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Coal industry in Czech Republic

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Abstract. Coal reserved in Czech Republic are estimated to be 10 billion tonnes – bituminous coal about 37%, brown coal about 60% and lignite 3%. Bituminous coal is produced in Northern Moravia – in 2017 production of bituminous coal was 5.5 milion tons. Brown coal is mined in Nord-Wester Bohemia – production of brown coal in 2017 was 38.1 milion tons. Significant quantities of bituminous coal are exported to Slovakia, Austria, Germany and Hungary. In accordance with the National Energy Policy, coal will remain the main source of energy in the country in the future, despite the increased use of nuclear energy and natural gas. The government expects that in 2030 energy from coal will account for 30.5% of energy produced. There are five coal companies in the Czech Republic: OKD, a.s., the only bituminous coal producer and four brown coal mining companies: Severočeské doly a.s., owned by ČEZ, the largest producer of brown coal, Vršanská uhelná a.s., with coal resources until 2055, Severní energetická a.s. with the largest brown coal reserves in the Czech Republic and Sokolovská uhelná a.s., the smallest mining company extracting lignite. OKD operates coal in two mines Důlní závod 1 – (consists of three mines: ČSA Mine, Lazy Mine, Darkov Mine) and Mine Důlní závod 2 (two mines Sever, Jih). The article also presents a pro-ecological solution for the management of waste heaps after coal enrichment - a plant for the enrichment of coal waste from the Heřmanice heap.

1. Coal resources in the Czech Republic

The amount of the geological coal resources, determined by the Czech Geological Survey (Geofond) was estimated at 1519 million tonnes of bituminous coal and 2362 million tonnes of brown coal, of which 181 million tonnes and 871 million tonnes, respectively, were classified as recoverable resources [1,2]. The prospective resources were determined at the level of 6000 million tonnes of bituminous coal and 8820 million tonnes of brown coal [1].

According to the Czech government's energy policy, coal will remain to be the main energy source of the country in the future, despite increasing uses of nuclear energy and natural gas. The government expects that energy generated from coal will reach 30.5% of the total energy produced in 2030 [3,4,5].



2. Coal deposits in the Czech Republic

2.1. Bituminous coal

The largest bituminous coal deposits are situated in the Upper Silesian Coal Basin. The basin is one of the largest in Europe, with the surface area of 6500 km². A larger proportion of that basin is situated within the territory of Poland, with about 1/6 (or 1200 km²) in the Czech Republic. The Czech area of that basin is called the Ostrava-Karviná Coal Basin. [1]. Figure 1 presents the locations of bituminous coal resources [6].

