SLOVENSKÁ ENERGETICKÁ AGENTÚRA
(SLOVAK INNOVATION AND ENERGY AGENCY)
Bajkalská 27, 827 99 Bratislava 27

ACCREDITED ACTIVITIES DEPARTMENT
Rudlovská cesta 53, 974 28 Banská Bystrica

T E C H N I C A L R E P O R T

Name:

ANALYSIS OF THE NATIONAL POTENTIAL FOR HIGH-EFFICIENCY COGENERATION

Elaborated by: Dr. – Ing. CHPoslava Šoltésová, CSc.
Dr. – Ing. Jozef Šoltés, CSc.

Telephone: +421(48)4714630
+421(48)4142354
Fax: +421(48)4714639
E-mail: lem@seabb.sk
Internet: www.sea.gov.sk
Company ID: 00002801
Bank details: State Treasury, Account No: 7000062596/8180

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1 Introduction

Sustainable development of the energy industry in Europe with respect to environmental protection as well as operational economy and return on investments is closely related to an increase in energy efficiency.

Cogeneration is one possible form of technology through which the objectives of the EU on increasing energy efficiency may be realised. Among the major benefits of cogeneration are savings in primary energy, a reduction in losses relating to energy distribution and a decrease in emissions. Increased utilisation of cogeneration can also contribute positively to the security of energy supply and to improving the competitive situation of the EU and its Member States in the energy industry. Support for high-efficiency cogeneration based on demand for useful heat is one of the EU's priorities.

The potential for the use of cogeneration as a measure to save energy is underused within the EU at present. It is therefore necessary to take measures to ensure that this potential is better exploited within the framework of the internal energy market.

Directive No 2004/8/EC of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market came into effect in March 2004. Its main objective is:

- to increase energy efficiency and improve security of supply by creating a framework for promotion and development of high efficiency cogeneration of heat and power based on useful heat demand and primary energy savings in the internal energy market, taking into account the specific national circumstances especially concerning climatic and economic conditions..

Article 6 of Directive 2004/08/EC defines the responsibilities of EU Member States with regard to establishing an analysis of the national potential of high-efficiency cogeneration:

1. Member States shall establish an analysis of the national potential for the application of high-efficiency cogeneration, including high-efficiency micro-cogeneration.
2. The analysis shall:
   - be based on well-documented scientific data and comply with the criteria listed in Annex IV to Directive 2004/08/EC;
   - identify all potential for useful heating and cooling demands suitable for the application of high-efficiency cogeneration, as well as the availability of fuels and other energy resources to be utilised in cogeneration;
   - include a separate analysis of barriers, which may prevent the realisation of the national potential for high-efficiency cogeneration. In particular, this analysis shall consider barriers relating to the prices and costs of and access to fuels, barriers in relation to grid system issues, barriers in relation to administrative procedures, and barriers relating to the lack of internalisation of the external costs in energy prices.

The submitted analysis of the national potential for high-efficiency cogeneration in the Slovak Republic meets the requirements of Article 6 of Directive 2004/08/EC.

The analysis fulfils all of the criteria set out in Annex IV to the Directive:

- the analysis considers:
  - the types of fuel that are likely to be used to realise national cogeneration potential, including specific considerations on the potential for increasing the use of renewable energy resources in the national heat markets via cogeneration;
  - the types of cogeneration technologies as set out in Annex I to the Directive that are likely to be used to realise the national potential;
  - the type of separate production of heat and electricity to be replaced with high-efficiency cogeneration;
  - a division of the potential into modernisation of existing capacity and construction of new capacity.
- the analysis includes appropriate mechanisms to assess the cost-effectiveness within the limits of primary energy savings of increasing the share of high-efficiency cogeneration in the production of national energy;
- the analysis of cost-effectiveness considers the obligations of the Slovak Republic arising from climate change commitments accepted by the EU pursuant to the Kyoto Protocol to the United Nations Framework Convention on Climate Change;
- the analysis of national cogeneration potential is specified in relation to the timeframes 2010, 2015, 2020 and includes cost estimates for each of the timeframes.

In terms of its content and methodology, the submitted analysis has been prepared in accordance with the Guidelines for Determining the National Potential for High-Efficiency Cogeneration. The analysis takes into account legislation in force in the Slovak Republic at the time of the preparation of the analysis.

2 Definitions, acronyms and units of physical measurement

2.1 Terms and Definitions

For the purposes of this analysis of the national potential of high-efficiency cogeneration, the following terms and definitions shall apply:

a) cogeneration shall mean the simultaneous production of heat and electricity, or of heat and mechanical power, within a single process;
b) electricity producer using cogeneration shall mean a natural or legal person that produces electricity by means of cogeneration and that has the relevant licence to generate electricity pursuant to Act No 656/2004 Coll., or that produces electricity by means of cogeneration for its own consumption;
c) useful heat shall mean heat produced in a cogeneration process which is intended to satisfy an economically justifiable demand for useful heat or cooling;
d) demand for useful heat or cooling which is economically justifiable shall mean demand which does not exceed the need for heating or cooling which would otherwise be satisfied by production processes other than cogeneration under economically competitive conditions;
e) small-scale cogeneration shall mean cogeneration units whose installed electric power exceeds 50 kW inclusive but does not exceed 1 MW;
f) micro-cogeneration shall mean cogeneration units with a maximum installed electric output of 50 kW;
g) high-efficiency cogeneration shall mean cogeneration of small-scale and micro-cogeneration resulting which make savings in primary energy compared to separate heat production and separate electricity production, or cogeneration resulting in primary energy savings in the amount of at least 10% in comparison to separate heat and separate electricity production;
h) back-up electricity shall mean electricity supplied through the electricity grid whenever the cogeneration process is disrupted, including maintenance periods, repairs, etc.;
i) top-up electricity shall mean electricity supplied through the electricity grid in cases where the demand for electricity is greater than the electrical output of the cogeneration process;
j) cogeneration unit shall mean a unit that can produce electricity or mechanical power and heat or cooling within a single production process;
k) cogeneration technology shall mean a gas turbine working in a combined cycle generating heat; a back-pressure steam turbine; a condensing process-steam turbine; a regenerative-cycle steam turbine; a combustion engine; a micro-turbine; a Stirling engine; a fuel cell; a steam engine; a Rankin Organic Cycle; and any other type of technology or combination of technologies which meets the conditions set out in Article 3, subparagraph a) of Directive 2004/08/EC;
l) heat-measuring device shall refer to a device serving the purpose of removing hear from the surroundings without its subsequent use, e.g. steam condensers, compressor coolers, by-passers, condensate coolers, liquid media coolers, gas coolers, oil coolers, compressed air coolers, smoke-stacks, etc;
m) balance interval shall mean the timeframe required for gaining data for establishing the necessary energy balances;
n) using the following energy:
    a. total useful heat shall mean total heat supplied from the cogeneration resource to satisfy an economically justifiable demand within the balance interval;
    b. total electricity/mechanical power shall mean the total amount of electricity produced on terminals of the generator/gross mechanical power on the cogeneration unit within the balance interval;

c. total energy in fuel shall mean the total energy relating to calorific capacity of the fuel (not to combustion heat) entering the cogeneration unit within the balance interval;
d. useful heat from cogeneration shall mean heat generated via the cogeneration process and supplied by the cogeneration unit to satisfy an economically justifiable demand within the balance interval,
e. electricity/mechanical power generated via cogeneration shall mean electricity or mechanical power generated by through a process relating to the production of useful heat via cogeneration by the cogeneration unit within the balance interval, the amount of which is counted pursuant to Annex II to Directive 2004/8/EC;
f. fuel energy for cogeneration shall mean fuel energy used in producing electricity/mechanical power via cogeneration and heat produced via cogeneration within the balance interval;
g. useful heat outside cogeneration shall mean heat generated outside the cogeneration process from the cogeneration unit to satisfy an economically justifiable demand within the balance interval;
h. electricity/mechanical power generated outside cogeneration shall mean electricity or mechanical power generated in the cogeneration unit within the balance interval outside the cogeneration process (difference between the total electricity or mechanical power generated and electricity or mechanical power produced during the cogeneration process),
i. energy in fuel outside cogeneration shall mean the difference between the total fuel energy and the fuel energy for cogeneration entering the cogeneration unit within the balance interval.

o) having the following economic indicators:
a. overall efficiency shall mean the ratio between the total sum of electricity or mechanical energy production, total heat and total energy fuel input within the balance interval;
b. efficiency shall mean the ratio between total electricity or mechanical energy production, useful heat output from a cogeneration process and total energy in fuel divided by the fuel input used for heat outside the cogeneration process within the balance interval;
c. cogeneration efficiency shall mean the ratio between electricity/mechanical energy produced in a cogeneration process, useful heat from cogeneration and fuel input for cogeneration within the balance interval;
d. electricity/mechanical power efficiency produced outside cogeneration shall mean the ratio between electricity/mechanical power produced outside a cogeneration process and fuel input used for producing electricity/mechanical power produced outside the cogeneration process;
e. efficiency of useful heat produced outside the cogeneration process shall mean the ratio between useful heat produced outside the cogeneration process and fuel input used for generating useful heat outside the cogeneration process;
f. cogeneration coefficient shall mean the ratio between electricity/mechanical power produced via cogeneration and useful heat produced via cogeneration within the balance interval;
g. loss of electricity from cogeneration shall mean the ratio between lost electricity or mechanical power from the cogeneration process and the increase in the amount of useful heat produced via cogeneration within the balance interval.

2.2 List of acronyms used

KVET electricity/mechanical power and heat (cooling) cogeneration (hereinafter ‘cogeneration’)
CHP combined heat and power

CHS centralised heat supply
DHS decentralised heat supply
CH central heating
DHW domestic hot water
RES renewable energy resources
CGU cogeneration unit
SF EU Structural Funds

2.3 Physical quantities and units of physical measurement used

Quantities:

- E energy in fuel
- A mechanical power or electrical work
- Q heat
- • change in quantity
- • efficiency
- • cogeneration coefficient
- • electricity loss from cogeneration

Units:

- kW kilowatt
- MW megawatt
- MWh megawatt hour
- GWh gigawatt hour
- GJ gigajoule
- PJ petajoule

Indices:

- e relating to electricity
- m relating to mechanical power
- t relating to heat
- CHP relating to the cogeneration process
- n-CHP relating to processes independent of cogeneration.

3 Summary

The total amount of electricity produced from cogeneration units amounts to 11,957 GWh, which in the Slovak Republic represents 39% of the total amount of electricity produced. Of this, electricity produced via the process of cogeneration amounts to 4,871 GWh, representing 16% of total electricity production. Useful heat produced via cogeneration amounts to 58,854 TJ, which in the Slovak Republic represents 30% of the total production of useful heat.

The most frequent cogeneration technologies used in the Slovak Republic are gas turbines. In terms of installed electric output, cogeneration technologies using steam turbines represent 88%, in terms of total electricity generation 88% and in terms of electricity produced via the cogeneration process 70%. Other cogeneration technologies used are the steam and gas cycle, combustion engines and gas turbines. Other types of cogeneration technologies are used very rarely in the Slovak Republic.

In terms of the fuel used in cogeneration units, it is possible to say that there is a reduction in the use of solid and liquid fossil fuels. In the previous period, we could see a visible increase in the use of nuclear fuel. Increase in the consumption of natural gas is clear, in particular in medium-sized and small cogeneration units. There is also an increase in consumption of renewable energy resources (for cogeneration this concerns biomass, in particular).

Over the last ten years in the combined heat and electricity generation industry, a substantial drop in heat consumption has occurred due to the implementation of cost-effective measures in respect to both consumption and distribution, but particularly with regard to consumption. The total potential of savings during generation and distribution in the Slovak Republic has not been utilised fully; however, it is possible to expect that the realisation of projects focused on energy savings in this area will not follow the same tendency as it has until now.

With regard to electricity consumption, we can see a gradual increase after a steep decline in the early 1990s, which resulted from a collapse of industrial production in the Slovak Republic.

The growth of electricity and heat generation using high-efficiency cogeneration will mean an increase in low and medium-sized cogeneration units, in particular with regard to renewable energy resources and bio-fuels. The modernisation of existing cogeneration units on the basis of steam turbines will contribute to this increase.

With regard to the technologies used in cogeneration, backpressure steam turbines and extraction condensing turbines will be used in most cases. In medium-sized and small units, the most frequently used technology will be the combustion engine.

Technical potential based only on the need for useful heat and on the cogeneration facility installation possibility will represent 19,921 GWh of electricity produced in the Slovak Republic by 2020, which is four times the amount produced today. In terms of respective technical potential, production via small and medium-sized cogeneration units will particularly prevail.

