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Innovative Mining Techniques and Technologies - Review of Selected KOMTECH-IMTech 2019 Conference Proceedings – Part 1

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Abstract:

The subject-matter of selected papers, presented at the 20th Jubilee Scientific and Technical Conference KOMTECH-IMTech 2019, are discussed in the article. Special attention is paid to the role of coal in the world and the EU countries. Some information about Mine 4.0 against the characteristic features of Industry 4.0 is given. The article is ended with general conclusions.
Part 1 presents the role of coal in the global economy with special attention being paid to the global energy demand, hard coal production rates, changes in coal demand as well as changes of electric energy sources over the years 2011-2018. A contribution of the KOMAG Institute to development of the Polish mining industry in independent Poland is discussed.

Streszczenie:

W artykule została przedstawiona tematyka wybranych referatów wygłoszonych podczas 20 Jubileuszowej Konferencji Naukowo-Technicznej KOMTECH-IMtech. Szczególną uwagę zwrócono na rolę węgla na świecie oraz w krajach UE. Opisano wkład KOMAG-u w rozwój polskiego górnictwa w niepodległej Polsce. Podano informacje na temat kopalni 4.0 na bazie charakterystycznych cech Przemysłu 4.0. Artykuł został zakończony ogólnymi wnioskami. Część 1 przedstawia znaczenie węgla w światowej gospodarce ze szczególnym uwzględnieniem zapotrzebowania na energię , wielkości produkcji węgla kamiennego, zmian w popycie na węgiel oraz zmian źródeł energii w latach 2011-2018. Omówiono wkład Instytutu KOMAG w rozwój polskiego górnictwa w niepodległej Polsce. **(Innowacyjne techniki i technologie dla górnictwa - przegląd wybranych referatów z konferencji KOMTECH-IMtech 2019 – część 1)**

1. Role of coal in the global economy

The role of coal in the world economy with a special emphasis on the role of coal in the EU countries was presented by Janusz Olszowski, President of the Mining Industrial and Trade Chamber. From Fig. 1 it can be clearly seen that the global energy demand increased significantly, in particular over the recent two years.

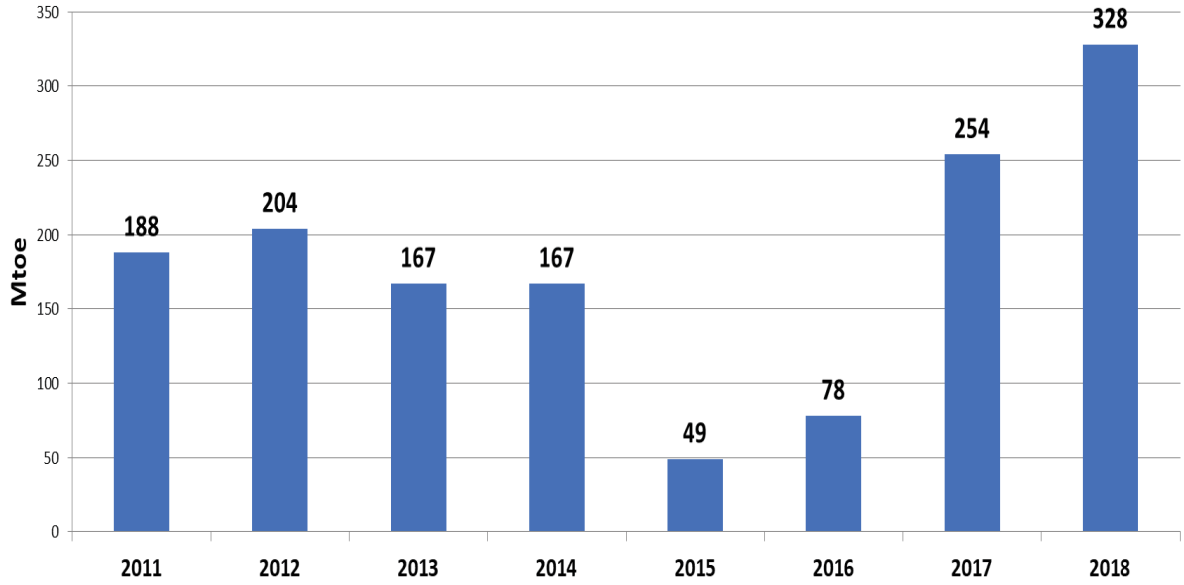

Fig. 1. Global energy demand over the years 2011-2018 [6]

Presenting the role of coal in the global economy, it is worth analyzing a share of different fuels in the world energy mix first of all. The data from the year 2000 and the year 2018 were available, so they were taken for comparison as it is shown in Fig. 2.

