Slovak Environmental Agency

Banská Bystrica

Energy and its Impact on the environment in the Slovak Republic 2009

Indicator Report

2010

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Contents

Foreword

Report *Energy and its Impact on the Environment in the Slovak Republic 2009* is one of task outcomes listed in main task program of the Slovak Environmental Agency and Ministry of Environment of the Slovak Republic that is titled as *Assess Effects of Selected Sectors in Economic Activities on Environment and Implementation of Environmental Aspects into Sectoral Policies.* This has been already the third report. The first report was completed in 2005.

Within the task in 2005, sets of indicators and indicative sectors 'reports were completed for agriculture, forestry, transportation, energy, industry and tourism. The reports, in full, assess a correlation between economical sector and environment through environmental indicators and are focused on key questions and issues. Document was submitted for comments within relevant resort, other resorts, and at routine daily meeting of Ministry of the Environment. Further work procedure was approved and adopted at the daily routine meeting. The Slovak Environmental Agency was instructed to proceed in the assessment through updating of indicators database in a year interval and summary sectoral reports in two-year intervals. At the same time, an obligation to publicize the indicators and reports on the webpage was laid www.enviroportal.sk/sektor/.

Summary

What is the present state and trend of energy in the Slovak Republic?

The present state and trend in the energy are dependent on available energy sources, energy requirements of the state, as well as an implementation speed of needful reforms.

Trends in Energy

- In view of natural conditions and current technical options, Slovakia is a country deficient in primary fuel-based energy sources. Almost 90% of the primary energy sources (nuclear fuel included) are imported. Brown coal and lignite belong to domestic sources of fossil fuels. Similar situation is in the field of liquid and gaseous energy sources where the inland production is less than 5%.
  (Indicator Structure of primary energy sources by fuels)
- Nuclear power plants in the Slovak Republic produce more than 53% of total electricity. The residual volume of the total electricity is produced by thermal power plants and hydroelectric power plants. In the heat power plants, the most frequently used fuel is black coal, closely followed by brown coal and natural gas. Share of biomass, waste, and biogas on the electricity production is minimal. The hydroelectric power plants are the only important source of the electricity, which utilize renewable energy sources.
  (Indicator Electricity production by sources and fuels)
- Despite of a slight increase in 2008, gross inland energy consumption has significantly decreased since 2003. It is a positive tendency and it is important for fulfilling an objective of energy strategy, which is to decreaseenergy intensity. In Slovakia, the gross inland energy consumption per capita is still lower than an average consumption in the EU 25, although, it had increased recently. On present, it does not achieve more than 95% of the European average value. In recent years, the nuclear energy plays an extraordinary important role.
  (Indicator Gross Inland energy consumption)
- Final energy consumption has a decreasing tendency every year. From 1995 to 2008, the significant decrease was recorded for solid fuels (60%) and heat (75%). Vice versa, the consumption of the renewable energy sources started to increase and it is a positive fact (by 16% since 2001). The most frequently used energy sources are gaseous fuels. But their share decreased by 11% in the monitored period. However, the consumption of the liquid fuels has increased by 25% since 1995.
  (Indicator Final energy consumption by fuels)
- In the sector of industry, transport, commercial and public services, the final fuels and energy consumption has slightly increased since 2004. Stable trend has been seen in the agriculture and the consumption in the households has decreased.
  (Indicator Final fuels and energy consumption by sectors of the economy)
- In total, the electricity consumption has been increasing and it achieved the increase of about 15% in 2008 compared to the 1998. From all sectors, the industrial sector has the highest share in this increase and as well as the highest share in the final electricity consumption. The sector of commercial and public services shows a slight increase. The consumption in the sector of agriculture, transport and households is balanced.
  (Indicator Final electricity consumption by sectors of the economy)
- GDP growth in fixed prices, which increased from 1997 to 2008 approximately by 40%, was accompanied with a balanced consumption of the energy sources (decrease by 2%). Since 1997, the energy intensity was declining annually. It declined by more than 40% in 2008 and it was caused mainly by a growth in the manufacturing with higher added value and adoption of cost saving measures. Despite of positive trend, the energy intensity of the Slovak Republic is still 1.5 times higher than the average intensiveness of the OECD countries.
  (Indicator Energy intensity of the economy in the Slovak Republic)
  By final energy consumption, the energy intensity in the Slovak Republic has been showing a declining trend since 1993 (decline by 51% by 2008). Also, the final energy consumption decreases. The GDP increases and it is a positive trend.
  (Indicator Energy intensity of the final energy consumption in the sectors of the economy)
- From 1998, the growth in the import and export of the electricity is continuous. In 2007, the

import of energy exceeded its export. In 2008, the import of energy with volume of 33 883 TJ was higher than export with volume of 32 008 TJ. It created a balance of 1 875 TJ in the favour of the import. Slovakia as an exporter of the electricity changed to be an importer. From the long-term perspective, it is not an acceptable situation for the country.
(Indicator Import and export of the electricity)

- Yearly consumption of natural gas is approximately 6.3 billion cubic meters and national gas production is approximately 3% of total consumption. The residual balance of natural gas is imported from Russia. In total, gas in volume of 66.4 billion cubic meters was transferred by Slovakian natural gas pipeline in 2009.
  (Indicator Import and export of natural gas)
- Annually, Slovakia imports oil in the volume of about 5.5 million tons from Russian Federation. The imported crude oil in the volume of 3.2 million tons is used to cover the inland consumption. The national oil sources are approximately 2% of final consumption.
  (Indicator Import and export of liquid fuels)
- At present, domestic brown coal represents approximately 79% of brown coal consumption, which is needed for production of electricity and heat. It plays an important role in security of electricity supply. The unbalanced volume of needed brown coal and all black coal is imported. The import decreased by 10% in 2008 compared to the 2007.
  (Indicator Import and export of solid fuels)

What is an impact of energy on environment in the Slovak Republic?

Energy belongs to sectors, which significantly pollute the environment. Harmonization of energy and environment has become one of the most important and strategic tasks in solving the environmental issues. Therefore, the energy has to follow the principle of sustainable development. In Slovakia, future reduction of negative effects of energy on environment might be provided by promoting the usage of renewable energy sources and austerity energy solutions.

Air

- Total greenhouse gases emissions expressed as CO_2 equivalents have decreased almost by 34% compared to basic year of 1990. The sector of energy has the most significant share in the greenhouse gas emissions. In 2008, the share was nearly 65% (decrease by 8% compared to the 1990). During monitored period, the air emissions of greenhouse gases from the sector of energy decreased by 16% as a result of lower manufacturing and changed fuel base in favour of clean fuels and fuels of better quality.
  (Indicator Greenhouse gases emissions from energy)
- Emissions of air pollutants have been continuously decreasing since 1990 as a result of lower manufacturing, energy consumption as well as a change in the fuel base in favour of cleaner fuels and fuels of higher quality class.
  (Indicator Emissions of air pollutants from energy production and consumption)

Waste Water

- Of all areas within the energy, electricity industry contributed the most to total volume of discharged wastewater. The greatest load exists in indicators for insoluble substances and chemical oxygen demand for COD_{Cr} (dichromate).
  (Indicator Waste water from energy)

Waste

- By types of waste, the greatest amount of waste, produced by dominant electricity producer Slovenské elektrárne a.s., originates from the burning process in the thermal power plants. The amount of this waste gradually decreases resulting from lower volume of electricity produced from the coal. Also the waste from gas industry has a decreasing tendency. Slovenský plynárensky priemysel, a.s. Bratislavaproduced more than 7 000 tons of waste in 2009. More than 50 types of waste are managed in the gas industry and those are generated during the plant operations and other supporting and maintenance services.
  (Indicator Energy waste generation)
- At present, the nuclear power plants are the most important source of electricity in the electricity grid. Generation of spent nuclear fuel (SNF) and radioactive waste (RAW) in solid or liquid form is an inevitable consequence of the energy production at the nuclear power plant. From 2005 to 2009 a significant reduction in generation of solid and liquid radioactive

waste occurred due to shutting the 1st and 2nd Block at the Jaslovské Bohunice (V-1) Nuclear Power Plant down as well as upgrade of existing equipment.
(Indicator Generation of radioactive waste)

Is the eco – efficiency of the energy improving in the Slovak Republic ?

In general, it might be stated that environmental efficiency of the energy is moderate as the share of the energy in economical value of the SR increased while usage of environmentally-undesirable fuels was lower and it consequently resulted in reduced emission load on the environment.

- Compared to the basic year of 1998, the energy increased its share in overall GDP while generation of greenhouse gas emissions, basic pollutant substances, and consumption of fossil fuels with negative impacts on the environment decreased. Generally, the trend in the environmental efficiency of the energy might be assessed as positive.
  (Indicator Environmental efficiency of energy with regard to fuel and energy consumption)

1. Introduction

Indicator Report **Energy and its Impact on the Environment in the Slovak Republic 2009** is a third report and it is focusing on evaluation of environmental impact of the energy as one of economic sectors in Slovakia, and environmental aspects, which are in the process of being implemented in the energy policy.

Integration of environmental policy into sectoral policies commenced at the European Council Summit in Cardiff. It represents an all-European process, in which environmental policy purposes and goals are reflected in the sectoral policies and which aims to provide a sustainable development.

Indicators sets – measurable indicators that are evaluated through **sectoral reports** are an effective tool to assess integration of the environmental aspects into the energy policy.

Assessment of the impact of the energy sector on the environment respects a creating and evaluating process of the indicators, which is ensured by activities of European Environment Agency (EEA), Organization for Economic Cooperation and Development (OECD), and Statistical Office of the European Commission (EUROSTAT) and development of sectoral reports at the European level.

A purpose of such formulated report for a sector of energy in Slovakia is to gain:

- Basic document to identify the impact of the energy on the environment;
- Grounds to assess efficiency of environmental measures application into the energy policy;
- An basic document for the implementation of Cardiff process and Lisbon Stategy under conditions of the Slovak Republic;
- An effective tool for the evaluation of strategic objectives or long-term priorities of the National Sustainable Development Strategy.

The report is primarily focused on the evaluation of the correlation between energy and environment. It contains a marginal assessment of some economic and social factors that have a significant but indirect impact on the environment. It includes environment experts´ opinions as well as opinions of experts from the energy sector.

The report is to serve mainly politicians as an appropriate tool for decision making process, experts and pedagogues from the environment field and energy, and finally to students and public engaged in environment matters.

2. Methodology

The indicator report is based on a methodology implemented by the European Environment Agency, established in Copenhagen (EEA). It is a process; in which implementation of the environmental aspects into economic activities sectors and sector's impact on the environment is assessed through the indicators analyses. The evaluation process is focused on two stages:

1. Stage: Preparation and processing of a list of aggregated and individual indicators by D-P-S-I-R model;
2. Stage: Writing the indicators sector report.

Chain of causal indicator links according to the DPSIR model is a methodological tool for integrated assessment of the environment. Within individual chain links, the aggregated and individual indicators are defined as following:

- **Driving forces** (**D**) – they are starting mechanisms of processes in a society and they initiate
- **Pressure** (**P**) with an negative impact on the environment (contamination, depletion of mineral sources) or a positive impact, which is an immediate cause of changes in the
- **State of the environment (S**). Deterioration of the environment's state - its elements usually cause a negative
- **impact** (**I**) to human health, biodiversity, functions of eco-systems, and it logically leads to formulating of measures and tools concentrated on elimination or remedy of environmental damages in the last chain link- and it is
- **Response (**R**)**

The analyzed individual energy-environmental indicators of the Slovak Republic in the D-P-S-I-R structure are in detail available at the web page www.enviroportal.sk/indikatory/. It includes description of the indicator, trend assessment, and identified political objectives in relation to indicator, international comparison, and reference to topics.

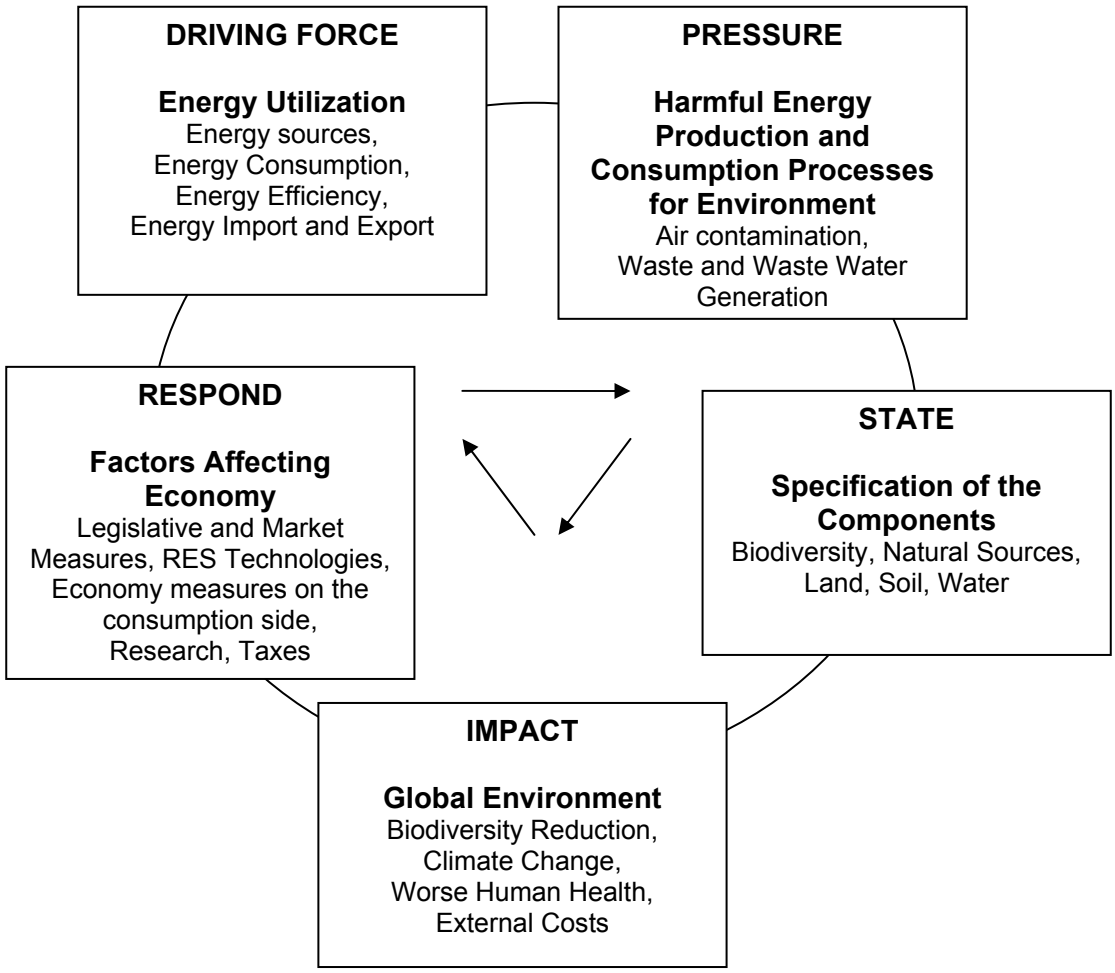
The set of environmental indicators, arranged by D-P-S-I-R model, serves as a theoretical base for preparation of **indicator report.** The main priority of the report is to understand **causal-consequential correlations** between an activity of human being and state of the environment by means of D-P-S-I-R causal chain link and in such way to offer an innovative view of the state and trend in the environment through the integrated assessment.

The indicator report is focused to answer four key political questions:

1. What is current status and trend of energy in the Slovak Republic?
2. What impact does energy have on environment in the Slovak Republic?
3. Does eco - efficiency of the energy in the Slovak Republic increase?
4. Do actual legislative and financial mechanisms support the implementation of environmental measures into energy in the Slovak Republic?

The D-P-S-I-R model for the energy is a simplified formulation of reality. There are more existing correlations and factors (e.g. social and economic), which have significant effects on the environment and they are not included within the model.

D-P-S-I-R model for Energy



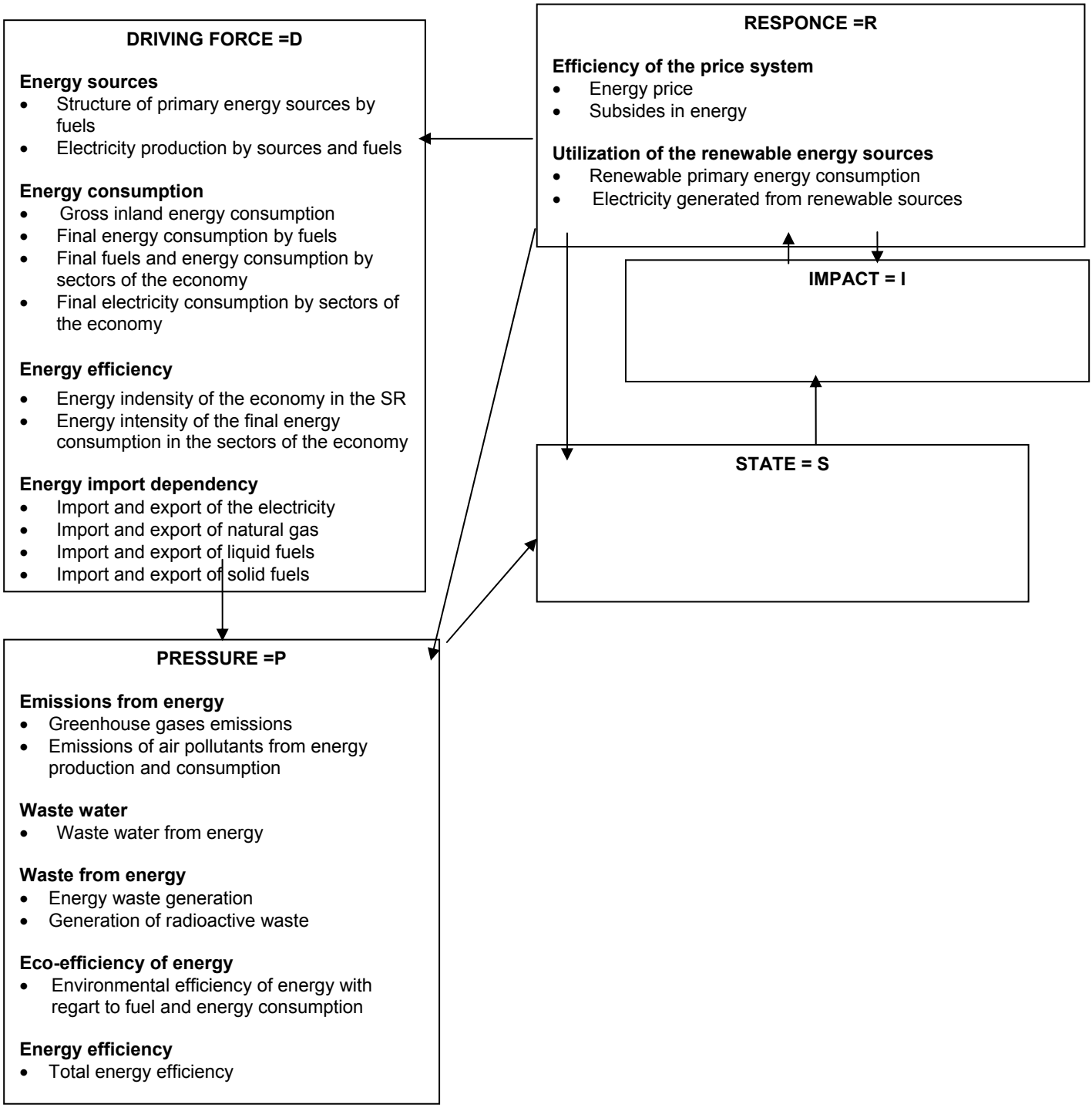
Based on indicators analyzed by the EEA and OECD, the Eurostat prepared a list of 23 energy and environmental indicators under Slovakia's conditions.

