

The new national energy concept 2015 - The future of brown coal in the Czech Republic

*Milan Mikoláš*¹, *Roman Kozel*², *Šárka Vilamová*³, *David Paus*⁴, *Alexander Király*⁵, *Petr Kolman*⁶,
*Marian Piecha*⁷ and *Martin Mikoláš*⁸

Reserves of brown coal in the Czech Republic are, in the long term view, still recognized as the main domestic fuel and energy resource. The biggest issues, concerning the use of these domestic resources, are, according to the authors, the existence of the "Resolution of the Government of the Czech Republic No. 444" of 30 October, 1991 together with the new State Energy Concept, which was approved in May this year, and which states that the CR will export three out of four key fuels and energy resources, namely oil, gas and nuclear fuel. Brown coal is, therefore, the only domestic energy resource that allows a long-term guarantee leading towards reducing the energy dependence.

Key words: reserves, brown coal, energy concept, source, dependence

Introduction

Brown coal (furthermore referred to as BC) is in the Czech Republic (furthermore only CR) the main domestic fuel and energy resource not only now, but also in the future. This primary energy source (from now on called PES) is mostly used for the production of electricity and heat. In the balance-sheet of the PES, brown coal is clearly a resource with the highest consumption. In the resource mix used for electricity production, brown coal is in the first place, second place is occupied by the nuclear power (furthermore as NE). Moreover, the BC is used for central heat production in the highest share amounting to 45 %, followed by second most used natural gas (from now on as NG) in the amount of 25 % and black coal in the amount of approximately 6 %.

The most important aspects of today's BC market are the large combustion plants within which in particular the large resources (furthermore as LCP), the share of these resources on the total BC consumption is approx. 94 % of the annual production. The fundamental part of the overall needs of BC until the year 2050 is composed by a prognosis of these LCP needs with the total number of 45. The prognosis of consumption of the LCP is based on their durability (greening of all these sources by the end of 2020 if they plan to operate after this period), and on the expected development of the installed thermal and electrical performance, which takes into account their annual usage, anticipated changes in the heat consumption and any changes in the fuel base.

1 The issue of efficient use of brown coal reserves beyond territorial environmental limits

There is a fundamental issue within the area of BC and that is the efficiency of the use of BC reserves beyond the territorial and environmental limits (from now on called the TEL) and the approach to the use of these large reserves of BC. The importance of such a decision consists in the real possibility to fundamentally prolong the life of the most important open-casts of BC in the CR specifically within the ČSA and Bilina open-casts.

The provision of sufficient raw material base for the smooth operation of the energy and the heat generation sector over the horizon of 2050 depends on properly timed prolongation of the life – cycle of two open-casts mentioned above.

It is therefore necessary to pay special attention to the issue of TEL, especially in terms of providing the required raw material base for the operation of power and heat generation projects, ensuring consistent

¹ doc. Ing. Milan Mikoláš, Ph.D., VSB-Technical University of Ostrava, Faculty of Mining and Geology, milan.mikolas@vsb.cz

² Ing. Roman Kozel, Ph.D., VSB-Technical University of Ostrava, Faculty of Mining and Geology, roman.kozel@vsb.cz

³ doc. Ing. Šárka Vilamová, Ph.D., VSB-Technical University of Ostrava, Faculty of Mining and Geology, sarka.vilamova@vsb.cz

⁴ Ing. David Paus, Ph.D., VSB-Technical University of Ostrava, Faculty of Mining and Geology, david.paus@vsb.cz

⁵ JUDr. Alexander Király, Ph.D., VSB-Technical University of Ostrava, Faculty of Mining and Geology, alexander.kiraly1@vsb.cz

⁶ Ing. Petr Kolman, VSB-Technical University of Ostrava, Faculty of Mining and Geology, petr.kolman@vsb.cz

⁷ Ing. Marian Piecha, Ph.D., LL.M., Ministry of Industry and Trade Czech Republic, piecha@mpo.cz

⁸ Ing. Martin Mikoláš, VSB-Technical University of Ostrava, Faculty of Mining and Geology, martin.mikolas.st@vsb.cz

protection of mineral resources against any prevention or encumbrance of their future conquest and maintaining the mining capabilities.

Based on the horrific state of air pollution in the North Bohemian region, particularly in the basin areas, there were significant changes within these areas after the year 1989, not only from the energy perspective but also from the environmental one.

In the period before 1989, the brown coal mines were operating without any technology ensuring its desulphurization, removal of nitrogen oxides and in general, it can be stated that the used technology, which should ensure the removal of solid pollutants (furthermore referred to as SP) from the exhaust gases, was on a very low level. By this fact, the government of that time decided to deal with this situation, which resulted in the attenuation of brown coal mining in the form of three Government Resolutions of The Czech Government (furthermore only GR) from the year 1991, today known as TEL.

It concerns the following three GR:

- GR No. 331/1991 - termination of mining of the Chabarovice brown coal mine,
- GR No. 490/1991 - territorial environmental limits on brown coal mining in the Sokolov brown coal basin,
- GR No. 444/1991 - territorial environmental limits on brown coal mining in the North Bohemian coal basin and energy.

The aforementioned GR aimed at improving the quality of air in the North Bohemian region and should have significantly contributed to as quick improvement of environment situation as possible. GR No. 444/1991 also relies on (mentions) the proposal of limit values of air pollution. Current emission levels are, however, well below the level that was set for 2005. Also, the limits are hardly ever exceeded, today as shown in Table 1.

Tab. 1. Comparison of emission limit values according to GR No. 444/1991 [1].

