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Brown coal and lignite issues from the perspective of sustainable development in Slovakia

Introduction

Coal as a mineral raw material falls into the category non-renewable resources. Its content in the Earth's crust is limited and it undergoes regeneration only under specific geologic conditions over the course of hundreds, thousands, or even millions of years. The sustainable use of mineral resources depends mostly on their protection and efficient management (Gałuszka, Migaszewski 2009).

Coal is expected to remain, for a considerable time, the dominant fuel for electricity generation around the world, and in particular for many of the countries of Central and Eastern Europe (Ilie 2010).

Mine gases endanger mining operations, hence it is necessary to assure their dilution or exhausting. We can use exhausted mine gas in different ways, from supplying the natural gas network to using it in household appliances in the same place (Zelenak 2003).

The gasification of coal is the oldest method of producing hydrogen. Coal gasification is a process that converts coal from a solid to a gaseous state (Wittenberger, Pinka 2009). The gas that is created is very similar to natural gas and can be used to make chemicals, fertilizers, and/or electric power. Being the cleanest of all coal-based electric power technologies, gasification has significantly lower levels of air emissions (including volatile mercury), solid wastes, and wastewater (Sidorova, Wittenberger 2006).

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In recent years, the mining of lignite and brown coal in Slovakia has been closely linked to the production of electricity and heat from the Novaky power plant (ENO) (Michalikova et al., ed. 2008).

Domestic brown coal production covered 78% of demand in the Slovak Republic in 2009; the remaining amount was imported, almost exclusively from the Czech Republic (Slovak Minerals Yearbook 2010).

The sustainability of coal mining in the coming years in Slovakia is closely associated with raw materials reserves, new mining technologies, the development of the Novaky power plant (ENO), and the government's commitments to national economic interests through securing the energy supply or state aid. Of course, all of these factors must be considered in the context of international obligations, such as those related to climate and environment, particularly air protection (Analysis of the functioning... 2011).

As Zacher (2011) emphasizes, important areas of studies, research and discussions on sustainability include government policies, business strategies, and the behaviour of citizens, not to mention the global dimension of the issue. Methods of consideration and decoding sustainable development vary depending on scientific field and discipline (Borys 2011).

1. Coal mining in the Slovak Republic and international issues

According to "Analysis of the fuel – energy resources and exploitation of opportunities and resources from the prognostic point of view of economic efficiency" dated January 2010 (Slovak Minerals Yearbook 2010), Slovakia has more than 1 billion tons of geological resources of coal. Of this amount, at least 100 million tons could be extracted from the deposits in Novaky, Cigel, Handlova, Gbely, Modry Kamen, Horne Strhare and Beladice (Table 1). The Beladice deposit has not been developed; it is potentially suitable for the advancement of underground gasification technology.

Balanced brown coal and lignite deposits in Slovakia can be found in several stratigraphic horizons almost exclusively from the Tertiary period. Economically the most important

TABLE 1

Recognized deposits of fuels in Slovakia (as of 1st January 2010) (Analysis of the number... 2011)

TABELA 1

Rozpoznane złoža paliw na Słowacji (według stanu na 1 stycznia 2010)

No.	Mineral	Number of deposits	Reserves economic (Gg)	Reserves potentially economic (Gg)
1.	Brown coal	7	50,186	137,153
2.	Lignite	7	221,839	337,836



Fig. 1. Economically the most important deposits of brown coal mined in Slovakia

1 – Novaky, 2 – Cigel, 3 – Handlova

Source: Analysis of the number... 2011

Rys. 1. Najważniejsze z punktu widzenia gospodarki złoża węgla brunatnego eksploatowane na Słowacji

1 – Novaky, 2 – Cigel, 3 – Handlova

are three brown coal deposits – Novaky, Handlova and Cigel, located in the Upper Nitra Basin (Fig. 1). They cover an area of about 70 km².

Domestic exploitation of lignite is around 2.38 to 2.55 million Mg per year (the years 2006 to 2007 were negatively affected by the Novaky mine accident). The consumption of lignite is approximately equal.

Total coal consumption in Slovakia in recent years was 8.2 to 9.45 million Mg, most of which was imported from abroad.

