Journal of Energy Technology

JET Volume 7 (2014) p.p. 39-52
Issue 2, May 2014

www.fe.um.si/en/jet.html

GLOBAL TRENDS AND THE THERMAL ENERGY CAPACITIES GREATER THAN 10 MW IN SLOVENIA

SVETOVNI TRENDI IN STANJE TERMOENERGETIKE NAD 10 MW V SLOVENIJI

Dušan Strušnik℟

Keywords: thermal energy, trends, primary sources, coal, thermo-power station, Kyoto protocol, ecology, electricity, fire

Abstract

Thermal energy is the most significant form of energy production and is of key importance for satisfying global energy needs. When combusting primary fuel in thermal power stations, environmentally dangerous greenhouse gases are released as a consequence of obtaining electrical and thermal power. Strict environmental energy legislation requires thorough changes to thermal power stations. This paper analyses global, European and Slovene trends of the consumption of primary sources (coal, natural gas, etc.) and the adjustment of thermal power stations to energy needs and environmental legislation. Two anticipated scenarios (Basic and Blue) of trend flows are discussed, and guidelines are given. Thermal energy facilities, development guidelines and the energy dependences of Slovenia will be presented.

Povzetek

Termoenergetika je najpomembnejša panoga pridobivanja energenta in je ključnega pomena pri zadoščanju globalnih energetskih potreb. Z zgorevanjem primarnih goriv se v termoelektrarnah sproščajo okolju nevarni toplogredni plini, pri čemer pridobivamo električno in toplotno energijo.

℟ Corresponding author: Dušan Strušnik, Energetika Ljubljana d.o.o., enota TE-TOL, Toplarniška 19, 1000 Ljubljana, Slovenija. E-mail address: dusan.strusnik@gmail.com.

Zaradi stroge okoljsko-energetske zakonodaje, se bo moral termični način pridobivanja energentov temeljito spremeniti. Analizirali bomo svetovne, evropske in slovenske trende porabe primarnih virov (premog, zemeljski plin…) in prilagoditev energentov na energetske potrebe in okoljsko zakonodajo. Obravnavali bomo predvidena scenarija (osnovni in modri) gibanja trendov in podali smernice. Predstavili bomo termoenergetske objekte, razvojne smernice in energetsko odvisnost Republike Slovenije.

1 GLOBAL TRENDS OF THERMAL ENERGY

Thermal energy science is concerned with the usage of thermal energy and its transformation into other forms of energy. The oldest heat sources are the sun and fire. Fire has been a vital source of energy since prehistory and is one of the oldest human inventions, [1], used directly for heating, cooking and lighting. Human mental development, which is based on division and separation (mine-yours, left-right, etc.), enables discovering deeper stages and seeks the essence of an object in its details. This led from the discovery of fire to the ability to transform thermal energy into mechanical force and other forms of energy.

The need for energy is ever increasing throughout the world as the global population continues to grow numerically and economically. The growing need for energy is the greatest in Asia, especially in the growing economies of China and India. The largest parts of the world´s energies are spent by the USA and China, [2]. Despite an encouraging level of developing low-carbon energy production, without the usage of fossil fuels, the world's energy needs cannot be satisfied.

Estimations of world's supply of primary energy sources shows that this supply is very limited and (except for coal) will not satisfy the normal supply of world's needs to the end of the 21st century, [3]. With regard to exploiting primary sources, coal has the leading position, with which natural gas partly competes. The developing technology of obtaining energy from gas is expanding, as are techniques for the extraction of gas from solid primary sources (coal, wood, slate, etc.). With the gasification of solid fuel, transport becomes more economical, and pollution is reduced. With the continued development of gas technology bringing about greater efficiency, gas will take the leading role.

1.1 Usage trends of coal, gas and production energy

From a global perspective, most energy is produced by burning coal ore and gas. Consumption has changed according to the growth of the population, technological progress, economic status, supplies, etc. This trend was linearly increasing until 1995, stabilized by 2008 and recently has even decreased. The consumption of coal did not stabilize because of decreased global energy needs but because of increased production of energy from other sources.

From Fig. 1, it is evident that since 2006 there has been a production increase of gas, oil, biomass and a lower consumption of coal.

The consumption trends of energy sources indicate that we are aware of ecological issues and that cleaner technologies are used (Kyoto protocol).

