Status and impact of Slovenian lignite industry

Study by Jure Vetršek

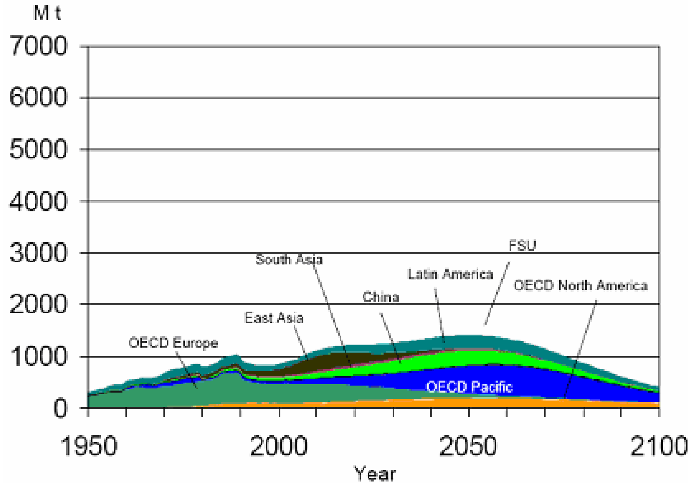
focus
association for sustainable development

Maurerjeva 7
1000 Ljubljana, Slovenia
tel: + 386 1 515 40 80
info@focus.si
www.focus.si

This study is supported by the Swedish NGO Secretariat on Acid Rain.

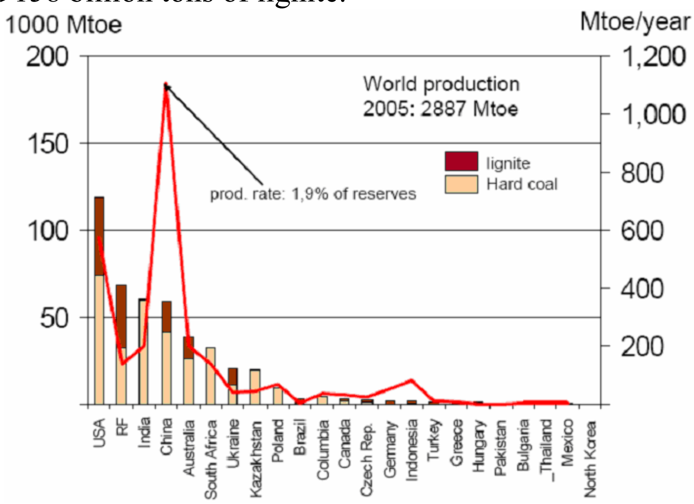
Lignite Resources and Use

Based on the assessment that reserve data may be taken as upper limit for practically relevant coal quantities to be produced in the future, production profiles are developed. The following figure provides a summary of past and future world coal production in energy terms based on a detailed country-by-country analysis. This analysis reveals that global coal production may still increase over the next 10 to 15 years by about 30 percent, mainly driven by Australia, China, the Former Soviet Union countries (Russia, Ukraine, Kazakhstan) and South Africa. Production will then reach a plateau and will eventually decline thereafter. The possible production growth until about 2020 according to this analysis is in line with the two demand scenarios of the International Energy Agency (IEA) in the 2006 edition of the World Energy Outlook. However, the projected development beyond 2020 is only compatible with the IEA alternative policy scenario in which coal production is constrained by climate policy measures while the IEA reference scenario assumes further increasing coal consumption (and production) until at least 2030. According to our analysis, this will not be possible due to limited reserves.



Graph 1: World lignite production prognosis

According to the latest assessment by the WEC total proved recoverable world reserves at end 2002 mount up to 479 billion tons of bituminous coal and anthracite, 272 billion tons of sub bituminous coal and 158 billion tons of lignite.

