Economic and technical evaluation of the application of a central heat supply system in the SR and comprehensive assessment of the national potential for the application of a central heat supply system. Comprehensive assessment of the national potential for the application of high-efficiency cogeneration

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Introduction

Pursuant to Section 14 (2) of Act No 309/2009 on support for renewable energy sources and high-efficiency cogeneration, amending certain acts, as amended, transposing Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market, and the subsequent amendments to the act implementing parts of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, the Ministry of the Economy of the Slovak Republic (further also the 'ME SR') within its competence carries out a comprehensive assessment of the national potential for the application of high-efficiency cogeneration and publishes it on its website.

The content of this report complies with the requirements of Section 14 (2)(a) to (k) of Act No 309/2009 and Section 6 (2) of Act 321/2014 on energy efficiency, amending certain acts

Definitions

For the purposes of a comprehensive assessment of the national potential for high-efficiency cogeneration:

a) cogeneration means the technological process in which electricity and heat or mechanical energy and heat is produced simultaneously;
b) electricity produced through cogeneration means electricity produced in the cogeneration process in cogeneration facilities;
c) cogeneration facility means a facility using cogeneration technology in its technological part;
d) cogeneration technology means a combustion turbine with a combined cycle, steam back-pressure turbine, steam-condensing extraction turbine, combustion turbine with heat recovery, internal combustion engine, fuel cell, organic Rankine cycles, or any other type of technology used to ensure cogeneration;
e) useful heat means heat produced through cogeneration to satisfy economically justifiable demand for heating or cooling;
f) economically justifiable demand means demand not exceeding the demand for heating or cooling that would have to be satisfied under competitive conditions through processes other than cogeneration;
g) cogeneration with very low output means cogeneration in cogeneration facilities with installed electric output of less than 50 kW per facility;
h) cogeneration with low output means cogeneration in cogeneration facilities with installed electric output from 50 kW inclusive to 1 MW per facility;
i) cogeneration with high output means cogeneration in cogeneration facilities with installed electric output starting from 1 MW inclusive per facility;
j) high-efficiency cogeneration means cogeneration with very low or low output achieving primary energy savings compared to the separate generation of heat and separate generation of electricity, or cogeneration with high output achieving primary energy savings of at least 10% compared to the separate generation of heat and separate generation of electricity;
k) price of electricity means the electricity price approved or determined by the Office for the Regulation of Network Industries for electricity produced from renewable energy sources or electricity produced through high-efficiency cogeneration;
l) electricity price for losses means the arithmetic mean of prices of electricity to cover the losses of all operators in regional distribution networks; the electricity prices to cover the losses of operators in regional distribution networks are approved or determined by the Office for the Regulation of Network Industries;
m) supplementary payment means the difference between the price of electricity and the electricity price for losses paid to electricity producers from renewable energy sources or electricity producers using high-efficiency cogeneration by operators of the regional distribution networks to which facilities of electricity producers are connected or within which these facilities are situated
n) heat supply means heat sales for heating, heat sales for preparation of hot water, sales of heat in hot water, heat sales for cooling or heat sales for other purposes;

o) heat supplier means a natural or legal person holding a licence for heat production, heat production and distribution, or heat distribution
p) licence means a trade licence for heat production, heat production and distribution, or heat distribution
q) heat distribution means distribution of heat and heat supply to customers;
r) centralised heat supply means heat supply through public heat distribution from one or more facilities producing heat;
s) public heat distribution means a heat distribution part of a thermal facility system intended for heat supply to multiple customers
t) efficient centralised heat supply means a centralised heat supply system delivering at least 50% of heat produced from renewable energy sources or 50% of heat from industrial processes, 75% of heat produced through cogeneration, or 50% of heat produced by combination of the methods referred to above;
u) thermal facility system means a facility for heat production, distribution or consumption;
v) heat distribution means transport of heat through a public distribution system to customers;
w) central district heat source means a facility for producing heat with a maximum thermal input of up to 20 MW used for central heating, shared preparation of hot water or other purposes for multiple buildings with external heat distribution;
x) heat source in centralised heat supply means a facility for heat production used for the purposes of centralised heat supply;
y) facility for heat production means a facility used to transform various forms of energy into heat; this includes buildings, as well as technological equipment;

List of abbreviations

CHP	cogeneration of electricity and heat or mechanical energy and heat
HE CHP	high-efficiency cogeneration of electricity and heat
CU	cogeneration unit (CHP facility with an internal combustion engine)
CHS	centralised heat supply
DHS	decentralised heat supply
RES	renewable energy sources
SEMO	short-term electricity market organiser
ENO	Nováky power plant
PEC	primary energy consumption
ME SR	Ministry of the Economy of the Slovak Republic
ORNI	Office for the Regulation of Network Industries
SO SR	Statistical Office of the Slovak Republic
SIEA	Slovak Innovation and Energy Agency

Abstract

In 2014, 4 473 GWh electricity was produced in Slovakia using high-efficiency cogeneration, accounting for 14.7% of total electricity production in Slovakia. The volume of heat supply from high-efficiency cogeneration of 11 446 GWh accounts for 32.8% of the overall production of useful heat.

Electricity production in steam-condensing extraction turbines and in steam back-pressure turbines are currently the two prevailing cogeneration technologies. The share of these facilities is 58% of the overall installed output and 83% of the overall volume of heat produced through high-efficiency cogeneration. The share of the installed output of electricity and heat cogeneration using internal-combustion engines has increased significantly over the last five years. The installed output of this technology currently accounts for 26.8% of the overall installed output.

As regards fuels, fossil fuels have the largest share in cogeneration with natural gas accounting for 21%, hard coal for 18% and lignite for 10%. The share of RES has increased significantly over the last five years. Biomass currently accounts for 12% and biogas for 9%. Besides the constructed heating plants which combust biomass, the overall share of biomass combustion is also due to the combined combustion of biomass with fossil fuels in the existing or reconstructed heat sources in public and privately owned heating plants.

The most extensive utilisation of the technical potential for high-efficiency electricity and heat cogeneration over the next few years is anticipated particularly in the existing small and medium-sized heat sources (heating plants, central district boiler houses) combusting natural gas, and through installation of electricity and heat cogeneration technology with internal-combustion engines.

Economic modelling of the application of high-efficiency cogeneration in Slovakia in view of the currently provided support has proven the profitability of the installation of cogeneration technologies. Further development of these technologies may be affected by the development in fuel and electricity prices, and the stability of the legislative and regulatory environment.

Slovakia has an extensive centralised heat supply system covering more than 54% of the overall demand for heat. Over the last 20 years, production and supply of heat from centralised heat supply systems has reduced significantly mainly due to the enforced energy efficiency policy in the housing and municipal sectors, in services and in industry.

Heat consumption for heating and hot water service in residential properties supplied with heat from CHS systems decreased by 26% between 2004 and 2014. The average nominal annual heat consumption for heating dropped from 85.8 kWh/m^2 to 61.5 kWh/m^2.

Heat consumption for heating is expected to fall by 8.5% from 2014 to 2020. The above-mentioned reduction in consumption will be achieved mainly by the continued thermal insulation of residential buildings.

1. Assessment of the legal regulations governing the conditions applicable to business activities concerning high-efficiency cogeneration and central heat supply systems

1.1 The legal regulations governing the conditions applicable to business activities concerning cogeneration and central heat supply systems

The basic legislative framework for power engineering is currently Act No 251/2012 on power engineering, amending certain acts, while the legislative framework for thermal engineering is Act No 657/2004 on thermal engineering, as amended, and Act No 250/2012 on regulation in network industries, as amended, as well as implementing regulations issued pursuant to these acts.

The support for electricity production in facilities for electricity and heat cogeneration is addressed comprehensively in Act No 309/2009 on the promotion of renewable energy sources and high-efficiency cogeneration, amending certain acts, as amended. The act regulates in particular the conditions for producing electricity from renewable sources and high-efficiency cogeneration of electricity and heat, and the rights and obligations of electricity producers. This act transposes Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market into the legislation of the Slovak Republic. This has helped to create conditions for optimising the functioning of the market in electricity with regard to cogeneration, as well as conditions for supporting electricity and heat producers in their efforts to reconstruct the existing production capacity or invest finance in construction of new capacity. Producers will be able to apply for funding from national and European funds and may be supported through the determined purchase prices, in accordance with the binding regulations.

Act No 309/2009 was amended in 2014 by Act No 321/2014 on energy efficiency, amending certain acts[1] to the following extent

- introduction of a system for the release and administration of guarantees of the origin of electricity produced by high-efficiency cogeneration or electricity and heat;
- definition of the basic principles applicable to the economic and technical evaluation of the application of high-efficiency cogeneration in the Slovak Republic;
- stipulation of the obligation of the Ministry of Economy SR to complete comprehensive assessment of the national potential for high-efficiency cogeneration.

The same act also amended Act No 251/2012, by modifying the process of issuing approvals to operate facilities for generating electricity on the basis of the economic and technical assessment of projects, compliance with comprehensive assessment of high-efficiency cogeneration, and comprehensive assessment of the national potential for centralised heat supply.

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[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC of the European Parliament and of the Council was transposed by Act No 321/2014 on Energy Efficiency amending certain acts. Directive 2012/27/EU adopted the requirements of the original Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market amending Directive 92/42/EEC. Annexes I and II for the calculation of HE CHP were fully adopted in the new directive. The original principles and procedures were therefore retained in the calculation of HE CHP. New Delegated Commission Regulation (EU) No 2015/2402 of 12 October 2015 reviewing harmonised efficiency reference values for the separate production of electricity and heat in application of Directive 2012/27/EU of the European Parliament and of the Council and repealing Commission Implementing Decision 2011/877/EU was issued pursuant to Directive 2012/27/EU.

1.2 System for supporting high-efficiency cogeneration

Act No 309/2009 on the promotion of renewable energy sources and high-efficiency cogeneration, amending certain acts, stipulated the support for high-efficiency cogeneration gradually modified from 1 January 2010 and currently applied as follows:

1. preferential connection of facilities producing electricity (further only as the 'facility') to the regional distribution network, preferential access to the network, preferential transfer of electricity, distribution of electricity and supply of electricity;
   - *applicable to all electricity produced through high-efficiency cogeneration in facilities without limitations on the installed output throughout the facility's lifespan.*
2. purchase of electricity for the electricity price for losses by the operator of the regional distribution network to which the facility is connected directly or through a local distribution network;
   - *applicable to all electricity produced through high-efficiency cogeneration in facilities with a total installed output of up to 125 MW or 200 MW if the power engineering share of renewable energy sources in the fuel is greater than 30% or if the power engineering share of gases generated as a by-product of the metallurgical production process in the fuel is greater than 40%. The support may be applied to facilities with a total installed output of up to 500 kW throughout the lifespan of the facility and in the case of other facilities for 15 years from the year the facility is put into operation or the year of reconstruction or modernisation of the technological part of the facility.*
3. Supplementary payment, i.e. the difference between the determined fixed price (rate) and the electricity price for losses;
   - *applicable to all electricity produced through high-efficiency cogeneration in facilities with a total installed output of up to 5 MW and up to 125 MW or 200 MW if the share of useful heat delivered for technological purposes is not more than 40% of the useful heat. The support may be claimed for 15 years from the year the facility is put into operation or from the year of reconstruction or modernisation of the technological part of the facility. The supplementary payment may also be claimed for facilities producing electricity for immediate consumption in the place of production, i.e. without supply to the distribution network.*
4. assumption of the responsibility for deviations in relation to the operators of regional distribution networks;
   - *applicable to facilities with a total installed output of up to 500 kW. The support may be applied to facilities with a total installed output of up to 500 kW throughout the lifespan of the facility and in the case of other facilities for 15 years from the year the facility is put into operation or the year of reconstruction or modernisation of the technological part of the facility.*

Electricity produced in facilities for electricity and heat cogeneration is exempt from the consumer tax on electricity (Act No 609/2007 on the consumption tax on coal, electricity and natural gas, as amended) if it is supplied directly to the end consumer of electricity or consumed by the producer, providing the production is confirmed by certification of the origin of electricity produced through high-efficiency cogeneration and as long as the facility for electricity and heat cogeneration has not been amortised pursuant to a special regulation (Act No 595/2003 on income tax), but no longer than 12 years from the year of putting the facility for electricity and heat cogeneration into operation.

The price of electricity produced from renewable energy sources and through high-efficiency cogeneration is determined by the regulatory authority in generally applicable legal regulations/decrees. When determining the price, the authority takes into account the applied cogeneration technology, the fuel type, the time of putting the facility for producing electricity into operation, the extent of the facility's installed output, and, if appropriate, the extent of investment costs of reconstruction or modernisation of the facility producing electricity.

The purchase price of electricity comprises two elements - the electricity price for losses and the supplementary payment. The price for losses reflects the market price of electricity and is defined as the arithmetic average of prices of electricity to cover the losses of all operators in regional distribution networks. The supplementary payment as the second element of the purchase price of electricity is paid to the producer of electricity from high-efficiency cogeneration by an operator of the distribution network to which the producer's facility is connected or within which the facility is situated. The supplementary payment is the difference between the electricity price (the determined fixed price or the electricity price for determining the supplementary payment) and the electricity price for losses.

The electricity price for determining the supplementary payment during the years following the year in which the facility of the electricity producer is put into operation is equal to that valid the year in which the facility of the electricity producer is put into operation. This price is determined for one calendar year and the regulatory authority may change the price with the supplementary payment taking into account any previous year's significant increases or decreases in the prices of the raw materials used to produce electricity.

The electricity price for determining the supplementary payment applicable to electricity producers who received aid for acquiring facilities for electricity production from support programmes funded from the state budget or funds of the European Union was reduced until 2012. These electricity producers have not been eligible for the support in the form of compulsory purchase of electricity by operators of the distribution network and the supplementary payment since 2014. The electricity price determined by the regulatory authority for the following period, no longer than three years, must not be lower than 70% of the price valid in the relevant year.

Electricity producers through cogeneration who supply electricity to the regional distribution network claim both components of the price, i.e. the electricity price for losses and the supplementary payment. Electricity producers through cogeneration who consume the electricity produced only claim the supplementary payment.

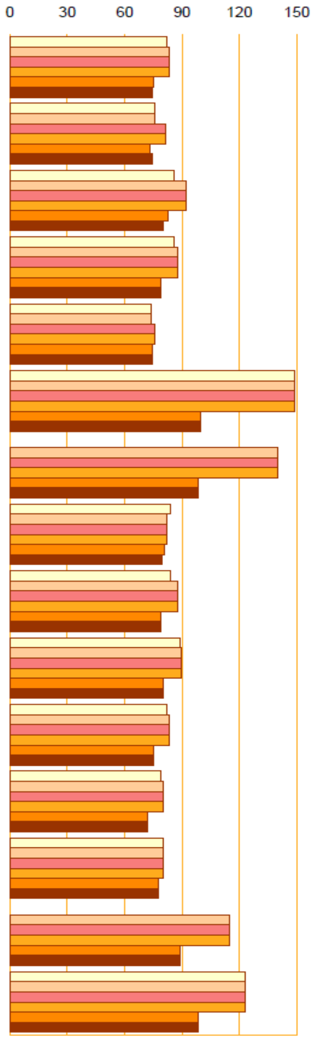
An overview of the prices of electricity produced through high-efficiency cogeneration (specified

fixed price) for determining the supplementary payment from 2011 until the present is provided in

Table 1.

Table 1: Specified fixed price of electricity produced by cogeneration (EUR/MWh)

Technology/fuel		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
combustion turbine with a combined cycle		81.87	83.06	83.06	83.06	74.75	74.75
combustion turbine with heat recovery		75.59	75.59	80.99	80.99	72.89	74.69
internal combustion engine	natural gas	85.89	91.7	91.7	91.7	82.53	80.26
	fuel oils	85.89	87.66	87.66	87.66	78.89	78.89
	mixture of air and methane	73.94	73.94	75.52	75.52	74.39	74.39
	catalytically treated waste	149.00	149.00	149.00	149.00	99.82	99.82
	from thermal fission of waste and its products		140.00	140.00	140.00	98.4	98.4
steam back-pressure turbine or steam-condensing extraction turbine	natural gas	83.65	81.71	81.71	81.71	80.97	79.76
	fuel oils	83.65	87.73	87.73	87.73	78.96	78.96
	lignite	88.72	89.3	89.3	89.3	80.37	80.37
	hard coal up to 50 MW inclusive	82.15	83.16	83.16	83.16	74.84	74.84
	hard coal over 50 MW	78.87	79.81	79.81	79.81	71.83	71.83
	municipal waste	80.00	80.00	80.00	80.00	77.60	77.60
steam back-pressure turbine or steam-condensing extraction turbine gas produced by thermochemical gasification of waste in gasification generators or			114.71	114.71	114.71	89.05	89.05
organic Rankine cycle		123.24	123.24	123.24	123.24	98.31	98.31



The operator of the distribution network is required to purchase electricity and pay the electricity price for losses. The electricity producer is entitled to the supplementary payment from the distribution network operator for the actual amount of electricity produced during the calendar month through high-efficiency cogeneration reduced by own technological electricity consumption. Operators of regional distribution networks receive compensation for the cost of this supplementary payment and the costs relating to assuming the responsibility for deviation.

The development of the cost of supporting electricity produced from renewable energy sources and by high-efficiency cogeneration through supplementary payments according to the types of primary energy over the last few years is shown in the following Table 2.

Table 2: Development of supporting the electricity produced from renewable energy sources and by high-efficiency cogeneration through supplementary payments according to the types of primary energy

Primary energy		2012			2013			2014		
		Volume of electricity for supplementary payment (MWh)	Supplementary payment amount (EUR)	Average supplementary payment (EUR/MWh)	Volume of electricity for supplementary payment (MWh)	Supplementary payment amount (EUR)	Average supplementary payment (EUR/MWh)	Volume of electricity for supplementary payment (MWh)	Supplementary payment amount (EUR)	Average supplementary payment (EUR/MWh)
CHP + RES[2]	biomass	414 179	26 370 996	63.67	405 412	29 391 685	72.50	611 802	49 115421	80.28
	biomass and fossil fuel	85 512	5 317 163	62.18	103 800	7 436 652	71.64	77 405	6 078 982	78.53
	biogas	257 743	21 102 504	81.87	446 130	39 598 516	88.76	522 655	46 380 151	88.74
	hard coal	9 711	219 716	22.63	6 650	223 152	33.56	8 470	308 028	36.37
	lignite	184 025	5 084 351	27.63	180 659	7 285 900	40.33	153 934	6 411 014	41.65
	catalytically treated waste	2 271	201 855	88.88	771	77 078	99.97	1 441	147 231	102.17
	municipal waste				23 524	1 516 021	64.45	17 686	1 352 238	76.46
	municipal waste with fossil fuel							14 885	989 951	66.51
	gas from WWTP	3 262	110 340	33.83	2 975	133 294	44.80	5 859	237 459	40.53
	landfill gas	56 074	3 119 429	55.63	23 139	1 567 372	67.74	10 577	495 817	46.88
	natural gas	724 027	17 836 661	24.64	882 425	33 056 661	37.46	1 148 653	45 541 946	39.65
	natural gas and coal	295 446	5 282 813	17.88	381 095	10 303 973	27.04	433 815	12 891 181	29.72
	TOTAL CHP + RES	**2 032 250**	**84 645 828**	**41.65**	**2 456 580**	**130 590 304**	**53.16**	**3 007 182**	**169 949 419**	**56.51**
RES	solar energy	624 272	204 792 003	328.05	589 729	193 892 317	328.78	583 405	193 364 628	331.44
	hydropower	678 410	8 761 953	12.92	784 746	18 879 132	24.06	870 174	23 280 197	26.75
	wind energy	6 360	31 798	5.00	5 504	86 146	15.65	6 120	114 162	18.65
	TOTAL **RES**	**1 309 042**	**213 585 754**	**163.16**	**1 379 979**	**212 857 595**	**154.25**	**1 459 699**	**216 758 987**	**148.50**

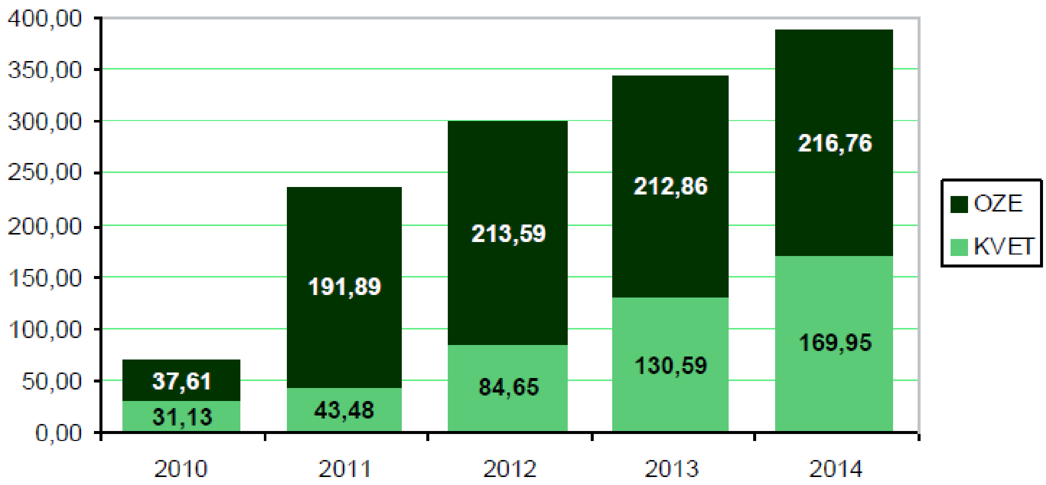
Source: SIEA according to the ORNI's publically available materials.

