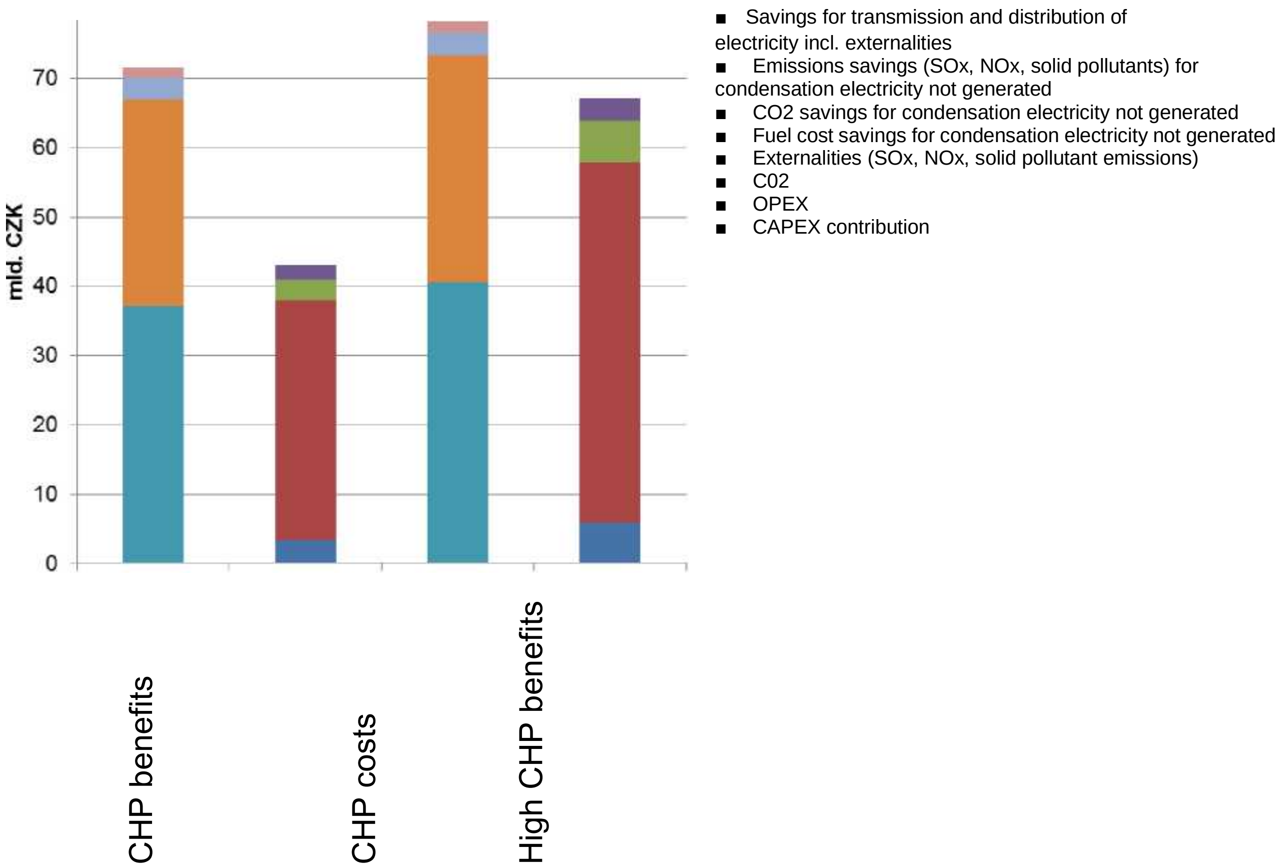
11.5 Scenario comparison and interpretation of CBA results

The most significant potential in the growth of high-efficiency CHP in the Czech Republic is in small- and medium-sized sources burning gas fuels, supplemented by the development of sources using RSE or alternative fuels. While gaseous fuels may supplement or replace separate generation of heat, renewable energy sources and alternative solid fuels often represent just a change in the existing fuel base for CHP (especially coal).

