Renewable Energy Sources

Efficient ways of reducing emissions in the energy industry include in particular an increase in efficiency of energy conversion of coal-firing power plants, enhancing the gas and nuclear energy contributions to electricity and heat generation, wider utilisation of renewables and, on the other hand, rational use of energies by consumers.

By applying renewables in addition to environmental benefits also the state´s independence on fuel and energy exports increases, foreign currency savings are made and new jobs created.

Renewable-based energy sources (except for hydroelectric power plants) have as yet played a negligible role in Slovakia´s energy balance. However there is the global trend toward more intensive use of these clean energies, therefore their higher utilisation is enshrined among the strategic goals of energy policies of most of the countries worldwide, including Slovakia.

The Slovak Republic´s total renewable potential has been estimated to be about 100,400 TJ/yr, of which 25% or so are currently being used. Our renewable based energy sources generate on aggregate 24,470 TJ/yr of energy, thereby covering 3.5% of total consumption of all types of energy. In particular used is the energy of water streams and the use of wind energy and biomass is getting off the ground. So far, solar energy has been used at minimum rates.

Renewables today make a 16% or so contribution to the electricity generation, about 1% less major HPP´s. The crucial role in the generation of electricity in the country will continue to be played by nuclear and thermal power plants. Renewables except for major HPP´s will remain in the near future to be merely complementary sources, in particular of local and regional importance.

Real development of renewables will only be possible on the assumption of effective supportive legislative and economic measures such as: incentive purchase prices, state and regional subsidies, soft investment credits in the construction of installations, country-wide support schemes, promotion of domestic manufacture of equipment, tax reliefs and strong research support.

Biomass Energy

Biomass constitutes both the world´s and Slovakia´s highest renewable energy potential. It is comprised of materials of plant and animal origin, fit for energy utilisation. Biomass is considered in terms of CO2 emissions to be a neutral fuel, since only as much CO2 is released in burning it as is received by the plant while growing. There are by the source of origin:

- forest biomass - fuel wood, branches, stumps, roots, bark, sawdust,
- agricultural biomass - grain and rape straw, hemp, animal excrements, wastes,
- wood-working industry wastes - cuttings, shavings, sawdust,
- municipal refuse - solid combustible waste, landfill gas, sludge gas.

Fast-growing tree species (willow, poplar) and plants (hemp) are intentionally for energy purposes.

High-grade biomass products are:

- **Solid fuels:**

  wooden chips, pellets and briquettes - are made from forest wastes and wood-working company wastes (branches, shavings, sawdust) - as a fuel lend themselves for automated household boilers.

- **Gaseous products:**

  synthesis gas (wood gas) - this is largely CO, which is obtained by pyrolitic gasification of wooden wastes, serves as a fuel for gas engines and co-generation units

- **Biogas**

  it is largely methane that is produced by oxygen-free fermentation of organic waste, the rest is an environmental-friendly excellent fertiliser. The first biogas power station is run in the municipality of Bytča based on excrements from farm animals. Certain waste water treatments plants (Banská Bystrica, Žilina) make use of the formed sludge gas to generate electricity.

- **Liquid biofuels:**

  bio-oil - is made in particular of oilseeds and fully substitutes for diesel fuel with a calorific value of as high as 39 MJ/kg

- **Bio-alcohol (ethanol)**

  obtained through alcohol fermentation and distillation of a water solution of sugar-yielding plants (beetroots, potatoes, etc.) and used as an admixture to engine petrol (calorific value of 22-25 MJ/m3).

Solar Energy

It is the most accessible and cleanest form of renewable energy. In cloudless weather solar radiation having an output of 1,000 W/m2 hits the earth surface - radiation intensity. The amount of energy of the solar radiation hitting a horizontal area in this country per year ranges from 950 to 1200 kW/m2. In case of a south-oriented and inclined area at an angle of 30° this value may come in the south of Slovakia to as much as 1,500 kWh/y/m2.

Solar energy is used by means of active and passive solar systems to generate heat or electricity:

Active solar systems are:

• Flat solar collectors - serve to generate hot water or hot air where the solar radiation is captured by an absorber in which the heat is conveyed to the liquid or air. They may cover as high as 60% of the annual household hot water consumption or can also be the source of complementary low-potential heating.

• Concentric collectors - serve to prepare hot water with higher efficiency. Reflection channels with a parabolic profile concentrate the sunrays to the tubes located in the focal point with heat carrying liquid.