Economic potential is based on technical potential; however, unlike the technical one, the economic potential includes economic profitability of the respective investment, which is influenced not only by economic factors but also by factors other than economic and time-related factors. The economic potential represents the actual value of the potential of high-efficiency cogeneration in the selected timeframes whilst adhering to input preconditions. The total economic potential of the electricity cogeneration process

represents 5,394, 6,308 and 7,445 GWh in the respective timeframes 2010, 2015 and 2020.

The economic potential of high-efficiency cogeneration is represented in particular by the modernisation of existing cogeneration units on the basis of steam turbines, the increasing use of the steam and gas cycle as well as the increasing number of medium-sized and small units on the basis of combustion engines using mainly renewable energy resources and bio-fuels.

The starting point for the utilisation and further development of cogeneration is relatively good. CHS and CHP commodities have long been established, with quality knowledge and the required technologies available.

The objectives of the national policy express support for high-efficiency cogeneration. One of the basic priorities of the policy is a simple increase in electricity and heat cogeneration.

Support for cogeneration has been declared in ÚRSO (Regulatory office for network industries) Decree No 2/2005, which sets out fixed purchase prices for electricity produced via cogeneration technologies. Other forms of support are investment incentives subsidised by the state budget as well as by the EU's Structural Funds.

In order to meet the economic potential of high-efficiency cogeneration, it is necessary to implement many measures. In the near future, it will be particularly necessary to implement the following:

- enactment of Act No 656/2004 Coll. on the Energy Sector and on Amendment and Supplement of some Acts and Act No 657/2004 Coll. regulating the Heat Supply Sector;
- enactment of an Order to define criteria for the support for electricity and heat cogeneration;
- enactment of an Order to define the content and form of the application for the certificate and the content and form of the certificate of origin of electricity produced by means of high-efficiency cogeneration;
- consolidation of the preferred purchase price system for electricity produced via cogeneration with the preferred purchase price system for electricity produced via high-efficiency cogeneration;
- implementation of investment incentives based on the EU's Structural Funds for high-efficiency cogeneration in the next programme period for 2007-2013;
- elaboration of an investment incentive system based on resources from the national budget of the Slovak Republic.

4 Method and starting points of the analysis

4.1 General

In order to determine the existing situation, which is necessary in order to analyse the national potential for high-efficiency cogeneration in the Slovak Republic, the following details were used:

1) data from the databases of the ŠÚ (Statistical Office of the Slovak Republic) in the area of energy industry of the Slovak Republic over the years 2001-2004;
2) energy policy approved by the Government of the Slovak Republic on 11 January 2006;
3) data on cogeneration during the year 2005 acquired from individual operators under Section 2 of Order of the Ministry of Economy of the Slovak Republic No 136/2005 Coll.

Monitoring of electricity and heat generation in the Slovak Republic was based on statistical data for the years 2001-2004. In this period, statistical monitoring of electricity and heat generation and consumption was almost integrated, and it is possible to monitor the year-to-year changes in the respective industry relatively accurately.

Updated data that meets the requirements set out in Directive 2004/08/EC was acquired from details specified in paragraph 3; however, data acquired by the Statistical Office in the respective area fails to comply with the requirements of EUROSATOM and Directive 2004/08/EC.

Data necessary for defining trends in the energy industry is acquired from the details specified in paragraph 2 for the period commencing in 1993, and the forecast is expected until 2020 with 5-year steps.

4.2 Situation of the electricity and heat market

Table 4.2-1 and Figures 4.2-1 to 4.2-3 show shares of individual primary fuels and types of energy in electricity and heat produced via CHS units.

Primary fuels and types of energy	Annual generation of		
	electricity [GWh/y]	heat in the CHP [TJ]	heat in the CHS heating stations and boiler plants [TJ/y]
Black coal	3,342	13,115	90
Brown coal	2,339	16,080	889
Other fossil fuels	422	5,251	4,210
Heavy fuel oil	735	9,786	885
Natural gas	2,421	13,808	37,132
Other resources	34		
Nuclear energy	17,026	2,270	
Industrial waste	0	149	226
Solid municipal waste	30	573	253
Wood and wood residues	3	1,141	3,068
Biogas	2	218	189
Other renewable resources	-	0	6,531
Water energy	4,207		
Geothermal energy	0	144	
Wind energy	6		
Total	30,567	62,535	53,472

Table 4.2-1: Electricity and heat produced via CHS systems in the Slovak Republic in 2004

In terms of electricity production:

- more than 55% of electricity produced in the Slovak Republic is generated from nuclear fuel;
- the share of fossil fuels in electricity production represents approximately 30%, while solid fuels are used most frequently;
- the share of RES (13-19%) is represented in particular by electricity produced via large water power plants and is substantially influenced by amount of rainfall in the catchment area of the Danube River and its tributaries;
- the share of other RES in electricity production is insignificant.

In terms of heat production:

- approximately 60% of heat is generated through CHS units, of which more than half is produced by means of cogeneration;
- in case of local boiler plants, natural gas is the most prominent fuel;
- the share of RES in the local boiler plants is statistically lower than 1% (the official statistic, however, does not include the entire consumption of lignocelluloses biomass for the purpose of heat production in local resources).

Heat production supplied to CHS units may be characterised as follows:

- the most frequently used fuel is natural gas (approximately 46%);
- of the other fossil fuels, solid fuels prevail – brown and black coal;
- the share of RES represents more than 6%, with the highest share in wood and wood residues, the share of liquid fuels (in particular heavy fuel oil) is lower than 10%.

Heat produced via CHP units may be characterised as follows:

- diverse fuels used;
- prevailing fuel – brown and black coal;
- relatively low share of RES.

[Figure – 'Share of resources in total electricity production']

(Key: geotermálna energia = geothermal energy, OZE = renewable energy resources (RES), veterná energia = wind energy, vodná energia = hydraulic energy, ostatné obnovite•né = other renewable resources, hnedé uhlie a lignit = brown coal and lignite, •ierne uhlie = black coal, bioplyn = biogas, drevo a odpady z dreva = wood and wood residues, tuhý mestský odpad = solid municipal waste, priemyselný odpad = industrial waste, ostatné fosílne palivá = other fossil fuels, •ažký vykurovací olej = heavy fuel oil, zemný plyn = natural gas, jadrová energia = nuclear energy, iné zdroje = other resources)

Fig. 4.2-1: Share of resources in total electricity production in 2004

[Figure – ‘Share of resources in total heat production’]

(Key: lokálne kotle - ZPN = local boilers using natural gas, lokálne kotle - propán-bután = local boilers using propane-butane, lokáln• kotle - uhlie = local boilers using coal, lokálne kotle - biomasa = local boilers using biomass, lokálna výroba tepla -iná = local heat generation -other, teplárne - CZT = CHS combined heat and power stations; výhrevne a centrálne kotolne– CZT = heating stations and centralised boiler plants)

Fig. 4.2-1: Share of resources in total heat production

[Figure: ‘Share of resources in total heat production for the CHS’]

(Key: iné zdroje = other resources, jadrová energia = nuclear energy, zemný plyn = natural gas, •ažký vykurovací olej = heavy fuel oil, ostatné fosílne palivá = other fossil fuels, priemyselný odpad = industrial waste, tuhý mestský odpad = solid municipal waste, drevo a odpady z dreva = wood and wood residues, bioplyn z •isti•iek = biogas from purification plants, •ierne uhlie = black coal, hnedé uhlie a lignit = brown coal and lignite, geotermálna energia = geothermal energy, OZE = renewable energy resources(RES))

Fig. 4.2-1: Share of Primary Energy Resources (PES) in heat production supplied to the CHS systems

4.3 Situation of electricity and heat cogeneration

The volume of electricity and heat produced through cogeneration resources is derived from the database on cogeneration data for 2005 acquired from individual operators according to Section 2 of Order No 136/2005 Coll. of the Ministry of Economy of the Slovak Republic. Table 4.3-1 shows basic information on cogeneration in the Slovak Republic.

Generation technology	Number	Total installed output	Electricity generated	Useful heat
	[pcs]	[MW]	[MWh]	[TJ]
Steam and gas cycle	3	240	1,150,430	3,773
Gas turbines	5	25	123,644	1,249
Steam condensing (turbines)	24	1,432	8,367,035	11,970
Steam backpressure (turbines)	51	729	2,128,104	40,988
Combustion engines	185	35	179,176	835
Other	1	1	8,709	38
Total	269	2,462	11,957,098	58,854

Table 4.3-1: Basic information on cogeneration for 2005

[Figure – 'Total installed electric output of cogeneration facilities']

(Key: parné protitlaké turbíny = steam backpressure turbines, plynové turbíny = gas turbines, parné kondenza•né turbíny = steam condensing turbines, spa•ovacie motory = combustion engines, ostatné = the other, PPC = steam-gas cycle)

Fig. 4.3-1: Division of the total installed electric output of cogeneration facilities in 2005

[Figure – 'Total amount of electricity produced via cogeneration facilities']

(Key: parné kondenza•né turbíny = steam condensing turbines, plynové turbíny = gas turbines, parné protitlaké turbíny = steam back-pressure turbines, PPC = steam-gas cycle, ostatné = the other, spa•ovacie motory = combustion engines)

Fig. 4.2-2: Total amount of electricity produced via cogeneration facilities in 2005

[Figure – 'Useful heat produced via cogeneration facilities']

(Key: parné kondenza•né turbíny = steam condensing turbines, plynové turbíny = gas turbines, parné protitlaké turbíny = steam back-pressure turbines, PPC = steam-gas cycle, ostatné = the other, spa•ovacie motory = combustion engines)

Fig. 4.2-3: Useful heat produced via cogeneration facilities in 2005

[Figure – 'Share of fuels in electricity and heat production in cogeneration facilities']

(Key: jadrové palivo = nuclear fuel, iné = other, rafinérsky plyn = refinery gas, •VO = light fuel oil, •ierny lúh = alcohol fuel, bioplyn = biogas, drevný odpad = wood residues, koks.plyn = coke-oven gas, vysokopecný plyn = blast-furnace gas, •U = black coal, ZPN = natural gas, HU = brown coal, konvertorový plyn = air refining gas, •VO = heavy fuel oil)

Fig. 4.2-3: Share of fuels in electricity and heat production via cogeneration units for 2005

4.4 Expected development of demand for electricity and heat in the Slovak Republic

The expected development of demand for electricity and heat is based on the presumptions defined in the energy policy of the Slovak Republic. Demand for energy in individual sectors was determined based on the expected growth rate of the GDP as well as on specific energy consumption.

[Figure – 'Development of consumption of primary energy resources']

(Key: obnovite•né zdroje energie = renewable energy resources, teplo z jadrových elektrární = heat generated in nuclear power plants, ropa = crude oil, zemný plyn = natural gas, uhlie = coal)

Source: Ministry of Economy of the Slovak Republic

Fig.: 4.4-1: Development of consumption of energy resources in the Slovak Republic

The expected development of the consumption of energy resources in the Slovak Republic is clearly set out in Figure 4.4-1. Table 4.4-1 shows an overview of development of the gross domestic energy consumption and its anticipated further development.

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002	2003
Gross domestic consumption [PJ]	755	744	766	780	777	756	761	768	792	791	798
Year	2004	2005	2010	2015	2020	2030					
Gross domestic consumption [PJ]	806	808	801	820	836	831					

Source: Ministry of Economy of the Slovak Republic
Note * new methodology as from 2001
Table 4.4-1 Development of gross domestic energy consumption

Tables 4.4-2 and 4.4-3 show the respective expected development of the extraction or consumption of brown coal and natural gas as the fuels most frequently used as cogeneration resources at present.

Year	2005	2010	2015	2020	2030
Brown coal extraction [kt]	2,400	2,400	2,100	1,800	900

Source: Ministry of Economy of the Slovak Republic
Table 4.4-2: Expected development of brown coal extraction

Year	2005	2010	2015	2020	2030
Total natural gas consumption [bill. m^3]	6.5	6.9	6.95	7.0	7.1

Source: Ministry of Economy of the Slovak Republic
Table 4.4-3: Expected development of natural gas consumption

Tables 4.4-4 and 4.4-5 and Figure 4.4-2 show the expected development of electricity and heat generation.

