



Digital Transformation in Mining Sector in Vietnam

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Abstract

Digital transformation is one of the inevitable trends in today's world. Vietnam is one of the pioneer countries following this trend and has launched a national digital transformation program. Digital transformation has attracted great interest from both the community of scientists and managers in general and in the field of coal mining and other minerals. Currently, researchers have been focusing on issues, such as the theory of digital transformation in both state and the business sector, the relationships between digital transformation and the building of e-government or digital government, and between digital transformation and effective national administration. In this study, the method of document-based analysis (Desk review) was used to analyze and evaluate the current situation of digital transformation of the coal and mineral mining industry and identify achievements as well as limitations of the digital transformation process in the coal and mineral mining industry in Vietnam.

The study presents the following issues: (1) Some general issues about digital transformation, in which the concept of digital transformation is clarified; Meaning of digital transformation in the field of coal and mineral mining; Requirements for digital transformation in the field of coal-mineral mining. (2) The current status of digital transformation in coal-mineral mining in Vietnam, including applying advanced technologies in exploration and mining, and application of advanced technologies in mining and environmental protection.

Keywords: digital transformation, coal-mineral industry, mechanization

1. Introduction

1.1. Concepts of digital transformation

Digital transformation is a component of the fourth technology revolution. From the literature review, "Digital Transformation" is often seen as the process of changing from a traditional business model to a digital one by applying new technologies such as big data, the Internet of things (Internet of Things - IoT), cloud computing (Cloud) to change the way of operating, leadership, work process, and company culture.

In Vietnam, digital transformation is the integration of digital technology into the operations of businesses and organizations to change their ways of operation, and business models, and to provide value to customers. In other words, it is a change in operating methods, procedures, and culture, and based on digital platforms to achieve more effective goals (M.H. Nguyen, 2020).

Digital transformation enhances adaptability and focuses more on data collection, processing, analysis, and useful information to all levels of decision-making. This helps businesses become smart, creative, and quickly and effectively adapt to changes.

Vietnam is one of the few countries in the world that has a strategy and plan for digital transformation. On June 3, 2020, with the issuance of Decision 749/QĐ-TTg on approving the "National digital transformation program to 2025, with orientation to 2030", the Government of Vietnam confirmed that digital transformation is an inevitable process of the country in order to accelerate the modernization of the distribution system, to improve the competitiveness of enterprises, and promote the development of domestic and export markets. The government

has made Vietnam's vision for the year 2030, in which Vietnam will become a digital, stable, and prosperous country. The country will pioneer employing new technologies and models and changing the government's operations fundamentally and comprehensively in management and administration, production, and business activities. In addition, this will make changes in people's lifestyles and work, and allow the development of a safe, humane, and widespread digital environment. The national digital transformation program comprises dual goals of developing a digital government, digital economy, and digital society and forming Vietnamese digital technology enterprises with global competitiveness (Government of Vietnam, 2020)).

Digital transformation in the field of coal and mineral mining is the integration and application of advanced digital technology platforms in all fields of mining, such as management, planning, exploration, transportation, processing and mineral enrichment, cooperation, calling for investment, sales, customer care,... Also, advanced technologies are applied in all stages of production and business chains of mining companies, in order to optimize operations, reduce costs, increase profits, distribute value chains, increase competitiveness, assure safety at work, and contribute to environmental protection and sustainable exploitation of mineral resources.

The focusing areas of digital transformation in enterprises are proposed as a model with the aim of clarifying the levels of digital transformation in enterprises, including (1) strategy, (2) business model, and (3) administration model.

1.2. Inevitable requirements for businesses on the need for digital transformation for the coal mining industry

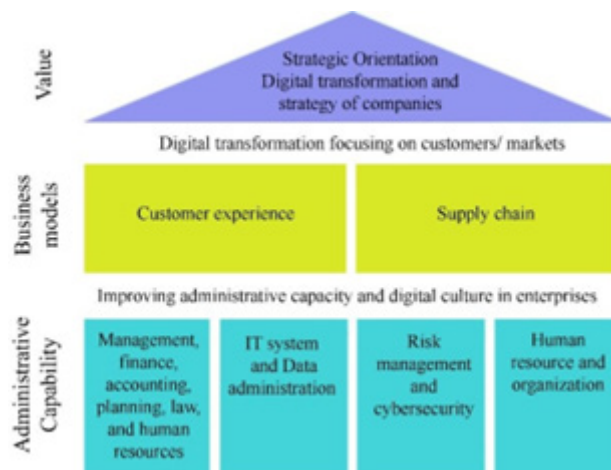


Fig. 1. Digital transformation model in enterprises (Ernst & Young, Digital Transformation Guidelines)
 Rys. 1. Model transformacji cyfrowej w przedsiębiorstwach (Ernst & Young, Digital Transformation Guidelines)

Currently, coal mines have been exploited more and more deeply due to the depletion of coal reserves. This leads to an increase in the cost of fuel which is seen as the driving force of the exploitation process and creates extra costs in transportation, ventilation, drainage, methane fire safety, etc. Besides, deep mining still needs to improve the efficiency of the work to ensure the safety of workers and equipment.

Another challenge is the lack of business capital and difficulty in raising investment capital. This is because mining enterprises often need large investment capital, a long time for having profits, and many costs incurred. Therefore, in order to operate effectively, mining companies need to prepare a large amount of capital to cover both short-term and long-term expenses, and counterpart funds. In order to achieve the level of coal mining output according to Decision No. 403/QĐ-TTg on “Planning coal industry development to the year 2020, with a vision to the year 2030”, all coal mining companies will need a total investment of about 269,000 billion VND, with an average of 17934 billion VND per year (nangluongvietnam.vn.news/vn).

Moreover, other problems include inefficient management of investment capital, poor assessment methods for investment projects, scattered investments, and limitations in the development of business strategies and investment forecasts. These may cause a series of bad investment projects of VIANCOMIN in subsidiaries and affiliates in recent years, causing losses of trillions of dong, leading to a huge amount of debt up to more than 100,000 billion VND, with an interest of 12 billion VND every day (thuonghieucongluan.com.vn and kienthuc.net.vn).