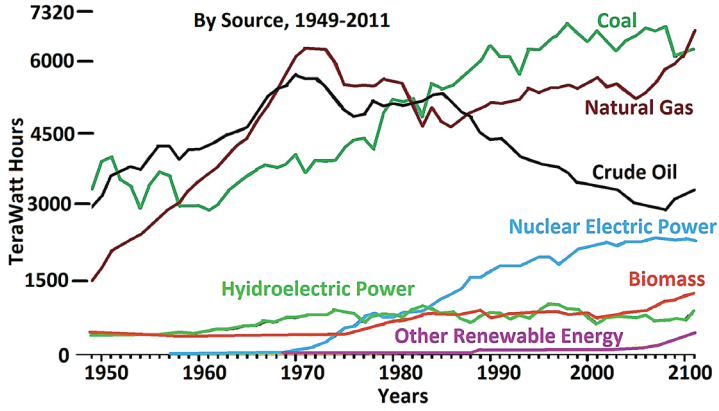

Figure 1: *Global trends of fuel consumption, EIA [4]*

The Kyoto protocol is an international treaty that attempts to reduce the emission of carbon dioxide and five other greenhouse gases. This protocol has been valid since February 2005. By 2009, the treaty had been ratified by 183 countries and the European Union. At the time of signing the protocol, 37 developed countries and 15 member countries of the European Union agreed to the obligations of reaching the Kyoto aims, [5]. In Article 17 of the Kyoto protocol, the trading of emission quotas is defined. Consequently, in the case of emissions of greenhouse gases that are higher than allowed, the signatory countries have to buy emission quotas on the market. These greenhouse gas emission quotas, which are granted to the member states, will be reduced in the course of time, which means that the countries will have to buy quotas on the market or invest into new technologies. As a result of this treaty, we can expect further decreases of coal technology, as the technology for natural gas will be economically more favourable. There has been a decrease of emissions of carbon dioxide produced by burning coal and an emission increase of carbon dioxide produced by burning gas since 2006 (Fig. 2). This trend should also continue in the future.

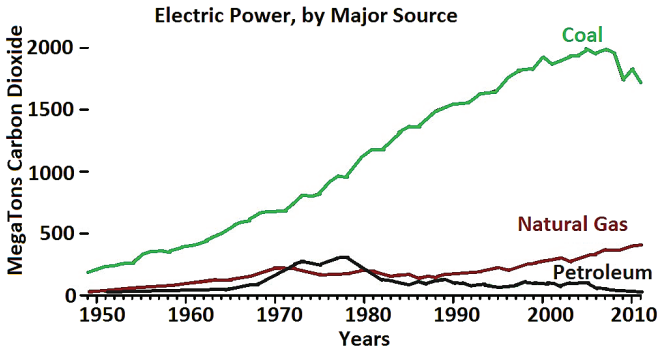

Figure 2: *Emission of gas CO_2, EIA [4]*

A negative trend of coal usage is evident in thermoelectric plants, as modern gas technologies for producing electricity are becoming increasingly effective, efficient and profitable. If the progressively demanding ecological restrictions are also considered, gas has massive potential. Global energy usage trends also indicate a decrease of coal technology and an increase of gas technology (Fig. 3).

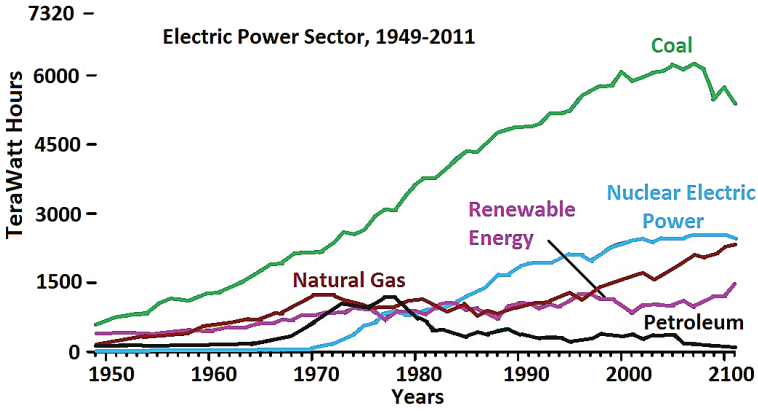

Figure 3: *Production of electricity, EIA [4]*

From a global perspective, in 2002 50% of electricity was produced by burning coal and 18% by burning gas. By 2012, the production of electricity obtained from coal had been reduced by 37%; the production of electricity obtained from gas had increased by 34%. It is notable that the increased gas consumption is matched with the beginning of gas production from unconventional sources (e.g. slate) in 2009.