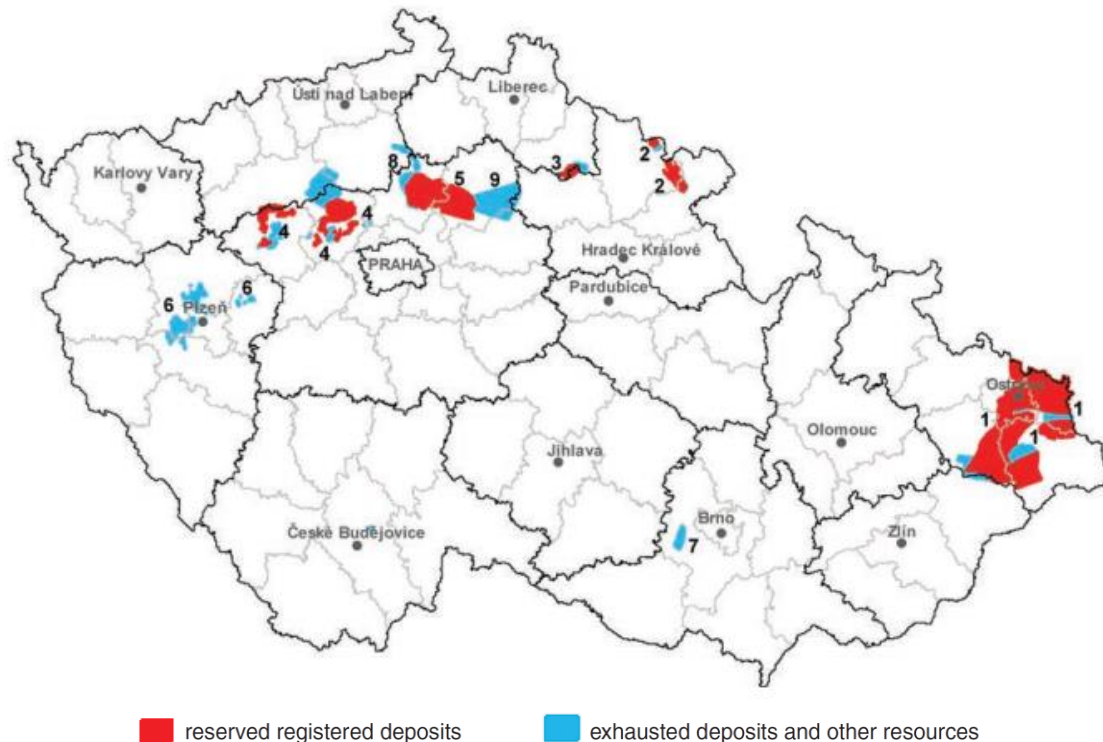


Figure 1. Bituminous coal deposits in Czech [6]: 1. Czech part of the Upper-Silesian Basin, 2. Czech part of the Intra-Sudetic Basin, 3. Krkonoše Mts. Piedmont Basin, 4. Central Bohemian Basins (namely Kladno-Rakovník Basin), 5. Mšeno Part of Mšeno-Roudnice Basin, 6. Plzeň Basin and Radnice Basin, 7. Boskovice Graben, 8. Roudnice Part of Mšeno-Roudnice Basin, 9. Mnichovo Hradiště Basin.

2.2. Brown coal

The Czech Republic has 714 million tonnes of exploitable recoverable brown coal reserves (2016) [6]. In addition to a coal basin in northern Bohemia and another basin near the town of Sokolov, there are coalfields in the south of the country, although they are not economically viable [2]. Production of brown coal totalled 38.6 million tonnes in 2016 [6].

Figures 2 and 3 present the locations of bituminous coal, brown coal, and lignite resources [6].