List of aggregated and individual energy and environmental indicators in the Slovak Republic by D-P-S-I-R model

Position in the D[1]-P[2] -S[3]-I[4]- R[5] structure	Aggregated indicator	It. No.	Individual indicator
Driving force	Energy sources	1.	Structure of primary energy sources by fuels
		2.	Electricity production by sources and fuels
	Energy consumption	3.	Gross inland energy consumption
		4.	Final energy consumption by fuels
		5.	Final fuel and energy consumption by sectors of the economy
		6.	Final electricity consumption by sectors of the economy
	Energy efficiency	7.	Energy intensity of the economy in the Slovak Republic
		8.	Energy intensity of the final energy consumption in the sectors of the economy
	Energy import dependence	9.	Import and export of the electricity
		10.	Import and export of natural gas
		11.	Import and export of liquid fuels
		12.	Import and export of solid fuels
Pressure	Emissions from energy	13.	Greenhouse gases emissions from energy
		14.	Emissions of air pollutants from energy production and consumption
	Waste water	15.	Waste water from energy
	Waste from energy	16.	Energy waste generation
		17.	Generation of radioactive waste
	Eco-efficiency of energy	18.	Ennvirinmental efficiency of energy with regart to fuel and energy consumption
	Energy efficiency	19.	Total energy efficiency
State	-		-
Respond	Efficiency of the price system	20.	Energy price
		21.	Subsides in energy
	Utilization of the renewable energy sources	22.	Renewable primary energy consumption
		23.	Electricity generated from renewable energy sources

[1] D- Driver
[2] P- Pressure
[3] S- State
[4] I- Impact
[5] R- Respond

Chain of causal energy and environmental indicator links according to the DPSIR model in the Slovakia's sector of energy



3. Implementation of Environmental Policy into Energy

The implementation process of the environmental policy into the energy runs at the European level as well as the national level. Accession of the Slovak Republic into the European Union and execution of new energy policy with principles of sustainable development shall help to accomplish an objective – reduce negative impact of the energy on the environment. This cardinal objective might be accomplished through promoting of programmes enabling to increase a share of eco-suitable and economically-acceptable energy systems, which are mainly based on new and renewable sources, and enforcing of more effective and less contaminating processes of transformation, transfer, distribution, and usage of energy at justified and adequate energy supply now and in future.

3.1. Political Framework for Implementation of Environmental Policy into Energy in the European Union

In **1989, the Cardiff summit** laid the foundations for coordinated Community action that was focused on environment protection principles. The Commission gradually concentrated its activities to develop and integrate environmental aspects into the sectoral policies of **energy**, transportation, agriculture, internal market, industry, fishery, and economy.

Within the energy sector, the initial step was made when the **First European Integration Strategy for the Energy Sector** was adopted in **November 1999**. This strategy was revaluated in a supporting document presented at the European Council meeting in Goteborg in 2001. The proposals from revaluated strategy were incorporated in a document of the European Commission from 2000 „ **Green Paper – Towards a European Strategy for the Security of Energy Supply** (CEC, 2000)“, in which many priority activities were outlined, including a support of energy-effective technologies.

In 2001, the European Council asked to develop the first **evaluating report on integration of environmental aspects within energy and transportation policies.** In the report, market trends for these sectors are evaluated, political initiatives of the European Community, and outlooks of future activities leading to permanently sustainable development are described (CEC 2001).
Based on the mentioned report in 2001 and 2002, the European Commission proposed several new initiatives to strengthen the integration of the environmental aspects into the **European Energy Policy** (CEC, 2001). They were developed as directives on promotion of electricity from renewable energy sources and bio fuels. Furthermore, **the European Action Plan for Energy Efficiency** (CEC, 2001), as well as measures for liberalization of electricity and natural gas markets and activities supporting to solve the climate change were outlined. Another important initiative of the European Commission was a proposal of directives on energy efficiency and promotion of cogeneration. In April of 2006, the directive on energy end-use efficiency and energy services was adopted.

On March 9, 2006, the European Commission issued **Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy** in order to create a common European energy policy and to address major energy-related issues such as ongoing complicated situation at the oil and gas market, growing dependence on energy imports and related need for diversification, increasing importance of climate change, and increasing need for transparency of energy markets. In the Paper, three main pillars of the EU energy policy were determined: **competitiveness, sustainability and security of energy supply** (EC, 2006).

The European Council adopted a complex **Action Plan for Energy Policy for 2007 – 2009** as an important milestone in development of energy policy for the Europe and stepping-stone for its next action, which is based on a **Communication of the European Commission "An Energy Policy for Europe**". The Action Plan sets up very ambitious quantified targets for energy efficiency, energy from renewable energy sources and utilization of bio fuels (CEC, 2007).

In December of 2008, the EU leaders adopted an extensive package of measures aiming to reduce contribution of the EU to global warming, and to ensure reliable and sufficient supplies of energy (EC, online). Dramatic breakthrough in the development of the policy has its roots in the obligation of the European Union to **reduce emissions from greenhouse gases by 20% by 2020**, **increase energy efficiency to save 20% of the EU energy consumption by 2020, to reach 20% of renewable energy in the final energy consumption in the EU by 2020, and to reach 10% of biofuels in the final consumption of vehicles by 2020.**

As a part of the **energy and climate package,** a set of several documents developed by the European Commission and focused on energy were adopted; Energy Policy for Europe, Road Map for Renewable Energy Sources, Report on Progress in Biofuels, Report on Progress in Electricity from Renewable Energy Sources, Prospects for the Internal Gas and Electricity Market, Priority Interconnection Plan, Sustainable Power Generation from Fossil Fuels, A European Strategic Energy Technology Plan, Nuclear Clarification Programme, and Limiting Global Climate Change to 2 degrees Celsius.

In order to achieve targets of the energy policy, the EU adopted several legislative regulations in 2009 and 2010. The most important ones are directive on promotion of electricity from renewable energy sources, directive concerning common rules for the internal market in electricity, directive concerning common rules for internal market in natural gas, directive on minimum reserve of crude oil and/or oil products, directive on framework for setting eco-design requirements for energy-using products, directive on evaluating energy consumption, directive on energy performance of buildings, and finally a directive to set a programme for encourage of economic recovery by financial support from the Community.

The **Green Paper: Towards the European Strategy for Security of Energy Supply ",** issued by the EC on November 29, 2009, is addressed to issues of increasing the EU dependence on energy imports, challenges relating to climate change, internal energy market, as well as measures concerning supply and energy products demand, renewable energy sources and nuclear power including (EC, 2008).

On November 10, 2010, the Commission presented new strategy for competitive, sustainable and secure energy. In the Communication, **Energy 2020 – Strategy for Competitive, Sustainable and Secure Energy**, the priorities for the energy field are set up for next 10 years. The Commission outlines measures to be taken in order to solve a question of energy savings, achieving market competitiveness in price and secure energy supply, and strengthening of the EU position in the technology environment (EC, 2010).

3.2. Political Framework for Implementation of Environmental Policy into the Energy in the Slovak Republic

The first strategic document within the energy sector was an **updated Energy Concept for SR by 2005**, which was adopted on September 30, 1997 by the Resolution of the Government No. 684/97. New trends in liberalization of energy within Europe, difficulties in electro-energy sector and heat generation industry as well as application of the Act No.

70/1998 Coll. on energy initiated an adoption of **Energy Policy for the Slovak Republic** in 2000. The policy was approved by Resolution No. 5/2000 of the Slovak Republic's Government (Ministry of Economy of the SR, 2000) and its framework had three base pillars for a purpose of change:

- preparation for integration into internal market of the European Union;
- security of energy supply;
- sustainable development.

The **Concept of Using of Renewable Energy Sources**, adopted in April 2003, laid the basic framework for a progress in utilization of the Slovakia's renewable energy sources (Ministry of Economy of the SR, 2002). The potential of development in renewable energy sources is analysed in a **Renewable Energy Sources Action Plan for 2002 – 2012**, which was prepared in 2002 (2002).

In 2004, the Slovak Republic's Government approved **Renewable Energy Sources Review Report** by its Resolution No. 667. In the report, the national indicative target for RES electricity in final electricity consumption in 2010 was set up for 19% (Ministry of Economy of the SR, 2004).

National Program of Biofuels Development, approved in 2005, contains indicative targets as reference values for the years of 2006 to 2010 and at the same time creates stimulating economic and legislative conditions for meeting the indicative targets under Directive No. 2003/30/ES (Ministry of Economy of the SR, 2005).

The economic development, trends in liberalization of the energy within Europe, accession of the Slovak Republic into the European Union, and adoption of new EU directives for the energy sector initiated a development of new energy policy, which was adopted in January of 2006. The **Energy Policy of the Slovak Republic** is a base for further routing of the development in the electricity industry, heat generation industry, and gas industry, crude oil refining and transportation, coal mining, and utilization of renewable energy sources. It was developed for the period of 25 years (Ministry of Economy of the SR, 2005).

The implementation of the legal regulations, which are reflected in the adopted acts, helps the Slovak Republic to integrate into the internal market of the European Union. General binding rules, issued on the basis of these acts, are a part of the energy legislative (Ordinances of the Ministry of Economy of the Slovak Republic and Institute for Regulation of Network Industries, and directives of the Government).

On April 25, 2007, the Government of the Slovak Republic approved the **Strategy for Higher Utilization of Renewable Energy Sources** (Ministry of Economy of the Slovak Republic, 2007), in which it is stated to develop and submit the **Action Plan for Utilization of Biomass for the years 2008 to 2013** (Ministry of Agriculture and Rural Development of the Slovak Republic, 2008). The plan was submitted in 2008 and it is focused on meeting the objectives, which would have a significant positive impact on the environment and would contribute to improvement of climate conditions, reduction of greenhouse gasses in atmosphere, and diversification of energy sources at increasing energy security.

The objective of the **Energy Security Strategy of the Slovak Republic**, developed in 2007, is to achieve competitive energy, which would be ensuring safe, reliable, and effective supply of all forms of energy at reasonable price while taking the customer protection, environment protection, perpetually sustainable development, safeness of supplies, and technical safety into the account (Ministry of Economy of the Slovak Republic, 2007).

In 2007, **The Concept of Energy Efficiency by 2016** was adopted and it outlined a goal to reduce theenergy intensity to the average level of original fifteen (15) member states of the EU (Ministry of Economy of the SR, 2007). **The Energy Efficiency Action Plan for the**

years 2008 to 2010 was approved in October of 2007. It is a strategic document, which determines quantifies objectives, defines existing as well as new recommended measures for energy savings and establishes mechanisms to ensure completion and monitoring of the recommended measures (Ministry of the Economy of the SR, 2007).

The basic legislative framework for energy efficiency is given by the **Act No. 476/2008 Coll. on Efficiency by Using Energy** (thereinafter "Act on Energy Efficiency") adopted on November 4, 2008 and some more acts and their proclamation. The Energy Efficiency Act is implementing the Directive No. 2006/32/EC. This act represents a framework for rational using of energy, determines requirements for energy efficiency at transformation, transfer, transport, distribution, and consumption of the energy, monitors and supports the energy efficiency, defines obligations of natural persons, natural persons – entrepreneurs, legal bodies and organs of state administration when using the energy. Its objective is to increase energy end-use efficiency and encourage development of energy services.

Other acts stipulating the requirements for energy efficiency increase in the Slovak Republic are:

- **The Act No. 555/2005 Coll. on Energy Efficiency in Buildings** as amended was adopted on November 8, 2005. This act implemented the Directive No. 2002/91/EC on Energy Performance of Buildings into the national legislative of the Slovak Republic. It defines measures leading to improvement of energy efficiency in buildings with the aim to optimize indoor conditions in buildings and reduce CO_2 emissions emitted from maintenance of buildings and stimulates the respective competences of public authorities. Furthermore, it determines an obligation to ensure that, when buildings are constructed, sold, or rented out, an energy performance certificate is made available. The act specifies a framework for minimum energy performance requirements for new buildings. Those will be given in the technical norms in detail.
- **The Act No.17/2007 Coll. on Regular Inspection of Boilers, Heating Systems and Air Conditioning Systems** was adopted on December 13, 2006. This act supplements the Act No.555/2005 on energy efficiency in buildings in such way that the Directive No. 2002/91/EC on Energy Performance of Buildings is fully harmonized. It determines procedures and intervals for regular inspection of boilers, heating systems and air-conditioning systems and expertness to execute regular inspections of boilers, heating systems, and air-conditioning systems in non-production buildings, which consume energy.
- **The Act No.665/2007 Coll. on Eco-design and Use of Energy-using Products** (Act on eco-design) was adopted on December 11, 2007. This act partially implemented the Directive No. 2005/32/EC on establishing a framework for setting of eco-design requirements for energy-using products. The term of eco-design means the integration of environmental aspects into product design with an aim of improving the environmental performance of the product throughout its whole life cycle, i.e. ensuring that the products put on market meet requirements for as low energy consumption as possible and at the same time meet the requirements for specified environmental aspects (such as water consumption, material consumption, air emissions, water emissions, soil contamination, noise, radiation, and waste).
- **The Act No.309/2009 Coll. on Promotion of Renewable Energy Sources and High-efficiency Cogeneration.** This act transposed the EC Directive on high-efficiency cogeneration promotion into the Slovakia's legislative. The act establishes especially the conditions and manner for promotion of electricity production from RES and high-efficiency combined production of electricity and heat, stipulates rights and obligations of electricity producer, purchase price for electricity, and supports the production of bio-methane.

At present, the energy savings gained through implemented measures of the first national Energy Efficiency Action Plan are evaluated. At the same time, **The Second Energy Efficiency Action Plan** is under a process of being prepared. It will be for the years **2011 to 2013** and will contain new measures for increasing energy efficiency in individual sectors of

the Slovakia's national economy as well as supporting mechanisms ensuring completion of these measures.

The Slovak Republic developed the **National Action Plan for Energy from Renewable Energy Sources** in October 2010. In the plan, national targets until 2020 for a share of energy from RES in the sectors of transportation and electricity, heat, and cold air supply were specified. The SR is obliged to increase utilization of renewable energy sources from **6.7% (2005) to 14% in 2020** in proportion to gross overall energy consumption. Based on adopted action plan, Slovakia should concentrate mainly on using of the biomass (Ministry of Economy of the SR, 2010).

4. What is the present state and trend of energy in the Slovak Republic ?

Energy plays a key role in the national economy of the country. In the Slovak Republic, quite a number of reforms within energy sector were implemented. Despite the restructuring of the national economy, the Slovak republic belongs to the EU countries with higher energy intensity. However, it might be stated that Slovakia had decreased its energy intensity approximately by 40% in the period from 1997 to 2008.

Slovakia as a member state of the European Union is a part of wider economy space and political grouping. The energy policy of Slovakia is closely connected with the energy policy of the European Union as well as with trends in offer and demand on energy sources within the world-wide economy. The outcomes of this policy are macroeconomic stability, modernization of national economy, high speed rate of the economic growth, and integration of Slovakia into the European Union.

Considering limited national energy sources, the Slovak Republic gains 90% of the primary energy sources by acquisition from outside the territory of the EU internal market (Russia, Ukraine). The only rather substantial domestic energy source is brown coal. In brown coal production, a gradual decrease is anticipated and from long-term viewpoint it is not possible to consider its production to be sufficient to cover requirements concerning electricity and heat production. Domestic natural gas (about 3% on annual consumption) and crude oil (2% on annual consumption) sources are negligible.

The individual indicators, describing the actual trends, serve to characterize state and trend in the energy sector in Slovakia from 1993. The individual indicators belong to the group of driver and pressure category indicators. Their detailed characteristics are given on the webpage www.enviroportal.sk/indikatory/.

List of aggregated and individual energy-environmental indicators relevant for definition of main trends in energy

Position in the D-P -S-I- R structure	Aggregated indicator	Individual indicator
Driver	Energy sources	Structure of primary energy sources by fuels
		Electricity production by sources and fuels
	Energy consumption	Gross inland energy consumption
		Final energy consumption by fuels
		Final fuel and energy consumption by sectors of the economy
		Final electricity consumption by sectors of the economy
	Energy efficiency	Energy intensity of the economy in the Slovak Republic
		Energy intensity of the final energy consumption in the sectors of the economy
	Energy import dependence	Import and export of the electricity
		Import and export of natural gas
		Import and export of liquid fuels
		Import and export of solid fuels
Pressure	Energy efficiency	Total energy efficiency

4.1 Trends in Energy

The Energy Policy, adopted in 2006, **set out principal objectives and frameworks of energy development in long-term perspective** and stated that ensuring maximum economic growth while retaining sustainable development was conditioned by reliable energy supplies at optimal costs and adequate environment protection (Ministry of Economy of the SR, 2006).

The energy policy was a starting point for development in the electricity industry, heat industry, gas industry, production and transport of oil, coal production, and use of renewable energy sources. It **defined three objectives**:

1. Ensure, at maximum efficiency, safe and reliable supply of all forms of energy in requested quantity and quality;
2. Reduce the share of gross domestic consumption of energy in gross domestic product – decrease theenergy intensity;
3. Ensure sufficient volume of electricity to meet demand on an economically-effective principle.