Year	2005	2010	2015	2020	2030
Electric energy generation [TWh]	31.0	26.5	38.1	38.1	35.5

Source: Ministry of Economy of the Slovak Republic
Table 4.4-4: Expected development of electric energy production

Year	2005	2010	2015	2020	2030
Heat generation in CHS [PJ]	111.35	111.08	112.59	113.46	115.52
Heat generation in DHS (decentralised heat supply) [PJ]	83.50	88.51	92.05	93.89	96.14

Source: SEA
Table 4.4-5: Expected development of heat production

[Figure – 'Expected development of energy production']

(Key: výroba tepla v TJ a elektriny v GWh = heat generation in TJ and electricity generation in GWh, rok = year, teplo CZT = heat generated via CHS resources, teplo DZT = heat generated via DHS resources, elektrina = electricity)

Fig. 4.4-2 Expected development of energy production

4.5 Cogeneration technology

Chapter 4.3 provides a short description of the existing situation of cogeneration technologies in the Slovak Republic. It is clear that, at present, electricity produced via steam extraction-condensing or backpressure turbines is the most prominent. With respect to expected economic development in the Slovak Republic, one cannot expect that mass replacement of the existing structure of cogeneration could be realised. It is clear that new technologies will be preferred to a more considerable extent, as characterised by:

- higher energy efficiency;
- higher proportion of electricity production;
- higher flexibility concerning required changes in the unit output;
- lower operating expenses;
- flexibility of fuels used;
- technologies enabling production of cooling as well as production of heat.

The utilisation of new technologies will be influenced in particular by:

- the situation on the fuel market (primarily - import possibilities and price);
- promotion of renewable fuels in cogeneration to a more considerable extent;
- prices of fossil fuels and nuclear fuel;
- purchase price of electricity from different cogeneration technologies;
- the importance of useful heat or of useful cooling in the future;
- support of cogeneration on the part of the state in the form of purchase prices of output energy of by means of investment incentives.

Based on the abovementioned facts, it is possible to expect the following development in respect to the development of new or reconstruction of existing cogeneration resources:

Technology	Expected development
Steam and gas cycle	With respect to the possibility of useful heat or cooling placement for economically acceptable installed outputs of the respective technology, it is not possible to rely on an extensive implementation of the respective technology. In the Slovak Republic, there are very few locations where the installation of the respective technology would be economically acceptable.
Gas turbines with heat regulation	• Presumption of a more extensive utilisation of this technology in the Slovak Republic is based particularly on the possibility of subsidy either in the form of purchase prices or investment incentives as well as by means of the development of prices of natural gas.
Steam turbines – brown coal	• As this concerns technology that is economically efficient at higher outputs, no increase is expected in the number of units working on this basis; • Due to the fact that most of the existing resources have been in operation for more than 30 years, there is a presumption of their gradual reconstruction, aiming at: § increased energy efficiency; § increased share of electricity production; § possibility of burning renewable fuels; § increased flexibility of the respective resources; § flexibility of fuels used; § fulfilment of operating requirements for environmental protection.
Steam turbines – black coal	• For the respective technology, the same as is specified in the previous cell of this table shall be applicable.
Steam turbines – liquid and gas fuels	• For the respective technology, the same as is specified in the previous cell of this table shall be applicable. • In addition, it will be necessary to assess the operation of the respective technologies in terms of increase in prices of products based on crude oil and natural gas.
Steam turbines – renewable resources	• As this concerns technology that is economically efficient at higher outputs, no increase in the number of resources working on this basis is expected. • Possibility of the respective technology promotion is based on gradual substitution of the fuel base in case of steam resources using brown or black coal.
Steam engines – renewable resources	• As this concerns technologies that are economically efficient at lower installed outputs, the future utilisation thereof is expected. • Utilisation of the respective technology is conditional both on investment incentives and on determination of a fixed purchase price of electricity produced.
Combustion engines – natural gas	• The respective technology is installed in the Slovak Republic in many applications. Its further extensive utilisation depends in particular on development of RES prices. Possibility of its utilisation in particular in the service industries.
Micro-turbines	• The respective technology has not been used in the Slovak Republic yet. Its more extensive utilisation is expected in the case of installations directly in building other manufacturing characters than using natural gas combustion.
Combustion engines – biogas	• A more extensive utilisation of the respective technology in the Slovak Republic is conditioned in particular by the possibility of subsidies or in the form of purchase prices or by means of investment incentives. • It is possible to use biogas from waste water treatment plants or biogas generated during agricultural biomass fermentation. • In case of insufficient stimulation, it is possible to utilise the respective technology in the process of biogas production based on solid biomass.
ORC (Organic Rankin Cycle)	• The respective technology has not been used in the Slovak Republic. Yet It is expected that the respective technology in relation to biomass combustion will be used. A combination of a cogeneration unit (a boiler burning biomass with subsequently activated ORC) and a boiler using natural gas intended for peak operation of the unit appears to be meaningful. • Another possible use for the ORC will be utilisation of residual heat, e.g. from exhaust-heat boilers during the existing generation based on gas turbines.
Stirling engines	• As the respective technology is primarily in the stage of trial operation, it is not expected to be applied extensively in the Slovak Republic in the near future. It will remain in the stage of pilot projects and trial operations.
Fuel cells	• With respect to enormous investment expenses, extensive application of the respective technology is not expected until 2020. The respective technology will remain in the stage of pilot projects or trial operation.

Table 4.5-1: Expected development of implementation of new CHP technologies or reconstruction of theirs

4.6 Economic conditions of cogeneration application on the energy market

Application of cogeneration on the energy market depends on multiple economic factors, of which in particular the following are of great importance:

- investment expenses of individual cogeneration technologies;
- prices of the individual fuels applied in cogeneration;
- purchase prices of electric energy and heat;
- operating parameters; in particular, operating efficiency of the respective unit;
- annual utilisation of the installed output;
- relating operating specific expenses of the respective technologies.

One of the most important factors of the assessment of the efficiency of the implementation of cogeneration resources is the investment exigency of the installed electric output thereof (in kW). Table 4.6-1 shows an overview of investment expenses relating to individual cogeneration technologies, which should be taken into account in case of the application thereof in the Slovak Republic. The details for 2005 are based on the average actual prices in the Slovak Republic; where the respective technology has not been installed in the Slovak Republic, the average price shows the respective investment in the EU Member States in which the respective technology was installed and used. The expected development of investment results from multiplication of the initial price by the amount of inflation expected in the Slovak Republic. The expected development of specific investment may be considerably different, in particular in the case of technologies which are still being developed (e.g. photovoltaic systems), and which may even reach an adverse tendency. Table 4.6-1 and Figure 4.6-1 provide a summary of the details of specific investment expenses.

Technology	Specific investment exigency of the cogeneration resource in relation to installed electric output [SK/kW]			
	2005	2010	2015	2020
Steam and gas cycle	42,000	46,645	51,803	57,532
Gas turbines with heat regulation	38,000	42,202	46,870	52,053
Steam turbines - solid fuels	52,000	57,751	64,137	71,230
Steam turbines – liquid and gaseous fuels	39,000	43,313	48,103	53,423
Steam engines – renewable fuels	56,000	62,193	69,071	76,710
Gas engines and turbines	66,000	73,299	81,405	90,408
Micro-turbines	52,000	57,751	64,137	71,230
Combustion engines	35,000	38,871	43,169	47,944
ORC – cycles	134,000	148,819	165,277	183,555
Stirling engines	82,000	91,068	101,140	112,325
Fuel cells	660,000	560,000	540,000	540,000

Table 4.6-1: Specific investment exigency of cogeneration resources

Fuel	Specific price of fuel [SK/GJ]			
	2005	2010	2015	2020
Brown coal – Czech (including import)	102	112	122	133
Brown coal – Slovak	103	113	124	134
Black coal	115	127	138	150
Biomass	129	142	155	168
Natural gas – high consumption	298	334	374	419
Natural gas – medium consumption	309	346	388	434
Natural gas – low consumption	358	401	449	503
Nuclear fuel	54	68	74	78

Table 4.6-2: Specific fuel prices

Technology	Fixed purchase prices of electricity produced via cogeneration [SK/MWhJ]			
	2005	2010	2015	2020
Steam and gas cycle (within 50 MW of the installed electric output)	1,950	2,100	2,250	2,450
Gas turbines with heat regulation	1,800	1,950	2,100	2,250
Steam turbines – brown coal	1,900	2,050	2,200	2,400
Steam turbines – black coal	1,650	1,800	1,950	2,100
Steam engines – liquid and gaseous fuels	1,800	1,950	2,100	2,300
Combustion engines – natural gas	2,0580	2,250	2,500	2,700
Micro-turbines	3,000	3,500	4,000	4,500
Combustion engines – biogas	2,500	2,800	3,200	3,400
ORC – cycles	3,500	4,500	5,000	5,000
Stirling engines	3,000	4,000	4,500	5,000
Fuel cells	3,000	6,000	8,000	10,000

Table 4.6-3: Fixed purchase prices of electricity produced via cogeneration

Technology	Prices of heat generated in the CHP [SK/GJ]			
	2005	2010	2015	2020
Steam and gas cycle	329	368	412	461
Gas turbines with heat regulation	410	459	514	576
Steam turbines – brown coal	255	280	306	332
Steam turbines – black coal	285	313	342	333
Steam engines – liquid and gaseous fuels	320	358	401	449
Steam turbines –renewable resources	240	264	288	312
Combustion engines – natural gas	450	504	564	632
Micro-turbines	-	540	605	678
Combustion engines – biogas	-	500	550	600
ORC - cycles	-	520	570	620
Stirling engines	-	580	640	680
Fuel cells	-	[1)]	[1)]	[1)]

Note: [1)] prices will be determined by means of electricity purchase prices

Table 4.6-4: Prices of heat produced via cogeneration

Technology	Other specific operating expenses [SK/GJ]			
	2005	2010	2015	2020
Steam and gas cycle	31	33	36	38
Gas turbines with heat regulation	22	23	26	28
Steam turbines – solid fuels	19	20	22	23
Steam engines – liquid and gaseous fuels	68	72	76	78
Steam engines – renewable fuels	58	60	63	65
Gas engines and turbines	-	54	58	61
Micro-turbines	44	46	49	50
Combustion engines	-	58	60	63
ORC - cycles	-	76	79	82
Stirling engines	-	-	70	74
Fuel cells	31	33	36	38

Table 4.6-5: Other specific operating expenses

[Figure – 'Specific investment exigency of cogeneration resources']

(Key: merné investície [Sk/kW] = specific investment, (illegible text), parne stroje = steam engines, plynove motory a turbiny = gas engines and turbines, mikroturbiny = micro-turbines, spa•ovacie motory = combustion engines, ORC – cykly = ORC cycles, Stirlingove motory = Stirling engines, palivove •lánky = fuel cells)

Fig. 4.6-1: Comparison of specific investment exigency of cogeneration resources

An important factor for the economic assessment of the implementation efficiency of cogeneration unit operation is fuel prices relating to the cogeneration process. Table 4.6-2 and Figure 4.6-2 provide a comparison of the specific prices of fuels relevant for cogeneration. The average specific prices are always related to the calorific capacity of the respective fuel.

[Figure – 'Specific prices of cogeneration resource fuels']

(Key: merné ceny palív [Sk/GJ] = specific prices of fuels, hnede uhlie •eské = brown coal Czech, hnede uhlie slovenske = brown coal Slovak, •ierne uhlie = black coal, ZPN-ve•koodber = RES-large consumption, ZPN-stredný odber = RES-medium consumption, ZPN-maloodber = RES-low consumption, jadrove palivo = nuclear fuel, biomasa = biomass)

Fig. 4.6-2: Comparison of specific prices of cogeneration resource fuels

[Figure - Purchase prices of electricity from cogeneration resources]

(Key: výkupná cena elektriny [Sk/kW] = purchase price of electricity, PPC (do 50 MW inštalovaného výkonu) = Steam and gas cycle (within 50 MW of the installed electric output), spalovacie turbiny s reguláciou tepla = gas turbines with heat regulation, parné turbiny – hnede uhlie = steam turbines – brown coal, parne turbiny – •ierne uhlie = steam turbines – black coal, parne turbiny – kapa•ne a plynne palivá = steam engines – liquid and gaseous fuels, spa•ovacie motory = combustion engines, mikroturbiny = micro-turbines, spa•ovacie motory-bioplyn = combustion engines-biogas, ORC-cykly = ORC cycles, Stirlingove motory = Stirling engines, palivove •lánky = fuel cells)

Fig. 4.6-3: Comparison of purchase prices of electricity from cogeneration resources

Another important factor for the economic assessment of implementation efficiency is purchase prices of electricity produced via the cogeneration process. Table 4.6-3 and Figure 4.6-3 provide an overview of such prices. Fixed purchase prices are determined on an annual basis pursuant to the Decree of the ÚRSO.

