Estimation of competitiveness of brown coal exploitation from the Trbovlje- Hrastnik mine

Ocena konkurenčnosti pridobivanja rjavega premoga iz Rudnika Trbovlje-Hrastnik

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Abstract: Coal is a fossil fuel, which, due to vast deposits of coal worldwide, boasts the longest exploitation time line of all fossil fuels. When it comes to power generation, coal has proven the most cost effective of all fossil fuels. A comparison of the cost of coal mined at the Trbovlje-Hrastnik mine (RTH) has been carried out using the cost of coal mined at the Ojstro mine (where mining is more cost-intensive than at the Trbovlje mines Plesko polje and III. polje). The competitiveness of the Ojstro mine coal has been assessed against the comparative advantages of the prices of produced coal and alternative energy sources, in particular the prices of imported coal and natural gas. The production price of coal from the Ojstro mine presently amounts to 3.33 EUR/GJ; in the entire studied period, this considerably exceeds the prices of coal in the European markets ranging between 1.75 EUR/GJ and 1.87 EUR/GJ in 2009, and between 2.38 EUR/GJ and 2.63 EUR/GJ in 2015. The calculations show that, considering the above assumptions, the interval of purchase price for imported coal ranges from 3.32 EUR/GJ to 3.48 EUR/GJ in 2009, and the prices will progressively climb from 4.16 EUR/GJ to 4.51 EUR/GJ in 2015. This effectively means that the

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production cost of coal from the exploitation field of the Ojstro mine in 2009 is already lower or approximately the same as the purchase price for imported coal; over the coming years that ratio continues to improve in favour of coal from the Ojstro mine.

Izvleček: Premog je fosilno gorivo, ki ima zaradi svojih velikih svetovnih zalog tudi najdaljšo časovno perspektivo izkoriščanja. Tako proizvodnja kakor tudi poraba premoga v svetovnem merilu strmo naraščata vse od leta 2000 dalje. Cenovno je premog izmed vseh fosilnih goriv za proizvodnjo električne energije najugodnejši energent. V Evropi je bilo do leta 1999 čutiti težnjo padanja tako proizvodnje kakor tudi porabe premoga, po tem letu pa se je težnja padanja ustavila ali celo obrnila, pri tem pa je začela naraščati vrzel med proizvodnjo in porabo, kar kaže na vseevropski porast odvisnosti od uvoženega premoga. Slovenska proizvodnja premoga ima od leta 1992 naprej težnjo upadanja, ki se bo s predvidenim zaprtjem premogovnikov v Zasavju še poglobila in bo kljub sočasnemu upadu porabe znova povečala razliko med porabo in proizvodnjo premoga, kar bo nadalje vodilo do povečane odvisnosti od tujih energijskih virov.

Konkurenčnost pridobivanja premoga v Rudniku Trbovlje-Hrastnik (RTH) smo primerjali pri stroškovno najzahtevnejši jami Ojstro, stroškovna cena za odkopavanje v jami Trbovlje (Plesko polje in III. polje) je nižja. Konkurenčnost pridobivanja premoga iz jame Ojstro temelji na primerjalni prednosti cen pridobljenega premoga in cen alternativnih energentov iz tujine, predvsem cen uvoženega premoga ter zemeljskega plina. Proizvodna cena premoga v odkopanem polju jame Ojstro, 3,33 EUR/GJ, je v celotnem preučevanem obdobju bistveno višja od cen premoga na evropskih trgih, ki so v letu 2009 od 1,75 EUR/GJ do 1,87 EUR/GJ, v letu 2015 pa bodo med 2,38 EUR/GJ in 2,63 EUR/GJ. Izračuni kažejo, da je glede na omenjene predpostavke interval nabavne cene premoga iz uvoza v letu 2009 od 3,32 EUR/GJ do 3,48 EUR/GJ, z leti pa bodo meje intervalov naraščale in bodo v letu 2015 dosegle vrednosti od 4,16 EUR/GJ do 4,51 EUR/GJ, kar pomeni, da je proizvodna cena premoga iz odkopnega polja jame Ojstro že v letu 2009 manjša ali približno enaka nabavni ceni premoga iz uvoza, razmerje med obema cenama pa se z leti izboljšuje v korist premoga iz odkopnega polja jame Ojstro. Upoštevajoč proizvodno ceno premoga iz odkopnega polja jame Ojstro je že v letu 2010 manjša kot nabavna cena zemeljskega plina, kot premogu alternativnemu energetskemu viru,

razmerje med obema cenama pa se bo z leti še izboljševalo v korist premoga iz odkopnega polja jame Ojstro.

Key words: brown coal, competitiveness, electricity power supply and demand, energy sources, cost comparison
Ključne besede: rjavi premog, konkurenčnost, povpraševanje in oskrba z električno energijo, energijski viri, primerjava stroškov

Introduction

Up until and including the year 2009, Rudnik Trbovlje-Hrastnik (RTH) will supply the thermal power plant Termoelektrarna Trbovlje (TET) with coal in the planned amount of 0.6 million ton per year. Despite all economic and environmental disadvantages of coal, the EU will not significantly reduce the current consumption of domestic and imported coal. It would be reasonable to treat coal reserves in the Republic of Slovenia in a similar way. Replacing coal with other fossil fuels (probably with gas) will inevitably decrease the self-sufficiency in the Republic of Slovenia and increase the import dependence in electricity production as well.