The following **main priorities** were set to facilitate meeting of the objectives of the energy policy:

- Replace to-be-closed electricity productions plants in the way so as to ensure production of electricity volume sufficient to primarily cover the domestic demand, on an economically –effective principle;
- Adopt measures focusing on energy savings and increasing energy efficiency on the consumption side;
- Decrease dependency on energy supplies from risk-borne regions – diversification of acquiring energy sources as well as transport transits;
- Utilise domestic primary sources for electricity and heat production, on economically-effective principle;
- Increase utilisation of combines production of electricity and heat;
- Utilise nuclear power industry as a diversified, economically efficient and adequately environmentally acceptable option for electricity production;
- Ensure nuclear power plant operation safety;
- Increase the share of renewable energy sources in electricity and heat production in order to create adequate sources necessary for coverage of domestic demand;
- Complete the plant and network construction in order to facilitate safe and reliable transport, transmission, and distribution of electricity and gas;
- Build new transmission trunks in order to improve connection with the EU internal market as well as third countries market;
- Support utilization of alternative fuels in the transportation

For energy sector, the Slovak Republic has started to prepare strategic and legislative frameworks for increasing the energy efficiency. It might be already stated, that implemented measures brought achievements but their evaluation would be available in close future. The Slovak Republic will further endeavour to follow the European trend in creation and completion of packages of measures for increasing the energy efficiency which are cross-sectional solutions for the field of energy security increase and climate protection, promote using of renewable energy sources and development of market in parallel decrease of energy dependence of the Slovak Republic on import, and finalize the shift to competitive energy sector.

4.1.1. Energy Sources Balance

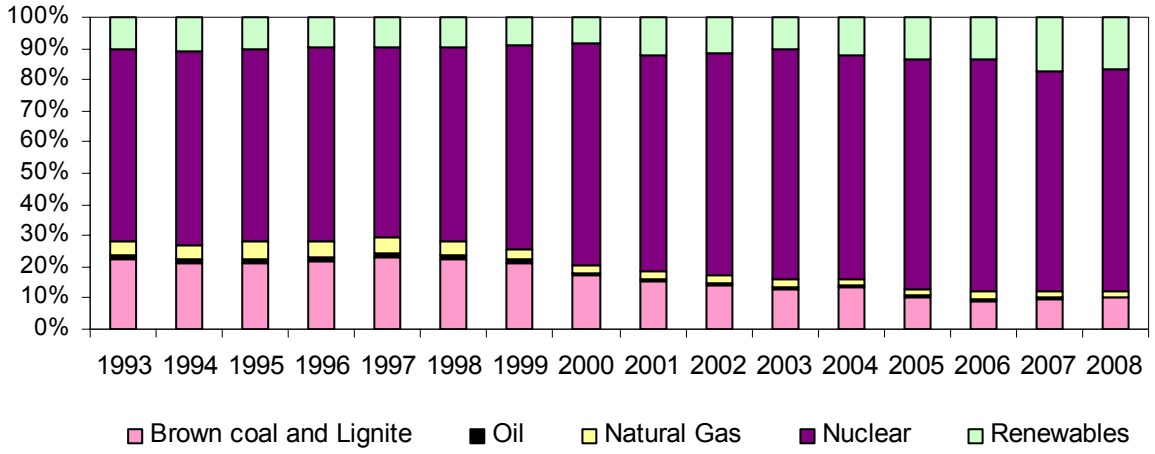
In view of natural conditions and current technical options, Slovakia is a country deficient in the primary fuel-based energy sources. Almost 90% of the primary energy sources (nuclear fuel included) are imported. Brown coal and lignite belong to domestic sources of fossil fuels. Similar situation is in the field of liquid (national sources of 2%) and gaseous (national sources of 3%). From renewable energy sources, water energy and biomass have the highest share on primary production.

The structure of used primary energy sources in the Slovak Republic from 1993 to 2008 is characterized by a lower consumption of solid, liquid, and gaseous fuels and increased consumption of renewable energy sources.
In the monitored period, the consumption of solid fuels was gradually **decreasing by 40%** until 2007 when it achieved its lowest value. In 2008, the consumption increased by 12% compared to the 2007. The **decrease** in consumption **of liquid fuels** in the monitored period was almost **70%**. The consumption of the **gaseous fuels decreased** almost by **60%** with several slight variations in 2008 compared to the 1993. By contrast, the consumption of **renewable energy sources increased** by more than **70%** at the cost of other fuels.
Recently, nuclear fuel has started to play an important role in the structure of the Slovakia's primary energy sources. Owing to replacement of oil components by bio fuels, just slight increase in the oil consumption is expected mainly in the transportation.

At present, **domestic brown coal** amount to some 79% of brown coal consumption necessary for production of electricity and heat. It plays an important role in ensuring safe electricity supply. The remaining required volume of brown coal and the entire required volume of black coal are catered for by means of import. In brown coal production, gradual decrease is anticipated and from the long-term viewpoint it is not possible to consider lignite production to be sufficient to cover requirements concerning electricity and heat production. National brown coal, however, remains the only non-renewable source necessary to ensure reliability of the entire system. The resource policy of the Slovak Republic with respect to mineral sources substantiates the national interest in further effective utilisation of this energy source. Utilisation of national supplies of coal in production of electricity for the period from 2005 to 2010 is a general economic interest in the field of power industry. To ensure the required quantity of coal for electricity production, it will be necessary to open coal supplies in mining fields of originally three separate mines (this concerns making available supplies in already opened coal beds by means of new opening and preparatory works) (Ministry of Economy of the Slovak Republic, 2008).
The consumption of **natural gas** in the Slovak Republic in 2009 was about 5.9 billion cubic meters. The national natural gas consumption was approximately 3% of total consumption.
The remaining volume is imported from the Russian Federation. It is expected that consumption of the gas by 2013 will remain at the current level. The consumption will probably slightly increase; however, it will not be a significant increase by 2030. By 2013, or 2030, the share of natural gas in primary energy sources may decrease but will still remain above the average European level (Ministry of Economy of the SR, 2008).
Annually, Slovakia imports **oil** in the volume of some 5.5 million tons. The volume is guaranteed on the basis of a long-term international contract with the Russian Federation. About 3.2 million tons of total imported oil volume is used to cover domestic consumption. National oil production contributes to the total oil consumption at some 2%.
At present, more than 57% of electricity is produced in **nuclear power plants.** Nuclear fuel supplies are ensured via long-term contracts with the Russian Federation. It is appropriate to support transition to enhanced fuel with better utilisation of nuclear material in the nuclear fuel resulting in its decreased consumption. In relation to utilisation of nuclear fuel for electricity production, the key question lies in storage of burnt atomic waste as well as disposal of closed atomic power plant equipment. Resolving this issue, the Slovak Republic will act in accordance with the EU policy.

Currently, **renewable energy resources,** including large hydroelectric power plant potential, are used to produce about 4.7 TWh of electricity, which stands for about 17% of gross domestic electricity consumption (Eurostat, 2010). The total available potential of individual types of renewable energy sources enables to increase their share in overall electricity production up to 19% in 2010, 24% in 2010, and 27% in 2030. The most promising renewable source for heat production is biomass. Its total yearly potential that is suitable for energy production purposes is about 75.6 PJ. The biomass is also a prospective source for electricity production (Ministry of Economy of the SR, 2007).

Structure of primary energy sources by fuels (1000 toe)



Source: EUROSTAT; Processed by: Slovak Environmental Agency

Indicator Structure of primary energy sources by fuels

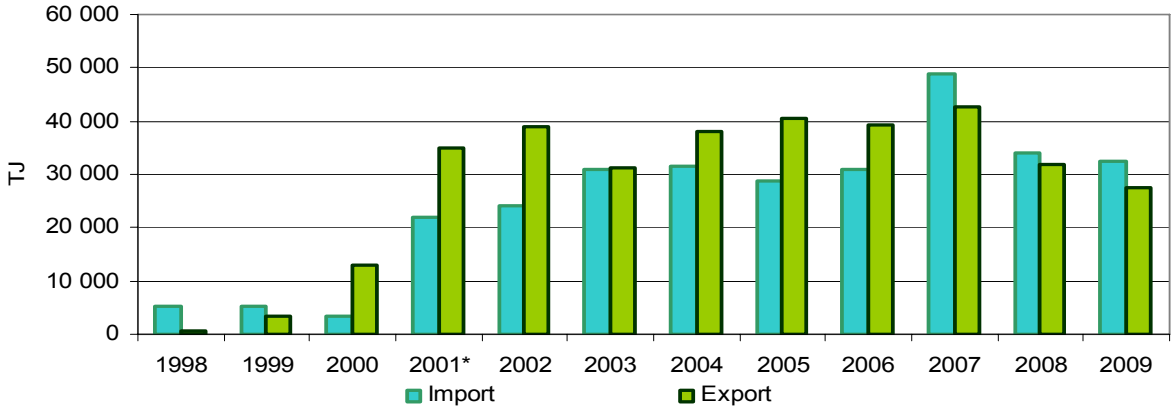
4.1.2. Import Dependence on Energy Sources

Covering of the society's demand for energy is one of key issues. Especially, a society that is depended on foreign energy sources has to pay a special attention to this sector. As the Slovak Republic belongs to the poorest countries with respect to own energy sources, it has to acquire most of the needed fuel-energy sources by import to cover domestic consumption. It is very important to ensure security of these energy supplies.

Electricity

From 1998 to 2007, electricity import as well as export was continuously increasing. In 2007, import of the electricity even exceeded its export. In 2008, the electricity import and export achieved volumes of 33 883 TJ and 32 008; it stands for a balance of **1 875 TJ in favour import.** Slovakia as an exporter of the electricity changed to be an **importer**. From the long term perspective, it is not an acceptable situation for the country. Because of global financial crises, estimated consumption of imported electricity decreased in the period from 2009 to 2012. It is believed that the Slovak Republic will become the exporter of the electricity again after 2012 when completion of new production facilities is expected (Malženice - electric power plant with hybrid steam-gas combined cycle and 3rd Block of Power Plant Mochovce).

Trend in Electricity Import and Export (TJ)

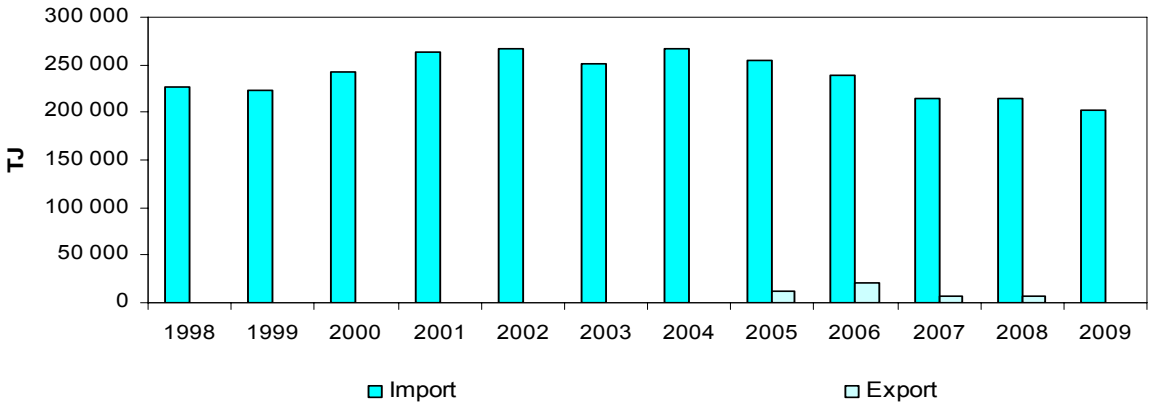


Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Import and export of the electricity*

Natural gas

In 2009, annual natural gas consumption was **5.9 billion cubic meters**, out of which national gas production was about 3%. The remaining volume is imported. In **2008**, Slovakia **imported 6 266 million cubic meters** of natural gas. From 1998, the imported volume of natural gas was slightly increasing until 2004. Since that time, the imported gas **has been decreasing**. In **2008**, it **dropped below the level of the 1998.** From 1998, the gas export has been minimal. However, it was rapidly increasing from 2004 to 2006. The gas export decreased in last two years and remains stable. **Totally in 2009 66.4 billion cubic meters of gas was transported via Slovakia's natural gas pipeline system.**

Trend in Natural Gas Import and Export (TJ)



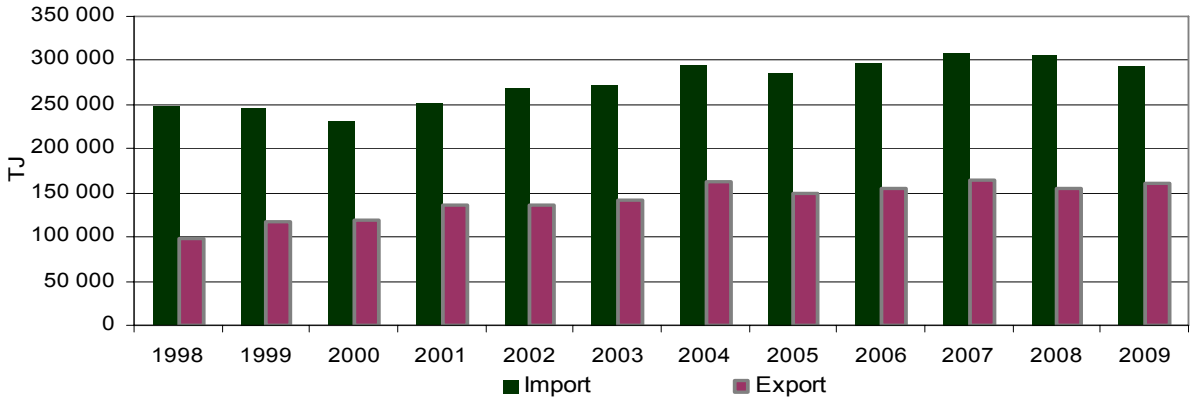
Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Import and export of natural gas*

Security in supplies of natural gas as well as other fuels plays a key role. **In January 2009**, the EU and Slovakia's **gas industry** had sustained the **most critical crises** in its history. The supplies of natural gas from Russian Federation to Slovakia were cut off almost for two weeks due to a gas dispute between Russian and Ukraine gas companies. The Slovak Republic experienced an emergency situation in the gas industry (SPP, 2010).
In order to ensure gas deliveries and to be able to provide electricity in case of failure of the only energy source, it is necessary to promote effective and costly acceptable diversification of gas sources as well as diversification of transport gas routes. Therefore it is important to support investments in infrastructure and provide underground reservoirs with sufficient volume capacity. The capacity of the gas transportation pipeline is at the level of more than 90 billion cubic meter per year (Ministry of Economy of the Slovak republic, 2008).

Oil

Annually, the Slovak Republic **imports** oil in the volume of **about 5.5 million tons** from Russian Federation. 3.2 million tons of oil acquired by import is used to cover the domestic consumption. The national gas production contributes to the total oil consumption at about 2%. From 1998 to 2008, **the oil and oil products imports as well as exports were continuously growing** (increase in import by almost 20% and increase in export by 37%).
The oil security, ensuring oil supply and related activities in times of an oil crisis are set by respective legal regulations of the Slovak Republic. Construction and maintenance of emergency reservoirs for oil and given oil products (defined as well as obligatory 90-days emergency reserves) are important parts of the regulation process, which aims to ensure stability for domestic oil market. Slovakia has been fulfilling this obligation. In 2009, the Slovakia's reserves were sufficient for 92 days (A. Duleba, Z. Lisoňová, 2009).

Trend in Oil and Oil Products Import and Export (TJ)



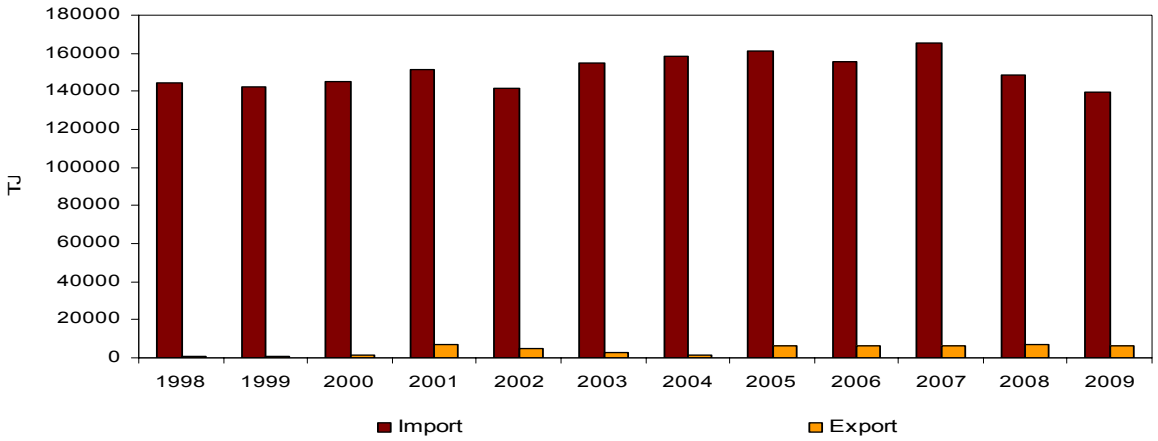
Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Import and export of liquid fuels*

Considering future trend in domestic consumption of oil products, it seems that oil delivery from safe and the most economically-efficient sources have to be provided in order to cover the domestic consumption. It will be necessary to ensure stability in oil supplies for next 20 to 25 years. Furthermore, at least doubled volume of actual oil level will have to be provided (Ministry of Economy of the SR, 2008).

Coal

At present, **domestic brown coal** amounts to some 79% of brown coal consumption necessary for production of electricity and heat. It plays an important role in ensuring safe electricity supply. The remaining required volumes of brown coal and the entire required volume of black coal are catered for by means of import. The import volume in 2008 **decreased by 10%** compared to the 2007. **From 1998 to 2007,** the import of solid fuels was increasing; however it sustained several variations in 2002 and 2006. In the monitored period, the **solid fuel export** achieved its highest values in 2001. Then it had been showing a decreasing trend until 2004. After 2004, it **started to increase again until 2008** and it achieved an increase of **almost 80%**. In brown coal production, gradual decrease is anticipated and from the long-term viewpoint it is not possible to consider brown coal production to be sufficient to cover requirements concerning electricity and heat production. National brown coal, however, remains the only non-renewable source necessary to ensure reliability of the entire system.