Compared to the Baseline Scenario, meeting demand for heat from alternative (developmental) scenarios presents additional benefits and additional costs, which are presented in the following graph. From the CBA it follows that the benefits of both alternative scenarios exceed the additional costs. This is a function in particular of:

- Cost savings on fuel for condensation electricity not generated, replaced by electricity generated by high-efficiency CHP
- Emissions savings for condensation electricity not generated, replaced by electricity generated by high-efficiency CHP

Table 8 Total incremental costs and benefits of alternatives scenarios compared to the "Baseline Scenario"



The foregoing graph illustrates the total incremental benefits and costs for the evaluation period (2016 - 2025). The incremental benefits exceed the incremental costs in both of the alternative scenarios. The benefit across society is higher for "CHP" scenario implementation. For the "High CHP" scenario, the high total fuel costs (mix of sources with high use of natural gas) and high investment in new CHP sources to a great extent cancels out the benefits of this variant, and therefore this scenario does not achieve the absolute benefit levels of the "CHP" scenario. In this context it is worth noting that this is view in respect of the whole of society – the market on its own does not reward high-efficiency CHP source operators for the energy and emissions savings which arise from co-generation of electricity and heat. Energy market trends in recent years by contrast present the risk that CHP will become unprofitable for operators and investors of high-efficiency CHP.

11.6 Sensitivity analysis.

Based on the growth model for heat generation in the Czech Republic, those factors have been identified which most significantly affect the CBA results. A sensitivity analysis has been performed for those factors.

Overview of factors for which a sensitivity analysis has been performed:

- Fuel price (of brown coal and natural gas for central sources)
- Year-on-year increase in the price of CO2 emissions permits
- Discount rate
- Valuation of externalities caused by NOx, SOx and solid pollutant emissions The results of the sensitivity analysis are depicted in the following tables.

11.6.1 Sensitivity analysis for "CHP" scenario

Table 26 Sensitivity analysis of NPV to the fuel price for the "CHP" scenario

NPV [bn CZK]		Baseline brown coal price [CZK/GJ]							
		35	40	45	50	55	60	65	70
Baseline natural gas price [CZK/GJ]	185	11.02	13.18	15.34	17.50	19.66	21.82	23.98	26.15
	190	10.95	13.12	15.28	17.44	19.60	21.76	23.92	26.08
	195	10.89	13.05	15.21	17.37	19.54	21.70	23.86	26.02
	200	10.83	12.99	15.15	17.31	19.47	21.63	23.79	25.95
	205	10.76	12.93	15.09	17.25	19.41	21.57	23.73	25.89
	210	10.70	12.86	15.02	17.18	19.35	21.51	23.67	25.83
	215	10.64	12.80	14.96	17.12	19.28	21.44	23.60	25.76
	220	10.57	12.74	14.90	17.06	19.22	21.38	23.54	25.70
	225	10.51	12.67	14.83	16.99	19.15	21.32	23.48	25.64
	230	10.45	12.61	14.77	16.93	19.09	21.25	23.41	25.57
	235	10.38	12.55	14.71	16.87	19.03	21.19	23.35	25.51
	240	10.32	12.48	14.64	16.80	18.96	21.13	23.29	25.45
	245	10.26	12.42	14.58	16.74	18.90	21.06	23.22	25.38
	250	10.19	12.35	14.52	16.68	18.84	21.00	23.16	25.32

It is clear from this table that with a rising brown coal price the NPV of the "CHP" scenario is economically more effective. In contrast, the decline in NPV with the rising price of natural gas is given mainly by the growth in operating costs in sources burning natural gas (micro-cogeneration, small and medium-sized CHP).

Table 27 Sensitivity analysis of NPV to the CO2 permit price for the "CHP" scenario

	Year-on-year price increase [€/yr.]							
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
NPV [bn CZK]	10.49	12.69	14.89	17.08	19.28	21.48	23.68	25.87

The preceding table shows that a higher year-on-year increase in the permit price increases the benefits of the "CHP" scenario (impact of higher generation efficiency in high-efficiency CHP compared to separate electricity generation).

