

# Hard coal in power industry and coking coal production – global and European perspective

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**Abstract**—The purpose of the paper is to present the previous and current trends in hard coal production and consumption in the world, in Europe and Eurasia. In the paper statistical data analysis was used concerning hard coal and legal acts analysis that regulate hard coal production in Europe. Main research techniques are: literature and legislation review as well statistical analysis. In conclusion it is stated that despite the existing possibilities of coal utilization in European power industry, in future it is hard to expect a significant excavation and consumption volume increase due to environmental restrictions and financial problems in European hard coal mining.

**Keywords**— hard coal in the world, hard coal in Europe, hard coal consumption and production.

## I. INTRODUCTION

COAL is currently an important energy resource in many economies in the world [1] [2]. Nevertheless, its significance in energy balance is systematically decreasing due to the exhaustion of deposits of this resource and hazards to the environment that are connected with its utilization [3] [4]. In table 1 there is a structure of energy sources presented in the particular regions in the world in 2014. Sources for each country amounts to 100%.

Table 1. Structure of energy sources in the world in 2014 [%]

Region	Energy source					
	crude oil	natural gas	coal	nuclear energy	hydro-power	renewable source
North America	36.75%	30.09%	17.53%	7.67%	5.61%	2.35%
South and Middle America	46.26%	22.53%	4.33%	0.69%	23.47%	2.72%
Europe	34.96%	23.68%	17.07%	11.08%	7.04%	6.16%
Eurasia	23.60%	46.62%	18.20%	6.44%	4.14%	1.01%
Middle East	49.00%	49.08%	1.05%	0.12%	0.73%	0.03%
Africa	41.88%	27.20%	23.43%	0.77%	6.30%	0.42%
Asia and Pacific	27.47%	11.17%	52.35%	1.51%	5.99%	1.52%

Source: own work based on: [5]

According to data included in table 1, coal as an energy

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resource is most intensively utilized in Asia and Pacific region. It also has a strong position of African energy balance. It remains a strong resource in Eurasia, North America and Europe too. It has little significance in South and Middle East, where crude oil dominates [6]. Taking into account the significance of this resource, in this article an attempt was made to analyze and assess the historical and present trends concerning hard coal production and consumption in Europe and in the world along with the factors determining the trends.

## II. HARD COAL IN THE WORLD

Due to a significant and increasing in time demand for energy amongst the Asian countries, since 2002 a clear coal production rise and consumption in the world (chart 1) [7] [8] [9] [10] has taken place, confirmed by a well-adjusted linear trend function. However, since 2008 hard coal consumption in the world is lower than the production of this resource. It should also be emphasized that since the beginning of 90s coal production and consumption have been distinctly decreasing in more economically developed regions in the world such as Europe and Eurasia. Nevertheless, in the last five years in these regions there has been a slight rise of coal consumption noted. In the regions of relatively low coal utilization in power industry (South and Middle America, Middle East and Africa), both coal consumption and production remain on a stable level (chart 2 and 3).

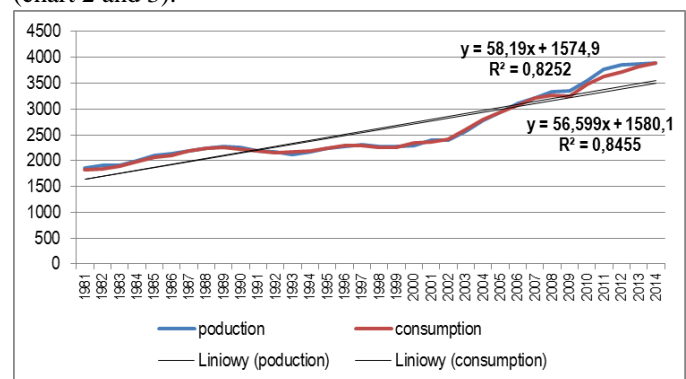


Chart 1. Coal production and consumption in the world in years 1981-2014 [Mtoe]

Source: own work based on: [5].

The increase of coal consumption in Asian economies, mostly in Chinese and Indian economy, is driven by economic boom and dynamic growth of these markets as well as by the availability of this resource and its high price advantage in

relation with other energy carriers, also regarding expensive and low-efficient renewable energy sources [11] [12] [13]. Not without significance for hard coal consumption rise is also the disaster in nuclear power plant in Fukushima that triggered an increased demand for coal in Japan and seriously threatened the image of nuclear power in the world [14] [15] [16]. The Asian markets of a growing demand for coal also encompass Bangladesh and the Philippines [17] [18].

