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Current Status of Coal Mining and Some Highlights in the 2030 Development Plan of Coal Industry in Vietnam

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Abstract. Coal mining is one of the key mining industries in Vietnam. Coal is also an important fuel for many other industries. Currently, coal mining is mainly concentrated in Quang Ninh coal basin, the proportion of open-pit coal mining and underground mining is quite similar. However, according to Decision 403/QD-Ttg on approving the adjustment of the Vietnam coal industry development plan up to 2020, considering the prospects by 2030, the mining output will be from 51 to 54 million tons by year 2025 and from 55 to 57 million tons by 2030. In which, the proportion of underground coal mining will increase gradually compared with that of open-cast mining, specifically, by 2030, the proportion of the later compared to that of the former will be only 11%. According to this plan, open-pit coal mines have been shifting to underground mining technology, due to the increasingly deep conditions of coal seams. The following article will analyze the current status of coal mining in Vietnam and some highlights of the coal industry development plan to 2030, in order to provide a general picture of Vietnam's coal industry in the future.

Keywords: Coal mining, Depvelopment plan, Mining technology, Environmental protection

1. Current status of coal mining in Vietnam

1.1 Distribution of coal resources in Vietnam

Vietnamese coal is distributed in all three regions: the North, the Central and the South. In the mainland, coal is found in some main coal basins: Northeast, An Chau, Lang Son, Red River, Nong Son. There are also several small, scattered coal storage areas such as Song Da (Muom Lum, Suoi Bang, Doi Hoa), Nghe Tinh (Dong Do, Huong Khe), Chay river (Hong Quang), etc., in which coal reserves and resources are concentrated in the Northeast and Song Hong basins. Coal in the continental shelf of Vietnam is distributed in the Red River, Hoang Sa, Truong Sa, Phu Khanh, Cuu Long, Nam Con Son [1, 2].

1.2 Exploration work

Coal exploration in Vietnam has gradually clarified the geological structure, resources, and coal reserves in the coal basins in the mainland. The Northeast, An Chau, Lang Son and Red River basins are identified as essential coal basins.

Coal in the Northeast basin has been searched, explored and exploited since the 19th century. Up to now, the geological structure of the Northeast basin has been thoroughly evaluated. This is Vietnam's leading coal mining area with large reserves such as Mao Khe, Vang Danh, Ha Lam, Khe Cham. Most of the coal mines in the Northeast basin have been assigned by the State to Vietnam National Coal-Minerals Holding Corporation Limited (Vinacomin) and Dong Bac Corporation to manage and exploit. Currently, the exploration work in the Northeast basin has been completed to the level of -300m (except for the new mines: Dong Trieu - Pha Lai, Bao Dai, Cuoc Be). However, exploration work in the Northeast basin continues to be carried out to increase the reliability of the remaining coal reserves [1, 2, 3, 4].

Some mines with large reserves and resources such as Khanh Hoa, Nui Hong, Lang Cam, Phan Me in An Chau coal basin have been invested and explored through many stages. The geological structure has been basically clarified. However, Khanh Hoa mine and Nui Hong mine need to continue exploring correct coal reserves and resources [2].

1.3. Coal mining

Vinacomin and Dong Bac Corporation are two leading coal production and trading units in Vietnam, which supply 95% of domestic coal production.

There are 5 large open-pit mines with over 2.0 million tons/year (Cao Son, Coc Sau, Deo Nai, Ha Tu, Tay

Nam Da Mai), the remaining open-pit mines with a total of 100 to 200 thousand tons/year and some open seam mining points with a capacity of fewer than 100 thousand tons/year. There are about 30 underground mines currently in operation, of which 11 have large deposits, have relatively comprehensive technology and infrastructure, with a capacity of 1.0 million tons/year or more, such as Mao Khe (2.0 million tons), Trang Bach (1.2 million tons), Nam Mau (2.5 million tons), Vang Danh (3.7 million tons), Binh Minh (1 million tons), Ha Lam (2.4 million tons), Nga Hai (1.5 million tons), Khe Cham III (2.5 million tons), Khe Tam (2.5 million tons), Lo Tri (2.0 million tons) and Mong Duong (1.5 million tons) [5]. New mines are under construction, such as Nui Beo (2.0 million tons) and Khe Cham II-IV (3.5 million tons). The remaining mines have a capacity of fewer than 1.0 million tons/year. The mining area is narrow, reserves are small or scattered, and there are no conditions to develop high output and apply synchronously.