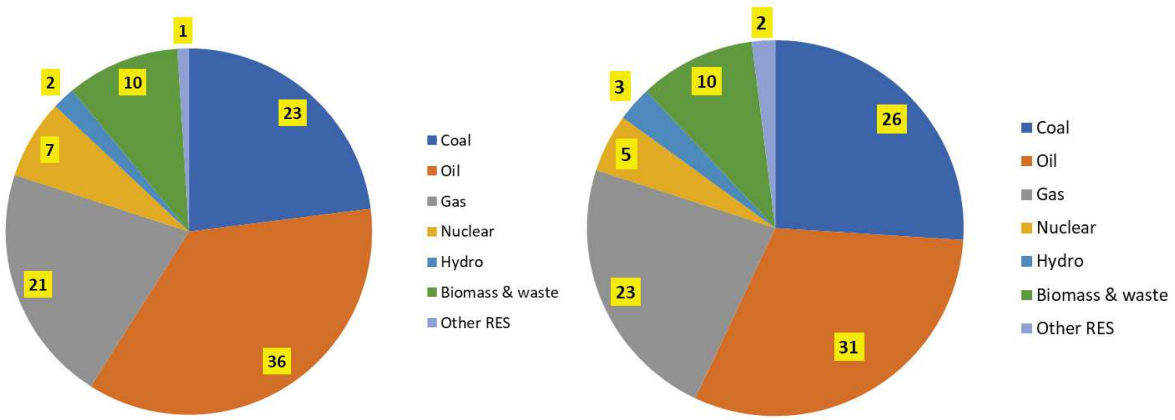

Fig. 2. Share of fuels in the global energy demand in 2000 and 2018 [7]

Bearing in mind the figures, reflecting the global energy demand, the hard coal production rates should be taken into consideration. They seem to be stable over the period under analysis, i.e. the years 2010-2018, as it can be seen in Fig. 3.

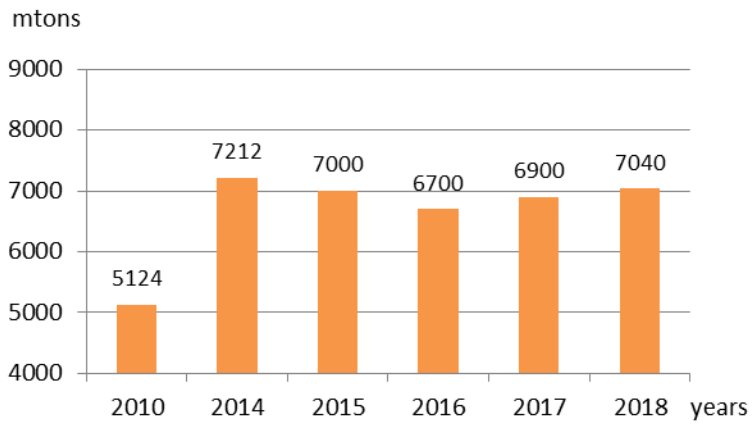

Fig. 3. Global hard coal production rates over the years 2010-2018 [6]

It should be highlighted that the global production rates in 2018 in comparison with 2017 show the increase of 2.5%, i.e. 7.04 billion tons. A significant increase can be seen in China, Indonesia, India and Russia but a decrease occurs in the USA, Columbia, Canada and EU countries. Due to climate changes and anti-coal campaigns the coal demand shows a decreasing trend starting in 2014 as it can be seen in Fig. 4.