Trend in Solid Fuels Import and Export (TJ)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Import and export of solid fuels*

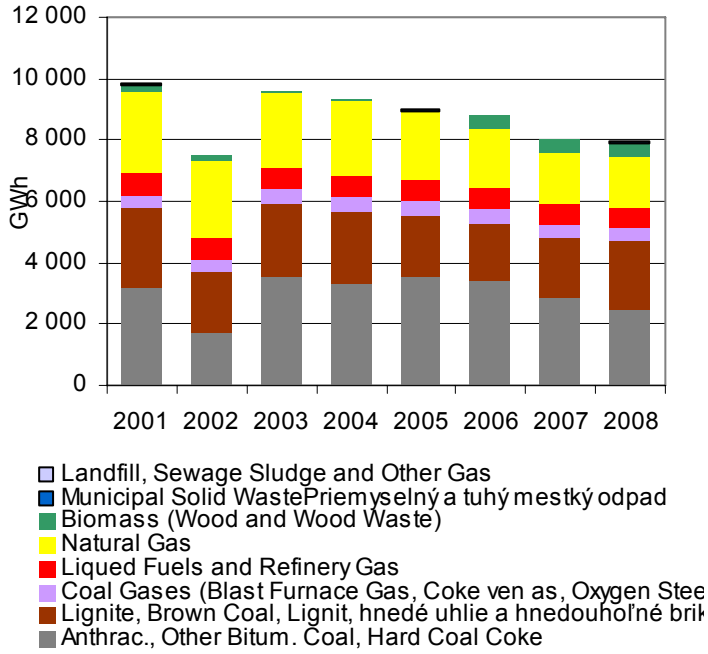
4.1.3. Production of Electricity and Heat

In the Slovak Republic, the electricity and heat are produced from national energy sources and acquired by means of import.

Electricity

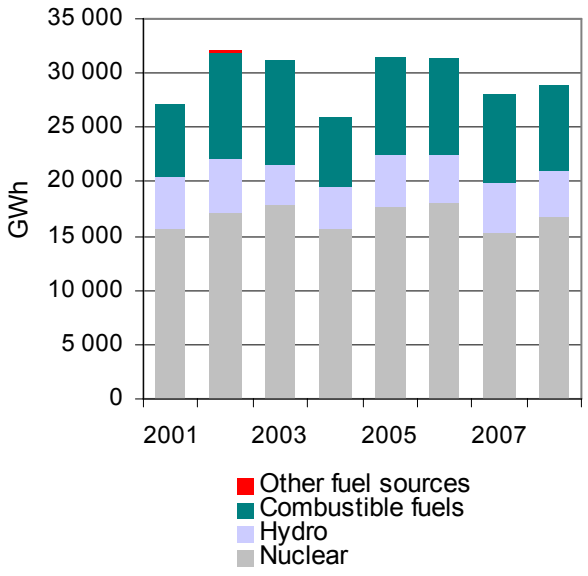
In 2009, the total electricity volume produced in Slovakia was 26 074 GWh. **The nuclear power plants** generated **more than 53%** of total electricity. **Thermal power plants** and **hydroelectric power plants** generated more **than 28% and 17.5%** of the electricity. The 0.3% of the remained electricity volume was produced by **other sources.** In the monitored period, the electricity production **decreased by almost 20% in 2009** and achieved the value approximately from 2001 (by about 4% lower than in 2001).

Trend in production of electricity from fuels in the SR (GWh)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Electricity production by sources and fuels*

Trend in production of electricity by source in the SR (GWh)



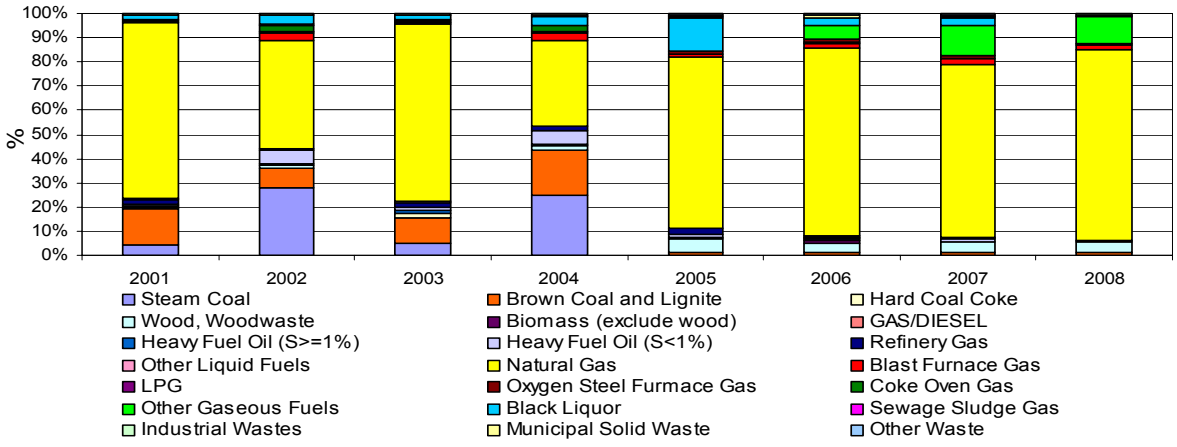
Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Electricity production by sources and fuels*

The years of 2006 to 2009 brought many changes into the structure of the Slovak Republic electricity industry. In order to meet the obligations of Slovakia from the accession negotiations with the European Union, many large electricity plants were taken out of service during this period due to their obsolete design and not fulfilling the environment requirements.
The year of **2009** showed a **12% decrease in the electricity production on the year of 2008** mainly **due to outage of the 2nd Reactor in Jaslovské Bohunice Plant** on December 31, 2008. In total, the production of electricity decreased approximately by 2 900 to 3 000 GWh. **Slovakia** as an exporter of the electricity **changed to be an importer**. From the long term perspective, it is not an acceptable situation for the country.
For **electricity production in the Slovak Republic**, **the most used fuels** are **black coal** (heat power plants), **brown coal** (electricity power plants, heat power plants), and **natural gas** (heat power plants). The renewable energy sources such as biomass, waste, and biogas are used for the electricity production in the minimal volume.

Achieving one of the principal target of the Slovakia's Energy Policy, namely to ensure production of electricity in volume saturating the demand on economically-effective principle, will be only possible by catering for sufficient production resources for its production. This key target of the Energy Policy can be met by increasing performance of the existing production facilities, and construction of new production facilities.

Heat
Production, supply, and consumption of heat make up for a significant part of the Slovak power industry. In the Slovak Republic, the most frequently used fuels for heat production are black coal (heat power plants), brown coal (heat power plants), and natural gas (heat only plants). From renewable energy sources, wood and wooden waste is at most used for heat production at heat power plants and boiler rooms. Compared to the 2001, the production of heat decreased by almost 20% in 2008 (heat power plants and heat only plants).

Trend in production of Heat Only Plants in 2009 (%)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency

Until 1990s, emphasis was put on centralised heat supply ("CHS"). Deformed electricity and natural gas prices for households has lead to the tendency to disconnect from the CHS and opt for individual heating based on gas or electricity. This situation, however, has been recently changing significantly, owing to gas price increase. At present, still most of the apartment blocks are supplied with heat from public power industry, which includes CHS, heat only plants heat supplies from industrial companies. These industrial companies have a special position as they apply the most effective process of fuel usage at the combined production of electricity and heat. Over the recent period, general interest in construction of

smaller combined electricity and heat production units has increased. This trend is expected to develop further.

Development of Slovakia's heat industry in medium and long term will focus on more **extensive utilisation of renewable resources** based on use of **biomass** and **geothermal energy.** The prerequisite for this assumption to become true is motivating heat price. Utilisation of such sources is also possible owing to implementation of new technology equipment in CHS with high performance. More significant use of **solar collectors,** which are today used rather rarely, is also anticipated (Ministry of economy of the Slovak Republic, 2008).

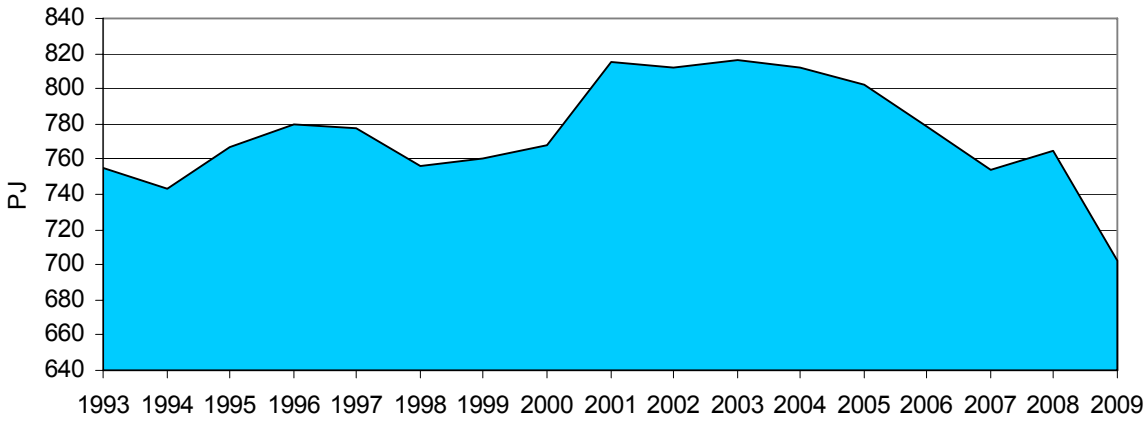
4.1.4. Energy Consumption

From 1993 to 2008, trend in gross domestic energy consumption was oscillating. From 1993 to 2003, the consumption was slightly increasing and vice versa. From 2001 to 2003, the consumption increased by 15% and reached its highest value of 816 PJ in 2003. Since that time, the consumption has started to decrease and it has a direct positive impact on improvement of the environment and climate change. In 2007, the energy consumption equalled to level of energy consumption from 1993. In 2008, however, it slightly increased by approximately 2% compared to the 2007 and achieved the value of 764 PJ.

Gross Inland Consumption

The gross domestic energy consumption has been showing a decreasing trend. It is a positive process as one of the SR Energy Policy objectives is to reduce the share of gross domestic energy consumption on gross domestic product, i.e. reduce theenergy intensity. The Slovakia's gross domestic energy consumption per capita is still lower than average consumption of energy in the EU 25 and achieves around 765 PJ. Although it recorded an increase recently, still does not exceed more than 95% of the EU 27 average level (Eurostat, 2009).

Trend in Gross Inland Energy Consumption in the SR (PJ)



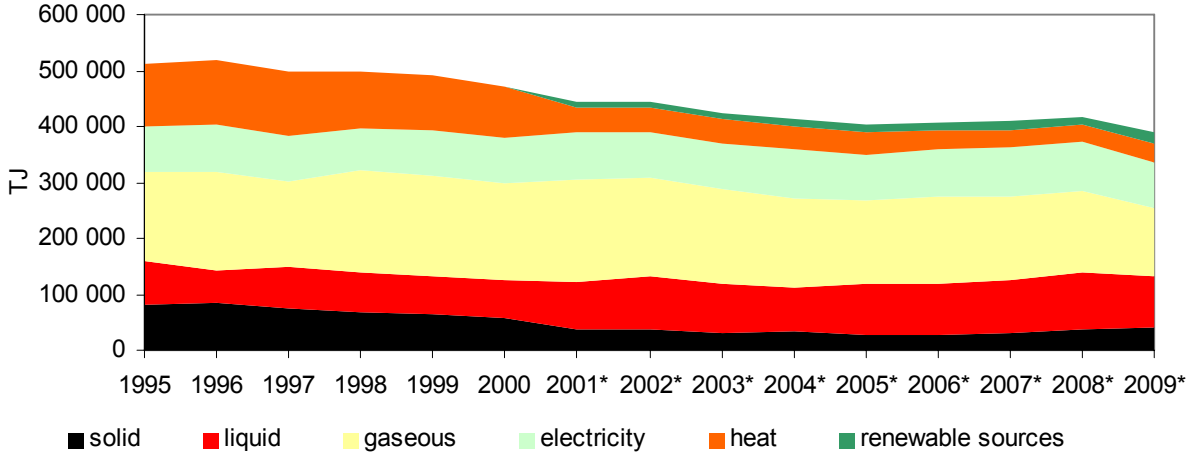
Data for the period from 2001 to 2005 were revised and put more exactly.
Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Gross inland energy consumption*

Final Energy Consumption by Fuels in the SR

The structure of the used fuel base is varied, gaseous and liquid fuels prevail. From 1995 to 2009, the most significant consumption decrease of **more than 75%** was observed for **heat.** From 1995, a significant decrease was monitored also for solid fuels and it lasted until 2006. Solid fuels dropped by more than **60%** by 2006. From 2006 to 2008, their share slightly increased (8%). By contrast, the most significant increase from 1995 in the volume and share

on total energy consumption is observed for **liquid fuels (25%).** The most frequently used energy sources are **gaseous fuels** but their share decreased approximately by **11%** in the monitored period.
The revised methodology of the Statistical Office of the Slovak Republic from 2002 that was used also for 2001 enables to monitor the consumption of the **waste and fuels renewable energy sources.** However, these are least used sources in the energy production of the national economy. From 2001, their share was gradually increasing and reached about **16%** increase by 2008 despite of slight decrease in 2008.

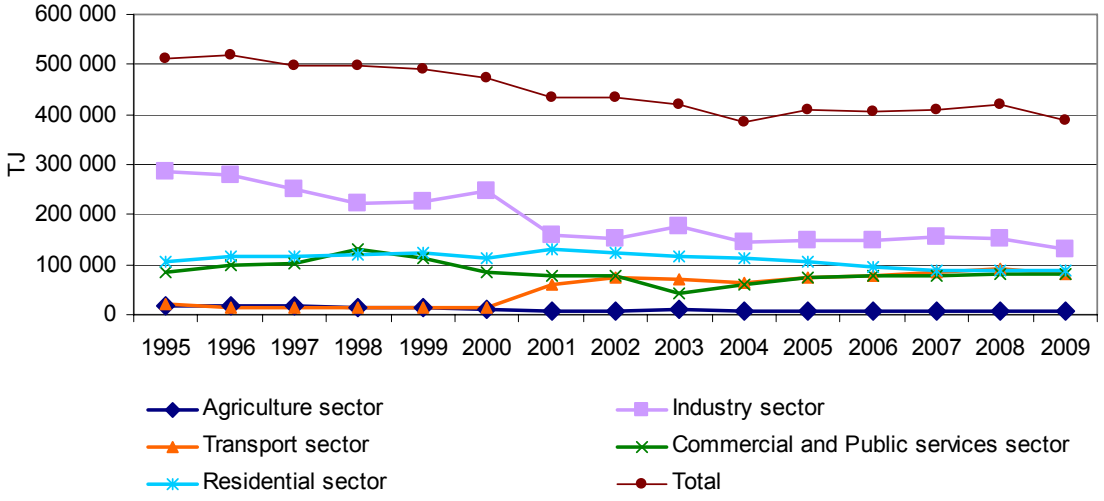
Trend in Final Energy Consumption by Fuels in the Slovak Republic (TJ)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
*Note: * According to the revised methodology of the Statistical Office of the Slovak Republic, 2002*
Indicator Final energy consumption by fuels

Based on the final energy consumption data, it is stated that the energy consumption for all sectors has a decreasing tendency since 1995. By 2008, it decreased by about 20%. In 2003, it started to slightly increase in the sectors of industry, transportation, and trade and services. The stable trend has been shown in the agricultural sector. The households recorded a decrease in the consumption but it slightly increased in 2008.

Trend in Final Consumption of Fuels and Energy in the Sectors of the Slovak Economy (TJ)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
*Note: * According to the revised methodology of the Statistical Office of the Slovak Republic, 2002*
Indicator: Final fuel and energy consumption by sectors of the economy

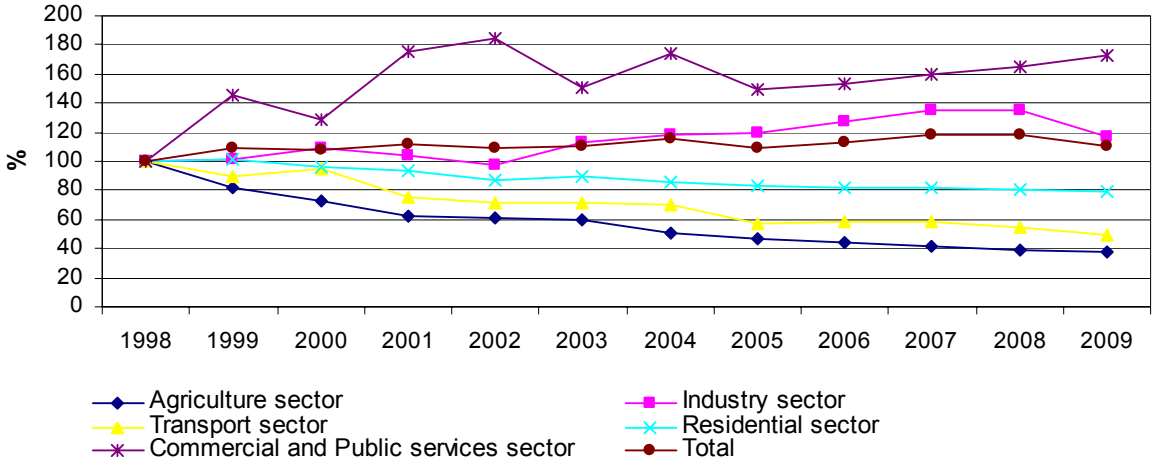
From 1995 to 2008, the final energy consumption in the **agricultural sector** decreased by about 65%. Share of agriculture on final fuels and energy consumption has been recently stabilized at the level of about 3%. The consumption of solid fuels has a decreasing trend.
In the monitored period, the brown coal and lignite prevailed, although, the consumption of brown coal decreased from 42 597 tons in 1998 to 3 946 tons in 2008. It stands for more than 90%. In liquid fuels, the highest consumption is recorded for diesel oil. Its consumption started to slightly increase in 2007. From 1998 to 2008, the diesel oil consumption dropped by more than 30% in total. In gaseous fuels, the highest consumption is recorded for natural gas. Its consumption slightly increased in 2008 compared to the 2007. In the entire monitored period, the natural gas consumption recorded a decrease higher than 50%. Consumption of wood, industrial waste and biogas has the most significant share on final consumption of renewable fuel and waste sources. The heat consumption decreased by 40% in the same monitored period.
Theenergy intensity of the Slovakia's **industry** is still very high compared to other member states of the European Union. In 2008, the share of Slovakia's industry on final energy consumption was 40.4% (The industry share in the EU 27 was 27.2%). From 1995 to 2001, total energy consumption in the industry decreased by almost 55%. From 2001 to 2008, the trend in the final consumption is stable except for few slight variations. In 2008, the consumption of gaseous fuels (by more than 30%) and liquid fuels (approx. by 60%) in the industry decreased. Consumption of solid fuels recorded a stable trend. Since 2001, it is possible to monitor also the consumption of renewable fuel and waste sources. The most frequently used is wood and industrial waste (increase by about 98%). In the monitored, heat consumption significantly increased (by more than 60%).
Final energy consumption in the **transport** sector increased by almost 80% in the period of thirteen years and it is still increasing. Total liquid fuels consumption has the highest share (97%) on total fuel consumption. By contrast, the share of total solid and liquid fuels consumption and electricity consumption is low. From 1998 to 2008, the electricity consumption is stable compared to the other fuels. Consumption of gaseous and liquid fuels has an increasing trend. The consumption of solid fuels in 2008 almost doubled compared to the 2007. An increase in the total energy consumption is caused mainly by an increase in the consumption of solid fuels and oil and oil-based products from liquid fuels. It proves that prognosis on energy consumption increase in this sector start to be accomplished and Slovakia is approaching the EU average.
In 2008, the total energy consumption in the **sector of services** almost reached the value from 1995. It is lower only by fewer than 4%.
For **households,** the total fuel and energy consumption has been decreasing. From 1995, it decreased by 15%. In the period of ten years, the electricity consumption for households decreased by about 20%. The most frequently used fuel in the household is brown coal. From 2001, the most frequently liquid fuel used in the households is bottled gas. In 2002, it was added to the liquid fuels category by new methodology of the Statistical Office in the Slovak Republic. The Slovak Republic still belongs among the most gasified countries in Europe. In the category of renewable energy source, wood is the most frequently used fuel.