1.4. Mining Technology

a. Open-pit mining technology

Implementing the sustainable development policy, the coal industry has promoted technological innovation over the years, invested in modern equipment and large capacity. At present, the technical level of open-pit mines has reached an advanced level.

- Increased application of technology to loosen the soil by mechanical methods, especially in residential areas, works that need to be protected by hydraulic dam heads, and large-capacity plough up to 670 KW (Komatsu D575A); using advanced blasting methods (creating edges, creating breakwaters, differential blasting, etc.) with high-performance, environmentally-friendly explosives, etc.; tested and applied the automatic fuel distribution and monitoring system; are conducting research and applying software to design, manage and operate mines equivalent to countries with developed mining industries [6, 7, 8, 9].

- The plan to connect 3 mines Deo Nai - Coc Sau - Cao Son brings high efficiency, reducing the peeling coefficient, the transport arc. Open-pit coal production units have invested many excavators with bucket capacity from 10-12 m^3; cars with a tonnage of 90-100 tons and are testing 04 cars with a load of 130 tons; gradually apply computerization and automation to monitor the operation of equipment, towards the application of centralized monitoring and control [6, 7].

Fig. 1. Synchronization of large-capacity equipment in open-pit coal mining.

Presently, the used equipment fleet is as follow:

+ Drill with diameter d_{lk} = 200÷300 mm;

+ Hydraulic excavator with bucket capacity E = 3,5÷12 m^3, power shovel with E = 5÷10 m^3;

+ For hauling waste rocks, use of dump trucks with payload of 55÷60 tonnes and 90÷120 tonnes;

+ For hauling coal, use of dump trucks with payload of 30÷40 tonnes;

+ Equipment fleet for mining and hauling comprise hydraulic excavators with E=3,0÷6,7 m^3, maximal digging depth hs ≥ 8÷9 m and dump trucks of 25÷58 tonnes to transport coal from the working face to the bunker of crush station.

+ Beside that, at present Vinacomin (Cao Son surface coal mine) has invested the belt conveyor system and crush station with hauling capacity of 20 million m^3 of waste rocks to the waste dumps.

+ For hauling coal, use of dump trucks with payload of 30÷40 tonnes.

b. Underground mining technology

Currently, coal industry units have promoted the application of mechanization (CGH) of stages from mining, transportation (people, coal, materials) in underground mining, the application of mining CGH today. It is being replicated in both quantity and variety of technologies. Significantly, the synchronous CGH furnace lines, lowering the ceiling to recover top coal at Ha Lam Coal Company, have a capacity of 1.2 million tons/year, contributing to improving coal production by CGH in the past year. The coal industry is contributing to improving working conditions, improving labour safety for workers in the pits, improving labour productivity and overall production efficiency for the coal industry.

Advanced technologies of countries with developed mining industries (Russia, Japan, Poland, China, etc..) have been gradually put into testing, evaluation and application; Specifically:

- Longwall mining technology, fully mechanised (mining by shearer, supporting by shield support), top coal caving (or single-pass longwall), roof controlled by full caving.