Even after the year 2009, RTH intends to continue exploitation of coal from the Trbovlje mines (III. polje, Plesko polje), the Ojstro mine and from the already closed-down Hrastnik mine where there are still considerable coal reserves available. Considering the competitive conditions on the energy market, it will be reasonable to exploit all coal reserves.

In September 2008, our team at the Faculty of Natural Sciences and Engineering in Ljubljana elaborated the study "Justifiability of exploitation of the remaining coal reserves in the mines Ojstro and Trbovlje after the year 2009 and the closed-down section of the Hrastnik mine - Phase I", followed by Phase II and Phase III of this Study in March 2009. The objective of the Study was an assessment of feasibility and economic justifiability of continued exploitation after the year 2009, upon expiration, pursuant to the valid law, of state subsidies for pre-emptive dispatching of electricity from TET and upon termination of coal exploitation pursuant to the Act Regulating Gradual Closure of the Trbovlje-Hrastnik Mine.

In Phase I of the Study, the following activities were carried out:

- Evaluation of the approved expert report on coal reserves,
- Estimation of exploitation reserves in the coal layer Ojstro and Trbovlje,
- Determination of the necessary scope of additional exploration regarding coal reserves,
- Determination of the scope of preparatory works, from the technological, time schedule and financial aspect,
- Determination of excavation time schedule in relation to the coal's quantitative and energy value,

In Phase II of the Study, the following activities were carried out:

- Estimation of exploitation reserves in the coal layer of the already closed-down section of the Hrastnik mine,
- Determination of the scope of exploration and safety measures in the process of coal exploitation,
- Assessment of competitiveness of coal exploitation based on the data acquired from the Study and data on prices and transport costs for alternative energy fuels (imported coal and natural gas).

In Phase III of the Study, the following activities were carried out:

- Assessment of significance of electricity produced from this energy source for stable electricity supply in Slovenia and in the market relevant for Slovenian electricity suppliers and consumers.
- Assessment of influence of eventual opening works on the production, added value, employment rates as well as export and import currents of the Slovenian economy.

The Study provided answers to the fo lowing questions:

- Quantities of exploited coal and its calorific value,
- Indication of the scope of geological, geomechanical and hydrogeological research,
- Indication of the scope of opening facilities,
- Elaboration of time schedule and economic evaluation of costs for preparation works and excavation as well as economic model for the trend of its own price for GJ of produced energy.

The final result of the Study is the assessment of eligibility of continued exploitation.

Statistical indicators of global production and consumption of coal

Coal is a fossil fuel, which, due to vast deposits of coal worldwide, boasts the longest exploitation time line of all fossil fuels. According to Energy Information Administration (EIA), the world's coal production reached 7,036 million »short ton« (1 short ton = 907.18 kg) in

the year 2007, while the consumption amounted to 7,193 million »short ton«.

Both production and consumption of coal have been demonstrating a strong upward trend on a global scale since the year 2000, when they were both at a level of approximately 5.000 million »short ton«. Figure 1 illustrates global production and consumption of coal from the year 1992. When it comes to electricity generation, coal has proven the most cost effective of all fossil fuels. Figure 2 illustrates the price of fossil fuels used for electricity production from 1995–2008.

Until the year 1999, Europe witnessed a downward trend of both production and consumption of coal, but after that year, the downward trend was stopped or even reversed. Figure 3, indicating European production and consumption of coal in Europe from 1992–2007, also illustrates an increase of the gap between production and consumption, indicating a pan-European increase in dependence on imported coal.

In the year 2006, 306,200 TJ of primary energy was used in Slovenia. Domestic energy sources were sufficient to cover 47 % of all Slovenian needs, and 53 % of energy needs were covered by imported sources which are mostly used for transport and heating. The main energy source in Slovenia is crude oil and its derivatives representing a more than

Figure 1. World coal production and consumption 1992–2007 (MST), Source: Energy Information Administration

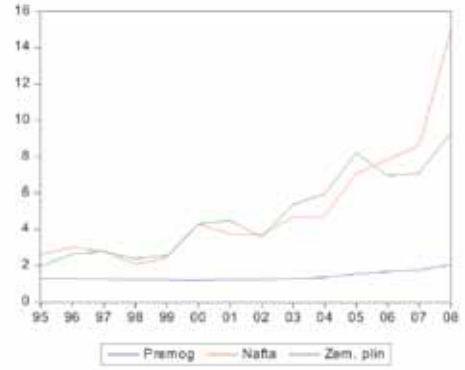

Figure 2. Fossil fuel prices for electricity production from 1995–2008 ($/MBtu), Source: Energy Information Administration

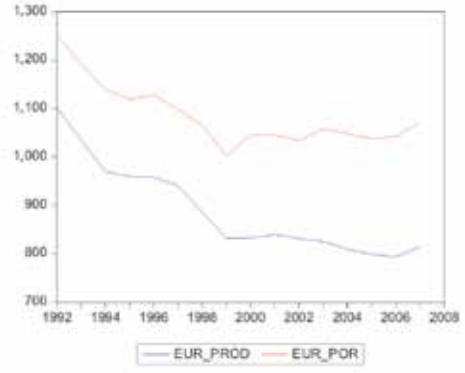

Figure 3. Coal production and consumption in Europe 1992–2007 (MST), Source: Energy Information Administration

34 % share, followed by nuclear energy and solid fuels with approximately 20 % each, natural gas with 13 % and renewable energy sources with 10 %.