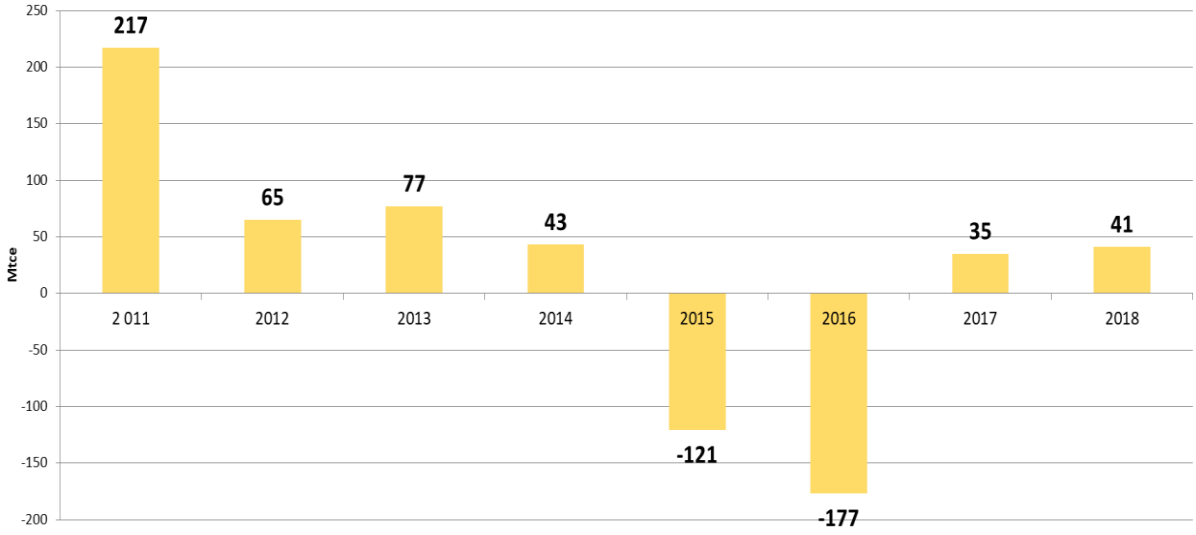

Fig. 4. Changes in coal demand over the years 2011-2018 [6]

In 2018 the production rate of electric energy in the world reached 26615 TWh and it is important to highlight the fact that 64% of electric energy was generated from fossil fuels and 26% - from renewables. However, 23% of energy was generated from gas, 19% - from hydro and others, 10% - from nuclear sources, 7% - from photovoltaics and wind as well as 3% - from oil. As regards the EU countries in 2018 the electric energy production rate reached 3282 TWh. However, 40.5% of electric energy was generated from fossil fuels and 34.3% - from renewables, being more precise 23.8% - from renewables and others, 10.5% - hydro, 25.2% - nuclear sources, 18.9% gas, 20% - coal and 1.6% from oil. These data were published in the BP Statistical Review of World Energy 2019. In Fig. 5 changes of electric energy sources in 2018 against 2017 are shown.

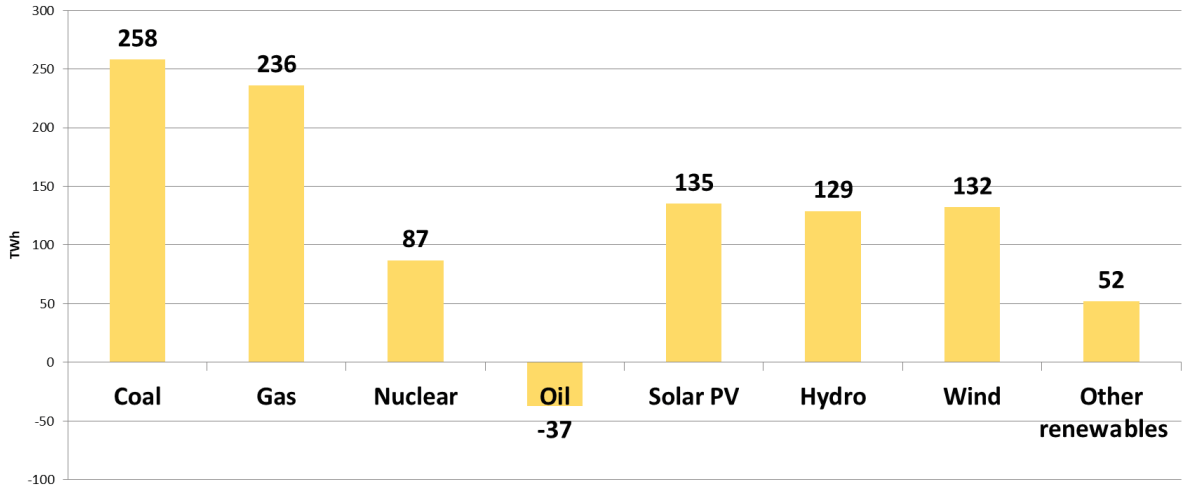

Fig. 5. Changes in electric energy sources in 2018 against 2017 [7]