From the safety perspective, the flight altitude needs to In recent years, labor productivity in the coal mining sector has gradually improved but is still quite low compared to the common level in some other countries in the region and in the world. According to the assessment of the Intergovernmental panel on climate change (IPCC), Vietnam is one of the five countries that will be most affected by climate change [3, 14]. Climate change makes the occurrence of natural disasters such as storms, floods, lightning, and landslides more frequent and serious, causes many difficulties in ensuring mine safety, reduces mining productivity, and significantly increases the cost of disaster prevention and recovery.

In addition, there are many other difficulties that Vietnamese coal mining companies are facing such as increasingly strict regulations of environmental protection, competition from cheap imported coal sources, instability of price and purchasing power of the coal consumption market, the decrease in the coal industry's attractiveness to labor.

To overcome the challenges posed to coal and mineral mining companies in Vietnam, it is necessary to have quick changes. The most important change might be the effective application of scientific and technical advances from the fourth industrial revolution (4.0) into each stage of the management, production, and business processes, and this is a mandatory requirement of the nature and survival of businesses. In a study, McKinsey predicted that digital transformation in the global mining industry will reduce costs by 17% in 2025. Therefore, it can be noted that digital transformation is no longer an idea or vision for the future, in fact, it is a compulsory activity for production and business enterprises in general. Vietnamese mining companies must urgently implement digital transformation to adapt to new changes in the 4th digital age.

In Vietnam, basically, the energy industry is divided into two groups: the material and fuel industry and the electricity industry. Furthermore, in the raw material and fuel extraction industry, there are two main industries: the coal mining industry and the oil extraction industry. Therefore, it can be said that the energy industry includes three main industries: the coal mining industry, the oil and gas extraction industry, and the electricity industry.

In the national digital transformation program, energy is one of eight priority areas for implementation. According to Decision No. 749 dated June 3, 2020, on approving the National Digital Transformation Program to 2025 and orientation to 2030 of the Prime Minister, “For digital transformation in the energy sector, priority is to be given to focusing on the power sector towards maximizing and automating networks for efficient power supply, connecting digital meters to improve speed and billing accuracy, identifying network problems faster, helping users save energy, and detecting losses of electrical power” Coal and mineral mining is one of the key resource extraction sectors of the country and is managed and exploited by Vinacomin. Therefore, digital transformation in

this field is extremely important, contributing to improving the production efficiency of enterprises and national economic potential.

Digital transformation brings many benefits to coal mining enterprises from management to research and business. Coal mining enterprises can optimize operating costs and increase labor efficiency; better reach and satisfy customers; leaders make timely and more accurate decisions when switching from the traditional model to the application model of modern technologies.

Practical experience shows that the successful formula of enterprise digital transformation is the combination of five pillars: (i) Digital business culture and strategy; (ii) Connect and optimize customer experience; (iii) Process optimization; (iv) Technology; (v) Data analysis and management.

2. Status of digital transformation in the coal-mineral sector in today's Vietnam

2.1. Applying advanced technologies in exploration and exploitation

a. Inevitable trend of mechanization in the exploration, exploitation, and processing of the coal-mineral industry

In order to grasp the trend and advantages of digital transformation, Vinacomin has promoted the application of IT and the application of computer software in some stages of the chain of coal production; For example, Vinacomin's geological data mining and management system allow the construction and integration of geological data into a geological data bank (N.C.Nguyen, 2022).

Typically, VINACOMIN has applied a coal flow monitoring system that provides information about coal volume and quality to its units in a complete and intuitive way. A geologic data bank helps to upgrade the document management and operational management system to standardize the management procedure of administrative documents. In addition, they integrate digital signatures and move forward to document interoperability throughout the group, subsidiaries, and affiliated units, and have many other information technology ideas. Deo Nai Coal Joint Stock Company – VINACOMIN has conducted 34 projects of computerization, automation, and application of information technology in production. In particular, it is worth noting that the company employs online recording and statistics software, Google Sheets. Ung Bi Coal Joint Stock Company – VINACOMIN has deployed a software environment for assigning daily tasks, instead of handwritten like before, which reduces the time to do this job from 60–120 minutes to about 10 minutes, integrating fingerprint and face recognition into the daily shift delivery process, ... (baoquangninh.com.vn)

In the context of the strong impacts of the 4.0 technology revolution on production and business as well as all activities of social life, the coal-mineral industry has also experienced great efforts in facilitating innovations through constantly applying modern technologies and implementing digital transformation in production, business, and coal-mineral exploitation. It is confirmed that mechanization is an inevitable trend of VINACOMIN.

- For open-pit mines

+ Completing the technical connection of mines that have the same mineral deposits (e.g. Deo Nai – Coc Sau; and

Cao Son – Khe Cham II), developing and expanding existing open-pit mines in the direction of increasing the stripping ratio; maximizing the exploitation capacity in accordance with the planning on dumping, transportation, and drainage, protecting the landscape and environment, actively responding to climate change and extreme weather.

+ Basically, mechanization is undertaken at all stages of production; systematically applying heavy mechanized equipment to reduce costs, such as 130 metric ton dump trucks (Ha Tu mine), large-diameter drills (up to 269 mm), hydraulic excavators with 12 m³ for the volume of a bucket, the transportation system combining trucks and conveyor. For example, in Cao Son mine, the conveyor transports waste rock with a designed capacity of up to 20 million m³/year; Improving the quality of drilling–blasting activities to reduce the cost of rock removal for open-pit coal mines.

+ Researching on applying new technologies and using materials for road construction in order to utilize local materials and reduce costs of trucks' tires; studying and testing the automatic fuel distribution and monitoring system and investing in applying modern software to manage from design to operation and production monitoring.

- For exploiting crude coal tar:

Over the years, VINACOMIN has made efforts to implement digital transformation, constantly investing capital to purchase equipment, and applying modern technology in production and business, especially the group has been applying mechanized equipment in coal mining, therefore, the volume of crude coal tar has been increasing in recent years.