[2] In the case of biomass, biogas, landfill gas and gas from wastewater treatment plants the supplementary payment also applies to electricity produced otherwise than by high-efficiency CHP. The fixed price for these facilities is determined as the price for electricity produced from RES, rather than electricity produced by high-efficiency CHP.

The cost of supporting electricity produced from renewable energy sources (solar energy, hydropower and wind energy) through supplementary payments has increased significantly since 2011 primarily due to the compensation of purchase prices from photovoltaic power plants. These costs did not increase significantly during the following years. They increased from EUR 191.89 million in 2011 to EUR 216.76 million, i.e. an increase of 12.96%. The effect of legislative moderation of the support for electricity produced from renewable energy sources has become apparent.

On the other hand, the cost of supporting electricity production through cogeneration (support for using renewable energy sources in CHP facilities and for high-efficiency CHP especially using fossil fuels) increased significantly. It increased from EUR 43.48 million in 2011 to EUR 169.95 million, i.e. an increase of 290.9% as shown in Chart 1 below.

Chart 1: Development of the cost of supporting electricity produced from renewable energy sources and by electricity and heat cogeneration in million EUR



Source: SIEA according to the ORNI's publically available materials.

The compensating mechanism for covering the increased cost of producing electricity by high-efficiency cogeneration and from renewable sources is implemented through the tariff for operating the system.

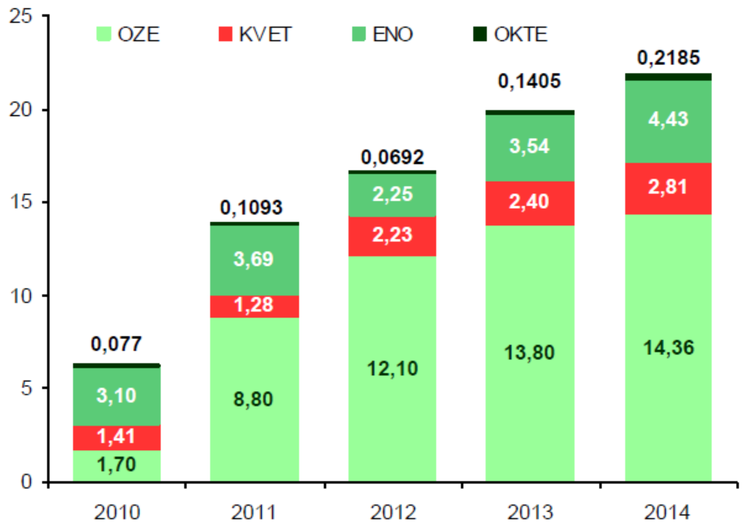
Development of the tariff for operating the system is shown in Table 3 and Chart 2 below.

Table 3: Development of the rate for operating the system (EUR/MWh)

Development of the tariff for operating the system (TPS)					
Year	RES	HE CHP	ENO	SEMO	Total
	EUR/MWh				
2010	1.702	1.407	3.095	0.077	**6.28**
2011	8.8048	1.2836	3.6934	0.1093	**13.89**
2012	12.1016	2.2306	2.2456	0.0692	**16.65**
2013	13.7952	2.404	3.5403	0.1405	**19.88**
2014	14.3572	2.8106	4.4337	0.2185	**21.82**

Source: ORNI

Chart 2: Structure of the tariff for operating the system (EUR/MWh)



Source: ORNI

The mechanism for supporting electricity produced from renewable energy sources and high-efficiency cogeneration has a significant impact on the applied rate for operating the system and this has influenced the end price of electricity for all electricity consumers significantly over the last few years. The rate for operating the system increased greatly mainly due to the intensive construction of facilities for producing electricity from renewable energy sources (especially photovoltaic power plants during 2009 and 2010) and supporting them in accordance with the valid directives of the EU, high-efficiency cogeneration of electricity and heat, support for producing electricity from local coal (in accordance with Directive No 72/2009/EC), and the costs of activities of the short-term electricity market organiser, which contributes significantly to liberalising the market in electricity on a limited territory.

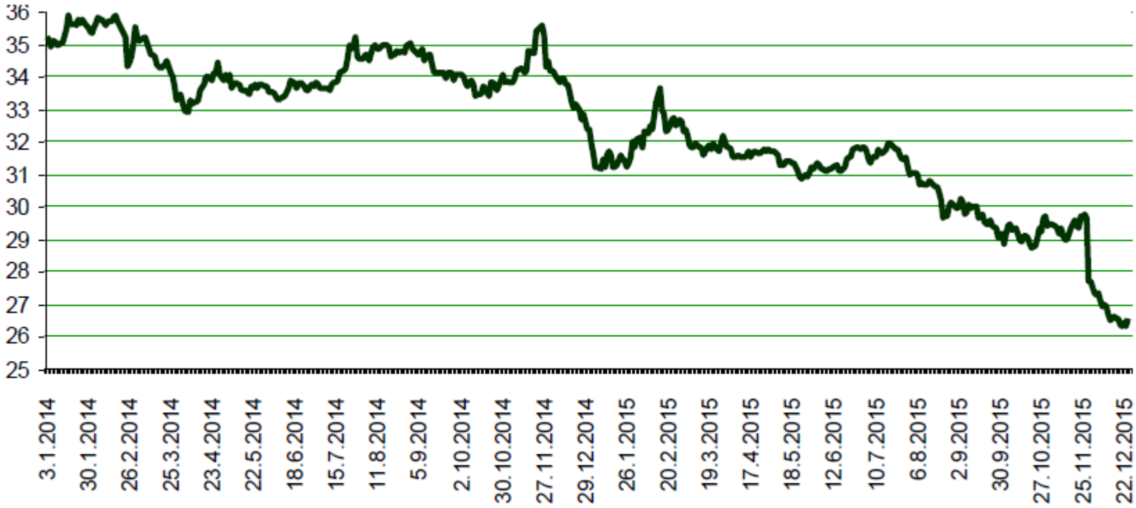
The drop in electricity prices on the global markets is another major factor influencing the increase in the rate for operating the system. The electricity price on the EEX exchange in Leipzig, which has a major impact on the electricity price on the Slovak market, has demonstrated a significantly declining trend for all products of this exchange since 2014.

Since the electricity produced from renewable energy sources and by high-efficiency cogeneration is supported mainly by the so-called supplementary payment, which is essentially the difference between the market price of electricity and the electricity price determined by the regulatory authority for individual technologies (specified fixed price), any decrease in the price on the global markets logically results in a higher supplementary payment and consequently also a higher rate for operating the system as the source of funds for supplementary payments.

The highest average supplementary payments for electricity produced by cogeneration were those recorded in 2014 for facilities using catalytically treated waste to the amount of 102.17 EUR/MWh, biogas to the amount of 88.74 EUR/MWh, and biomass to the amount of 80.28 EUR/MWh. The highest average supplementary payment for electricity produced from renewable energy sources was that recorded for electricity produced from solar energy to the amount of 331.44 EUR/MWh.

Electricity prices on the EEX exchange in Leipzig fluctuated over the last two years between 35.85 and 26.35 EUR/MWh, as shown in the following Chart 3.

Chart 3: Development of electricity prices on the EEX exchange in Leipzig over the last two years (EUR/MWh)



A total of 4 466 MWh of produced electricity was supported through supplementary payments in 2014, of which

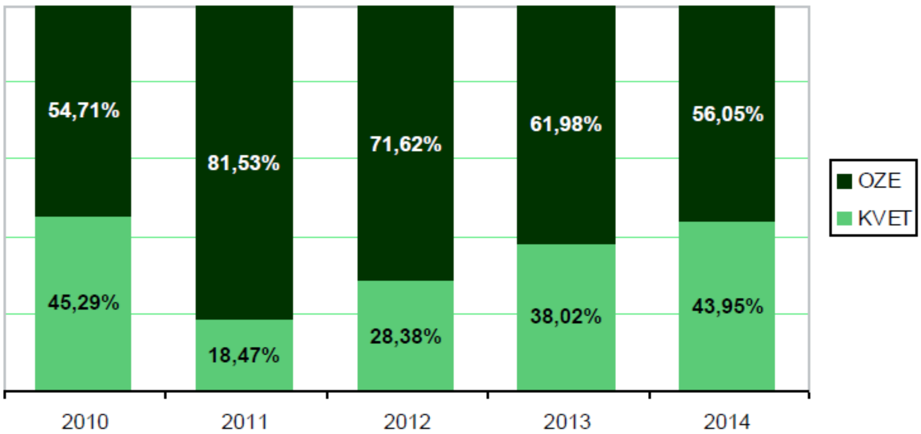
- 3 077 MWh (67.32%) accounted for electricity from cogeneration - CHP technologies using renewable energy sources and high-efficiency CHP;
- 1 459 MWh (32.68%) accounted for electricity produced from renewable energy sources - solar energy, hydropower and wind energy;

Of the total cost of support amounting to EUR 386.708 million the electricity produced:

- by cogeneration accounted for EUR 169.949 million 43.95% - CHP technologies using renewable energy sources and high-efficiency CHP;
- from renewable energy sources (solar energy, hydropower and wind energy) accounted for EUR 216.758 million (56.05%).

The development of the cost of supporting electricity produced from renewable energy sources (solar energy, hydropower and wind energy) and by cogeneration (support for using renewable energy sources or for high-efficiency CHP) through supplementary payments over the remaining years is shown in Chart 4.

Chart 4: Development of the cost of supporting electricity produced from renewable energy sources (solar energy, hydropower and wind energy) and by electricity and heat cogeneration through supplementary payments in %.



Source: SIEA according to the ORNI's publically available materials.

The current system for supporting electricity produced from renewable energy sources and by high-efficiency cogeneration greatly increased the disproportion between the volume of electricity required for covering losses in the electricity supply system and the volume of electricity from compulsory purchasing. The surplus electricity resulting from this disproportion is sold by distribution companies on the electricity market at a loss amounting to the difference between the market price of electricity and the regulated price of electricity from compulsory purchasing since the market sales price of electricity has reduced significantly. The liquidity of surplus electricity on the market has reduced dramatically due to the extensive surplus electricity in the system.

Despite the undoubtable benefits of the system of purchasing prices in terms of guaranteed stability for investors, the current system for supporting electricity produced from renewable energy sources and by high-efficiency cogeneration will be hardly (unpredictably) sustainable.

2. Assessment of the useful heat and cold demand in central heat supply systems suitable for the application of high-efficiency cogeneration with low and very low output

The Slovak Republic is one of the countries with an extensive centralised heat supply. The majority of heat sources and distribution systems was established and developed simultaneously with the development or urban conurbations, in particular the housing and municipal development and civic amenities constructed up until 1990. The heat from centralised heat supply systems is delivered mainly to flats and the industrial and service sectors. These systems offer the greatest potential for the application of high-efficiency cogeneration of electricity and useful heat.

The market for heat has demonstrated a decrease in the supply of heat through centralised heat supply systems (hereinafter the ‘CHSS’) over the last few years. This has been caused mainly by reduced demand for heat in residential buildings due to thermal insulation and streamlining measures. The significant extent of the measures implemented in residential buildings throughout Slovakia suggests that the trend of the previous years may slow down over the following few years.

Customers disconnecting from centralised heat sources has also had a negative impact on the size of the market for heat but this trend is not expected to continue on a greater scale. The currently adopted legislative framework stipulates strict conditions for terminating consumption and practically prevents consumers from disconnecting from heat sources using renewable energy sources. The legislation also addresses the construction of new thermal facility systems, stipulating that this construction is not to be permitted in the case of any negative impact on the cost-effectiveness and energy efficiency of the affected existing thermal facility systems, on the environment or on the cost of heat supplied to end consumers. These measures provide a certain degree of assurance that the market in heat will be more stable in future, although the size of the market is naturally influenced by climatic conditions. In addition, the application of Directive 2012/27/EU on energy efficiency and its impact on reducing final energy consumption also must be considered.

The volume of consumed heat can be quantified according to the details of end heat energy consumption reported by the Statistical Office SR with added data on the consumption of fuel used to produce heat.

2.1 Current status

Natural gas, lignite and hard coal are currently the most common sources for cogeneration of electricity and heat. The following tables provide an overview of the actual consumption of these energy sources for the last few years and the anticipated development in their consumption.

Table 4: Total coal consumption in the SR in kt (Source: Statistical Office SR, Ministry of Economy SR)

	2010	2011	2012	2013	2014
Extraction: brown coal and lignite	2 378	2 376	2 292	2 050	1 900
Import: brown coal and lignite	647	611	715	700	700
Import: hard coal	3 807	3 984	3 928	3 807	3 807
Import: hard coal coke	610	468	218	200	200
Total (kt)	**7 442**	**7 439**	**7 153**	**6 757**	**6 607**

The domestic extraction of brown coal shows a downward trend. The power engineering policy of the SR anticipates stabilisation of the domestic production at 1 800 kt from 2015 to 2030. Black coal is used to a significant extent in metallurgy and manufacturing and its consumption will depend on the development of this industrial segment.

Table 5: Total natural gas consumption in the SR in GWh (Source: SPP)

	2010	2011	2012	2013	2014
Total natural gas consumption in Slovakia (GWh)	57 300	57 900	54 200	54 800	46 200

Consumption of natural gas is also showing a downward trend. Natural gas is the predominant fuel in the production of heat. The effect of increasing the energy efficiency in production, distribution and consumption of heat is reflected in the decreasing consumption of natural gas. The reduction in natural gas consumption is also greatly influenced by the rising share of the use of biomass in heat production. The significant year-on-year decrease in natural gas consumption during 2014 compared to 2013 was caused mainly by the climatic conditions during the heating season in 2014. The average degree days during this year were the lowest over the last twenty years. According to the power engineering policy of the SR the anticipated consumption of natural gas over the next few years will be around 50 000 GWh with a slightly rising trend.

The analysis of the production of useful heat according to individual sources for heat production and the statistics of the reported consumption of primary fuels and energy shows that the annual production of useful heat is currently at 41 TWh.

Table 6: Total heat production in Slovakia in GWh (Source: SIEA, individual sources converted according to the data on fuel consumption from the Statistical Office SR)

		2010	2011	2012	2013	2014
Public and industrial heating plants, boiler plants - centralised heat supply systems	(GWh)	24 002	23 459	21 795	21 392	19 063
Individual heat supply - local boiler rooms (households, services)	(GWh)	19 370	19 241	18 783	18 952	15 790
TOTAL	(GWh)	**43 372**	**42 700**	**40 579**	**40 344**	**34 853**

As regards the structure of the fuels and energy used to produce heat, natural gas is the dominant fuel. The shares of individual fuels in the production of heat are listed in the following table.

Table 7: Total annual heat production in GWh according to the primary fuel and energy types in Slovakia

Primary fuels and energy		**2010**	**2011**	**2012**	**2013**	**2014**
natural gas	(GWh)	30 600	30 228	28 064	27 400	22 149
coal	(GWh)	6 765	5 803	4 374	4 247	4 165
wood and wood waste	(GWh)	1 293	1 689	2 643	2 969	3 068
biogas	(GWh)	75	83	523	753	853
nuclear energy	(GWh)	1 526	1 287	1 373	1 167	844
other fuels*	(GWh)	3 112	3 981	3 895	4 101	3 775
TOTAL	(GWh)	**43 372**	**43 072**	**40 872**	**40 638**	**34 853**

*oil and petroleum products, waste incineration, lyes, metallurgic gases, useful heat from chemical production

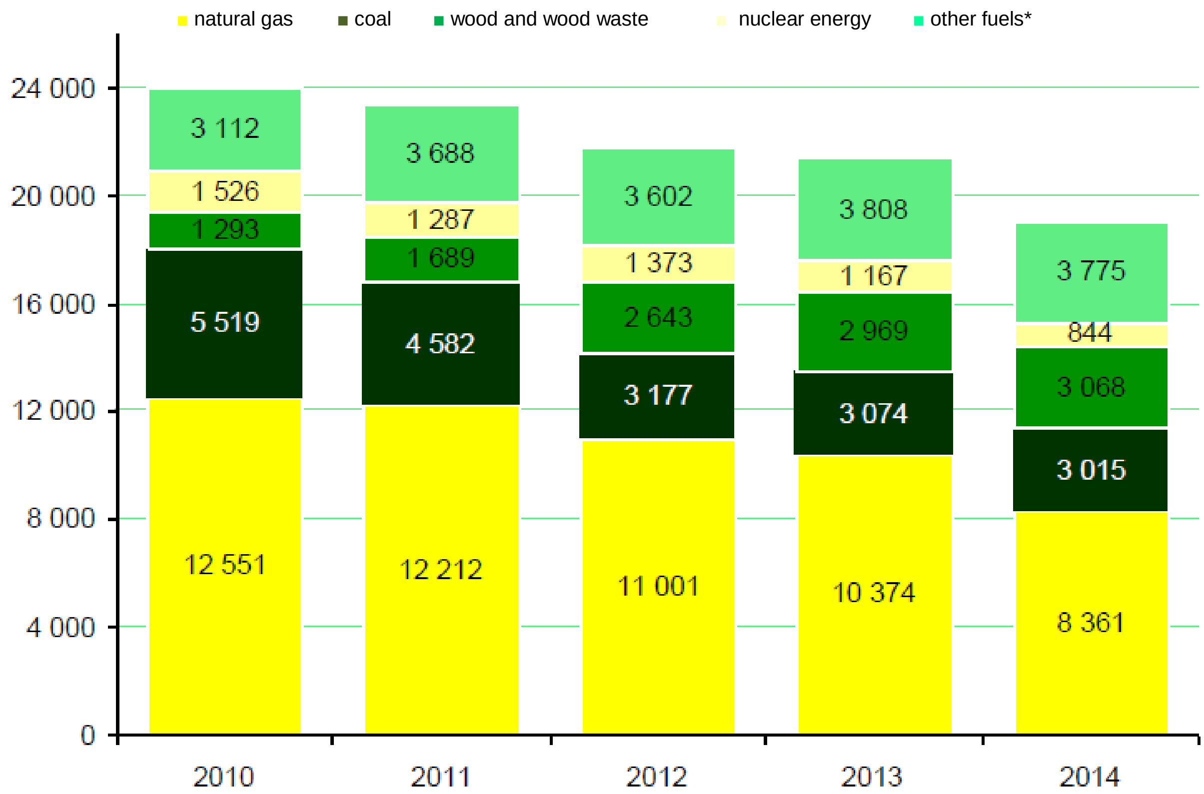
Production of heat and the structure of fuels used in centralised heat supply systems with the greatest potential for application of high-efficiency cogeneration are shown in the following table and chart.

Table 8: Annual heat production in GWh according to the primary fuel and energy types in centralised heat supply systems

Primary fuels and energy		**2010**	**2011**	**2012**	**2013**	**2014**
natural gas	(GWh)	12 551	12 212	11 001	10 374	8 361
coal	(GWh)	5 519	4 582	3 177	3 074	3 015
wood and wood waste	(GWh)	1 293	1 689	2 643	2 969	3 068
nuclear energy	(GWh)	1 526	1 287	1 373	1 167	844
other fuels*	(GWh)	3 112	3 981	3 895	4 101	3 775
TOTAL	(GWh)	**24 002**	**23 752**	**22 089**	**21 686**	**19 063**

*oil and petroleum products, waste incineration, lyes, metallurgic gases, useful heat from chemical production

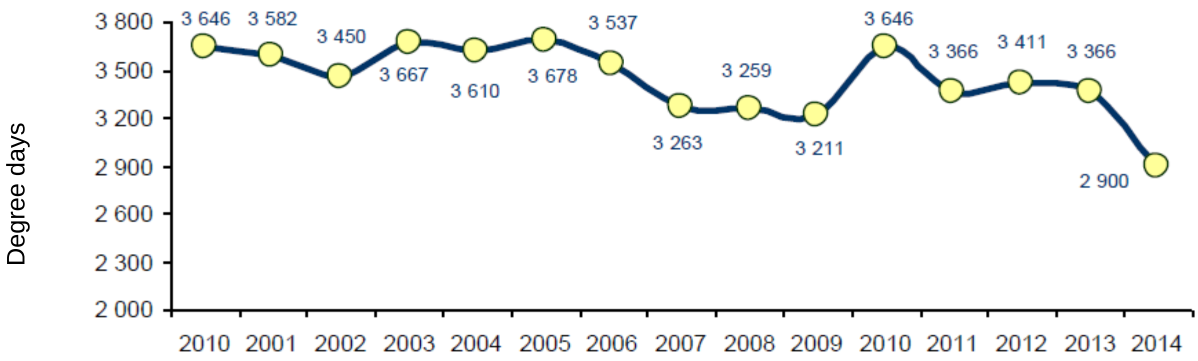
Chart 5: Annual heat production in GWh, according to primary fuel and energy types, in centralised heat supply systems



As mentioned previously, the declining consumption of fossil fuels is largely due to the reduction in their consumption for the production of heat, in particular in the case of natural gas. The share of biomass in the production of heat has increased by more than 100% over the last few years. The production of heat from other fuels (oil and petroleum products, waste incineration, lyes, metallurgical gases, useful heat from chemical production, etc.) has been at an almost constant level during the monitored period. This heat is used mainly in the industrial sector for technological purposes.