More detailed conclusions can be drawn after having analyzed the production rates of hard coal and lignite as well as an import in EU countries in 2018 (Fig. 6).

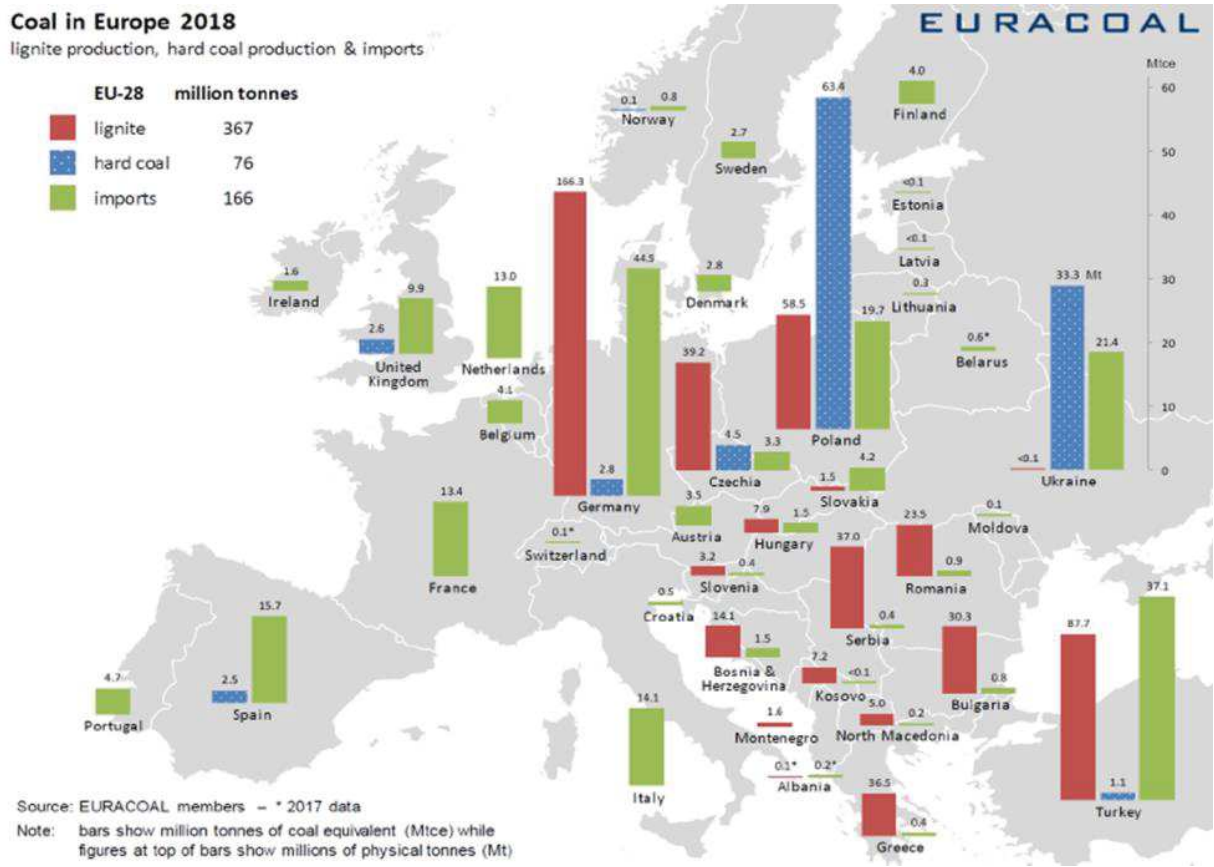

Fig. 6. Coal in Europe in 2018 [8]

Plans for eliminating coal from the energy mix in EU countries are shown in Fig. 7.