According to reports of Vinacomin, the production of crude coal tar in the period from 2017 to 2020 was presented as follows: The total output of crude coal tar exploited from 2017 to 2010 increased. Figure 2 shows that in 2017, the total mining output was 40,501 thousand tons, of which open-pit coal reached 14,804 thousand tons, underground coal was 24,884 thousand tons, and other methods were 812 tons. In 2018, the total number was 42,939 thousand tons, of which open-cast coal reached 16,281 thousand tons, underground coal was 25,854 thousand tons, and other methods were 803 tons. In 2019, the total number was 46,9675 thousand tons, of which open-pit coal reached 18,858 thousand tons, underground coal was 27,149 thousand tons, and other methods were 668 tons. 2019 is also a year with higher coal mining output than 2017, 2018, and 2020. In 2020, the total mining product is 44,894 thousand tons, of which open-pit coal reaches 17,194 thousand tons, underground coal is 27 thousand tons, 145 thousand tons, and the other method 555 tons. Total coal mining product in 2020 decreased by 1,781 thousand tons compared to 2019 but was still higher than those in 2017 and 2018. In 2020, there was a decrease in the coal mining rate due to the Covid-19 pandemic which has seriously affected all areas of social life, especially in production and business.

- For underground coal mine

In underground coal mining, the geological conditions of mines with many faults, the complex structure of the coal seam, and the thickness and slope angle of the seam are uneven, making it difficult to apply mechanization. Therefore, the rate of mechanized working tunnels (using continuous miners) only reached 13.4% in 2018, and 15% in 2019. The

Unit: thousand tons

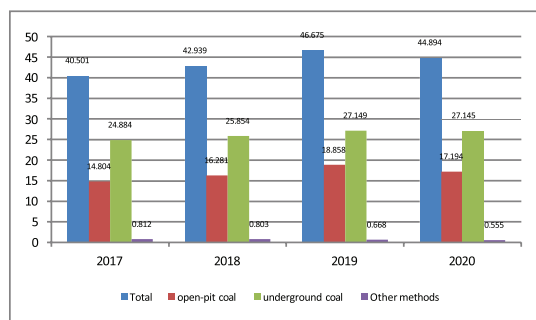


Fig. 2. The output of exploited crude coal tar in the 2017–2020 period. (Source: The reports of VINACOMIN and DONG BAC)
Rys. 2. Wydobywanie wydobywanej surowej smoły węglowej w latach 2017-2020. (Źródło: raporty VINACOMIN i DONG BAC)

Unit: %

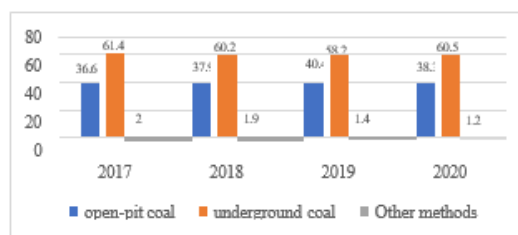


Fig. 3. Contribution rate of crude coal tar production by different exploitation methods (Source: The reports of VINACOMIN and DONG BAC)
Rys. 3. Wskaźnik udziału produkcji surowej smoły węglowej różnymi metodami eksploatacji (Źródło: Raporty VINACOMIN i DONG BAC)

increase in the rate of mechanization was due to the Ha Lam Coal Joint Stock Company where there were two mechanized working tunnels with a capacity of 1.8 million tons of coal per year. In these two tunnels, self-advancing hydraulic ceiling supports (including continuous miners, GK, GX, ZH frame/chain rack, ZRY staging, XDY TLDD rack...)

Thanks to the effective application of mechanized equipment, coal production and productivity of units in VINACOMIN increased significantly, helping VINACOMIN to successfully achieve the objectives in production and business, and improve business conditions, working conditions, and ensure labor safety in coal mining.

Facing difficulties due to complex geological conditions, deep mining, high pressure, and the potential risk of gas explosions, VINACOMIN actively took the initiative of using technological solutions in production.

Typically, an automatic methane explosion (CH₄) control system has been introduced into tunnels, helping VINACOMIN to master the assessment of methane content in coal seams. As a result, a series of centralized automatic methane monitoring systems have been put into operation in most underground mines and connected to the internet for remote monitoring.

+ Design and construction of underground coal mines with a high degree of mechanization, and modern and heavy equipment, including design and construction of mine shafts (Ha Lam, Nui Beo, Khe Cham II-IV, and Mao Khe).

+ Promote the application of systematic mining mechanization, especially the mechanized longwall working tunnels with a capacity of up to 1.2 million tons/year is applied at Ha Lam Coal Joint Stock Company; use light hydraulic ceiling supports, combined with frame rack and chain rack; maximize applications of modern ceiling supports in areas with

suitable conditions, completely replacing wooden pillars and heading to replace single hydraulic cylinders; use ZRY and GM hydraulic ceiling supports in areas of medium thickness and steep seams to replace old technologies of coal mining; apply mechanization in most stages of transportation; promoting the application of mechanization to excavate tunnels with anchors in order to improve productivity and safety.

+ Improve the level of automation in monitoring and control of drainage pumping stations in working tunnels (applied in Ha Lam, and Vang Danh), conveyor transport (applied in many mines), power stations (applied in Ha Lam, and Nui Beo), emulsifying fluid supply stations (applied in Khe Cham, Thong Nhat), automatic ventilation systems (applied in Mao Khe, and Thong Nhat); apply energy saving solutions, to reduce labor, improve production and business efficiency.

- For coal screening and processing

+ Renovating and building new coal screening and processing plants with deep processing technology and modern equipment suitable to the characteristics of regional coal such as pressurized gas sedimentation machine, wheel suspension, multi-curved sieve sloping surface... double-sealed sludge treatment by pressing and drying system. Product quality after processing with a high recovery rate from 85–90%, waste rock Ak>80%, and loss of finished products in processing approaches 0%.

+ New investment has been made to improve the automation system of screening and processing stages, ensuring digitization, automation, and centralized control.

(i) For other mineral open-pit mines:

Open-pit mines such as bauxite Tan Rai, Nhan Co, Dong Sin Quyen, Dong Ta Phoi, have been applying heavy mining equipment and continuous transportation to reduce the cost

of production. Applying automatic equipment monitoring systems and researching and investing in applying software to manage from planning to production operation.

(ii) For other mineral underground mines:

+ Using new high-productivity mining and transportation equipment for underground mines such as lead-zinc mines in Thai Nguyen – Bac Kan region and making new investments in copper mines Vi Kem – Lao Cai, a tin mine southwest of Nui Phao.

+ Applying robotics in production inspection and administration; applying energy-saving solutions to reduce costs, and labor, and improve production and business efficiency.

(iii) For the field of mineral processing:

+ New investments in the mineral selection, refining, and processing factories in recent years have been researched and invested from the very beginning with advanced technology and equipment with high levels of mechanization, automation, and IT usage for different minerals and climatic conditions of each mining region.