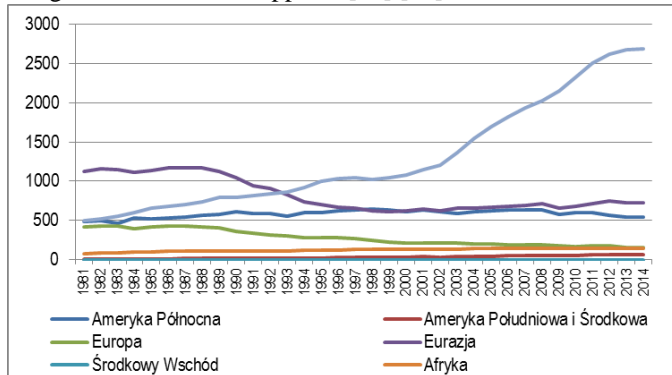


Chart 2. Hard coal production in particular regions in years 1981-2014 [Mtoe]

Source: own work based on: [5].

A decreasing hard coal production and consumption in Europe also comes from the crisis in a mining industry, hard coal price advantage loss or deterioration as well as accompanying systematic liquidation of mining enterprises, intensified by advancing decarbonization [19] [20] as well as a growing utilization of renewable energy sources that follows it [21] [22]. In 2010 a difficult financial situation of European mining enterprises was additionally deteriorated by the Council Decision of 10 December 2010 on State aid to facilitate the closure of uncompetitive coal mines (2010/787/EU), that does not allow subsidizing unprofitable hard coal mines by the state, reducing at the same time the possibility of state aid for European Union hard coal mining that was previously provided by the Council Regulation (EC) No 1407/2002 of 23 July 2002 on State aid to the coal industry [23] [24].

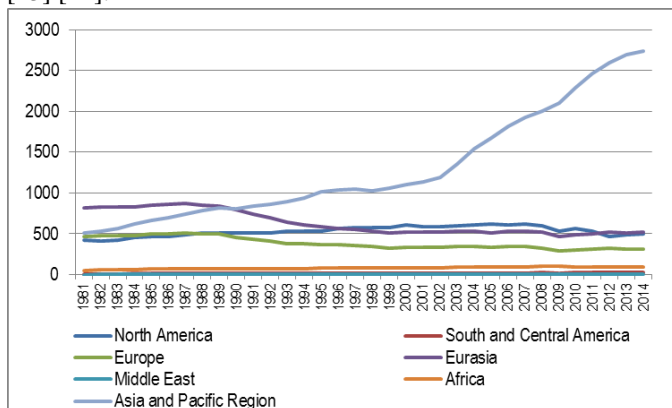


Chart 3. Hard coal consumption in particular regions in years 1981-2014 [Mtoe]

Source: own work based on: [5].

These days the largest coal production, both power and coking coal, is noted in China (table 2 and 3). China is also the main importer of this resource [25] [26]. In the group of coal producers and importers there are also India and Germany (table 4). The key coal producers and exporters in the global economy are: Indonesia, Australia, Russia and United States of America (USA).

Table 2. Main coal producers in the world in 2014

Country	Share in total production [%]	Country	Share in total production [%]
China	45.52%	Russia	4.44%
USA	11.56%	South Africa	3.27%
India	7.84%	Germany	2.44%
Indonesia	6.25%	Poland	1.83%
Australia	5.87%	Kazakhstan	1.53%

Source: own work based on: [27]

Table 3. Main producers of power, coking coal and lignite in the world in 2014

Power coal	Coking coal	Lignite
China	China	Germany
USA	Australia	Russia
India	USA	USA
Indonesia	Russia	Poland
South Africa	India	Turkey
Australia	Canada	Australia
Russia	Mongolia	Greece
Kazakhstan	Ukraine	India
Colombia	Poland	Czech Republic
Poland	Kazakhstan	Serbia

Source: own work based on: [27].

Table 4. Main coal importers and exporters in the world in 2014

Importers	Exporters
China	Indonesia
Japan	Australia
India	Russia
South Korea	USA
Chinese Taipei	Colombia
Germany	South Africa
Great Britain	Canada

Source: own work based on: [27].