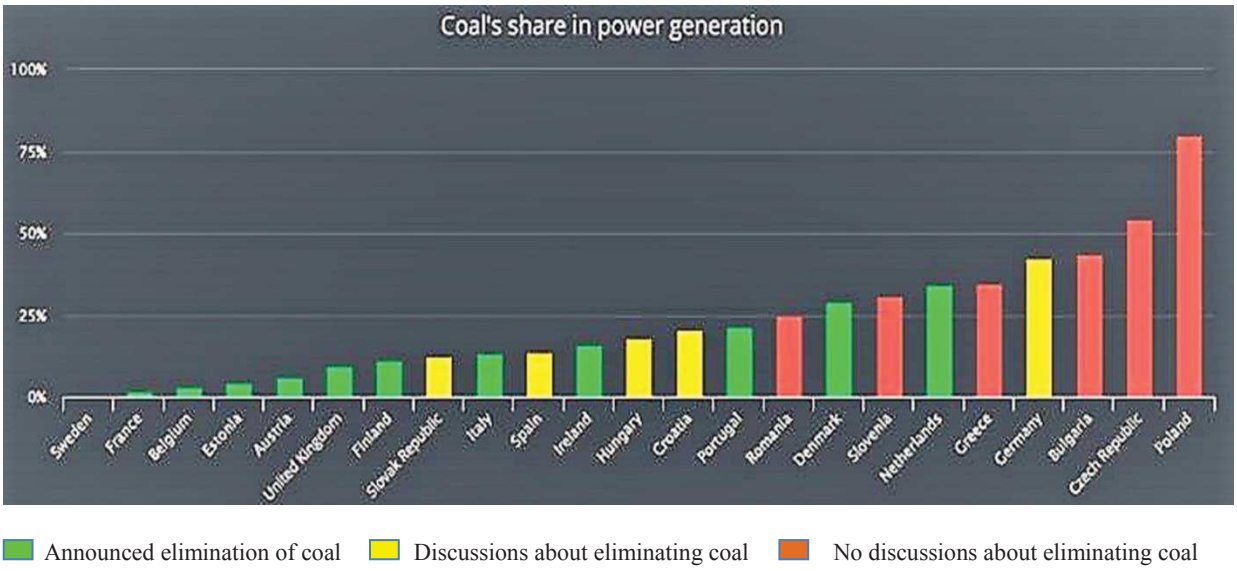

Fig. 7. Planned eliminations of coal from energy generation processes [6]

According to the latest political announcements till the year 2030 28% of the existing coal-fired power plants will be closed down. Germany intends to reduce the power of coal-fired plants to 17 GW till 2030. The next step will consist of a total elimination of electric energy, generated from coal, till the year 2038. After having analyzed the information, given in Mr. Olszowski's presentation, it should be highlighted that over the years 2000-2018 the global hard coal production increased from 3639 m tons to 7040 m tons. During the same period, electric energy production from coal increased from 1066 TWh to 2024 TWh. Reduced production of coal in the USA and Western Europe was compensated by an increase of coal production in China, India and South-Eastern Asia. In total 40% of the global electric energy is generated from coal.

At present 78 countries use coal for generating electric energy, whereas in 2000 there were only 66 countries. According to the latest information, given by politicians, in the near future 16 countries are going to join the group of coal users for electric energy production. A survey of the present global economy as regards sources of energy and forecasts of coal demand indicate clearly that coal will not be completely eliminated from the energy mix and for many years to come it will be an important source of energy. However, the majority of West European countries plan to eliminate coal as an energy source over the years 2022-2030, except for Germany which plans to achieve that objective in 2038. In the East European countries, the coal demand is on a stable level and most of these countries do not plan to eliminate coal from the energy mix. The countries, which are non-EU members, such as the Balkans and Turkey, plan development of coal-fired power plants.