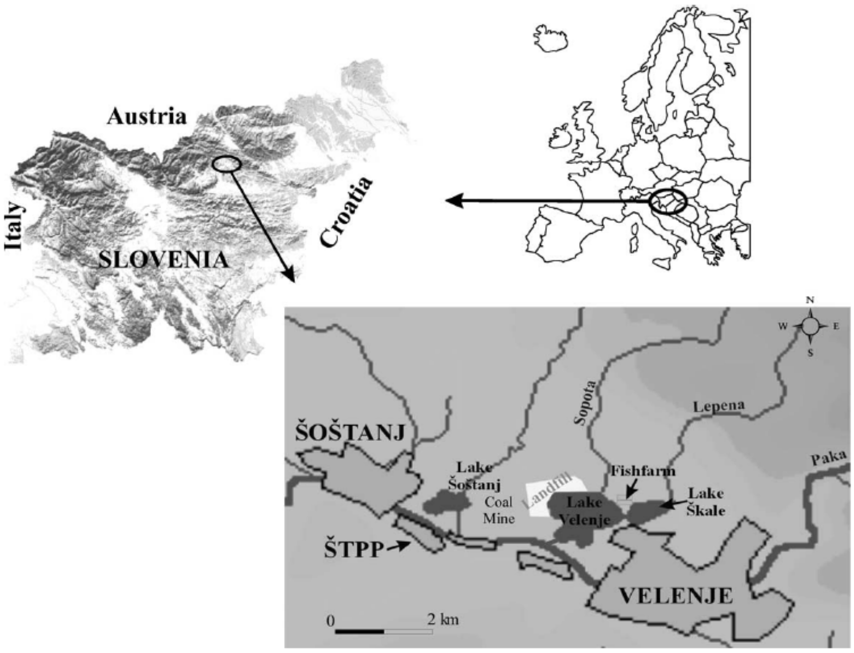


Graph 2: Global lignite reserves and production

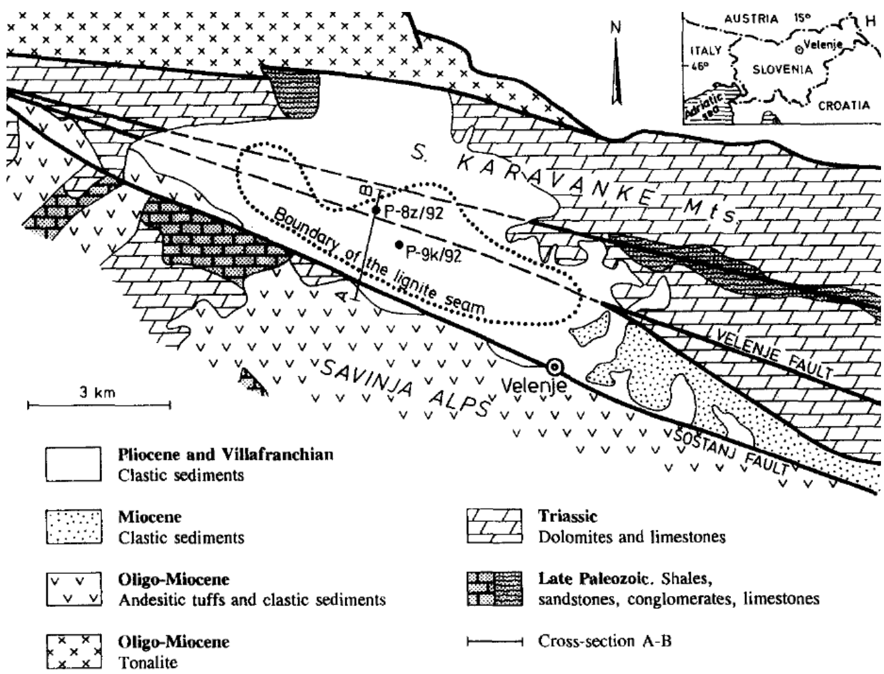
Global coal production will reach its peak around 2025 at 30 percent above present production in the best case.