Final Electricity Consumption in the National Economy Sectors
The Slovakia's population living standards as well as achieving standards comparable with those of the EU developed countries is, among other things, impacted also by sufficient volume of electricity at cost ensuring not only the economy competitiveness but also its availability for the population.

In 2008, the consumption of electricity per capita (4585 kWh/capita) in the Slovak Republic was 20% lower than in the EU 27 (Eurostat, 2009).
Since 1998, the total electricity consumption was increasing and this trend is ongoing also in 2008. In the entire monitored period, the electricity consumption increased by 15%. Traditionally, the electricity consumption is highest **in the sector of industry** (50% share). Its consumption is still increasing. From 1998 to 2008, it increased by more than **25%.**

In the monitored period, also the electricity consumption **in the sector of trade and services** increased by up to **40%.**
Sector of **agriculture** has the lowest share on electricity consumption. It recorded a decrease by about **60%** compared to the 1998. The electricity consumption decrease of transportation on total electricity consumption is more than **45%** in the monitored period. The share of **households** on total electricity production is 18%. In last 10 years, it decreased by about **20%.**

Trend in final electricity consumption in the economy sectors in the SR (TJ)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
*Note: * According to the revised methodology of the Statistical Office of the Slovak Republic, 2002*
Indicator Final electricity consumption by sectors of the economy

Electricity has a specific position within energy sources as the production and usage of electricity unlike other fuels and energy **is not necessarily connected with a negative impact on the environment.** The electricity is considered to be clean if it is produced and consumed with high efficiency, if it substitutes energy produced by combusting process of the low-energy fuels, or if it is produced from renewable energy sources.
Further trends in the electricity production are an important factor for strategic planning at all levels. It is expected, that the electricity consumption will increase by **1.6%** yearly (reference scenario). **By 2030**, the electricity consumption increase is estimated for 13.5 TWh, which stands for **almost 46% increase** compared to the actual consumption (Ministry of Economy of the SR, 2008).

4.1.5 Energy Efficiency

Within the European Union, the energy delivery is one of the most important priority, which interfere with political, economical, and society's life. In parallel, several internal and external factors are intersected here; high price of the energy raw material in the worldwide market, relatively limited reserves of the energy sources in the territory of the EU, constant increase in overall demand on energy and increase of the energy consumption, growing requirements on transportation and distribution of energy.

Therefore it is urgent to approach new tendency that is controlled energy demand, adoption and completion of energy cost saving measures, the most effective utilization of energy at its consumption, as well as searching for new alternative renewable energy sources, and their utilization. Higher efficiency of the energy end-use and completion of energy cost saving measures may significantly contribute to **reduction of the emissions from CO_2 and other greenhouse gases**, and reduced consumption of primary energy sources and that will positively affect energy security as well as energy price for the consumers.

Energy Intensiveness Strategy and Energy Efficiency Action Plan of the Slovak Republic state the following measures that are focused to reduce theenergy intensity for the years 2008 to 2010:

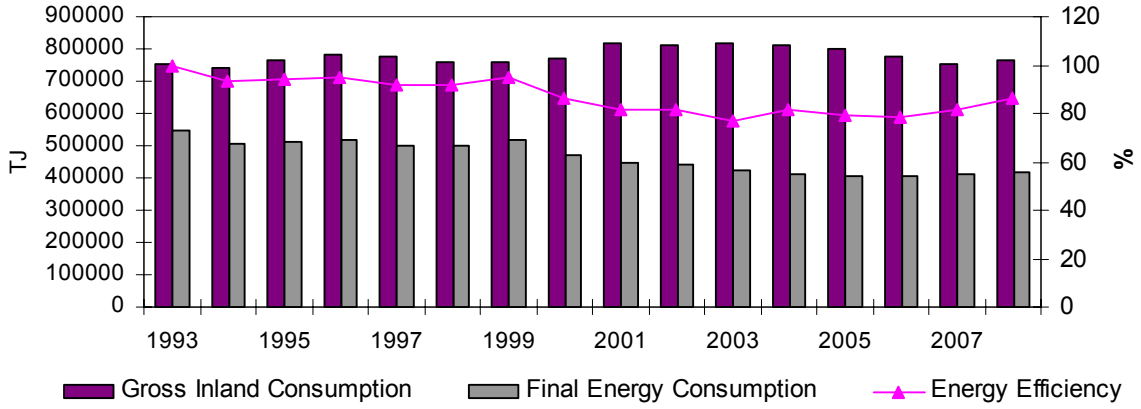
- Gradually reduce theenergy intensity up to the average level of theenergy intensity in original fifteen (EU 15) member states of the EU.
- In accordance with the Directive 2006/32/EC on Energy End-Use Efficiency, meet the adopted overall national indicative energy saving target of 9% for the period of 9 years (2008 – 2016), i.e. 37 215 TJ.
- During following 5 years (2017 – 2021), meet the yearly saving target of 0.5% of the energy end-use consumption.
- The saving target for the end – use consumption for the years 2022 to 2030 was set up at the level of 0.1% yearly.
- Achieve the intermediate national indicative saving target for the third year (2010) at the level of 3% of the energy end-use consumption; i.e. 12 405 TJ (Ministry of Economy of the SR, 2007).

Energy savings and measures in the field of energy efficiency relate to all basic sectors of the energy consumption and usage. They are concentrated on buildings, appliances, industry and agriculture, transportation, energy production and transfer, distribution and sale of the energy to end users. The horizontal measures relate to some or all sectors of the consumption. The public sector plays a special role. In individual sectors, two categories of measures are defined. The first category contains measures, which are based on existing policies, legislative regulations, and promoting programmes. In the second category, new measures to achieve energy savings are proposed.

Total Energy Efficiency

From 1994 to 2008, the gross domestic consumption increased by 2% while final energy consumption in the same period decreased by almost 25%. These trends are caused by decreasing energy efficiency despite of its slight increase in recent years. From 1994 to 2008, it decreased by almost 15%. In 2008, the energy efficiency in the Slovak Republic was **57.6%** which is about 10% less than the energy efficiency of the EU 27 countries (Eurostat, 2009).

Trend in Energy Efficiency in the SR from 1993 to 2008



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator *Total energy efficiency*

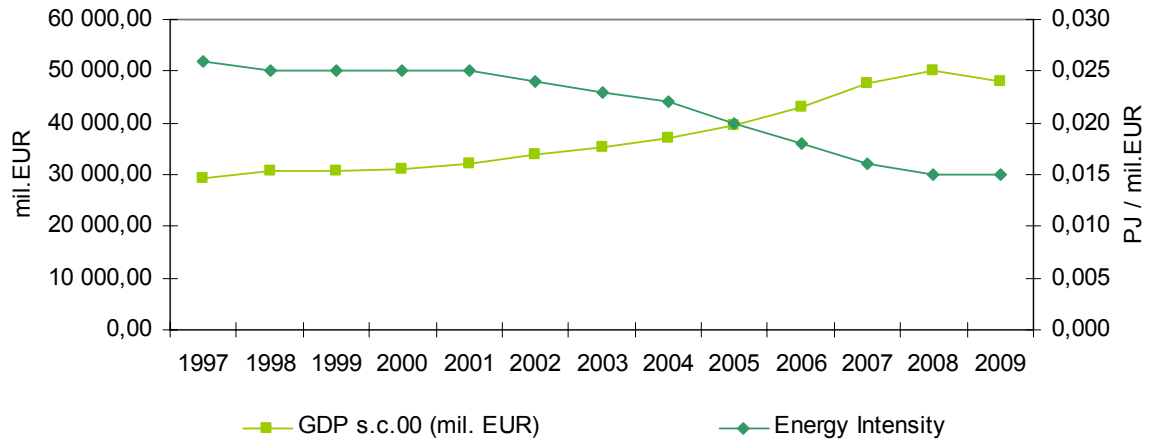
Energy Intensity

Theenergy intensity, defined as the ratio of gross inland energy consumption (GIC) to gross (GDP) domestic product, is an important economic indicator, which is also used for international comparison (GIC/GDP = EI). From 1997 to 2008, the growth in the GDP increased by approximately 40%, and it is suggested that it was accompanied with a balanced consumption of the energy sources, which decreased by 2% in the monitored period. It might be stated, thatenergy intensity **has been steadily declining** since 1997. In 2008, it declined by more than 40% compared to the year of 1997 and it was caused mainly by the growth of production with a higher added value and implementation of the cost saving measures on both the production, and consumption sides.

The estimate of the gross final energy consumption up to 2030 is based on its moderate growth. It is believed that up to 2015, the growth in the GDP will be faster than decline in theenergy intensity. However, after the year of 2015, it is expected thatenergy intensity will be decreasing faster that the growth in the GDP will be increasing.

Despite of the positive trend, theenergy intensity of the Slovak Republic is still about 1.5 times higher than the average intensiveness of the OECD countries (Ministry of Environment of Slovak Republic, 2009).

Trend in the GDP Growth and Energy Intensity



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator Energy intensity of the economy in the Slovak Republic

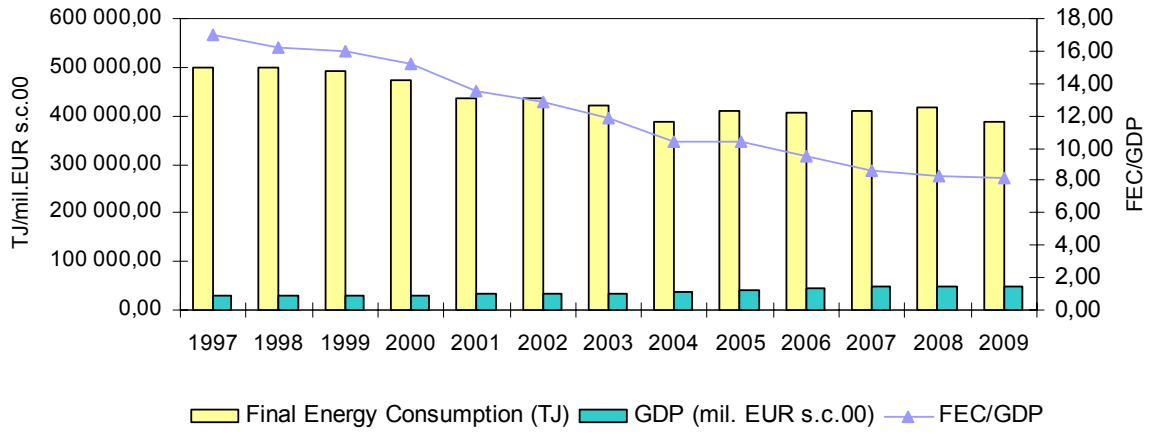
Data are given in fixed prices, which were calculated by chaining of volume indices to reference year of 2000. Conversion rate of 30.1260

Energy Intensity in the Final Energy Consumption in the sectors of the economy

The Slovakia's energy intensity by total energy consumption has been having a decreasing trend since 1993. The final energy consumption decreases and GDP growth increases which is a **positive tendency.** It is a result of gradual completion of cost saving measures on the consumption side.

Correlation between energy consumption and growth of the driver (GDP) in the sector can be distinguished only if the decline of the energy intensity is proportional to the growth of the driver. Such proportion has not been seen in any sector yet albeit a positive trend of decline in theenergy intensity and growth of the driver was recorded in all sectors of the Slovakia's national economy but households from 1997 to 2008.

Trend Energy Intensity of Final Energy Consumption (TJ, EUR million s.c.00)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indicator Energy intensity of the final energy consumption in the sectors of the economy

The sector of agriculture shows a positive tendency even for future. From 1997 to 2008, theenergy intensity was decreasing. By 2004, it dropped by up to 97%. From 2004 to 2008, its level is more or less stable. Even the energy consumption had a similar tendency during this period except for the 2004 when it dropped by 96%. However, it did not change until 2008. Also, the driver (GDP) continuously increased by 30% in the sector of agriculture. Usage of alternative sources, especially using of biomass for energy purposes has not been seen in the energy balance and energy efficiency because the alternative fuels under existing economic conditions (without adequate promotion of the state) are not able to compete with conventional fuels. The biomass permanently proves to be a perspective national energy source, especially for ensuring the central heat production.

The sector of industry shows a positive tendency even for future. From 1997 to 2008, theenergy intensity declined almost by 80% whiles the driver (GDP) in the monitored period increased by 65%. From 1997 to 2001, the final energy consumption in the sector of industry decreased by about 40%. From 2001 to 2008, the final consumption is more or less stable. From history, the Slovak Republic is typical in its industry with a significant share in low processing rate, high resource, energetic, and transportation intensity. The importance of theenergy intensity reduction increases with rising energy price.

From 2001 to 2008, **the sector of transport** was alternately showing positive and negative tendency. Theenergy intensity increased two times and vice versa. In the monitored period, it finally decreased by 5% in total. From 2008, the final energy consumption increased due to higher fuel consumption by 30%. Also the driver (GDP) was increasing and achieved a 35% increase by 2008. Due to the limited scope of water and air transport, the road to energy savings leads through the promotion of rail over road transport and public over individual transport.

The energy intensity of the **households sector** shows a slightly decreasing tendency.

The population growth from 1996 to 2008 was very moderate. In this sector, the final energy consumption decreased by more than 20% in the monitored period. In future, this tendency might be disrupted by an increasing trend in the electricity consumption, mainly due to higher comfort of inhabitants, and equipping the households with new appliances. There is a space to educate inhabitants through propagation of energy-effective appliances. The potential of energy saving by population is very high (EEA, 2008).

5. What is an impact of energy on environment in the Slovak Republic?

Energy belongs to branches, which significantly pollute the environment. Problems to ensure sufficient volume of energy and as well as environment of good quality are an essential part of scientific prognosis on population development.
Harmonization of energy and environment has become one of the most important and strategic tasks in solving the environmental issues. Therefore, the energy has to follow the principle of perpetually sustainable development. Next chapters are addressed to impact of the energy on environment; specifically to an air as its component and waste as one of risk factors.

5.1 Air

The energy has the most significant share on emissions from greenhouse gases to on total greenhouse gasses emissions in the Slovak Republic and it amount **65,8%** in 2008 (it is a decrease by 8% compared to the 1990). It contributes especially to generation of carbon dioxide, methane, less to nitrous oxide, and basic polluting substances mainly such as sulphur oxide (SO_2), nitrogen oxides (NO_x), and solid polluting substances.

List of individual energy-environment indicators, which are relevant do describe impact of the energy on air quality and climate change

Position in the D- P -S – I - R structure	Individual indicator
Driver	Structure of primary energy sources by fuels
	Electricity production by sources and fuels
	Gross inland energy consumption
	Final energy consumption by fuels
	Final fuel and energy consumption by sectors of the economy
	Final electricity consumption by sectors of the economy
	Energy intensity of the economy in the Slovak Republic
	Energy intensity of the final energy consumption in the sectors of the economy
Pressure	Greenhouse gases emissions from energy
	Emissions of air pollutants from energy production and consumption
State	-
Respond	Energy price
	Grants in energy
	Renewable primary energy consumption
	Electricity generated from renewable energy sources

5.1.1. Driving forces in Energy

Driver indicators in relation to air quality and climate change are Structure of Primary Energy Sources by Fuels, Electricity Production by Sources and Fuels, Gross Inland Energy Consumption, Final Energy Consumption by Fuels, Final Fuel and Energy Consumption by Sectors of the Economy, Final Electricity Consumption by Sectors of the Economy, Energy Intensity, and Energy Intensity of Final Energy Consumption in the Sectors of the Economy. All these indicators are listed the Chapter No. 4.