The trend of energy consumption in Europe is decreasing, because of the financial crisis; both trends (the energy trend and financial crisis) are simultaneous. There is a decrease in economic activity, including industry, production, and purchasing power; consequently, the need for energy is also decreasing. Nevertheless, increased consumption of gas can be observed, because of the lower usage of coal (Fig. 4). European consumption trends are compatible with global trends and are based on cleaner technology.

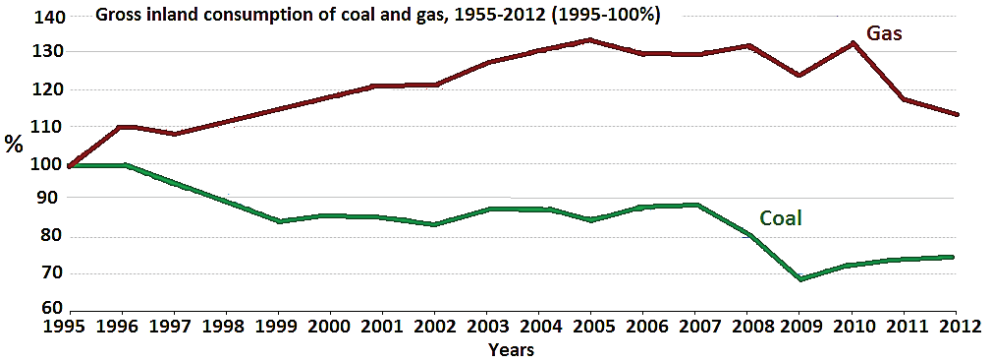

Figure 4: *Usage of coal and gas [6]*

In March 2007, The European Commission for a Lower Carbon Society accepted additional commitments [7].

These commitments are:

- Emissions decrease of greenhouse gases by 20% and, according to special conditions, even by 30%, in the period from 1990 to 2020,
- increase of renewable energy sources by 20%, and
- improvement of energy efficiency by 20%.

1.2 Long-term trends

Long-term global trends indicate a steady increase of energy needs, which will be provided by increased usage of already known fuels. Of key importance to fuel usage are economic guidelines. The International Energy Agency, [8], has presented two anticipated scenarios: the Basic and the Blue courses of events. They represent a basis for further economic development strategy and are based on implementation of low carbon technologies to 2050, [9].

According to the Basic Scenario, any new energy or environmental policy will not be accepted. The average anticipated global economic growth is per 3.1% yearly.

The Blue Scenario is based on a low carbon society. It anticipates that by the year 2050 the global emissions of carbon dioxide will decrease to a level of 50% of the current amount and that global temperatures will not rise by more than 2°C or 3°C. This goal can only be achieved when there will also be a decrease of the emission of other greenhouse gases, in addition to the measures for reductions of carbon dioxide, [9]. To achieve the aims defined in the Blue Scenario, significant reductions in emissions in all sectors will have to be achieved by 2050: electricity, industrial and building sectors. In this case, the difference between the produced and consumed energy will have to be substituted by alternative sources.

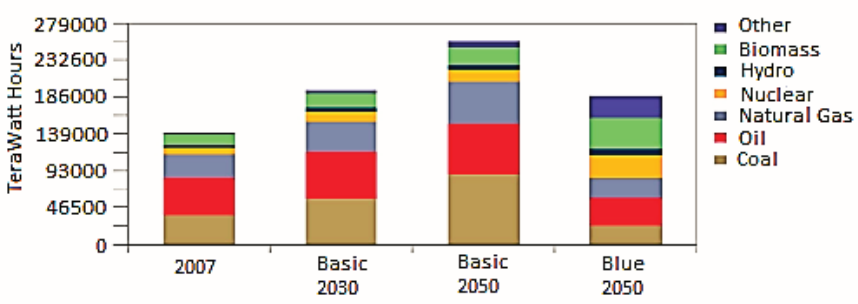

Figure 5: *Primary energy needs according to the energy source and guidelines scenario [9]*

The IEA's prediction of a consumption trend of coal and gas is shown in Fig. 6.