The imports of lignite, according to the Statistical Office, amounts to around 0.8 to 0.9 million Mg per year, and comes from the Czech Republic. They are directed mainly to large heating plants (Analysis of the functioning... 2011).

In recent years, the mining of lignite and brown coal in Slovakia has been closely linked to the production of electricity and heat from the power plant in Novaky (hereinafter called “ENO”), namely the electro-energy sector.

One of the major objectives of EU energy policy is the security of energy supplies and the creation and maintenance of a functional internal market. Of course, this does not limit the rights of Member States to determine the conditions for exploiting their energy resources, the choice between different energy sources and the general structure of energy supply.

The modernization of the ENO has been a long debated issue. The Energy Policy of the Slovak Republic and Energy Policy Strategy for Slovakia until 2030 consider the modernization of blocks no. 1 and 2 as well as the replacement of one of blocks 3 or 4. It is a solution under the new guidelines of the European Parliament and Council 2010/75/ES of 24 November 2010 on industrial emissions. For the investor – the Slovak power plant, however, this requires a long-term guarantee of the supply of coal for the production of

electricity. In the operation of the ENO after 2012, the cost of CO₂ emissions will play an important role, as, in compliance with European Parliament and Council 2009/26/EC of the European Trading Scheme allowances, Slovakia is in the group of countries in which the electro-energy sector requires a 100% auction system of quotas (Analysis of the functioning... 2011).

Regarding the EU's international commitments and Slovakia, the most significant in the sector is the Kyoto Protocol (Climate Protection – ends in 2012) and the Gothenburg Protocol (abate acidification, eutrophication and ground level ozone – ended in 2010). Slovakia fulfills its obligations under such international agreements. It is assumed that Slovakia will fulfil its continuing commitments (Jablonska, Timcak 2006).

The Slovak Republic participates in the cooperative programme on coal in sustainable development as carried out by UNECE. It is open to governmental and non-governmental entities from the UNECE region, together with other areas of the world, concerned with and interested in any sector of the coal to energy chain. The focus is on issues such as government policies, environmental regulations, the technical, economic, social and financial aspects of restructuring, industry decentralization, liberalization, privatization and globalization, and these issues' impact on coal in power generation.

The programme regularly brings together representatives of governments, industries, finance, trade, research, and other sectors of the economy and society in order to obtain information, exchange experience, make professional contacts, establish business relations, and debate and find solutions to the critical issues confronting decision-makers in the coal and thermal power industries and related sectors in eastern and western Europe and other regions of the world.

The coal programme also focuses on the role for coal in the context of the three pillars of sustainable development, economic, social, and environmental, as well as on issues relating to improving the public image and acceptance of coal within the ECE region (UNECE 2011).

2. Social-political aspects of sustainable development in conditions of coal mining

The support for coal mining influences the social situation in the associated regions not only for the 4,464 employees in coal mining, but also for the producers of electricity across the downstream sector, an estimated 15,000 employees.

The average state aid assigned to access coal reserves during the years 2007 to 2009 accounted for about € 4 million per year. These funds were intended for new production capacity creating up to 500 jobs. In this case, the subsidy was based on € 25,000 to 27,000 per job.

The state aid allocated to foreign investors for creating jobs is € 50,000 to 75,000 per job. Thus, domestic business entities had not been discriminated against, the aid in the creation of 500 jobs could have amounted to € 25–37.5 million (Sivakova 2011).

According to the Director of the European Association Euromines' Corina Hebestreit, domestic brown coal mining in Slovakia is important, even though annual appropriations represent € 33 million, meaning that every Slovak family subsidizes this production by approximately € 17 per year. It is not only the question of the € 17 per family, but also of searching for possible alternatives. It should be noted that it is estimated energy consumption in Europe will increase by almost 50% by 2030. European countries can deal with this situation by utilizing their own resources or through energy imports. In Slovakia, less domestic coal means more Russian gas or nuclear fuel. The European Union promotes greater use of own energy supplies by EU member states (Kovacik 2010).