Lignite in Slovenia – Velenje mine

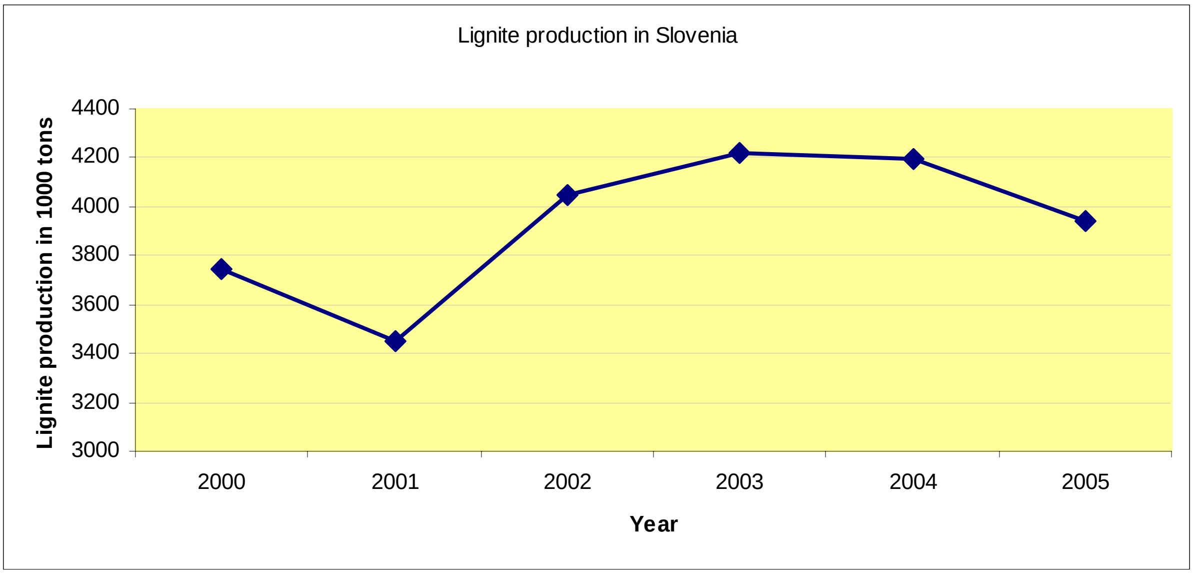
There is only one lignite mine in Slovenia. It is located in Šaleška valley. It is deepest lignite mine in the world, its main goal is to supply fuel for Šoštanj thermo power plant. They extracted 3.933.754 tons of lignite in the year 2006, which provided 28.642 mio SIT of income and 100,7 mio SIT profit. Average price, calculated on lignite energy content was 584,79 SIT/GJ. The Velenje mine is one of biggest employer in the region, with 1761 workers which is 10 % less than in previous year. Average caloric value of lignite extracted in the year 2006 was 11.213 kJ per kg.



Picture 1: Location of Velenje mine



Picture 2: Geological sketch map of the wider Velenje mine area.