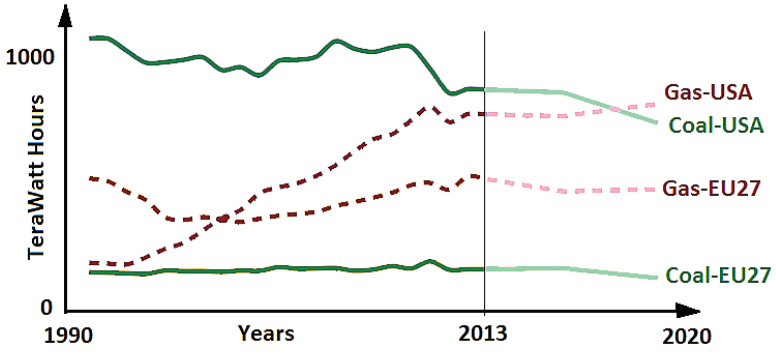

Figure 6: *Consumption trends of coal and gas, IEA [8]*

2 STATUS OF THERMAL ENERGY IN SLOVENIA

Slovene and European trends have no fundamental differences, because they are based on the same environmental and energy directives. Slovenia consumes solid fuel in thermoelectric plants for the production of electricity and thermal energy. Because the domestic production of solid fuel does not satisfy current needs, some fuel is imported (Fig. 7). Over time, the amount of imported solid fuel has been quite consistent, and it will gradually increase in the future, because of a decrease of domestic production.

The largest deficiencies in the usage of coal are its greenhouse gases. Therefore, the usage of domestic coal is in the future will be limited to lignite from the Velenje coal mine, for the production of electricity. The Kyoto protocol goal is the long-term reduction of all coal usage. The gradual closing of the Velenje coal mine is predicted around the year 2054. The closing of the Trbovlje-Hrastnik mine is predicted to occur in 2015, in accordance with the law on the developmental restructuring of the region. With the gradual decrease of the amount of coal usage, coal remains an element of domestic energy supply because of its strategic reliability and the diversification of energy sources, [10]. By 2020, Slovenia will have gradually stopped importing coal for the production of electricity.

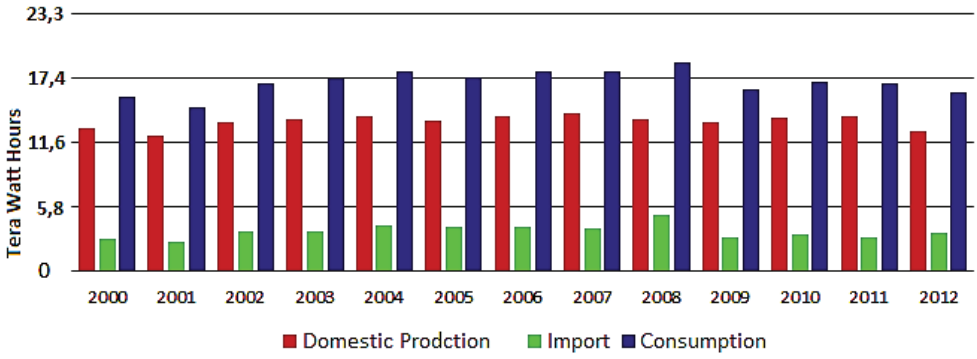

Figure 7: *Consumption trends of firm fuels in Slovenia [11]*

Slovenia imports almost all its natural gas. The energy needs for natural gas are increasing, and its price is formed on the market. The global trend is based on increased consumption of gas; higher gas prices can thus be expected. As a consequence, there will be increased energy dependence and more expensive energy for the consumer.

For the supply of natural gas, the gradual convergence with the neighbouring markets will be of key importance. The competitiveness of the natural gas market will improve. Gas consumption will depend on electricity production, especially in high-efficiency joint production in local supply and industry.

The assurance of energy service from remote heating systems will have priority over the extension of gas networks to new regions, [10].