The largest coal deposits are localized in Asia and Pacific region as well as in North America and Eurasia (chart 4). In the group of the countries of the greatest potential concerning coal mining there are the leading producers of this resource, that is: USA (26.6%), Russia (17.6%) [28], China (12.8%), Australia (8.6%), India (6.8%) and Germany (4.5%) [29]. However, it should be emphasized that a considerable level of

coal reserves in case of China does not translate into a self-sufficiency indicator<sup>1</sup> due to a huge excavation volume of this resource [30]. Accordingly, as data in chart 5 shows, the highest coal self-sufficiency is specific for North America and Eurasia, mostly including USA (266 years) and Russia (452 years). Therefore, it may be stated that taking into account the current coal production and consumption in the world it is an energy resource providing energy security in a long-term, especially in these regions and countries that are its main consumers. China is an exception here because despite the largest coal deposits its self-sufficiency amounts to 31 years only considering an extreme coal consumption in the economy [31] [32].

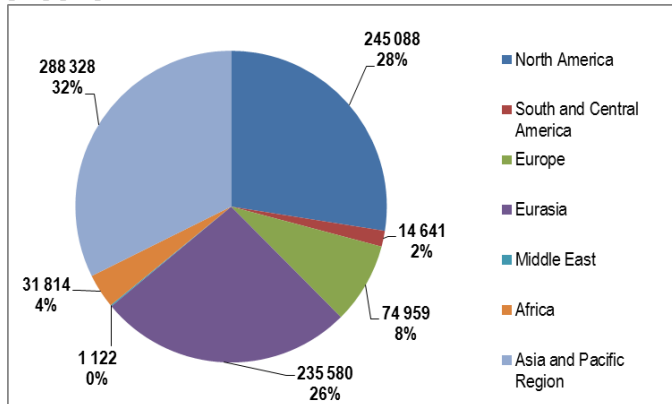


Chart 4. Coal deposits in the particular regions in 2014 [Mtoe]

Source: own work based on: [5].

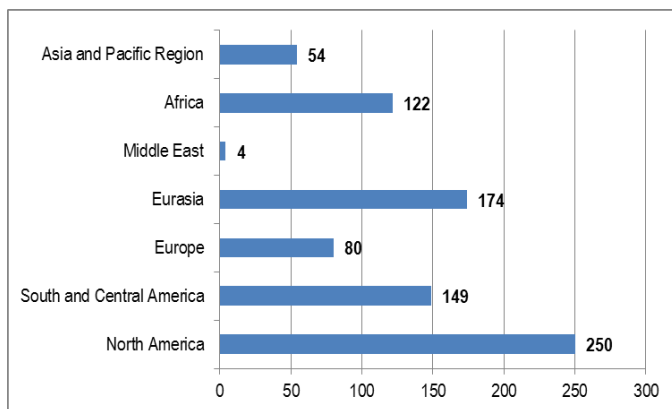


Chart 5. Coal self-sufficiency in particular regions of the world [years]

Source: own work based on: [5].

### III. HARD COAL IN EUROPE AND IN ASIA

According to data presented above, Europe and Eurasia possess coal deposits at the level of 8% and 26% of global resources, what corresponds to self-sufficiency at the level of 80 and 174 years. A considerable coal availability and self-sufficiency cause that it is a resource present in energy balances of many European countries (table 5). It is a

dominant energy source in Bulgaria, Czech Republic, Kazakhstan and Ukraine. It also has an important significance in: Austria, Denmark, Finland, Greece, Holland, Ireland Germany, Portugal, Russia, Romania, Turkey, Ukraine, Hungary and Great Britain.

Despite a large extent of coal utilization in Europe and Eurasia, both mining and consumption of this resource, since the beginning of 90s, have been systematically decreasing, what is confirmed by well-adjusted linear trend functions (chart 6 and 7). A low production and consumption increase in relation with the previous periods occurred in years 2010-2014 both in Europe and in Eurasia. The main reason for this increase is a rising demand for electricity (chart 8) and lower development pace of renewable energy sources than expected [33] [34] [35]. A huge significance for coal utilization in power industry also belongs to prices fall of this resource in connection with its over-supply in USA and Australia in a form of export to European countries.

<sup>1</sup> R/P – reserves to production ratio is calculated as a relation of reserves to hard coal production volume in a given year.