Parameter [t*km ⁻²]		mining districts				
		Chomutov	Most	Teplice	Ústí n/L	Louny
Specific emissions of SO ₂	The limit value for 2005	42	63,4	25	29	42,1
	The actual emissions for 2003	28	34,7	23,8	14,4	7,7
	The actual emissions for 2012	15,4	54,7	20,2	6,8	0,3
Specific emissions of solid pollutants	The limit value for 2005	12	37	13	10	9
	The actual emissions for 2003	1,4	1,3	1,3	0,6	0,8
	The actual emissions for 2012	1	1,6	0,6	0,3	0,2

Achieving these values was possible thanks to massive investments in energy facilities carried out during the 90s. All sources burning BC and black coal were equipped with the desulphurization technologies and efficient removal of SP.

Air protection is currently being comprehensively addressed in the National Emission Reduction Programme of the Czech Republic and within the regional plans focusing on reducing emissions. All of the above government resolutions can be therefore considered as (prematurely) fulfilled. The limit values of polluting substances, which served as the groundwork for the GR No. 444/1991 were established in a completely different environmental situation back in the 90s and the values are very different from today's values. From the perspective of air quality, the current situation in the North-Western Bohemia, particularly in the basin, is completely different.

2 State Energy Concept and Raw Material Policy

State Energy Concept (from now on SEC) is a fundamental part of the Czech Economic Policy. It serves as a means of state responsibility, which creates conditions for reliable and long-lasting energy supplies at affordable prices as well as a situation favorable to their efficient use. Furthermore, it takes the environment into account, but also respects the principles of sustainable development. The state fulfills its legal liability by setting the legislative framework and policies for operation and development of the energy sector.

SEC in its vision specifies the state's priorities and determines the objectives that the state aims to achieve when influencing the development of energy sector in the perspective of the next 30 years in terms of market-oriented economy.

Implementation of the priorities and objectives of the SEC will be evaluated by the Ministry of Industry and Trade (MIT CR) at three-year intervals. The Ministry will inform the government about the results of this implementation, and if needed, it will present proposals for changing the SEC.

2.1 State Energy Concept from 2004

The SEC, approved in 2004 and based on GR CR No. 211 from 10 March 2004, as an integrated energy document, which was grounded on elaborated analyzes and in an optimal way balanced the energy needs and possibilities of our country until the year 2030. This SEC is not valid from 18 May 2015.

The SEC is the energy future of the Czech Republic based on a balanced share of nuclear and coal energy and renewable energy sources, thus supporting the independence of our country's primary energy imports from politically unstable regions. Until recently, the valid SEC has consisted of the following three core priorities:

- ultimate energy independence,
 - security of supplies,
 - sustainable development,
- and that is fully in accordance with the intentions of the developed countries.

According to this SEC, the state counted with the use of the brown coal reserves for electricity and heat energy production. Although, in compliance with the "Adjusted Green scenario" in the SEC approved by the government, it is presumed that the share of using coal for the electricity production will be at approx. 37 % by the year 2030 (i.e. decrease by 26 % compared to almost 63 % share in 2004).

The import dependency ratio of the Czech Republic in 2004 was around 32 % (for energy consumption). Dependence on imports of oil, gas and nuclear fuel is virtually 100 %.

SEC counted with the following limit values for import dependency:

- a maximum of 45 % in 2010,
- a maximum of 50 % in 2020,
- a maximum of 60 % in 2030.

The SEC had already placed emphasis on decreasing the pace of dependency on energy import by taking measures, namely in the areas of energy efficiency growth, promotion of RES and increase and greater availability and prolonging the life of the indigenous solid fuels, primarily B. In case of developing new efficient coal resources, it is essential to release the resources of BC in the necessary amount for at least another 40 years of operation.

SEC from the year 2004 evaluated the so-called "Green scenario" as follows:

- no primary energy source should be administratively blocked,
- the scenario provides to subjects in energy sector the widest offer of energy resources,
- the scenario is the way that counts with the lowest energy import and the lowest impacts on employment reduction,
- out of all the scenarios, it gives the best insight beyond 2030 as the increased availability of BC resources can supply a new generation of coal-fired power plants, which will replace existing coal power plants after 2010,
- the scenario shows the best resistance to fluctuations in world prices with favorable impacts on electricity and heat prices from large plants since the domestic mining of BC has the most transparent costs,
- this scenario follows the historical traditions of the CR,
- the scenario was the most frequently recommended alternative in the public debate on the SEC proposal.

The input presumptions and the need to reduce administrative and other limitations on the development of energy sources were the crucial elements for the "Green scenario". "Green scenario" was included in the set of six scenarios presented for public discussion by the MIT in June 2003. SEC is evaluated by the MIT CR and presented to the government of the Czech Republic for approval or further adjustments. Time to evaluate this SEC (still valid) is three years.

The needs of our country in the field of primary energy sources (PES) with forecasts up to 2030 are shown in Table 2 based on the recently valid SEC.

Tab. 2. The share of individual PES according to SEC 2004 - Green scenario [2].

PES		2000	2005	2010	2015	2020	2025	2030
Black coal	PJ	265	229	212	210	227	209	174
Brown coal	PJ	612	507	509	480	434	389	374
Natural gas	PJ	316	373	359	353	366	366	370
Oil and oil products	PJ	311	273	276	256	232	221	213
Atomic fuel	PJ	148	286	286	286	286	330	375
Electricity (balance)	PJ	-36	-40	-35	1	18	18	1
Other Fuels	PJ	11	8	9	9	8	7	7
RES and secondary sources	PJ	44	93	159	187	215	269	283
PES total	PJ	1 671,0	1 729,0	1 775,0	1 782,0	1 786,0	1 809,0	1 797,0

2.2 Raw Material Policy of the Czech Republic

Raw material policy in the field of raw materials and their resources is formed by the Czech government in three main frameworks: political, legislative and administrative in order to create reliable, affordable and long-term sustainable supply of raw materials. The raw material policy is in terms of the Competence law strategic document stating the aims of the state in the area of raw materials in line with the needs of economic and social development, including environmental protection. [3]

The raw material policy also addresses the prospect of using domestic raw materials. Therefore, the main objective of every state must be to ensure the raw materials input and thus the functioning of its economy. The basic method how to achieve such goal is the economical use of its own raw material potential. That is why it is advisable, regarding raw material and energy security, in those cases, when possible; to use the raw material potential of the CR. In the case of BC, it is beyond doubt.