2. The hard coal mining industry in Silesia, Poland

Tomasz Rogala, President of Polska Grupa Górnicza (PGG), Polish Mining Group and of EURACOAL, the European Association for Coal and Lignite highlights the importance of the coal industry's value chain and progress in clean coal technologies. It is worth mentioning the triangle of values and challenges: technology, society and economy. The problems resulting from the restructuring process of the hard coal mining industry are extremely difficult in Silesia. In 2019 200 thousand jobs in Silesia were related to coal and these jobs paid 50% more than the average salary in the region. 719 million Euros of fiscal payments were transferred to the central government and 181 million Euros per year are spent by the PGG on machines and equipment. An implementation of the carbon capture and storage (CCS) processes gives positive results. The same concerns clean coal technologies (CCT). At present, the PGG is involved in the projects oriented onto coal gasification as

an alternative to conventional combustion processes and is, therefore, supporting the EU's circular economy as shown in Fig. 8. presenting Carbon Capture and Utilisation – CCU.

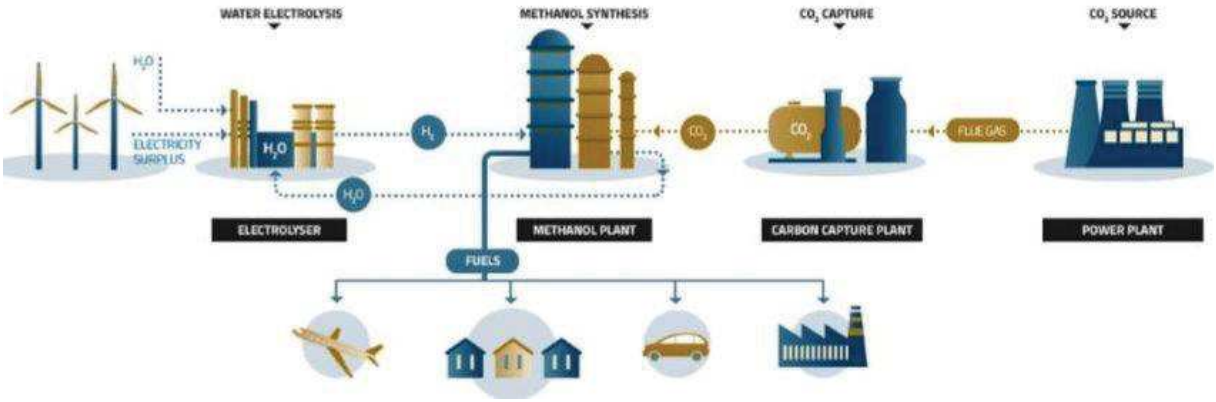

Fig. 8. Circular economy – coal power plant and carbon capture and utilization [9]

The picture of the decarbonisation process in Poland does not seem to be pessimistic. In the year 2000, there were 42 operating coal mines in Silesia, which accounted for 10% GDP. In 2018 20 coal mines were still operating (Fig. 9). As the ultimate goal for all the European regions is to achieve a zero-emission economy by 2050, then a significant number of areas will be abandoned or degraded unless appropriate action is taken. According to Jan Bondaruk, Deputy Director for Environment at the Główny Instytut Górnictwa (GIG), Central Mining Institute, Poland, this process should not be perceived as a disaster but as a chance. Post-mining can be a key economic asset for the circular economy, for geothermal energy from mine water, post-mining infrastructure as well as cultural and leisure services.