The climatic conditions during heating seasons have a major impact on heat consumption for heating. The remarkably mild weather in 2014 was reflected strongly in absolutely the lowest heat production during the monitored period. The development of the degree days in Slovakia determined by the weighted average is shown in the following chart.

Chart 6: Development in the number of degree days over the last fourteen years.



The structure of fuel consumption is expected to remain largely unchanged over the next few years, with natural gas being the most commonly used fuel.

3. Prognosis for the development of demand for useful heat and cold over the next ten years

As mentioned previously, the development of heat consumption has shown a decreasing trend over the long term and this trend is expected to continue. The production and supply of heat from CHS systems has decreased significantly over the last 10 years mainly for the following reasons:

- heat consumption, in particular in the housing and municipal sector, in services and industry decreases as the energy efficiency policy is implemented;
- the last few years have been characterised by a major trend in disconnecting from the centralised supply and construction of boiler rooms in houses owing to the extensive gas supply network in the SR, the favourable prices of natural gas and availability of high-efficiency boilers.

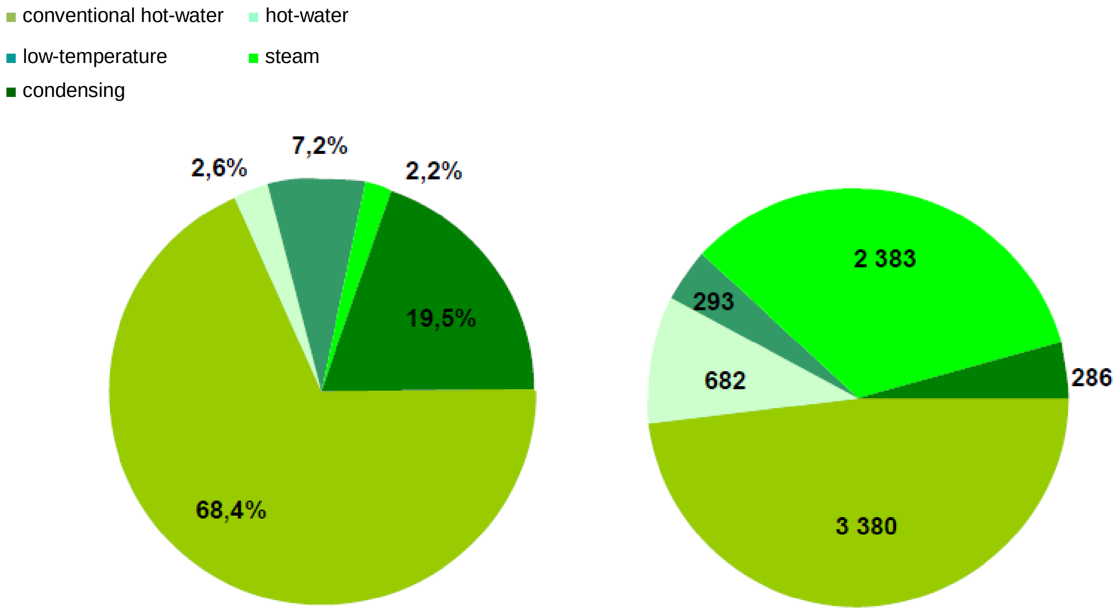
3.1 Energy efficiency potential of the centralised heat supply infrastructure

The current thermal facility systems in CHS networks used to produce and distribute heat, as well as the anticipated development in heat consumption by major heat consumers were analysed in order to determine the anticipated consumption of useful heat for the next few years. The analysis was based on the results of verification of the cost-effectiveness of thermal facility systems carried out in regular intervals by the Slovak Innovation and Energy Agency - a contribution organisation established by the Ministry of Economy of the Slovak Republic - for heat suppliers (holders of licences to conduct business activities in heat engineering) pursuant to the obligation stipulated in Act No 657/2004, as amended.

3.1.1 Heat production and distribution

Facilities for producing and distributing heat belonging to heat suppliers with a total annual heat supply of approximately 11 000 GWh representing almost 75 % of the market in heat in Slovakia were analysed. The shares of individual boilers according to types and installed output are shown in the following chart.

Chart 7: Proportion of the number of boilers according to their type in centralised heat supply systems and their installed output (MW)

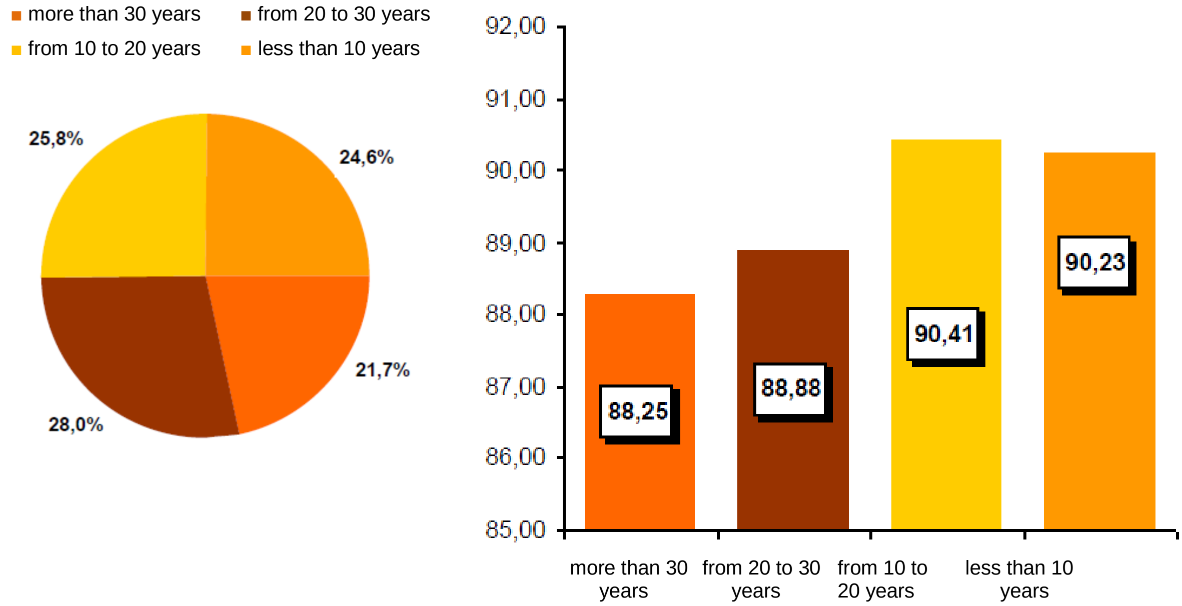


Conventional hot-water boilers using mainly natural gas installed in central boiler houses and heating plants account for the largest share according to the number of boilers and according to the installed output. Although the number of steam boilers accounts for a small part of the overall number, their share in the total installed output is significant. Boilers in public and industrial heating plants for cogeneration of electricity and heat prevail in this sector.

The share of condensing boilers in the total installed output is the lowest, despite the relatively high number of these boilers. Boilers of this type are used mostly in central boiler rooms for heating and hot water service.

The number of boilers has changed by almost 50% over the last twenty years. Mainly condensing and low-temperature boilers have been installed. This was partly due to their availability on the market and partly due to the technical conditions for their installation. The implemented energy-efficiency measures led to a decreasing temperature gradient of heating water compared to the calculated conditions applied when dimensioning the original heating systems. The numbers of boilers according to the time of their installation and guaranteed efficiency of heat production are shown in Chart 8.

Chart 8: Proportion of the number of boilers according to their age in centralised heat supply systems and their guaranteed heat production efficiency



Significant numbers of heat exchangers for utilising the latent heat of exhaust fumes have been installed in exhaust sections of conventional boilers running on natural gas in Slovakia over the last twenty years and this has resulted in the efficiency of heat production increasing by approximately 4% over the guaranteed efficiency.

It is safe to say that the current technical standard of facilities for producing heat in CHS systems matches the European standard and the conditions for their further development have been created (in technical and economic aspects, despite the regulation of heat prices).

Warm and hot-water distribution is predominant in CHS systems. Steam distribution is mostly used to supply heat to industrial consumers. A major part of heat distribution systems is 15 to 30 years old and this age is reflected in their technical condition. The basic data on the analysed distribution systems is provided in Table 9.

Table 9: Data on analysed heat distribution in centralised heat supply systems

Type of distribution	Total length	Heat at the distribution inlet	Heat at the distribution outlet	Efficiency of heat distribution
	(km)	(GWh)	(GWh)	(-)
primary steam	69.90	2 258	1 889	0.837
primary hot-water	816.97	3 306	2 968	0.898
primary warm-water	734.15	2 600	2 431	0.935
secondary	1 181.78	2 049	1 937	0.945

A certain part of the primary heat distribution system has been operated at excess capacity due to the significant decrease in heat consumption over the last 15 years and this has resulted in an increase in relative distribution losses of heat. Steam distribution systems are a problematic part of the primary heat distribution systems due to their extensive wear and tear and low cost-effectiveness.

3.1.2 Buildings

Heat supply from the CHS system is provided to approximately 16 000 residential buildings with a total of 650 620 flats occupied by more than 1.8 million residents. The heat consumption in residential buildings has shown a downward trend over the long term and this trend is expected to continue, although at a slower pace. The heat consumption over the last 15 years decreased mainly due to improved thermal properties of external walls of buildings achieved with thermal insulation and replacement of doors and windows, and this trend is set to continue. The implementation of streamlining measures in the technical facilities of buildings (hydraulic regulation of heating systems and hot water distribution, insulation of circulation pipes in hot water distribution, installation of thermoregulation valves) also plays a significant part in reducing consumption.

The development of heat consumption in residential buildings was analysed according to the actual annual heat consumption for heating and hot water service from the relevant number of residential buildings (from 6 000 to 12 000 annually) recorded in the energy efficiency monitoring system operated by the Slovak Innovation and Energy Agency. The heat consumption in Slovakia was derived from the specific indicators of heat consumption.

The development of actual heat consumption for heating and hot-water service is shown in the following charts.

Chart 9: Development of the actual heat consumption for heating and hot water in residential buildings with heat supplied from CHS systems (GWh)

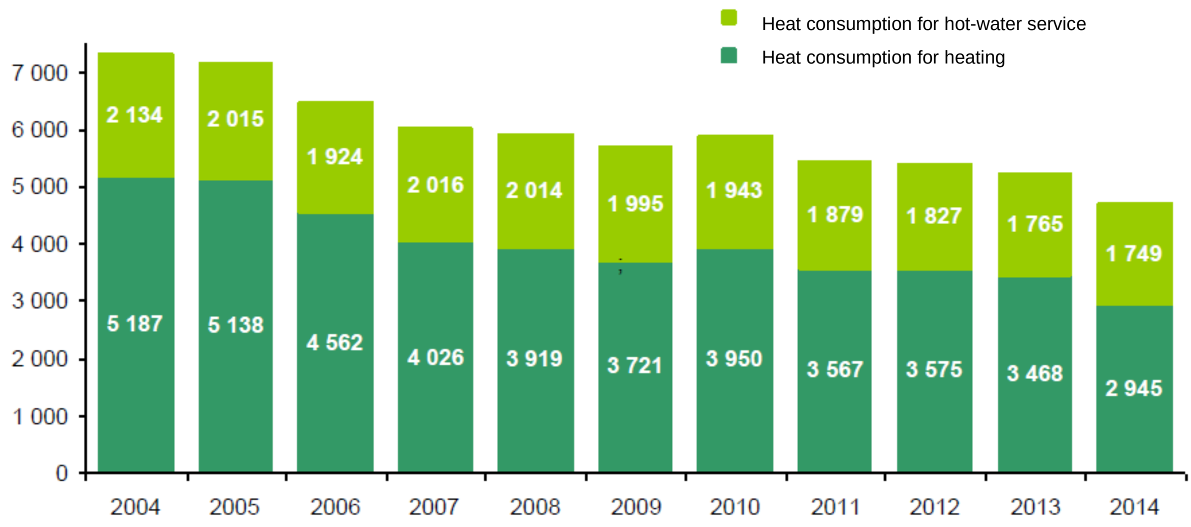
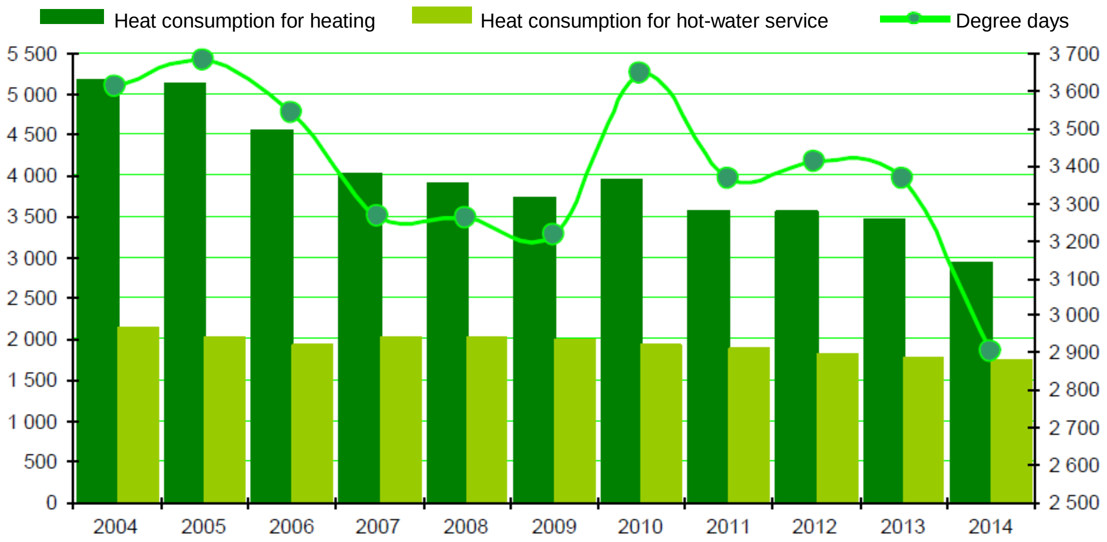


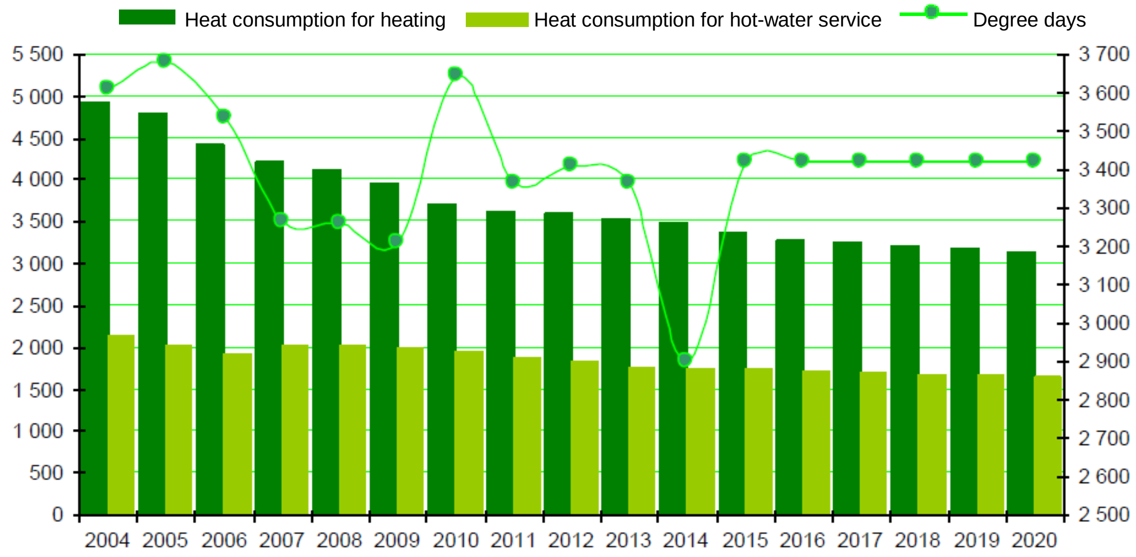
Chart 10: Development of the heat consumption for heating and hot water in residential buildings with heat supplied from CHS systems (GWh) with indication of degree days during the analysed years



The chart above shows that in addition to the reduced heat consumption due to the implemented energy-efficiency measures, the heat consumption for heating also depends on the number of degree days influenced by the climatic conditions during individual years.

To facilitate correct comparison of consumption in the individual years, the following chart shows the actual heat supply for heating converted to average degree days over the last ten years and the anticipated development in heat consumption up to 2020.

Chart 11: Actual and anticipated development of heat consumption (GWh) in residential buildings converted to average degree days



Heat consumption for heating and hot water service in residential properties supplied with heat from CHS systems decreased by 26% between 2004 and 2014, which in absolute numbers means a decrease of 1 800 GWh of heat.

The average specific heat consumption for heating calculated according to the actual heat consumption for heating and converted to the average degree days dropped from 85.8 kWh/m to 61.5 kWh/m. Heat consumption for heating is expected to fall by 8.5% from 2014 to 2020, i.e. by 450 GWh. The above-mentioned reduction in consumption will be achieved mainly by the continued thermal insulation of residential buildings.

Specific indicators of heat consumption in hot water have stabilised over the last few years and no significant reduction in heat consumption in this segment is expected over the next years. The current average consumption of hot water in the SR is 10.5 m/person.year and the specific consumption of heat is approximately 1000 kWh/(person.year).

3.2 Prognosis for the development of heat consumption

The prognosis for the development of heat consumption over the next few years is based on the analysis of the potential energy efficiency of thermal facility systems providing a major part of heat supply in central heat supply systems and the anticipated development in heat consumption for heating mainly residential buildings using heat from these systems. In addition to the decrease in heat consumption in residential buildings, a significant reduction in heat consumption is expected in public buildings using heat from CHS systems. The anticipated heat consumption in developing urban agglomerations (industry, housing construction) has also been considered. The potential increase in heat consumption will be mostly covered by the anticipated decline in heat supply to existing heat consumers. The prognosis does not anticipate any significant increase in heat supply for the production and delivery of cooling. Heat consumption in individual heat supply, mainly in family houses, is expected to fall slightly, partly owing to the implementation of national programmes (financial aid for thermal insulation and application of small appliances using renewable energy sources). Also in this sector, the increase in heat consumption resulting from the construction of new family houses will be mostly compensated by the reduced consumption from the existing family houses.

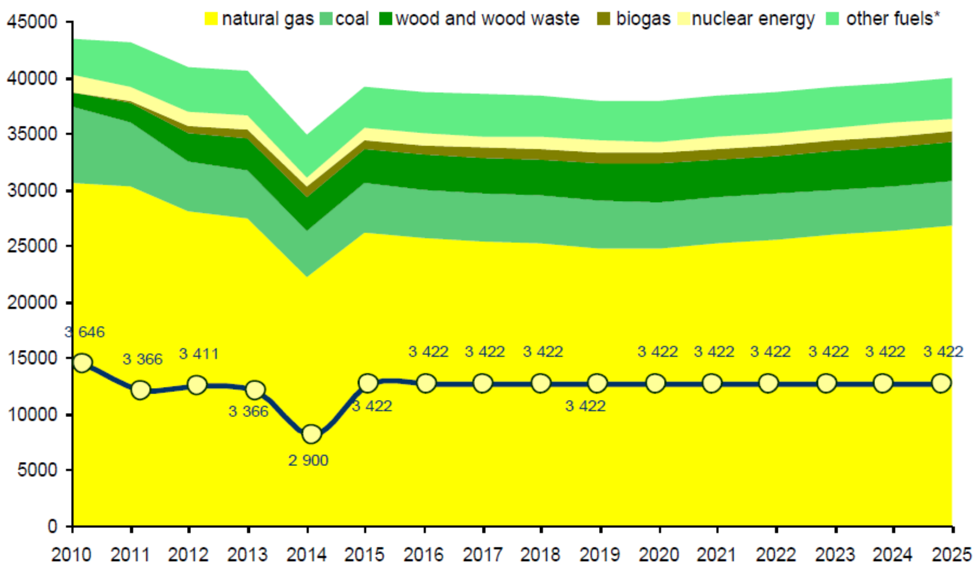
The anticipated heat consumption over the next ten years has been modelled on these assumptions. The actual heat consumption was used as the basis and the last known consumption in 2014 was corrected for the following years (anticipated heat for heating) according to the average degree days.