+ During production operation, VINACOMIN has researched, improved, and innovated technologies at some stages to be more suitable to actual conditions, contributing to reducing costs, and improving production and business efficiency, typically as:

+ In the selection of copper, zinc, and iron ores: Researched, manufactured, and put into effective use the system of cell flotation equipment and researched to replace and use environmentally friendly flotation agents, therefore it helps to increase the net ore yield from 92.52% to 94.0% for iron, from 25.2% to 27.0% for copper, and from 91.8% to 92.7% for zinc (Figure 4).

+ In alumina smelting: focusing on mixing, neutralizing materials, adjusting technologies, and regularly learning and applying solutions to optimize production such as: improving the process of feeding and draining the concentration system - adjusting the solution, changing the diameter of the pipes and plates of the separators at Lam Lam Aluminum Company Copper; Taking advantage of the second condensate of the condensation station for recycling, improving the filter system for the bottom flow pumps in the red mud washing area at Dak Nong Aluminum Company, thereby reducing the consumption of raw materials (coal, sedimentation aids), improving production efficiency.

- For the field of mechanical engineering

+ VINACOMIN's mechanical engineering has gradually developed in the direction of modernizing repairing mechanics, and developing mechanical engineering with focusing on promoting technology research, investing in equipment to increase mechanical engineering capacity, step by step mastering designs and technologies to manufacture imported equipment and spare parts. Using modern technological equipment in precision machining stages and gradually automating the production stages, including specialized equipment for the production of hydraulic cylinders; assembly of heavy trucks; manufacture of industrial alloy chains; rolling steel for tunnels, specially shaped steel, and making rollers.

+ The mechanical production division of VINACOMIN has researched and mastered the manufacturing technologies and produced a series of key mechanical products, such as the production of all kinds of hydraulic struts, supports, and soft

rigs (CCTL), DW, XDY, GK, ZH, GN, GM 20/30...); conveyor belts used in the mining industry (BT, BT-VMC, BTC...); cable car winch (TCCN), excavator (VMC E500-1, ML 01-0.15, XD-0.32...), rake chute (SKAT), electric train (TDM, TD...), starting verbs, explosion-proof transformers, soft starters used in underground mines (KDP, TBKP, TBHPD, TKMP...), screening equipment (vibrating screens, feeders, beaters...), spare parts replacement equipment for repairing drilling machines, excavators, automobiles especially, VINACOMIN's mechanical engineering division has linked and cooperated with design and construction consultancy units in VINACOMIN to successfully carried out the EPC project for designing, manufacturing, construction and installation of coal screening plants, Tan Rai bauxite ore screening plant, Nhan Co bauxite ore screening plant, and Vang Danh 2 screening plant.

b. Achievements in mechanization in exploration, extraction, and processing of the coal-mineral industry

In 2015, VINACOMIN employed mechanized longwall working tunnels with a capacity of 600,000 tons/year at Ha Lam, Duong Huy, Khe Cham Coal Companies and mechanized longwall working tunnels for thin-seam coal mining with a capacity of 180,000 tons/year at Quang Hanh Coal Company. At the same time, the mechanization for the exploitation of slope seams with a combination of 2ANSH ceiling supports combined with planers and ZRY soft rigs at Mao Khe, Uong Bi, Hong Thai Coal mines initially improved the working conditions, achieved productivity, and ensured labor safety.

In 2016, the mining output by mechanization technologies of VINACOMIN reached about 1.42 million tons, accounting for 7% of underground mining output. This level of production has far exceeded previous years, nearly two times the production level in the year 2015.

In 2017, over 14,221 billion VND was invested in upgrading the mining system. All signals and operating parameters of each conveyor were transmitted to the control center. This project optimized the number of workers operating the conveyor lines, from 45 operators/day and night of production to 12 workers. With this system, the operator could monitor the entire operation of the conveyor lines, and remove metal mixed in coal. At the same time, they could identify each location at risk of incidents to coordinate with the organization to fix the problem as quickly as possible, ensuring safety in the production process (THINK TANK VINASA, 2019).

VINACOMIN used 96 hydraulic ceiling supports, cutting machines, scrapers, and conveyors for transporting coal. After more than one year of operation, the mechanized longwall working tunnels of Mong Duong Coal have exceeded the design capacity.

According to VINACOMIN's business result reports, in the first 9 months of 2017, the Group's coal production by mechanization reached 1.95 million tons, equal to 225% compared to the same period in 2016. The length of the tunnels is 8,113 m, with an increase of 22% from the plan and an increase of 79.3% compared to the same period in 2016 (THINK TANK VINASA, 2019).

In 2018, the group's coal output reached 36.95 million tons, exceeding 4% compared to the plan at the beginning of the year, and up 5% compared to that of 2017. Coal consumption reached 40.5 million tons, an increase of 4 million

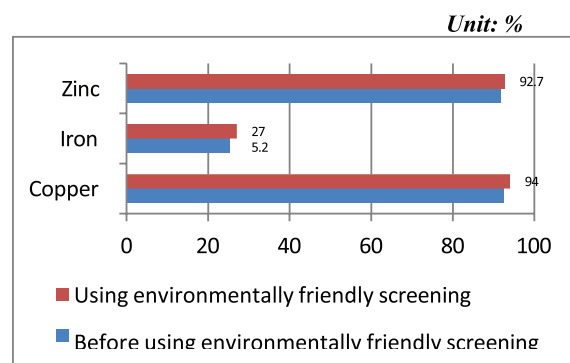


Fig. 4. Actual extraction rate of ore concentrates when effectively applying the cellular flotation system and using environmentally friendly screening (Source: The reports of VINACOMIN and DONG BAC)

Rys. 4. Rzeczywista wydajność wydobycia koncentratów rudy przy efektywnym zastosowaniu flotacji komórkowej i zastosowaniu przesiewania przyjaznego dla środowiska (Źródło: raporty VINACOMIN i DONG BAC)

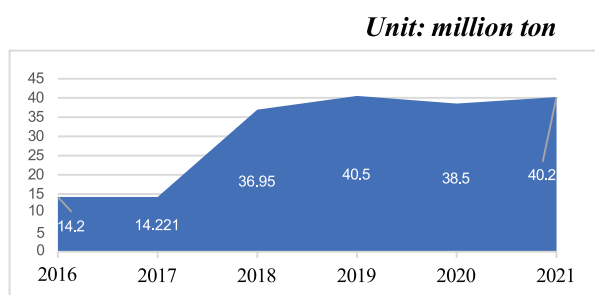


Fig. 5. Coal output in the 2016 -2020 period (Source: The reports of VINACOMIN and DONG BAC)

Rys. 5. Wydobycie węgla w latach 2016-2020 (Źródło: Raporty VINACOMIN i DONG BAC)

tons compared to the 2017 plan and increased by 5 million tons compared to that of 2017. Meanwhile, the electricity output produced by VINACOMIN reached 9.4 billion kWh (accounting for nearly 5% of the country's electricity output). VINACOMIN's revenue in 2018 reached VND 121,700 billion, up 13% compared to that of 2017. Its profit reached VND 4,000 billion, up 1,000 billion compared to that of 2017.