Table 28 Sensitivity analysis of NPV to the discount rate for the "CHP" scenario

	Discount rate [%/yr.]							
	0.50	1.25	2.25	3.00	3.75	4.50	5.25	6.00
NPV [bn CZK]	28.48	26.42	24.92	23.88	22.89	21.96	21.08	20.25
	6.75	6.94	7.50	8.00	8.50	9.00	9.50	10.0
NPV [bn CZK]	19.47	19.28	18.73	18.26	17.81	17.37	16.95	16.54

Table 29 Sensitivity analysis of NPV to emissions valuation for the "CHP" scenario

	iple of emissions cost							
	0	eline value	2	5	7	10	15	20
[bn CZK]	18.60	19.28	19.96	22.00	23.35	25.39	28.79	32.18

The model works with the valuation of externalities caused by NOx, SOx and solid pollutant emissions using the values given in Chap. 11.2.2. The NPV of this valuation of externalities is designated the baseline value. Further values in the table express the NPV for the "CHP" scenario for various multiples of the baseline value of valuation of individual emission types. For valuation values for emissions calculated under the CASES project11 (on average 14x higher than the baseline values) the NPV for the "CHP" scenario exceeds 28 bn CZK. It is clear that where the valuation of the impact of emissions is higher, then the NPV of the "CHP" scenario rises (emissions from separate electricity generation weigh down the "Baseline Scenario").

11.6.2 Sensitivity analysis for "High CHP" scenario

Table 30 Sensitivity analysis of NPV to the fuel price for the "High CHP" scenario

NPV [bn CZK]		Baseline brown coal price [CZK/GJ]							
		35	40	45	50	55	60	65	70
Baseline natural gas price [CZK/GJ]	185	0.08	2.28	4.47	6.67	8.86	11.06	13.25	15.45
	190	-0.13	2.07	4.26	6.46	8.65	10.85	13.04	15.24
	195	-0.34	1.86	4.05	6.25	8.44	10.64	12.83	15.03
	200	-0.55	1.65	3.84	6.04	8.23	10.43	12.62	14.82
	205	-0.76	1.43	3.63	5.83	8.02	10.22	12.41	14.61
	210	-0.97	1.22	3.42	5.62	7.81	10.01	12.20	14.40
	215	-1.18	1.01	3.21	5.41	7.60	9.80	11.99	14.19
	220	-1.39	0.80	3.00	5.20	7.39	9.59	11.78	13.98
	225	-1.60	0.59	2.79	4.99	7.18	9.38	11.57	13.77
	230	-1.81	0.38	2.58	4.77	6.97	9.17	11.36	13.56
	235	-2.02	0.17	2.37	4.56	6.76	8.96	11.15	13.35
	240	-2.23	-0.04	2.16	4.35	6.55	8.75	10.94	13.14
	245	-2.44	-0.25	1.95	4.14	6.34	8.54	10.73	12.93
	250	-2.65	-0.46	1.74	3.93	6.13	8.33	10.52	12.72

It is clear from this table similar conclusions apply as for the "CHP" scenario - that with a rising brown coal price the NPV of the "CHP" scenario is economically more effective. In contrast, the decline in NPV with the rising price of natural gas is given mainly by the growth in operating costs in sources burning natural gas (micro-cogeneration, small and medium-sized CHP).

Table 31 Sensitivity analysis of NPV to the CO2 permit price for the "High CHP" scenario

	Year-on-year price increase [€/yr.]							
	0,0	0,5	1,0	1,5	2,0	2,5	3,0	3,5
NPV [bn CZK]	-1.14	1.05	3.23	5.42	7.60	9.79	11.97	14.16

The preceding table shows that a higher year-on-year increase in the permit price increases the benefits of the "High CHP" scenario (impact of higher generation efficiency in high-efficiency CHP compared to separate electricity generation).