As indicated in Figure 4, Slovenian coal production has been, since the year 1992, experiencing a downward trend which will fall even more after the planned closing of mines in the Zasavje region by the year 2015 – pursuant to the Act Regulating Gradual Closure of the Trbovlje-Hrastnik Mine and Development Restructuring of the Region (Official Gazette of the Republic of Slovenia, No. 61/2000) – and will, despite simultaneous decrease of consumption, again enlarge the difference between consumption and production of coal, which will lead to an increased dependence on imported energy sources.

With the purpose of studying the relevance of re-opening of the mine's exploitation fields, the price competitiveness of coal exploitation in the area of the Ojstro mine has been evaluated in comparison with alternative energy sources such as imported coal and natural gas. In the following text, we assessed the significance which the electricity produced from the studied energy source has in Slovenian electricity market. And finally, we assessed the influence that the eventual opening works in the exploitation field of the Ojstro mine might have on various macroeconomic variables of the Slovenian economy.

Figure 4. Coal production and consumption in Slovenia 1992–2007 (MST), Source: Energy Information Administration

Assessment of price competitiveness of coal exploitation from the Ojstro mine

The competitiveness of coal exploitation from the Ojstro mine is based on the comparative advantage of the prices of produced coal and foreign alternative energy sources, in particular the prices of imported coal and natural gas. Therefore, the following estimation of coal price trends in the European market has been made, together with the estimation of trends of purchase prices for imported coal in the period 2009–2015, and followed by analogue estimates of price trends for the alternative energy source, natural gas. The reference point for estimating the coal price trends are the prices of Richards Bay and ARA coal in European Energy Exchange EEX. For the year 2009, the price of both products has been calculated as an average of quarterly futures contracts in the current year.

Equally, coal prices until the year 2013 have been acquired from prices contained in annual futures contracts. For the years 2014 and 2015, a 3 % growth of coal prices is predicted. Since the prices are given in USD/t, a conversion into EUR/GJ was also made. The production price of coal in the area of exploitation field of the Ojstro mine amounts to 3.33 EUR/GJ (Dervarič, 2008: Table 11), with an assumption that the average energy value of coal for electricity production is 27 GJ/t (Energy Conversion Facts), and, furthermore, that the exchange rate EUR/USD is 1.29 and remains unchanged during the studied period. Final results are listed in Table 1, with prices in EUR/GJ in the last two lines. It is evident that in the entire studied period, the production price of coal from the Ojstro mine, which amounts to EUR 3.33 EUR/GJ, considerably exceeds the prices of coal in the European markets ranging between 1.75 EUR/GJ and 1.87 EUR/GJ in 2009, and between 2.38 EUR/GJ and 2.63 EUR/GJ in 2015. The calculations have been made using exclusively exchange prices of coal which significantly differ from the purchase price of coal in the global market; namely, to calculate an adequate purchase price, it is strictly necessary to add sea shipping and railway transport charges as well as various handling charges to the exchange prices of coal. The distribution of additional charges is shown in Table 2.

Table 1. Coal price evaluation in European market, Source: EEX, EIPF (February, March 2009)

	2009	2010	2011	2012	2013	2014	2015
	USD/t						
RB	61.11	68.81	73.13	76.88	78.13	80.47	82.89
ARA	65.26	74.40	80.35	85.20	86.45	89.04	91.71
	USD/GJ						
RB	2.26	2.55	2.71	2.85	2.89	2.98	3.07
ARA	2.42	2.76	2.98	3.16	3.20	3.30	3.40
	EUR/GJ						
RB	1.75	1.98	2.10	2.21	2.24	2.31	2.38
ARA	1.87	2.14	2.31	2.45	2.48	2.56	2.63

Note:

- RB – Richards Bay, South Africa;
- ARA – Amsterdam-Rotterdam-Antwerpen (60 % Africa, 30 % Colombia, 10 % Australia)
- The exchange rate EUR/USD is 1.29 and is assumed to remain unchanged throughout the entire period.
- The average energy value of coal amounts to 27 GJ/t.

Table 2. Imported coal price evaluation, Source: Slovenian Railways' tariffs, EIPF

	2009	2010	2011	2012	2013	2014	2015
Richards Bay ($/t)	61.11	68.81	73.13	76.88	78.13	80.47	82.89
Cargo shipping, charges ($/t)	21.39	24.08	25.60	26.91	27.35	28.16	29.01
Railway transport, charges ($/t)	17.67	17.67	17.67	17.67	17.67	17.67	17.67
Handling charges ($/t)	15.48	15.48	15.48	15.48	15.48	15.48	15.48
Total charges ($/t)	54.54	57.24	58.75	60.06	60.50	61.32	62.16
Coal purchase price ($/t)	115.65	126.05	131.88	136.94	138.63	141.79	145.05
Coal purchase price ($/GJ)	4.28	4.67	4.88	5.07	5.13	5.25	5.37
Coal purchase price (EUR/GJ)	3.32	3.62	3.79	3.93	3.98	4.07	4.16
ARA ($/t)	65.26	74.4	80.35	85.2	86.45	89.04	91.71
Cargo shipping, charges ($/t)	22.84	26.04	28.12	29.82	30.26	31.16	32.10
Railway transport, charges ($/t)	17.67	17.67	17.67	17.67	17.67	17.67	17.67
Handling charges ($/t)	15.48	15.48	15.48	15.48	15.48	15.48	15.48
Total charges ($/t)	55.99	59.19	61.28	62.97	63.41	64.32	65.25
Coal purchase price ($/t)	121.25	133.59	141.63	148.17	149.86	153.36	156.96
Coal purchase price ($/GJ)	4.49	4.95	5.25	5.49	5.55	5.68	5.81
Coal purchase price (EUR/GJ)	3.48	3.84	4.07	4.25	4.30	4.40	4.51

Note:

- RB – Richards Bay, South Africa;
- ARA – Amsterdam-Rotterdam-Antwerpen (60 % Africa, 30 % Colombia, 10 % Australia)
- The exchange rate EUR/USD is 1.29 and is assumed to remain unchanged throughout the entire period.
- The average energy value of coal amounts to 27 GJ/t.