Table 5. Structure of energy sources in Europe and in Eurasia in 2014 [%]

No.	Country	Energy source					
		crude oil	natural gas	coal	nuclear power	hydropower	renewable
1	Austria	37%	22%	11%	0%	25%	6%
2	Azerbaijan	36%	61%	0%	0%	3%	0%
3	Belgium	50%	25%	5%	16%	0%	5%
4	Belarus	34%	65%	0%	0%	0%	0%
5	Bulgaria	24%	14%	35%	19%	5%	4%
6	Czech Republic	20%	18%	39%	17%	2%	4%
7	Denmark	43%	19%	18%	0%	0%	20%
8	Finland	34%	10%	14%	21%	11%	10%
9	France	32%	16%	5%	39%	6%	2%
10	Greece	52%	12%	26%	0%	5%	5%
11	Spain	44%	20%	8%	10%	6%	13%
12	Holland	48%	38%	10%	1%	0%	3%
13	Ireland	51%	30%	10%	0%	1%	8%
14	Kazakhstan	22%	17%	58%	0%	3%	0%
15	Lithuania	48%	43%	3%	0%	2%	4%
16	Germany	34%	23%	25%	7%	1%	9%
17	Norway	24%	9%	1%	0%	65%	1%
18	Poland	24%	15%	56%	0%	1%	4%
19	Portugal	45%	15%	11%	0%	13%	15%
20	Russia	22%	53%	13%	6%	6%	0%
21	Romania	27%	34%	17%	8%	10%	3%
22	Slovakia	21%	29%	19%	21%	7%	2%
23	Switzerland	39%	11%	0%	20%	28%	2%
24	Sweden	28%	2%	3%	30%	27%	10%
25	Turkey	27%	33%	27%	0%	11%	2%
26	Turkmenistan	24%	76%	0%	0%	0%	0%
27	Ukraine	10%	34%	36%	16%	3%	0%
28	Uzbekistan	7%	85%	2%	0%	5%	0%
29	Hungary	29%	38%	13%	17%	0%	3%
30	Great Britain	35%	33%	18%	8%	1%	5%
31	Italy	39%	36%	9%	0%	7%	8%
32	Others	34%	14%	23%	2%	24%	2%
33	Total Europe and Eurasia	30%	33%	17%	9%	7%	4%

Source: own work based on: [5].

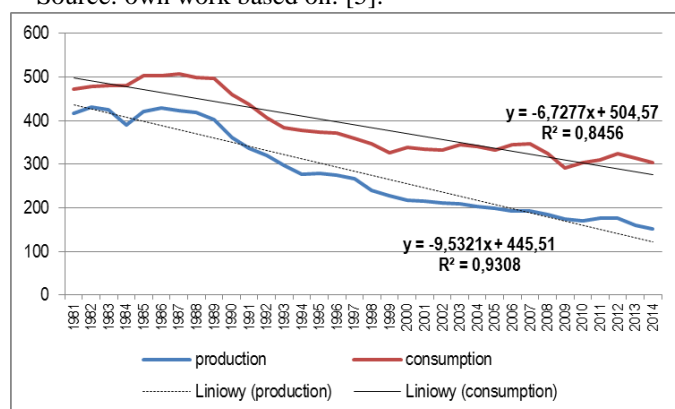


Chart 6. Coal production and consumption in Europe in years 1981-2014 [Mtoe]

Source: own work based on: [5].

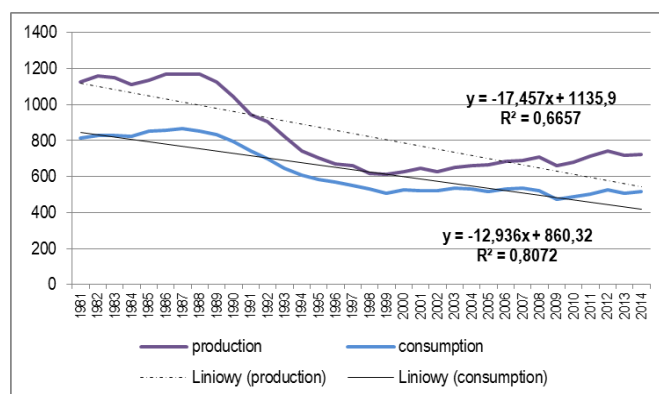


Chart 7. Coal production and consumption in Eurasia in years 1981-2014 [Mtoe]

Source: own work based on: [5].

According to charts 6 and 7 a yearly hard coal production decrease in Europe amounts to about 9.5 Mtoe and in Eurasia 17.5 Mtoe. In turn, a yearly fall of European consumption of

this resource equals 6.7 Mtoe. Eurasian consumption is yearly decreasing by about 12.3 Mtoe. It is worth noting that the level of both parameters in Eurasia is higher than in Europe, furthermore, production in this region clearly outnumbers hard coal consumption. In Europe hard coal consumption is higher than its production in the whole analyzed period, and in the last ten years, the gap between these volumes is significantly growing.