• Solar (photovoltaic) cells - work on the principle of the photoelectric phenomenon and directly convert the light into DC electric current. The basic types are:

- cells with crystalline silicone - are expensive and their efficiency ranges between 12 and 20%
- cells with amorphous silicone - are considerably cheaper, their efficiency ranges between 8 and 20%.

Crystalline solar cells are integrated into the so-called solar modules or panels and provide an output of 100 - 130 W/m2. A solar panel sized 1 m2 generates in this country 100 - 140 kWh of electricity a year. The price of thus generated kWh comes to SKK 15 - 32 and the cost of purchase to 200,000 to 600,000 SKK/kW.

The world´s largest photovoltaic power plant with a total capacity of 5 MW is under construction (2004) in Germany.

Passive solar systems

constitute architectural solutions providing for heating of interior space of buildings using sunrays. These are various conservatories, glass roofs, etc.

Wind Energy

Over the recent years the wind industry has seen a tremendous development with power rising over 30% year-on-year. The installed capacity of the world´s wind power plants achieved in late 2003 39,000 MW, as did annual generation over 90 TWh. 1.5 to 2.5 MW wind power plants are today commonly built. The world´s biggest wind turbine has an output of 4.5 MW (Germany). Modern wind turbines produce a minimum noise and are also acceptable by the surrounding area.

Large-scale wind farms having an output of up to 400 MW are under preparation or implementation. Offshore sites where turbines are erected outright at sea as far as 20 km off the coast offer vast perspectives. The EU plans to erect by 2010 wind power plants with an output of up to 75 GW.

Slovakia has moderate wind energy potential (600 GWH/y) as compared to seaside countries. There are few suitable sites in this country to install wind turbines, where winds average at least 5 m/sec. Good wind conditions are often in protected natural areas.

The first wind park Cerová (Small Carpathians) having a capacity of 2.4 MW (4 x 660 kW) has been operated since October 2003. The structure was financed up to 60% or so of costs through PHARE funds. The 500 kW wind power plant on Ostrý vrch (Myjava) was put into trial operation in July 2004 and the construction of the wind park Skalité (Kysuce) with a capacity of 4 x 500 MW is nearing completion. The installation costs come to about 45 m SKK/MW.

Hydraulic Energy

Hydropower can technically be used with the highest conversion efficiency of all energy sources (over 90%). Hydroelectric power plants (HPP´s) make use of the hydropower potential of the streams, which is a product of the average streams and heads of a given stream section.

Slovakia´s technically usable hydropower potential is 7,361 GWh/y and at present it is used at 243 hydroelectric power plants up to 57.5%. A 2,500 GWh/y worth potential remains to be used. The dominant projects designed to enhance hydropower potential utilisation are the HPP Sereď (51 MW) and the HPP Nezbudská Lúčka (22.5 MW) on the Váh river. Also a large number of sites for small hydroelectric power plants (SHPP) on the rivers of Hron, Upper Váh, Poprad, etc., with a capacity of 0.1 to 5 MW are also available in the Slovak Republic. The most perspective is the Hron river, where 23 HPP´s with a combined capacity of 350 MW and generation of 200 GWh/y can be constructed. The potential of possible micro-sources on Slovakia´s minor streams is not negligible, either.

The cost to construct a water work with a SHPP ranges between 60 and 150 m SKK/MW, in the event of an already erected water management section this comes to 30 up to 60 m SKK/MW. The rate of return on hydropower investment is about 20 years with the current purchase electricity prices (1.50 SKK/kWh), which brings about an disinterest to develop such sources. The purchase prices are expected to be shortly adjusted upward, thereby giving fresh impetus to the development.

The construction of hydropower works within SE, a.s., has now become stagnant because of an unsatisfactory cost-effectiveness of the projects or by reason of a tough financial standing of our company. Therefore the hydropower development programme is focused particularly on backfitting older hydroelectric power plants (efficiency and capacity increases), where acceptable cost-effectiveness indicators can be delivered.

Geothermal Energy

It represents rich energy potential on Earth. In Slovakia, the temperature rises on average 3°C per 100 m of well. Geothermal water supplies are divided into renewed supplies and non-renewed supplies. As for renewed supplies, the exploitation is effected through a single well and the cooled water is drained into the streams. Non-renewed supplies must be replenished on a regular basis, therefore in addition to the extraction well also a re-injection well must be drilled to drive the geothermal water back into the ground along with noxious gases and salts following the heat exchange. This is a way that fully complies with today´s environmental criteria.

There are a host of geothermal sources in the world, where overheated steam or hot water coming out of the ground is fit for direct electricity generation in a steam turbine (Italy).