Table 3. Gas price evaluation in Europe (2010–2015), Source: Bloomberg, Financial Times, EEX, EIPF

Ø spot 02/2009	2010	2011	2012	2013	2014	2015
USD/MMBtu						
4.10	4.85	5.52	5.84	5.84	5.84	5.84
USD/GJ						
3.88	4.59	5.23	5.53	5.53	5.53	5.53
EUR/GJ						
3.01	3.56	4.05	4.29	4.29	4.29	4.29

Note:
- The exchange rate EUR/USD is 1.29 and is assumed to remain unchanged throughout the entire period.
- Conversion factor is 1 MMBtu = 1.05506 GJ.

The calculation of purchase prices for imported coal is again based on prices of Richards Bay and ARA coal in European Energy Exchange EEX as listed in Table 1. Considering average sea shipping charges, an average share of sea shipping is calculated in the coal's purchase price in the amount of 35 % of purchase price, furthermore, handling charges in the amount of 12 EUR/t (i.e. EUR 1.2 per each started 100 kg of actual mass) and railway transport charges in the amount of EUR 13.7 per ton at the distance of 161–170 driven km and amount of 15 t should be added. Additionally, the items for handling charges and railway transport are assumed to be fixed, while the dynamics of sea shipping charges follows the dynamics of price growth. The results are listed in Table 2.

The calculations shown indicate that considering the above-mentioned assumptions, the interval of purchase price for imported coal ranges from 3.32 EUR/GJ to 3.48 EUR/GJ in the year 2009, and the prices will progressively climb from 4.16 EUR/GJ to 4.51 EUR/GJ in 2015. Considering the production price of coal from the exploitation field of the Ojstro mine amounting to 3.33 EUR/GJ, it is lower or approximately the same as the purchase price for imported coal already in 2009, and over the coming years that ratio continues to improve in favour of the Ojstro mine.

Another energy fuel competitive to coal from the exploitation field of the Ojstro mine is natural gas. Similarly as

with imported coal, the price dynamics for the time period 2010–2015 has been estimated for natural gas, based on data for spot prices and prices contained in futures contracts.

The reference point for the current spot price of natural gas was acquired as an average of daily spot prices in February 2009. We acquired the data on prices contained in futures contracts for natural gas supply from EEX website as an average of prices in futures contracts GUD Natural Gas Futures and NCG Natural Gas Futures for the years 2010–2015 and used these prices to calculate interim growth rates. Considering the assumption that the dynamics of the spot price will converge towards the dynamics of prices of futures contracts for natural gas, we estimated, on the basis of the above-mentioned interim growth rates, the price dynamics of natural gas in the studied period. Basic data on natural gas prices is expressed in USD/MMBtu. Therefore, the factor 1 MMBtu = 1.05506 GJ (Bioenergy Conversion Factors(was used in conversion. The results are listed in Table 3.

The calculations shown in Table 3 indicate that considering the above-mentioned assumptions, the price of natural gas will range from 3.65 EUR/GJ to 4.29 EUR/GJ in the period 2010–2015. Considering the production price of coal from the exploitation field of the Ojstro mine amounting to 3.33 EUR/GJ, it is lower than the purchase price for natural gas (as an energy source alternative to coal) already in 2010, and with years, the ratio between both prices is improving to the benefit of coal from the exploitation field of the Ojstro mine.

Estimation of economics of electricity produced from coal mined from the Ojstro mine

The estimation of economic viability of the Ojstro mine coal being used for power generation purposes is based on the assumption that the coal intended for electricity production would be used in the thermal power plant Termoelektrarna Trbovlje (TET). At the same time, however, the overall electricity market in Slovenia should be analysed in terms of electricity supply and demand. The following text therefore briefly presents the construction of both functions in the Slovenian electricity market based on the study by Bole, Volčjak (2006), followed by their upgrade in terms of the EU's environmental conditions regarding CO_2 emissions, both with a special accent on TE Trbovlje as the principal consumer of coal from RTH.

The function of electricity supply is a function of limit costs in all production volumes, except in production of peak electricity (in the event of "peaks"

of electricity consumption) when it is necessary to switch on the production unit - power plant with the highest limit costs. Namely, the price for electricity from a limit unit should exceed the variable costs for the amount paid by a consumer for electricity in the periods of highest loads. The amount is, naturally, high enough to (usually) cover the fixed costs for all (including limit) producers. Basic production units (for production in "range") have low limit costs and high fixed costs. In "peak" production units, the amount of costs is exactly reversed. Limit costs of hydro power plants and the nuclear power plant are usually considerably lower than in thermal power plants.

In case of hydro power plants, limit costs also include the opportunity costs of water use and, in Slovenia, also concession charge costs. In thermal power plants, however, the additional fuel is by far the largest component of limit costs. In the future, opportunity costs of greenhouse gas emissions will be important for thermal power plants, i.e. costs of additional purchase of rights, which might significantly increase the thermal power plants' limit costs.

It can be expected that limit costs of individual production units will increase with growth of electricity production, particularly if production approaches the production unit's maximum capacity. However, foreign empirical studies do not confirm such limit costs increase of individual production units (power plants) in actual production volumes. The electricity supply functions are therefore horizontal in parts. The construction of the electricity supply function is described in detail in Bole, Volčjak, 2006.