Table 10: Actual and anticipated heat consumption in Slovakia

		2010	2012	2014	2015	2017	2019	2021	2023	2025
Public and industrial heating plants, boiler plants - centralised heat supply systems	(GWh)	24 002	22 089	19 063	20 864	20 790	20 453	20 669	21 162	21 666
Individual heat supply - local boiler rooms (households, services)	(GWh)	19 370	18 783	15 790	18 279	17 647	17 484	17 617	17 911	18 214
TOTAL	(GWh)	**43 372**	**40 872**	**34 853**	**39 143**	**38 437**	**37 937**	**38 286**	**39 073**	**39 881**

The anticipated heat consumption over the next ten years has been modelled on these assumptions. The actual heat consumption was used as the basis and the last known consumption in 2014 was corrected for the following years (anticipated heat for heating) according to the average degree days.

Chart 12: Actual and anticipated overall development in heat consumption (GWh) in Slovakia and anticipated shares of fuels and energy in heat production



Natural gas is expected to remain as the main fuel in heat production. The increase in the share of biomass in heat production is not expected to be as significant in near future as in the previous five years, due to the availability of this fuel.

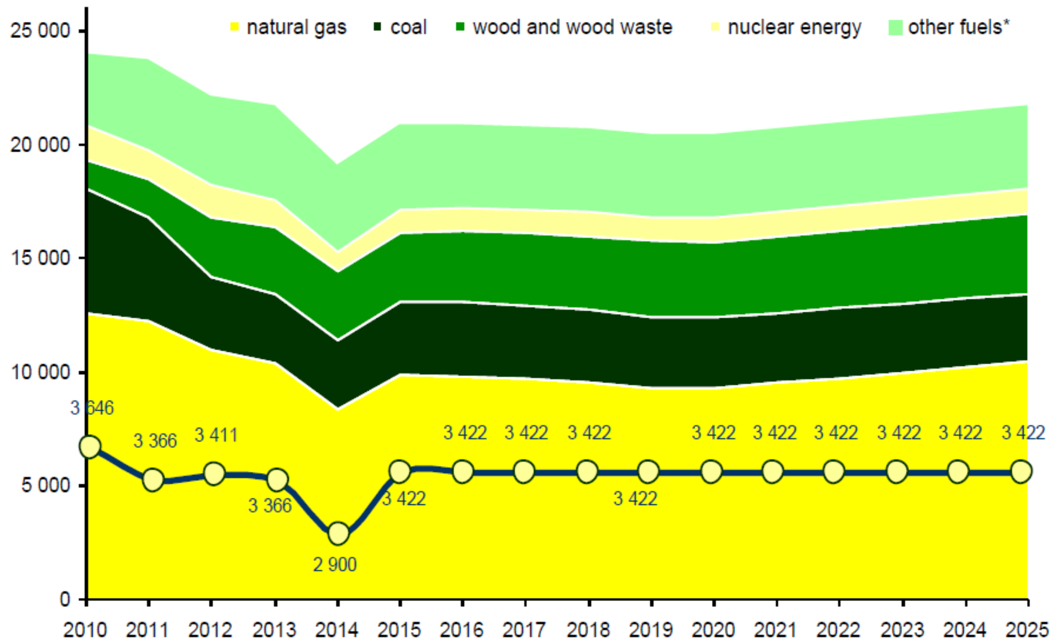
The anticipated development in heat consumption in CHS systems in Slovakia and the shares of fuels and energy used to produce heat are shown in the following table and chart.

Table 11: Actual and anticipated heat consumption in Slovakia in centralised heat supply systems

Primary fuels and energy		2010	2012	2014	2015	2017	2019	2021	2023	2025
natural gas	(GWh)	12 551	11 001	8 361	9 875	9 686	9 285	9 497	9 983	10 479
coal	(GWh)	5 519	3 177	3 015	3 230	3 221	3 157	3 095	3 033	2 973
wood and wood waste	(GWh)	1 293	2 643	3 068	3 059	3 183	3 311	3 378	3 446	3 515
nuclear energy	(GWh)	1 526	1 373	844	996	1 037	1 078	1 089	1 111	1 133
other fuels*	(GWh)	3 112	3 895	3 775	3 704	3 663	3 622	3 611	3 589	3 567
TOTAL	(GWh)	**24 002**	**22 089**	**19 063**	**20 864**	**20 790**	**20 453**	**20 669**	**21 162**	**21 666**

*oil and petroleum products, waste incineration, lyes, metallurgic gases, useful heat from chemical production

Chart 13: Actual and anticipated development of heat consumption (GWh) in centralised heat supply systems converted to average degree days, and anticipated shares of fuels and energy in heat production



4. Assessment of the potential for additional high-efficiency cogeneration over the next ten years

The potential for additional high-efficiency cogeneration needs to be assessed in the context of the current and the anticipated balance or energy production and electricity consumption in the SR. The assumptions of the current energy policy of the SR and the annual ‘Reports on the Outcomes of Monitoring Security of Electricity Supply’, completed by the Ministry of the Economy, suggest that the country’s own electricity production covers the existing electricity consumption almost completely. It is believed that once the commenced construction of new facilities for producing electricity is completed, construction of any additional larger sources will not be necessary to cover the electricity consumption in the SR until 2030.

4.1 The current situation in electricity production in Slovakia

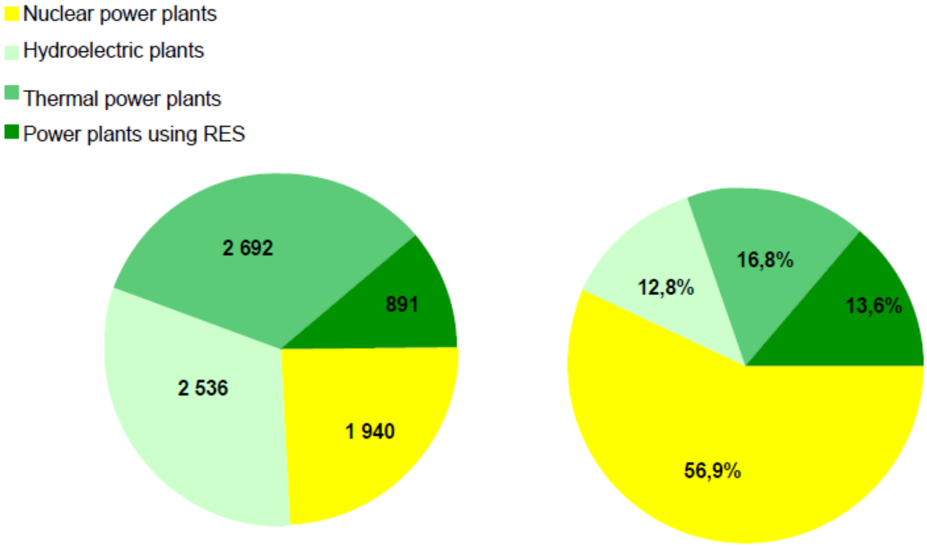
In Slovakia, the country’s own electricity production and consumption has lately been almost balanced and the country is self-sufficient in terms of electricity production. Import in 2013 accounted for as little as 0.3% and in 2014 approximately 4% of the consumption in the SR. The small difference between consumption and production was covered by electricity imports. Although it would have been possible to cover this deficit from domestic sources, importing electricity was economically more efficient than production in the SR.

The shares of individual facilities in electricity production in the SR is shown in Table 12 and Chart 14.

Table 12: Installed output of equipment generating electricity and annual electricity production in 2014

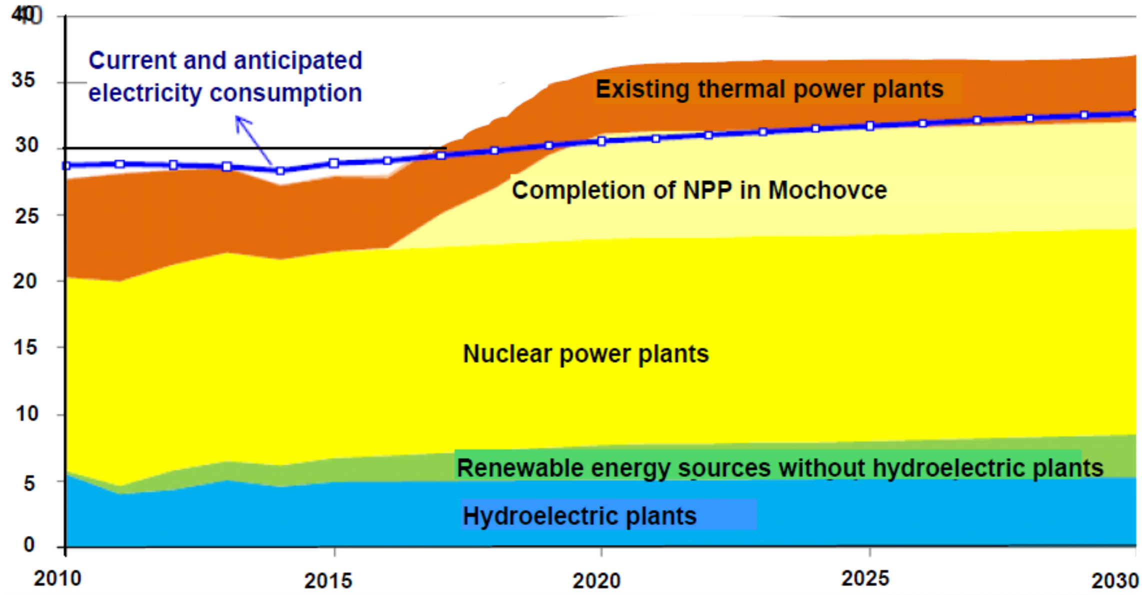
<table>
<tr><th colspan="2">Technology (2014)</th><th>Installed output
(MW)</th><th>Annual electricity production
(GWh/year)</th></tr>
<tr><td colspan="2">Nuclear power plants</td><td>1 940</td><td>15 499</td></tr>
<tr><td rowspan="5">Thermal power plants</td><td>Lignite</td><td>568</td><td rowspan="5">3 479</td></tr>
<tr><td>Hard coal</td><td>440</td></tr>
<tr><td>Natural gas</td><td>1 076</td></tr>
<tr><td>Crude oil</td><td>195</td></tr>
<tr><td>Fuel mixture</td><td>413</td></tr>
<tr><td colspan="2">Hydroelectric plants</td><td>2 536</td><td>4 572</td></tr>
<tr><td rowspan="4">Using RES</td><td>Photovoltaic</td><td>531</td><td>476</td></tr>
<tr><td>Biomass</td><td>254</td><td rowspan="4">3 228</td></tr>
<tr><td>Biogas</td><td>103</td></tr>
<tr><td>Wind energy</td><td>3</td></tr>
<tr><td colspan="2">Other</td><td>17</td></tr>
<tr><td colspan="2">Total</td><td>8 076</td><td>27 254</td></tr>
</table>

Chart 14: Percentages of installed output of power plants within the electricity supply system in the SR (MW) and their shares in electricity production in 2014 (%)



Once blocks 3 and 4 of the nuclear power plant in Mochovce—with an installed output of 471 MW each—are completed, the electricity distribution system in the SR will have a significant surplus or rather pro-export electricity balance.

Chart 15: Prognosis of the development of electricity consumption in TWh and its coverage with the available electricity production up to 2030



Source: ME SR

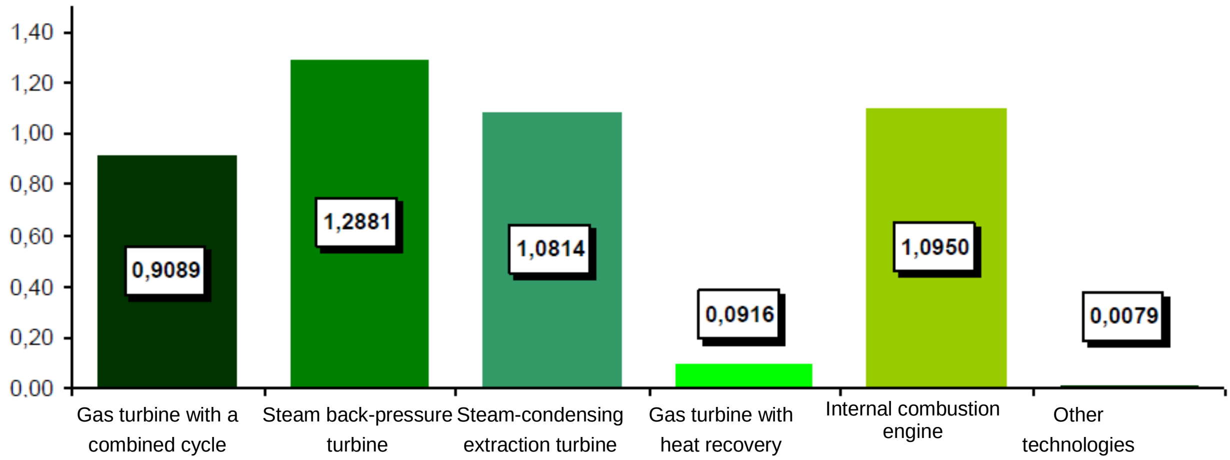
4.2 Current situation in electricity and heat cogeneration

The current (year 2014) basic balance of electricity and heat production by cogeneration according to types of technology is shown in Table 13 and Chart 16.

Table 13: Structure of electricity and heat cogeneration

CHP technology (2014)	Electricity		Heat	
	Installed output (GW)	Produced electricity (TWh)	Installed output (GW)	Produced heat (TWh)
Gas turbine with a combined cycle	0.3949	0.9089	0.3320	0.7732
Steam back-pressure turbine	0.5770	1.2881	1.8182	5.1180
Steam-condensing extraction turbine	1.6311	1.0814	4.9020	4.1182
Gas turbine with heat recovery	0.0254	0.0916	0.0834	0.1766
Internal combustion engine	0.1871	1.0950	0.2069	1.2291
Other technologies	0.0012	0.0079	0.0048	0.0307
Total	**2.8167**	**4.4728**	**7.3473**	**11.4459**

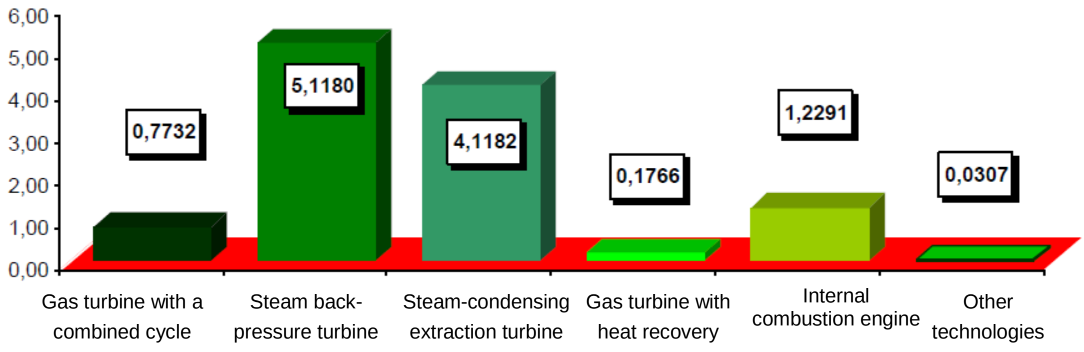
Chart 16: Structure of electricity production by cogeneration (TWh/year)



The overview provided above shows that steam-condensing extraction turbines and back-pressure turbines installed in public and privately owned heating plants and power plants are the dominant cogeneration technologies. Technologies with a gasification cycle and internal-combustion engines are also relatively significant sources in electricity production.

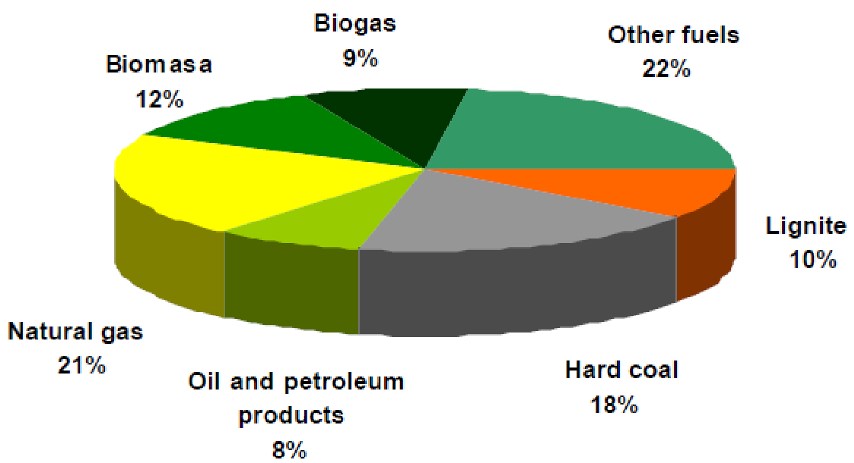
As shown in the following chart, cogeneration technologies with back-pressure gas turbines and condensing extraction turbines contribute the most to heat production.

Chart 17: Structure of heat production through cogeneration (TWh/year)



As regards fuels, fossil fuels have the largest share in cogeneration, in particular, natural gas and coal. The share of biomass and biogas has increased significantly over the last five years. Besides the constructed heating plants which combust biomass, the overall share of biomass combustion is also due to the combined combustion of biomass with fossil fuels in the existing or reconstructed heat sources in public and privately owned heating plants.

Chart 18: Shares of individual fuels in cogeneration facilities in 2014



4.3 Potential for additional high-efficiency cogeneration over the next few years

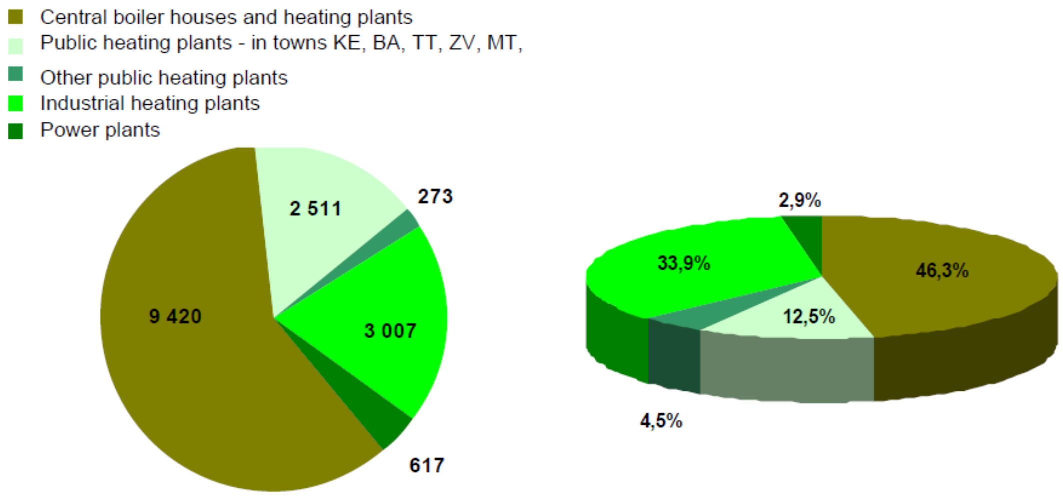
The previous chapter briefly documents the current status in cogeneration of electricity and heat. It is clear that electricity production in steam turbines, whether condensing extraction or back-pressure turbines, is currently the dominant technology. Reconstruction and modernisation of the facilities using this cogeneration technology is more likely in near future than construction of new sources for cogeneration. Most of these facilities are outdated (many being older than 30 years).

Reconstruction of boilers for burning biomass with coal and construction of new boilers for burning biomass have been carried out in these facilities over the last few years and this trend can be expected to continue, although at a much more moderate pace.

Only a moderate increase in the installed output of large sources with steam and gas turbines is anticipated and this increase will be achieved through the necessary reconstruction of the existing cogeneration technologies. In this sector of electricity production through cogeneration and in particular in heating plants with condensing extraction steam turbines, the existing facilities have lately been reconstructed and modernised but sometimes also replaced with gas internal-combustion engines, using natural gas and achieving an electric output of up to 10 MW per engine. This is necessary due to the declining demand for useful heat and the technical and economic conditions for operating these facilities

The greatest potential for additional high-efficiency cogeneration is anticipated in the existing CHP systems used to supply heat to end consumers. The current analysis of heat production and supply from these thermal facility systems has been completed to identify this potential.