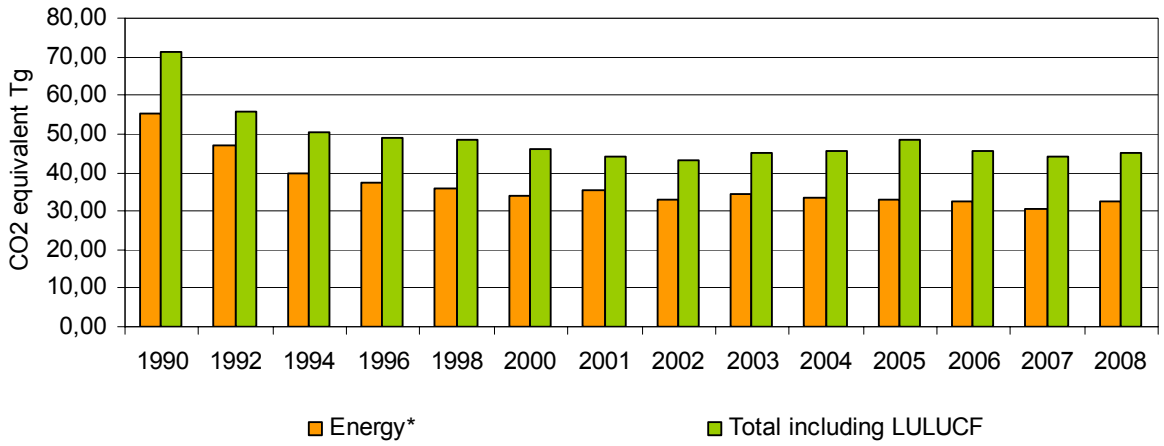
5.1.2. Pressure of Energy on Air Quality and Climate Change

The energy mainly shares in the generation of emissions of the greenhouse gasses; mostly carbon dioxide (CO_2) and methane, and less nitrous oxide (N_2O).

5.1.2.1. Greenhouse Gases Emissions

In 2008, the total greenhouses gasses emissions were 48 831.11 Gg (without LULUCF sector), which stand for reduction almost by 34% compared to the reference year of 1990. The greenhouse gases emissions increased by 2.3% against 2007. In the Slovak Republic, the total greenhouse gasses emissions have been stabilized or have been increasing just slightly.
The energy sector has still main share in the aggregated emissions from the greenhouse gasses. In 2008 compared to the 2007, they slightly increased and achieved 65.8%. During monitored period, the air emissions of greenhouse gases from the sector of energy decreased by about 12% as a result of lower manufacturing and changed fuel base in favour of clean fuels and fuels of better quality (currently natural gas). It is important to highlight that the 2008 was the first year of Kyoto Protocol Commitment (2008 – 2012). In the Kyoto Protocol, the Slovak Republic undertook to maintain and keep the aggregated greenhouse gas emissions at 8% below the emissions level from 1990.

Trend in aggregated greenhouse gas emissions in the Slovakia's sector of energy from 1990 to 2008 (CO2 equivalents Tg)

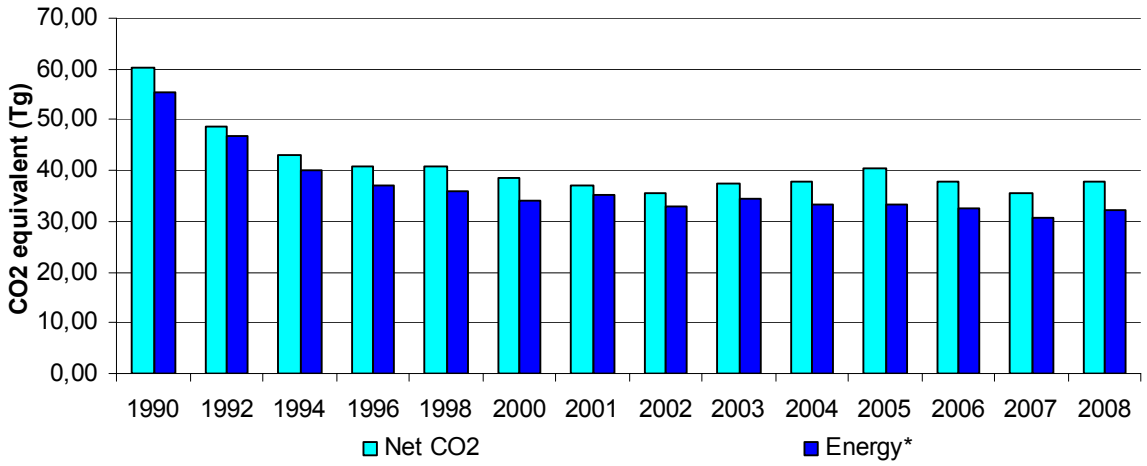


* Emissions from transport included, updated years of 1990 to 2007
Source: Slovak Hydrometeorological Institute; Processed by: Slovak Environmental Agency
Indicator *Greenhouse gases emissions from energy*

CO_2 Emissions from Electricity and Heat Production

In 2008, the total net CO_2 emissions increased by 4% compared to the 2007 and **decreased** by **42%** compared to the basic year of 1990 (emissions from transportation included).
Surely, the significant decrease of the CO_2 emissions coheres in decreasing energy intensity from 1993, higher share of the services in the GDP growth, higher portion of natural gas in fuel base, structural changes in the industry, decreasing energy consumption in energy-demanding sectoral branches (except for metallurgy), and finally also positive impact of direct and indirect legislative measures. An increase in emissions is anticipated in connection with revived Slovakia's industry, new sources, and a shift to the solid fuels owing to increased price of natural gas. Thanks to its proportion of electricity produced from nuclear sources, Slovakia is today among countries with a very low level of CO_2 emissions in proportion to the amount of electricity produced.

Trend in CO_2 Emissions from Energy compared to the Total CO_2 Emissions in the SR (CO2 equivalent Tg)



* Emissions from transport included, updated years of 1990 to 2007
Source: Slovak Hydrometeorological Institute; Processed by: Slovak Environmental Agency
Indicator *Greenhouse gases emissions from energy*

Methane Emissions from Electricity and Heat Production

Leaks of natural gas in low-press distribution pipelines are significant source of methane emissions from the energy. Methane (CH_4) releases into the atmosphere also during brown coal production and biomass incineration. The total methane emissions decreased from 73.44 Gg in 1990 to 38.36 Gg in 2008 and it stands for almost 7% decrease (Slovak Hydrometeorological Institute, 2009). Production of electricity and heat does not belong to large contributors of the methane emissions and it recorded a decrease in the generation of methane emissions in the monitored period(*Indicator* *Greenhouse gases emissions from energy*).

5.1.2.2. Air Emissions of Polluting Substances from Production and Consumption of Energy

Production of electricity and heat from fossil fuels is connected with production of emissions from SO_2, NO_x, CO, and basic polluting substances. Within the framework of air protection, it is necessary to continue to make the energy production base more environmentally friendly with the aim of reducing the production of pollutants discharged into the atmosphere.

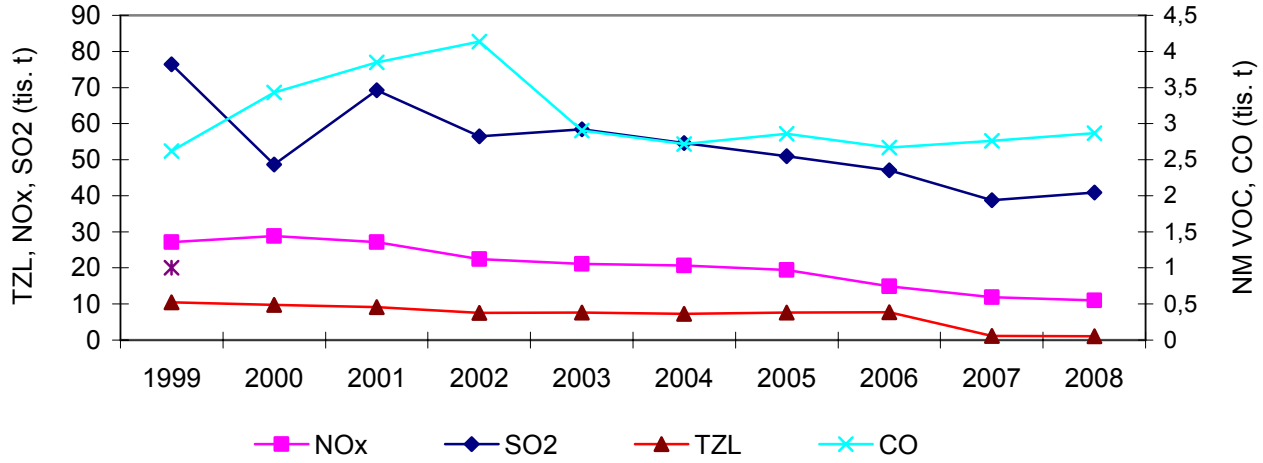
From 1990 to 2008, the emissions of the polluting substances from the energy significantly decreased. The highest decrease was recorded for solid polluting substances (approx. 90%), and oxides of sulphur (SO_2, 87%). The NO_x emissions and CO emissions decreased by 57% and 52% in 2008 compared to the basic year (Slovak Hydrometeorological Institute, 2009). They declined as a result of a drop in the consumption of solid fuels, such as black and brown coal and heavy fuel oils, as well as changed fuel base in favour of clean fuels and fuels of better quality.

The air protection legislation in force in the Slovak Republic specifies emission limits for these substances – i.e. the maximum permissible concentration values of harmful substances that must be adhered to by facilities burning fossil fuels. These values are fully harmonised with the emission limits accepted in European Union legislation.

In the medium and long run, there has been a **continuous positive trend** in Slovakia towards the **gradual reduction of harmful substances discharged into the atmosphere**. This decline is a result of the gradual reduction of the proportion of electricity and heat production in power plants burning fossil fuels, while extending the use of reconstructed

facilities with progressive fluid technologies and reliable operation of technologies cleaning the products of combustion.

Trend in emissions of air polluting substances from stationary sources in the sector of the energy (thousands tons)



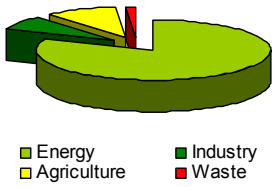
Source: Slovak Hydrometeorological Institute; Processed by: Slovak Environmental Agency
Indicator *Emissions of air pollutants from energy production and consumption*

5.1.3. Quality State of Air - Impacts

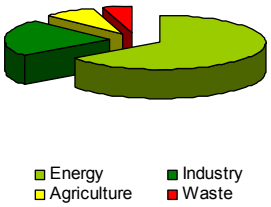
The energy belongs to sectors, which the most effect the environment and heath of people. The energy as the largest contributor to total emissions from the greenhouse gases has the highest impact on the climate change and strengthening greenhouse effect. Many projects and studies are dedicated to analyses and evaluation of negative effects from production and consumption of the energy. Slovakia as a member state of the EU undertook to reduce the emissions from the greenhouse gas by 20% (compared to the level from 1990) by 2020.

Share of individual sources on emissions from greenhouse gases in the SR

1990 **2008**



1990		2008
81,5%	1. Energy*	65%
7,3%	2. Industry**	22,5%
9,8%	3. Agriculture	8,0%
1,5%	4. Waste	4,5%



Source: Slovak Hydrometeorological Institute, Emissions as of April 15, 2010, actual years 1990 to 2007, LULUCF included, Processed by Slovak Environmental Agency
*total emissions, including emissions from transport sector, **total emissions, emissions from F-gases including

5.1.4. Respond

Legislative and other measures, which are adopted on international and national level, are a respond to actual quality state of the atmosphere and climate change.

At the United Nations Conference on Environment and Development (Rio de Janeiro, 1992), United Nations Framework Convention on Climate Change was adopted. In the Slovak Republic, the convention became effective on November 23, 1994. Slovakia accepted all commitments resulting from the convention; reduction of emissions from greenhouse gases to the level from 1990 by 2000 included. Furthermore, the Slovakia set up its national objective to meet the "target from Toronto"- 20% decrease of emissions by 2005 compared with 1998. At the United Nations Framework Convention on Climate Change in Kyoto in December of 1997, the Slovak Republic undertook to reduce the production of greenhouse gases by 8% by 2008 compared with 1990 and maintain them at the same level until 2012. In the meantime, Slovakia has been successful in meeting these targets.
In 2003, based on the **Kyoto Protocol**, the European Union adopted a Directive No. 2003/87/EC establishing a scheme for greenhouse gas emissions allowance trading within the Community. The Slovak Republic transposed this directive by the SR National Council Act No. 572/2004 Coll. on trading with emissions quotas as amended. This system should be changed from January 1, 2013.
Also the Energy Policy of the Slovak Republic from 1996 is concerned with greenhouse gas emissions problems. The reduction of greenhouse gas emissions in the energy sector will be encouraged by:

- Greater energy efficiency of electricity production and promotion of more effective conversion technologies and higher grade fuels,
- Greater proportion of energy from renewable sources and highly efficient cogeneration of heat and electricity.

The European Union has been the leader in global warming combat. Thanks to a package of measures for the field of climate and energy, adopted in December 2008, key measures were implemented to achieve much higher reduction of the emissions by 2020 (at least by 20% compared with 1990), to increase a portion of renewable energy sources (wind energy, solar energy, energy from biomass, etc) so they amount 20% of the total energy production (currently it is ± 8,5 %), and finally to reduce the energy consumption by 20% compared with original plan for 2020 through improvement of energy effectiveness.
The European Union anchored its commitment in the **Decision No. 406/2009/EC of the European Parliament and of the Council** of 23 April 2009 on the effort of member states to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emissions reduction commitments up to 2020. Climate change as an urgent topic was discussed by 119 states´ and governments´ leaders on the **United Nations Climate Change Conference in Copenhagen in December 2009.** At the summit, many countries opposed the draft of an Accord, on the other side, agreed to meet in 2010. However, all leaders admitted that the accord will help to accomplish a progress in reduction of the greenhouse gas emissions, increase efforts at greenhouse gas emissions reductions, and increase efforts in adaptation process. The main assignment of all states remains to develop a generally binding document. Reduction by 20% is not sufficient to prevent a dangerous climate change and therefore, the European Union undertook to cut the emissions by 30% below 1990 levels if other large contaminators fairly contribute to meeting the ambitious targets of the accord on climate change.
In the long run, **the Slovak Republic supports the opinion** that developed countries should jointly reduce the emissions by from **60% to 80% below 1990 levels by 2050.**

5.1.4.1. Promotion of Renewable Energy Sources Utilisation (RES)

At present, the renewable energy sources are one of the main tools that are to help the European Union to accomplish its three cardinal objectives from the energy policy – competitiveness, permanently sustainable development, and security of supplies.

In 1997, the European Parliament and Council adopted White Paper for a Community Strategy and Action Plan, in which the European Commission undertook to double the

portion of the renewable energy sources on gross consumption (from 6% in 1995 to 12%). In order to promote the utilisation of the renewable energy sources, the Commission submitted **also other documents**; Green Paper: Towards a European Strategy for the Security of Energy Supply (2000), Promotion of Electricity Production from Renewable Energy Sources (2005), Action Plan for Biomass (2007), Report on Progress in Renewable Energy Sources for Electricity (2007), and Energy Policy for Europe (2007).
In order to respond to the environmental challenges, the European Union adopted climate and energy package as a set of legal regulations. Among other things, the European Union undertook to **increase the portion of the renewable energy sources on total consumption by 20% compared with 1990 level by 2020**. Furthermore, it committed to **increase the share of bio fuels in the transportation by 10%** (EC, online).

In 2009, the directive **on promoting to use the electricity from renewable energy sources** was adopted. It set up the national targets for the share of the renewable energy sources by 2020. Based on this directive, the Slovak republic adopted the National Action Plan in October of 2010. The plan states an aim to **achieve 14% share of the renewable energy sources use** (Ministry of Economy of the SR, 2010). The document is based on legal regulations of the Slovak Republic and other adopted documents such as Energy Policy of the Slovak Republic, Energy Security Strategy of the Slovak Republic, Strategy of Higher Utilization of Renewable Energy Sources in the Slovak Republic, and National Strategic Reference Framework for the Period of 2007 – 2013.

State in the RES usage
The portion of the renewable energy sources in the Slovak Republic has a positive tendency, and national gross consumption of the RES increased by 50% in last 5 years.

Gross RES consumption (TJ) from 2002 to 2008

Sources	2002 [TJ]	2003 [TJ]	2004 [TJ]	2005 [TJ]	2006 [TJ]	2007 [TJ]	2008 [TJ]
Biomass	10 549	12 347	15 641	16 822	17 388	20 912	21 712
of it wood	10 549	12 347	14 439	15 361	15 628	19 302	19 801
municipal waste	0	0	1 202	1 461	1 760	1 610	1 911
Biogas	136	150	237	205	318	314	433
Geothermal energy	228	192	195	337	397	438	362
Solar energy	37	41	45	50	-	-	1
Total	**10 950**	**12 730**	**16 118**	**17 414**	**18 103**	**21 664**	**22 507**

Source: Ministry of Economy of the SR; Processed by: Slovak Environmental Agency

In the Slovak Republic, the **biomass** with its **60% share** is the most used renewable energy sources. In 2008, its share increased by 50%. For energy purposes, the biomass is the most frequently used in pulp and paper industry, and printing industry. However, the usage of biomass for the energy purposes still lagging behind most of the developed European states in relation to volume and quality. The share of biomass fuel on the total energy consumption in the Slovak Republic amounts only 2.8% while this share in the developed countries with comparable natural conditions is in the range from 7% to 20% (Obrcianová D., Gonda Ľ, Kunský M, Agriculture as a sources of biomass for energy purposes in Slovakia, Environmental Magazine, 2009).

From 2002, the **biogas** consumption has increased almost by 70% but Slovakia is still lagging in its using compared to surrounding countries. In 2009, the 86,725 PJ of motor fuels were in operation, from which the bio fuel amount 3.4% (Ministry of Economy of the SR, 2010). Currently, four facilities for production of the biogas from cattle manure and one facility for production of the biogas from agricultural biomass are in operation. Their total

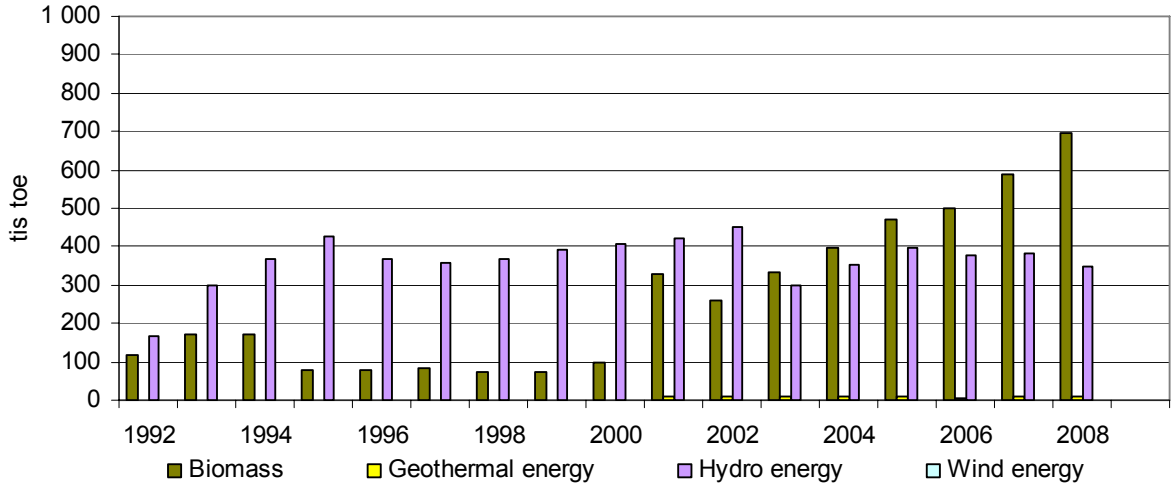
electricity output is 1.3 MW. Wastewater treatment plants are an important source of biogas. In 2004, 24 co-generation units were in operation using their own biogas.