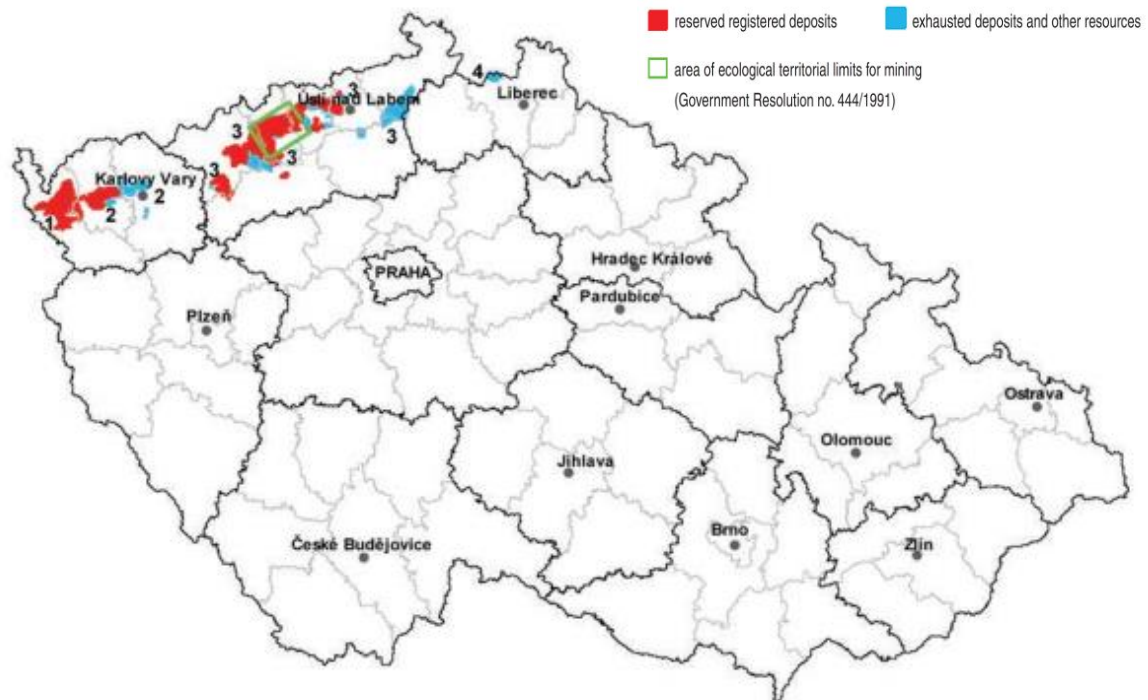


Figure 2. Brown coal deposits in Czech [6]: 1. Cheb Basin, 2. Sokolov Basin, 3. North–Bohemian Basin, 4. Czech part of the Zittau (Žitava) Basin.

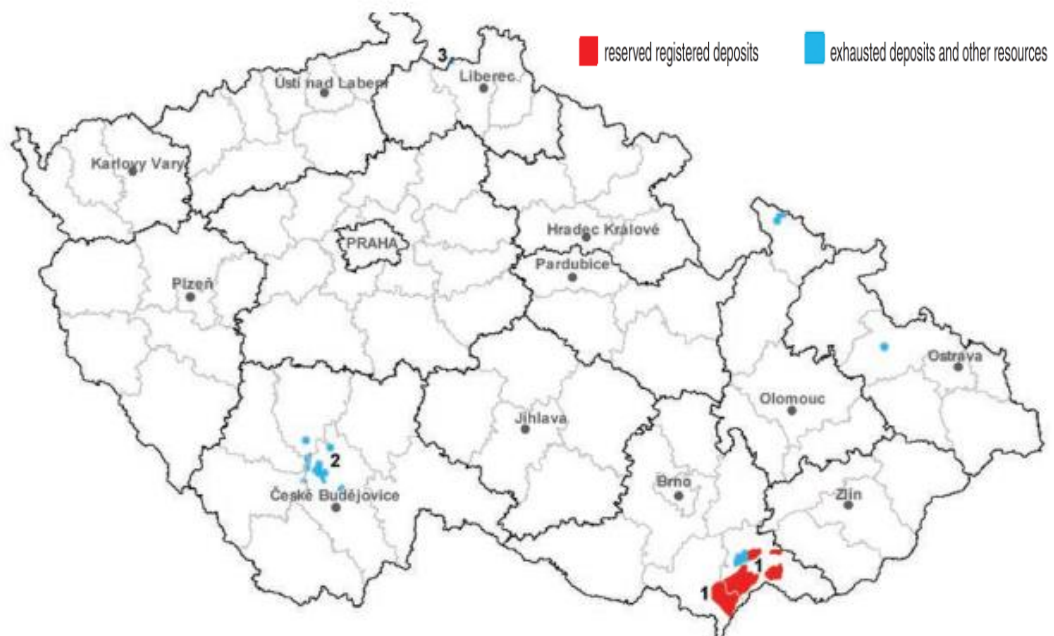


Figure 3. Lignite deposits in Czech [6]: 1. Vienna Basin, 2. Ceské Budejovice Basin, 3. Czech part of the Zittau (Žitava) Basin.

3. The structure of coal industry in the Czech Republic

Five coal mining corporations operate in the Czech Republic. OKD, a.s. is the only bituminous coal producer [7]. The remaining four brown-coal mining companies are the following: Severočeské Doly a.s., the largest brown coal producer [8], Vršanská uhelná a.s., with the resources available until 2055, Severní energetická a.s., with the largest reserves of brown coal in the Czech Republic [9], and Sokolovska uhelná a.s., the smallest coal mine [10]. The state energy enterprise ČEZ is the largest consumer of coal and an essential provider of electricity in the Czech Republic [2].

