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Circular Economy Model and the Implementation in Vietnamese Coal Mining Industry

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Abstract. The circular economy is the economic model that has been applied for a long time in the world. This model is applied at all three levels: micro (enterprise-level), intermediate (industry level, industrial zone level), and macro-level (local level, regional level, or national level). Vietnamese Coal Mining Industry has been having important contributions to the socio-economic development of Vietnam. However, this industry also causes lots of issues about environmental pollution. In the context of resource depletion, environmental pollution and the cost of exploiting and processing increases with the deep exploiting process; the tastes of utilizing resources, minimizing environmental pollution, and creating more value-added for this industry are inevitable requirements. Because of the tasks, applying the circular economy model into this industry (both intermediate and micro-level) is the urgent solution for the sustainable development of the Vietnamese Coal Mining Industry. The paper uses a combination of research methods such as theoretical research, case study research, statistical data analysis, etc., to propose the circular economy model for the Vietnamese Coal Mining Industry and some solutions to deploy this model into the industry's operations towards sustainable development.

Keywords: Circular economy model, Vietnamese coal mining industry, Sustainable development

1. Introduction

In the context that the need of using natural resources is increasing to meet the need of humanity development. Along with the inadequacies of the linear economy such as resource waste and also the current state of resource depletion and environmental pollution, the circular economy model is being studied and applied widely in many developed countries in the world. In order for this model to maximize its effectiveness, it is necessary to apply synchronously at all three levels: the enterprise level, the industry level, and the local or national level. In Vietnam, the circular economy model has also begun to be researched and applied in some fields such as agriculture, industry, etc.

Vietnamese coal mining industry has formed and developed for hundreds of years. The industry has been being one of the key economic sectors of Vietnam. Besides the industry's achievements, such as providing mineral materials for other industries; exporting coal to receive foreign currency for the country, creating hundreds of thousands of jobs for the population, etc., the industry causes many negative impacts such as resource depletion and environmental degradation pollution. Especially in the current context that the coal mining industry is no longer the exclusive economic sector of Quang Ninh (The main coal mining area of Vietnam), the goals of sustainable development and harmony with other economic sectors, for example, tourism, services, etc., are being seriously considered by the Government and the Province. In that context, applying the circular economy model into the industry is the optimal solution to maximize using of mineral resources, reuse the unwanted output of the operation process to expand the value chain, and minimize the negative impact of this industry on the environment.

Meanwhile, there are not many studies about the circular economy model in the context of Vietnam and also Vietnamese coal mining industry. Therefore, it is necessary to establish a circular economy model suitable for the characteristics of the coal mining industry. It will create the basis for implementing solutions towards the sustainable development goals of the industry.

2. Theoretical basis of the circular economy model

2.1. The definition and roles of the circular economy

a) Definition

There are lots of different definitions of the circular economy. The circular economy describes an industrial economy that is designed to produce no waste or pollution [1]; the circular economy is a new economic model with huge economic potential in zero waste [2]; or the circular economy describes an economic system that based on business models that replace the concept of “end of life” by reducing,

reusing, recycling and recovering materials in manufacturing, distributing and consuming processes at the micro-level (products, companies, consumers), intermediate levels (eco-industrial parks) and macro levels (cities, regions, countries and furthermore) with the aim of sustainable development that based on ensuring environmental quality, economic prosperity, and social justice, serving the interests of both present and future generations [3].

Thus, it could be understood that the circular economy is an economy in which the undesired outputs (waste) of production processes are fully utilized. These undesired outputs will become inputs of the further production processes. So it could extend the value chain, and also reduce environmental pollution, towards sustainable development goals.

b) The roles of the circular economy

*) For businesses

This model helps businesses:

- Expanding the value chain by using unwanted outputs and recycling them as the inputs for further production processes.

- Reducing the cost by reusing some materials many times.

- Reducing economic losses and also negative impacts on workers' health that be caused by emission activities.

- It showed the social responsibility of companies. Thereby it is enhancing the reputation and competitive position of the companies.

*) For nations

- Using reasonably and efficiently resources, especially non-renewable ones.

Increasing more GDP/GNP by recycling or reusing unwanted outputs of companies in the economy creates more jobs for laborers.

- Reducing waste of manufacturing into the environment to reduce environmental pollution and also the consequences of them for the country.

In the context of resource depletion and environmental pollution, applying the circular economy model is an important measure to help the country achieve sustainable development goals.

2.2. The circular economy model

The circular economy model could be applied at all three levels: micro, intermediate and macro levels. However, in the paper, the authors present the application of the model to the Vietnamese coal mining industry. So the paper is mainly focused on the micro and intermediate levels. Therefore, the eco-industrial park model is a reference model to apply the circular economy model to this industry.

The eco-industrial park is a manufacturing and service-providing businesses community located in the same location. The companies that be the community members seek to improve economic, environmental, and social effectiveness through collaboration on the management of environmental and natural issues [4]. Businesses in the eco-industrial parks have industrial symbiosis. It means that there is a cooperation between businesses in an industrial park to optimize using of inputs and outputs such as raw materials, energy, water, waste, scrap, etc., in their operation process.