If there occurred sudden attenuation of coal-mining, its impacts on the industry and economy of Slovakia could be briefly summarized as follows:

- the greatest impact would be the impact on jobs – estimated direct and indirect job losses would amount to 10,000 to 12,000 employees, directly in mining companies and the ENO and indirectly in the supply chain of related goods and services,
- Slovakia's dependence on imported primary energy needed for the operation of the ENO would be increased,
- the security of the energy supply, particularly electricity and heating in the region would be reduced,
- energy from domestic coal would possibly be replaced by increased import volumes of natural gas, which would also result in an increase in electricity prices,
- within the budget of the Slovak Republic, there would be an income loss due to lower VAT revenues, duties and income tax revenues (Analysis of the functioning... 2011).

3. Environmental aspects of sustainable development on conditions of coal mining

The state of the environment in the Slovak territory is differentiated. The Slovak Republic has introduced environmental regionalisation. The environmental regionalisation of Slovakia represents a cross-sectional source of information on the state of the environment and reflects differentiated states of the environment in different parts of the country.

The regions show varying degrees of individual environmental loads and different risk factors. These impacts, loads, or hazards show (along with a variety of natural conditions) mainly anthropogenic characteristics (Lumnitzer, Kralikova 2002).

The process of environmental regional classification marks regions of particular quality or the level of endangerment of the environment through analyses of individual components (including the risk factors) of the environment, as well as partial syntheses within the specific component of the environment or inter-component syntheses, respectively.

One of the final outputs is a map that evaluates the Slovak territory in 5 degrees of environmental quality (Fig. 2), which is the basis for identifying areas with the greatest environmental loads (State of the... 2008).

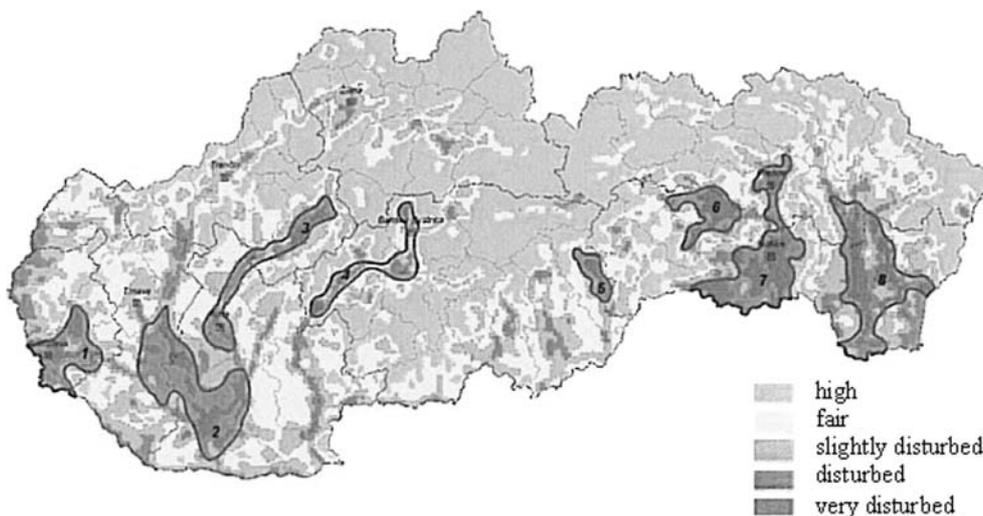


Fig. 2. Quality of the environment and the loaded areas (No. 3 – deteriorated region of Upper Nitra)

Source: State of the... 2008

Rys. 2. Jakość środowiska i obszary obciążone (Nr 3 – zdegradowany region Górna Nitra)

The territory of Upper Nitra includes areas in the 5th and 4th degrees of environmental quality, which signifies a disturbed and very disturbed environment.

3.1. Air pollution

The affected areas show large industrial sources that are major representatives of fuel-energy, mining, and chemical industries. Other sources that contribute to air pollution include mostly traffic, suspension and re-suspension of particles from insufficiently cleaned roads, construction sites and other municipal areas, household heating systems for solid fuel, coal stores in the district of Prievidza, and energy sector tailing dumps.