In the construction of the supply function, the power plants are categorised according to the height of their limit costs, i.e. according to the order of their switching into the network (supply) in an efficient regulation of schedule; first the hydro power plants on the Drava river, then hydro power plants on the rivers Sava and Soča, the nuclear power plant Krško (NEK), the thermal power plant Šoštanj, TE-TO Ljubljana and Trbovlje and, finally, at "peaks" in the total consumption or in the event of sudden failure (as a system reserve), the power plant Brestanica. "Total consumption" means here the sum of domestic threshold consumption, plus differences between export and import of electricity; the threshold production is naturally higher than total consumption for transmission losses (approximately 2 %). The function was further expanded by import supply. The thus constructed supply function is shown in Figure 5 as the blue stair-step curve *S*.

When analysing the market, the function of electricity demand should also be assessed. The demand function is specified in the normal manner, with

a price variable and other factors - demand variables. In tests for both electrical products, some explanatory variables known from foreign empirical research were tested as well (hourly variables of wind strength, temperature and cloudiness, monthly variables of industrial production, total domestic consumption, GDP), but except the spot price of electricity, only the variables of temperature and industrial production were statistically significant. The construction of the function is further described in BOLE, VOLČJAK, 2006.

After the liberalisation of the electricity market, the gross currents of electricity across borders of Austria, Croatia and Italy have increased considerably, even in short periods (days, months). Therefore, when analysing the equilibrium in the market in the more recent period, it is necessary to consider the overall (gross) electricity market. Due to substantially higher electricity prices in Italy, electricity is normally (net) exported across the border with Italy and net imported across the borders with Austria and Croatia. The demand function is therefore expanded by export demand from Italy. The thus constructed demand function is shown in Figure 5 as the magenta curve *D*, with the horizontal section representing export to Italy.

The equilibrium in the electricity market is established in the point of intersection of the functions (curves) of supply and demand. It is evident from Figure 5 that with the current electricity prices, the total production of TET is included in the switching schedule of Slovenian electricity producers, as the equilibrium point is situated to the right and above the section of supply by TET. This means that the limit costs of TET, which depend on the price of coal from RTH, are still low enough to enable the sales of the entire production of TET.

The second phase of limiting CO_2 emissions in the EU began already last year. The increase of prices of emission certificates will cause a relative rise of prices of electricity from thermal power plants in relation to other electricity producers.

Such change in limit costs of electricity producers (i.e. shift in the electricity supply) would be of secondary meaning to TET, as long as the size of change in limit costs didn't influence the schedule of production-supply of "peak" electricity. However, if the change in limit costs caused a change of TET's position in the electricity production schedule, the consequences could be drastically large for RTH, as they would cause either a reduction in coal's purchase price that would enable TET to keep its position in the production schedule, or a reduction in consumption of coal from RTH for an entire shift of TET's position in the electricity supply sched-

ule through the balanced realisation of electricity in the market.

The nature of supply from domestic electricity producers prevents the prices of emission certificates to change the TET's position in the production schedule. But it is necessary to consider, in the analysis of the schedule, the gross function of electricity supply, i.e. the import electricity as well. As the limit costs (the price) of import electricity exceed the TET's limit costs, TET has until now entered the electricity supply schedule before the total supply of import electricity.

An increase of limit costs of import electricity in the event of increase in the price of emission certificates would be considerably lower than in TET, as the import electricity is derived from economies where coal is little used for electricity production (e.g. Austria) or where commitments for CO_2 emission reductions are substantially less strict, either due to non-development or non-membership in the EU (e.g. Bulgaria and Bosnia). A larger increase in prices of emission certificates could therefore cause the import electricity supply to start entering the electricity supply before TET, which would prevent TET from entering entirely into the electricity supply. The equilibrium point (intersection of supply and demand) in the electricity market is namely in the initial section of the import electricity supply. Furthermore, for the period until the year 2014, no visible shift of the gross demand function is expected, as there are no changes planned for cross-border transmission capacities with Italy and therefore they won't provide any larger export of electricity to Italy, which would actually cause a sufficient shift of the gross electricity demand function to the right and made it possible for the total production of TET to enter into the electricity supply even after the increase of prices of emission certificates. Let us study the possible effects of changed prices of emission certificates on the electricity supply by looking at two scenarios of reduction of available CO_2 certificates (European Commission, 2004). The first one is the "Kyoto forever" scenario where the volume of CO_2 emission in the EU would reduce by 5.5 % below the level from the year 1990 and remain there until 2030. The second scenario, "the Gothenburg initiative", predicts reduction of CO_2 emission in the EU by 13 % until 2020 and by 21 % until 2030. Figure 6 shows CO_2 emission for both alternative scenarios and for a spontaneous scenario without interventions. The necessary decrease of emitted certificates in both scenarios is illustrated in Figure 7. A significant reduction of available emission certificates would probably substantially increase their price. The estimates of the bottom limit of the certificate price increase by 2030 amount to 41 EUR/t

of CO_2 in the first scenario and exceed 136 EUR/t in the second scenario (in prices from 2000).