- Longwall mining technology, supported by hydraulic props (self-moving frame, chain-linked frame, light shield support, XDY support, hydraulic prop)

- Mining technology in dip direction, supported by 2ANSH support, mining by plough, roof controlled by full caving

- Mining technology in diagonal direction, supported by soft shield support, mining by drilling-and-blasting, roof controlled by full caving;

- Mining technology in horizontal-inclined slice, supported by hydraulic props (or frame), mining by drilling and blasting, roof controlled by full caving;

- Other technologies: sub-level stoping, room and raise, room and diagonal raised, supported by hydraulic props (or wood), mining by drilling and blasting, roof controlled by full caving to extract medium-thick seam, seam dip angle >45^o, protective pillars, resources loss and coal loss.

Currently, Vietnam's coal industry is deploying a variety of underground coal mining technologies. However, the application of mining technologies by synchronous mechanization and advanced technologies to increase the kiln's capacity depends significantly on the geological conditions of the area. While countries in the world have a significant advantage, especially reserves of pit coal are concentrated in coal seam thickness, angle slope, length according to the large and stability, in Vietnam, most of the coal mine tunnel furnaces with coal seams with thickness from thin to medium, large slope angle, according to the short length and often divided by milling out the geology.

Therefore, the application of synchronous mechanization technology and advanced technologies to increase the capacity of the market furnace in recent years is still only at the level of selecting several qualified units. Favourable to apply and expected to be replicated in units with similar geological conditions, the rest are mainly traditional mining technologies.

The output of underground coal mining by technology from 2015 to 2020 is as shown in Table 1. The distribution of underground coal mining output by technology in 2020 is as shown in Fig. 2 [8].

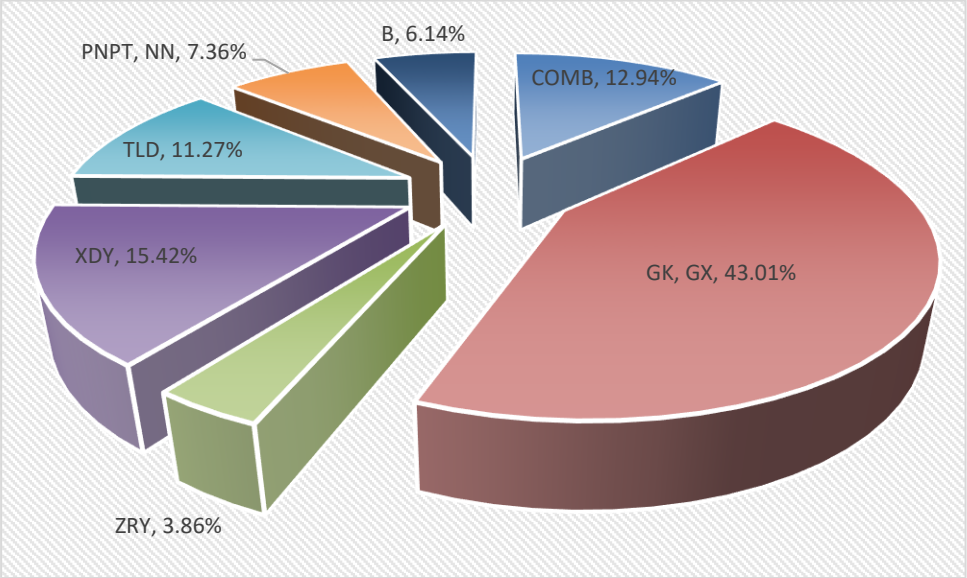

Fig. 2. Distribution chart of underground mining output by technology in 2020.

Tab. 1. The output of underground coal mining by technology from 2015 to 2020.

No.	Technology	Coal production, 10^3 ton					
		2015	2016	2017	2018	2019	2020
	Coal production by technology	19,820	20,296	21,716	22,420	23,486	23,532
1	COMB	701	1,336	2,537	2,951	2,868	3,045
2	GK.GX	5,409	7,143	8,044	8,862	9,728	10,120
3	ZRY	23	128	265	857	800	909
4	XDY	5,796	5,148	4,468	3,989	4,146	3,629
5	TLĐ	4,336	3,722	3,135	3,180	2,814	2,652
7	PNPT, NN	2,896	1,994	2,151	1,912	1,732	1,733
8	B	659	825	1,116	669	1,398	1,444

(a) (b)

Fig. 3. Synchronized mechanized furnace at Ha Lam Coal Company (a) and Mong Duong (b).