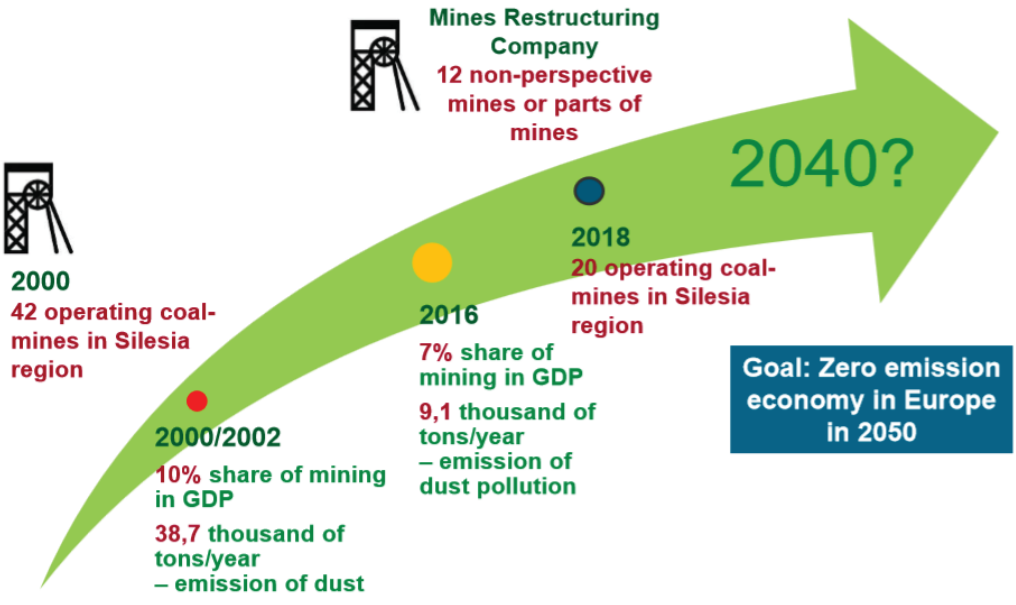

Fig. 9. Transition pathway in Silesia, Poland [9]

Researchers have started to promote a smart closure of mines to reuse these newly abandoned areas in the most sustainable way, analyzing different scenarios. The ecosystem restoration seems to be crucial. There is an enormous potential for creating a new value chain, but as it is not yet a mainstream practice, no information is available on the cost-effectiveness of land rehabilitation. However,

a realization of several projects confirms efficient and cost-effective restoration processes that respect the ecosystem and biodiversity and directly or indirectly benefit local authorities and society.

3. Technological achievements of the coal sector during 2011-2017 are as follows:

- Automation and digitalization in coal mines (integrated ICT technologies in coal mines, e.g. new sensor technologies, mine power engineering and real-time process reconciliation).
- Health and safety (an implementation of devices for dust control and ventilation-on-demand, gas control and novel rescue devices).
- Protection of the environment (mine water usage, environmental monitoring, land reclamation and restoration).
- Sustainable coal technologies (capturing CO_2, implementation of emission reduction systems – smart control and sensors, co-firing coal with solid waste or biomass).
- Improvement of the coal use (optimized systems for the preparation of coking fuel blends, co-processing and an improvement on catalysts in coal liquefaction, development of novel porous carbon materials).
- Alternative use of coal-security of energy supply (underground coal gasification, production of syngas, simplified gas cleaning, methanol or Fischer-Tropsch-fuels).

4. Coal challenges and recommendations

Presenting the future of the coal sector, it is indispensable to highlight the efforts which should be made to increase social acceptance and awareness of the sector. All the energy-intensive industries agree on the need to further develop clean technologies to reduce their carbon footprint. The push towards technology-intensive mining practice to increase mining stability is specific to the coal sector. Post-mining and land restoration continue to challenge the coal industry. The sector also explores alternative use of coal areas for renewables, while increasing the value of coal products (e.g. gasification and integrated hydrogen production). It should be borne in mind that digitalization and the digital transformation challenge the coal industry and provide an opportunity to improve the sector.

Coal challenges for the next decade include:

- Clean Coal Technologies reducing the carbon footprint.
- Technological leadership towards sustainable mining.
- Alternative use of coal areas for renewables.
- Valorisation of coal products.
- Mine reclamation, land restoration and post-mining activities.
- Digital transformation.
- Workforce development.

The recommendations, suggested by Elisabeth Clausen and Nicholaos Koukouzas who are experts representing the Research Fund for Coal and Steel, are as follows:

- Carbon capture, utilisation and storage (CCUS) in other energy-intensive industries.
- Geothermal, pumped hydroelectric storage, energy storage, photovoltaics, wind.
- Coal gasification, integrated hydrogen production, methanol production.
- New methods and approaches for mine closure, long-term stability and safety.
- Clean coal technologies by automation and digitalization, advanced mining technologies.
- Skills, knowledge management, lifelong learning education, re-employment, social awareness and acceptance.