The main coal producers and consumers in Europe and in Eurasia are presented in table 6. Most of key coal users are also found in the group of leading producers. An exception in this case are Italy and Holland where hard coal is used but they are not considerable producers of this resource. Therefore, it may be stated that the countries basing their energy balance on coal are able at least partially satisfy the demand for coal on their own, guaranteeing at the same time energy security.

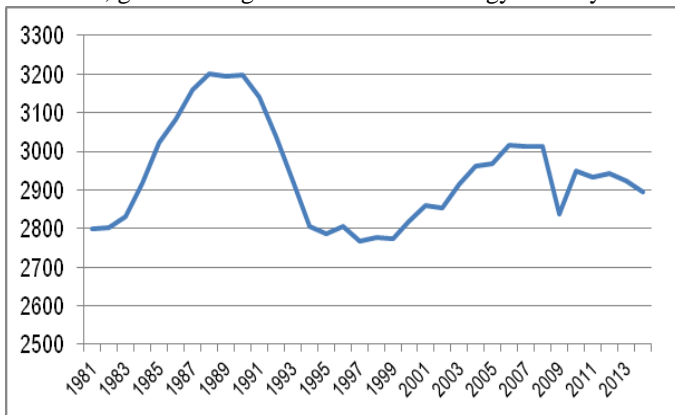


Chart 8. Electricity consumption in Europe and Eurasia in years 981-2014 [Mtoe]

Source: own work based on: [5].

Table 6. Main coal consumers and producers in Europe and Eurasia in 2014

Consumers	Share in total consumption [%]	Producers	Share in total production [%]
Russia	18.38%	Russia	36.68%
Germany	15.98%	Kazakhstan	12.97%
Poland	11.02%	Poland	12.78%
Ukraine	8.37%	Ukraine	10.19%
Great Britain	7.18%	Germany	9.56%
Kazakhstan	7.10%	Czech Republic	3.99%
Turkey	6.48%	Turkey	2.94%
Italy	2.87%	Great Britain	1.73%
Spain	2.03%	Greece	1.54%
Holland	1.64%	Bulgaria	1.05%
Greece	1.40%	Romania	1.03%
Bulgaria	1.16%	Hungary	0.44%
Romania	1.10%	Spain	0.36%
Total	84.71%	Total	95.26%

Source: own work based on: [5].

Energy security in a prospective approach is also provided by significant deposits of this resource and their self-sufficiency for the main coal consumers in Europe and Eurasia (chart 9 and 10). However, it is worth noting that in a relatively short time, because not exceeding 30 years, these deposits will be exploited in Romania, Czech Republic and Great Britain. In Poland, coal deposits self-sufficiency involves quite a short time perspective too, amounting to 38 years only. The greatest resource potential and self-sufficiency of hard coal deposits belongs to Russia. In Germany, Kazakhstan and Ukraine we may see another high potential, what translates into self-sufficiency exceeding 200 years. Among the European countries, over a-hundred-year self-sufficiency of hard coal reserves may be noted in Spain and Turkey [36] [37].

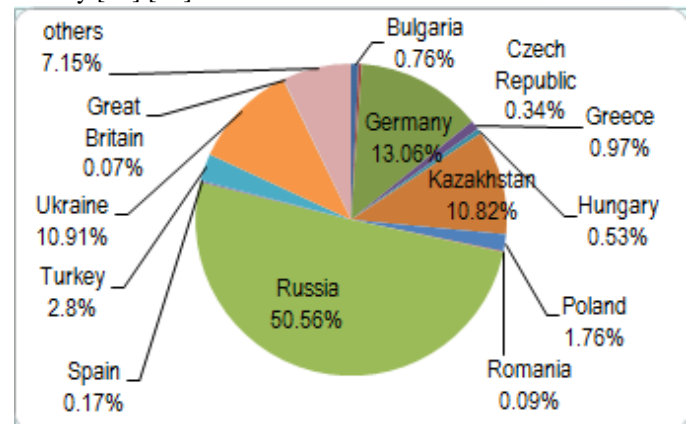


Chart 9. Share of particular countries in total coal deposits in Europe and Eurasia [%]

Source: own work based on: [5].