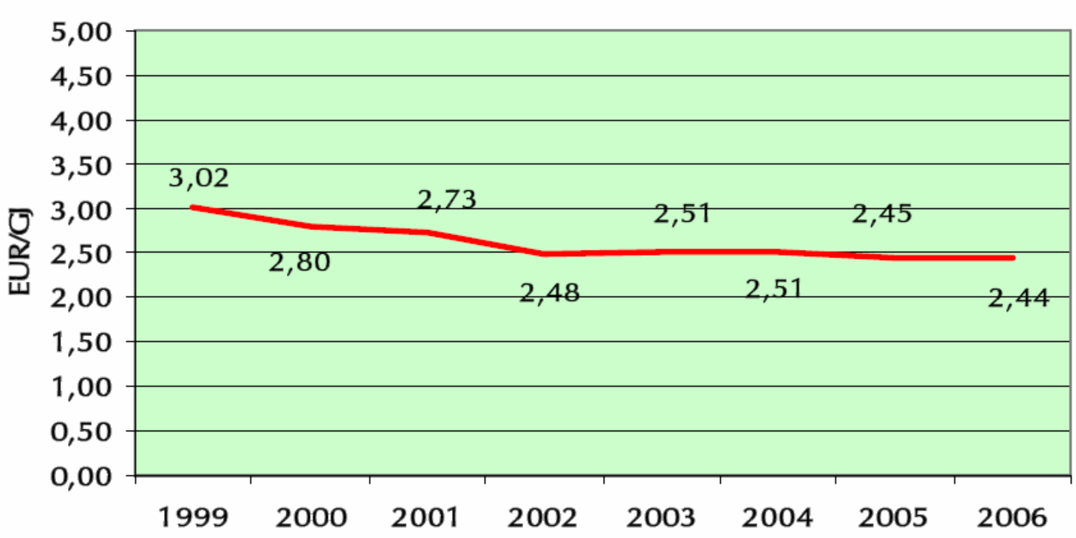


Graph 3: Yearly lignite production of Velenje mine.

Perspectives for Lignite Deployment in Power Generation

Lignite Characteristics

Average sulphur content of the lignite extracted in the Velenje mine, from year 2000 to 2005 was 1,36 % with caloric value 11.213 kJ per kg. The average percentage of ash in coal is approximately 18%, and the moisture content is approximately 38%.



Graph 4: Price of the lignite produced in Velenje mine in the period from 1999 – 2006

The Fuel of Many Hurdles

Mine as fuel has many disadvantages like: inhomogeneous composition of ore which results in unreliable fuel parameters and uncertainty especial about most important parameter – caloric value. Last is decreased also because of high water content which results in high processing energy needed for preparation of fuel for usage. Because of its low caloric value, high volumes are needed. Lignite harmful environmental impact is a result of high sulfur and other foreign substances which have also excessive harmful effects on human health.

Lignite Extraction

Lignite is usually extracted in open pits, because large quantities can be processed in this way. Because of the low thermal value of lignite, an enormous mass of material must be excavated for supplying a sufficient quantity of combustible material to any power plant. Surface devastation plays a minor role in Slovenia, because only lignite mine is an underground one. Problem occurs due to ground emersion and damage on building which result from this.

Devastation and Resettlement

As mentioned, surface devastation by mining plays minor role in the case of Velenje mine, because it is an underground mine. Beside heavy pollution, due to lignite burning in the Šoštanj power plant, few other problems occurred.

Main harmful effects are result of air pollution due to burning of lignite and deposition of ash.

Harmful heavy metals emissions

The annual emissions of dangerous pollutants to the atmosphere are estimated to be about 314 kg Hg, of which about 80 % is in elemental form and the remaining is in volatile Hg^{2+} compounds and/or bound to particles Due to the hydro meteorological conditions and the height of the stack, most of the emitted Hg is subject to long range transport, rather than local deposition.

Pollution of lake Velenje

Lake Velenje is located in one of the most polluted regions of Slovenia, the Šaleška Valley. There are two major sources of pollution: the coal-fired thermal power plant in Šoštanj (ŠTPP) and the coal mine in Velenje. Lake Velenje has 1 273 000 m2 surface area and contains 22 900 000 m3 of water. The average depth is 17.9 m, with the deepest point 53.7 m. At the beginning of the ŠTPP operation a mixture of ash and water flowed directly into Lake Velenje. From 1982, the ash settled into the ash landfill, and the excess water flowed further into the lake. Due to $Ca(OH)_2$, which is formed from substances in ash, water pH increased to 12. Under those conditions life was not possible and the lake was biologically dead. ŠTTP introduce some measures to improve its quality, which finally results in revival of lake's ecosystem, so nowadays fish can be found in the lake.