Table 32 Sensitivity analysis of NPV to the discount rate for the "High CHP" scenario

	Discount rate [%/yr.]							
	0.50	**1.25**	**2.25**	**3.00**	**3.75**	**4.50**	**5.25**	**6.00**
NPV [bn CZK]	10.80	10.34	9.77	9.36	8.99	8.63	8.29	7.97
	6.75	**6.94**	**7.50**	**8.00**	**8.50**	**9.00**	**9.50**	**10.0**
NPV [bn CZK]	7.67	7.60	7.39	7.21	7.04	6.87	6.71	6.55

Table 33 Sensitivity analysis of NPV to emissions valuation for the "High CHP" scenario

	Multiple of emissions cost [EUR]							
	0	**Baseline value**	**2**	**5**	**7**	**10**	**15**	**20**
NPV [bn CZK]	7.44	7.60	7.76	8.25	8.58	9.06	9.87	10.69

The model works with the valuation of externalities caused by NOx, SOx and solid pollutant emissions using the values given in Chap. 11.2.2. The NPV of this valuation of externalities is designated the baseline value. Further values in the table express the NPV for the "High CHP" scenario for various multiples of the baseline value of valuation of individual emission types. For valuation values for emissions calculated under the CASES project11 (on average 14x higher than the baseline values) the NPV for the "CHP" scenario approaches 10 bn CZK. It is clear that where the valuation of the impact of emissions is higher, then the NPV of the "High CHP" scenario rises (emissions from separate electricity generation weigh down the "Baseline Scenario").

11.7 CBA Summary

The objective of the CBA was to evaluate the defined mix of heat generation/supply for 2016 - 2025 in the baseline and alternative scenarios in terms of their society-wide benefit in the Czech Republic. Identification of the most beneficial scenario was based on a comparison of the incremental costs/benefits of the alternative scenarios compared to the baseline scenario. For the CBA the methodology prepared in accordance with the requirements of Part 1 of Annex IX of EU Directive 2012/27/EU was used.

For scenario comparison purposes, in all scenarios the same quantity of electricity supplied and heat consumed in the Czech Republic is assumed. In scenarios with a higher level of electricity from high-efficiency CHP, saved fuel costs (primary energy savings), reduced grid losses and saved costs for externalities are thus taken into account in comparison with separate generation of electricity and heat.

Table 34 Use of the technical potential of developing CHP technologies

	Technical potential	CHP scenario
Micro-cogeneration	5.0 PJ by 2025	0.9 PJ by 2025
Small and medium-sized CHP plants using gaseous fuels	13.7 PJ by 2025	4.6 PJ by 2025
CHP on renewable energy sources and other alternative fuels	9.5 PJ by 2025	3.2 PJ by 2025

The CBA shows that the incremental benefits exceed the incremental costs in both of the alternative scenarios. The benefit across society is higher for "CHP" scenario implementation. Calculated to net present value the additional savings under this scenario are 17.65 bn CZK. Under the "CHP" scenario it is assumed that in the 2016 – 2025 evaluation period there will be commissioned 33 MWe of micro-cogeneration, 227 MWe of small and medium-sized CHP on gaseous fuels and 62 MWe of newly commissioned CHP sources on renewable energy sources and other alternative fuels. The use of the technical potential in heat supply of developing CHP technologies is shown in the following table.

Thanks to the installation of these new small and medium-sized sources with high-efficiency CHP an increase in electricity from high-efficiency CHP of 1.3 TWh (by 2025) will also be achieved.

For the "High CHP" scenario, the relatively high total fuel costs (mix of sources with high use of natural gas) and high investment in new CHP sources to a great extent cancels out the benefits of this variant, and therefore this scenario does not achieve the absolute benefit levels of the "CHP" scenario.

It can be seen from the sensitivity analysis that there is a significant impact on the final NPV of fuel prices, the price of emissions permits and also of costs for externalities, which can vary significantly depending on the methodological approach. However, in reality the situation where NPV<0 should not occur in the case of the "CHP" scenario.

From the foregoing it is clear that from a whole-society perspective the Czech Republic should develop the conditions for growth of combined generation of electricity and heat to meet the “CHP” scenario in which the highest benefits for society as a whole are demonstrated.