Chart 19: Structure of heat sources in centralised heat supply systems according to the installed thermal output in MW used for ensuring heat supply and their share in the overall heat production



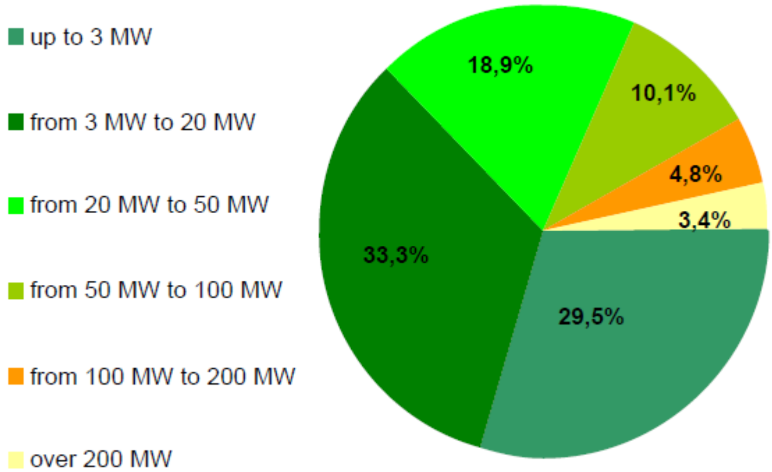
Heat is supplied mainly from public and industrial heating plants with technologies for cogeneration of electricity and heat. Further development of these thermal facility systems is limited by the demand for useful heat within the reach of the existing heat distribution networks. No significant increase in the supply of heat from these facilities is expected in near future. Any potential increase resulting from development of the territories covered will be offset mainly by the anticipated reduction of supply to the existing consumers of heat, due to the measures implemented to achieve energy efficiency.

As shown in Chart 19, the share of installed output of facilities for the separate production of heat in the CHS systems, accounting for more than 46% of the total heat supply, is very significant.

The technical potential for high-efficiency cogeneration of electricity and heat is expected to be used most in the sector of small and medium-sized heat sources (heating plants, central boiler rooms) using natural gas.

The total installed output of these sources amounting to 9 420 MW includes a 29.5% share of heat sources up to 3 MW and a 33.3% share from 3 MW to 20 MW, as shown in Chart 20.

Chart 20: Structure of heat sources in centralised heat supply systems used for ensuring heat supply according to the installed output



The assessment of the potential for additional high-efficiency cogeneration was carried out according to the actual heat supply for heating and hot water service for the residential and non-residential sector for individual sources in districts in the SR. The designed output of cogeneration facilities and volume of the produced electricity and heat was determined by the ratio of the produced electricity and supplied heat, and the annual operating hours.

The potential for additional high-efficiency cogeneration determined in this manner is shown in Table 13. This potential is also economically viable under the current economic conditions (the investment costs of CHP technologies, prices of natural gas, electricity, heat, etc.). The potential would be viable even if the purchase price of electricity from CHP changed dramatically, provided that the electricity is mainly consumed by the electricity producers for their own purposes.

The current and potential infrastructure of centralised heat supply and cogeneration of electricity and heat in Slovakia is illustrated in Figure 1.

The technical potential for the application of cogeneration with low and very low output in the context of the demand for useful heat can be identified in developed industrial zones and parks within the country but with a low level of accuracy in view of the occupancy of these parks by investors. A part of these industrial zones and parks currently receives heat from the existing infrastructure of privately-owned heating plants. The locations of industrial zones and parks in Slovakia are shown in Figure 2.

Table 14: Current heat supply in district towns in the SR and potential for electricity and heat cogeneration with low and very low output, part 1

District	Heat supply			Potential for CHP		
	Heating	Hot water service	Total	Total number (comb. engines)	Total output	
					Thermal	Electric
		(GWh)		(-)	(kW)	(kW)
Banská Bystrica	184.95	79.94	264.89	27	7 617	6 591
Banská Štiavnica	9.82	5.21	15.03	6	560	447
Brezno	15.99	6.58	22.57	9	702	561
Detva	31.90	14.09	45.99	2	1 537	1 331
Krupina	12.61	6.32	18.93	2	677	541
Lučenec	45.10	18.08	63.18	14	1 829	1 463
Poltár	6.38	2.74	9.13	1	234	187
Revúca	35.75	11.90	47.64	7	907	725
Rimavská Sobota	47.95	16.32	64.27	4	452	361
Veľký Krtíš	36.24	13.36	49.61	3	524	420
Zvolen	104.20	52.66	156.86	10	795	636
Žarnovica	11.60	6.76	18.36	4	621	497
Žiar nad Hronom	88.02	40.31	128.33	1	80	64
Bratislava I.	175.56	32.07	207.63	24	2 717	2 173
Bratislava II.	449.70	143.21	592.92	14	1 392	1 113
Bratislava III.	869.88	77.11	946.99	17	2 119	1 695
Bratislava IV.	492.74	101.97	594.71	12	2 089	1 672
Bratislava V.	652.96	120.22	773.19	22	13 982	11 335
Malacky	72.13	17.46	89.59	9	1 943	1 555
Pezinok	17.08	1.01	18.09	4	675	540
Senec	18.63	0.01	18.64	3	712	570
Gelnica	9.70	4.00	13.70	3	448	359
Košice-outskirts	16.58	6.58	23.16	3	185	148
Košice I.	168.52	66.52	235.04	4	208	167
Košice II.	148.84	74.17	223.01	1	0	0
Košice III.	44.57	28.24	72.81	0	0	0
Košice IV.	78.17	31.75	109.92	1	16	13
Michalovce	60.69	30.75	91.44	19	3 659	2 929
Rožňava	52.23	18.66	70.88	17	1 231	986
Sobrance	2.97	2.13	5.10	3	239	192
Spišská Nová Ves	79.84	31.85	111.69	27	3 592	2 874
Trebišov	42.69	18.55	61.24	13	1 932	1 547
Komárno	72.61	32.86	105.47	16	765	612
Levice	91.57	40.47	132.05	20	2 414	1 932
Nitra	195.16	54.34	249.50	27	4 735	3 792
Nové Zámky	166.99	45.03	212.02	7	1 886	1 509
Šaľa	45.66	0.02	45.68	4	1 365	1 091
Topoľčany	106.93	18.06	124.99	1	1 949	1 754
Zlaté Moravce	32.30	5.55	37.84	3	766	613
Bardejov	55.68	20.84	76.53	11	2 233	1 787
Humenné	109.20	47.67	156.87	0	0	0
Kežmarok	20.49	11.33	31.82	10	1 279	1 022
Levoča	14.41	6.05	20.46	6	400	320
Medzilaborce	10.10	4.82	14.92	2	489	391
Poprad	104.01	49.72	153.73	35	4 649	3 720
Prešov	139.13	52.30	191.42	32	7 902	6 840
Sabinov	14.48	7.24	21.72	6	827	662
Snina	31.19	13.43	44.62	1	185	148

Table 15: Current heat supply in district towns in the SR and potential for electricity and heat cogeneration with low and very low output, part 2

District	Heat supply			Potential for CHP		
	Heating	Hot water service	Total	Total number (comb. engines)	Total output Thermal	Electric
		(GWh)		(kW)	(kW)	(kW)
Stará Ľubovňa	14.88	7.00	21.88	6	820	655
Stropkov	9.46	3.25	12.71	3	371	297
Svidník	24.09	8.55	32.64	7	1 019	815
Vranov nad Topľou	28.40	12.99	41.39	16	1 250	999
Bánovce nad Bebravou	38.40	6.67	45.07	6	1 195	956
Ilava	109.40	32.38	141.77	9	2 181	1 744
Myjava	57.24	10.92	68.16	7	1 274	1 019
Nové Mesto nad Váhom	75.37	16.24	91.62	16	2 464	1 970
Partizánske	68.33	13.41	81.75	10	1 994	1 595
Považská Bystrica	154.45	36.35	190.80	5	331	265
Prievidza	267.85	60.90	328.75	18	2 491	1 993
Púchov	41.22	14.49	55.71	8	336	269
Trenčín	138.86	35.39	174.26	31	4 902	4 024
Dunajská Streda	114.41	29.31	143.72	10	2 212	1 770
Galanta	21.54	9.59	31.13	7	973	779
Hlohovec	80.55	11.17	91.71	2	6 870	6 181
Piešťany	62.95	17.52	80.47	21	2 301	1 840
Senica	81.81	23.88	105.69	6	1 779	1 536
Skalica	85.06	15.70	100.75	9	1 459	1 169
Trnava	123.57	47.00	170.57	1	258	206
Bytča	18.37	7.20	25.57	3	491	393
Čadca	46.94	17.48	64.42	10	1 046	837
Dolný Kubín	49.45	18.35	67.80	8	2 157	1 724
Kysucké Nové Mesto	23.86	10.63	34.49	2	1 622	1 454
Liptovský Mikuláš	93.62	36.52	130.14	32	3 607	2 885
Martin	168.84	69.79	238.63	1	0	0
Námestovo	17.55	7.56	25.11	2	569	455
Ružomberok	75.91	25.38	101.29	1	31	25
Turčianske Teplice	5.96	2.61	8.57	2	253	203
Tvrdošín	13.24	7.00	20.24	3	334	268
Žilina	279.84	117.59	397.44	6	927	741
Total	7 685.32	2 223.08	9 908.41	735.00	133 035.00	108 952.00

The anticipated economic potential for cogeneration of electricity during the period ending in 2025 using cogeneration technologies was determined based on the assumptions mentioned above and the analysis of the confirmation of the ME SR of the consistency between investment plans and the long-term concept of the power engineering policy of the SR with regard to construction and reconstruction of cogeneration facilities. This potential is shown in Table 16 and heat supply in Table 17.

Table 16: Anticipated economic potential for producing electricity by cogeneration

Year	Actual				Assumption			
	2011		2014		2020		2025	
CHP technology	Installed output	Produced electricity	Installed output	Produced electricity	Installed output	Produced electricity	Installed output	Produced electricity
	(MWe)	(GWh)	(MWe)	(GWh)	(MWe)	(GWh)	(MWe)	(GWh)
Gas turbine with a combined cycle	394.9	874.0	394.9	908.9	394.9	947.8	394.9	967.6
Steam back-pressure turbine	583.0	1370.6	577.0	1 288.1	582.8	1340.4	594.4	1 367.2
Steam-condensing extraction turbine	1622.9	1299.9	1631.1	1 081.4	1647.4	1153.2	1663.9	1 164.7
Gas turbine with heat recovery	25.4	124.8	25.4	91.6	30.5	115.8	36.6	139.0
Internal combustion engine	47.1	231.5	187.1	1 095.0	261.9	1571.3	340.4	2 042.7
Other technologies	0.0	0.0	1.2	7.9	5.9	38.7	8.8	58.1
Total	**2 673.3**	**3 900.8**	**2 816.7**	**4 472.8**	**2 923.3**	**5 167.2**	**3 039.1**	**5 739.2**

Table 17: Anticipated economic potential for producing heat by cogeneration

Year	Actual				Assumption			
	2011		2014		2020		2025	
CHP technology	Installed output	Supplied heat	Installed output	Supplied heat	Installed output	Supplied heat	Installed output	Supplied heat
	(MW)	(GWh)	(MW)	(GWh)	(MW)	(GWh)	(MW)	(GWh)
Gas turbine with a combined cycle	332.0	748.2	332.0	773.2	346.2	806.4	353.4	823.2
Steam back-pressure turbine	1854.0	5359.2	1818.2	5118.0	1891.9	5325.8	1929.8	5 432.3
Steam-condensing extraction turbine	4873.0	4760.1	4902.0	4118.2	5227.6	4391.8	5279.8	4 435.7
Gas turbine with heat recovery	83.4	262.9	83.4	176.6	105.4	223.2	126.5	267.9
Internal combustion engine	52.9	264.2	206.9	1229.1	296.9	1763.8	386.0	2 292.9
Other technologies	0.0	0.0	4.8	30.7	23.7	151.3	35.5	227.0
Total	**7 195.3**	**11 394.6**	**7 347.3**	**11 445.9**	**7 891.7**	**12 662.2**	**8 111.1**	**13 478.9**

The current figures and the figures anticipated until 2025 for the electric and thermal output of cogeneration facilities, electricity production and heat supply according to types of cogeneration technology are illustrated in the following charts.

Chart 21: Existing electric output of facilities for cogeneration of electricity and heat and electric output of these facilities anticipated by 2025 (MW)

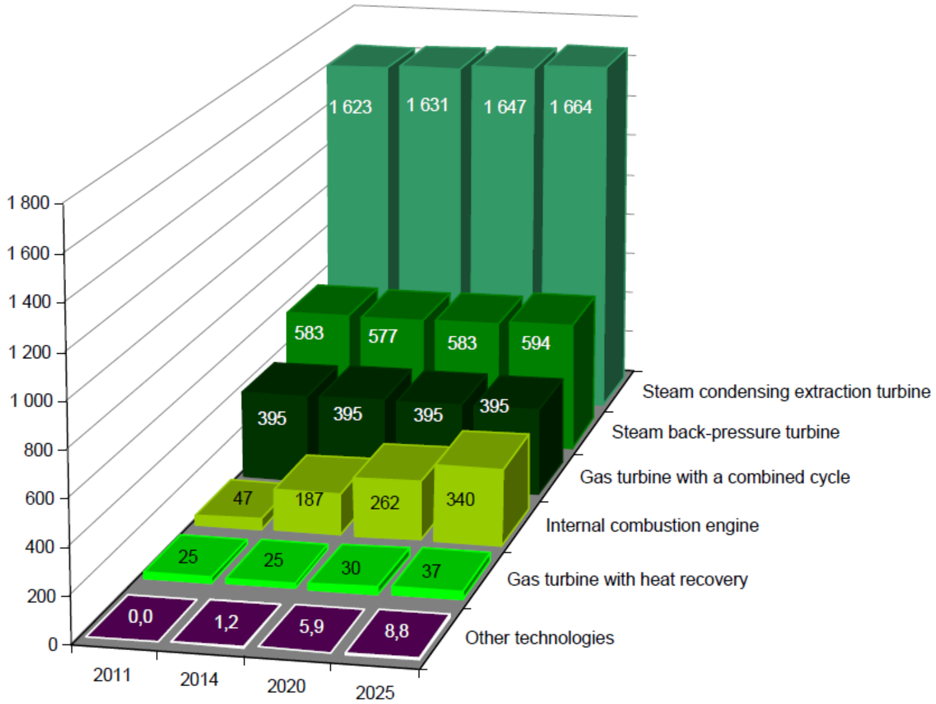


Chart 22: Existing and anticipated electricity production in the cogeneration process (GWh)

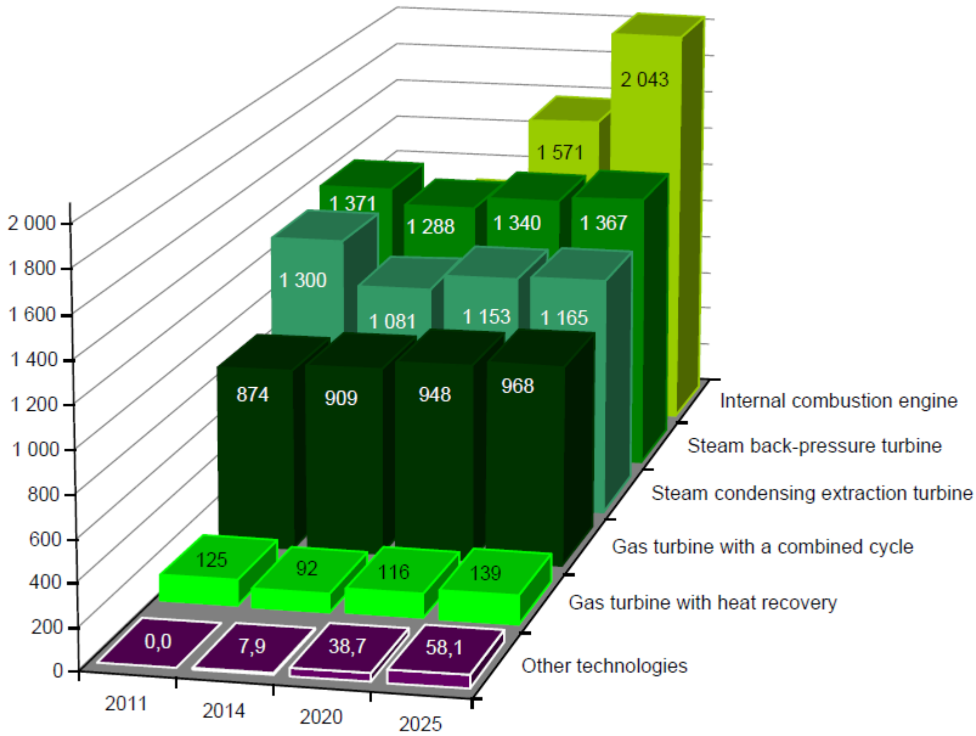


Chart 23: Existing thermal output of CHP facilities and thermal output of these facilities anticipated by 2025 (MW)

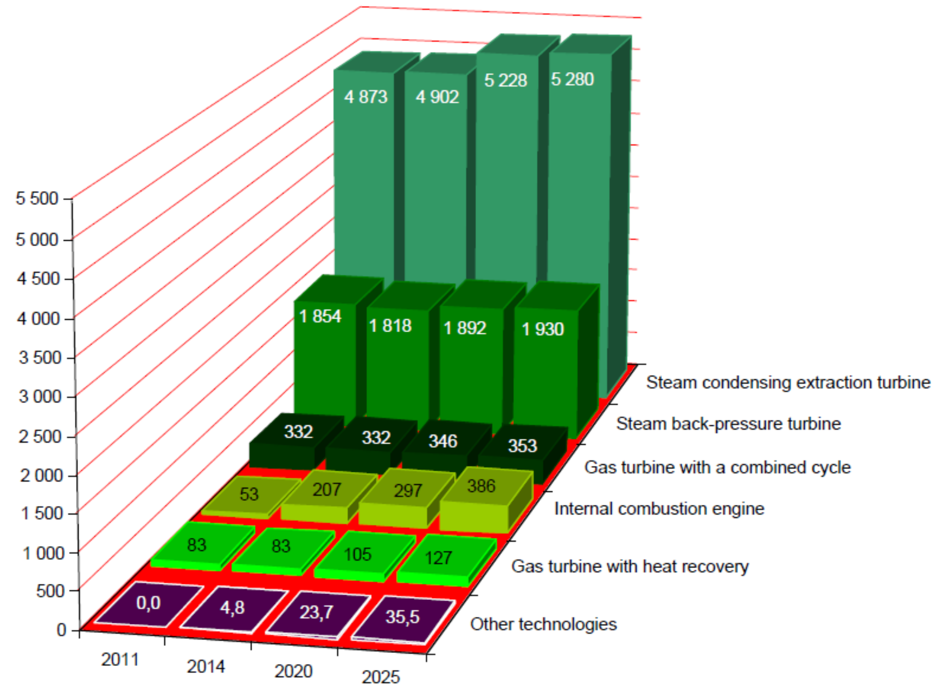


Chart 24: Existing and anticipated heat supply from facilities for cogeneration of electricity and heat (GWh)

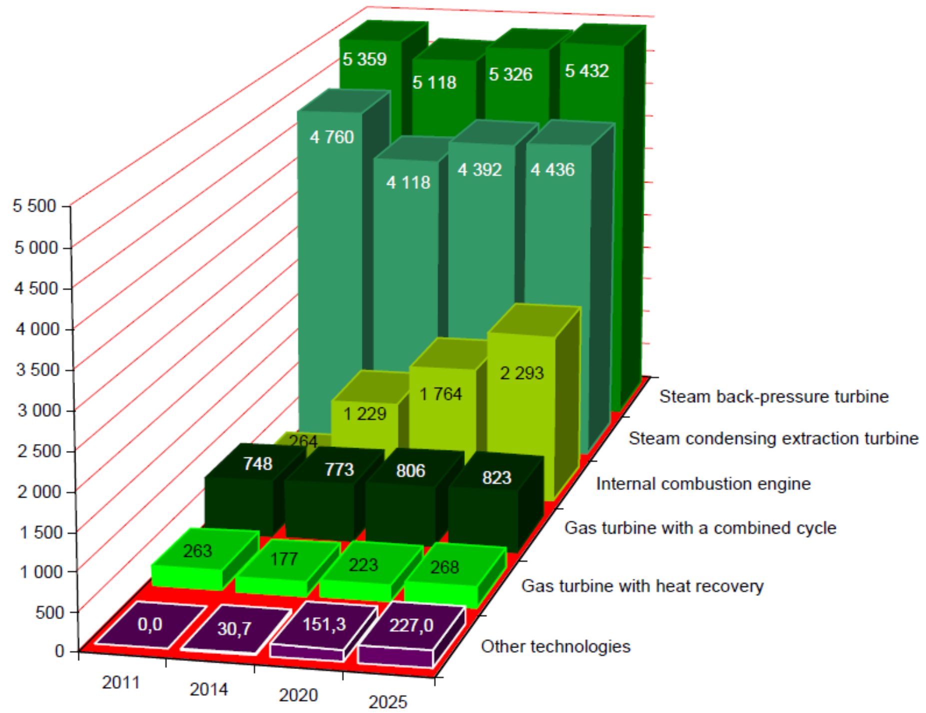


Figure 1: Current and potential infrastructure of centralised heat supply and cogeneration of electricity and heat in Slovakia