Raw material policy intends to use the reserves of BC exceeding the given limit values after the year 2035. At this point, the authors are in conflict with the perception of the MIT CR. MIT CR states with regard to the raw material policy that it is necessary to use the sources of BC exceeding the TEL under the following conditions:

- Preferential use of BC resources up to the TEL for heating industry,
- Closing the operation of unproductive BC resources,
- Construction of new nuclear power plants,
- Utilization of waste heat in the operation of nuclear power plants for heating of agglomerations,
- Incineration of municipal solid waste,
- Greening of BC resources,
- Support of renewable energy sources. [3]

2.3 State Energy Concept in 2015

After very long negotiations, the new SEC was approved by the Czech government on 18 May 2015.

Without a doubt, it was necessary to update the SEC from 2004; nevertheless, the authors are in conflict with the standpoint of the MIT CR. The Ministry brought in a plan, which should significantly reduce the proportion of BC in the area of PES for electric power and heat production, and basically aims at its complete clearance from the PES market around the year 2040.

2.4 Optimized Scenario According to Processors

MIT CR as a Processor prefers the Optimized Scenario. The actual scenario leads to sustainable energy, which is based on an economically efficient utilization of domestic and quasi-domestic energy sources, strengthening energy security of the country. At the same time, this scenario assumes, placing emphasis on domestic sources, development of resources with a high share of domestic supplies and with operational costs concentrated mainly in the Czech Republic, and therefore with relatively limited impact on the trade balance.

Development of nuclear energy will have a positive impact not only on production independence, but also on sustainability and development of technical know-how in the field of nuclear research and suppliers, which will allow engaging Czech power engineering in international supply chains.

The share of individual PES until 2045 according to this scenario is shown in Table 3. At the moment, the MIT CR is considering this scenario as the only possible one.

The authors, on the other hand, feel strongly about the Safe and sufficient Scenario out of all the other possible scenarios. This Scenario supports the mining of BC beyond the TEL at CSA and Bilina open-casts.

Tab. 3. The share of individual PES according to the Optimized Scenario SEC 5/2015 [4].

PEZ		2010	2015	2020	2025	2030	2035	2040	2045
Black coal	PJ	194,3	184,6	164,2	163,2	143,9	143	136,3	130,5
Brown coal	PJ	564,3	505,2	448,8	330,2	307,4	253,5	150	150
Natural gas	PJ	336,1	338,9	344,5	348,6	357,9	361,4	381,2	380,9
Oil and oil products	PJ	378,4	385,8	374,2	366,8	348,7	326,2	301,5	296,3
Atomic fuel	PJ	305,4	343,6	343,6	343,6	343,6	449,2	471,3	471,3
Electricity (balance)	PJ	-53,8	-80,1	-58,9	-22,3	-11,9	-29,9	-13,3	-10,3
Other Fuels	PJ	10,5	12,9	13,8	17,2	19,5	19,5	19,5	19,5
RES and secondary sources	PJ	119,1	161,4	195,6	223,9	247,5	273,7	299,8	302,2
PES total	PJ	1 854,30	1 852,30	1 825,70	1 771,10	1 756,50	1 796,60	1 746,40	1740,4

Note. Other fuels: drained gas, industrial waste and alternative fuels, municipal solid waste (not restored).

2.5 Demands of heat according to SEC 2004 compared in accordance with SEC 5/2015

As already mentioned, MIT CR is in the favor of the Optimized scenario. The following graph shows the differences in the heat of BC in the current and valid Green Scenario under the SEC 2004 and the new SEC 5/2005 – the Optimized Scenario.

From this comparison, it is apparent that the state is planning to stop the use of reserves of BC in the CR within the PES after the year 2030. The state is not clearly stating how shall this deficit be replaced nor when it is going to be replaced – when and who is going to pay for it.

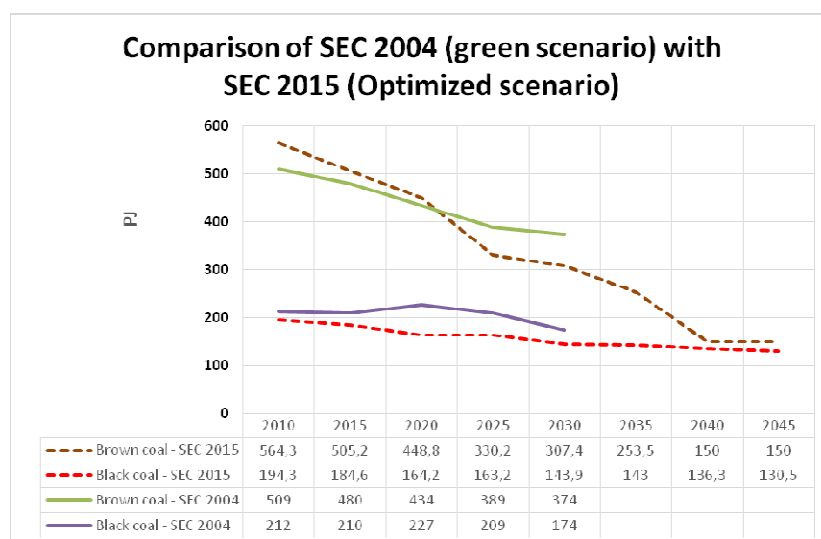


Fig. 1. Comparison of heat demand for PES – BC – old and new SEC

3 Current point of view of MIT CR regarding the territorial environmental limits

It is a matter of fact that the newly approved SEC does not efficiently deal with the use of BC exceeding the TEL. Currently, there is the newly approved SEC, but the secondary documents have not yet been solved.