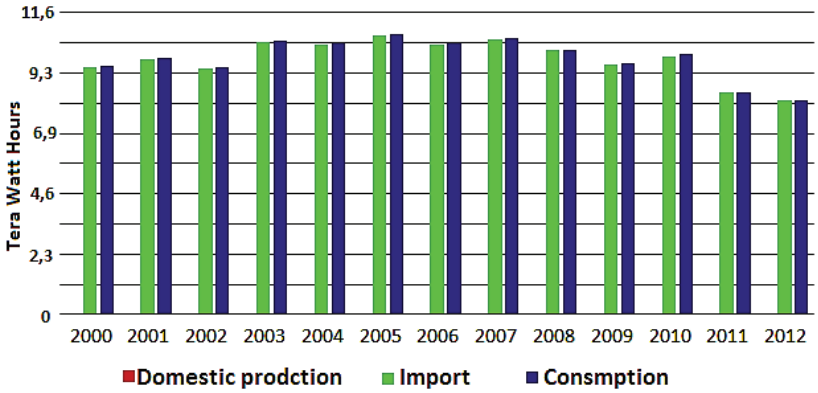

Figure 8: *Trend of natural gas in Slovenia [11]*

Fig. 9 shows the usage of energy sources, which is fairly stable. On average, Slovenia imports 51% of its energy resources (energy dependence), and this will increase in time. Most energy is produced by burning solid fuels.

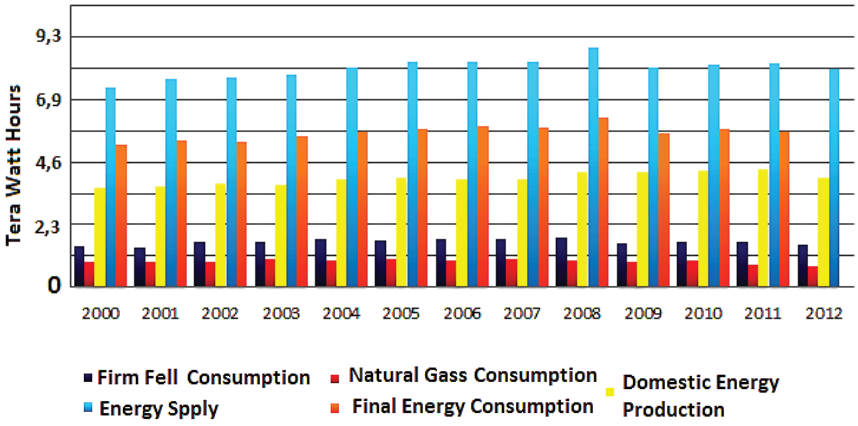

Figure 9: *Energy indicators in Slovenia [11]*

2.1 Thermal energy facilities with more than 10 MW capacity in Slovenia

Thermoelectric plant Šoštanj (TEŠ)

With 779 MW of power, TEŠ produces one third of the energy in the country. The annual production of electricity ranges from 3500 GWh to 3800 GWh. The annual production of thermal energy for remote heating of the Šaleška valley is from 400 GWh to 450 GWh. For the abovementioned production of electricity and thermal energy, from 3.5 to 4.2 million tons of coal and around 60 million m^3 of natural gas is used every year, [12].

Table 1: *Specified power of generators [12]*

Block	Fuel	Specified power of generators
Steam block 1	Lignite	Permanently halted on 31 March 2010
Steam block 2	Lignite	Permanently halted in 2008
Steam block 3	Lignite	75 MW (to be permanently halted in 2015)
Steam block 4	Lignite	275 MW (to be permanently halted in 2015)
Steam block 5	Lignite	345 MW (to be permanently halted in 2027)
Two gas blocks	Natural gas	2 × 42 MW (permanently halted in 2027)

After the acceptance of the Strategic Development Plan of TEŠ in June 2004, Block 6, with 600 MW, power will gradually replace the technologically outmoded and economically unprofitable Blocks 1, 2, 3, 4 and 5. This is a nationally important project, which the government accepted on 12 October 2006 and amended in 2008. It is a part of the Resolution of the National Energy Programme and of the Resolution of National and Development Projects for the period from 2007 to 2023. For the same amount of produced energy, Block 6 will use approximately 30% less coal, thereby significantly lowering emissions, [12].

Thermoelectric plant Toplarna Ljubljana (TE-TOL)

TE-TOL is the largest combined heat and power generation in Slovenia. It supplies more than 90% of the needs of the remote heating system of Ljubljana, which represents approximately 50% of such needs for Slovenia, [13]. The electricity produced represents 3% of the needs for electricity in Slovenia.

Table 2: *Specified power [13]*

Block	Fuel	Specified power of generators	Specified thermal power
Steam block 1	Brown coal	42 MW	94 MW
Steam block 2	Brown coal	32MW	94 MW
Steam block 3	Brown coal Biomass	50 MW	152 MW
LPB	Oil		150 MW

Since 2002, only Indonesian coal (low sulphur content) has been used in TE-TOL, because of the requirements of ecological legislation. The coal must have a high heating value and low sulphur content (under 0.2%) and ash (1–3%), [13]. Otherwise, the company would have to invest in expensive technology for cleaning emissions. In the boiler of Block 3, wood chips also have been used since 2008, replacing 20% of the coal. From renewable energy sources, approximately 8% of thermal energy and electricity is produced.