An air quality management zone was defined for the territories of Nitra and the district of Prievidza, to monitor the PM₁₀, and SO₂ pollutants in the area.

3.2. Surface water contamination

Surface water shows relatively heavy contamination, due to anthropogenic activities. The upper region of the river shows that there has been a long term impact of the wastewater from the mining industry on water quality. Other industrial activities have also had a negative impact on water quality as follows: production of plastics, heavy chemistry, electric power plants, heating stations, the leather-processing industry, and the food-processing industry in the river's central region.

3.3. Ground water contamination

Ground water is negatively affected by a high concentration of industrial and agricultural activities, which is reflected in its chemical composition.

Limit values for heavy metals were exceeded for the categories of Al and As. Organic substances that showed exceeded values include organic carbon, and poly-aromatic hydrocarbons. Also the limit values for pesticides were exceeded in the formation of groundwater inside quaternary sediments (Study of quarry... 2009).

3.4. Natural and soil conditions

Natural and soil conditions rank the territory among areas with poor agricultural output production forecasts. A low proportion of arable land and a high proportion of permanent grassland, relatively high relief dynamics and the consequences of mining, limit the development of crop and livestock production in the territory. Arable land occurs mainly at lower elevations in the western part of the territory. The utilization of land for agricultural production is gradually changing due to the transformation of agriculture (Fazekasova 2003).

4. Assessment of expected impacts in terms of their significance and time

The effect of utilizing all the energy sources that coal offers is obvious. Besides traditional natural coal-bed methane, gas generated by underground gasification can also be used. Technologies for obtaining gas have already been ranked among the clean coal technologies (Clean Coal Technology – CCT) and are considered to have advantages as well as disadvantages.

Underground coal gasification (UCG) is also a technology for gas recovery in situ. The principle is based on the existence of at least two wells (often a series of wells), namely an injection well and a production well, drilled into the coal bed. After ignition of the seam, an oxidizer is blown into the injection borehole and a low to medium calorific gas is gathered by the production well. In the bearings, chemical reactions similar to those in conventional gasifying generators occur. The extracted gas is of diverse quality which is dependent on the quality of coal, the type of oxidant, coping with the process, etc.

The main advantages of the technique mentioned include the reduction of two major greenhouse gases, namely methane and carbon monoxide.

All technologies for the capturing of methane are appreciated these days, as methane is an emission gas which has up to 20-times greater effect on the atmosphere than CO₂.

Current research of UCG technology is also aimed at the consumption of CO₂.

In the case of UCG technology, no emission gas is consumed; however, the idea of installing UCG technology, as well as the possibility of CO₂ storage in the incurred cavity after coal gasification is interesting.

Despite the fact that the technologies for extracting gas from coal deposits are considered to be “clean coal technologies”, they have their own impact on the environment. Obtaining gas from coal deposits can also generate pollution.

From the perspective of capturing, these technologies certainly have their advantages; however, it should also be noted that leaks in the process of methane capturing may cause explosions.

Overall, the possible contamination related to underground gasification and extraction of methane from coal beds can be divided into the following areas:

- impact on the geological environment,
- impact on water,
- contamination during the treatment of gas,
- contamination during the drilling operations (Skvarekova, Bakalar 2011)

A comprehensive evaluation of the impacts of underground coal gasification was carried out (Table 2). The summary of the expected impacts in terms of significance and the distribution of the time period were examined by a verbal numeric scale (rating system).

Individual indicators were allocated with point values. A range from + 5 (positive effect) to – 5 (negative impact) was used. Extreme values are of particular importance.

Points were awarded based on the following range of verbal significance:

- 0 – minimal or negligible impact,
- 1 – a slight impact, local, short-term, eliminable with available means; minimum difference in comparison to the initial state,
- 2 – an effect of moderate importance to the long duration of an action, it can be mitigated by available means; a perceptible difference in comparison to the initial state,
- 3 – significant effects due to prolonged exposure of a small area or short-term exposure of a larger area, it can be mitigated by protective measures; a significant difference in comparison to the initial state,
- 4 – very significant impact, the intervention of a large territory, it can be mitigated by demanding resources or compensation; a very significant difference in comparison to the initial state,
- 5 – an influence of extreme importance, long-term and spatially extensive action, meaning worsening (or improving) the current state of the territory, mitigation measures are technically unfeasible or extremely challenging (Study of quarry... 2009).