VINACOMIN has seven mechanized lines for coal slope seam exploitation in operation. Mining output by these lines grew significantly, from more than 720,000 tons in 2015 to more than 3 million tons in 2018 (accounted for 13.3% of the total coal underground production).

In 2019, VINACOMIN's production output reached 40.5 million tons of coal and consumption reached 44 million tons. This had been the highest output achieved by the Group since 2014. Domestic coal consumption reached 42.95 million tons, an increase of 8% compared to that of 2018. The coal supply for electricity production reached 36.06 million tons, an increase of 6.8 million tons. The Group's revenue in 2019 reached VND 131,500 billion, an increase of 9% compared to that of 2018.

VINACOMIN's coal output has reached 40.5 million tons, an increase of 9% compared to that of 2018 and about 6 times higher than that of 1995 (7 million tons). Since its establishment in 1995, after 25 years of development, VINACOMIN has exploited 700 million tons and consumed 715 million tons of coal. To achieve this output, VINACOMIN has excavated 5.2 thousand km of tunnels, 3 times the length of Vietnam, excavated 206 km/year on average, and excavated an average number of 3.4 billion m³ of soil and rock, with 128 million m³/year. Total coal revenue increased from VND 1.3 trillion in 1994 to VND 62.26 trillion in 2018; Labor productivity in

terms of crude coal tar in 2018 reached 572 tons/person per year, an increase of 3.45 times compared to that of 1995.

VINACOMIN has strongly applied sciences and technologies in its production to increase labor productivity, and mining output, and save the country's mineral resources. For underground mines, VINACOMIN increasingly uses modern mining technologies, such as mechanized systems for coal mining and mine shafts with depths from 350 to 500 meters. The total output of coal extracted by mechanization from 2002 to the end of 2017 reached 12.75 million tons. In 2008, the rate of coal mining by mechanized systems only accounted for about 3% of the total coal production, but now it has increased to 15%. The length of tunnels in 2019 exceeded 40,000 meters, reaching over 18% of the total excavation length. Along with that, mechanization and automation are also promoted to apply to ventilation and control of mine gas and drainage in underground mines (ncif.gov.vn)

Currently, VINACOMIN has 10 out of 13 units investing in automation systems for the main conveyor line from tunnels to outside. Thanks to the application of automation and computerization in coal production and processing, VINACOMIN has saved more than 900 workers; average labor productivity reached 714 tons of coal/person in 2019, an increase of 12% compared to that of 2018. The economic profit thanks to the application of automation and computerization of the whole corporation is estimated at 260 billion VND/person.

In 2020, VINACOMIN produced 38.5 million tons of coal and consumed 42 million tons; excavating soil and rock was over 188 million m³, excavating nearly 255,000 m³ of tunnels. In 2021, planning to exploit 38.5 million tons of coal and consume 42 million tons. The production conditions of mines are getting deeper and deeper, production costs are increas-

ing day by day, affecting to implementation of economic and technical targets of VINACOMIN. However, VINACOMIN still sets the target of coal production and consumption not lower than 2020; to ensure an adequate supply of coal to the households that have signed commitments with the Group. Particularly, mechanized coal production reached 15.8% of total coal production.

In 2020, VINACOMIN operates two light mechanized tunnels for the first time. After more than a year of being put into use, these systems have proved the investment efficiency and opened up new prospects for the underground coal mining field, especially in the areas of thick and conditioned seams with complex geological conditions.

VINACOMIN used two mechanized equipment systems for testing in the VM-L(7)-1 longwall working tunnel at -250/-100 m level of seam 7 in Vu Mon zone of Mong Duong Coal Joint Stock Company and the I-11-5 longwall working tunnel at the -320/-295 m level, seam 11 of Khe Cham I zone of Ha Long Coal Company. According to the assessment of the Institute of Mining Science, up to 2020, after nearly one year of operation, these two systems had the advantage of small size and weight, allowing them to be transported across roads. The tunnel's smallest usable area was up to 8.5 m². Its transportation and installation were more convenient. Ha Long Coal Company took only 18 days to complete the transportation and installation. For working tunnels in the Mong Duong coal mine, it took 25 days for installation (equivalent to 2/3 of the time for transporting and installing the medium and heavy complexes of mechanized systems applied in VINACOMIN's mines). The coal mining output of the two tunnels was about 300,000 tons/year. Labor productivity increased 1.5-2 times compared with that of old technologies (iimm.com.vn).

From October 2020 to now, the raw coal output of the light mechanized working tunnel has reached 247,000 tons, equal to 82% of the design capacity. Direct labor productivity is from 14 to approximately 29 tons/day/person, an average of 21.5 tons/day/person. Compared with the traditional tunnels with the same conditions in the company, the output of light mechanized working tunnels is more than 2 times higher, labor productivity increases by approximately 5 times, and costs are reduced from 5-18% (www.vinacomin.vn).

Figure 5 shows that in 2021, VINACOMIN exploited 40.2 million tons of coal, an increase of 7% compared to 2020. Consuming nearly 45 million tons, an increase of 6%; in which, domestic consumption reached nearly 43 million tons, an increase of 4%, and exported 1.7 million tons of coal, an increase of 192%. The total amount of coal in storage was 8.3 million tons. The Group also produced 1.43 million tons of alumina and consumed 1.45 million tons; exploiting 99.6 thousand tons of copper concentrate; producing 10.5 billion kWh of electricity, reaching 105% of the year plan. The average salary was 12.97 million VND/person/month (ncif.gov.vn).