The economic assessment is made not only based on the price of electricity, but is also influenced by the price of heat. This price is determined by the generating organisation based on the regulation defined by the ÚRSO that approves the respective prices and subsequently inspects them. Table 4.6-4 and Figure 4.6-4 provide the average prices of useful heat in the Slovak Republic generated by means of various cogeneration technologies.

In addition to the factors specified in the previous paragraphs, the economic assessment is also influenced by other operating expenses, which includes: expenses relating to repairs, maintenance, inspections, fees for environmental contamination (e.g. disposal sites for solid contaminating substances, emissions, waste water, etc.), wage expenses, administrative overheads, etc. Table 4.6-5 provides a summary of the average other operating expenses for the individual cogeneration technologies in the Slovak Republic, based on practical knowledge. In the case of technologies that are not yet used in the Slovak Republic, the estimates of such expenses are based on experience of the EU Member States in which the respective technologies are used.

[Figure – 'Prices of heat from cogeneration resources']

(Key: cena tepla [Sk/GJ] = price of heat, spalovacie turbiny s reguláciou tepla = gas turbines with heat regulation, parné turbiny – hnede uhlie = steam turbines – brown coal, parne turbiny – •ierne uhlie = steam turbines – black coal, parne turbiny – kapa•ne a plynne palivá = steam engines – liquid and gaseous fuels, spa•ovacie motory = combustion engines, mikroturbiny = micro-turbines, spa•ovacie motory-bioplyn = combustion engines-biogas, ORC-cykly = ORC cycles, Stirlingove motory = Stirling engines, palivove •lánky = fuel cells)

Fig. 4.6-4: Comparison of prices of heat produced via cogeneration resources

The information provided in the tables and Figures above indicate that it is necessary to take into account the continual increase in all factors coming into the economic assessment of the implementation efficiency of cogeneration in the years to come. Only in the case of new technologies (e.g. photovoltaic systems) is it possible to rely on a reduction of investment expenses in respect of implementation to a more considerable extent.

4.7 Starting points of the analysis

The information provided in Chapters 4.1 - 4.6 indicates that:

- most of electricity in the Slovak Republic is produced via steam cycles on the basis of nuclear fuel (approximately 55%) or using fossil fuels (27%);
- approximately 14% of electricity is produced using RES and most electricity is generated in hydraulic power plants,
- heat is mostly generated in the CHS (58.5%), of which 54% is generated via cogeneration resources, with the most prominent fuel in the case of the CHS sources is natural gas (46.5%), followed by HU (brown coal) and •U (black coal) (15.5% or 12%); RES represents 6.2%;
- the most prominent fuel in DHS is natural gas;
- from cogeneration resources, 4,800 GWh is generated by means of cogeneration, which represents 16% of total electricity produced and approximately 59,000 TJ of heat, which represents 32% of total heat production;
- prevailing cogeneration technologies in the Slovak Republic are steam extraction-condensing and back-pressure turbines;
- for cogeneration resources, an increase in the use of renewable fuels is expected as well as a reduction in the consumption of solid fossil fuels;
- in terms of demand, an increase in demand for electricity is expected together with a slight increase in demand for heat from the CHS and a relatively steeper increase in demand for heat from the DHS;
- in terms of cogeneration technologies, in particular the following is expected:
    - § reconstruction of the existing technologies based on steam turbines;
    - § development of cogeneration resources based on combustion engines and turbines using natural gas as fuel;
    - § development of medium-sized and smaller cogeneration units combusting renewable fuels using various cogeneration technologies (combustion engines, ORC cycles, etc.);
    - § development of small cogeneration units utilising in particular new technologies (micro-turbines, small combustion engines, etc.).

5 Current situation

5.1 Objectives of the national policy

5.1.1 Objectives of the national policy in the energy industry

The objectives of the energy policy in the Slovak Republic in the long-term are as follows:

1) to provide such a volume of production of electricity so as to satisfy an economically justifiable demand;
2) to provide a safe and reliable supply of all forms of energy in the required quantity and quality with maximum efficiency;
3) to reduce the ratio of the gross domestic energy consumption in the gross domestic product - reduction of energy demand.

For the purpose of realisation of the energy policy objectives, the following basic priorities have been defined:

1) to replace phased-out production units used for electricity production so long as due to such a replacement the production of an amount of electricity is provided which could primarily satisfy an economically justifiable domestic demand;
2) to take measures towards energy savings and improvement of energy efficiency on the part of consumption;
3) to reduce dependence of energy supplies from risk areas – diversification of energy resources acquisition as well as transport routes;
4) to utilise domestic primary energy resources for economically justifiable electricity and heat production;
5) to increase the use of electricity and heat cogeneration,
6) to utilise the nuclear energy industry as a diversified, economically efficient and reasonably acceptable environmentally-friendly possibility for producing electricity and heat;
7) to provide for nuclear safety where nuclear power plants operate;
8) to increase the share of renewable energy resources in electricity and heat production with a view to creating reasonable subsidiary resources necessary to satisfy domestic demand;
9) to make units and networks that are able to provide for the safe and reliable transmission, transport and distribution of electricity and heat;
10) to build new connecting lines with a view to improving interconnection with the internal EU market as well as with the market of third parties,
11) to support the use of alternative fuels in transport.

5.1.2 Objectives of the national policy in the area of cogeneration

For the purpose of the realisation of the defined objectives whilst adhering to the basic priorities, the following forms are expected in the energy policy:

<u>Provision for electricity production necessary to satisfy demand</u>

- provision for new outputs in the area of electricity production by means of installation of new cogeneration units;
- increase in output of the existing units designed for cogeneration;
- increase in the share of electricity production from cogeneration resources.

<u>Safety and reliability of the supply of all forms of energy in the required quantity and quality</u>

- reconstruction of the existing cogeneration units;
- diversification of cogeneration resources – use .f renewable fuels

Reduction in energy demand

- replacement of independent electricity and heat production with high-efficiency cogeneration;
- increase in usability of cogeneration resources:
  - § by means of an increase in the quantity of useful heat;
  - § by means of tri-generation.

Increase in energy efficiency

- increase in energy efficiency of existing cogeneration resources;
- installation of new energy efficient cogeneration resources (resources fulfilling the criterion of high-efficiency cogeneration).

5.2 Indicators of national development

The indicators of development in the national energy industry are documented by means of 10-year development. The base year used was 1993 (the first year of independence of the Slovak Republic) and the target year was 2003.

Table 5.2-1 clearly indicates the statistical development of gross domestic consumption.

Indicator	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002	2003
Gross domestic consumption [PJ]	755	744	766	780	777	756	761	768	792	791	798

Source: Ministry of Economy of the Slovak Republic

Note * new methodology as from 2001

Table 5.2-1: Development of gross domestic energy consumption

Figure 5.2-1 shows the development of GDP in fixed prices from 1995 and the development of demand for energy, from which it is clear that the increase in the GDP in the previous period was accompanied by the consumption of balanced energy resources. As from 1993, an annual average decrease in energy demand of 4% appears, which is caused in particular by the development of production with an increased added value and by the implementation of cost-effective measures in terms of both production and consumption.

[Figure: 'Development of GDP and demand for energy']

(Key: mld. Sk = SK bil., HDP = GDP, energetická náro•nos• = energy demand, pravá os = right axis)

Source: Ministry of Economy of the Slovak Republic
Fig. 5.2-1: Development of GDP and energy demand

[Figure – 'Energy demand in terms of purchasing power parity (PEZ/GDP ppp)']

(Key: mld. EUR = EUR billion, Slovensko = Slovak Republic, pomer energetickej náro•nosti SR ku EU15 = comparison of energy demand of the SR with the EU15, pravá os = right axis)

Source: Ministry of Economy of the Slovak Republic
Fig. 5.2-2: Energy demand in terms of purchasing power parity

The above Figure indicates that in 1995, the energy demand of the Slovak Republic was 2.3 times higher than the average in the EU-15; in 2003, this indicator was only 1.9 higher. Despite this positive development, the main reason for the consistently high energy demand is the persistent dominant share of the industry in formation of the GDP.

Figure 5.2-3 compares the consumption of PES per capita in the Slovak Republic and in the EU-15. PES consumption per capita in the Slovak Republic is still lower than the average in the EU-15 and amounts to less than 150 GJ per capita.

[Figure – 'PES consumption per capita']

(Key: PEZ/obyv. = PES per capita, Slovenska = of the Slovak Republic, pomer spotreby Slovensko/EU = consumption ratio the Slovak Republic/EU, pravá os = right axis)

Source: Ministry of Economy of the Slovak Republic

Fig. 5.2-3: PES consumption per capita in terms of GJ per capita

Based on the information on final consumption, it is possible to say that the final energy consumption has an annual downward trend. The reason for this is a gradual implementation of cost-cutting measures for consumption.

Indicator	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002	2003
Final energy consumption [PJ]	545	507	512	519	499	500	491	473	461	464	444

Source: Ministry of Economy of the Slovak Republic

Note * new methodology as from 2001

Table 5.2-2: Development of the final energy consumption

5.2.1 Trends in the structure of the use of fuels in the energy industry

Table 5.2.1-1 and Figure 5.2.1-1 show the development of fuel consumption intended for electricity and heat production.

Fuel	Fuel consumption [TJ]							
	Centralised heat		Decentralised heat		Electricity		Total	
	1993	2003	1993	2003	1993	2003	1993	2003
Solid fuels	64,604	24,015	6,373	5,158	62,081	78,102	133,058	107,275
Liquid fuels	27,308	9,661	2,894	250	12,520	5,122	42,722	15,033
Gaseous fuels	56,996	99,268	85,940	91,945	83,100	33,664	226,036	224,877
Nuclear fuel	1,005	2,015	0	0	131,614	207,645	132,619	209,660
Other	0	0	0	0	0	844	0	844
Total	149,913	134,959	95,207	97,353	289,315	325,377	534,435	557,689
Generation efficiency	0.854	0.860	0.836	0.843	0.322	0.345	-	-

Table 5.2.1-1: Development of fuel consumption for electricity and heat production

Based on the data provided in Table 5.2.1-1 and Figure 5.2.1-1, we can see a considerable decline in liquid fuel consumption in respect to fuel consumption for energy-related purposes, as well as a decline in liquid fuel consumption. Consumption of natural gas for energy-related purposes is relatively balanced. In respect to nuclear fuel, there is an increase resulting from the commissioning of two units in Mochovce nuclear power plant.

[Figure – 'Development of fuel consumption in the energy industry']

(Key: spotreba tepla v palive = consumption of heat in fuel, tuhé palivo = solid fuel, kvapalné palivo = liquid fuel, plynné palivo = gaseous fuel, jadrove palivo = nuclear fuel, iné = other)

Fig. 5.2.1-1: Development of fuel consumption for the purpose of electricity and heat production

5.2.2 Trends in the volumes of energy production

Table 5.2.2-1 and Figure 5.2.5-1 clearly indicate the development of electricity and heat production in the period subject to monitoring.

Type of energy	Energy production	
	1993	2003
Electricity [GWh]	25,874	31,178
Electricity [TJ]	93,146	112,241
Useful heat – CHS [TJ]	128,060	116,007
Useful heat – DHS [TJ]	79,567	82,092
Energy in total [TJ]	300,773	310,340

Table 5.2.2-1: Development of electricity and heat generation

[Figure – 'Development of electricity and heat production']

(Key: výroba energie [TJ] = energy production, Elektrina [TJ] = electricity, využitelné teplo = useful heat)

Fig. 5.2.2-1: Development of electricity and heat production

When monitoring the development of electricity production in the given period, a gradual increase is apparent. This is the result of drastic attenuation of industrial production in the years 1990-1992, the consequence of which was a considerable impact on electricity production at the beginning of the period subject to monitoring.

In the case of centralised production of useful heat, a downward tendency is visible, which results from:

- reduction in energy demand in respect to both technologies and heated premises;
- gradual disconnection of consumers from the CHS and their transfer to the area of the DHS, which is caused in particular by distorted prices on the heat market.

In the case of decentralised production of useful heat, a slight increase is visible. Two conflicting tendencies influence this indicator, namely:

- reduction in demand for energy for heated premises;
- development of new premises and disconnection from the CHS.

5.2.3 Trends in energy investment

Table 5.2.3-1 and Figures 5.2.3-1 and 5.2.3-2 clearly indicate the increase in installed output and gross electricity production.