This country´s geothermal waters have lower temperatures between 45°C and 130°C, therefore these are in fact suitable for heating only. They are utilised at 35 sites with a copmbined heating capacity of 75 MW and generation of 1,218 TJ/y to heat structures, swimming pools, greenhouses (town of Galanta - 1,240 flats and a hospital).

Slovakia has 25 prospective areas of geothermal resources with temperatures up to 150°C and in depths up to 5,000 m. The all-important of them is the Košice basin (Ďurkov) with potential of about 300 MW, where 3 trial wells have already been drilled, showing GT water temperatures to be as high as 130°C. The implementation of 8 extraction wells and 8 re-injection wells having a capacity of 100 MWt (2500 TJ) is expected under Phase 1 works. There are preparations underway to make use of the energy to heat the City of Košice, with a connection to the city central heat supply system. Also studied is the option to generate electricity (binary cycle) to cover the source self-consumption with a capacity of 3 MW or so.

Biomass Power Plants

The way of generating electricity at a biomass power plant

The fuel at these power plants is biomass or biofuel. Electricity generation is similar to that at thermal power plants in firing fossil fuels (coal, gas), but with substantially lower CO2 emission levels.

According to the type of biofuel used and bioenergy to electricity conversion equipment, there are a number of basic concepts of electricity generation. These are in particular:

- § steam boiler (stoker-fired, fluidised bed, etc.) for solid or gaseous biofuel with a steam turbine and an electric generator
- § internal combustion turbine with an electric generator for biogas from animal excrements or for wood gas - gasified wood
- § biogas or wood gas driven piston gas motor with a generator
- § bio-oil or ethanol driven piston motor with a generator
- • electrochemical fuel cell powered by biogas or liquid biofuel

To achieve the utmost utilisation of the fuel energy, the above sources are largely implemented as co-generation units.

Thermal Power Plants

Method of electricity generation in thermal power plants

Electricity generation in thermal power plants if characterized by the main source of generation being firing of coal, gas or mazout. Steam is produced in a boiler, and it drives a turbine connected to an alternator. Heat energy is converted to electric energy within the so-called steam cycle.

A thermal plant comprises several separate production units with specific size and power.

A conventional power plant consists of a boiler room, interposed machine room, machine room, electric power output, and auxiliary operations (coal loading, water treatment, water management, back fuel cycle, etc.). The following types of thermal power plants exist:

- condensating, whose main focus is generation of electricity,
- thermal plants whose main focus is combined generation of electricity and heat.

In a conventional condensating type thermal power plant, the electricity generation part is dominated by arrangement in production units. Every production unit of the power plant represents a separate generation entity – a separate power plant. By the method of combustion, solid fuel firing boilers are classified into grate, granulation, fusion, and fluidized-bed type. Boilers firing solid and gas fuels are in addition to the above mentioned boilers.

Every power plant unit may be operated independently. The principle of operation is quite simple. Stockpile coal is moved by a bulldozer into an underground bunker, wherefrom it is taken by a coaling belt into a coal holder located at every boiler. The coal is gradually dried and ground to powder that is subsequently fired in the boiler. Pipe or membrane type evaporators are located in the boiler walls; there, water turns into steam and the steam generated (of a high temperature and pressure) is led to steam cylinder, wherefrom it is led through pre-heaters and postheaters via steam distribution pipes to turbine blades. The turbine is connected to a generator.

Turbine and electric generator comprise a single train – turbogenerator. In the turbogenerator, heat energy is converted into electric energy. Electric energy thus produced is led through a system of transformers and distribution grid to end-consumers. Having delivered its energy to turbine blades, the steam condensates in heat exchanger – condenser. Upon passing the turbine, the steam temperature and pressure get reduced. The steam changes its state and turns into water called condensate. Large quantities of cooling energy are needed for steam to condensate. Surface water from a stream or a reservoir is used for cooling. If there is a plenty of cooling water, flow-through system of cooling is used; circulation system of cooling with water being cooled in cooling towers is used for places with insufficient supply of cooling water.

On their way to the stack, flue gases produced during the firing of coal heat water in economizer, which is a heat exchanger for combustion gas. Cooled stack gases then pass through electrostatic filters where ash is caught, and continue to the stack.

To reduce nitrogen and sulfur oxides, desulfurization and denitrification equipment are installed to conventional boilers. For fluidized-bed boilers, desulfurization and denitrification is resolved directly by the boiler technology.

Nuclear Power Plants

Method of electricity generation in nuclear power plants

The principle of electricity generation in nuclear power plants is similar to that of conventional thermal power plants. The difference consists in the source of heat only. In thermal plants, heat is produced from fossile fuels (coal, gas) whereas in nuclear power plants, nuclear fuel is used (natural or enriched uranium).