Radioactive contamination

Currently almost a million tones of coal ash is produced prom Šoštanj power plant per year. Fly ash with a U content of at least 25 mg/kg is transported as slurry is was disposed at first into a lake and later into wet ponds on a depository of an area of 0.50 km. The deposited ash has direct contact with the lake water. It was found that the soil of the surrounding environment contains 40 Bq/kg of ^{238}U and ^{226}Ra, 70 - 90 Bq/kg Pb (in the upper layer of 10 cm), 35 Bq/kg and 400 Bq/kg of ^{40}K. It is expected that, in the next few years, the radioactivity of the lake water will slowly decrease due to the operation of a closed water cycle system introduced in the transport of fly ash slurry. This will be a key countermeasure for reducing radioactive and chemical pollution of surface waters caused by deposited fly ash.

Relief changes due to mining

Because of underground coal exploitation, the ground is gradually subsiding and forms hollow depressions that are filled with water. These processes caused the formation of Lake Š kale, Lake Velenje, and Lake Šoštanj. These negative influences have been addressed in early 80's and have been quite successful. Nowadays they do not present a mayor problem.

Ground shaking

Another disturbing phenomenon for local inhabitants, which results from lignite mining, is ground shaking. Representatives form mine Velenje claim, that this shaking isn't dangerous and is caused by traffic, underground water etc. Periodical ground movement values, recorded with seismograph, vary from 0,6 up to 1,1 mm/s and only occasionally reach 2-3 mm/s. Mine Velenje claims, that this is in allowed limits. The mine also established a hot line thru which, citizens will be able to complain and inform the Mine about damages on buildings and other observations. Special commission will examine every recorded case and if they find out, that damage was caused by mining, they will refund it.

Influenced area

Mine has, according to the concession contract, an influence area of 1104 ha from which around half is in municipality Šoštanj and other half in Velenje. Total area opened with mining is 584 ha. In the areas, which are no longer under influence of mining, sanitation measures have been introduced. These measures are: forest preserving, sanitation of depredated areas and buildings and with this preparation of areas for new activities.

The "Mining Curse"

The influence of mining closure is not present in a lignite mining areas, because only lignite major lignite mine in Velenje is still active in the large extends. This phenomenon can be observed in brow coal mining area in Zasavje basin. There were three mining towns in last 200 years in this area: Zagorje, Trbovlje and Hrastnik. Mine in Zagorje is already closed from 1994 other two came in the closure procedure in this year. There has been some influence on Zagorje's economy and unemployment in the first years after the closure, but successful measures, which resulted from the special government law, too place. Nowadays mining history and influence in Zagorje is almost forgotten, so this site can be a good example also for Velenje municipality when it's mine will be closed.

Lignite Power Generation

Characteristics of Lignite Power Plants

Due to its low calorific value, three times the quantity of mined lignite must be burned to achieve the same thermal energy as hard coal, or four times the amount required with fuel oil.

Šoštanj Power Plant – the biggest power plant in Slovenia

Picture 3: View on ŠTPP

The coal-tired Šoštanj thermal power plant has been in operation since 1972. It is only thermal power plant in Slovenia that is using lignite as energy source, and that is Šoštanj thermal power plant (ŠTPP). It is located in Šaleška valley in Velenje, central Slovenia. It is one of two biggest power plants in Slovenia, other is nuclear power plant Krško.

ŠSTPP's capacity is 775 MW. It has five separate units. All units use electrostatic precipitators for fly ash removal. Unit 4 has also installed a wet flue gas desulphurization system. Yearly approximately 4 000 000 t of coal is burned and approximately 800 000 t of slag and ash is deposited near Lake Velenje. Approximately 2000 tons of fly ash is emitted into the atmosphere with flue gases. The ŠTPP's stacks are 100, 150 and 230 m high. A basement inversion normally protects the bottom of the valley against pollution. Highest, subsidence inversion prevents dispersion of stack gases, which thus, accumulate under the air layer with the temperature inversion. These gases are sinking above the valley slopes, but do not reach the bottom of the valley

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SO_2	80.5	80.1	86.1	80.6	51.7	51.8	53.1	55.0	47.7	44.2	18.1	22.9	13.3	7.9
NO_x	10.8	10.5	11.6	11.3	10.1	10.2	11.6	11.9	9.1	10.4	11.4	12.8	10.9	8.9
CO_2	–	–	–	–	–	–	–	–	–	3.59	4.21	4.74	4.47	4.54

– = No measurement was carried out.