Fuel	Installed output		Gross electricity production	
	1993	2003	1993	2003
Nuclear fuel	1,760	2,640	11,323	17,864
Hydroelectric energy	2,093	2,507	3,891	3,672
Fossil and renewable fuels	3,262	3,052	8,667	9,612
Other primary energy resources	0	10	0	30
Total	7,115	8,212	25,874	31,178

Table 5.2.3-1: Development of electricity and heat production

[Figure – ‘Development of the installed output of electricity resources]

(Key: inštalovaný výkon [MW] = installed output, jadrové palivo = nuclear fuel, vodná energia = hydroelectric energy, fosilne and obnovitelné zdroje = fossil and renewable resources, iné zdroje primárne energie = other primary energy resources)

Fig. 5.2.3-1: Development of the installed output in the electricity resources

In terms of individual types of fuels, an increase in the installed output of nuclear fuel and hydroelectric energy is visible. Output of units using fossil fuels is decreasing gradually, in particular due to their phasing-out. In terms of renewable solid fuels, a gradual increase is visible; however, the share thereof in terms of overall fuel consumption is low.

In terms of electricity, there is a considerable increase, notably in nuclear fuel. A decrease in fossil fuels is obvious. The amount of electricity produced on a water base depends on total rainfall in the respective catchment areas and is therefore substantially changeable. In terms of percentage, electricity production in hydroelectric power plants varies between 13% and 19%.

[Figure – ‘Gross electricity production’]

(Key: výroba elektriny[GWh] = electricity generation, jadrové palivo = nuclear fuel, vodná energia = hydroelectric energy, fosilne and obnovitelné zdroje = fossil and renewable resources, iné zdroje primárne energie = other resources of primary energy)

Fig. 5.2.3-2: Development of gross electricity production

6 Determination of the technical potential of cogeneration

The total volume of useful heat in the Slovak Republic represents approximately 198,000 TJ. Of this amount, 62,500 TJ – or 31.5% - represents useful heat produced via the process of cogeneration. The rest represents production via CHS resources (heating stations and centralised boiler plants – approximately 53,500 TJ (27%), or decentralised boiler plants and individual resources – approximately 82,000 TJ, or 41.4%.

In addition, approximately 68.5% of useful heat produced in the Slovak Republic is produced by means of separate production. It is evident that the cogeneration process cannot replace the entire volume of separate heat production. In the following Chapters, we provide an analysis, which indicates how much separate heat production in the individual groups of resources cogeneration may replace.

6.1 Cogeneration technologies relevant for various market sectors

The following table indicates possibilities for individual cogeneration applications for new medium-sized and small units in the locations of existing heat resources in relation to the fuel and heat supply unit used.

Cogeneration technology	Fuel	Useful heat supply system	Heat consumption character	Supplies for various market sectors
Type of source: Heating station				
steam boiler + steam back-pressure turbine	coal, heavy fuel oil, natural gas, biomass	steam, hot water after transformation in heat extraction station	relatively constant consumption with a high proportion of process extraction	a high proportion of industries + a low proportion of municipal sector
gas turbine, + exhaust-heat boiler + peak hot-water boiler	natural gas	very hot water, hot water after transformation	less changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities, industries
steam boiler, steam engine + peak hot-water boiler	biomass natural gas	steam, hot water after transformation	less changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities, smaller industries
incinerating facility, combustion engine + peak hot-water boiler	biomass natural gas	very hot water, hot water after transformation	less changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities, industries
combustion engine + peak hot-water boilers	natural gas	very hot water, hot water after transformation	considerably changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities
Type of source: Centralised boiler plant				
boiler, ORC cycle + peak boiler	natural gas biomass	hot water	changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities, smaller industries

incinerating facility, combustion engine + peak boiler	biogas natural gas		less changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities, industries
combustion engine + peak boiler	natural gas		considerably changeable consumption depending on the outside temperature	municipal sector – apartments, services, state-administration premises, hospitals, community facilities
Type of source: Decentralised boiler plant				
combustion engine + peak boiler	natural gas	hot water	considerably changeable consumption depending on the outside temperature	premises of non-industrial character (residential premises, state-administration premises, hospitals, hotels, schools, rental office buildings, etc.)
micro-turbine + peak boiler	natural gas			
combustion engine + peak boiler	biogas		changeable consumption depending on the outside temperature	free-standing premises of non-industrial character
fuel cells – peak boiler	natural gas		considerably changeable consumption depending on the outside temperature	premises of non-industrial character (residential premises, state-administration premises, hospitals, hotels, schools, rental office buildings, etc.)
Type of source: Individual source				
combustion engine + peak boiler (anti-noise and anti-vibration measures)	natural gas	hot water	considerably changeable consumption depending on the outside temperature	family houses, small premises
micro-turbine + peak boiler	natural gas			
fuel cells – peak boiler	natural gas			

Table 6.1-1: Application of the individual cogeneration technologies from new medium-sized and small resources

Table 6.1-2 indicates the possibilities for the application of cogeneration technologies after reconstruction and modernisation of the existing cogeneration resources.

Existing technology	Technical possibilities
power plants: boilers designed for coal combustion + extraction-condensing turbines	• reconstruction of boilers to enable combustion of biomass together with coal; • installation of new boilers enabling combustion of biomass; • additional installation (where technically possible and economically profitable) of back-pressure turbines with a view to increasing energy efficiency
combined heat and power stations: boilers designed for coal combustion + back-pressure turbines	• reconstruction of boilers to enable combustion of biomass together with coal; • installation of new boilers enabling combustion of biomass; • additional installation (where technically possible and economically profitable) of condensing turbines with a view to increasing electricity

	production and improving the provision of energy services
combined heat and power stations: boilers designed for liquid fuels + back-pressure turbines	• installation of new boilers enabling combustion of biomass (only in locations where this is technically possible); • additional installation (where technically possible and economically profitable) of condensing turbines with a view to increasing and improving electricity production; • installation of gas turbines and exhaust-heat boilers with a view to improving the provision of energy services; • installation of the PPC
combined heat and power stations: boilers designed for combined combustion of solid and liquid fuels + turbines (back-pressure , extraction-condensing)	• application of the abovementioned selected measures

Table 6.1-2: Application of individual cogeneration technologies for modernised cogeneration resources.

Table 6.1-2 indicates that the reconstruction or modernisation of existing cogeneration resources under conditions available in the Slovak Republic – either power plants or combined heat and power stations – is in consideration. Most of such sources are outdated both technologically and technically (the majority of them are between 30 and 55 years old). No radical reconstructions and modernisation are intended in terms of the steam and gas cycle and in gas turbine and combustion engine technologies, given that the respective cogeneration resources were installed in the course of the last 10 to 15 years.

In addition to the above-mentioned possibilities, there is also the possibility - available under the conditions in the Slovak Republic - of a comprehensive re-structuring of the energy industry of the selected location including installation of the steam and gas cycle.

6.2 Technical potential of the increase in cogeneration of useful heat supplied by centralised heating stations and boiler plants

Heat supplied from heating stations and centralised boiler plants is supplied in the form of:

- steam;
- very hot water;
- hot water.

Table 4.2-1 clearly indicates the structure of fuels in heating stations and centralised boiler plants. Natural gas is the most frequently used fuel. Renewable and secondary fuels are particularly used in industries.

The total theoretical potential (all useful heat from the respective types of sources) represents 52,472 TJ. Recalculation of the theoretical potential to the technical potential is performed in accordance with the methodology set out in Chapter 6.6 and conducted in Chapter 6.7.

As a replacement for the existing independent heat generation, the following cogeneration technologies come into question:

- steam boiler, steam back-pressure turbine;
- gas turbine, exhaust-heat boiler + peak boiler;
- steam boiler, steam engine – peak boiler;
- incinerating facility, combustion engine – peak boiler;
- boiler, ORC cycle – peak boiler.

The following fuels in particular come into question:

- natural gas;
- biomass;
- biogas;

It is also possible to use other fuels to a certain extent.

6.3 Technical potential of the increase of cogeneration for useful heat, as supplied by decentralised and separate sources

Heat supplied from decentralised boiler plants and individual sources is supplied in the form of hot water.

Figure 4.2-1 clearly indicates the structure of fuel in such sources. The most frequently used fuel is natural gas oil. Renewable and secondary fuels are utilised to a very limited extent.

The total theoretical potential (all useful heat from the respective types of sources) represents 82,092 TJ. Recalculation of the theoretical potential to the technical potential is performed in accordance with the methodology set out in Chapter 6.6 and conducted in Chapter 6.7.

As a replacement for the existing independent heat production, the following cogeneration technologies come into question:

- micro-turbine + peak boiler;
- combustion engine + peak boiler]
- fuel cells + peak boiler.

The fuels that come into question are notably natural gas, biogas - to a limited extent - and biomass. It is also possible to use other fuels to a certain extent.

6.4 Technical potential of increase in demand for cooling, which may be produced by means of heat

Cooling based on tri-generation is, under the conditions of the Slovak Republic, installed to a limited extend only. Estimations of demand for such a technology as well as assessment of technical conditions of the respective installations are based mainly on experience of the EU Member States in which such a technology is used and on the climatic conditions of the Slovak Republic.

Supplies of cooling come into question in particular with respect to centralised boiler plants and boiler plants installed in non-industrial premises serving as office space, state-administration premises, hospitals, accommodation facilities, etc. or in the food industry.

Based on a survey of the current situation, climatic conditions and experience relating to the installation of similar technologies in the EU-15 Member States, the technical potential of useful heat for production of cooling in cogeneration units replacing independent heat production in centralised boiler plants is estimated to be 1,815 TJ. The technical potential of useful heat for production of cooling in cogeneration units replacing independent heat production in decentralised boiler plants is estimated to be 4,720 TJ.

6.5 Technical potential of the modernisation of existing cogeneration units

Determination of the technical potential is based on gradual reconstruction and modernisation of existing cogeneration units that are older than 15 years. In addition to the above, such a category of resources includes technologies based on steam back-pressure turbines and extraction-condensing turbines. Steam and gas cycle, gas turbines with heat regeneration and combustion engine technologies were installed after 1990, which means that their reconstruction is now improbable.

The theoretical potential of such modernisation represents in total:
- 76 units designed for cogeneration (steam back-pressure and extraction-condensing turbines);
- 2,162 MW of installed electric output;
- 3,424 GWh of generated electric energy;
- 52,997 TJ of useful heat.

In facilities such as power plants and combined heat and power stations designed for cogeneration, the following methods of modernisation come into question:
- reconstruction of boilers to enable them to also incinerate biomass;
- installation of new boilers for combustion of biomass;
- additional installation (where technically possible and economically profitable) of back-pressure turbines with a view to increasing energy efficiency;
- additional installation (technically possible and economically profitable) of condensing turbines with a view to increasing electricity production and improving provision of energy services;
- installation of gas turbines and exhaust-heat boilers with a view to improving the provision of energy services;
- installation of the steam and gas cycle.

6.6 Method of calculating technical potential

The technical potential of the Slovak Republic is calculated separately for each technological group of facilities designed for cogeneration. The method of calculation is uniform and is based on the total potential relating to independent electricity and heat production. The starting point is demand for useful heat. The total demand for useful heat is then multiplied by coefficients of the individual technological groups.

- Coefficient of recalculation of the total demand for useful heat for the individual technological groups
  This coefficient considers possibilities of substitution of independent electricity and heat production by means of the respective cogeneration technology.

- Coefficient of the combined-heat-and-power-station module
  This coefficient considers the ratio of useful heat produced in the cogeneration process to the total useful heat produced in the cogeneration resource.

- Cogeneration coefficient
  This coefficient takes into account the ratio between the electricity/mechanical power produced in the cogeneration process and the useful heat produced from the cogeneration process within the balance interval.

- Coefficient of an increase in demand for useful heat intended for producing cooling
  This coefficient takes into account probable demand for cooling produced in cogeneration for the respective technology.

- Coefficient of other impacts on the cogeneration process
  This coefficient takes into account planned as well as unplanned outages of the unit (general repairs, common repairs, failures, etc.), during which the cogeneration unit is out of operation.

- Coefficient of an increase in demand for cogeneration due to an increase in demand for electricity and heat
  The respective coefficient takes into account an increase in demand for electricity and useful heat in the future until 2020.

- Time of maximum utilisation
  The time of maximum utilisation specifies the time during which the respective unit would have to be operated at nominal capacity to produce the same quantity of energy as it is generated during ordinary annual operation of the respective unit.

- Coefficient of the reserve of capacity
  This coefficient takes into account all reserves, the level of over-design of the respective unit as well as ratio of non-operating output of the respective units.

The specific values for the individual coefficients necessary for calculation of the CHP technical potential were determined on the basis of ~~specific~~ average values reached for the respective types of technology. In case of resources using technologies that have not yet been implemented in the Slovak Republic, the average values for operation in the respective units in the EU-15 Member States were used.