From 1 January 2016 onward, TE-TOL will not be able to achieve the allowed emission of carbon dioxide (200 mg/m³); its average annual concentration around 400 mg/m³. With the transitional national plan, in which TE-TOL was included in December 2012 and is valid until 1st July 2020, the company will change the primary fuel from coal with natural gas. This gasification phase (PPE-TOL) is one of the measures in the transitional national plan of Slovenia.

Thermoelectric plant Trbovlje (TET)

TET is the largest energy facility in the Zasavje region. Together with the Zasavje coal mines, it had been a key element for the development of many factories, industrial and craft plants, traffic and social services in Zasavje and Slovenia. TET currently has two units; the steam block produces electricity from brown coal from the Zasavje coal mines, while the two gas blocks use natural gas and oil for the production of electricity; they are a reserve in the electrical energy system of Slovenia. TET sells the remaining amount of electricity independently on the market, [14].

Table 3: *Specified power of generators [15]*

Block	Fuel	Specified power of generators
Steam block	Brown coal	125 MW
Two gas blocks	Oil	Complete power 63 MW

The vision of TET is the construction of a gas-steam electric power plant that has the possibility of being upgraded with an integrated gas combination cycle, which requires the gasification of coal or fuel oil as remainder in the process of refining oil and the implementation of neutralization technology of greenhouse gases. This vision also requires the renovation of gas blocks with a combined coal and wooden biomass unit with the possibility of using the heat energy for the heating of Zasavje. With the renovation of the gas blocks, the extraction of coal from the Trbovlje-Hrastnik coal mine would be extended, or the coal would have to be substituted by imports.

Thermoelectric plant Brestanica (TEB)

TEB provides reliable and safe electricity production, with the aim of remaining the leading provider of systemic services of tertiary regulation while simultaneously being an indispensable reserve electricity source for the Krško nuclear power plant. With its services, TEB is a reliable reserve electricity source for the electrical system of Slovenia at its most critical moments. With its fast aggregates, the plant enables rapid intervention at times of system overload or a cut out of Slovene electric power plants or power lines, thereby preventing collapses of the electrical energy network with quick intervention, restructuring of the electrical energy network after a failure, and providing an independent and direct energy source for the Krško nuclear power plant, [16].

Table 4: *Specified power of generators [16]*

Block	Fuel	Specified power of generators
Three gas blocks	Oil or natural gas	3 × 23 MW
Two gas blocks	Oil or natural gas	2 × 114 MW

The policy of the company is to keep or to increase its share of the market of systemic services of tertiary regulation on the domestic and foreign electricity markets, to optimise business costs, to provide high start-up reliability and availability of company devices, to continue with its active role in the maintenance chain of hydroelectric power plants on the lower River Sava and to maintain a quality system according to the ISO 9001 standard. Its purpose is to continue with the substitution of gas blocks with 3 × 23 MW power with new blocks, which will correspond both to ecological standards and the technical demands of tertiary regulation, and quick start up in the case of a collapse of the electrical networks, [16].

3 CONCLUSION

With the increasing population, development and economic growth, the need for energy has also increased. From a global perspective, energy needs are currently very different from continent to continent. The largest increase is in the developing economies of China and India. The biggest energy needs but with rather moderate growth is seen in the USA. European needs are decreasing somewhat, which is connected with economic indicators. The world is becoming increasingly ecologically conscious; consequently, environmental legislation, which is based on decreased emissions of greenhouse gases and environment protection, is of key importance. From a global perspective, the human factor represents only 4% of carbon dioxide emissions into the atmosphere. The warming of the oceans represents the largest part, i.e. 90%, of the increase of carbon dioxide concentration in the atmosphere. When the oceans' temperature decreases, carbon dioxide is absorbed, but when the temperature rises, carbon dioxide is released. Human use of energy, therefore, contributes only a small part of greenhouse gases; the rest is a consequence of the natural warming of the atmosphere (solar radiation, protective ozone layer, etc.). Nevertheless, environmental legislation forces the energy industry to buy new and more expensive technologies or to buy emission quotas. The global, European and Slovene energy industries have adjusted to the environmental guidelines with lower coal usage and greater usage of natural gas. The thermal energy industry of Slovenia uses both energy sources for the production of thermal energy and

electricity in rather old and obsolete systems. In the transitional period until 2020, fundamental changes must occur, which will be seen in the closing of coal thermoelectric plants and investments into gas thermoelectric plants. The reason for this is also the closing of coal mines in Slovenia, as from 2015 only the coal mine in Velenje will be in operation. This, however, means that Slovenia will be increasingly dependent on imports. We will be able to import the energy sources in the primary form (coal, gas, oil) or as a final product in the form of electricity.