The dotted lines in Figure 5 indicate the predicted change of the electricity supply function resulting from increase of certificate prices in both scenarios. It is obvious that an increase of limit costs of TET in the event of predicted consequences of the first scenario ("Kyoto forever") for the emission certificate price would be to small to change the schedule of TET's entering into the electricity supply. But at the same time, in the event of predicted increase of emission certificate price, the second scenario could, in the years 2014 and 2015 and definitely two or three years later, compromise TET's position in the electricity production schedule, as TET's limit costs would be substantially higher than electricity import price. This would cause the total production of TET to be excluded from the schedule of producers' entering in the energy system.

Analysis of the impact of eventual opening works in the Ojstro mine on Slovenian economy

The analysis of economic impact assesses the contribution of business activity, project or investment or change in production scope to the economy of a region or state. The analysis is based on the system of input-output models that constitute a part of national accounts of the economy. Input-output models show mutual connections between the sectors of the economy. They indicate the structure of production, production costs and revenues generated in the production process, currents of products and services produced within the framework of domestic economy, and currents of products and services with foreign countries. Using the input-output models, it is possible to establish the structure of production of a certain sector, share of added value, salaries and other labour costs, indirect and direct taxes and the number of workplaces necessary for the production of certain amount of output.

In the input-output modelling, direct and indirect effects should be distinguished. Indirect effects are additional revenues, workplaces, salaries and taxes directly generated or paid by the company carrying out a new project or investment, as in this case RTH with its investment into opening and exploration works in the area of the Ojstro mine. Direct effects are changes in the revenues of other companies in Slovenia, in the revenues of the entire population or in collected taxes resulting from the investment into the opening

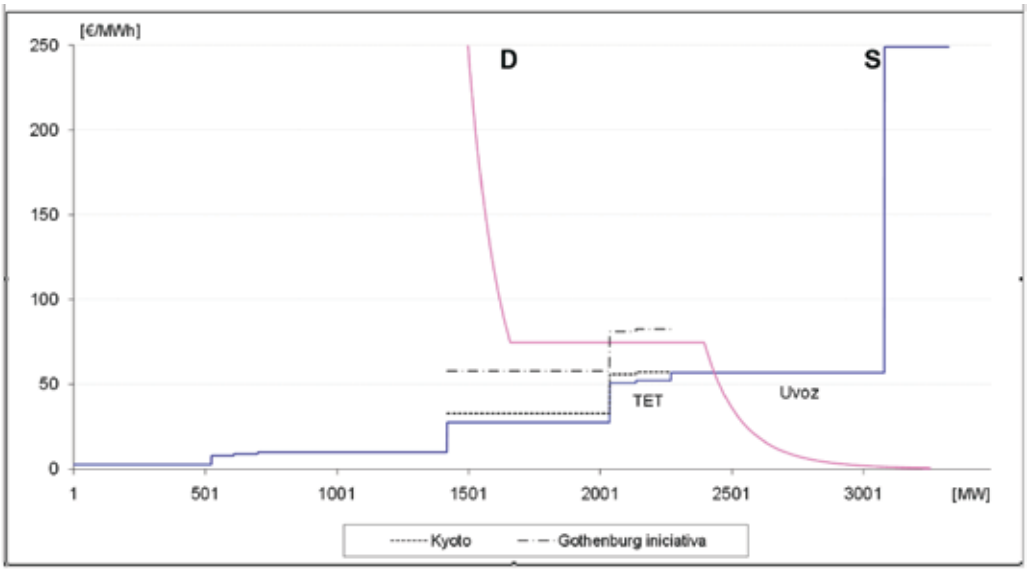

Figure 5. Gross electricity market (demand and supply) in the emission certificate reduction scenarios, Source: Bole in Volčjak (2006), European Energy and Transport – Scenarios on Key Drivers

Note: the ordinate represents the volume of allocated certificates in the volume share in 2006

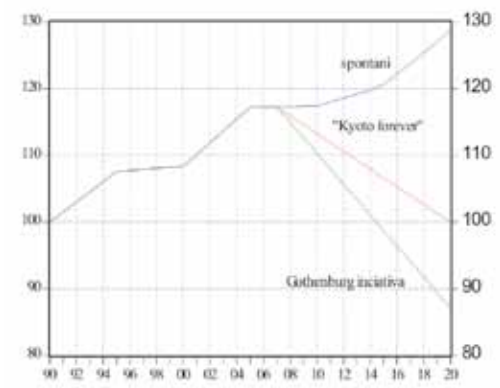

Figure 6. CO_2 emission reduction scenarios, Source: European Commission, 2004, EIPF

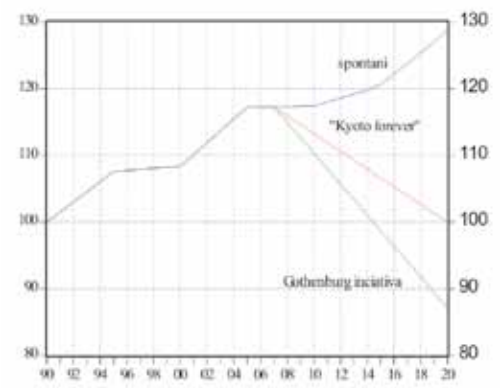

Figure 7. Emission reduction of allocated certificates at CO_2 emission shorten, Source: European Commission, 2004, EIPF

and exploration works. Indirect effects are derived from three factors. First, the company RTH acquires the inputs needed for investment and further production from the suppliers. This increases their revenues. Suppliers also acquire a part of their inputs from sub-suppliers. The effect of increased demand thus moves upwards on the value chain. Second, the employees at the company RTH and the employees at the company's suppliers spend their revenues and thus increase the demand for goods and services of numerous companies in Slovenia and their revenues as well. Similarly, the population's increased demand is transferred upwards on the value chain and influences an even larger number of companies. Total effects are the sum of direct and indirect effects. They represent an overall change in the economic activity of the country (value of production, added value, employment rates, import-export currents) resulting from RTH's investment in opening and exploration works.