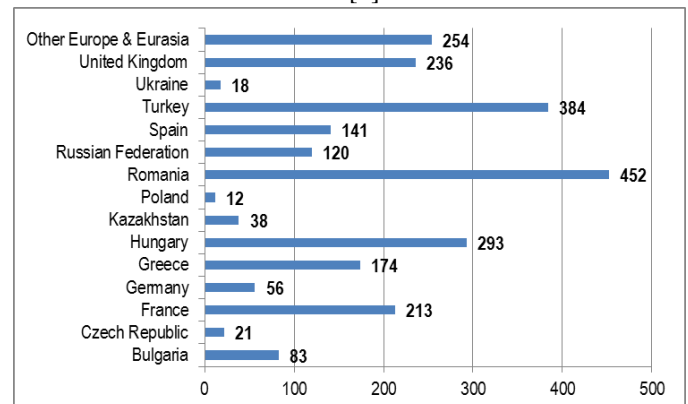


Chart 10. Coal deposits self-sufficiency in Europe and Eurasia [years]

Source: own work based on: [5].

In Europe hard coal utilization in economy is limited in a significant way by the restrictions concerning carbon dioxide emission as well as sulfur and nitrogen compounds, also by promotion of renewable energy sources aimed at decarbonization and oriented at pro-ecological priorities achievement in power industry [38] [39] [40] [41] [42]. The guidelines in this area are formulated as documents in force in

the countries of the European Union. Their list along with a synthetic description of the most important decisions are presented in table 7.

Table 7. European Union regulations concerning energy policy

Name	Date of coming into force	Description
Climate Package	2008	Reduction of greenhouse gas emission until year 2020 by 20%. Increasing energy effectiveness by 20% as a result of transmission losses reduction and efficiency increase in terms of energy production. Increasing the share of renewable energy sources in total consumption by 20%.
Directive no. 2009/29/EC	2009	Setting CO <sub>2</sub> limits in the period of 2012-2020 and the rules of emission trading for power and heating industry of nominal power provided in fuel over 20 MW.
Directive no. 2009/28/EC	2009	Determining the guidelines concerning power promotion and utilization coming from renewable energy sources.
Directive no. 2010/75/EC	2010	Setting new standards of SO <sub>2</sub> NO <sub>x</sub> and ash emission in a perspective of 2014-2016. These standards are several times lower than the previous ones. The standards relate to the objects of fuel combustion for energy purposes, of nominal power provided in fuel over 50 MW.
Directive no. 2011/27/EC	2011	Determining the rules of CO <sub>2</sub> allocation out of charge in years 2012-2020.
New Climate Package	2020	Further emission reductions and tightening the provisions of Climate Package

Source: [43]

The utilization of coal in Europe is not supported by the aforementioned Council Decision of 10 December 2010 on State aid to facilitate the closure of uncompetitive coal mines (2010/787/EU). Until 2010 the EU hard coal mining was systematically subsidized within the frames of Council Regulation (EC) No 1407/2002 of 23 July 2002 on State aid to

the coal industry [44]. According to the Regulation, maintaining domestic energy security was justified by granting state aid for unprofitable coal mines [45]. However, financial support for hard coal mining encompassed a wide subject range that included: aid for closure of unprofitable mines, operating aid, investment aid and aid for inherited extraordinary costs connected with sector restructuring. The categories of aid for hard coal mining were reduced by the aforementioned Decision, according to which state aid may only be granted for:

costs of closure of uncompetitive mines, including current production losses, providing that the mines would be finally liquidated to 31st December 2018,

extraordinary financial costs financed until the end of 2026, mostly connected with social costs (employee pensions and benefits for those who were dismissed) and technical costs (securing infrastructure of liquidated mines).

Accordingly, aid for initial investments as well as non-specified time limit of aid were withdrawn, what stops internal initiatives concerning sector competitiveness improvement [46]. Meanwhile, state aid, in the years of Council Regulation (EC) No 1407/2002 of 23 July 2002 on State aid to the coal industry in force, was used by almost all the countries where hard coal mining was functioning, however, the greatest beneficiaries were: Germany, Spain, Poland, France and Romania [47]. Such significant reduction of the range of state aid for hard coal mining contributes to closure of unprofitable hard coal mines and decrease of this resource production. This process has already started in Polish economy [48] [49] [50].

#### IV. CONCLUSION

In relation with the above, despite the existing possibilities of coal utilization in European power industry, in future it is hard to expect a significant excavation and consumption volume increase due to environmental restrictions and financial problems in European hard coal mining. Nevertheless, it should be noticed that many European countries still use coal in economy and the change of energy supply sources is a long-term and costly process. The production reduction in Europe may therefore lead to a considerable dependence of the economies on hard coal import, including from USA, Australia or Colombia.

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