The implementation of UCG technology in the observed region would mean the creation of new stationary and mobile sources of underground rock environment and groundwater pollution as a result of waste.

Based on a comprehensive assessment of the proposed action, it can be stated that it could bring a socially unacceptable risk to the area, specifically the significant impairment of health or the environment (groundwater and nearby hot springs in Bojnice). The implementation of operations could affect the population’s health since the partition is placed in close proximity to residential areas.

TABLE 2

Comprehensive evaluation of the impacts of underground coal gasification

TABELA 2

Kompleksowa ocena wpływu podziemnej gazyfikacji węgla

Indicators	Influence	Operation	After operation
Impacts on the population			
The quality of life	The barrier effect	0	0
	Effects on scenic landscape	-1	-1
	Job Offer	+1	+1
Health hazards	Noise	-1	0
	Emission	-4	-2
	Judder	0	0
Impacts on the natural environment and protected areas			
Rock environment	Disturbance of the ground	-1	0
	Pollution of the ground	-3	-1
Climate	Effects on air quality	0	0
	Microclimatic changes	0	0
Surface water	Effects on surface water quality	0	0
	The influence of the surface water rule	0	0
Underground water	Effects on underground water quality	-4	-2
	The influence of the underground water rule	-2	-1
Biota	Effects on the rare biota	-2	-1
	The effects on USES (Territorial System of Ecological Stability)	-1	-1
Protected Areas	Large and small-scale protected areas	-1	-
	Areas of importance and protected areas	-1	-1
	Protective zones of natural resources, mineral and thermal waters	-2	-
Impacts on the urban environment and land use			
Recreation and Tourism	Restriction or development of recreation and tourism	-3	-1
	Intervention into the area of recreation and sport	0	0
Agricultural	Scope of agricultural land	0	0
	Contamination of agricultural land	-1	-1
Forestry	Area coverage of forest land	-4	0
	Impact on Forest Management	-1	-1
Aquaculture	Effect on the water structure	0	0
	Impact on water resources of protection zones	-1	-1
Waste Management	Waste production	-2	-2
Cultural relics	Impact on archaeological sites	0	0

Conclusions

Lignite and brown coal mining has been the subject of many discussions in Slovak media, particularly in relation to mining accidents (Mine Handlova 2006, 2009).

The existence of the electricity and heating plant Novaky (ENO) is necessary for the security and stability of the electricity network in Slovakia. It is an important electro-energetic hub of the north-western part of Slovakia and the region, directly linked to wholesale electricity providers (Ziar nad Hronom, Novaky). It serves as a supplier of support services to level out anomalies. The only possible substitute of coal for the ENO is gas. Both materials are imported and electricity will not be substantially cheaper. Moreover, technically, especially in winter, the delivery of imported coal cannot be ensured in the required quantity and in the required time due to freezing temperatures (Sivakova 2011).

Maintaining the energy source the ENO has a significant impact on the region of Upper Nitra as it facilitates the achievement of all three pillars of sustainable development, of course, subject to environmental investments. It will undoubtedly also help to maintain social cohesion, and its most important contribution is to safeguard the security of the electricity supply.

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ROLA WĘGLA BRUNATNEGO W ZRÓWNOWAŻONYM ROZWOJU SŁOWACJI

Słowa kluczowe

Górnictwo węgla, społeczno-polityczne aspekty zrównoważonego rozwoju, środowiskowe aspekty rozwoju zrównoważonego, zatrudnienie

Streszczenie

Artykuł przedstawia sytuację górnictwa węgla na Słowacji, koncentrując się na społeczno-politycznych i środowiskowych aspektach jego zrównoważonego rozwoju.