The necessary opening works and their costs as well as exploration costs by individual exploitation fields in the area of the Hrastnik mine are itemised in detail in the Study (Dervarič, 2008), so Table 4 shows only their summary for the area of the exploitation field of the Ojstro mine. The opening and exploration costs in the area of the Ojstro mine have been estimated to the amount of EUR 2 million.

Table 4 also shows the potential production of the exploitation field of the Ojstro mine amounting to 730.000 t. Considering the actual calorific value of exploited coal in the amount of 11 GJ/t, the last column contains an average cost of opening and exploration per energy unit and amounts to 0.249 EUR/GJ.

Table 4. R&D costs at Ojstro pit, (Dervarič 2008)

Field	Production	Calorific value	Opening and exploration costs	Opening and exploration costs
	(t)	(GJ/t)	(€)	(€/GJ)
the Ojstro mine	730,000	11	2,000,000.00	0.249

Table 5. R&D costs at Ostro pit and their impact on slovenian economy

Sector of the economy	Change in production value (in 1000 EUR)	Change in share of added value (in basis points)	Change in number of employees	Change in import (in basis points)
A Agriculture, forestry	19.23	0.63	1	0.23
B Fishing	0.05	0.00	0	0.07
CA Mining of energy-producing materials	2036.96	18.59	11	49.08
CB Mining of ores and stones, except energy materials	10.10	0.05	0	0.41
DA Manufacture of food products, beverages, prepared feeds for farm animals and tobacco products	12.61	0.22	0	0.11
DB Manufacture of textiles, leather clothes, textile products and articles of fur	38.71	0.52	1	0.41
DC Manufacture of leather, foortwear, leather products, except apparel	3.31	0.04	0	0.12
DD Processing of wood, manufacture of products of wood, except furniture	84.99	1.19	2	1.52
DE Manufacture of pulp, paper and paperboard and articles of paper and paperboard	18.85	0.34	0	0.20
DF Manufacture of coke, refined petroleum products, nuclear fuel	53.34	0.00	0	0.44
DG Manufacture of chemicals, chemical products, man-made fibres	55.11	1.05	0	0.33
DH Manufacture of rubber and plastic products	29.62	0.39	0	0.25
DI Manufacture of other non-metallic mineral products	74.07	0.80	1	0.75
DJ Manufacture of metals and fabricated metal products	476.88	4.91	5	1.18
DK Manufacture of machinery and equipment	155.70	5.15	6	2.00

DL Manufacture of electrical and optical equipment	103.90	1.75	2	0.64
DM Manufacture of transport equipment	6.74	0.09	0	0.07
DN Manufacture of furniture and other manufacturing, recycling	20.90	0.69	1	0.52
E Electricity, gas and water supply	102.75	3.19	1	1.07
F Construction	88.73	2.53	4	0.41
G Wholesale and retail trade, repair of motor vehicles and other household goods	41.37	7.74	8	0.65
H Accommodation and food service activities	11.36	0.50	1	0.22
I Transport and storage	60.33	2.12	2	0.28
J Financial intermediation	58.68	2.31	1	0.53
K Real estate activities, rental and business service activities	243.82	8.65	4	0.51
L Public administration and defence, compulsory social security	2.89	1.16	1	0.19
M Education	3.43	1.38	1	0.24
N Human health and social work activities	1.49	0.54	1	0.11
O Other public, common and personal service activities	23.44	1.65	2	0.45
P Private households as employers of personnel	0.00	0.00	0	0.00
TOTAL	3839.37	68.18	55	62.99

In calculation of impacts of eventual opening works at the exploitation field of the Ojstro mine on Slovenian economy, the planned size of investment for opening and exploration works in the amount of EUR 2,000,000.00 was taken into account and the Supply table at purchasers' prices from the year 2005, issued by the Statistical office of the Republic of Slovenia and partitioned to 30 sectors, was used. The results are listed in Table 5.

The second column of Table 5 shows the absolute change in value of production by economy sectors. It is evident that, as expected, the investment impact is the strongest in the sector »Mining of energy-producing materials«, with an increase in production by approximately EUR 2,037,000. The observed investment also has a strong impact (over EUR 100,000) on production in the sectors »Manufacture of metals and fabricated metal products« (EUR 477,000), "Real estate activities, rental and business service activities" (EUR 244,000), "Manufacture of machinery and equipment" (EUR 156,000), "Manufacture of electrical and optical equipment" (EUR 104,000) and "Electricity, gas and water supply" (EUR 103,000). The eventual opening works have a slightly less strong impact on the construction sector, where there is a production increase by EUR 89,000 and on the sector "Processing of wood, manufacture of products of wood, except furniture" which would have an increase of EUR 85,000. In other sectors, the impact on production is less pronounced or negligible. The entire effect of production increase amounts to EUR 3,839,000.

It is evident from the third column of Table 5 that the structure of added value is changed the most in the sector "Mining of energy-producing materials" where its share increases by 18.6 base points. A change (an increase) in share of added value can also be noted in the sectors "Real estate activities, rental and business service activities" (8.7 base points), "Wholesale and retail trade, repair of motor vehicles and other household goods" (7.7 base points), "Manufacture of machinery and equipment" (5.2 base points) and "Manufacture of metals and fabricated metal products" (4.9 base points). In other sectors, the effect on added value is less pronounced or negligible.