Fuel in the form of fuel assemblies is placed in reactor pressure vessel to which chemically terated water flows. The water flows through channels in the fuel assemblies and removes the heat that is produced during fission reaction. Water coming from the reactor has a temperature of about 297°C; it is then led through the hot arm of the primary piping into heat exchanger – steam generator. In steam generator, water flows through a bunch of pipes and delivers the heat to water from secondary circuit and has a temperature of 222°C. When cooled down, primary circuit water is led back to reactor core. Secondary circuit water is evaporated in steam generator and the steam is led via steam collector to the blades of a turbine. The turbine shaft turns a generator that generates electric energy.

Having delivered its energy to the turbine, steam condensates in condenser, and getting back to water state, it flows back, via heaters, to steam generator. In condenser, the mixture is cooled by a third cooling circuit. In this latter circuit, water is cooled by air flowing from the bottom to the upper part of the cooling tower due to so-called chimney effect. The stream of air takes along water steam and small water droplets, and that is why clouds of steam form above the cooling towers.

SE, a.s., electricity generation for December 2005

05.01.2006

In December 2005, Slovenské elektrárne generated a total of 2,480.3 GWh of electricity with a year-on-year index of 1.038, meeting its business plan up to 116.1%. Exports oscillated around 85 MW, peaking at 799 MW on 27 December 2005.

Nuclear power plant units made the biggest contribution to the electricity generation at 73.9%, generating 1,833.4 GWh on aggregate.

The contribution to SE, a.s., generation by thermal power plants accounted for 15.8%, generating 392.2 GWh. Operation of the units was secured so as to meet power electricity and support services supplies.

Hydroelectric power plants saw their generation come to 254.7 GWh, making a 10.3% contribution to SE generation.

Since the beginning of the year Slovenské elektrárne has generated a total of 26,471 GWh, with an index of 1.035 as compared with last year. The electricity generation plan is being fulfilled up to 115.0%.

DECEMBER 2005

Produce energy in MWh to : 31.12.2005

factory	DECEMBER	year: 2005
SE-EBO	1 212 293	11 486 566
SE-EMO	621 091	6 239 944
JE total	1 833 384	17 726 510
SE - EVO	260 965	2 577 392
SE - ENO	131 228	1 683 361
TE SPOLU	392 193	4 260 753
SE - VE	254 749	4 483 638
SE total	2 480 326	26 470 901

Natural gas trading

The most advantageous and attractive natural fuel, which also protects the environment, is natural gas. It belongs to the most economic energy carriers for heating, cooking, preparation of industrial hot water and it is used in many industrial branches of the economy of the Slovak Republic. Large reserves of natural gas in the world have predetermined it to become the fuel of the future.

Presently, the share of natural gas in the primary energy consumption of the Slovak Republic represents approximately 32%.

A natural monopoly company in the gas industry in Slovakia is the joint-stock company, the Slovak Gas Industry, with its seat in Bratislava.

The goal of a joint-stock company SPP in the Slovak Republic is the provision of a continuous balance between supply and consumption of natural gas with consideration towards the effectiveness and reliability of transportation and distribution of natural gas to customers in accordance with concluded contracts on supply. SPP's goal is also to provide transit transportation of natural gas through the territory of the Slovak Republic in accordance with concluded international contracts, i.e. the provision of a constant supply to domestic customers of natural gas in determined quality and provision of transit transportation for foreign customers.

Purchase of natural gas

Purchase of natural gas for the joint-stock company SPP is taken care of by the Section for Trading in Natural Gas from the following sources:

- import from the Russian Federation
- from domestic sources
- supply from contracts on mutual assistance with foreign gas industry companies

The goal of the joint-stock company SPP is to create the preconditions for the reliable and economic operation of the gas industry network of the Slovak Republic and to look for optimal solutions for the natural gas supply of the Slovak Republic.

The import of natural gas from the Russian Federation is performed on the basis of a long-term contract on supply and transportation of natural gas through the territory of the Slovak Republic with the Russian exporter of natural gas, the company Gazexport Moscow. The joint-stock company SPP purchases approximately 97% of its need for natural gas for the Slovak Republic from foreign countries.

Purchasing from domestic sources is performed according to annual contracts concluded with Nafta, a joint-stock company, Gbely. Exploitation from domestic sources represents approximately 3% of the needs of SPP, a. s.

The supply of natural gas from contracts on mutual assistance is used for the coverage of peak consumption during the winter period. These contracts on assistance are related to another area of activities of the Trading in Natural Gas Section - preparation and balancing of contracts on transit and storage of natural gas in underground gas storage facilities in the territory of Slovakia and abroad.