References

[1] Wikipedia: [Online]. Access to: http://sl.wikipedia.org/wiki/Ogenj#Odkritje_in_zgodovina_ognja [05.07.2013].

[2] **M. Obrecht:** *Študij dejavnikov pri modeliranju razvoja trajnostne energije*, Univerza v Mariboru, Ekonomsko-poslovna fakulteta Maribor, 2012, pp. 50-51, [Online]. Access to: http://dkum.uni-mb.si/IzpisGradiva.php?id=22929 [04.07.2013].

[3] Državni zbor RS: *Resolucija o nacionalnem energetskem programu*, Predlog 6.11.2003, pp. 6, [Online]. Access to: http://www.vlada.si/fileadmin/dokumenti/cns/doc/0311120737551_46v7.doc [02.07.2013].

[4] U.S. Energy Information Administration (EIA): [Online]. Access to: http://www.eia.gov/ [05.07.2013].

[5] Wikipedia: [Online]. Access to: http: http://sl.wikipedia.org/wiki/Kjotski_protokol [06.07.2013].

[6] European Commission EUROSTAT: [Online]. Access to: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home [05.07.2013].

[7] European Commission of Climate Action, The 2020 climate and energy package: [Online]. Access to: http://ec.europa.eu/clima/policies/package/index_en.htm [05.07.2013].

[8] International Energy Agency (IEA): [Online]. Access to: http://www.iea.org/ [06.07.2013].

[9] **B. Pišotek:** *Tehnologija zajemanja CO2 ter preučevanje njihovega vpliva na delovanje energetskih sistemov*, Univerza v Mariboru, fakulteta za strojništvo, 2013, pp. 3-8.

[10] Nacionalni energetski program Republike Slovenije (NEP): *Osnutek predloga Nacionalnega energetskega programa Republike Slovenije za obdobje do leta 2030*, Institut "Jožef Stefan", Ljubljana, Slovenija, Center za energetsko učinkovitost (CEU), 2011, pp. 95-107, [Online]. Access to: http://www.mg.gov.si/fileadmin/mg.gov.si/pageuploads/Energetika/Zelena_knjiga_NEP_2009/NEP_2010_2030/NEP_2030_jun_2011.pdf [04.07.2013].

[11] Statistični urad Republike Slovenije (SURS): [Online]. Access to: http://pxweb.stat.si/pxweb/dialog/statfile2.asp [04.07.2013].

[12] Termoelektrarna Šoštanj (TEŠ): [Online]. Access to: http://www.te-sostanj.si/si/ [05.07.2013].

[13] Energetika Ljubljana, enota TE-TOL: [Online]. Access to: http://www.te-tol.si/ [05.07.2013].

[14] Wikipedia: [Online]. Access to: http://sl.wikipedia.org/wiki/Termoelektrarna_Trbovlje [05.07.2013].

[15] Access to: http://sl.wikipedia.org/wiki/Termoelektrarna_Trbovlje [05.07.2013].

[16] Termoelektrarna Brestanica (TEB): [Online]. Access to: http://www.teb.si/ [04.07.2013].

Nomenclature

CO_2	Carbon dioxide
EIA	U.S. Energy Information Administration
EUROSTAT	European Commission Statistic
GWh	Giga Watt Hour
IEA	International Energy Agency
MW	Mega Watt
Mtoe	Million Tonnes of Oil Equivalent
NEP	National Energy Programme of Slovenia
LPB	Low Pressure Boiler
PPE-TOL	Toplarna Ljubljana gas-steam energy source
RS	Republic Slovenia
SURS	Statistical Office of Slovenia
TEB	Brestabica thermoelectric plant
TWh	Tera Watt Hour
TE-TOL	Toplarna Ljubljana thermoelectric plant
TEŠ	Šoštanj thermoelectric plant
TET	Trbovlje thermoelectric plant