CURRENT AND POTENTIAL INFRASTRUCTURE OF CHS AND COGENERATION OF ELECTRICITY AND HEAT

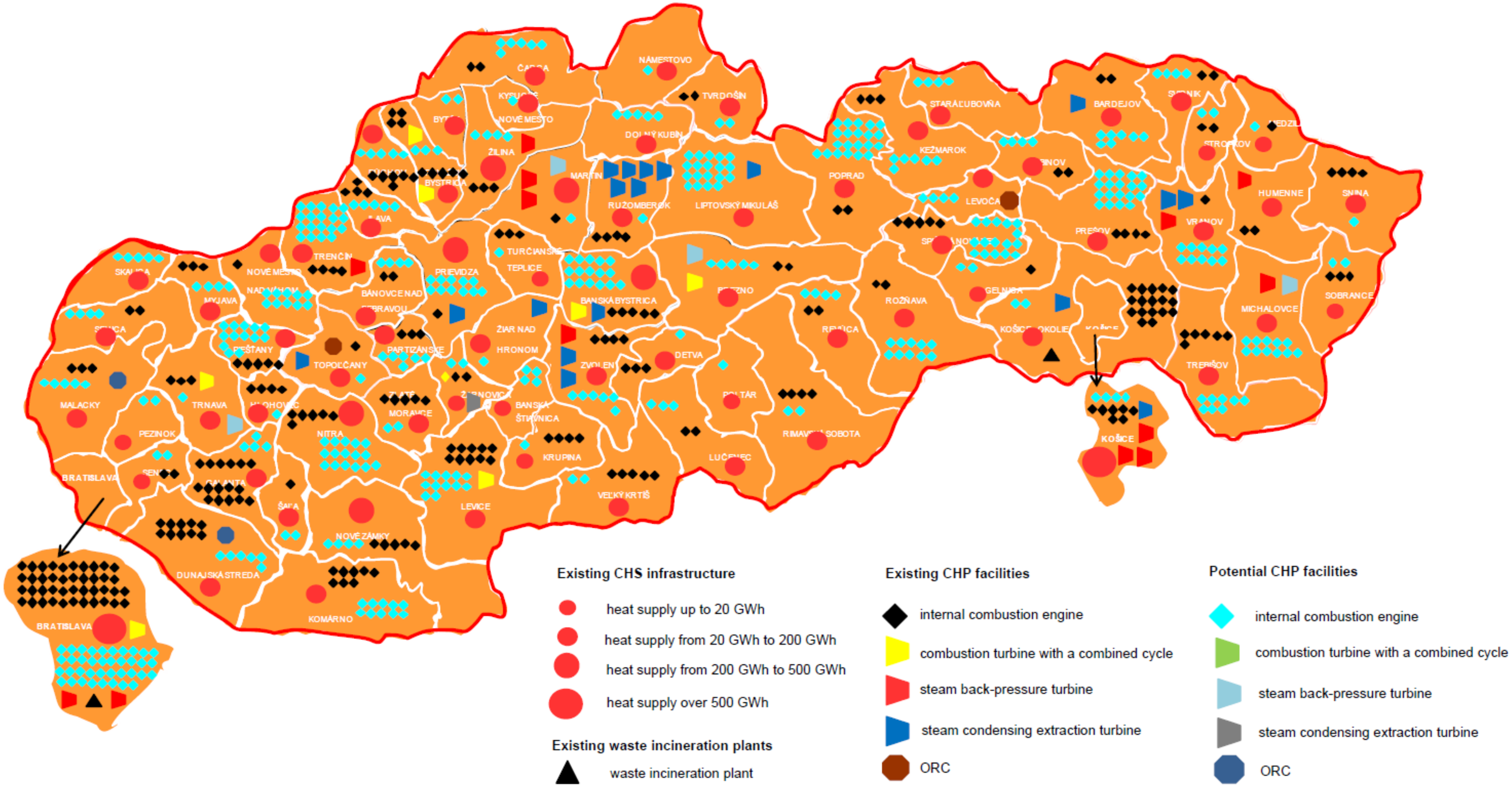


Figure 2: Industrial zones and industrial parks in Slovakia

Industrial zones and industrial parks in Slovakia

5. Proposal for a solution to increase the share of high-efficiency cogeneration on the energy market over the next ten years.

Effective operation of CHS systems, be they small or extensive systems for heat supply, is the key prerequisite for effective utilisation of high-efficiency CHP. The updated concept for municipal development in thermal engineering must be compiled for these purposes by 2019. Pursuant to Section 31 of Act No 657/2004 on thermal engineering, as amended, this obligation applies to all municipalities with more than 2 500 inhabitants if suppliers or consumers who divide the volume of supplied heat to the end consumer operate within their territories. The municipal development concept may be included in local and regional low-carbon strategies, which can be supported from the Quality of Environment Operational Programme, priority axis 4 'Energy-efficient low-carbon economy in all sectors' during the 2014-2020 programme period of the European Structural and Investment Funds (ESIF).

The approval of and compliance with the concept for municipal development in thermal engineering will allow for the planning and long-term operation of CHP sources in locations with demand for useful heat. The prerequisites for mobilising investment into the construction of new and the modernisation of existing CHS systems, therefore, must be provided to create 'efficient CHS systems' with a high share of heat supplied from CHP facilities.

Suitable measures for supporting efficient CHS systems with CHP facilities include:

- giving preference to efficient CHS systems over heat production systems that currently do not meet the conditions applicable to efficient CHS systems and are not expected to fulfil these conditions before 2025;
- allowing interconnection of existing CHS systems in order to fulfil the conditions applicable to efficient CHS systems;
- applying all potential bonuses permitted by the rules governing State aid when providing State aid from national or EU resources to CHP facilities supplying heat to efficient CHS systems;
- when calculating the primary energy factor for the assessment of the energy efficiency of buildings, assessing CHP facilities in a manner which ensures that the primary energy savings achieved through cogeneration of electricity and heat is taken into account in the context of heat supply;
- simplifying the mechanism for connecting CHP facilities with low output to the electricity distribution network and stipulating a clear procedure showing when facilities for producing electricity from RES can be connected and when CHP facilities can be connected in a specific location;
- reviewing the regulation of heat price for heat produced through high-efficiency CHP in order to assess removal of regulation of this heat price;
- supporting the production and supply of biome thane to gas distribution networks with the aim of using this fuel in CHP facilities, while meeting the conditions applicable to efficient CHS systems.

Since reference values for CHP facilities from nuclear installations have been stipulated since 2016 and the SR plans to further develop nuclear energy, it is appropriate to assess the options for expanding the application of high-efficiency CHP from these installations by supplying heat to more remote urban conurbations in greater detail by completing a viability study. This would facilitate the elimination of fuel combustion in these municipalities, and consequently reduce the emission of pollutants into the air and increase the security of heat supply due to the reduced need to import natural gas from abroad.

The provision of information especially for designers, energy auditors and providers of energy services needs to be intensified in advisory services for the entrepreneurial sector to disseminate the latest information on the effective use of high-efficiency CHP.

6. Progress report on achieving the share of high-efficiency cogeneration, using high-efficiency cogeneration and utilising the potential for high-efficiency cogeneration

This report, drafted based on the data of the Statistical Office of the Slovak Republic on engineering for the period from 2011 to 2014, the data provided by the Energy Efficiency Monitoring System operated by the Slovak Innovation and Energy Agency under authorisation of the ME SR, and individual consultations with representatives of the parties concerned, is provided in accordance with the tables predefined by the European Commission in Annex 1, Table 22.

The following chapters analyse:

- electricity and heat production using high-efficiency cogeneration;
- shares of fuels in electricity and heat production using high-efficiency cogeneration;
- extent of primary energy savings;
- extent of CO_2 emission savings.

6.1 Electricity and heat production using high-efficiency cogeneration

Table 18 below shows details of installed output, production of electricity and heat by high-efficiency cogeneration, and volumes of consumed fuel.

Table 18: Electricity and heat production using high-efficiency cogeneration

High-efficiency cogeneration of electricity and heat	Year	2011	2012	2013	2014
Installed electric output	(GW)	2.673	2.733	2.809	2.817
Electricity production	(TWh)	3.901	4.285	4.721	4.075
Installed thermal output	(GW)	7.195	7.281	7.368	7.347
Production of useful heat	(TWh)	11.395	11.870	12.298	11.027
Fuel consumption	(PJ)	79.583	72.044	75.723	67.107

35 new sources with CHP technology were installed in 2012 - internal-combustion engines and one CHP facility with steam-condensing extraction-turbine technology. The total installed electric output of the facilities installed in 2012 is 59.6 MW.

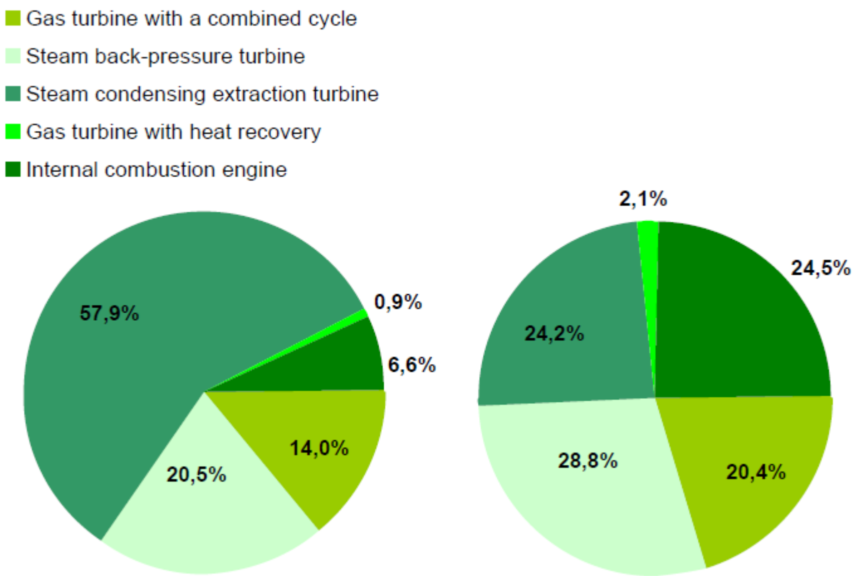
81 new sources with CHP technology were installed in 2013 - 79 sources with internal-combustion engines and 2 ORC cycles with a total installed electric output of 87.1 MW.

13 new sources with CHP technology were installed in 2014 - internal-combustion engines with a total installed electric output of 14.9 MW.

The increase in the installed output of new sources with CHP technology during the period from 2012 to 2014 was also reflected in an increase in the overall electricity production through high-efficiency cogeneration and in the production of useful heat. Despite this positive trend of increasing installed output, the production of electricity by high-efficiency cogeneration and the production of useful heat from the original CHP sources demonstrates a downward trend.

Individual applied cogeneration technologies according to the size of installed electrical output and their shares in electricity and heat production using high-efficiency production during the last assessed year 2014 are shown in the following Chart 25.

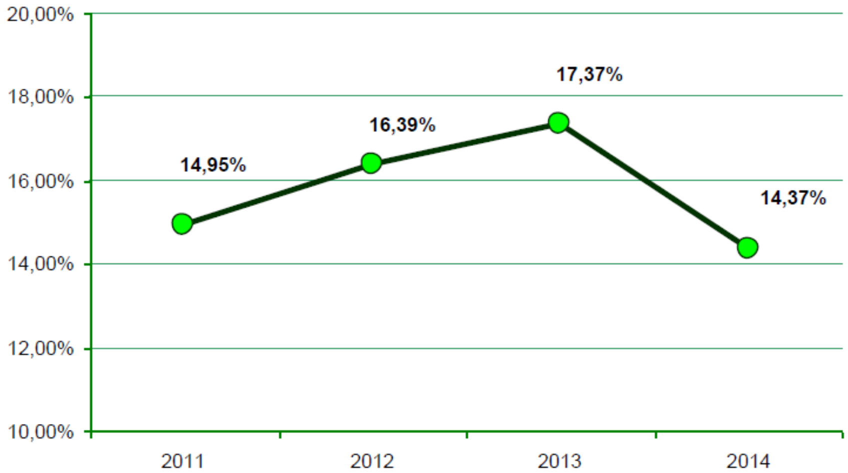
Chart 25: The structure of cogeneration technologies according to the size of installed electrical output in 2014 and their share in electricity and heat production using high-efficiency cogeneration



The highest output of individual electricity and heat cogeneration technologies is installed in public and industrial heating plants and power plants. Although the installed output of the cogeneration technology with an internal combustion engine only accounts for 6.6% of the total installed output, its share of the total electricity and heat production by high-efficiency cogeneration is almost one quarter. Cogeneration technologies with an internal combustion engine have been mainly put into operation during the last period. The share of biogas has increased in addition to combusting natural gas.

The development of the share of electricity production using high-efficiency cogeneration in the overall electricity production in Slovakia is shown in the following chart.

Chart 26: Development of the share of electricity production using high-efficiency cogeneration in the overall electricity production in Slovakia



The climatic conditions and termination of delivery of useful heat for Bratislava's central heat supply system from the gasification cycle of PPC Power, a.s., Bratislava were among the causes of the significant decline in 2014 compared to 2013.

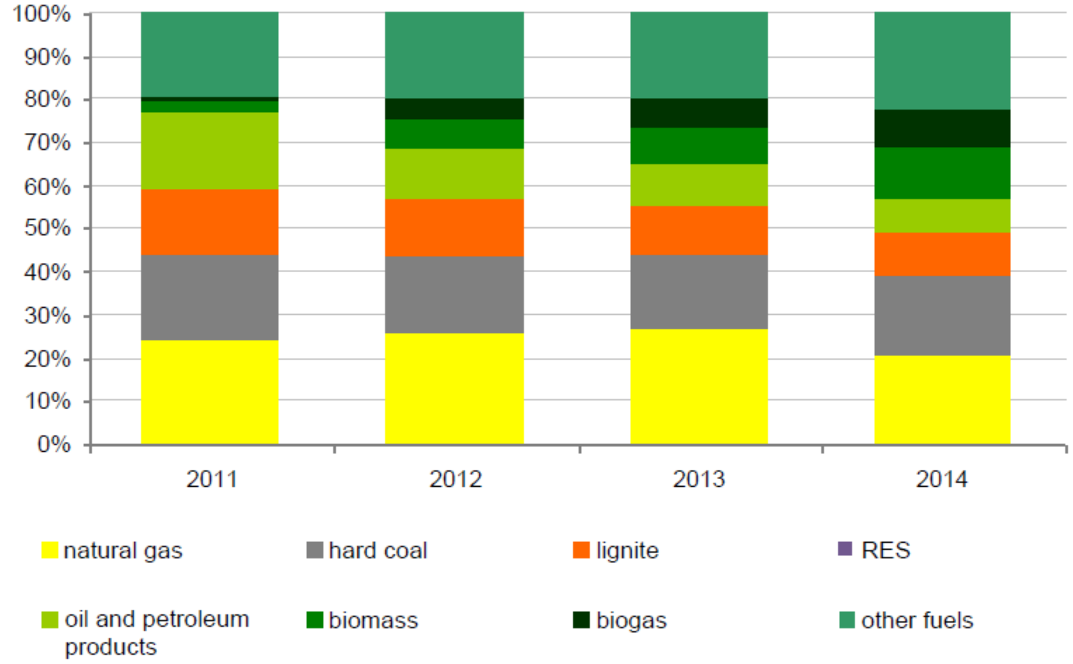
6.2 Share of fuels in electricity and heat production using high-efficiency cogeneration

The increase in the installed electric output of sources with cogeneration technology using internal-combustion engines during the period from 2011 to 2013 resulted in a slight increase in the share of natural gas and particularly biogas, which increased from 0.35% in 2011 to 7.1% in 2014. Furthermore, the share of biomass has gradually increased since 2011 from 2.5% in 2011 to 12.9% in 2014.

This increase is due to the environmental policy focusing on reducing emissions of sulphur oxides and especially due to the application of the current support mechanism for electricity production from renewable energy sources.

Chart 25 below shows the share of fuels in electricity and heat production using high-efficiency cogeneration for the period from 2011 to 2014.

Chart 27: Development of the shares of fuels in electricity and heat production using high-efficiency cogeneration

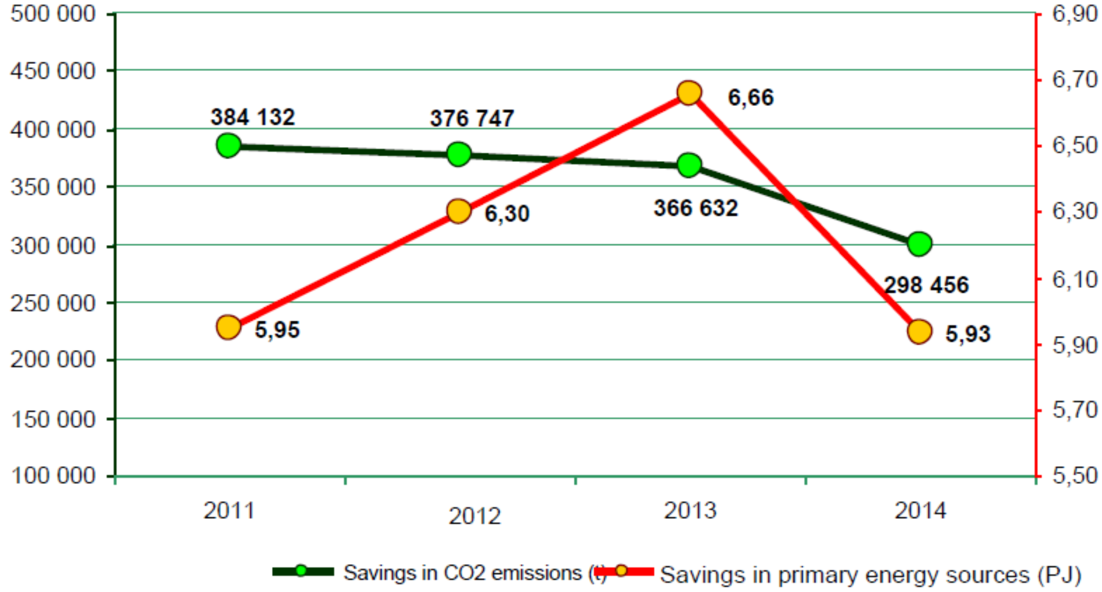


The year-on-year share of the consumption of natural gas in 2014 compared to 2013 relates to the limited operation of the gasification cycle of PPC Power, a.s., Bratislava.

6.3 Extent of primary energy savings and savings in CO_2 emissions

The extent of primary energy savings and savings in CO_2 emissions for the period from 2011 to 2014 achieved through high-efficiency cogeneration of electricity and heat is shown in Chart 28 below.

Chart 28: Extent of primary energy savings and savings in CO2 emissions



The decreasing trend in the emissions of carbon dioxide does not run parallel to the curve of savings in primary energy sources, as this trend is influenced especially by the share of gas, nuclear fuel, biomass and biogas in the total savings in primary energy sources.

7. Consideration of the economic and technical evaluation of the application of high-efficiency cogeneration in the Slovak Republic

In view of the developed central heat supply system in Slovakia with a large number of small and medium-sized heat sources (heating plants, central boiler houses) combusting natural gas, the most extensive utilisation of the technical potential for high-efficiency electricity and heat cogeneration over the next few years is expected in cogeneration technology with low-output internal-combustion engines. The economic and technical evaluation focused mainly on this technology.

7.1 Chosen method of economic and technical evaluation of the application of high-efficiency cogeneration

The economic evaluation is specific as it needs to consider not only the standard economic criteria influencing the assessment of construction of electricity and heat cogeneration facilities, but also the conditions in the currently applied and anticipated system for regulating eligible costs in the price of heat and electricity through the regulatory authority.

The price of heat produced through cogeneration is currently determined as the maximum price taking into account the eligible costs and adequate profit.