In order to provide for the uninterrupted and smooth supply to customers in accordance with the contract, natural gas is stored in the underground gas storage facilities Láb I. - III. construction and Láb IV. construction. Presently, the capacity of the underground storage facility Dolné Bojanovice in the Czech

Republic is used. The total volume of the stored natural gas represents 1,6 - 2,0 bill. m^3.

Supervision of the safe and reliable transportation of natural gas in the determined quality and balance between sources and consumption of natural gas in compliance with the rules for co-operation with the partners intrastate and the foreign dispatching units is provided by the Slovak Gas Industry dispatching.

Natural gas sales

Natural gas sales by SPP, a state-owned enterprise since 1994 showed a constant increase, which has been caused by the area gasification, increase of the number of customers and last but not least by the fact that natural gas is a competitive fuel in all industrial sectors.

The most important category for natural gas sales within SPP, a state-owned enterprise is the category of large industrial customers. A comparison of the consumption of individual consumer categories:

- households: 25,3%
- small consumers: 5,3%
- large industrial: 69,4%

Development of the number of customers

By the end of 2000, the Slovak Gas Industry, a state-owned enterprise supplied natural gas to 1 343 986 customers.

Gas customers who's off-take gas device is connected to gas industry installations, are divided into individual consumption categories. Categorization of customers is as follows:

a) Households (population)
b) Small off-take
c) Commercial
d) Large industrial

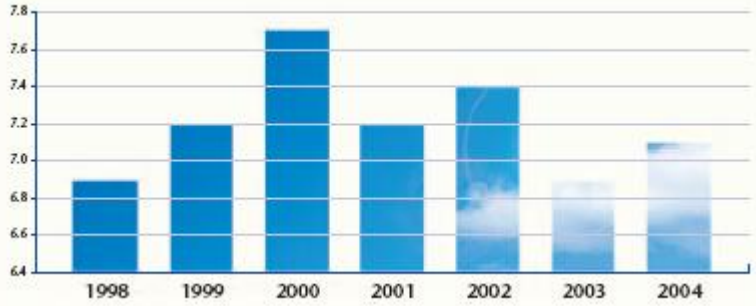
Customers in the category large industrial are divided according to the type of the gas consumption into:

- technology consumer
- heating consumer

		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
NG transit transmission (in bcm)		-	74,1	74,5	79,0	81,4	77,6	84,1	88,3	79,2	71,5	70,4
NG sales (in bcm)	**in SR**	5,7	5,9	5,9	6,3	6,6	6,8	6,8	7,0	7,0	7,5	7,1
	to large industries	4,6	4,7	4,5	4,8	4,8	4,8	4,7	4,7	4,9	5,0	4,7
	to small off-takers	0,2	0,2	0,3	0,3	0,3	0,4	0,4	0,4	0,4	0,4	0,4
	to households	0,9	1,0	1,1	1,2	1,5	1,6	1,8	2,0	1,8	2,1	2,0
Number of NG customers	**in SR**	938 034	984 370	1 031 589	1 081 358	1 140 597	1 208 574	1 265 856	1 305 861	1 343 986	1 372 778	1 402 395
	large industries	3 448	3 750	4 063	4 244	4 503	4 781	4 999	5070	5 219	5 292	5398
	small off-takers	27 697	29 571	31 349	32 991	35 216	39 621	42 654	44 844	47 577	50 857	53735
	households	906 889	951 049	996 177	1 044 123	1 100 878	1 164 172	1 218 203	1 255 947	1 291 190	1 316 629	1 343 262
Grid construction development in SR (in km)	**local networks**	8 683	10 288	10 854	12 296	13 812	15 923	18 195	19 521	20 931	21850	22865
	long-distance pipelines	4 681	4 861	5 051	5 191	5 340	5 580	5 752	5 883	5 963	6094	6141
Number of gasified communities in SR		523	650	790	1023	1193	1419	1639	1804	1935	2006	2104

Purchase of Natural Gas
In 2004 SPP a. s. purchased a total volume of 7.1 billion m3 of natural gas. This was by 2.3 % more than in the year 2003. The share of imported gas represented 97.8 % of the total purchased volume, and purchases from domestic production, 2.2 %.

The pattern of natural gas purchase development between 1998 – 2004 (in billion m³)



Natural Gas Sales

	Volumes (in million m³) in 2004	Number of consumers in 2004
Large consumers	4 251	5 770
Small consumers	466	59 538
Households	1 816	1 375 483
Total	6 533	1 440 791