By secondary documents, the authors mean the following: Mining Act, the National Action Plan for the Development of Nuclear Energy, GR No. 444/1991 Coll., and still not updated Raw Material Policy.

The MIT CR did not make it clear, while approving the new SEC, whether the resources beyond the TEL will be used or not. Czech government wants first to decide on further extraction and only later on the concept that opens the way for the construction of nuclear power plants. "Any breach of limits is just a first step in a long journey that would one day lead to exploitation," said the Minister of Industry and Trade Jan Mládek earlier this year. His vision was that the ASEC 2015 will be approved as a general document carrying the reference that he would like to build the energetics on nuclear energy as well as on the available resources of BC.

According to MIT CR, there might be altogether four options in the field of TEL issue. Firstly, the TEL will be kept in its current state. Secondly, the TEL will be exceeded to the fullest extent, including the demolition of Horní Jiřetín and Černice villages. The Ministry wants to avoid proposing these two options, and they would like to propose only the third and fourth option. It appears that the government is only

considering exceeding the TEL in the Bilina open-cast or exceeding the TEL in the Bilina open-cast and partial exceeding the TEL at the CSA open-cast so that both villages will be preserved. The Minister of MIT CR is for the second option considered by the government, i.e. exceeding the TEL of the Bilina open-cast and partially at CSA open-cast.

We, on the other hand, highly recommend extracting the BC resources beyond the TEL at both localities to the full, particularly to ensure the fuel for power and heat generation for another at least 40 years. This recommendation is issued due to very high investments of large combustion plants, who (all) applied for the National Transitional Plan to reduce emissions and should, therefore, have sufficient quantities of fuel. And on the other hand, because the Bilina open-cast cannot cover the demand for thermal coal alone in the future due to supplying the new Ledvice power plant.

Last but not least, the attitude of the state towards (not) building the nuclear piles in Dukovany nuclear power plant (from now on as NPPD) and Temelín nuclear power plant (from now on as NPPT). Nevertheless, there are three available options. The first one is finishing the construction of nuclear reactors by CEZ Inc. at their own risk. The second option presumes that CEZ Inc. will set up a subsidiary, which a supplier of technology, as well as capital, could enter. The third option is the possibility of a guaranteed completion of the power plant by the state.

Because the state has still not given its clear opinion regarding the construction of new nuclear resources, the authors of the article do not assume that there would be an agreement, which would lead to a construction of new non-coal source, within the next 10-15 years.

3.1 Active brown-coal sites in the Czech Republic

The mining company Severočeské doly a.s. (from now on referred to as SD as) owns two brown coal mines, namely Libouš and Bílina.

Libouš open-cast

In 2014, the extraction of this open-cast amounted to 12.12 million tons of BC. Reserves of BC up until January 1st, 2015 leveled up to 211.07 million tons with a calorific value of about 11 MJ / kg. The open-cast supplied the following power plants: Tušimice II, Pruněřov I, Pruněřov II, Mělník II, Mělník III and heating plant United Energy. 11.281 million tons of BC were delivered to the CEZ, a.s. power plants in 2014, i.e. 93 % of the total open-cast extraction. The share of this brown coal open-cast on the total BC delivery to power plants owned by CEZ, a.s. was 54 % in the same year.

According to model extractions, the presumed termination of mining at this open-cast is around the year 2032.

Bílina open-cast

In 2014, the extraction of this open-cast amounted to 9.6 million tons of BC. Reserves of BC up until January 1st, 2015 within the TEL reached million tons with a calorific value of about 14.5 MJ / kg. In 2014, the open-cast supplied the following power plants: Hodonín, Ledvice, Mělník I, Mělník III, Poříčí, and heating plants Dvůr Králové and Trmice. 3.374 million tons of BC were delivered to the CEZ, a.s. power plants in 2014, i.e. 35 % of the overall production. The rest, i.e. 65 %, was delivered to the heating plants and among small consumers. The proportion of the brown coal mine in the total deliveries of BC to power plants to CEZ, a.s. power plants was approx. 16 % in the year 2014.

The future of this open-cast is influenced by the existence of the current TEL. Beyond the TEL limits, there is another 104 million tons of extractable coal reserves that are mineable by longwall fronts of the open-cast. In the case that TEL are exceeded, the actual mining would not affect the neighboring settlements.

According to calculations of model extractions, and in the case that the TEL will not be exceeded, the operating life of this open-cast could be around the year 2030.

Reserves of this open-cast in the case the TEL will be breached amount to 238.25 million tons of brown coal. Presumption of mining termination at this open-cast is then around 2050 according to the model extractions.

Overall mining of SD a.s. in 2014 was 21.72 million tons of BC out of which CEZ, a.s. power plants were supplied with altogether 14.665 million tons of BC, i.e. 67.4 % of the mines' total extractions. The proportion of other customers (heating plants, small clients) on the total extraction of SD, a.s. was 32.6 %, which equals to 7.055 million tons of BC.

Locations of Vršanská uhelná, a.s.

Vršany and Jan Šverma open-casts

The mining company Vršanská uhelná, a.s. (furthermore referred to as VU, a.s.) owns Vršany – Šverma open-cast. The mining at this open-cast in the year 2014 amounted to 6.47 million tons of BC. Reserves of BC up until January 1st, 2015 are at 272.97 million tons with a calorific value of about 10.8 MJ/kg. In the year 2014, the open-cast supplied Počerady, Mělník I, Mělník II power plants. In the same year, 4.79 million tons of BC were supplied to CEZ, a.s. power plants, i.e. 74 % out of the total production of this open-cast.