The effects on Slovenian employment are shown in the fourth column of Table 5. The results have been rounded to the whole number and show the strongest effect in the sector "Mining of energy-producing material" where the number of employees is increased by 11. In the sector "Wholesale and retail trade, repair of motor vehicles and other household goods", the number of employees is increased by 8 persons, in the sector "Manufacture of machinery and equipment" by 6 persons and in the sector "Manufacture of metals and fabricated metal products" by 5 persons. In other sectors, the effect on employment is less pronounced or negligible. The total effect of the investment on Slovenian employment is 55 newly employed persons.

The fifth column of Table 5 shows the investment's effect on import currents of the Slovenian economy. It is evident that the import is increased by nearly half a percent in the sector "Mining of energy-producing materials". An increase of

import can also be noted in the sector "Manufacture of machinery and equipment" (2 base points) and in the sector "Processing of wood, manufacture of products of wood, except furniture" (1.5 base points). In other sectors, the impact on import is less pronounced or negligible.

Conclusion

The calculations show that, considering the above assumptions, the interval of purchase price for imported coal ranges from 3.32 EUR/GJ to 3.48 EUR/GJ in 2009, and the prices will progressively climb to 4.16–4.51 EUR/GJ in 2015. This effectively means that the production cost of coal from the exploitation field of the Ojstro mine in 2009 is already lower or approximately the same as the purchase price for imported coal; over the coming years that ratio continues to improve in favour of coal from the Ojstro mine.

The projection of coal price trends shows that the coal at the RTH location, mined from the already closed-down Hrastnik mine can be sold at maximum 3.32 EUR/GJ, representing economy of costs that would be still acceptable. The coal could also be exploited in the long term (i.e. after 2015), at 3.32 EUR/GJ at the actual location of TET. However, any additional transport costs would increase the price of coal and result in operating loss.

Summary

Coal price forecasts indicate that RTH coal (the Ojstro mine, Plesko polje, III. polje) and even the coal from the already closed-down Hrastnik mine could be sold at a maximum of 3.32 EUR/GJ. That price would make the cost of operation economically viable. The coal could be mined in the long term (i.e. after 2015) at 3.32 EUR/GJ at the actual location of the Trbovlje thermal power plant. Any additional transport costs, however, would push the cost of coal upwards and result in operating loss.

The assessment of economic viability of the Ojstro mine coal being used for power generation purposes is based on the assumption that electricity would be generated at the local thermal power plant i.e. Termoelektrarna Trbovlje (TET). At the same time, however, the overall electricity market in Slovenia should be analysed in terms of electricity supply and demand and in conjunction with the existing or proposed CO_2 emissions standards applicable in EU, and in the context of TET as the principal consumer of RTH coal. At the current prices of electricity the entire TET output feeds into the power grid of Slovenian electricity producers as the power system equilibrium point is located to the right and above TET's supply segment. This effectively means that TET's break-even costs, which are directly subject to the price of RTH coal, are still low enough to make TET competitive in the market.

Under the initial CO_2 emissions scenario proposed by EU, the increase of TET's break-even costs would not be significant enough to change TET's role and function in the Slovenian power supply system. However, the second scenario with the proposed price increase of emission certificate allowances would push TET's break-even costs considerably above the price of imported electricity, which could seriously threaten TET's position as a supplier of electricity to the Slovenian market as early as 2014 and 2015, and definitely two or three years after that. As a result, the entire TET output would be excluded from the Slovenian power generation and distribution grid.

When determining the impact of reopening the Ojstro mine on the Slovenian economy, the investment involved in the reopening of the mine and associated exploration works has been estimated at EUR 2,000,000. The biggest effects of the investment would be felt in the sector "Mining of energy-producing materials", boosting production output by roughly EUR 2,037,000. The proposed investment would also give a significant production boost (in excess of EUR 100,000) to the following industry sectors: "Production of metals and fabricated metal products" (EUR 477,000); "Real estate activities, rental and business service activities" (EUR 244,000); "Manufacture of machinery and equipment" (EUR 156,000); "Manufacture of electrical and optical equipment" (EUR 104,000); and "Electricity, gas and water supply" (EUR 103,000). The impact on production output in other sectors would be less pronounced or negligible. The proposed investment would boost overall production by EUR 3,839,000. The biggest change in the share of value added would occur in the sector "Mining of energy-producing materials" (up 18.6 points). A change (increase) in the share of value added is also indicated in the following sectors: "Real estate activities, rental and business service activities" (up 8.7 points); "Wholesale and retail trade, repair of motor vehicles and other household goods" (up 7.7 points); "Manufacture of machinery and equipment" (up 5.2 points); and "Production of metals and fabricated metal products" (up 4.9 points). The impact on value added in other sectors would be less pronounced or negligible. The biggest impact on employment can be noted in the sector "Mining of energy-producing materials", resulting in 11 new jobs. Eight new jobs would be created in the sector "Wholesale and retail trade, repair of motor vehicles and other household goods", six in the sector "Manufacture of machinery and equipment", and five in the sector "Production of metals and fabricated metal products". The impact on employment in other sectors would be less pronounced or nil. The total effect of the proposed investment on national employment would be 55 new jobs. Imports would increase by just under half a percent in the sector "Mining of energy-producing materials". Also noteworthy are the impacts on imports in the sector

"Manufacture of machinery and equipment" (up 2 points) and the sector "Processing of wood, manufacture of products of wood, except furniture" (up 1.5 points). The impact on imports in other sectors would be less pronounced or negligible.

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