Table 1: Annual emissions of SO_2, NOx (10^3 t) and CO2 (10^6 t) from ŠTPP in the period 1991-2004

It was estimated that in the period 1980 - 2001, additionally to SO2 and NOx, approximately 298 t per y of Zn, 60.6 t/ 1 of Cr, 42.8 t/y of Ni, 22.1 t/y of Pb, 15 t/y of Cu, 4.5 t/y of As, 0.3 t/y of Hg and 0.2 t/y of Cd were emitted.
The area influenced by ŠTPP extends to Austria. The extremely high SO_2 emissions were reduced by the installation of desulphurization devices at Unit 4 (in February 1995) and at Unit 5 (in November 2000), but emission of NO_X was almost unchanged as one can see in the table above. In spite of SO_2 emissions reduction, the synergism between SO_2 and ozone should not be neglected. The ecological improvement program of ŠTPP did not change the emission of NO_X, which is the main precursor of ozone. Ozone in combination with SO_2 (emissions are still approximately 10 000 t/y) has extreme negative effect on environment and people. In 2004 SO_2 emission was reduced to 10 % of that in 1991

Thermal Power Plant Šoštanj is currently in the period of a new investment cycle.. Technological renewal will cause the closure of those units which have come to the end of their service life and will make possible for the units (B5) which will be operating after the year 2020 to comply with the best available technologies (BAT).

Comparability of the power plant with BAT will enable competitive position of electricity production and ensure achieving high environmental standards. Higher and higher net electricity recoveries have become the aim of the technological renewal at new units as well as the guidance for implementing measures in existing units. In The Development Plan of Thermal Power Plant Šoštanj is to increase production to 5,000 GWh from the year 2013 onwards with installation of gas turbines in unit 5 and constructing a new 600 MW coal-fired unit. Gas turbines will increase the efficiency and yield recovery of unit 5 whereas yield recovery of unit 6 will be for one third higher than yield recovery of bigger two units; at the same time the CO_2 emissions, despite increased power of thermal power plant, will be relatively reduced according to ŠTTP management. In The Development Plan of HSE group 2006-2015, which was adopted by the Government of the Republic of Slovenia in December 2006, both investments are taken into consideration in relation to investments into new production capacity for electricity production.

	Production (GWh)	Power (MW)
2002	4114	662
2003	3911	662
2004	4018	662
2005	4129	672

Table 2: Production of electricity and real power from lignite in ŠTTP

Destroying Villages for Profit

Cultural heritage is destroyed only in form of architectural damages due toe ground immersion which consequence of underground mining. There are no records about archeological findings in areas destroyed by mining. These areas are areas of mine facilities and ash from TPPŠ deposit grounds.

External Costs

Here is presented only part of external cots due to air pollution from ŠTPP. Fuel life cycle is not evaluated, decrease of life quality etc. In order to get more accurate data, one should imply European ExternE methodology for external cost of energy production calculation on Slovenia. But this extends subject of this study.

Social costs per ton of emissions (€)	CO_2	SO_2	NO_x
Human health	/	1530	470
Forest devastation	/	1760	1220
Damage on buildings	/	480	320
Climate change	7	/	/

Table 3: Specific social costs for OECD countries

Social costs per ton of emissions (€)	CO_2	SO_2	NO_x
Human health	/	75735000	5086071
Forest devastation	/	87120000	13202142
Damage on buildings	/	23760000	3462857
Climate change	30170000	/	/
sum	30170000	186615000	21751071,43
All together	**238.536.071 €**		

For calculation are used average annual emissions from table 1. No comment is needed, figures speak for themselves

CO_2 Reduction Technologies

Several technologies for lowering emission of CO_2 in thermal power plant are known. Here will be mentioned only few. One option is co-Firing of low-carbon fuel, such as biomass. This is currently happening in local district heating and coal powered power plant in Ljubljana, but only minor shares of biomass are introduced. Another possibility is improvement of power plant technology, which is happening all the time. Its goal is to increase efficiency which does not exceed 40 %.