4. Organisational structure of the bituminous coal industry

Coal is mined in the Czech Republic only by the OKD a.s. (Ostravsko-karvinské doly) company. In 2016, the bituminous coal output reached 6.7 million tonnes [11], in comparison to 5.5 million tonnes in 2017 [5]. Coal is mined in two plants: Důlní závod 1 (ČSA, Lazy, and Darkov minefields) and Důlní závod 2 (Sever and Jih minefields). Coal mining was ended in Závod Útlum-Jih coal mine (Staříč and Chlebovice minefields) on 31.03.2017 [12].

Figure 4 presents the locations of OKD coal mines. Currently, mining is carried out in the active part of the district, with minefields on the area of 133.65 km² [12], totalled 38.6 million tonnes in 2016 [6].

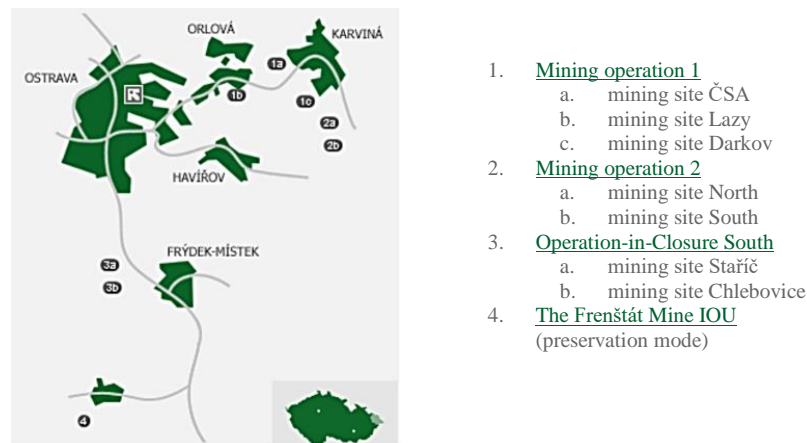


Figure 4. OKD mines location.

The coal layer thickness amounts to 1.5-6.5 m. Mining is conducted by the longwall caving system, with the use of shearer loaders (90.2%) and coal plows (9.8%). Mechanical casing (95.1%) and individual hydraulic casing (4.9%) systems are applied [2]. The OKD company has also been testing the room-and-pillar system as a potential mining method in the Důlní závod 2 coal mine. In each coal mine, coal is agglomerated in processing plants where it is classified as either coking or steam coal, based on specific quality parameters [2]. Coal is agglomerated in the whole grain-size range. Dense-liquid concentrators and dense-medium cyclones are applied as standard agglomeration methods.

5. Brown coal deposits

The Czech Republic has 714 million tonnes of exploitable recoverable brown coal reserves (2016) [6]. In addition to a coal basin in northern Bohemia and another basin near the town of Sokolov, there are coalfields in the south of the country, although they are not economically viable. [2].

6. Mining waste management in bituminous coal mines

Coal extraction has been conducted in the Ostrava-Karviná Coal Basin for about 200 years. Deposition of large quantities of mining waste on heaps in the area of Ostrava is one of the mining consequences. The heaps are subjected to land reclamation processes, with some recovery of energy materials or aggregate production. An example of such waste management projects is found at the Heřmanice storage grounds [13, 14, 15, 16, 17, 18, 19].

6.1. Heřmanice Heap in Ostrava

The Ostrava heap occupies the total surface area of 100 hectares and it is 250 m high. The heap contains about 21 million tonnes of mining waste.

The waste processing plant located on the Ostrava-Heřmanice, constructed in 2016-17, is owned by the Ostravská těžební a.s. company [20]. The purpose of that project was to process the waste generated along the bituminous coal production in the Ostrava area in the previous century. The plant is supposed to remove any negative influences of mining waste on the environment. Processing methods allow for obtaining energy coal mixes and aggregates for the building industry. Complete heap land reclamation will be an additional benefit [13, 14, 15, 16, 17, 18, 19].