The rest amounting to 1.68 million tons, i.e. 26 %, was supplied to heating plant and a coal preparation plant in Komořany (from now on ÚUK) which is owned by the company Severní energetická, a.s. (from now on Sev.en).

The share of this brown coal open-cast on the total supply of brown coal for power plants of CEZ, a.s. was 23 % in 2014.

Presumption of mining termination at this open-cast is around 2056 according to the model extractions.

Localities of Severní energetická, a.s.

The company Sev.en owns the CSA and ÚUK open-casts. The mining at this open-cast in the year 2014 amounted to 3.32 million tons of BC. Reserves of BC up until January 1st, 2015 were at 17.67 million tons with a calorific value of about 17.5 MJ/kg. TEL apply to this open-cast. In 2014, this open-cast supplied fuel to power plants Chvalčovice, Poříčí, Unipetrol and heating plants Otrokovice, Strakonice, Mondi Štětí and steelmaking company Třinecké železářny – Moravia Steel.

The future of this open-cast is affected by the existence of the current TEL. Beyond these limits, there are another 287 million tons of extractable BC reserves at the II. phase of the mine's development. In the case that limits will be exceeded, the mining will affect the neighboring settlements, in particular the town of Horní Jiřetín and Černice settlement.

Presumption of mining termination at this open-cast is around 2021 in the case that TEL are not exceeded. If they were exceeded, the mining could continue beyond the horizon of 2100.

Localities of Sokolovská uhelná, a.s.

The mining company Sokolovská uhelná, a.s. (from now on referred to as SU, a.s.) is the owner of Jiří-Družba open-cast. The mining at this open-cast in the year 2014 amounted to 6.16 million tons of BC. Reserves of BC up until January 1st, 2015 leveled up to 99.73 million tons with the caloric value of about 12.5 MJ/kg. In 2014, this open-cast supplied fuel amounting approximately half of its production to its own power plants: thermal and combined cycle plants. The rest was supplied to external customer's market.

The company, with its output of 620 MW, is one of the largest producers of electricity in the Czech Republic. Additionally, it supplies the neighboring industrial and urban agglomeration, including Karlovy Vary with heat at about 1,900 TJ per year.

Presumption of mining termination at this open-cast is around 2040 according to the model extractions.

4 Differences between the heat required under SEC 5/2015 and possibilities of open-casts according to a variability of possible yearly extractions

The following three alternatives of mining models compare their possibilities in the field of heat with the possibilities required by SEC 5/2015 in the "favored" Optimized Scenario, respectively in the Scenario, which is safe and self-sufficient.

In other words, we have all the active BC localities within the CR with every mining scenario, where we know their average calorific value on the one hand and the annual mining plan on the other hand. These values show the calculated subsequent final heat at each location. After counting all the heat, we have the amount of heat from all the localities that we then compare to heat in accordance with the new SEC 2015.

The amount of heat, which the market with BC lacks according to individual model mining productions, is shown in the following Tables 4, 5, 6 and Graphs 2, 3, 4.

4.1 Heat with mining production under the TEL

This alternative presents the same finding as in the case of differences in mining production and needs of BC during its mining to the limit of TEL.

The still valid Raw Material Policy from 2012 states that it is wise to expect a lack of BC on the market around the year 2035. We can confirm this statement.

Tab. 4. Comparison of heat according to SEC 5/2015 with mining under the TEL [PJ].

Open-cast	Calorific value Q_i^f	2015	2020	2025	2030	2035	2040	2045
Libouš	11MJ*kg ⁻¹	14,5	12	11	10			
	heat [PJ]	159,5	132	121	110	0	0	0
Bílina	14,5MJ*kg ⁻¹	9,5	9,5	8	5,25			
	heat [PJ]	137,75	137,75	116	76,125	0	0	0
ČSA Let	17,5MJ*kg ⁻¹	3	2,5					
	heat [PJ]	52,5	43,75	0	0	0	0	0
Vršany	10,8MJ*kg ⁻¹	6,5	6,1	6,1	6,6	6,6	6,6	6,6
	heat [PJ]	70,2	65,88	65,88	71,28	71,28	71,28	71,28
Centrum	15MJ*kg ⁻¹	0,4						
	heat [PJ]	6	0	0	0	0	0	0
Jiří	12,5MJ*kg ⁻¹	7,5	5					
	heat [PJ]	93,75	62,5	0	0	0	0	0
Družba	12,5MJ*kg ⁻¹	0,5		4	4			
	heat [PJ]	6,25	0	50	50	0	0	0
total mining		41,9	35,1	29,1	25,85	6,6	6,6	6,6
total heat		525,95	441,88	352,88	307,405	71,28	71,28	71,28

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	352,88	307,405	71,28	71,28	71,28
heat according to the Optim.Scenario	505,2	448,8	330,2	307,4	253,5	150	not stated
difference	20,75	-6,92	22,68	0,005	-182,22	-78,72	

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	352,88	307,405	71,28	71,28	71,28
heat according to the Safe Scenario	505,2	461,2	339,2	310,9	255,6	160,2	160,2
difference	20,75	-19,32	13,68	-3,495	-184,32	-88,92	-88,92