Recreantly a lot of attention is given to CO_2 Capture and Storage (CCS) technologies development. One must know, that according to Swedish experiences, this technology is very expensive and does not show fruitful results. Cost of different variants of CCS are shown in the table below.

CO_2 Elimination Costs (Ruhr University)	
Process	**Euro per Ton of CO_2**
CO_2 capture in power plant	15 - 65
CO_2 transport	
rail	2 - 10 liquid, > 10 dry ice
pipeline	1 - 11
Storage	
oil or gas reservoirs	5 - 10
deep saline aquifers	15 - 20
deep sea storage	60 - 80
Alternative Compensation	
forestation	5 - 20

Table 4: CCS costs

Organic Rankine cycle is also another technology which increases the efficiency of thermal power plant by using the heat on the lower temperature level. One very successful implementation is Kalina technology which is used on Iceland for geothermal sources exploitation. Another option on the demand side is automated meter reading. Safe supply and avoided long distances distribution losses could be avoided with decentralized generation. In Slovenia especially biomass cogeneration facilities have great potential.

Conclusion

The lignite industry plays an important role in Slovenian energetics, because Šoštanj thermo power plant, which uses lignite from nearby mine produces one third of Slovenian electricity. Both companies are also an important employer in Šaleška valley. Domestic lignite is also very important Slovenian domestic energy recourse, and closure would increase already very high imported energy dependence. Both mentioned companies depend on each other and local economy on them. Large extends of surface devastation due to open pit lignite mining is not the case for Slovenia, because Velenje mine is an underground one. Big problem remains pollution from the ŠTPP, because Šaleška valley has been one of the most polluted areas in Slovenia. Resettlement took place also in minor extend, only because of subsiding.

In Slovenian strategic plan another block of ŠTPP is planed with nominal power of 600 MW and additional block of nuclear power plant Krško. Both projects are not needed, and policy maker will need to decide which one is more accepted. Author's opinion is, that large increase of domestic renewable sources (RES), such as solar, biomass and geothermal should be introduced. Fulfillment of energy needs with RES will not be possible, if energy demand increase continues, therefore efficient energy use measures are crucial for safe end economically acceptable energy supply. Biggest problem of Slovenian lignite industry is the same as in other European countries and that are external costs of energy production form fossil fuels. If these environmental and social costs would be counted in, RES would be more completive. Problem is in extremely low electricity price in Slovenia.

Resources

1. Status and Impacts of the German Lignite Industry, Jeffrey H. Michel
2. Annual report of ŠTPP 2006, ŠTPP
3. Annual report of ŠTPP 2005, ŠTPP
4. Yearly publication of ŠTTP 2006, ŠTPP
5. Coal: Resources and future production, Energy Watch Group
6. Influence of the Šoštanj coal-fired thermal power plant on mercury and methyl mercury concentrations in Lake Velenje, Slovenia; Jože Kotnik, Milena Horvat, Vesna Mandič, Martina Logar
7. Radioactive contamination of surface waters from a fly-ash depository at Velenje (Slovenia); Liljana Mljač,
8. Pretok July 2007, paper of ŠTTP,
9. Petrographic composition and depositional environments of the Pliocene Velenje lignite seam; M. Markič, R.F. Sachsenhofer,
10. Norway spruce needles as bioindicator of air pollution in the area of influence of the Šoštanj Thermal Power Plant, Slovenia; Samar Al Sayegh Petkovšek, Franc Batič, Cvetka Ribarič Lasnik
11. Modelling of mercury geochemical cycle in Lake Velenje, Slovenia; Jože Kotnik, Milena Horvat, Vesna Jereb
12. Annual report of mine Velenje 2006, mine Velenje