Owing to the application of knowledge and experience gained from the construction of similar processing plants in other countries, the Ostrava Plant is distinguished by the use of modern technologies and it can be presented as a model of the process line for the heap land reclamation. The process line was designed in the way allowing for the production of construction aggregates, without organic energy components, with the recovery of energy coal mixes in the same process. The company employs about thirty specialists experienced in waste processing, former miners laid off under a restructuring process conducted in the OKD coal mines [16]. It is worth mentioning that several Polish companies participated in the capital investment there: the Institute of Non-Ferrous Metals of Gliwice delivered a flotation machine and the Progress Eco Company delivered screening units. Figure 5 presents a view of the mining waste processing plant.



Figure 5. Coal waste processing plant [16].

In addition, research work was carried out on this heap, which dealt with the flotation of coal waste from the Heřmanice dump. Trčková (2015) tested samples from this site [15]. The flotation reagents Polyethylene Glycol (Foam) and Gyrol (Waste Oil for polishing Si Plates), PP 90 automotive gear oil, and Mogul 15W-40 engine oil were used for testing. The aim was to verify the possibility of flotation from this raw material [15]. Fox (2014) dealt with flotation of waste from the Heřmanice waste rock, where the flotation agents Montanol 800 and Montanol 551 were tested [22]. The aim of the work was to find out if there was sufficient amount of coal in the waste that could be used [21]. This work was followed by Volrábová (2018), whose aim was to optimize coal flotation from the Heřmanice wasteland. The optimization of coal flotation from the Heřmanice waste rock consisted of testing the best concentration of the Montanol 551 [22].

The bachelor thesis, realized at the Department of Environmental Engineering, characterized refurbishment and reclamation projects on the territory of the city of Ostrava, and it was intended to evaluate the course of remediation and reclamation. This thesis contains the legislative conditions necessary for rehabilitation and reclamation, the reclamation division and the process of remediation and reclamation, resulting in an ecologically balanced landscape that is suitable for human life. It also contains specific remediation and reclamation projects that are processed in the city [23]. The work of Janštová (2018) focuses on the Heřmanice dam and the study of the occurrence of selected pollutants. These are mainly heavy metals such as chromium, copper, nickel and zinc [24].

7. Organisational structure of the brown coal industry

Brown coal is mined in the central part of the Czech Northern Brown Coal Basin by two mining companies: Vršanská uhelná a.s. (VUAS) and Severní energetická a.s. (Sev.en), belonging to the Sev.en corporation [7].

The Sev.en manages the largest brown coal deposit in the country, with the ČSA open-pit mine (Figure 6), holding the reserves estimated at 750 million tonnes of good quality brown coal, with the calorific value of up to 17500 kJ/kg. The reserves are adequate for the continuation of brown coal extraction in the next one hundred years. Mining operations will continue within the present deposit boundaries until 2024. 3.6 million tonnes of brown coal was extracted there in 2015 [25]. The ČSA mining operations were limited by the Government's Resolution on Mining Limits of 1991 (UV No.444/1991), and the validity of the limits was confirmed by the Czech government in October 2015, with a recommendation to revise the decision in 2020 [26].

Besides the ČSA, the Sev.en Group also conducted deep-mine operations in the area of the Centrum Coal Mine (Důl Kohinoor a.s.). However, the business was ended after 128 years of mining on 1.04.2016. That was the last Czech brown-coal deep mine [25]. In 2013, the Sev.en acquired the 800 MW coal-burning Chvaletice Power Plant, which allowed for the establishment of a new integrated Mine and Power Plant organisational structure. After 2015, the Power Plant was upgraded to meet the most rigorous environmental protection requirements. Consequently, its lifetime was extended until 2030 [7].

The Vršanská uhelná a.s. (VUAS), belonging to the Sev.en Energy Group, mines brown coal in the Vršany Coal Mine (Figure 7), located in the central part of the North Bohemian Coal Basin. The local coal resources will allow for the longest period of extraction in the Czech Republic. In 2013, the company signed a fifty-year contract for the delivery of coal to the ČEZ Počeradý Power Plant. That long-term contract assures the future of the Vršany Coal Mine and the economic stability of in the north of the Czech Republic [7]. In 2015 r., VUAS produced 6.7 million tonnes of brown coal, employing 706 workers [27].