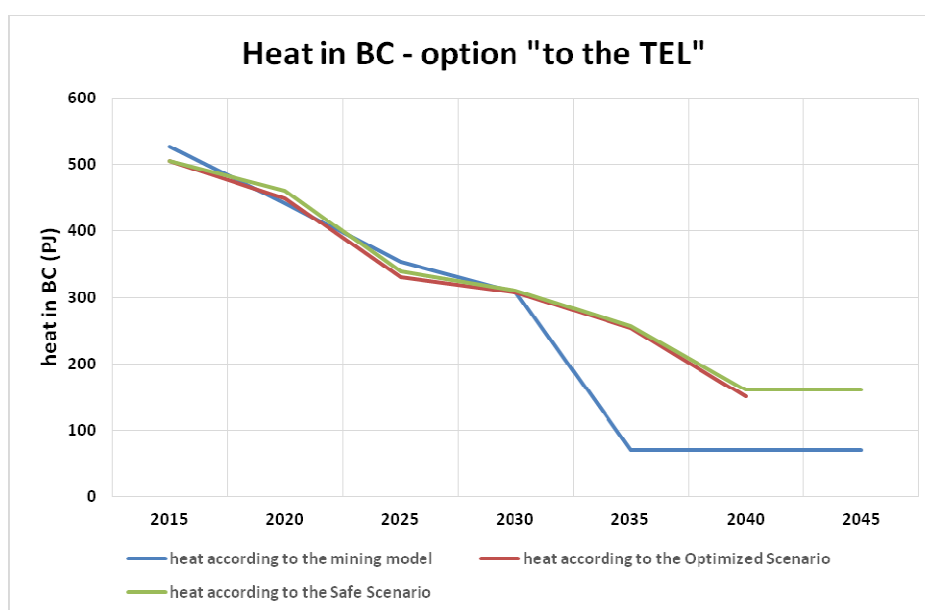


Fig. 2. Possibilities of heat with mining to the limits of TEL in comparison with SEC 5/2015 [PJ].

4.2 Heat with mining production of Bilina open-cast exceeding the TEL

Based on the following Table 5, it is evident that the situation will turn for the better around the already mentioned year 2030 thanks to Bilina outcast mining production development. Nevertheless, not even this case of model mining production can cover the total demand for BC within the market, for more information see Chapter 5.

Tab. 5. Comparison of heat according to SEC 5/2015 with mining production beyond the limits of TEL at the Bílina outcast [PJ].

Open-cast	Calorific value Q_i^F	2015	2020	2025	2030	2035	2040	2045
Libouš	11MJ*kg ⁻¹	14,5	12	11	10			
	heat [PJ]	159,5	132	121	110	0	0	0
Bílina	14,5MJ*kg ⁻¹	9,5	9,5	8	7	6	6	6
	heat [PJ]	137,75	137,75	116	101,5	87	87	87
ČSA Let	17,5MJ*kg ⁻¹	3	2,5					
	heat [PJ]	52,5	43,75	0	0	0	0	0
Vršany	10,8MJ*kg ⁻¹	6,5	6,1	6,1	6,6	6,6	6,6	6,6
	heat [PJ]	70,2	65,88	65,88	71,28	71,28	71,28	71,28
Centrum	15MJ*kg ⁻¹	0,4						
	heat [PJ]	6	0	0	0	0	0	0
Jiří	12,5MJ*kg ⁻¹	7,5	5					
	heat [PJ]	93,75	62,5	0	0	0	0	0
Družba	12,5MJ*kg ⁻¹	0,5		4	4			
	heat [PJ]	6,25	0	50	50	0	0	0
total mining		41,9	35,1	29,1	27,6	12,6	12,6	12,6
total heat		525,95	441,88	352,88	332,78	158,28	158,28	158,28

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	352,88	332,78	158,28	158,28	158,28
heat according to the Optim.Scenario	505,2	448,8	330,2	307,4	253,5	150	not stated
difference	20,75	-6,92	22,68	25,38	-95,22	8,28	

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	352,88	332,78	158,28	158,28	158,28
heat according to the Safe Scenario	505,2	461,2	339,2	310,9	255,6	160,2	160,2
difference	20,75	-19,32	13,68	21,88	-97,32	-1,92	-1,92

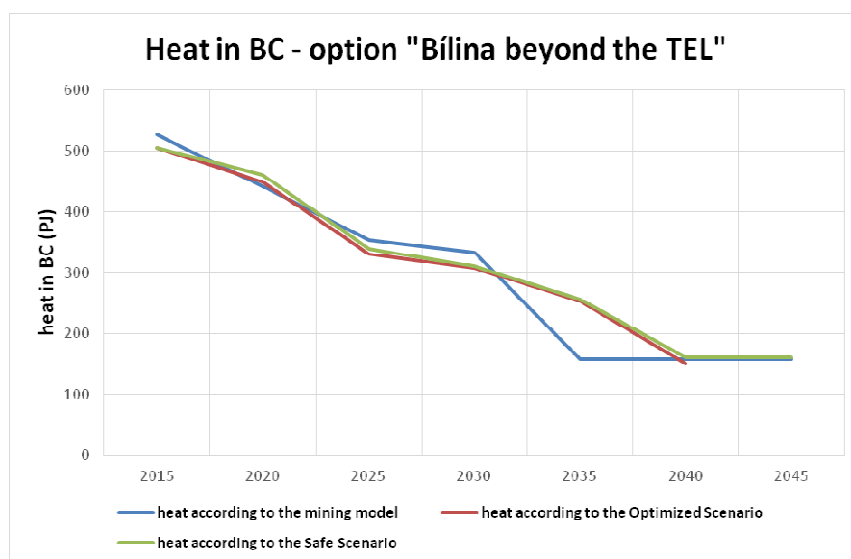


Fig. 3. Possibilities of heat at Bilina open-cast mining production beyond the TEL in comparison with SEC 5/2015 [PJ].

4.3 Heat with mining production of Bilina and CSA open-casts beyond the TEL

The most noticeable difference between the presented alternatives and confirmation that it is necessary to mine at both open-casts is shown in Table 6. There is a lack of coal on the market only in the second phase of CSA open-cast opening and then in the year 2035. However, this alternative is the only possible one from the author's perspective.

According to the extractions model showing mining beyond the TEL on both localities, heat is considered as heat for the BC area in the new SEC.