Geothermal energy is used for heat generation and recreation purposes. In Slovakia with its more than 100 geothermal springs with water of temperature from 16 °C to 126 °C, has good prerequisites to use the geothermal energy. In 2004, the geothermal energy was used in approximately 36 localities in Slovakia with heat production capacity amounting to 131 MWt, which stand for 2.3% of total geothermal energy potential. The current situation in the use of geothermal energy is unsatisfactory considering the potential that this renewable energy source has to offer.

In Slovakia, the usage of **solar and wind energy** is negligible. The **wind energy** is currently the most rapidly growing energy branch within the EU. Wind energy potential on a worldwide basis can cover 10% of total energy demand. In 2008, **Slovakia** contributed to the European statistics by its feasible potential of 6 MW and production of 8200 MWh, which did not cover even **0.1%** of its own demand (Lauro T, Gnida M, Economic and environmental contributions of renewable energy sources, Environmental Magazine, 2009). In case of **solar energy**, the technically feasible potential in Europe is still relatively low. It is estimated that 500 to 700 m^2 of solar collectors was installed annually **in Slovakia** in the mid 1990s. From 2000 the number of installed solar collectors grew swiftly until the beginning of 2003, when solar collectors were reclassified to the higher VAT rate category. **In 2009**, there were approximately **110 000 m^2** of solar collectors in use in Slovakia and they were mostly used as heat source for preparation of hot service water and for heating water in pools.

Hydro Energy - The technically feasible hydro energy potential in Slovakia for the production of electricity is 7 361 HWh per year and currently is used in 243 hydropower plants, meaning that the potential is utilized at the level of 58%. The remaining potential of 2 500 GWh/year is to be used (Lauro T, Gnida M, Economic and environmental contributions of renewable energy sources, Environmental Magazine, 2009).

Trend in final consumption of energy from renewable energy sources (thous. TOE)



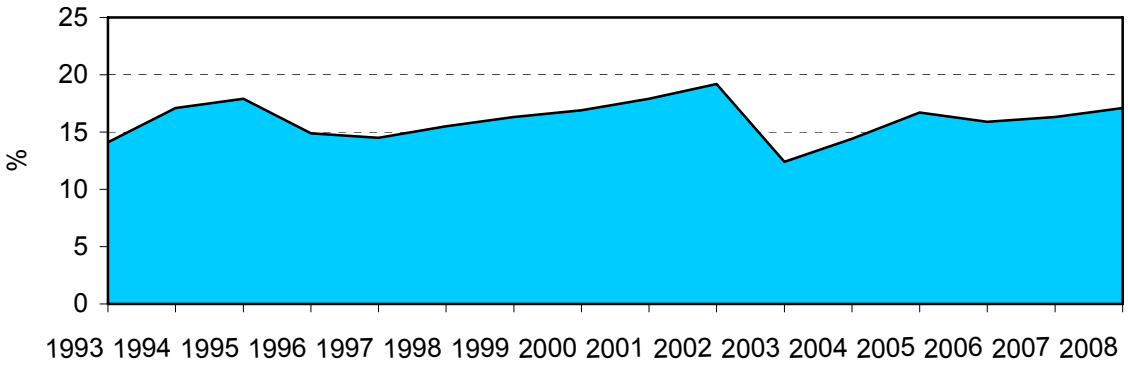
Source: EUROSTAT; Processed by: Slovak Environmental Agency
Indicator Renewable primary energy consumption

In 2008, the share of energy from the RES on gross final energy consumption was **8.4%** (target of 14% in 2020) and increased by more than 50% compared to the 1993. Despite it, the Slovak Republic is still about 18% below the average level of the EU 27. The European average level of RES energy share in 2008 was 10.3%. In Slovakia, mainly the energy usage of biomass has been increasing. In 2008, the biomass share was more than 65% on all renewable energy sources (mainly wood and wood waste). The share of hydro energy was approx. 33%. Geothermal, solar, and water energy have a minimal share. Share of

renewable energy sources for heat production on total energy consumption is **6.4%** (Eurostat, 2009).

In 2008, **17.1 %** (4783 GWh) of produced electricity on gross electricity production was coming from renewable energy sources, which stands for an increase of 18% against 1993 (EU 27 average – 2 716.6%). (Eurostat, 2009)
The Slovak Republic has its national indicative target for RES electricity on total electricity consumption set for **19 %** until 2010. (The original value of 31%, which was determined by the EU, was reduced).

Trend in contribution of the electricity produced from RES to final electricity consumption (%)



Source: EUROSTAT
Indicator: Electricity generated from renewable energy sources

According to the **National Action Plan for Energy from Renewable Sources**, it is estimated that total consumption of the energy from RES will be 76 PJ by 2020. It means that Slovakia will exceed the estimated production by 6 PJ of energy from the renewable energy source (considering the expected amount of energy at the level of **70 PJ**, which corresponds to the target of **14%** for the year of 2020). The RES usage comes out of a principle of minimizing the costs at integrated approach to the RES and target of greenhouse gases emission reduction.
The prerequisites are based on effective usage of technically feasible potentials of the renewable energy sources.

Total and technically feasible potential of RES

Source	Total potential		Technically potential	
	TJ	GWh	TJ	GWh
Hydro energy:	23 760	6 600	23 760	6 600
Large hydro-electric power plants	20 160	5 600	20 160	5 600
Small hydro-electric power plants	3 600	3 600	3 600	1 000
Biomass	120 300	33 400	120 300	33 400
Forestry biomass	16 900	4 700	16 900	4 700
Agricultural biomass	28 600	7 950	28 600	7 950
Biofuels	7 000	1 950	7 000	1 950
Biogas	6 900	1 900	6 900	1 900

Other biomass	60 900	16 900	60 900	16 900
Wind energy	*	*	2 160	600
Geothermal energy	174 640	48 500	22 680	6 300
Solar energy	194 537 000	54 038 000	34 000	9 450
Total	**194 855 700**	**54 126 500**	**202 900**	**56 350**

**Total potential of wind energy has not been determined, and technically feasible potential is determined based on 2002*
Source: Strategy for Higher Utilization of Renewable Energy Sources in the SR

It is expected that biomass, geothermal, and solar energy will gradually replace the fossil fuels for heat production. Lower growth in the RES usage is expected for electricity production.
The **10%** target for **biofuels** share by 2020 in the transport corresponds to 6 PJ providing that bio fuels of 2nd generation produced from waste, residuals, non-food, pulp, and lignite-pulp material will dominate. Owing to low share of electric cars, the usage of electricity from the RES in the transport is expected at the level of 200 GWh (Ministry of Economy of the SR, 2010).

The Europe takes the lead in the field of technologies for the usage of the renewable energy sources and has the merit that this field goes further in the development.
Although technologies using renewable energy sources are more demanding per unit of installed capacity than the conventionally used ones, investing into renewable energy sources still brings more advantages if we take the external cost related to use of energy from fossil sources (harm to environment) into consideration.
However, the overall picture is not bright. The fact that expected development of renewable energy sources use is not achieved is caused by barriers that reduce the will to invest in projects that use renewable energy sources.

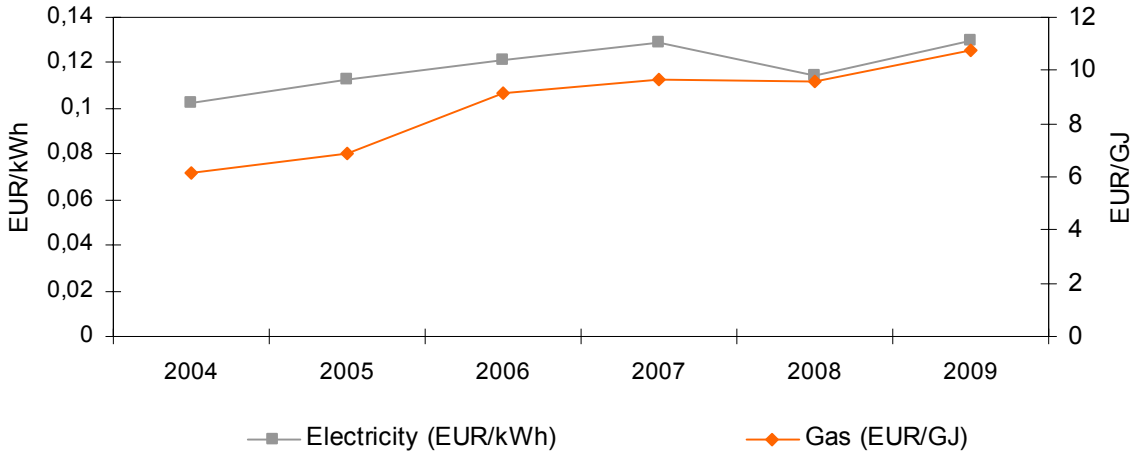
Estimated cost for construction of equipment and investment related to achieving the 14 % proportion of renewable energy sources on final energy consumption are **in total € 3.3 to 4.3 billion.** The dispersion is caused by an option of using various types of renewable energy and by uncertainty of future technology price reduction (Ministry of Economy of the SR, 2010).

5.1.4.2. Economic Tools in Energy

Energy, ecology, and economy have wide interdisciplinary coverage regarding Slovak national economy. Equability and balance of these terms and their mutual interlinking are one of cardinal prerequisites for energy security and permanently sustainable development of the society. As the gas crises in January of 2009 showed, the energy, ecology, and economy has to be perceived not only in terms of regional development, but also from wider aspect of European and worldwide space.

Prices
Since January 1, 2003, the prices are regulated by an independent institution **Regulatory Office for Network Industries**. The Act, under which the Regulatory Office for Network Industries was established, put the Regulatory Office for Network Industries under an obligation to set up the regulated prices which reflect costs and adequate profit from executing the services. In addition, cross-subsidies were eliminated and end-users get right signals when making decisions about energy use. In Slovakia, it helped to create prerequisites for increasing the efficiency in the energy, as well as conditions for liberalization in trading with electricity and natural gas were created and electricity and natural markets opened for industrial consumers.

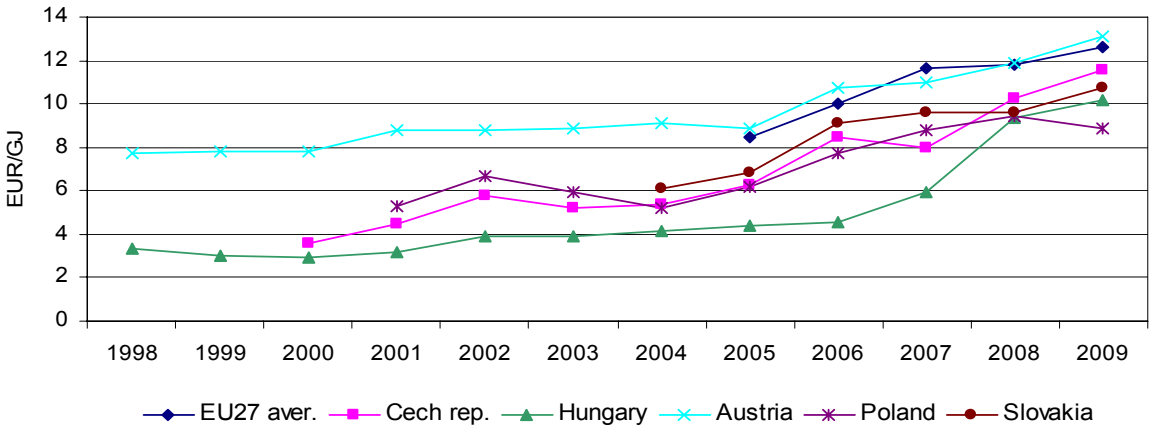
Trend in prices for electricity and gas in the SR (EUR/kWh) (EUR/GJ)



Source: EUROSTAT; Processed by: Slovak Environmental Agency
Indicator Energy price

Since 1997, the price for energy in the Slovak Republic has been continuously increasing. Until 2003, the energy prices were deformed by cross-subsidies. These cross-subsidies were completely eliminated for all categories of consumers in 2004. In 2008, the price for electricity and gas decreased. In 2009, the price returned back to its original value from 2007. **The energy price** reached the value below the European average in 2005. However, only Austria from neighbouring states has the electricity more expensive. Among the European Union member states, Slovakia is the country with the 13th most expensive electricity (1st half of 2009).
Regarding the **gas price**, Slovakia within region moved up one place behind Czech Republic and Austria, which are even more expensive. Poland and Hungary still have gas cheaper than Slovakia. A significant change in the energy price occurred for firms as the suppliers of the energy compensated their loss resulting from a fact that were not allowed by Regulation Office for Network Industries to increase the price of energies for households. While the gas and electricity price for the Slovak companies was at the level below the European average in 2006, during the 1st half of 2010 the Slovak companies started to purchase the 4th most expensive gas and the 3rd most expensive electricity in Europe (ÚRSO,2010).

Trend in electricity price for households (EUR/kWh) – international comparison



Source: EUROSTAT; Processed by: Slovak Environmental Agency
Indicator Energy price

Within new regulation policy for the period of 2009 to 2011, new procedures are defined for Commission for Regulatory and Regulatory Office for Network Industries in relation to legal

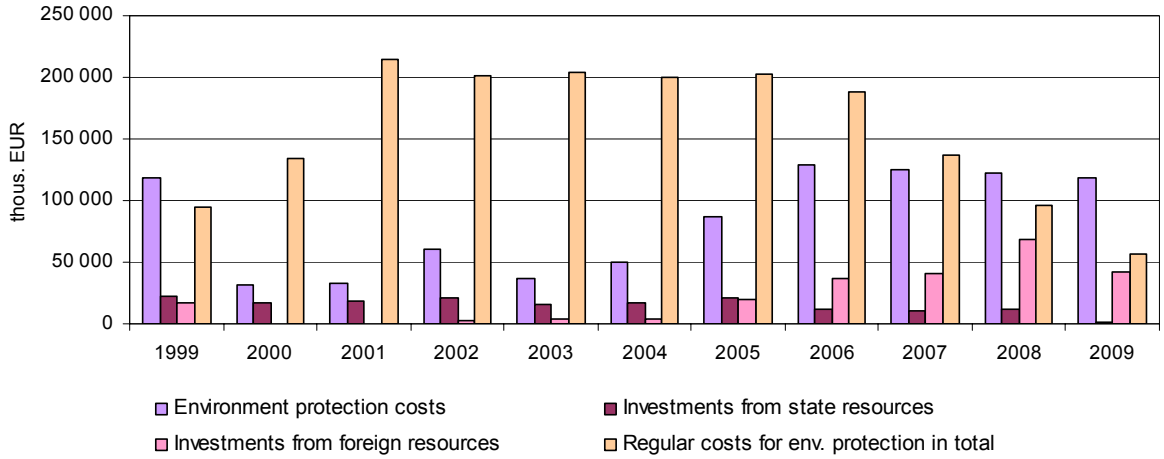
regulations of the Slovak Republic. The policy, in the full scope, transposes revisions, and amendments resulting from relevant regulations such as Act No. 656/2004 Coll. on power industry as amended, Act No. 657/2004 on heat industry as amended by Act No. 99/2007 Coll., and Act No 309/2009 Coll.

Subsides

Implementing the energy cost-savings measures and meeting the objectives under Energy Policy in the field of renewable energy sources use can not be done without enhanced financial support by means of funds from public resources.

From 1999 to 2008, the investments from foreign resources **increased** by **75%**. From 2005, the regular costs for environmental protection are decreasing. In 2008, they reached the level from 1999. Investments on environmental protection had a decreasing tendency from 1999, but increased from 2003 to 2006. They are stabilized since 2006. Also, the investments from state sources are stable from 2006. In total, they decreased by 47% compared to the 1990.

Environmental Protection Costs (Thousands EUR)



Source: Statistical Office of the Slovak Republic; Processed by: Slovak Environmental Agency
Indikátor Subsides in energy

Currently, the support is focused especially on reduction of the energy dependence on conventional energy sources through improved energy efficiency and development of the renewable energy sources. In recent years, the emphasis is put on support of renewable energy sources use also in case of small consumers.

The estimated investment that is inevitable to meet the set objectives in the electricity production by 2030 is **approximately €15 million**. From this sum, 44% of the financial means is for renewable energy sources, 36% for nuclear sources, 15% for heat sources, and 5% for the pumped-storage hydroelectricity dam at Ipeľ River (Ministry of Economy of the SR, 2008).

Within financial support from the EU for the energy industry, the financial means might be drawn from the EU funds: Operational Programme Competitiveness and Economic Growth (sponsor Ministry of Economy of the SR), Operational Programme Environment (sponsor Ministry of Environment of the SR), Programme for Rural Area Development (Ministry of Agriculture and Rural Development), Programme Intelligent Energy for Europe (IEE).

The Slovak Government approved the **Program for Higher Utilization of Biomass and Solar Energy for the Years 2007 to 2015** within set measures aimed to mitigate the consequences of economical crises, and with a purpose of meeting the objectives of Strategy for Higher Utilization of Renewable Energy Sources in the Slovak Republic in the field of heat production from biomass and solar energy. The government budget € 8 million for this program. The € 4,5 million is still available (November of 2010).