The Severočeské doly a.s. (SD) brown coal mine (Figure 8), belonging to the ČEZ a.s. of Chomutov, operates in the north-western part of the Northern Coal Basin and it is located east of the town of Most. SD mines brown coal in two coalfields: Nástup Tušimice and Bílina [28]. The Doly Bílina coal mine produces brown coal with low content of sulphur and delivers it to power plants. The Doly Nástup Tušimice coal mine produces brown steam coal. The SD's annual output amounts to 21 million tonnes and the company is the largest brown coal producer in the Czech Republic [8].

The Nástup Tušimice brown coal minefields are located between the towns of Chomutov and Kadaň, with one large open-pit mine producing 11,8 million tonnes of brown coal annually. After coal preparation in the crushing plant, brown coal is sent mainly to the power plants served by ČEZ [29].

The brown coal minefields of Bílina are extracted by one open-pit mine located between the towns of Bílina and Duchcov. Its annual production amounts to 9.9 million tonnes of brown coal. Coal is transported to the agglomeration plant in Ledvice and next to the Ledvice power plant, other industrial companies, and households. In 2017, the SD Group employed 4868 workers. [29] The company pays considerable attention to mitigation of the consequences of mining activities. In the Bílina coal mine, reclamation operations started on 17 hectares and have been completed on 137 hectares, with 32 and 67 hectares, respectively, in the case of the at the Nástup Tušimice coal mine [29].

The coal deposit located in the west of the Czech Republic and in the western section of the brown coal basin close to the Ore Mountain Range (Krušné hory), near the town of Sokolov, is mined by the Sokolovská uhelná coal mine (SU). The company operates one open-pit coal mine, the Jiří. In 2017, the mine's production amounted to 6.9 million tonnes. The brown coal from the Sokolov area is used mainly for electricity and heat generation, although the chemical side products of coal gasification are also important [10].

The SU company produces electricity and heat in its two plants: the Vřesová IGCC (2×200 MWe) and another heat and power plant (5×270 MWt), whose total annual production amounts to 3.5 TWh and more than 1800 TJ, respectively. The majority of heat is used by the corporation itself, although some quantities are supplied to the towns of Karlovy Vary, Nejdek, Chodov, Nová Role, Nové Sedlo, and Vintířov. The company also conducts operations for the sake of environmental protection, in particular, land reclamation projects on the lands degraded by open-pit mines, as well as and mining waste processing and disposal. The SU companies employed 1301 workers in 2017 [10].



Figure 6. Lom ČSA [30].



Figure 7. Lom Vršany [30].



Figure 8. Severočeské Doly Mine [28].

8. Electricity production and consumption in the Czech Republic

8.1. The Czech Energy Policy

The Czech energy policy is regulated by a number of documents issued by the Czech government:

- 1) The Czech Energy Policy Conception (SEK); amended in 2015 [3];
- 2) The National Action Plan for Smart Grids [31];
- 3) The National Action Plan for Rational Energy Consumption [32];
- 4) The National Nuclear Energy Development Plan [33];

The Czech national energy policy is based on the following assumptions: expansion of the existing nuclear power plants; gradual transition from coal- and gas-burning energy generation to that based on renewable energy sources, maintenance of a stable position of coal in the national energy mix (with the reduction of coal share from 45% in 2015 to less than 20% in the decades to come); combined heat and power generation (CHP), stable delivery of coal and other fuels to central-heating installations; increase of energy effectiveness, savings on each form of energy use; reconstruction and development of infrastructure (relating to electricity, gas etc.), integration of decentralised production systems, operating reliability, and energy transit services [3].

The key issues of the Czech energy policy are the following [3]:

- 1) Diversification of fuel importation (crude oil and natural gas) and expansion of transportation facilities;
- 2) Acceleration and simplification of administrative procedures for project design and permit issuance, in case of modernisation and construction of new facilities for power-generation infrastructure;
- 3) Strengthening of international co-operation on energy markets and development of regional markets, in particular in electricity and natural gas trading.