In 2021, VINACOMIN applied automation and computerization in management to increase labor productivity and product quality, and reduce costs. Many important missions and tasks have been carried out on schedule, bringing high efficiency in production, and making an important contribution to fulfilling the 2021 targets of production and business, such as mechanized working tunnels of factory five exceeding the design capacity of 320,000/300,000 tons/year. Specifical-

ly, on December 18, 2021, the company's coal output reached 1,561,536 tons, exceeding 101%; in which, coal mined output reached 1,511,398 tons. Coal consumption output reached 1,554,598 tons, reaching 101% of the plan.

In the field of open-pit mining, new technologies have been applied in mining down below the self-flowing drainage level, applying equipment to loosen soil and rock by the method without blasting; drilling and blasting technology in flooded borehole conditions; technology using excavator equipment for combined transport. Or in the field of coal screening, advanced screening technologies have been applied to improve the quality of finished products, make full use of sieved coal and bad quality coal by the technology of spinning and self-generating suspensions. In particular, the coal industry has actively designed and manufactured technologies and equipment to avoid dependence on foreign countries and increase the localization rate. Notably, the successful manufacture of equipment and application of construction technologies for mine shafts in the Nui Beo underground coal mine have contributed to improving the technical capacity of the engineers, and workers in mastering issues from design, technological process, equipment manufacturing, and construction of deep mining works.

2.2. Applying advanced technologies in mining and environmental protection

With the trend that coal demand has been increasing, improving the quality of coal, taking advantage of resources, and protecting the environment are the factors that coal producers put as the top priority. The application of advanced technologies in coal mining and processing has brought initial results in environmental protection and sustainable development. VINACOMIN has cooperated with Viet An Environmental Engineering Joint Stock Company Group to apply many centralized wastewater monitoring systems (Mao Khe Coal Company – VINACOMIN; Mong Duong Coal Joint Stock Company – Vinacomin), emission monitoring station (Cao Ngan Thermal Power Company – Vinacomin; Lam Dong Aluminum Company Limited – VINACOMIN) in the whole VINACOMIN with a total of 37 wastewater monitoring stations, including: Monitoring system centralized wastewater provides information on the volume and quality of wastewater at the units in a complete and intuitive manner; the VINACOMIN wastewater data mining and management system - allows the construction and integration of mine wastewater data belonging to VINACOMIN into one data bank; upgrade the document management and operation management system to standardize the operating document management business process, integrate digital signatures and move towards document interoperability throughout the Group, including subsidiaries, affiliates, and subsidiaries. subordinate units, and many other information technology systems (H.M.Nong et al., 2022).

- For the coal mining industry:

+Waste collection and treatment: by the end of 2020, 43 mine wastewater treatment stations (excluding domestic wastewater treatment stations and other industrial wastewater treatment stations) have been built with a total capacity of over 50,000 m³/h, equivalent to more than 200 million m³/year. This ensured that mines have wastewater treatment sta-

tions meeting environmental standards. The group built and maintained an industrial hazardous waste treatment plant in Quang Ninh, annually treating over 3,600 tons of hazardous waste from its units, of which over 50% of products are treated, reused for production. Waste cinder blocks generated from coal sifting are dumped into planned waste dumps. Ordinary industrial solid waste and daily-life solid waste generated in production shall be collected and treated in accordance with regulations.

+ Rehabilitation and restoration of the environment:

Planting trees to improve and restore the environment is now over 1,500 ha. Some typical environmental rehabilitation and restoration areas have been completed, such as dumping sites: Nam Deo Nai, Nam Lo Phong, Chinh Bac Nui Beo, a part of Dong Cao Son, and Nam Khe Tam – Dong Khe Sim dumping site. Implement the plan of planting trees with high density to quickly green the mine waste dumps, shorten the greening time from 5-6 years ago to 2-3 years now, contributing to limiting soil leaching, stone, reduce dust emissions, and rapidly improve the general landscape environment, especially in Ha Long city. From 2016 to now, VINACOMIN has conducted more than 10 projects to build dykes and dams to prevent landslides and erosion, about 20 projects of environmental rehabilitation and restoration, and nearly 40 projects of renovation and dredging of drainage systems and sedimentation lakes. Funding for this work is deducted from the centralized Environmental Protection Fund, environmental protection expenses, and investment costs of the unit.

+ Dust prevention: Currently, transporting coal to ports and to power plants in Quang Ninh, Thai Nguyen, and Lang Son is basically done by conveyors and railways to prevent the spreading of dust, and contribute to the improvement of the urban environmental landscape. By the end of 2020, VINACOMIN has utilized over 80 high-pressure dust-extinguishing nebulizers (both mobile and fixed) for its mines. Using a 50 m³ mine road irrigation vehicle to improve the capacity and efficiency of dust suppression on mine routes. Other anti-dust solutions in production have been enhanced: making hard dust covers on wagons, building car and wagon washing stations, making dust nets for coal warehouses, and covering coal trucks and warehouses with tarpaulins piles investing in the additional capacity of dust suppression water trucks, anti-dust water supply systems on waste dumps.

+ Renovation of the landscape and environment: The landscape reclamation has been carried out at 4 concentrated warehouses and ports (KM6, Lang Khanh, Ben Can, Dien Cong) and 6 production sites, and the same for other production sites, new mines are built with green – clean – beautiful criteria (Nui Beo, Ha Lam, Thanh Cong, Giap Khau); Specialized coal transport routes are improved to ensure drainage, planting trees on both sides to prevent dust and noise, and improve the landscape environment.

+ Environmental pollution control: VINACOMIN cooperates with Quang Ninh province to install more than 50 automatic environmental monitoring systems for coal mine wastewater, and transmit data directly to the Department of Natural Resources and the Environment in accordance with the provisions of the Law on Environmental Protection. Continuing to carry out concentrated environmental monitoring for residential areas at risk of being affected outside the man-

agement boundary to control and detect pollution risks, and promptly direct the implementation of preventive measures. Carrying out periodical environmental monitoring at the member unit in accordance with the approved environmental impact assessment report.