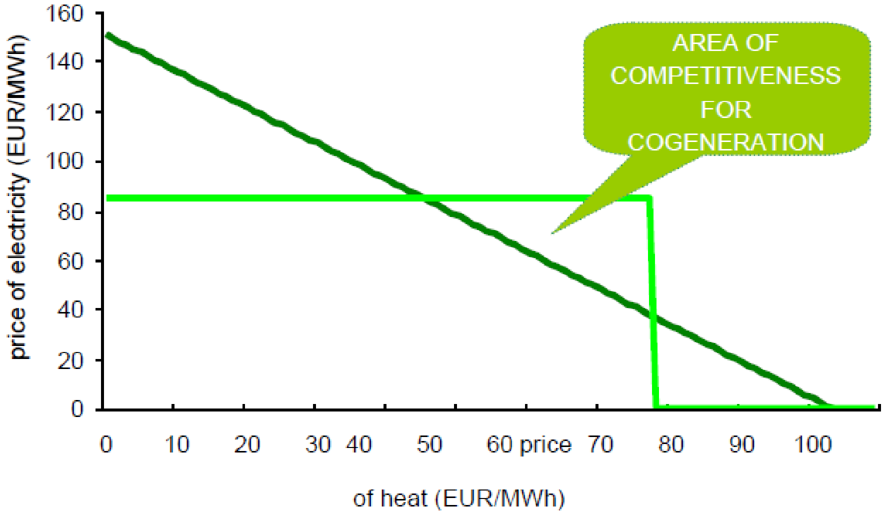
The electricity price for which distribution companies purchase electricity is determined as a fixed price (the support system is described in detail in Chapter 1.2). The price of heat and electricity is regulated annually by the regulatory authority.

The system for regulating economically eligible costs specifies the calculation and division of these costs - the so-called energy method used to allocate the share of the jointly expended eligible costs of cogeneration to electricity and heat.

The economic evaluation of the potential for the application of high-efficiency cogeneration using technology with an internal combustion engine and natural gas as a fuel involved economic evaluation with division of joint costs of the construction and operation of the cogeneration facility between electricity and heat, according to the so-called trade-value (economic) method. This method is the most suitable and the only possible in a liberalised economic environment. According to this method, the cost equivalent of the receipts from electricity (sold at market conditions) is deducted from the total costs of the entity producing electricity by cogeneration and the difference of the remaining costs is allocated to heat. If the price determined in this manner is competitive on the market, the construction of the relevant cogeneration facility is profitable. Otherwise, CHP may be implemented for the producer’s own electricity consumption or the existing supporting mechanisms may be used in the construction (to reduce the fixed costs).

The principle of the trade (or economic) method is illustrated in the following Figure.

Figure 3: Investment opportunities in the allocation of electricity and heat costs using the trade method of electricity and heat cogeneration.



The chart shows the so-called efficiency line, defined as a set of intersection points of the purchase (market) prices of electricity and heat from cogeneration that guarantee return on investment in the cogeneration facility. The end points of this line are determined by allocating all joint costs to the price of electricity (the intersection point with y axis) or to the price of heat (the intersection point with x axis). The chart also indicates the limit sales prices defining the rectangle of competitiveness. If the efficiency line crosses the rectangle of competitiveness, an area of competitive prices of heat and electricity from cogeneration is created. The intersection of the rectangle and the efficiency line creates a triangle with a size indicating the resulting saving in the cost of cogeneration of heat and electricity compared to the cost of separate electricity production and separate heat production. If the rectangle of competitiveness does not intersect with the efficiency line, the receipts from electricity and heat would be insufficient to cover the costs and the construction of the cogeneration facility would not be economically viable under these conditions.

In particular, the following current economic factors were applied when modelling the viability of the application of cogeneration using technology with internal combustion engine with natural gas as a fuel:

- the price of heat on the market in heat;
- the price of natural gas;
- the purchase price of electricity;
- investment costs of the cogeneration facility, method of funding the investment;
- operating parameters, in particular the operating efficiency of the facility;
- the annual utilisation of the installed output;
- specific operating costs.

7.2 Heat prices

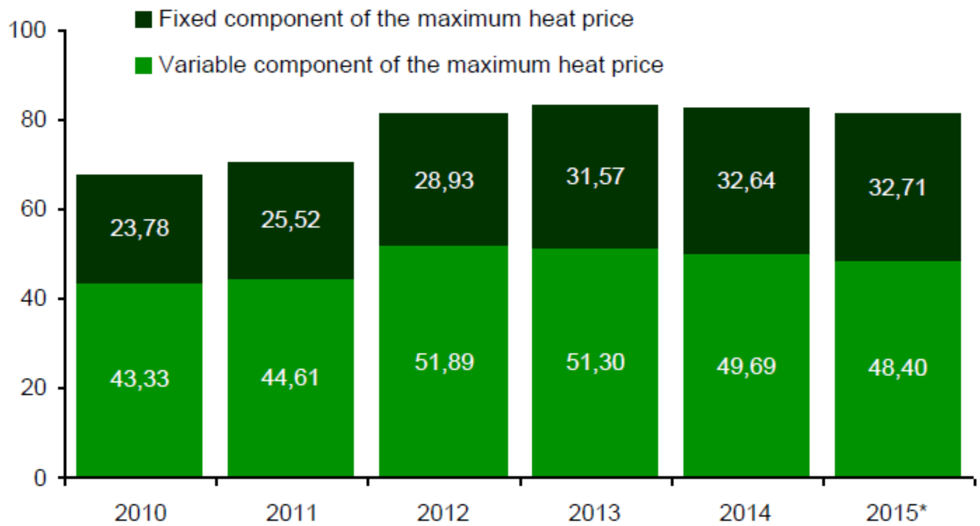
For the useful heat from cogeneration of electricity and heat to be sold on the market, its price must be competitive at least against the heat price currently applied on the market in heat. The actual average heat prices of regulated suppliers in Slovakia calculated by the weighted average are shown in Table 19 and in Chart 29.

Table 19: Development of heat prices[3] in Slovaki

Year	(EUR/MWh)	2010	2011	2012	2013	2014	2015**
Variable component		43.3	44.6	51.9	51.3	49.7	48.4
Fixed component	(EUR/kW)	126.05	135.26	153.33	167.31	172.99	173.38
	(EUR/MWh)	23.78	25.52	28.93	31.57	32.64	32.71
Resulting heat price*	(EUR/MWh)	67.11	70.13	80.83	82.87	82.34	81.11

*The heat price comprising two components converted to a single-component price **Anticipated heat price according to the pricing decisions of ORNI

Chart 29: Development of the average heat price in Slovakia (EUR/MWh)



7.3 Natural gas prices

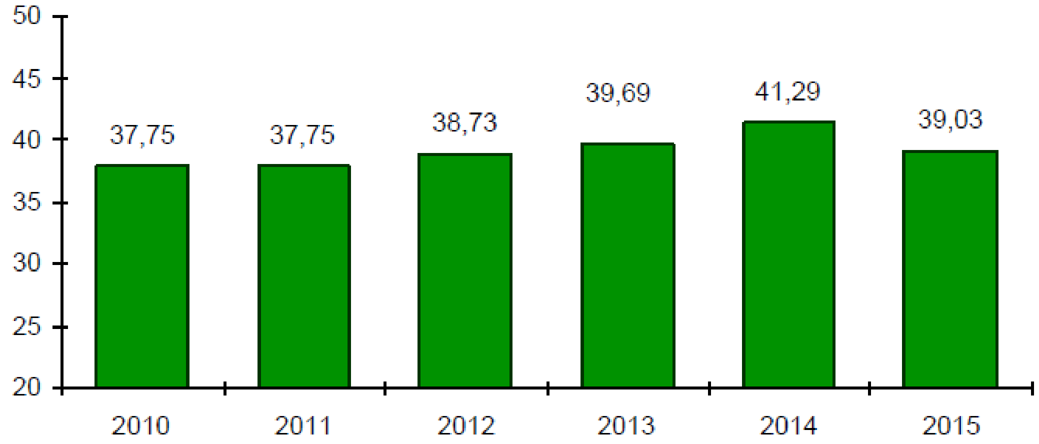
The price of natural gas applicable to the category of consumers with annual gas consumption higher than 100 MWh is not regulated and its level is determined by the development of the market price depending on the development of the price of oil and the EUR/USD exchange rate. Wholesale

[3] The prices are quoted exclusive of VAT.

consumers negotiate gas prices with suppliers individually, according to their specific parameters (volume of consumption, number of consumption points, nature of consumption).

A representative development of natural gas prices for the wholesale category with an annual consumption of natural gas around 50 000 MWh is shown in the following chart.

Chart 30: Development of the average natural gas price in the wholesale category in Slovakia (EUR/MWh)



The prices are determined according to the actual annual costs taking into account the consumption rates and other rates (variable and fixed) relating to the supply of gas. Natural gas used in cogeneration of electricity and heat is exempt from the consumer tax (Act No 609/2007 on consumer tax on coal, electricity and natural gas, as amended). The prices shown in the chart are determined for the energy in fuel using the volume combustion heat.

7.4 Electricity purchase prices

The price of electricity produced by cogeneration is determined by the regulatory authority through the so-called specified fixed price. When determining the price, the authority takes into account the applied cogeneration technology, the fuel type, the time of putting the facility for producing electricity into operation, the extent of the facility's installed output, and, if appropriate, the extent of investment costs of reconstruction or modernisation of the facility producing electricity.

The purchase price of electricity comprises two components: the price of electricity for losses and the supplementary payment. The price for losses reflects the market price of electricity and is defined as the arithmetical average of prices of electricity to cover the losses of all operators in regional distribution networks. The supplementary payment, as the second component, represents the difference between the specified fixed price of electricity and the electricity price for losses paid to electricity producers using high-efficiency cogeneration eligible for the support by operators of the distribution networks to which facilities of electricity producers are connected or within which these facilities are situated.

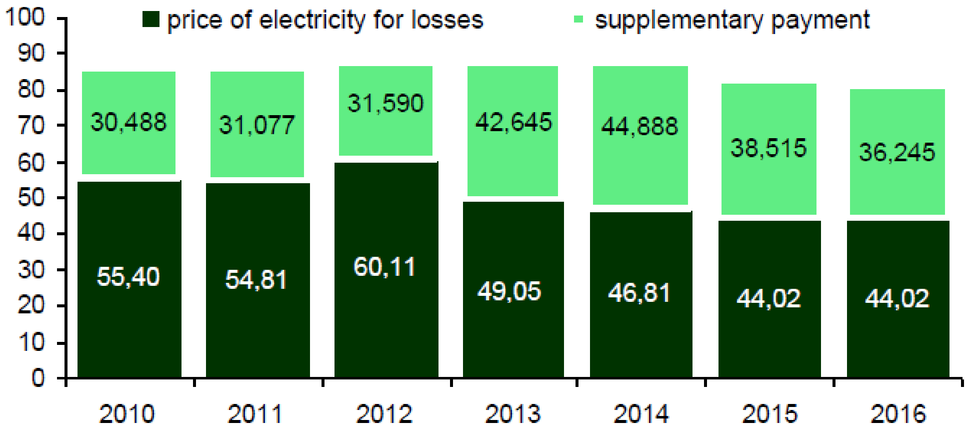
The specified fixed price of electricity for the purposes of determining the supplementary payment may change at annual intervals for specific electricity producers according to decisions of the regulatory authority if the economic parameters applied when determining the price change significantly (for example in the case of an increase or decrease of the fuel prices on energy markets).

The development of the purchase price of electricity produced by cogeneration using the internal combustion engine technology with natural gas as a fuel, the price of electricity for losses, and the supplementary payment calculated for information (assuming that the specified fixed price of electricity for determining the supplementary payment to the electricity producer does not change) is shown in the following table and chart.

Table 20: Development of specified fixed purchase price of electricity for determining the supplementary payment with internal combustion engine technology using natural gas, electricity prices for losses and the calculated supplementary payment

Year		2010	2011	2012	2013	2014	2015	2016
fixed price	(EUR/MWh)	85.89	85.89	91.7	91.7	91.7	82.53	80.26
price of electricity for losses	(EUR/MWh)	55.402	54.813	60.110	49.055	46.813	44.015	44.015
supplementary payment	(EUR/MWh)	30.488	31.077	31.590	42.645	44.888	38.515	36.245

Chart 31: Development of the purchase price of electricity produced through cogeneration with internal combustion engine technology using natural gas, electricity prices for losses and the calculated supplementary payment (EUR/MWh)



7.5 Economic evaluation of the application of high-efficiency cogeneration

As mentioned previously, the greatest technical potential of high-efficiency cogeneration of electricity and heat in Slovakia lies in the option of applying the cogeneration technology with low-output internal-combustion engines using natural gas as a fuel. The economic evaluation focused mainly on this technology.

The following models were assessed through the economic evaluation:

- evaluation taking into account the current conditions of support and the current conditions in regulation of the cost of electricity and useful heat in cogeneration facilities;
- modelling of the limit purchase price of electricity to maintain the competitive price of heat that guarantees the profitability of the installation of cogeneration.

The basic economic factors influencing the economic evaluation were derived from the analysis of the investment and operating costs of completed installations implemented during the last three years in existing heating plants and central boiler rooms with the total installed output of 14.4 MWe.

This involved evaluation of existing facilities for heat production using cogeneration facilities with minimal investment in construction. The specific economic indicators and the relevant operating data used in the economic evaluation are shown in the following table.

Table 21: Specific values used in economic modelling and basic operating data

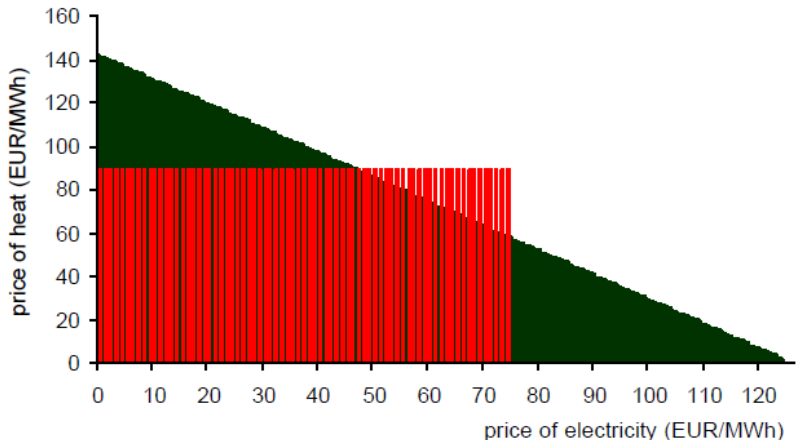
Investment costs	Variable component of costs		Fixed component of costs		Purchase price electricity	Competitive ofprice of heat	Thermal efficiency	Electric efficiency	Operating hours
	natural gas	other costs	operating costs	financial costs					
(EUR/MW_{e})	(EUR/MWh)	(EUR/MWh_{e})	(EUR/MWh_{e})	(EUR/MWh_{e})	(EUR/MWh)	(EUR/MWh)	(%)	(%)	(hours/year)
977.22	**37.77**	**1.86**	**24.55**	**9.28**	**88.98**	**75.00**	**44.47**	**40.17**	**7 823**

The specific investment costs also include the costs of connecting the electricity producer to the distribution network. In addition to the cost of fuel (exclusive of the consumer tax), the variable costs include other costs relating to the volume of the heat and electricity produced. The fixed costs contain the operating costs including payments for access to the distribution network (the so-called G-component), the cost of long-term contractual service (15 years), overhauls, depreciations and interest paid on an investment loan and reasonable profit (regulated). The timing of tax depreciation was applied in accordance with the binding legal regulations. The investments were funded by a commercial loan payable over an eight-year period under standard credit conditions. The financial costs (depreciations, interest paid on the investment loan) are expressed in the economic evaluation through the so-called annuity.

7.6 Outcomes of the economic evaluation of the application of high-efficiency cogeneration

The outcomes of the economic modelling of the viability of the application of high-efficiency cogeneration of electricity and heat using cogeneration technology with an internal combustion engine are illustrated in the following image.

Figure 4: Economic model under the current conditions of support for high-efficiency cogeneration through cogeneration technology with an internal combustion engine using natural gas.

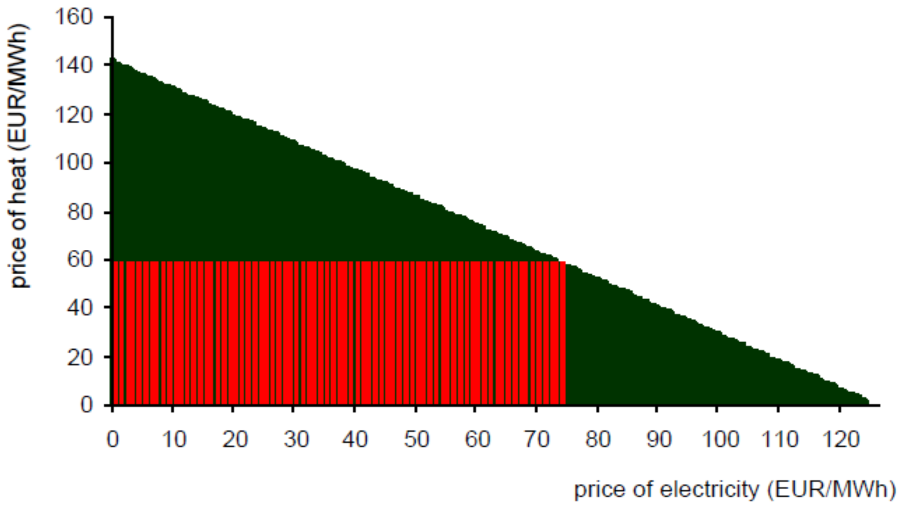


According to Figure 4, the application of the economic evaluation using the specific indicators listed in Table 21 and considering the current system of regulation of heat and electricity prices suggests that the system for supporting the electricity produced by cogeneration is highly favourable. The difference between the achieved receipts from electricity and heat and the total expended costs is positive. However, it is zero in view of the applied regulation to the detriment of the advantaged price of heat against the competitive price of heat.

As mentioned previously, determining the purchase price of electricity and the price of electricity for losses for cogeneration technology using an internal combustion engine with natural gas as a fuel is greatly influenced by the development of the natural gas and electricity prices on the energy markets, which have declined over the last few years. The regulatory authority responded by reducing the fixed price of electricity from 91.7 EUR/MWh in 2014 to 80.26 EUR/MWh valid from 2016. The economic evaluation of the application of high-efficiency cogeneration remains positive even with this reduced price, although to a lesser extent than previously.

The break-even purchase price of electricity at which the application of the cogeneration technology using an internal combustion engine with natural gas as a fuel remains profitable under the current price of natural gas was determined by modelling at approximately 60 EUR/MWh, as shown in Figure 5.

Figure 5: Economic model under the break-even conditions of support for high-efficiency cogeneration through the cogeneration technology with an internal combustion engine using natural gas



Even if this price was lower, cogeneration technology using an internal combustion engine with natural gas as a fuel may be economically viable if the electricity is consumed mainly for the electricity producer's own needs.

Economic evaluation of the application of high-efficiency cogeneration in Slovakia in view of the currently provided support has proven the profitability of installation of cogeneration technologies. Further development of these technologies may be affected by the development in fuel and electricity prices, and the stability of the legislative and regulatory environment.

8. Consideration of options of local and regional heat markets

Slovakia has an extensive centralised heat supply (CHS) system covering more than 54% of the overall demand for heat.

Approximately 350 entities - heat suppliers holding licences to conduct business activities in thermal engineering pursuant to Act No 657/2004 on thermal engineering currently operate on the market in heat.

CHS experienced significant development from the 1950s to the 1990s in connection with the extensive development of industrial production and development of high-density housing and civic amenities.

The following factors have been influencing the development of CHS from the 1990s to date:

- gradual liberalisation of fuel and energy prices, establishment of a competitive environment and arrival of foreign investors;
- adoption of new environmental and power engineering regulations, harmonising our legislation with EU legislation;
- availability of the latest technologies and facilities for the production, distribution, control and measurement of heat.

The factors referred to above caused stagnation in the construction of the new CHS systems and the planned and commenced construction projects were left uncompleted during this period. However, the entire process from production to the final heat consumption was significantly intensified during this period. Facilities for producing heat, such as condensing and low-temperature boilers, facilities for combusting biomass exclusively or in combination with other fuels, facilities for the cogeneration of electricity and heat, heat exchangers installed to utilise the heat from exhaust fumes, etc., are the typical new features. The projects carried out in heat distribution included mainly insulation of pipelines, heat exchangers with high specific outputs, and compact heat delivery stations for buildings. The projects in heat consumption included insulation, measuring heat for heating and hot water service, hydraulic regulation of thermal distribution systems, and installation of thermoregulation valves. The current period could be described as the period of ‘greening’ (in particular in heat sources in heating plants) and streamlining of the existing CHS systems.