Tab. 6. Comparison of heat needed according to SEC 5/2015 with the mining production beyond the TEL on both open-casts - Bilina and ČSA [PJ]

Open-cast	Calorific value Q_f	2015	2020	2025	2030	2035	2040	2045
Libouš	11MJ*kg ⁻¹	14,5	12	11	10			
	teplo [PJ]	159,5	132	121	110	0	0	0
Bilina	14,5MJ*kg ⁻¹	9,5	9,5	8	7	6	6	6
	teplo [PJ]	137,75	137,75	116	101,5	87	87	87
ČSA Let	17,5MJ*kg ⁻¹	3	2,5	5	5	5	5	5
	teplo [PJ]	52,5	43,75	87,5	87,5	87,5	87,5	87,5
Vršany	10,8MJ*kg ⁻¹	6,5	6,1	6,1	6,6	6,6	6,6	6,6
	teplo [PJ]	70,2	65,88	65,88	71,28	71,28	71,28	71,28
Centrum	15MJ*kg ⁻¹	0,4						
	teplo [PJ]	6	0	0	0	0	0	0
Jiří	12,5MJ*kg ⁻¹	7,5	5					
	teplo [PJ]	93,75	62,5	0	0	0	0	0
Družba	12,5MJ*kg ⁻¹	0,5		4	4			
	teplo [PJ]	6,25	0	50	50	4	0	0
total mining		41,9	35,1	34,1	32,6	17,6	17,6	17,6
total heat		525,95	441,88	440,38	420,28	249,78	245,78	245,78

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	440,38	420,28	249,78	245,78	245,78
heat according to the Optim.Scenario	505,2	448,8	330,2	307,4	253,5	150	not stated
difference	20,75	-6,92	110,18	112,88	-3,72	95,78	

	2015	2020	2025	2030	2035	2040	2045
heat according to the mining model	525,95	441,88	440,38	420,28	249,78	245,78	245,78
heat according to the Safe Scenario	505,2	461,2	339,2	310,9	255,6	160,2	160,2
difference	20,75	-19,32	101,18	109,38	-5,82	85,58	85,58

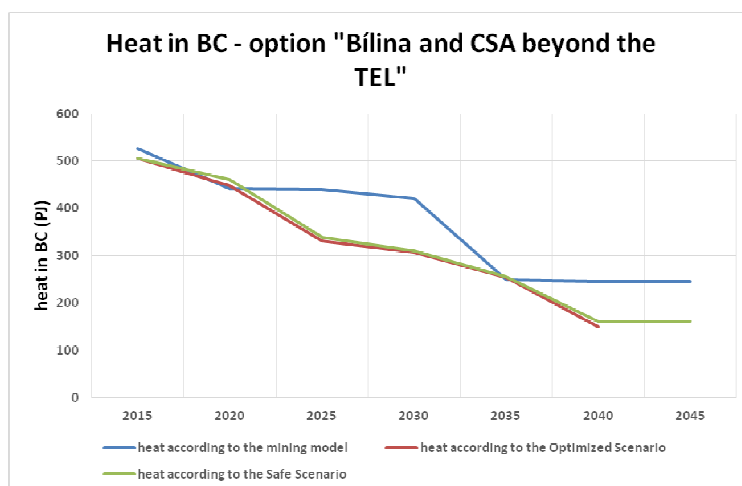


Fig. 4. Possibilities of heat with mining production of CSA and Bilina open-casts beyond the TEL in comparison with SEC 5/2015 [PJ].

It can be therefore stated that the demands of MIT CR in the area of PES for BC with the outcast until the year 2040 can be met only if the TEL will be completely exceeded. In other cases, this requirement cannot be fulfilled at all. [5]

5 Resources of BC beyond the TEL at Bilina open-cast and a new energy source

We assume that the TEL will be at least exceeded at the Bilina open-cast (which does not mean that there will be immediate mining production in this area) – this conclusion was drawn on the basis of clear political agreement. This open-cast does not have any problem with consisting in the demolition of villages as it is with the CSA open-cast. Another advantage of this open-cast is that its majority owner (SD, Inc.) “falls under” the CEZ, Inc.

The authors modeled the life of this open-cast until the year 2046 according to relevant annual extractions. If the resources, which are about 238.25 million tons of BC, are taken into account, and the consumption of new resource in Ledvice is deducted together with the consumption of its biggest consumers, according to their limiting lifetime (which also depends on greening the resources), we will come to a clear conclusion: it is not possible to satisfy the demand of the customers without exceeding the TEL at the CSA open-cast, see Table 7.

For other customers, including retail sale (graded coal), there are only 12 million tons of BC until its life is finished, i.e. until the year 2046!!! In practice, this scenario is absurd, and we are therefore highly recommending to begin mining production beyond the TEL also at the CSA open-cast – i.e. to ensure a full breach of TEL.

We expect a huge problem in existing or future agreements regarding the mining of BC. CEZ, Inc., which owns the SD Company, will primarily want to supply its own heat and power plants. Therefore, it is possible that some customers will not be able to get the same amount of BC as they were used to, or they will not get any BC at all.

Tab. 7. Prospective possibilities of black BC resources at the Bilina outcast with mining production beyond the TEL [mil. tons].

Reserves of BC Bilina open-cast exceeding the TEL [mil. tons]		238,25
ČEZ - ELEDVICE	NB 660MW + 110MW	76,8
	NB 660 MW	52
	Total consumption [mil. tons]	128,8
Total remaining for large production [mil. tons]		109,45
	ČEZ - EHODONÍN	3,9
	ČEZ - EMĚLNÍK 2	16
	ČEZ - EMĚLNÍK 3	54
	ČEZ - EPOŘÍČÍ	9,3
	Energy Ústí	1,95
	ČEZ - Teplárna D. Králové	0,02
	ČEZ - Tmice	12,5
Consumption of large plants[mil. tons]		97,67
Total remaining on the market for others [mil. tons]		11,78

6 Economics and Public need for BC beyond the TEL

The need for brown coal in the national economy beyond the binding limits is certainly a cogent argument for the Czech government to use the resources of BC beyond the set limits as a declaration of public interest.