1.5. Environmental protection work

Concerning environmental protection, currently, the coal industry has achieved achievements in many areas such as [9]:

- Collection and treatment of all kinds of waste: Invested in building more than one hundred wastewater treatment stations to ensure that mines have wastewater treatment stations that meet environmental standards (Fig. 4a); coal mining plants invest in large-capacity sludge filtration systems, using circulating water that is not discharged into the environment; Built and maintained an industrial hazardous waste treatment plant in Quang Ninh; waste soil and rock generated from coal sifting screens are dumped into planned waste dumps. Ordinary industrial solid waste and daily-life solid waste generated in production shall be collected and treated under regulations.

- Environmental improvement and restoration: Planted trees to improve and restore the environment. Implement the plan of planting trees with high density to green the mine waste dumps, limiting soil quickly and rock washing, reducing dust emissions, quickly improving the general landscape environment, especially in the Ha Long city (Fig. 4b). Carrying out more than projects to build dykes and dams to prevent soil and rock from being swept away, renovate and restore the environment, renovate and dredging drainage systems, and settling lakes.

(a)

(b)

Fig. 4. (a) Wastewater treatment and (b) landfill rehabilitation of Vinacomin.

- Dust prevention: Invested in coal transport conveyor lines. Currently, the transportation of coal to the port and the power plants in Quang Ninh, Thai Nguyen, and Lang Son is carried out by conveyors and railways to overcome the dust situation, contributing to improving the environmental landscape of the cities; Installed nearly one hundred high-pressure misting machines (both mobile and fixed) for coal production units. Invest in specialized mine road irrigation vehicles 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, covering coal trucks and warehouses with tarpaulins piles, invest in the additional capacity of dust suppression water trucks, anti-dust water supply systems on waste dumps.

- Environmental pollution control: The coal industry cooperates with Quang Ninh province to invest and install automatic environmental monitoring systems for coal mine wastewater and transmit data directly to the Resource base and environment under the provisions of the law on environmental protection. Continue to

conduct concentrated environmental monitoring for residential areas at risk of being affected outside the management boundary to control and detect pollution risks and promptly direct preventive measures. Carry out periodic ecological tracking at the member unit following the approved environmental impact assessment report (congdoantkv.vn).

- Climate change response: Construction of many dams and dykes to prevent soil and rock at the bottom of the landfill, currently, the coal mine waste dumps have 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 coal mining areas under the overall migration scheme of Quang Ninh province to ensure safety. population during the rainy season.

- Innovating technology to contribute to environmental protection: The investment in coal mining technology towards mechanization and hydraulics in underground mining (hydraulic struts, hydraulic struts, excavators), synchronous investment in large-capacity equipment in open-pit mining has reduced the consumption of wood against furnaces, reduced coal loss, and reduced emissions. The screening plants invest in large capacity sludge filtration equipment to increase the coal recovery rate, use circulating water, and reduce discharge to the environment. Invest in a soft-start system of electrical equipment to save electricity. Take advantage of the lousy quality coal outside the standard, invest in recruiting stations to upgrade the quality to take advantage of resources.

2. Some highlights in the coal industry development plan to 2030

According to the forecast of the Master Plan, Vietnam will have to import a large amount of coal, and domestic exploitation can only meet about 50% of the total coal demand. The orientation of the coal industry is to continue investing in renovating and expanding existing mines and investing in deep and new mines on the principle of maximum exploitation and efficiency of coal resources; ensure the socio-economic efficiency of coal mining; ensure the harmonization of the interests of enterprises, employees, the coal region and the economy in association with national energy security and sustainable development of the coal industry. Specifically, as follows [3, 4]:

- Regarding coal exploration: To step up exploration and improve the reliability of resource and reserve supply to meet the coal mining target according to the master plan and the stable and long-term development of the industry. Expand search and exploration; step up exploration and assessment of reserves to the bottom of the coal bed; improve the quality of assessing reserves and resources.