+ Climate change response: Construction of many dams and dykes to prevent soil and rock at the bottom of dumping sites. Currently, the coal mine waste dumps have basically enough dykes as planned, preventing soil and rock from flowing, ensuring safety for production and population; Building nearly three dozen reservoirs upstream of streams for drainage, regularly dredging the system of rivers and streams to reduce sedimentation and prevent flooding. Relocating hundreds of households in dozens of areas at risk of dangerous landslides and floods due to the influence of VINACOMIN's mining areas under the Quang Ninh Provincial Master Migration Project to ensure people's safety. residence during the rainy season.

- According to the general assessment of VINACOMIN, environmental protection in mining has achieved the following results:

+ In 2010, all sources of environmental pollution were treated and controlled (water, soil, and air); By 2015, it was to basically improve the main environmental indicators in sensitive areas (urban areas, residential areas, tourist attractions, etc.), and all mines met environmental standards; Up to now, VINACOMIN has fully met environmental standards throughout the mining area.

+ VINACOMIN has done a good job in propagating, educating, and disseminating knowledge about environmental protection to all officers and employees, not only for units directly involved in production but also for consulting units.

+ Up to now, VINACOMIN has made efforts to complete more than a dozen large projects and hundreds of small and medium projects, such as wastewater treatment works, hazardous wastes, landfill rehabilitation, dredging of rivers and streams, etc. construction of embankments and dams, new construction of roads to avoid people's livelihood, relocation of seaports, coal mining plants, etc. shall be deducted from production costs, environmental funds, environmental concentration costs, and other expenses.

+ VINACOMIN has built a 5 to 10-year long-term plan and roadmap for the treatment, management, and reuse of mine wastewater, reclamation, and restoration of waste dumps, dust treatment, capacity building environmental management.

+ VINACOMIN has built an environmental database for the whole industry to store and look up data.

+ VINACOMIN has strictly observed and strictly controlled the implementation of processes and technical standards for safety and environment in coal exploration, mining, transportation, processing, and use. The investor has made an environmental impact assessment report and submitted it in accordance with current regulations before issuing the mining license and closing the mine under the guidance of the Ministry of Natural Resources and Environment.

+ VINACOMIN has built 45 mine wastewater treatment stations with a capacity of more than 120 million m³/year. This is to ensure that all underground wastewater is treated according to standards; moving many working sites and coal

production plants out of the centers, contributing to improving the landscape environment and urban development of the mining area. In mid-2019, VINACOMIN terminated the operation of the Nam Cau Trang Coal Screening Plant (nearly 33 hectares). VINACOMIN has invested 1,600 billion VND in the coal processing center and concentrated coal warehouse in the Hon Gai area; dredging the Lang Khanh port channel to serve the relocation of a new production location. In phase 1, VINACOMIN builds a screening station with a capacity of 2.5 million tons of coal/year; a system of raw coal storage with a capacity of 48,000 tons; a closed conveyor system transporting coal from Ha Lam and Hon Gai mines to the center. The successful relocation of Nam Cau Trang Coal Screening Plant helps VINACOMIN to completely handle the problem of dust and noise environment affecting the surrounding urban area and Ha Long Bay (vietcleanair.vn).

- About the mining and mineral processing industry:

In the past years, companies in the mining and mineral processing industry have planted trees to green the waste dumps and closed mines, prioritizing the dumping of waste to end each area to soon restore the environment, and protect the landscape.

They employed a system to treat mine wastewater and ore extraction wastewater without fully reusing it to ensure environmental standards; built a hydrometallurgical sludge treatment system for a zinc electrolytic plant; increased capacity and scale of waste storage and treatment works to ensure thorough collection and treatment in accordance with regulations; complete installation of an automatic environmental monitoring system for wastewater and emissions. Increase recycling and reuse of waste for production and supply to other businesses.

They also strengthened anti-dust work, planted a green belt to prevent dust, installed high-pressure dust-extinguishing foggers at primary ore depots, and rock waste dumps, used specialized road irrigation vehicles, and strengthened anti-dust solutions to increase dust suppression efficiency (installation of anti-dust nets, use of modern and advanced equipment to create less dust...). They regularly carried out industrial cleaning and preserved the landscape and environment of the factory to ensure the thorough prevention of dust and noise emissions affecting the area's environment.

They built a system of dikes and dams at the bottom of waste dumps, dams of reservoirs to settle upstream soil and rocks, and regularly dredging rivers and streams to reduce drainage. Other activities were done, including regularly inspecting and reinforcing tailing ore reservoir dams to ensure safety and prevent the risk of dam overflow; formulating and proactively implementing plans to prevent chemical leakage and natural disasters to ensure the safety of production, population, and environment.

VINACOMIN has installed an anti-dust system in coal mining. Because some areas of the company still are next to scattered and interspersed residential areas, it is compulsory to have the lowest level of environmental pollution. Therefore, coal mining companies have purchased modern equipment to increase mining productivity and reduce the amount of dust generated in the process of mining and screening and improve climatic and working conditions for workers.

Typically, Mao Khe Coal Company invested more than seven billion VND to install a dust-proof system for sieve house 56 and the route next to the tunnel's door. The company cooperates with the local government in dredging and clearing the Cau Lim stream, especially the section through the residential area of Mao Khe ward, to ensure irrigation and drainage. All underground wastewater during the mining process of the company is pumped to two industrial wastewater treatment plants with a capacity of 1,800 m³/hour, treated up to standards before being released into the environment, and a part is reused in production. Domestic wastewater is collected to two treatment stations with a capacity of 500 m³/day, ensuring that all wastewater meets standards before being discharged into the environment. Mao Khe Coal Company also signed a contract with Quang Ninh Center for Monitoring of Natural Resources and Environment to monitor the environment, quality of wastewater, and receiving water on a quarterly basis to promptly detect and correctly overcome the risks of pollution (www.vinacomin.vn).

Underground mines aim to build a model of green mines, modern mines, and high-yield mines, applying maximum mechanization to all stages of production lines. VINACOMIN also completes the model of "Coal production and trade", mixing between domestically produced coal and imported coal with an appropriate ratio. In particular, priority is given to spending more than 7,400 billion VND on key projects, such as exploiting coal seams below -150 m of Mao Khe mine (Mao Khe Underground Coal Company); the II-IV mining coal underground (Ha Long Underground Coal Company). These projects were to increase capacity, helping the companies soon achieve the goal of a modern coal mine, with high productivity and quality.