Wydobycie węgla brunatnego na Słowacji jest w ostatnich latach ściśle związane z produkcją energii elektrycznej i ciepła głównie w elektrowni Novaky. Krajowa produkcja węgla brunatnego pokrywała ponad trzy czwarte zapotrzebowania Słowacji w ostatnich latach. Zrównoważony rozwój górnictwa węgla w najbliższych latach zależy od zasobów surowcowych, nowych technologii, rozwoju elektrowni Nowaky oraz od przyjęcia przez rząd decyzji dotyczących zabezpieczenia dostaw energii i pomocy publicznej, w ogólnym interesie gospodarczym i oczywiście w kontekście zobowiązań międzynarodowych, zwłaszcza tych dotyczących klimatu i środowiska, a w szczególności ochrony powietrza.

Trzy najważniejsze słowackie złoża węgla znajdują się w Zagłębiu Górna Nitra. W zagłębiu tym są obszary o czwartym i piątym stopniu jakości środowiska, co oznacza, że środowisko jest zanieczyszczone i bardzo

zanieczyszczone. Ponieważ należy się spodziewać, że węgiel w dalszym ciągu będzie dominującym paliwem do produkcji energii elektrycznej na świecie, a w szczególności w wielu krajach Centralnej i Wschodniej Europy, należy stworzyć warunki dla środowiskowo zrównoważonego rozwoju górnictwa węgla w nadchodzących latach w kontekście międzynarodowych zobowiązań. Ważne są zarówno bezpieczeństwo i stabilność systemu energetycznego Słowacji jak też utrzymanie zatrudnienia w regionie Górna Nitra.

Podziemne zgazowanie węgla (*ang.* UCG) jest nową technologią eksploatacji oraz technologią pozyskiwania gazu *in situ*.

W artykule przedstawiono kompleksową ocenę wpływu podziemnego zgazowania oraz wyszczególniono spodziewane jego skutki wraz z oceną ich znaczenia i rozkładu w czasie.

Na podstawie kompleksowej oceny proponowanego działania, należy stwierdzić, że może ono przynieść społecznie niedopuszczalne ryzyko w analizowanym obszarze, związane ze znacznym upośledzeniem zdrowia lub środowiska naturalnego (woda gruntowa i pobliskie gorące źródła w Bojnicach). Realizacja działań może mieć wpływ na zdrowie ludności, gdyż obszar ten znajduje się w pobliżu obszarów zamieszkałych.

BROWN COAL AND LIGNITE ISSUES FROM THE PERSPECTIVE OF SUSTAINABLE DEVELOPMENT IN SLOVAKIA

Key words

Coal mining, social-political aspects of sustainable development, environmental aspects of sustainable development, employment

Abstract

This paper presents the situation of coal mining in Slovakia, focusing on the social-political aspects and environmental aspects of its sustainable development.

In recent years, the mining of lignite and brown coal in Slovakia has been closely linked to the production of electricity and heat in the Novaky power plant. Domestic brown coal production covered more than three quarters of demand in the Slovak Republic in the last few years. The sustainability of coal mining in the coming years in Slovakia is closely associated with raw materials reserves, new mining technologies, the development of the Novaky power plant, and the government's commitments to national economic interests through securing the energy supply or state aid. Of course, of these factors must be considered in the context of international obligations, such as those related to climate and environment, particularly air protection.

The three most important Slovak brown coal deposits are located in the Upper Nitra Basin. This territory includes areas in the 5th and 4th degrees of environmental quality, signifying a disturbed and very disturbed environment. Since coal is expected to remain the dominant fuel for electricity generation around the world, and in particular for many of the countries of Central and Eastern Europe, it is necessary to create conditions for the environmental sustainability of coal mining in the coming years within the context of international obligations. Both the security and the stability of the electricity network in Slovakia and maintaining employment levels in the Upper Nitra region play important roles in this discussion.

Underground coal gasification (UCG) is a new mining technology and a technology for gas recovery *in situ*.

A comprehensive evaluation of the impacts of underground coal gasification was carried out in addition to summarization of the expected impacts in terms of the significance and distribution of the time period.

Based on a comprehensive assessment of the proposed action, it can be stated that it could bring a socially unacceptable risk to the area, specifically the significant impairment of health or the environment (groundwater and nearby hot springs in Bojnice). The implementation of operations could affect the population's health, since the partition is placed in close proximity to residential areas.