- Underground coal mining: To focus on developing large-volume underground mines according to the criteria "Green mine, modern mine, high-yield mine"; Connecting underground mines with the same mining conditions into large capacity mines; Continue to invest in coal mines as planned, meeting the highest coal demand for the economy. Units focus on ensuring the progress of coal mine projects; Continue to research and innovate mining technology in the direction of modern advanced associated with mechanization, automation and computerization; synchronously implement solutions to increase labour productivity.

- Open-pit coal mining: To develop and expand existing open-pit mines in the direction of improving the limiting coefficient of peeling, suitable to technical conditions and coal selling price; maximize the exploitation capacity following the planning on dumping, transportation, water drainage and environmental protection; Maximize the exploitation of resources assigned to management, including the resources in the areas protecting the underground works, the remaining resources after the underground mining... Continue to change synchronously and modernized equipment of mining and transportation lines in the direction of putting into use mobile equipment with large capacity, continuous transportation systems suitable to the conditions and scale of each mine. ; Optimize the technical parameters of the applicable mining system; increasing the application of vertical layer mining system, selective mining and thin-seam mining technology; technology for dumping temporary and internal waste dumps.

Any technology must apply the most advanced technology and management solutions to minimize the loss rate and dirty coal in mining and reduce energy consumption.

- Environmental protection: With the goal of green growth, developing in harmony, being environmentally

friendly, the need to develop a circular economy and a substantial transformation under the strategy from brown to green needs to continue implementing a number of contents such as [8]: Implement environmental protection policies for the coal industry in association with the goal of reducing greenhouse gas emissions, promoting circular economy and sustainable development; Strictly control waste sources that pollute the environment, strengthen the prevention of environmental incidents, effectively use all kinds of resources, respond to climate change and epidemics; Invest in a mine wastewater treatment system to ensure environmental standards; complete installation of automatic ecological monitoring system for waste water and exhaust gas; Research to increase recycling and reuse of wastes for production and supply to other businesses; Continue to strengthen industrial hygiene, plant trees to improve the landscape and environment of factory premises and other production areas; Proactively adapting to climate change, ensuring the safety of landfills, minimizing soil and rock backflow, and preventing the risk of flooding; reduce greenhouse gas emissions, enhance resource utilization, and limit climate change impacts; Planning the entire mine space including waste dumps, ground, excavation pits to be renovated into: mine park with regulating lake; Continuing the idea of renovating the landfill into a world-class golf course; Or renovate and build apartment buildings for coal industry officials or apartment buildings for low-income people in the province. Early application of approved scientific topics into practice, such as applying lime nanotechnology in mine wastewater treatment (instead of using conventional lime powder at present, the cost is high, which is not as effective as using nano lime). Using environmentally friendly Neoweb technology to improve the quality of mine roads.Recycling quarry waste stone into standard building materials.

3. Overall rating

In recent years, the coal industry has performed well to ensure sufficient coal for domestic demand, especially coal for electricity production, ensuring national energy security.

Mining engineering is interested and focused by the coal industry, especially in mining, excavation, ventilation - drainage, electromechanical - transportation, mechanics - manufacturing. There are many breakthroughs, bringing excellent efficiency, contributing to the overall achievement of coal production and business, affirming a critical role, throughout which is "technology is the root of all problems" that determines the success of the coal industry, the existence and development of the coal industry.

Currently, the coal industry has been promoting investment to promote growth based on development in both breadth and depth by applying new, advanced and modern technologies to improve labour productivity, quality and efficiency products and business performance; concentrate resources to implement approved coal mine projects; develop coal mines according to the criteria "Clean mine, safe mine, modern mine" [9].