In addition, VINACOMIN will promote investment in applying sciences and technologies in labor, to increase labor productivity and product quality, reduce costs, and improve the working environment; implementing key projects on schedule, looking for new investment projects, resolutely not investing in fields outside the industry; continue to implement the VINACOMIN restructuring project for the period of 2017 - 2020 and prepare to develop the VINACOMIN restructuring project for the period of 2021 - 2025 (cmsc.gov.vn).

3. Conclusions

In general, digital transformation in the field of coal and mineral mining has made certain progress and is consistent with the trend of digital transformation in Vietnam today as well as in the world. Thanks to the world's 4.0 technology platform, Vietnamese coal mining enterprises have created many successes, such as converting from traditional mining to a smart mining model which in turn helps to improve productivity, labor efficiency, and safety. At the same time, digital transformation has helped the mining process to reduce negative impacts on the environment, and ensure sustainable development. However, although in comparison with other products and business enterprises, the level of digital transformation in the field of coal and mineral mining is still slow, with the achievements, digital transformation in coal and mineral mining enterprises will certainly have further development in the future.

Literatura – References

1. Government of Vietnam (2020), Decision number 749/QD-TTg approved "National digital transformation program to 2025, a vision to 2030" in Vietnamese.
2. Digital Transformation Guidelines, a program to support businesses in digital transformation for the period 2021
3. 2025 of the Ministry of Planning and Investment, coordinated with the USAID LinkSME project, in Vietnamese.
4. Ran Liu, Dr.Pete Gailhofer Carl-Oto Grench Dr.Andreas Kohler Franziska Wolff(12/2019). Impacts of the digital transformation on the environment and sustainability.Beclin, Germany.p.136
5. Nguyen Hong Minh (2020), digital transformation in the oil and gas industry: current situation and prospects in Vietnam, Petroleum Magazine, No. 12-2020, pp. 4-11.
6. Nong Manh Hung, Hoang Van Khang, Nong Viet Trung, Nguyen Ngoc Bao (2022), Development trends of the environmental industry in terms of digital transformation associated with mining enterprises in Vietnam, Association Scientific workshop: Digital transformation of mining enterprises, Industry and Trade Publishing House, page 173
7. Nguyen Canh Nam (2022), The situation of applying digital transformation and digital technology in enterprises and the energy industry in Vietnam, page 30, Conference on Digital transformation in mining enterprises, Industry and trade publishing house.
8. VINACOMIN Group and Northeast Corporation
9. THINK TANK VINASA (2019), Vietnam in the digital transformation age, page 469, in Vietnamese.
10. <https://baochinhphu.vn/print/co-gioi-hoa-tu-dong-hoa-giai-phap-phat-trien-ben-vung-cho-nganh-than-102229916.htm>, in Vietnamese.
11. <http://ncif.gov.vn/Pages/NewsDetail.aspx?newid=22622>, in Vietnamese.
12. <http://iemm.com.vn/Tin-tuc/Tin-trong-va-ngoai-nuoc/29193/dot-pha-trong-cong-nghe-khai-thac-than-ham-lo>, in Vietnamese.
13. <http://www.vinacomin.vn/tin-tuc/co-gioi-hoa-hang-nhe-buoc-tien-moi-cua-nganh-than-202110281736582097.htm>, in Vietnamese.
14. <http://vietcleanair.vn/nganh-than-huong-toi-muc-tieu-phat-trien-ben-vung/cp.gov.vn/tin-tuc/t2212/ung-dung-cong-nghe-moi-trong-khai-thac-than.html>, in Vietnamese.
15. http://cmsc.gov.vn/xem-chi-tiet-VINACOMIN/-/asset_publisher/35kSuCATHogA/Content/VINACOMIN-can-oi-nang-luc-san-xuat-va-nhu-cau-thi-truong?, in Vietnamese.
16. Luu Thi Thu Ha (2019), TKV's capital for coal development investment: Current situation and solutions,<http://nangluongvietnam.vn.news/vn>
17. Vietnam Coal-Mineral Group owes more than VND 100,000 billion, paying interest of VND 12 billion every day, profits plummet" (2019),<https://thuonghieucongluan.com.vn>
18. Vietnam Coal and Mineral Industries Group is suffering a loss of VND 1,407 billion by the end of 2015 due to long-term financial investment activities" (2017)), <https://kienthuc.net.vn>
19. <https://baoquangninh.com.vn/chuyen-doi-so-trong-cac-doanh-nghiep-nganh-than-3182638.html>

Transformacja cyfrowa w sektorze wydobywczym w Wietnamie

Cyfrowa transformacja to jeden z nieuniknionych trendów w dzisiejszym świecie. Wietnam jest jednym z pionierskich krajów podążających za tym trendem i uruchomił krajowy program transformacji cyfrowej. Transformacja cyfrowa cieszy się dużym zainteresowaniem zarówno środowiska naukowców, jak i menedżerów w ogóle oraz w obszarze górnictwa węgla kamiennego i innych kopalni. Obecnie badacze koncentrują się na takich zagadnieniach, jak teoria transformacji cyfrowej zarówno w państwie, jak i w sektorze biznesowym, związki między transformacją cyfrową a budową e-government lub cyfrowego rządu oraz między transformacją cyfrową a efektywną administracją państwową. W niniejszym opracowaniu metoda analizy dokumentów (Desk review) została wykorzystana do analizy i oceny aktualnej sytuacji transformacji cyfrowej górnictwa węgla kamiennego i kopalni oraz identyfikacji osiągnięć i ograniczeń procesu transformacji cyfrowej w górnictwie węglowym i mineralnym. przemysł wydobywczy mineralów w Wietnamie.

W opracowaniu przedstawiono następujące zagadnienia: (1) Niektóre ogólne zagadnienia dotyczące transformacji cyfrowej, w których doprecyzowano pojęcie transformacji cyfrowej; Znaczenie transformacji cyfrowej w obszarze górnictwa węglowego i mineralnego; Wymagania transformacji cyfrowej w obszarze górnictwa węglowo-mineralnego. (2) Aktualny stan transformacji cyfrowej w górnictwie węglowo-mineralnym w Wietnamie, w tym zastosowanie zaawansowanych technologii w eksploracji i wydobywaniu oraz zastosowanie zaawansowanych technologii w górnictwie i ochronie środowiska.

Słowa kluczowe: transformacja cyfrowa, przemysł węglowo-mineralny, mechanizacja