The central heat supply system is, by its nature, a natural monopoly in heat supply to defined urban areas. In view of the dense and extensive gas distribution network, a competitive environment for central heat supply systems is currently practically limited to local heat sources with boilers running on natural gas at the level of boiler rooms for individual buildings. Central heat supply was disconnected intensively and in-house boiler rooms were constructed during the last few years mainly due to the distorted natural gas prices for individual consumer categories, providing a significant advantage to the construction of these heat sources. Disconnection from the central supply has lately been minimised due to legislative measures and the current rate structure of consumer categories for natural gas. The price of natural gas for retail consumers is higher than the price for wholesale consumers.

The current situation in CHS systems can be generally described by the following characteristics:

- The primary energy sources have reached the level of global prices. The production costs and the input fuel costs in particular have increased significantly over the last few years.

- Despite its regulation, the price of heat has become a major element in asserting one's position on the market in heat. The trend of consumers disconnecting from CHS systems motivated primarily by the distorted rates for natural gas was due to the excessive size of the existing systems and its impact on energy efficiency.
- The development of heat consumption has shown a decreasing trend over the long term and this trend is expected to continue. The production and delivery of heat has decreased significantly over the last 10 years due to terminated consumption of heat (especially in industrial consumers in towns with developed CHS systems for heating plants), which can be mainly attributed to the savings in heat for heating and hot water service achieved by the implementation of energy efficient measures in production (implementation of modern technical facilities for producing heat) and consumption (hydraulic regulation, installation of thermoregulation valves, insulation of residential buildings). The heat supply in individual CHS systems dropped by 30% to 40%.
- Non-systemic investments that were not divided between individual years occurred in certain CHS systems and resulted in high prices in these systems;
- the falling supply of heat has left the existing heat sources (heating plants, boiler rooms) over-sized. As the heat distribution systems also started to operate with surplus capacity, the energy efficiency of heat distribution dropped.
- The funding of investments and the modernisation of CHS systems is insufficient.
- As Act No 657/2004 on thermal engineering came into effect, a legislative framework stipulating that heat supply is of a regional nature was created. The assumption was that concepts for municipal development in thermal engineering (compulsory for municipalities defined in the act) would become a major strategic document directing the development of heat supply in municipalities in near future. However, not all municipalities use this tool sufficiently and this was one of the reasons behind the illogical disconnection of heat consumers from the central supply and the uncoordinated construction of new, technically and environmentally unjustified heat sources within the reach of the existing CHS systems.
- Over the last few years, many heating plants have been focusing on investments into facilities for providing supporting services to ensure the operational reliability of the electricity distribution network. The competition has increased and the market in this service has become saturated over the last few years particularly due to the increasing number of private providers who made targeted investments into new electricity producing facilities, focusing on supporting services with electricity production but usually without heat production.
- The price of heat from the heat supply systems of heating plants is distorted in many cases due to its distribution, where multiple businesses holding licences for producing or distributing heat operate.
- The current system for regulating heat prices allows all businesses to apply eligible regulated fixed expenses and a reasonable profit in their heat prices (in the chain from production to the sale of heat) and this negates the advantages of heat and electricity cogeneration.
- The price of heat applied by many heat suppliers (municipal commercial companies or commercial companies with a majority interest share of municipalities) is excessively burdened by the rental costs of the hired assets in connection with the production and distribution of heat for their owners - mainly municipalities. Only some of the municipalities reinvest these funds in the restoration and development of power engineering equipment. Most municipalities use the obtained funds to cover their budgetary needs and thus indirectly contribute to the technical degradation of their assets. In

another negative phenomenon, municipalities with territories including protection zones of external heat distribution networks claim financial compensation for easement from heat suppliers. Heat purchasers and end consumers therefore contribute to the financial activities of municipalities completely unrelated to heat supply through their payments for heat.

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As mentioned in Chapter 5, the planned development of CHS systems should be included in updated concepts for municipal development in thermal engineering. Recommendations from the compulsory energy audits completed by 5 December 2015 by all large companies, including heat suppliers, may serve as very relevant background material for drafting these concepts.

9. Consideration of municipal development concepts with regard to thermal engineering, particularly regarding possible interconnection of centralised heat supply systems17ad) and high-efficiency cogeneration aimed at establishing efficient centralised heat supply systems.

Act No 657/2004 on thermal engineering, as amended, grants municipalities certain competencies useful in directing the market in heat within their territories. The Act provides for the following basic competencies of municipalities:

- *issuing binding opinions on the compliance of the proposed construction of thermal facility systems with a total installed thermal output from 100 kW to 10 MW;*
- *issuing binding opinions on the compliance of business involved in thermal engineering with the concept of municipal development in thermal engineering;*
- *municipalities are authorised to request information on the condition and the potential for development of thermal facility systems from holders of licences for conducting business in thermal engineering;*
- *carrying out activities relating to declared states of emergency in thermal engineering.*

The drafted concepts for municipal development in thermal engineering (hereinafter, the ‘concept’) are intended as the background for exercising the competencies listed above.

The obligation for municipalities to draft concepts in accordance with the long-term thermal engineering policy of the Slovak Republic within the scope of the methodical guideline of the ME SR arises from Section 31 of Act No 657/2004 on thermal engineering, as amended.

Once approved by the relevant municipal council, the municipalities are required to integrate their concepts into the binding principles and regulations of their land management plans drafted pursuant to Act No 50/1976 (Building Act), as amended.

This integrated compulsory part of the concept becomes a reference point for the specialised municipal departments and for all participants on the market in heat operating within the municipality in decision making on the method of connecting buildings to utilities provided by the municipality and their compliance with the functional purposes of the municipal territory as approved in the relevant land management plan.

The key objective of the application of these concepts is to ensure that the production, distribution, supply and consumption of heat is permanently sustainable within the municipality's territory with regard to safety, efficiency and environmental impact. Besides addressing the development of the existing thermal facility networks and the construction of new thermal facility networks in the developed zones of municipalities, the concept is to consider the option of using available renewable energy sources and developing high-efficiency heat and electricity cogeneration to ensure that a reasonable and stable environment is provided to heat suppliers with regulated business activities to help them achieve return on their investment. On the other hand, the concept should guarantee heat purchasers and end consumers as participants on the market in heat transparent, safe, cost-efficient and environmentally friendly supply of heat at reasonable prices.

The amendment to the Act on thermal engineering in 2014 introduced legislative instruments for protecting existing efficient CHS systems and creating the prerequisites for more stable economic conditions for their use, including the development of high-efficiency cogeneration of electricity and heat.

Table 22: Electricity and heat production using high-efficiency cogeneration - Annex 1

Annex No 1				**High-efficiency cogeneration**								Newly constructed cogeneration facilities	Modernisation of existing cogeneration facilities	Installations in total (KGJ & other)[4]	Primary energy savings (PES)[5]	Prevented CO2 emissions
				Electricity production				**Heat production**								
				Electricity production by[6]cogeneration	Manufacturers: Public	Manufacturers: Industrial	Share in overall electricity production	Heat production by cogeneration	Manufacturers: Public	Manufacturers: Industrial	Share in overall heat production					
2011	electricity	installed output	[GW]	2.6733	2.1450	0.5283	0.1495					0.00280		8.05600	5.95 PJ	384132
		manufacturing	[TWh]	3.9008	2.1972	1.7036						0.00224		26.08822		
	heat	installed output	[GW]					7.1953	4.9611	2.2341	0.3605	0.01000		27.98739		
		manufacturing	[TWh]					11.3946	5.2558	6.1388		0.00977		31.60721		
	fuel	total	[PJ]	17.4123	9.8077	7.6047		50.8629	23.4607	27.4022		**0.05378**		**381.60093**		
		natural gas	[PJ]	5.4491	4.0300	1.4191		11.2189	6.4616	4.7573		0.00107		112.15200		
		hard coal	[PJ]	2.5616	1.1416	1.4200		11.0339	3.3960	7.6379				25.71400		
		lignite	[PJ]	2.0925	1.9290	0.1635		8.0358	7.5656	0.4702				34.53700		
		RES	[PJ]											14.49660		
		oil and petroleum products	[PJ]	2.9622	0.0181	2.9441		9.3011	0.0753	9.2257				11.28300		
		biomass	[PJ]	0.4931	0.2782	0.2149		1.3106	0.6508	0.6597		0.01933		16.44200		
		biogas	[PJ]	0.2257	0.2249	0.0008		0.2984	0.2907	0.0077		0.03042		1.04800		
		waste incineration	[PJ]	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000		0.00296		1.65800		
		landfill gas	[PJ]											0.85300		
		other fuels	[PJ]	3.6280	2.1858	1.4423		9.6642	5.0206	4.6436				163.41733		

[4] all types of facilities for electricity and heat cogeneration

[5] compared to the separate production of electricity and heat

[6] exclusively with regard to high-efficiency cogeneration pursuant to Directive 2012/27/EU

Annex No 1 - continued				Cogeneration of electricity and heat – Electricity production – Electricity production by[9] cogeneration	Electricity production – Manufacturers – Public	Electricity production – Manufacturers – Industrial	Electricity production – Share in overall electricity production	Heat production – Heat production by cogeneration	Heat production – Manufacturers – Public	Heat production – Manufacturers – Industrial	Heat production – Share in overall heat production	Newly constructed facilities for cogeneration	Modernisation of existing cogeneration facilities	Installations in total (KGJ & other)[7]	Primary energy savings (PES)[8]	Prevented CO2 emissions
2012	electricity	installed output	[GW]	2.7328	2.2045	0.5283	0.1639					0.05957		8.41200	6.30 PJ	376747
		manufacturing	[TWh]	4.2846	2.7994	1.4852						0.27509		26.13700		
	heat	installed output	[GW]					7.2811	5.0470	2.2341	0.3744	0.08586		27.49280		
		manufacturing	[TWh]					11.8703	5.6029	6.2674		0.33035		31.70876		
	fuel	total	[PJ]	19.1075	12.4843	6.6232		52.9368	24.9869	27.9500		**2.68934**		**392.40913**		
		natural gas	[PJ]	6.6083	5.5396	1.0687		11.9117	7.9761	3.9355		0.68678		117.10700		
		hard coal	[PJ]	2.5470	1.2564	1.2905		10.5430	3.2947	7.2484				20.93100		
		lignite	[PJ]	1.8491	1.6237	0.2253		7.3698	6.6899	0.6798				31.28400		
		RES	[PJ]											16.40480		
		oil and petroleum products	[PJ]	1.5959	0.0237	1.5722		6.8796	0.0945	6.7852				10.51200		
		biomass	[PJ]	1.5150	0.8466	0.6684		3.5565	1.3236	2.2329		0.75920		21.56400		
		biogas	[PJ]	1.3433	1.3413	0.0021		1.8842	1.8623	0.0219		1.24337		1.66800		
		waste incineration	[PJ]									0.00000		1.76700		
		landfill gas	[PJ]											0.92400		
		other fuels	[PJ]	3.6489	1.8529	1.7960		10.7920	3.7457	7.0463				170.24733		

[7] all types of facilities for electricity and heat cogeneration

[8] compared to the separate production of electricity and heat

[9] exclusively with regard to high-efficiency cogeneration pursuant to Directive 2012/27/EU

Annex No 1 - continued				Cogeneration of electricity and heat								Newly constructed cogeneration facilities	Modernisation of existing cogeneration facilities	Installations in total (KGJ & other)[10]	Primary energy savings (PES)[11]	Prevented CO2 emissions
				Electricity production				Heat production								
				Electricity production by[12] cogeneration	Manufacturers: Public	Manufacturers: Industrial	Share in overall electricity production	Heat production by cogeneration	Manufacturers: Public	Manufacturers: Industrial	Share in overall heat production					
2013	electricity	installed output	[GW]	2.8092	2.1955	0.6137	0.1737					0.07631		8.51300	6.66 PJ	366632
		manufacturing	[TWh]	4.7205	3.1223	1.5982						0.41278		27.17299		
	heat	installed output	[GW]					7.3682	4.9888	2.3794	0.3406	0.08705		27.43566		
		manufacturing	[TWh]					12.2975	5.5542	6.7433		0.47219		36.10208		
	fuel	total	[PJ]	21.0044	13.8930	7.1114		54.7191	24.7139	30.0052		**3.90964**		**398.37227**		
		natural gas	[PJ]	8.0740	6.7125	1.3615		12.2480	8.5385	3.7095		1.79505		123.04800		
		hard coal	[PJ]	2.5097	1.1650	1.3447		10.5624	3.1120	7.4504				21.92600		
		lignite	[PJ]	1.8003	1.5856	0.2147		6.7216	5.9488	0.7727				30.23500		
		RES	[PJ]											19.27060		
		oil and petroleum products	[PJ]	1.1875	0.0233	1.1642		5.8705	0.0906	5.7799				9.40200		
		biomass	[PJ]	1.7494	0.7955	0.9538		4.8280	1.3820	3.4461		0.00583		21.39500		
		biogas	[PJ]	2.2718	2.2698	0.0020		2.7110	2.6943	0.0167		2.02385		0.00000		
		waste incineration	[PJ]	0.1070	0.1070	0.0000		0.1200	0.1200	0.0000		0.08491		1.36200		
		landfill gas	[PJ]											2.29800		
		other fuels	[PJ]	3.3047	1.2343	2.0703		11.6576	2.8277	8.8299				169.43567		

[10] all types of facilities for electricity and heat cogeneration

[11] compared to the separate production of electricity and heat

[12] exclusively with regard to high-efficiency cogeneration pursuant to Directive 2012/27/EU

Table 22: Electricity and heat production using high-efficiency cogeneration - Annex 1

Annex No 1 - continued				**Cogeneration of electricity and heat**								Newly constructed cogeneration facilities	Modernisation of existing cogeneration facilities	Installations in total (KGJ & other)[13]	Primary energy savings (PES)[14]	Prevented CO2 emissions
				Electricity production				**Heat production**								
				Electricity production[1] by cogeneration	Manufacturers		Share in overall electricity production	Heat production by cogeneration	Manufacturers		Share in overall heat production					
					Public	Industrial			Public	Industrial						
2014	electricity	installed output	[GW]	2.8167	2.2030	0.6137	0.1629					0.01350		8.12200	5.93 PJ	298456
		manufacturing	[TWh]	4.0745	2.6031	1.4713						0.07987		25.00700		
	heat	installed output	[GW]					7.3473	4.9679	2.3794	0.3808	0.01489		27.19936		
		manufacturing	[TWh]					11.0266	4.2148	6.8118		0.08600		28.95437		
	fuel	total	[PJ]	18.1007	11.5235	6.5772		49.0064	18.5900	30.4164		**0.75237**		**365.40580**		
		natural gas	[PJ]	5.8395	4.8847	0.9547		8.0619	5.6632	2.3987		0.18671		98.10000		
		hard coal	[PJ]	2.3196	1.0109	1.3087		9.9348	2.5183	7.4165				17.59500		
		lignite	[PJ]	1.4634	1.2473	0.2161		5.2813	4.4711	0.8102				27.60900		
		RES	[PJ]											17.04280		
		oil and petroleum products	[PJ]	0.7406	0.0181	0.7225		4.4935	0.0677	4.4258				10.60900		
		biomass	[PJ]	2.0533	0.7806	1.2727		5.8905	1.0730	4.8175		0.00000		17.90900		
		biogas	[PJ]	2.7378	2.7372	0.0006		3.0693	3.0679	0.0013		0.56566		0.00000		
		waste incineration	[PJ]	0.1308	0.1308	0.0000		0.1423	0.1423	0.0000		0.00000		1.87600		
		landfill gas	[PJ]											4.01300		
		other fuels	[PJ]	2.8156	0.7139	2.1018		12.1328	1.5864	10.5464				170.65200		

13 all types of facilities for electricity and heat cogeneration

14 compared to the separate production of electricity and heat

Table 23: Electricity and heat production using high-efficiency cogeneration - Annex 2

Annex No 2				**TOTAL**	**Sector**					
					Industry	Residential, commercial and other services				Other
						Central heating	Other heating	Micro KGJ	central cooling	
2011	electricity	installed output	[GW]	2.6733	1.1651	0.0000			0.0000	1.5081
		manufacturing	[TWh]	3.9008	1.7002	0.0000			0.0000	2.2006
	heat	installed output	[GW]	7.1953	0.9197	5.7449			0.0072	0.5234
		manufacturing	[TWh]	11.3946	1.4565	9.0978			0.0114	0.8289
	fuel	energy in fuel	[PJ]	68.2752	14.0908	40.6105			0.0509	13.5231
2012	electricity	installed output	[GW]	2.7328	1.3080	0.0000			0.0000	1.4249
		manufacturing	[TWh]	4.2846	2.0507	0.0000			0.0000	2.2339
	heat	installed output	[GW]	7.2811	1.3950	5.3822			0.0073	0.4967
		manufacturing	[TWh]	11.8703	2.2742	8.7745			0.0119	0.8097
	fuel	energy in fuel	[PJ]	72.0443	19.2874	39.1307			0.0529	13.5733
2013	electricity	installed output	[GW]	2.8092	1.2714	0.0000			0.0000	1.5378
		manufacturing	[TWh]	4.7205	2.1365	0.0000			0.0000	2.5840
	heat	installed output	[GW]	7.3682	1.3441	5.4851			0.0147	0.5243
		manufacturing	[TWh]	12.2975	2.2433	9.1547			0.0246	0.8750
	fuel	energy in fuel	[PJ]	75.7235	19.4880	40.7347			0.1094	15.3913
2014	electricity	installed output	[GW]	2.8167	1.3741	0.0000			0.0000	1.4425
		manufacturing	[TWh]	4.0745	1.9878	0.0000			0.0000	2.0867
	heat	installed output	[GW]	7.3473	1.3572	5.3985			0.0147	0.5768
		manufacturing	[TWh]	11.0266	2.0368	8.1020			0.0221	0.8657
	fuel	energy in fuel	[PJ]	67.1073	17.8848	36.0043			0.0980	13.1201

Table 24: Electricity and heat production using high-efficiency cogeneration - Annex 3

Annex No 3 **Technologies**				TOTAL	Combined cycle gas turbines (CCGT) with heat recovery	Steam back-pressure turbines	Steam-condensing extraction turbines	Gas turbines with heat recovery	Internal-combustion engines	Micro turbines	Stirling engines	Fuel cells	Steam engines	ORC	Other[4]
2011	electricity	installed output	[GW]	2.6733	0.3949	0.5830	1.6229	0.0254	0.0471						
		manufacturing	[TWh]	3.9008	0.8740	1.3706	1.2999	0.1248	0.2315						
	heat	installed output	[GW]	7.1953	0.3320	1.8540	4.8730	0.0834	0.0529						
		manufacturing	[TWh]	11.3946	0.7482	5.3592	4.7601	0.2629	0.2642						
	fuel	energy in fuel	[PJ]	68.2752	7.1223	30.0866	27.1351	1.7253	2.2060						
2012	electricity	installed output	[GW]	2.7328	0.3949	0.5830	1.6311	0.0254	0.0984						
		manufacturing	[TWh]	4.2846	1.0319	1.3461	1.2772	0.1146	0.5148						
	heat	installed output	[GW]	7.2811	0.3320	1.8540	4.9020	0.0834	0.1098						
		manufacturing	[TWh]	11.8703	0.8962	5.3948	4.7598	0.2362	0.5834						
	fuel	energy in fuel	[PJ]	72.0443	8.5054	30.0751	27.0315	1.5567	4.8756						
2013	electricity	installed output	[GW]	2.8092	0.3949	0.5830	1.6311	0.0254	0.1736					0.0012	
		manufacturing	[TWh]	4.7205	1.1111	1.3339	1.2266	0.1013	0.9431					0.0045	
	heat	installed output	[GW]	7.3682	0.3320	1.8540	4.9020	0.0834	0.1920					0.0048	
		manufacturing	[TWh]	12.2975	0.9861	5.4748	4.5542	0.2048	1.0592					0.0185	
	fuel	energy in fuel	[PJ]	75.7235	9.1996	30.3355	25.8837	1.3533	8.8526					0.0987	
2014	electricity	installed output	[GW]	2.8167	0.3949	0.5770	1.6311	0.0254	0.1871					0.0012	
		manufacturing	[TWh]	4.0745	0.5105	1.2881	1.0814	0.0916	1.0950					0.0079	
	heat	installed output	[GW]	7.3473	0.3320	1.8182	4.9020	0.0834	0.2069					0.0048	
		manufacturing	[TWh]	11.0266	0.3539	5.1180	4.1182	0.1766	1.2291					0.0307	
	fuel	energy in fuel	[PJ]	67.1073	3.8092	28.5025	23.2407	1.1836	10.2067					0.1645	