The management of exploitation and protection of mineral resources closely followed the approved planning, achieved positive results, and made significant contributions to the country's socio-economic development, transforming the country's economic structure and increasing the proportion of industry.

To step up research and investment in the application of advanced technologies, increase mechanization, computerization and automation to coal production, processing and trading. At the same time, it is determined that the development of mechanization, computerization, and automation in line with the trend of the fourth industrial revolution must be paid attention to, and is a critical task in the management work to improve labour productivity, safety, reduce costs, improve working conditions for employees, protect the environment, ensure overall business and production efficiency and the sustainable development of the coal industry.

It is necessary to invest heavily in the mechanization of coal mining and quarrying while gradually automating some stages such as transportation, drainage pumping, ventilation control, mine gas, power stations, and production process in coal sieving and sorting plants, etc. towards connecting centralized monitoring and control systems and building advanced, modern coal mines with few people.

4. Conclusions

Vietnam's demand for coal energy balance is enormous but challenging because of its limited potential, technology and management experience.

The coal industry continues to carry out planning, investment, exploration and exploitation of domestic

coal to supply coal to the economy. Currently, there are large mining projects such as anthracite mining in Quang Ninh and the construction of mining infrastructure.

To sustainably develop the coal industry, it is necessary to research and apply advanced and appropriate science and technology in coal mining and processing as well as environmental protection activities...; strengthen cooperation with organizations and businesses from other countries to develop coal mining and use technologies in an environmentally friendly and safe manner, and at the same time research and find foreign coal sources to contribute ensure quality security for Vietnam.

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6. References

1. Government, 2008. Decision No. 89/2008/QD-TTg dated 07/07/2008 by the Prime Minister of Vietnam on: Approving the strategy for the development of Vietnam's coal industry until 2015, with a 2025 orientation (in Vietnamese).
2. Informatics, Technology, and Environment Joint Stock Company – Vinacomin, 2015. Planning of coal exploration up to 2020 and a 2030 orientation (in Vietnamese).
3. Government, 2016. Decision No. 403/QD-TTg dated March 14, 2016 by the Prime Minister of Vietnam on: Approving the adjustment of the plan of development of Vietnam's coal industry up to 2020, considering the prospects for the year of 2030 (in Vietnamese).
4. Government, 2017. Decision No. 1265/QD-TTg dated August 24, 2017 by the Prime Minister of Vietnam on: Approving the adjustment and supplementation of the master plan on development of Vietnam's coal industry up to 2020, with the consideration of development outlook to 2030 (adjusted), (in Vietnamese).
5. Vietnam Coal-Mineral Industry Group, 2021. Report on evaluating the results of implementation of Joint Resolution No. 33-NQLT/DUTKV-ĐUTQN, dated April 18, 2018 on strengthening leadership at all levels of Communist Party Committees in the implementation of environmental protection in the period of 2018 - 2020 (in Vietnamese).
6. Ministry of Industry and Trade, 2021. Technical report on developing and updating the action plan to respond to climate change in the industry and trade sector in the 2021-2030 period. (in Vietnamese)
7. Mining and Industry Investment Consulting Joint Stock Company – Vinacomin, 2021. the National Energy Plan for the period of 2021-2030, with a vision to 2050 (coal sub-sector) (in Vietnamese).
8. Informatics, Technology and Environment Joint Stock Company – Vinacomin, 2021. Project on environmental protection of Quang Ninh coal region for the period from 2020 to 2025 and a 2030 orientation (in Vietnamese).
9. Vietnam Coal and Mineral Industries Group (2021), Report on summarizing S&T research (in Vietnamese).
10. Report on results of application of annual technologies in the period from 2015 to 2020 By Vietnam National Coal - Mineral Industries Holding Corporation Limited and Dong Bac Corporation (in Vietnamese).