To be able to declare the public interest and, therefore, allow the process is a responsible act that needs confidence not only on a professional level but above all at a political level.

To support these claims, we provide the following:

- There is approx. 850 million tons of BC being blocked by the TEL (Bilina and CSA open-casts),
- Out of which approx. 104 million tons of BC at Bilina open-cast (heat equivalent of 1.508 PJ),
- At CSA open-cast, there is approx. 287 million tons of BC in the II. phase of open-cast development (heat equivalent of 5022.5 PJ)
- CSA open-cast has resources of BC amounting to 470 million tons at its III. and IV. phase of development (heat equivalent of 7050 PJ),

- Continuation of mining at these mines would prolong their life to the period around the year 2050 in the case of Bílina open-cast. In the case of CSA open-cast, the development in its II. phase is ensured at least until 2080, while its III., IV. stage extends the life far beyond the horizon of the year 2100,
- Thanks to mining production at these open-casts, fuel and energy balance and energy security of the state in the production of electricity and heat is ensured at least until the year 2050,
- Heat and power plants that have contracts with miners on supplies of BC depend on the demand for BC. Whether these contracts will be renewed or at which level, depends on the possibilities of BC extraction in each of the localities,
- Unless the Czech government takes a strong stand on the matter of breaching the TEL, there will be a catastrophic consequences in the matter of BC shares within the PES,
- The state has not secured a substitute for the lack of BC for heat and power plants,
- The state has not secured a new energy source for heat and power plants, burning BC,
- The state hesitates whether or not to finish building new nuclear piles and natural gas power stations, while there is no other possibility than breaching the TEL if the state does not want to increase its energy dependence on imports of PES.

Brown coal mining is only possible beyond the TEL and only if the state declares the mining as a public interest in order to ensure its energy security and self-sufficiency. Furthermore, it is essential for the Czech government to issue a clear statement regarding the land expropriation based on the declared public interest, in order to eliminate speculative attitudes of individuals leading towards restrictions or complete blockage of extraction of these BC resources for our future generations.

It is hard to understand why, in the times when all branches of the national economy, such as construction, engineering, metallurgy are supported for the sake of development, the expansion of mining production is held back not only bureaucratically, but also politically and it can be stated that this area is compared to other industry sectors being discriminated against. This state of things seems anomalous as even in a historical context mining was rated among the most important activities as it has always brought extraordinary values for our society.

We believe that suppressing or practically abandoning an important area of coal mining in the Czech Republic, in the current situation when the danger of political or energy crisis is everyday bread and the threat of unemployment hangs over everyone, cannot be considered wise.

7 Conclusion

Economic efficiency in the use of BC reserves, which exceed the TEL in SHP, prevails not even when compared to the economy of mining within the existing UEL, but especially when compared to the economy of their mining production, including the transportation to place of consumption, with the cost needed for importing the primary energy sources for production of electricity or heat to the CR. Brown coal is competitive even in the comparison with imported refined fuels.

Since the 90's, all of the old, energy consuming technological equipment has been replaced, and the neighboring buildings have been insulated, which has led to huge energy savings. Currently, a planned greening of all the brown coal resources, which consume approx. 94 % of brown coal on the market has been going on.

Implementation of brown coal mining beyond the existing TEL together with the use of clean coal technologies and renewable energy solutions programs (reasonably, without subsidies from the state and end consumers in terms of prices), including energy savings can provide a stable fuel and energy balance of the Czech Republic until at least the year 2060, if the reserves at Bilina and CSA open-cast (II. phase) will be used. If the resources from the CSA open-cast are also used in the III. and IV. phase, the balance is secured beyond the horizon of the year 2100.

Delaying the phase of "drawing" the rest of the North Bohemian lignite basin may significantly support the implementation of a time-consuming process of restructuring the heavy industry throughout the Northwest Bohemia and bring the solution of its tough social-economic stability, including the potential crisis within the employment field.

Thanks to ongoing mining production, there are enough financial resources to solve damages caused by mining, including the comprehensive revitalization of the landscape affected by mining activities. The continuing extraction of brown coal and its use in modern heat and power plants will provide the Czech Republic with a reliable energy supply in the fields of both energy and heat supply in the long term.

If the resources of brown coal exceeding the TEL are not going to be used, an early and advanced redirection of the area and development of the Czech energy sector to other resources should be done. This would mean enhanced imports of primary energy sources (natural gas, coal and lignite, oil, nuclear) or electricity with all the impacts that would have on the Czech fuel and energy balance, state energy security

and rising unemployment. In this case, one dare to say, that the imports of primary energy sources to the Czech Republic will rise from the current 45 % to 70-75 % around the year 2040.

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List of Abbreviations

CSA open-cast: Czechoslovak army open-cast
CEZ, a.s.: energy company
CR: Czech Republic
BC: brown coal
NE: nuclear energy
NPPD: nuclear power plant Dukovany
NPPT: nuclear power plant Temelín
LCP: Large Combustion Plants
MIT: Ministry of Trade and Industry
PEs: primary energy source
SD, a.s.: Severočeské doly, Inc.
SEC: State energy concept
Sev.en: Severní energetická, Inc.
SO₂: sulfur dioxide
SU, a.s.: Sokolovská uhelná, Inc.
SP: solid pollutants
GR: government resolution
TEL territorial environmental limits of BC mining
ÚUK: Komořany coal preparation plant
VUAS: Vršanská uhelná, Inc.

Resources

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