5. Contribution of KOMAG to development of the Polish mining industry in independent Poland

5.1. KOMAG scope of activity

At present KOMAG Institute of Mining Technology is one of the preferred providers of innovative technologies in the domain of mining machines and equipment for winning and beneficiation of minerals, in particular hard coal. KOMAG specializes in designing, testing, assisting and implementation of highly productive and reliable machines. Its history dates back to 1950. Over the period of nearly seventy years of the activity, it changed its name and organizational scheme several times, but it was always oriented onto designing, testing and implementing mining machines which are operator and environment friendly. Safety, reliability and productivity have always been key drivers of innovative solutions offered to mining machinery producers and end-users in mines. Since 1950 over 1100 technical designs of mining machines and equipment, implemented in Polish and foreign mines, have been developed. An innovative character of technical and technological solutions is confirmed by 4400 patents and utility patents granted to KOMAG over the period of its activity [4].

Describing a contribution of KOMAG to the development of the Polish mining industry in independent Poland, it is indispensable to give some historical facts.

5.2. Historical facts about the Polish hard coal mining industry after regaining independence

In his presentation, Prof. Aleksander Lutyński from the KOMAG Institute of Mining Technology concentrated on the past and present history of the mining industry in Poland. In 1918 there were two industrial regions in Poland. In the result of the plebiscite, Poland obtained 52 hard coal mines. After World War II, based on the Act dated 3rd January 1946 all the mines became state-owned [5]. In 1946 the annual hard coal production rate was 51 m tons, but the top production rate in the amount of 201 m tons was achieved in 1979. Over a period of 100 years of techniques and technologies of winning coal changed. These changes concerned exploitation systems, cutting methods, run-of-mine haulage and transportation of men and materials as well as beneficiation processes. In 1950 longwall, contour, deep-web shearers were introduced. At the end of 1957, the first shallow web shearer better suited to Polish coals was applied. In 1970 529 longwall shearers were in operation in the Polish mines. Simultaneously manual loading of the run-of-mine was replaced by mechanical loading [6]. In 1969 79% of the run-of-mine in longwall faces were loaded mechanically, but in roadways – only 28%. In the following years, loaders which eliminated manual loading of the run-of-mine were implemented. In 1946 90% of workings were supported with wooden supports, but in 1970 – 70% of workings were equipped with steel supports, in total 3000 longwall roof support units. Two mechanized longwall systems were in operation: ASI and BESTA, composed of powered roof supports, longwall shearers, scraper conveyors, supply power packs, signalling equipment and remote control systems. Further development of machines and equipment caused the implementation of full mechanization of coal exploitation processes, including loading as well as horizontal and vertical transportation. During the between-the-wars period, mechanical preparation of the run-of-mine was used on a large scale. In general, 80% of the run-of-mine was subject to separation according to the grain sizes in sorting plants [2]. Within the years 1946-1964 21 sorting plants, 19 washeries, 3 pneumatic separation plants and 6 flotation departments were constructed and 3 sorting plants, 4 washeries and 1 flotation department were developed. In 1963 130.7 m tons of the run-of-mine was produced and about 93% of it was subject to beneficiation processes [1, 3]. Activities oriented onto an improvement of productivity were accompanied by the activities oriented onto an improvement of miners' work safety. In 1997 66 preparation plants beneficiated coal from 57 mines. At present 40 preparation plants are in operation in 18 hard coal mines [5]. A radical improvement was confirmed by fatal accidents coefficient for a million tons of mined coal. In 1946 570 miners lost their lives, whereas in 2018 – 0.24.

6. Conclusions

- Presenting the role of coal in the global economy, it is worth analyzing a share of different fuels in the world energy mix – in 2018 26% of energy was generated from coal.
- In 2018 a significant increase in coal production rates can be seen in China, Indonesia, India and Russia but in the USA, Columbia, Canada and EU countries a decrease occurred.
- Analyzing the role of coal in the Polish economy, the whole value chain should be taken into consideration as well as the triangle of values and challenges: technology, society and economy.
- Technological achievements of the coal sector are oriented onto automation and digitalisation, health and safety, protection of the environment, sustainable coal technologies, improvement of the coal use and alternative use of coal in the aspect of energy supply.
- The ecosystem restoration seems to be crucial in the process of smart closure of mines.
- KOMAG had a fundamental impact on the development of the Polish mining industry in independent Poland.
- An implementation of the state-of-the-art mining machines and equipment, designed at KOMAG, enabled the Polish mining industry to be the world leader of the coal production rates.

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