6.7 Total technical potential of cogeneration

Table 6.7-1 and Figure 6.7-1 clearly indicate the total technical potential of high-efficiency cogeneration in the Slovak Republic in terms of technology and capacity of resources to 2020.

Classification of sources	Technology	Fuel	Generation of electricity in the cogeneration process [GWh]			
			Situation in 2005	Potential until 2020	Increase in technical potential	Note concerning increase in potential
Large sources (> 10 MW.)	steam and gas cycle (> 10 MW el.)	natural gas	1,079.9	1,433.9	354	new source
	steam extraction-condensing turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	1,350.6	1,539.7	189	modernisation of existing sources
	steam back-pressure turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	2,102.3	2,459.7	357	
Medium-sized sources (> 1 MW $_{el}$.)	steam back-pressure turbine (> 1 MW $_{el}$.)	natural gas, solid	25.4	25.4	0	modernisation
	steam back-pressure turbine (> 1 MW $_{el}$.)	biomass	0.3	378.3	378	new sources
	steam extraction-condensing turbine (> 1 MW $_{el}$.)	solid	0.5	0.5	0	
	gas turbine (> 1 MW $_{el}$.)	natural gas	123.6	1,365.3	1,242	
	steam engine (> 1 MW $_{el}$.)	biomass	0.0	88.2	88	
	incinerating facility + combustion engine (> 1 MW $_{el}$.)	biogas	0.0	141.1	141	
	large combustion engine (> 1 MW $_{el}$.)	natural gas	61.8	3,057.1	2,995	
	ORC cycle (> 1 MW $_{el}$.)	biomass	0.0	137.2	137	
Small sources (< 1 MW $_{el}$.)	small combustion engine (< 1 MW $_{el}$.)	natural gas	117.4	6,521.3	6,404	new sources
	small combustion engine (< 1 MW $_{el}$.)	biogas	0.0	337.0	337	
	micro-turbine (< 1 MW $_{el}$.)	natural gas	0.0	1,855.6	1,856	
	fuel cells (< 1 MW $_{el}$.)	natural gas	0.0	571.7	572	

Table 6.7-1: Technical potential of the high-efficiency CHP in the SR in terms of the technology and capacity of the sources to the year of 2020.

[Figure: 'Technical potential of cogeneration in terms of technology']

(Key: výroba elektriny = electricity generation, parná odberovo kondeza•ní turbina = steam extraction-condensing turbine, sply•ovacie zariadenie = incinerating facility, palivove •lánky = fuel cells, stav k roku = situation to the year of, illegible text)

Fig. 6.7-1: Technical potential of high-efficiency cogeneration in the Slovak Republic in terms of technologies and capacities of the sources to the year 2020

The table and figure above indicate that the highest technical potential in the Slovak Republic in the case of cogeneration installation is represented by the technology of combustion engines in medium-sized and small units. In case of large units, there is a certain potential for the steam and gas cycle and, in case of other technologies, gradual modernisation is being considered.

Considerably lower cogeneration potential is in case of medium-sized and small units utilising technologies combusting renewable sources and communal and industrial waste.

As far as modernisation of large units is concerned, the potential is represented in particular by the separate combustion of biomass. Further increase in capacities of large units utilising steam turbine technologies designed for natural gas or liquid fuels is not being considered.

Table 6.7-2 and Figure 6.7-2 provides a summary of the development of the technical potential of electricity produced by means of high-efficiency cogeneration.

Cogeneration resources	Parameter	Development of technical potential			
		2005 existing situation	2010	2015	2020
new resources	Generation of electricity in the cogeneration process [GWh]	0	3,481	8,412	14,504
	Installed electric output of the CHP unit [MW]	0	2,419	5,754	9,850
modernised resources	Generation of electricity in the cogeneration process [GWh]	0	1,013	2,409	3,492
	Installed electric output of the CHP unit [MW]	0	627	1,492	2,162
existing resources	Generation of electricity in the cogeneration process [GWh]	4,862	4,018	2,823	1,925
	Installed electric output of the CHP unit [MW]	2,462	1,835	970	300
Total cogeneration resources	Generation of electricity in the cogeneration process [GWh]	4,862	8,512	13,644	19,921
	Installed electric output of the CHP unit [MW]	2,462	4,881	8,216	12,312

Table 6.7-2: Development of the technical potential of electricity produced by means of high-efficiency cogeneration

[Figure: Development of the technical potential of electricity generation']

(Key: Výroba elektriny [GWh] = electricity production, existujúci stav = the existing situation, existujúce zdroje = the existing resources, modernizované zdroje = modernised resources, nové zdroje = new resources)

Fig. 6.7-2: Expected development of the technical potential of electricity produced by means of high-efficiency cogeneration

7 Determination of the economic potential of high-efficiency cogeneration

7.1 Method for calculating economic potential

Technical potential as determined in the previous Chapter forms a basis for the calculation to determine economic potential relating to the installation of new facilities as well as the modernisation of existing cogeneration units. It is logical that only a small part of the technically feasible investment also fulfils the criteria for respective investment profitability, without which such investment cannot be fulfilled under actual economic conditions. For this reason, Chapter 7 provides for the re-calculation of technical potential to economic potential, in which all criteria that have an impact on economic potential are taken into account. For this analysis, the criteria are divided into three groups:

- criteria for economic assessment of the investment;
- other criteria for assessment of the investment;
- time-related criteria for assessment of the investment.

7.1.1 Criteria for economic assessment of investments relating to technical potential

The economic criteria for each group of technologies pursuant to Chapter 6 are based on the following information:

- specific investment expenses;
- specific price of fuels;
- prices of heat;
- purchase and sales prices of electricity;
- other operating expenses;
- time of utilisation of the installed output;
- own electricity and heat consumption;
- combined-heat-and-power-station module;
- cogeneration coefficients;
- prepared investment incentives;
- prepared operating incentives.

On the basis of the abovementioned information, the basic economic criteria for profitability of investment in the respective technology were determined for each group of technologies. There is an assumption that the more economically profitable the respective investment is, the higher the investor's willingness to enter the respective investment.

Based on the abovementioned information and methods, coefficients of the respective investment profitability were determined for the individual cogeneration technologies pursuant to Chapter 6 as follows:

Classification of sources	Technology	Fuel	Economic coefficients of the respective investment profitability			
			by 2010	by 2015	by 2020	Note on the investment
Large sources (> 10 MW.)	Steam and gas cycle (> 10 MW el.)	natural gas	0.9	0.9	0.9	new source
	steam extraction-condensing turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	0.92	0.92	0.92	mod erniz ation of the exist ing

	steam back-pressure turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	0.95	0.95	0.95	
Medium-sized sources (> 1 MW $_{el}$.)	steam back-pressure turbine (> 1 MW $_{el}$.)	natural gas, solid	0.90	0.90	0.90	modernisation
	steam back-pressure turbine (> 1 MW $_{el}$.)	biomass	0.20	0.40	0.60	new sources
	steam extraction-condensing turbine (> 1 MW $_{el}$.)	solid	0.00	0.00	0.00	
	gas turbine (> 1 MW $_{el}$.)	natural gas	0.10	0.25	0.35	
	steam engine (> 1 MW $_{el}$.)	biomass	0.40	0.60	0.80	
	incinerating facility + combustion engine (> 1 MW $_{el}$.)	biogas	0.30	0.45	0.55	
	large combustion engine (> 1 MW $_{el}$.)	natural gas	0.15	0.20	0.30	
	ORC cycle (> 1 MW $_{el}$.)	biomass	0.25	0.35	0.45	
Small sources (< 1 MW $_{el}$.)	small combustion engine (< 1 MW $_{el}$.)	natural gas	0.15	0.25	0.40	new sources
	small combustion engine (< 1 MW $_{el}$.)	biogas	0.40	0.60	0.80	
	micro-turbine (< 1 MW $_{el}$.)	natural gas	0.07	0.15	0.25	
	fuel cells (< 1 MW $_{el}$.)	natural gas	0.05	0.10	0.20	

Table 7.1.1-1: Economic coefficients of the investment profitability

7.1.2 Other criteria for assessment of investments relating to technical potential

Other criteria for assessment of the investment represent willingness, ability and efforts on the part of investors to enter such new investments and related risks, to search for new solutions and to be willing to move towards energy savings and protection of the environment.

While determining coefficients for each group of cogeneration technologies coming into question in the Slovak Republic, the following criteria were taken into account:

- the main precondition for the realisation of the respective investment is the investor's interest to bear the risk for the following reasons:
  - ability to pay back the credit;
  - uncertainties concerning purchase prices and, in particular, prices of input fuels;
  - failure rate of new units;
  - uncertainty when adhering to the declared qualitative parameters of the unit;
  - uncertainty concerning weather conditions (in particular with respect to own cultivation of energy crop-plants).
- the project and construction readiness of the potential investor:
  - good-quality preparation of the project, in particular in the case of new, non-packaged units;
  - requirements for new premises, land and other related investments;
- the administrative management of the respective investment relating in particular to:
  - assessment and a correct selection from the offered options;
  - construction approval process;
  - final premises approval;

- putting the premises into trial operation;
- putting the premises into permanent operation;

- the management of the new technology operating demand:
  - in terms of necessary authorisations and knowledge of operation;
  - in terms of administrative and technical management of new technologies;
- active search for a modern solution of the existing situation:
  - in the area of energy savings;
  - in the area of the environment protection;
  - in the area of the services quality improvement.

Classification of sources	Technology	Fuel	Coefficients of the investment profitability based on other criteria			
			by 2010	By 2015	by 2020	Note concerning the investment
Large sources (> 10 MW.)	steam and gas cycle (> 10 MW el.)	natural gas	1.00	1.00	1.00	new source
	steam extraction-condensing turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	1.00	1.00	1.00	modernisation of existing sources
	steam back-pressure turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	1.00	1.00	1.00	
Medium-sized sources (> 1 MW $_{el}$.)	steam back-pressure turbine (> 1 MW $_{el}$.)	natural gas, solid	0.00	0.00	0.00	modernisation
	steam back-pressure turbine (> 1 MW $_{el}$.)	biomass	0.80	0.80	0.80	new sources
	steam extraction-condensing turbine (> 1 MW $_{el}$.)	solid	0.40	0.40	0.40	
	gas turbine (> 1 MW $_{el}$.)	natural gas	0.60	0.60	0.60	
	steam engine (> 1 MW $_{el}$.)	biomass	0.60	0.60	0.60	
	incinerating facility + combustion engine (> 1 MW $_{el}$.)	biogas	0.80	0.80	0.80	
	large combustion engine (> 1 MW $_{el}$.)	natural gas	0.60	0.60	0.60	
	ORC cycle (> 1 MW $_{el}$.)	biomass	0.80	0.80	0.80	
Small sources (< 1 MW $_{el}$.)	small combustion engine (< 1 MW $_{el}$.)	natural gas	0.15	0.15	0.15	new sources
	small combustion engine (< 1 MW $_{el}$.)	biogas	0.10	0.10	0.10	
	micro-turbine (< 1 MW $_{el}$.)	natural gas	0.10	0.10	0.10	
	fuel cells (< 1 MW $_{el}$.)	natural gas	0.20	0.20	0.20	

Table 7.1.2-1: Coefficients of investment profitability based on other criteria

7.1.3 Time-related criterion of the investment assessment

The time-related criterion of the investment assessment takes into account the fact that not all new cogeneration sources will be installed at the same time. In general, the same applies to investments in the modernisation of cogeneration units.

The time of commencement and subsequent completion of the respective investment depends on the following:

- economic, technological or physical service life of the existing cogeneration unit (modernisation) or of the facility designed for separate heat production (new cogeneration unit);
- presence of the investment means;
- project readiness of the investment;
- construction and contracting readiness of the investment;
- building permit.