Primary energy consumption amounted to 58.4 Mtoe in the Czech Republic in 2015. Energy generation figures were the following: 39.2% generated from coal (in total: 22.8 Mtoe of which 6.3 Mtoe from bituminous coal and 16.5 Mtoe from brown coal), 16.0% generated from natural gas (9.3 Mtoe), and 21.1% % from crude oil (12.3 Mtoe). Primary energy was supplemented by nuclear energy, in the proportion of 16.4% (9.5 Mtoe), energy generated by sun, water, and wind, in the total proportion of 1.0% (0.6 Mtoe), with biofuels and waste of 6.4% (3.8 Mtoe). [2]

In 2016, about 50.0% of gross total electricity (83.3 TWh) was generated from coal, 29.0% from nuclear fuel and 11.0% from sun, water, and wind [34]. Conventional coal-burning power plants represented the total power of about 10.8 GW. The Czech electricity market was fully opened in 2006 and the gas market in 2007 [2].

The dependence of the Czech market on energy imports has been rather modest; 30.4% of energy demand has been covered by importation [2]. However, import has been structurally unbalanced. The country's dependence on oil and natural-gas imports is estimated at 96-98% [2, 35]. A number of direct and indirect actions were taken to prevent further increase of energy imports, including the following: increase of energy effectiveness, promotion of renewable energy sources on the areas that are the most effective in that respect, with the goal to reach a 13% RES share in the final energy consumption by 2020 [4], as well as an efficient use of local solid fuel resources, mainly brown coal [2]. The directions of import and export of coal are shown in Figure 9.

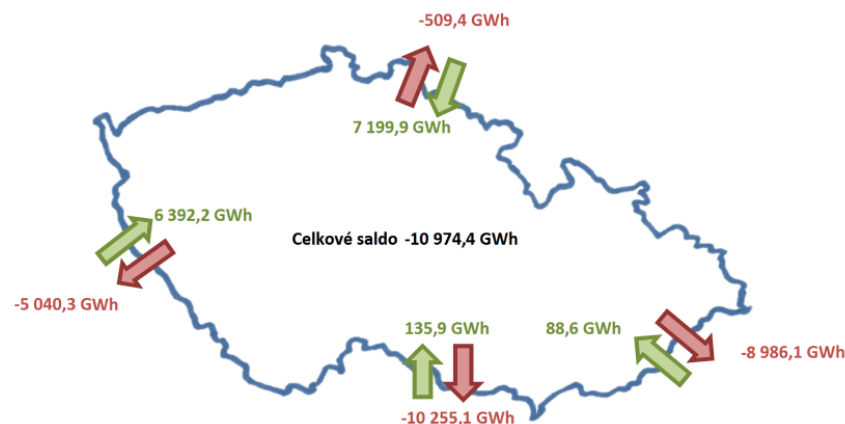


Figure 9. Directions of energy import and export [GWh] [2].

9. Conclusions

The Czech coal mining industry has always played and will continue to play a considerable role in the country's national economy. In 2015, the share of coal in gross electricity generation reached the proportion of 51.4% (gross electricity production refers to the total production from all energy sources) [34], while in 2017 the proportion was only 47% [34]. According to the Czech Energy Policy Conception approved in May 2015, the share of coal in electricity generation should be reduced to 11-21% until 2040 [3]. To ensure a balanced use of coal in that period, the coal-burning power plants were upgraded in the north of the Czech Republic. The 800 MW Tušimice II Power Plant was modernised to reduce CO₂ emission and prolong its operation until 2035 [36]. The lifetime of the Prunéřov II Power Plant was extended by 25 years after upgrades of three power blocks (750 MW), with effective CO₂ emission reduction by 40% [37]. The Ledvice 110 MW power block no. 4 and the new 660 MW power block no. 6 were commissioned in 2017, with their lifetimes planned for 40 years [38].

The Czech Republic is a significant brown-coal producer in Europe (with the extraction of 38.1 million tonnes in 2017, maintained at a stable level since 2010). The extraction of bituminous coal has been dropping each year and it amounted to 5.5 million tonnes in 2017 (ca. 20% less than in 2016) [4].

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