New directives on environmental aid are an important part of the climate and energy package adopted by the EU. These provide right stimulation for the member states and industry, in order to increase their efforts in the field of environment.
The state's support can facilitate individual companies in changing their behaviour and implementing procedures, which would be friendlier to the environment, or investing into ecological technologies. Furthermore, the state support can help also to the member states to adopt legal regulations or norms, which overreach the Community's norms and reduce unbearable limits for some companies.
Specific plans concerning the forms of the energy projects financing will depend on expectations of the investors, options to connect public investments with private ones, and effectiveness of implemented supporting programs. It is necessary to count on recession, which still resonates in the world and can negatively affect the project financing.

5.2. Waste water

The energy had the highest share on a volume of discharged waste water. Waste water produced by electric power plants comes mainly from technological and cooling processes, less from sewage sludge. The waste water from technology is chemically contaminated. In case of nuclear power plants, the waste water in the primary circuit is also radiochemical. Waste water, which originates from cooling processes, is mainly contaminated thermally.

Discharged volume of waste water from energy in 2009 (generation and electricity distribution)

	Volume (thous.$m^3.r^{-1}$)	NL ($t.r^{-1}$)	BSK_5 ($t.r^{-1}$)	$ChSK_{Cr}$ ($t.r^{-1}$)	NEL_{UV} ($t.r^{-1}$)
Cleaned	11 756,70	119,83	22,42	136,80	0,58
Unclean	6 019,52	20,74	4,11	18,54	0,01
Total	17 776,22	140,57	26,54	155,34	0,59

Source: Slovak Hydrometeorological Institute

Discharged volume of waste water from heat industry in 2009 (Production and distribution of water and steam)

	Volume (thous.$m^3.r^{-1}$)	NL ($t.r^{-1}$)	BSK_5 ($t.r^{-1}$)	$ChSK_{Cr}$ ($t.r^{-1}$)	NEL_{UV} ($t.r^{-1}$)
Cleaned	1 129,86	10,11	0,86	16,89	0,08
Unclean	1 125,59	0,33	0,00	0,85	0,00
Total	2 255,45	10,44	0,86	17,74	0,08

Source: Slovak Hydrometeorological Institute

5.3. Waste

Waste in the energy in a form of ash, slag, bottom ash, and fly ash is generated mostly from the burning of coal. The usage of nuclear material for energy purposes is connected with generation of spent nuclear fuel and radioactive waste.

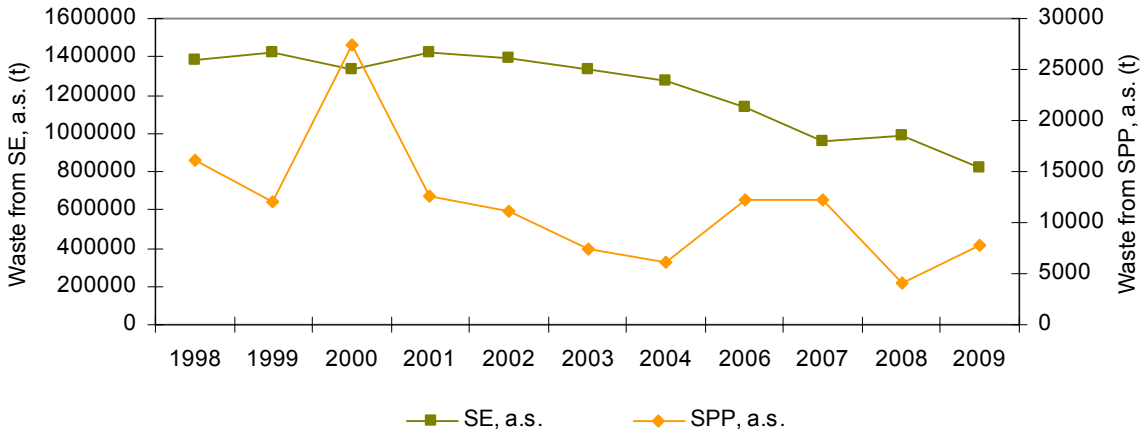
5.3.1. Driving forces in energy

Driver indicators in relation to waste production are Structure of Primary Energy Sources by Fuels, Electricity Production by Sources and Fuels, Gross Inland Energy Consumption, Final Energy Consumption by Fuels, Final Fuel and Energy Consumption by Sectors of the Economy, Final Electricity Consumption by Sectors of the Economy, Energy Intensity, and Energy Intensity of the Final Energy Consumption in the Sectors of the Economy. All these indicators are listed the Chapter 4.

5.3.2. Pressure of Energy on Waste Production

Waste from Energy

From the standpoint of the types of waste, the greatest amount of waste produced by the dominant electricity producer **Slovenské elektrárne a.s.** (SE,a.s.), originates from the burning of coal in thermal power plants. Ash materials generated from the burning of coal (ash, slag, bottom ash, fly ash) and stabilised FGD materials make up around 97% of all waste produced by SE, a.s. As a result of declining production of the electricity from coal, the amount of this waste is gradually decreasing. In 2009, the SE, a.s., produced 0.84 million tons of waste of all categories. By individual categories, **dangerous waste** makes up **1.01 %** and **other waste 98.9 %** of the total amount of waste (technological waste from thermal power plants, sludge from water treatment at the nuclear power plants, and mixed construction waste). It might be stated that the SE, a.s. recorded a decline in total waste production in 2009 compared to the 2008. The waste production has a positive tendency since 2001, except for the year of 2008 when a slight increase was seen in the total waste production compared to the 2007.



Source: SE, SPP ; Processed by: Slovak Environmental Agency
Indicator *Energy waste generation*

The **gas industry** deals with more than 50 types of waste generated in operational activities (such as repair and maintenance of gas lines, repair and maintenance of installations and technological facilities, disposal of technological facilities, cleaning of the transit system, etc.), as well as in service and support activities (transport, administration, cleaning of waterworks, etc.). The heavy use and consumption of large amounts of oil products is typical for the gas sector in general. The amount of waste used and the amount of oil waste generated depends on investment and reconstruction activities and disposal of installations and technological facilities, cleaning of the transit system, cleaning of waterworks, etc. In 2009, the Slovenský plynárensky podnik,a.s. (SPP, a.s.) produced 7 706 tons in total. In the category of other waste, the waste from construction activities has the highest share. The dangerous waste is made mainly of sludge and oils.

Radioactive Waste (RAW)

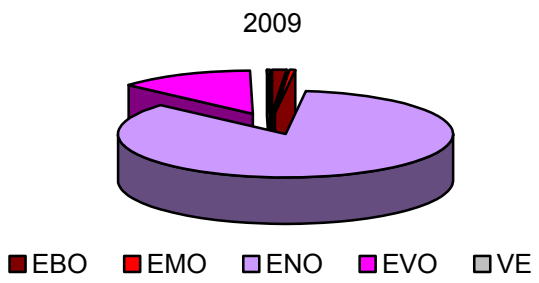
Significantly lower production of solid and liquid RAW recorded in individual nuclear power plants in the years from 2005 to 2009 resulted from shut-down of the 1st and 2nd Block at the Jaslovské Bohunice Nuclear Power Plant as well as modernization of other facilities equipment. **The first V-1 Block was shut down** on the basis of SR's Government Resolution No. 809/1998 on **December 31, 2006**. The spent nuclear fuel was relocated and stored in the in-process storage for spent fuel. The 2nd V-1 Block **was shut down on December 31, 2008** and all spent fuel was moved out of the reactor. In order to substitute the closed nuclear energy sources, the completion of the 3rd and 4th Blocks at the Mochovce Nuclear Power Plant was commenced. Its technically feasible potential will be two times by 440 MW. The deadline to start the operation of the 3rd Block is in 2012 and 4th Block in 20113.

From 2002 to 2006, total **volume of solid RAW** from Jaslovské Bohunice Nuclear Power Plant (V-1) decreased approximately by 1/4. In 2008, it recorded a slight increase, which related to shut-downs of both V-1 blocks. Equally, the volume of solid RAW from Bohunice V-2 Block decreased to 1/4 in 2009 compared to the 2005. The production of **liquid RAW** from Bohunice V-1 significantly decreased. The decline has been seen also in case of Bohunice V-2 Block. The nuclear facilities, which are under a process of decommissioning, disassembly, and demolition, generate only secondary RAWs.
The Mochovce Nuclear Power Plant produced 1/4 of solid RAW more in 2009 compared to the 2002. The volume of liquid RAW from Mochovce Nuclear Power Plant is stable from 2007.

5.3.3. State in Waste Production - Impacts

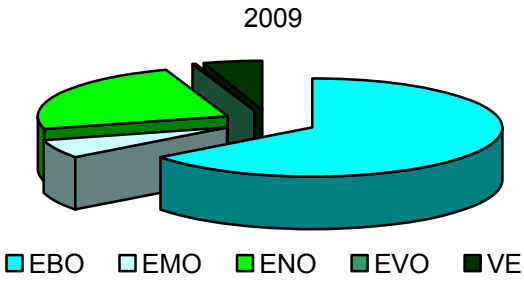
The SE, a.s., dominant electricity producer in the Slovak Republic decreases the volume of produced waste annually. It dispose its waste at own dumping sites (Electric Power plant in Nováky with dumping site for stabilizer, and Electric Power Plant in Vojany with dumping site for stabilizer), transfers the waste to dumping sites of other organizations based on concluded contracts and recovers it at own facility, or by contractors. The company SE, a.s. operates **two nuclear power plants** – Bohunice Nuclear Power Plant (EBO) and Mochovce Nuclear Power Plant (EMO), **two thermal power plants** – Vojany Thermal Power Plant (EVO), and Nováky Thermal Power Plant (ENO), and **34 hydro –electric power plants** – Trenčín Hydro-electric Power Plants (VE).

Share of individual SE, a.s. plants on waste production (%)



Source : SE,a.s. ; Processed by: Slovak Environmental

Share of waste recovering in individual plants of the SE, a.s. (%)



Source : SE,a.s ; Processed by: Slovak Environmental Agency

Agency
Waste recovering on a large scale depends on a character of waste and interest to reuse it on the side of customers. In the SE, a.s. plants, mainly sludge from cleaning of cooling water, ash, ferrous metals, non-ferrous metals, glass, paper, cardboard, oil, electronics scrap, etc are recovered. Up to 97.4% of waste is generated in the thermal power plants, 2.2% in the nuclear power plants, and 0.4% in the hydro – electric power plants.

State in nuclear energy use
Currently in Slovakia, four (4) blocks of nuclear power plants with a reactor of VVER - 440 design are in operation, from which:

1. Slovenské Elektrárne, a.s. (SE, a.s.), in terms of the Article No 2 of mutual accord a safe management of spent fuel and safe management of radioactive waste, operates the following nuclear facilities within its branches:

- Bohunice Nuclear Power Plant, SE, a.s., SE-EBO: V – 2/ 3rd and 4th Block
- Mochovce Nuclear Power Plant, SE,a.s., SE- EMO: 1st and 2nd Block

2. **Jadrová a vyraďovacia spoločnosť, JAVYS, a.s. (JAVYS a.s)**
   - In-process storage for spent fuel located at Jaslovské Bohunice facility
   - Technologies for processing and treatment of RAW, which are located at Jaslovské Bohunice and Mochovce facilities. Technology for RAW treatment is a part of Bohunice RAW Treatment Centre Processing Centre. Experimental facility equipment for RAW treatment is located also in Jaslovské Bohunice
   - National Radioactive Waste Repository, which is in operation from 2000, is loacted near Mochovce Nuclear Power Plant

3. **Výskumný ústav jadrovej energetiky, VUJE, a.s. (VUJE, a.s.)** operates incinerator facility and bitumenation line for radioactive waste at the Bohunice Nuclear Power Plant

5.3.4. Respond

In the field of waste management, the companies respond by adopting legislative regulations, which state the production and waste management (Act No. 409/2006 on Waste, full wording represents the Act No. 223/2001 Coll.)

In radioactive waste field, it is necessary to solve problems of nuclear security and storage of radioactive waste. **The Nuclear Regulatory Authority of the Slovak Republic** executes a state supervision upon nuclear security during radioactive waste and spent nuclear fuel handling. The principle regulation for peaceful usage of nuclear energy is the SR national Council Act No. 541/2004 Coll. on peaceful use of atomic energy (Atomic Act). The Nuclear Regulatory Authority of the Slovak Republic is an independent central organ of the state administration led by its chairman. The execution of state's supervision upon radiation protection is ensured by **Public Health Authority of the Slovak Republic** in terms of the SR National Council Act No. 355/2007 Coll. on health protection.

Sustainable development in the satisfaction of energy needs of the population in the Slovak Republic, typified by the fact that more than 50% of electricity is produced in nuclear power plants, requires permanent support for measures aimed at maintaining safety in the use of nuclear energy for energy production purposes, as well as measures comprehensively dealing with the whole lifecycle of these facilities. This means adequate investment in the disposal of nuclear facilities and the disposal of the spent nuclear fuel generated, so as to avoid unfavourable impacts on the environment. The implementation of the energy policy objectives in the area of continuous safeguarding of nuclear safety and operational reliability of nuclear power plants means the use of nuclear energy in Slovakia on the basis of a long-term concept covering all phases of the lifecycle of nuclear energy facilities.

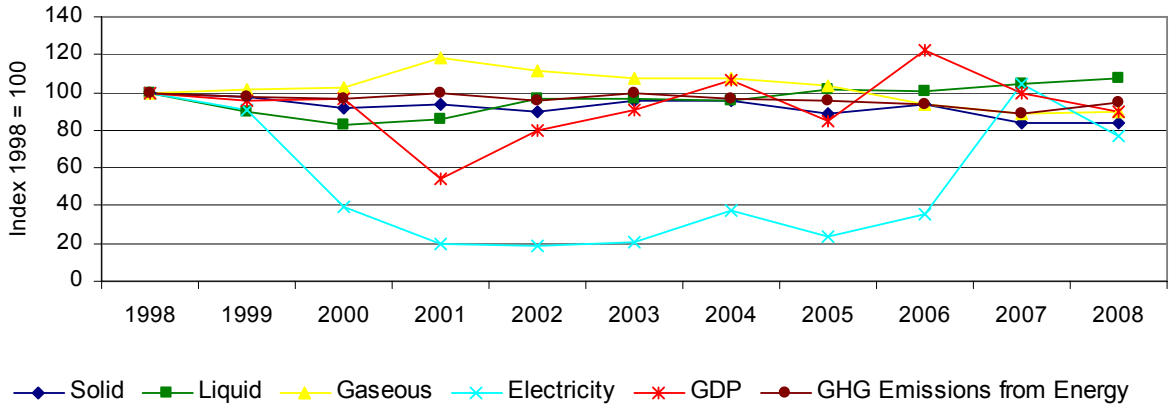
6. Is the eco-efficiency of energy improving in the Slovak Republic?

The success in implementation of environmental policy into sectors of economic activities might be characterized by correlative dependence between economic indicators of relevant sector (expressed by indicators of the GDP – Gross Domestic Product, or GAV - Gross Added Value) and negative influences of this sector on environment (e.g. trend in emissions of substances polluting air and water, exploitation of natural sources, energy, etc). These influences are a reflection of environmental efficiency or environmental efficiency of relevant sector. Roughly, the relevant sector of the economy activity becomes environmentally effective if its economic growth is ensured while its negative influences on environment are minimized. In general, it might be stated that environmental efficiency shows a positive tendency in the energy in relation to fuel and energy consumption as the proportion of the energy on total GDP has increased compared to the basic year of 1998 while production of emissions from greenhouse gases, basic polluting substances, and fossil fuel consumption with negative consequences on environment has decreased.

6.1. Eco - efficiency of Energy with regart to Consumption of Fuels

Total greenhouse gases emissions expressed as CO_2 equivalents have decreased almost by 34% compared to basic year of 1990. The sector of energy has the most significant share in the greenhouse gas emissions. In 2008, the share was nearly 65% (decrease by 8 % compared to the 1990). During monitored period, the air emissions of greenhouse gases from the sector of energy slightly decreased as a result of lower manufacturing and changed fuel base in favour of clean fuels and fuels of better quality (currently natural gas).

Eco-efficiency of energy with regart to fuel and energy consumption



Zdroj: Statistical Office of the SR, Slovak Hydrometeorological Institute; Processed by: Slovak Environmental Agency
Indicator *Environmental efficiency of energy with regart to fuel and energy consumption*

Technical changes enhanced by the combination of price stimulation, regulative and voluntary agreements in the field of buildings, appliances, and electric cars increased the effectiveness of the energy use in the industry, households, as well as in trade. However, there is still a significant unused potential to increase the energy effectiveness, low-cost solutions including. Concerning the production and energy transformation, market conditions and legislative reform in many OECD countries strengthened the tendency towards the shift of fuel from coal to natural gas and it brought environmental improvements. Fiscal policies (e.g. tax exemption, loans), compensation of entry tariffs (which compensate high transfer

and distribution costs of small energy producers from renewable sources by determination of favourable entry tariffs for these small producers for specified period), and merchantable trading certificates for renewable energy lead to a rapid development of renewable energy sources as well as stronger usage of steam-gas cycles even if their initial level is low. Thanks to this development, the carbon intensity in the energy production decreased and also reduction in emissions from sulphur dioxide, fly ash, and other pollutants continues. Combination of structural changes and increased energy effectiveness led towards separation of energy use from economic growth. It is improbable that more improvements will be achieved without more ambitious policies and measures, better environment internalization included.

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Abbreviations

CO	Carbon monoxide
COD_{Cr}	Chemical Oxygen Demand by Bichromate
Coll	Collection of Law
COM	Communication
EBO	Bohunice Nuclear Power Plant
EC	European Commission
EEA	European Environmental Agency
EU	European Union
EMO	Mochovce Nuclear Power Plant
EUR	Euro (currency)
EVO	Vojany Thermal Power Plant
g	gram
GAV	Gross Added Value
GDP	Gross Domestic Product
GJ	Giga-joule
IEE	Intelligent energy for Europe
kg	kilogram
LULUCF	Land use, land use change and forestry
m^3	Cubic meter
MWh	Megawatt hour
NATO/CC	North Atlantic Treaty Organization /Committee on the Challenges of Modern
MS	Society
NM VOC	Non-methane Volatile Organic Compounds
NO_x	Nitrogen oxides
OECD	Organization for Economic Cooperation and Development
PES	Primary energy sources
RAW	Radioactive waste
RES	Renewable energy sources
SK	Slovak Koruna
SO_2	Sulfur dioxide
SPC	Solid Particle Contaminants
SR	Slovak Republic
STN	Slovak Technical Norm
t	ton
VE	Trenčín Hydro-electric Power Plant