Classification of sources	Technology	Fuel	Coefficients of the time-related criterion			
			by 2010	by 2015	By 2020	Note concerning the investment
Large sources (> 10 MW.)	steam and gas cycle (> 10 MW el.)	natural gas	1.00	1.00	1.00	new unit
	steam extraction-condensing turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	0.40	0.80	1.00	modernisation of the existing units
	steam back-pressure turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	0.40	0.80	1.00	
Medium-size sources (> 1 MW $_{el}$.)	steam back-pressure turbine (> 1 MW $_{el}$.)	natural gas, solid	0.35	0.70	1.00	modernisation
	steam back-pressure turbine (> 1 MW $_{el}$.)	biomass	0.35	0.70	1.00	new sources
	steam extraction-condensing turbine (> 1 MW $_{el}$.)	solid	0.35	0.70	1.00	
	gas turbine (> 1 MW $_{el}$.)	natural gas	0.35	0.70	1.00	
	steam engine (> 1 MW $_{el}$.)	biomass	0.10	0.70	1.00	
	incinerating facility + combustion engine (> 1 MW $_{el}$.)	biogas	0.20	0.70	1.00	
	large combustion engine (> 1 MW $_{el}$.)	natural gas	0.35	0.70	1.00	
	ORC cycle (> 1 MW $_{el}$.)	biomass	0.20	0.60	1.00	
Small sources (< 1 MW $_{el}$.)	small combustion engine (< 1 MW $_{el}$.)	natural gas	0.30	0.60	1.00	new sources
	small combustion engine (< 1 MW $_{el}$.)	biogas	0.20	0.50	1.00	
	micro-turbine (< 1 MW $_{el}$.)	natural gas	0.05	0.30	1.00	
	fuel cells (< 1 MW $_{el}$.)	natural gas	0.05	0.30	1.00	

Table 7.1.3-1: Coefficients of time-related criterion

7.2 Total economic potential

In Table 7.2-1 and in Figure 7.2-1, comparison of existing electricity production by means of the individual cogeneration technologies and of the economic potential of electricity production until 2020 is provided. The individual cogeneration technologies are classified by the installed electric output in large, medium-sized and small units.

Classification of sources	Technology	Fuel	Electricity produced in the cogeneration process [GWh]			
			Situation in 2005	Potential until 2020	Increase in economic potential	Note concerning increase in potential
Large sources (> 10 MW el.)	Steam and gas cycle (> 10 MW el.)	natural gas	1,079.9	1,398.9	319	new source
	steam extraction-condensing turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	1,350.6	1,635.6	284.9	modernisation of the existing units
	steam back-pressure turbine (> 10 MW $_{el}$.)	solid, liquid, gaseous, biomass, other	2,102.3	2,672.7	570.4	
Medium-sized sources (> 1 MW $_{el}$.)	steam back-pressure turbine (> 1 MW $_{el}$.)	natural gas, solid	25.4	25.4	0.0	modernisation
	steam back-pressure turbine (> 1 MW $_{el}$.)	biomass	0.3	181.4	181.1	new units
	steam extraction-condensing turbine (> 1 MW $_{el}$.)	solid	0.5	0.5	0.0	
	gas turbine (> 1 MW $_{el}$.)	natural gas	123.6	286.7	163.1	
	steam engine (> 1 MW $_{el}$.)	biomass	0.0	42.3	42.3	
	incinerating facility + combustion engine (> 1 MW $_{el}$.)	biogas	0.0	62.1	62.1	
	large combustion engine (> 1 MW $_{el}$.)	natural gas	61.8	550.3	488.5	
	ORC cycle (> 1 MW $_{el}$.)	biomass	0.0	49.4	49.4	
Small sources (< 1 MW $_{el}$.)	small combustion engine (< 1 MW $_{el}$.)	natural gas	117.4	391.3	273.9	New units
	small combustion engine (< 1 MW $_{el}$.)	biogas	0.0	27.0	27.0	
	micro-turbine (< 1 MW $_{el}$.)	natural gas	0.0	46.4	46.4	
	fuel cells (< 1 MW $_{el}$.)	natural gas	0.0	22.9	22.9	

Table 7.2-1: Economic potential of cogeneration in terms of technology

Based on the abovementioned information, it is clear that the highest cogeneration potential is the modernisation of existing large units equipped with steam turbines. For the purpose of modernisation of a part of the respective units, combustion or partial combustion of biomass is being considered. A significant share of the potential is also represented by the potential of combustion engines and gas turbines. A certain potential is represented by medium-sized sources using biomass or biogas as fuel.

[Figure: 'Economic potential of cogeneration in terms of technology'

(Key: výroba elektriny = electricity generation, parná odberovo kondeza•ní turbina = steam extraction-condensing turbine, sply•ovacie zariadenie = incinerating facility, palivove •lánky = fuel cells, stav k roku = situation to the year of, illegible text)

Fig. 7.2-1: Economic potential of cogeneration in terms of technology

Table 7.2-2 and Figures 7.2-1 and 7.2-2 show the development of the economic potential of electricity production and installed electric output of cogeneration units in the period of the years 2005-2020.

Cogeneration units	Parameter	Development of economic potential			
		2005 Existing situation	2010	2015	2020
New units	Electricity produced via the cogeneration process [GWh]	0	532	1,076	2028
	Installed electric output of the CHP unit [MW]	0	122	248	466
Modernised units	Electricity produced via the cogeneration process [GWh]	0	1,501	3,003	3,753
	Installed electric output of the CHP unit [MW]	0	758	1,516	1,895
Existing units	Electricity produced via the cogeneration process [GWh]	4,862	3,361	2,229	1,664
	Installed electric output of the CHP unit [MW]	2,462	1,704	946	567
Total cogeneration units	Electricity produced via the cogeneration process [GWh]	4,862	5,394	6,308	7,445
	Installed electric output of the CHP unit [MW]	2,462	2,584	2,710	2,928

Table 7.2-2: Development of economic potential

Based on the information provided in the previous table:

- the highest economic cogeneration potential in the period until 2020 in respect to the modernisation of existing units utilising the following technologies:
  - § steam extraction-condensing turbines;
  - § steam back-pressure turbines;
- in the case of modernisation of the abovementioned units, an increase in the proportion of biomass combustion is being considered, either in the form of co-combustion with solid fossil fuels or by means of installation of new boilers designed for biomass combustion.

[Figure: 'Development of the economic potential of electricity production']

(Key: výroba elektriny [GWh] = electricity production, existujúci stav = the existing situation, existujúce zdroje = the existing sources, modernizované zdroje = modernised units, nové zdroje = new units)

Fig. 7.2-2: Development of the economic potential of electricity production by means of high-efficiency cogeneration

[Figure: 'Development of the economic potential of the installed cogeneration electric output]

(Key: inštalovaný výkon [MW] = installed output, existujúci stav = the existing situation, existujúce zdroje = the existing sources, modernizované zdroje = modernised untis, nové zdroje = new units)

Fig. 7.2-3: Development of the economic potential of the installed cogeneration electric output

- relatively high potential is also found in medium-sized and small units utilising the following technologies:
  - gas turbines;
  - combustion engines of higher as well as lower capacities;
  - micro-turbines.
- in the case of the respective groups of technologies combustion of natural gas is being considered;
- cogeneration potential may also be found in the installation of the steam and gas cycle, where, however, problems may develop with respect to how economical useful heat from such sources is;
- relatively low economic potential (despite of a considerably higher technical potential) is represented by medium-sized and small cogeneration units combusting biomass and biogas; in the case of the respective units, the following technologies come into question:
  - steam engines;
  - ORC cycles.
- in the Slovak Republic, other cogeneration technologies currently represent minimal economic potential; a certain change may occur in the case of a rapid decrease in investment expenses relating to fuel cells.

8 SWOT –cogeneration analysis

8.1 Fuels

8.1.1 Coal

At present, domestic brown coal represents approximately 79% of brown coal consumption necessary for electricity and heat production. It plays an important role in the provision of electricity supplies. The remaining necessary quantity of brown coal and all black coal is provided by means of export.

Year	2005	2010	2015	2020	2030
Brown coal extraction [kt]	2,400	2,400	2,100	1,800	900

Source: Ministry of Economy of the Slovak Republic

Table 8.1.1-1: Expected development of brown coal extraction until 2030

A gradual decrease in the extraction of brown coal is expected and, in terms of long-term development, it is not possible to consider brown coal extraction as sufficient to satisfy demand relating to electricity and heat production. Domestic coal, however, remains the only non-renewable source necessary to ensure the reliability of the units.

The raw-material policy of the Slovak Republic in the area of raw materials approved by Decree of the Government of the Slovak Republic No 722/2004 expresses the interest of society in further effective extraction of such raw materials for energy. Utilisation of domestic coal for the purpose of electricity production for the period 2005-2010 is of general economic interest in the energy industry outlined by Decree No 356/2005 enacted by the Government of the Slovak Republic. For the purpose of provision of the necessary quantity of coal intended for electricity production, it will be necessary to provide access to coal deposits in the extraction fields of three originally independent mines (this concerns access to reserves in already opened deposits by means of additional opening and preparatory work).

8.1.2 Natural gas

The annual consumption of natural gas is approximately 7 bill. m^3. Domestic extraction has a share in such consumption in the amount of approximately 3%. Other natural gas is imported from the Russian Federation.

Year	2005	2010	2020	2030
Total consumption of natural gas [bill. of m^3]	6.5	6.9	7.0	7.1

Source: Ministry of Economy of the Slovak Republic

Table 8.1.2-1: Expected development of natural gas consumption until 2030

In the following period, a slight increase in natural gas consumption is expected in particular due to the increase in consumption in the industries and in relation to electricity and heat production. Utilisation of natural gas is also suitable as it has minimum impact on the environment. Such a presumption is based on the preservation of the price of natural gas in relation to other primary sources. Considerable changes in the price of natural gas would possibly also result in changes in total consumption.

8.1.3 Crude oil

The Slovak Republic imports approximately 5.5 mill. t of crude oil annually. This volume is guaranteed under a long-term international contract concluded with the Russian Federation. Of the imported quantity of crude oil, 3.2 mil. t is used to satisfy domestic consumption. Domestic extraction has a share to the amount of approximately 2% of crude oil consumption.

Crude-oil security, which means provision for crude oil supplies and related activities in the case of a shortage in crude oil, is dealt with in the respective regulations of the Slovak Republic. Crude oil products are rarely used for the purpose of electricity and heat production (Chapter 4) and their consumption in the energy industry has a downward trend.

8.1.4 Nuclear fuel

At present, more than 55% of electricity is produced in nuclear power plants. Nuclear fuel supply is secured under long-term contracts concluded with the Russian Federation. It is advisable to support transfer to a more advanced fuel with an improved utilisation of the nuclear material in the nuclear fuel, which would result in a decrease in the consumption thereof. In relation to the shutdown of the Nuclear power plant V1 in Jaslovské Bohunice (JE V1), a decrease in supplies of nuclear fuel will occur until the possible commissioning of new units of nuclear power plants.

8.1.5 Renewable resources

At present, renewable energy resources, including hydroelectric potential of large hydroelectric power plants, represent the production of approximately 5.2 TWh of electricity, which means approximately 16% of domestic electricity consumption. The total useful potential of the individual types of renewable energy sources provides possibilities for an increase in their share of the total electricity production of up to 19% in 2010, up to 24% in 2020 and up to 27% in 2030.

The most promising renewable resource for cogeneration is biomass, for which the total annual potential suitable for energy utilisation represents approximately 75.6 PJ.

It is necessary to monitor the impact of the energy legislation and financial instruments on the support of the use of renewable energy sources, so as to analyse the barriers facing the use thereof and to take appropriate measures to remove such barriers. The most important measure in respect to increasing the share of RES in the total electricity and heat consumption is the enactment of relevant amendments to the respective legislation, which would support their increased utilisation. It is necessary to assess the support of renewable energy resources within the framework of the general economic interest in the energy industry.

8.2 Technologies

Development of new technologies, providing for high reliability, operability and robustness of existing technologies is one of the basic preconditions of the development of cogeneration intended for electricity and heat production in the Slovak Republic. The technologies implemented in the area of cogeneration should fulfil as a minimum the following criteria:

- high energy efficiency;
- high share of electricity production in the cogeneration process;
- low requirements for attendance, non-attended units if possible;
- modular facilities;
- minimisation of requirements for project-related activities;

- minimisation of requirements for construction readiness;
- minimisation of failure rate;
- increase in the interval between common and general repairs;
- extension of the regular maintenance period;
- high degree of automation relating to increase in safety and no-failure operation of the respective unit;
- low investment expenses.

8.3 Energy services

In relation to the implementation of Directive 2006/32/EC on energy end-use efficiency and energy services, mechanisms for the provision of energy services shall be created. With respect to the fact that this will concern a higher level of initiative in the area of energy efficiency, an increase in the number of units designed for cogeneration by means of small-scale and micro-cogeneration is expected.

8.4 Economic conditions, charges, taxes

Economic conditions, which are represented in particular by the development of fuel prices and input types of energy, purchase prices of electricity, sales prices of heat, the level of the respective investment expenses, availability of investment means, imposed taxes, financial services as well as by charges for contamination of the environment and trade with CO_2 emissions, have a considerable impact on the development of high-efficiency cogeneration.

Investment expenses in case of new constructions but also in case of modernisation of cogeneration units are high, which is why it is important to implement an effective system of support when securing the promotion of the economic potential of cogeneration in the Slovak Republic.

In addition to high investment expenses, a rapid increase in the price of natural gas has also had a negative impact on the development of cogeneration; it is necessary to realise that natural gas is the most frequently used fuel in medium-sized and small high-efficiency cogeneration units.

A disadvantage for cogeneration operators in the current conditions of the Slovak Republic is the implementation of uniform taxes. Whereas in certain countries of the European Communities, a reduced VAT rate is implemented for the products of cogeneration (e.g. in the Czech Republic), in the Slovak Republic there is a uniform tax to the amount of 19%. Prices of cogeneration products and the extension thereof may be influenced by the development of other taxes in the Slovak Republic, such as consumer tax. Other factors having a substantial impact on the development of cogeneration include CO_2 emission trading, charges for emissions of contaminating substances, charges for waste, etc.

8.5 Legislative framework

At present, Directive 2004/08/EC is not implemented in the legislation of the Slovak Republic to the full extent. Decree of the ÚRSO No 2/2005 which regulates the scope of price regulations in the power energy industry and the method of its performance, the scope and structure of eligible expenses, the method of determination of the amount of reasonable profit and the details of the proposal for the price and fixed prices of electricity produced via cogeneration technologies are also determined.

Amendment of Act No 656/2004 Coll. (the Energy Industry Act), in which all articles of Directive 2004/08/EC are implemented to the full extent, is ready for consideration by the Legislative Council of the Government. Two orders have also been prepared:

- Order to define criteria for support of electricity and heat cogeneration;
- Order to define the content and form of the application for the respective certificate and the content and form of the respective certificate to prove the origin of electricity produced by means of high-efficiency cogeneration.

Directive 2004/08/EC is to be implemented to the full extent after the enactment of the amendment to the Act and the subsequent implementing regulations.

8.6 SWOT analysis

Strong points

- saving of primary energy resources;
- increase in energy supply safety;
- interesting area for international investment;
- support of purchase prices of electricity;
- often dominating position on the heat market in the respective location;
- existence of investment incentives on the national as well as international level;
- increase in energy efficiency of the energy conversion processes;
- reduction in production of greenhouse gases, in particular CO_2;
- reduction in production of contaminating substances;
- possibility of connection of the respective source in the system of ancillary energy services provision.

Utilisation of RES:
- renewability of the energy resource;
- in terms of production of greenhouse gases, in particular CO_2, biomass is still regarded as neutral fuel (CO_2 is released in the process of combustion; however, approximately the same quantity of CO_2 is consumed from the atmosphere during growth of biomass);
- in most cases, insignificant content of sulphur;
- increased independence of import of energy resources;
- frequently, secondary raw material e.g. from the wood-processing industry, which is an advantage from economic point of view (price) as well as in terms of waste management;
- cultivation of biomass improves social circumstances (job opportunities) in the country during transformation of agriculture (transfer of food production to industrial one) and contributes to protection of the environment (it eliminates devastation of soil due to industrial or mining activities).

Weak points

- high investment expenses of the cogeneration unit;
- interconnection of electricity and heat production – upon decrease in heat consumption, in most cases decrease in electricity production occurs and vice versa;
- higher specific expenses relating to a generated unit of electricity or heat;
- in the case of a decrease in production, efficiency of the respective unit decreases while the specific production expenses increase;
- insufficient self-funding.

Utilisation of RES:
- non-proactive approach of the environment protection in case of utilisation of RES;
- lack of entrepreneurial infrastructure;
- insufficient structure in the area of consulting services;
- frequently, due to processing and transport, the price of biomass exceeds the price of fossil fuels;
- absence of effective biomass market;

- reliability of supply to the respective resource may be lower than in the case of other fuels;
- seasonal character of cultivation of energy crop-plants requires storage in a relatively large scope, if it is not stored freely on the site of occurrence;
- lower efficiency and lower output of the available facilities designed for energy utilisation of biomass (in comparison with facilities designed for fossil fuels such as natural gas, fuel oil, etc.);
- the development of certain units designed for processing and transport of biomass is not yet complete;
- risk of leak of hazardous substances in certain technologies (dioxines, dust, NO_x, solid and liquid wastes.

Opportunities

- extension of the market commodity by cogeneraetion operators and the subsequent partial reduction of dependence on development of the energy sales market;
- reduction of dependence on energy supplies in case of self-supply of electricity and heat from cogeneration.

Utilisation of RES:
- increase in importance of renewable energy resources in energy management is an opportunity for the development of new industries, including the building industry, with demand for production with a high degree of added value;
- due to an increase in the use of biomass, jobs will be created in relation to its cultivation, extraction and processing, which may considerably contribute to substitute programme for agricultural business activities and protection of landscape

Threats

- cheap electricity from existing power plants;
- current preferential purchase prices of electricity from cogeneration do not take into account actual expenses relating to the generation thereof by means of the respective cogeneration technologies;
- sharp rise in the price of natural gas as the most frequently used fuel in the case of cogeneration resources;
- support of the development, investment and operation of cogeneration units is expected due to increase in prices of electricity for final customers, which may also lead to the negative attitude of the public and subsequently to threatening of meeting objectives concerning their utilisation and finally to threatening of meeting the objectives relating to environmental protection.

Utilisation of RES:
- investment in renewable energy resources will depend as to whether it will be feasible to reduce specific investment expenses rapidly in order that the competitiveness thereof compared to traditional sources could be improved;
- failure to adhere to the construction schedule, reliability and technical parameters of the new facility in relation to insufficient financial means;
- negative opinion of the bodies administering environmental protection;
- for the manufacturer (cultivating and processing organisation), there is a certain entrepreneurial risk during the implementation and cultivation of a new type of biomass with a 2- to 8-year cycle (e.g. the issue of the position on the market);
- insufficient technological infrastructure, inappropriate and thus non-economic transport and processing of biomass;
- absence of a long-term and reliable domestic supply of biomass and a lack of experience concerning storage and processing of biomass (possibility of reduction in case of use of biomass in multiple-fuel systems);
- implementation of new (insufficiently tested) technologies and infrastructure, in

particular in the unclear situation of biomass subsidising.

9 National development strategy

9.1 Barriers identified in respect to cogeneration development in the Slovak Republic

Technical barriers:

General:
- decrease in industrial production with high demand for energy;
- increase in energy savings;
- disconnection of customers from the CHS;
- implementation of new technologies insufficiently tested in practice;
- interconnection of electricity and heat production – upon decrease in heat consumption a decrease in electricity production in most technologies used and vice versa;
- not adapted structure of distribution energy supply systems;
- in case of decrease in production, efficiency of the respective facility decreases and specific production expenses increase;
- insufficient awareness of the technologies used in high-efficiency cogeneration;
- insufficient support of applied research and development

RES:
- insufficient technological and organisational provision of fuel logistics;
- considerable inclination and inaccessibility of locations with occurrence of useful biomass;
- lack of experience concerning storage and processing of biomass;
- strong dependence on import of technological equipment.

Financial barriers:

General:
- lack of own financial resources;
- lack of means in the area of public finance;
- lack of guarantees to cover credit resources;
- long pay-back period of the invested means;
- the current preferential purchase prices of electricity from cogeneration do not take into account actual expenses relating to its production by means of the respective cogeneration technologies;
- sharp rise in the price of natural gas as the most frequently used fuel in terms of cogeneration resources.

RES:
- for the manufacturer (cultivating and processing organisation), there is a certain entrepreneurial risk during the implementation and cultivation of a new type of biomass with a 2- to 8-year cycle (e.g. the issue of the position on the market);
- failure to adhere to the construction schedule, reliability and technical parameters of the new facility in relation to insufficient financial means.

Administrative barriers:

General:
- exigency of administrative procedures relating to preparation of the respective investment (ownership relationships to immovables, approvals of the respective bodies, etc.);
- unhelpful approach of distribution companies;
- lack of specialist capacities in the area of environmental protection;

- administratively demanding procedures relating to determination and approval of electricity purchase prices,

RES:
- administratively demanding procedures concerning facilities with installed electric output exceeding 5 MW.

9.2 Support schemes

With respect to the fact that in the Slovak Republic only entities realising their business activities on the electricity market may be subsidised in the form of preferential purchase prices (Act No 656/2004 Coll. regulating the energy industry), it is necessary to prepare a mechanism of support in the form of support providing schemes to support electricity production for self consumption.

In the public sector, a possibility of investment project support is being considered with a view to utilising financial means of the Structural Funds, in particular the Regional Development Fund. In the private sector, supporting schemes are being prepared in accordance with the EU rules for the provision of the state subsidy, and possibilities for the provision of minimum support, regional support and environmental support shall be taken into account.

In order to develop the use of cogeneration units more quickly, a proposal for the creation of a revolving fund and a system of partnership between private and public sectors shall be established.

9.3 National strategy for cogeneration

<u>The existing situation</u>:

- the Government of the Slovak Republic pays due attention to cogeneration issue, evidence of which is enactment of the Government Decree No 29 of January 2006 - The Energy Policy of the Slovak Republic, where support and promotion of cogeneration is clearly declared in Article 3.1 "– objectives and priorities of the energy policy of the Slovak Republic for the period until 2020 with a view until 2030“;
- the Slovak Republic has much experience with respect to electricity and heat cogeneration, in particular technologies based on steam extraction-condensing and back-pressure turbines started being developed as early as in the 1950s;
- at present, support of cogeneration is declared in Decree of the ÚRSO No 2/2005, in which fixed purchase prices of electricity produced via cogeneration technologies are determined;
- in the Slovak Republic, modern technologies designed for cogeneration are available, as well as the respective expertise for project preparation and subsequent realisation of projects in the respective area;
- the long-term tradition of cogeneration in the Slovak Republic guarantees extensive and specialist knowledge concerning the operation thereof;
- the Slovak Republic has an efficient network of financial services, which can be used in case of realisation of projects concerning the respective area;
- investment incentives in cogeneration are currently secured as follows:
    - § by means of the “Scheme for support of energy savings and state support programme for the use of renewable energy resources”, within the framework of which support of cogeneration upon grouping of multiple small sources to create cogeneration unit with maximum installed output of 5 MW_e is declared;
    - § by means of financing by the Structural Funds under the “Sectoral operational programme for industries and services", measure 1.4 "Support of energy savings and utilisation of renewable energy resources” (providing

support for projects in respect to cogeneration production based on fossil fuels and renewable energy resources with maximum installed output of 5 MW_e in the form of regional support and with maximum installed output of 50 MW_e in the form of the environmental support).

The abovementioned facts are a good basis for a more extensive implementation of cogeneration given the conditions in the Slovak Republic. For future further development of the respective area of the energy industry and for the purpose of fulfilment of the defined objectives based on economic potential, however, it is necessary to take the minimum measures specified in the following paragraph.

Measures:

- enactment of the Act to amend Act No 656/2004 Coll. regulating the energy industry and Act No 657/2004 Coll. regulating the heat energy industry;
- enactment of the Order to define criteria for electricity and heat cogeneration support;
- enactment of the Order to define the content and from of the application for the issue of the certificate and the content and form of the certificate of origin of electricity produced by means of high-efficiency cogeneration;
- modification of the system of cogeneration electricity preferential purchase prices to comply with the system of high-efficiency cogeneration electricity preferential purchase prices;
- incorporation of investment incentives from the Structural Funds for high-efficiency cogeneration in the programme period 2007-2013;
- elaboration of the investment incentive system based on the national budget of the Slovak Republic.

10 Guarantee of origins of electricity produced via high-efficiency cogeneration

The bill of amended Act No 656/2004 Coll. amending Act No 656/2004 Coll. regulating the energy industry and Act No 657/2004 Coll. regulating the heat energy industry defines that the certificate of origin of electricity produced via high-efficiency cogeneration shall be issued by the ÚRSO on the basis of application submitted by the producer of electricity using cogeneration.

The certificate of origin shall be issued after fulfilment of the following conditions:

- producer of electricity using cogeneration has submitted the respective application and provided details in accordance with the relevant regulation;
- electricity is produced in a high-efficiency cogeneration unit.

The certificate of origin issued in the EU Member States shall be valid in the Slovak Republic as well and as such does not grant the right to benefit from the national support mechanisms.

The content and form of the application for the issue of the certificate of origin and the content and form of the certificate are governed by the relevant legal regulations.

Controls relating to the issuing of certificates of origin of electricity produced via high-efficiency cogeneration (as well as issuing the certificates as such) shall be carried out by the ÚRSO.