3. Research Methods

In this paper, the authors use some research methods:

3.1. Case study method

The method was used to research some specific cases to build the circular economy model that is suitable for the Vietnamese coal mining industry.

a) The case of using soil and rock waste from coal mining for leveling at sea encroachment projects in Quang Ninh, Vietnam

According to statistics, nowadays, Vinacomin manages about 1,210 million m^3 of soil and rock waste; Dong Bac Corporation manages about 268.5 million m^3 of soil and rock waste. The amount of soil and rock waste that is generated annually is about 150 million m^3 [8]. Currently, soil and rock waste from the coal mining industry in Quang Ninh is being used for sea encroachment projects. From 2020 to 2025, the demand for soil and sand for leveling in Quang Ninh province is estimated at about 100 million m^3/a years [8]. It will be a very potential market to consume the amount of soil and rock waste from coal mining.

Fig. 1. The dump of coal mining companies in Quang Ninh, Vietnam [8].

Fig. 2. Leveling activity for sea encroachment project at Phuong Dong urban area, Van Don - Quang Ninh [9].

Nowadays, soil and rock waste that from coal mining activities is causing very negative impacts on the environment, such as causing dust which greatly affects the residential areas around the mine. Therefore, using them for ground leveling in sea encroachment projects or traffic construction, etc., is a double-impact activity. It minimizes the negative impacts on the environment and also creates more value through being the input of the leveling operation.

b) The case of wastewater treatment at Viancomin - Vang Danh Coal Joint Stock Company

Coal mining activities generate a large amount of wastewater. The wastewater is acidic and also contains suspended solids, toxic heavy metals, etc. So it impacts so negatively on the environment. Faced with that situation, Vinacomin has built dozens of wastewater treatment stations, typically Vang Danh wastewater treatment stations. The station is designed with items such as the water route to the station, input monitoring chamber, reaction tank, settling tank, distribution tank, manganese filter tank, sludge condensate tank, and sludge press, etc. The station has a wattage of 3000 m^3/h. All wastewater in Canh Ga and Vang Danh areas is collected and thoroughly treated at this station. Annually, the station treats about 10 million m^3 of mine wastewater [10]. Mining wastewater after treatment is reused as domestic water for workers, and water sprayed to suppress dust, etc.

Thus, the treatment of mine wastewater helps reduce environmental pollution and also creates clean water to provide for the production and living of workers.

c) The case of methane treatment before, during, and after coal mining in some countries with developed coal mining industries in the world

According to estimates by the US Environmental Protection Agency (US EPA), the coal mining industry worldwide annually emits about 8-10% of total man-made methane. Thus, the emissions (including methane) from coal mining activities negatively impact the environment. Facing that situation, some countries with developed coal mining industries in the world, such as the USA, Australia, Russia, China, etc., have conducted methane recovery through drilling to remove methane before exploiting, during mining, and after the extraction process [7]. Thus, drilling to remove methane helps reduce the number of greenhouse gases released into the air and exploits large amounts of gas to provide input for the other production processes.

3.2. Statistical analysis methods

The methods were used to analyze the expected waste generated by the Vietnamese coal mining industry in the future.

a) Analysing the amount of soil and rock waste of coal mining activities

Tab. 1. The estimated amount of soil and rock waste from coal mining activities [5].

Areas	Total, 1000 m^3	Amount of soil and rock waste, 1000 m^3		
		2021÷2025	2026÷2030	After 2030
Uong Bi area	168,045	62,198	38,900	66,947
Hon Gai area	276,526	276,526	0	0
Cam Pha area	1,430,326	613,202	401,310	415,814
Other area	800,639	117,930	122,680	560,029
Total	2,675,536	1,069,856	562,890	1,042,790

Table 1 has shown that the amount of soil and rock waste from coal mining is very large. The waste of the Quang Ninh area (including Uong Bi, Hon Gai, Cam Pha) has a large proportion because it is still the main coal mining area in Vietnam. However, soil and rock waste tend to decrease over time in this area because open-pit coal mining is gradually shifting to underground mining. In the other areas, the amount of soil and rock waste has increased sharply because these mines are mainly small and are still exploited by open-pit mining technology.

In the future, the amount of soil and rock waste from coal mining is very large. So it is necessary to have treatment measures to both reuses the unwanted output and limit negative impacts on the environment.

b) Analysing the wastewater from coal mining operations

Tab. 2. The estimated amount of wastewater from coal mining in Vietnam [6].

Criteria	Unit	2021÷2025	2026÷2030
Amount of raw coal produced	Million tons/year	52.5	57.5
The average amount of mine wastewater	m^3/ton	2	2
Amount mine wastewater	Million m^3/year	105	115

Table 2 shows that the amount of wastewater is increasing with the increase of mining scale. This amount is also so large. Besides solid waste and wastewater, coal mining operations also emit many harmful gases such as CH_4, CO, SO_x, NO_x, etc. These wastes are required treatment not to cause environmental pollution. But it could also be a potential resource that could be used as an input for other economic activities.

4. The research results

From the above analysis, the authors propose the circular economy model that is suitable for the Vietnamese coal mining industry at both the industry level and the business level.

4.1. Industry-level model

Coal mining, processing, and trading activities in Vietnam are relatively concentrated and similar to industrial zones (in Quang Ninh, they are concentrated in three regions, including Uong Bi, Hon Gai, and Cam Pha). Based on the eco-industrial park model and the characteristics of the coal mining industry, the authors propose the circular economy model for the Vietnamese coal mining industry that is shown in Figure 3.

According to this model, the cooperation relationship between companies is shown that:

- Geological companies providing exploratory drilling services and methane recovery before, after, and also during the exploitation process;

- Environmental companies are providing wastewater and other waste treatment services to companies on coal mining, processing, trading, repairing, thermal power, etc.

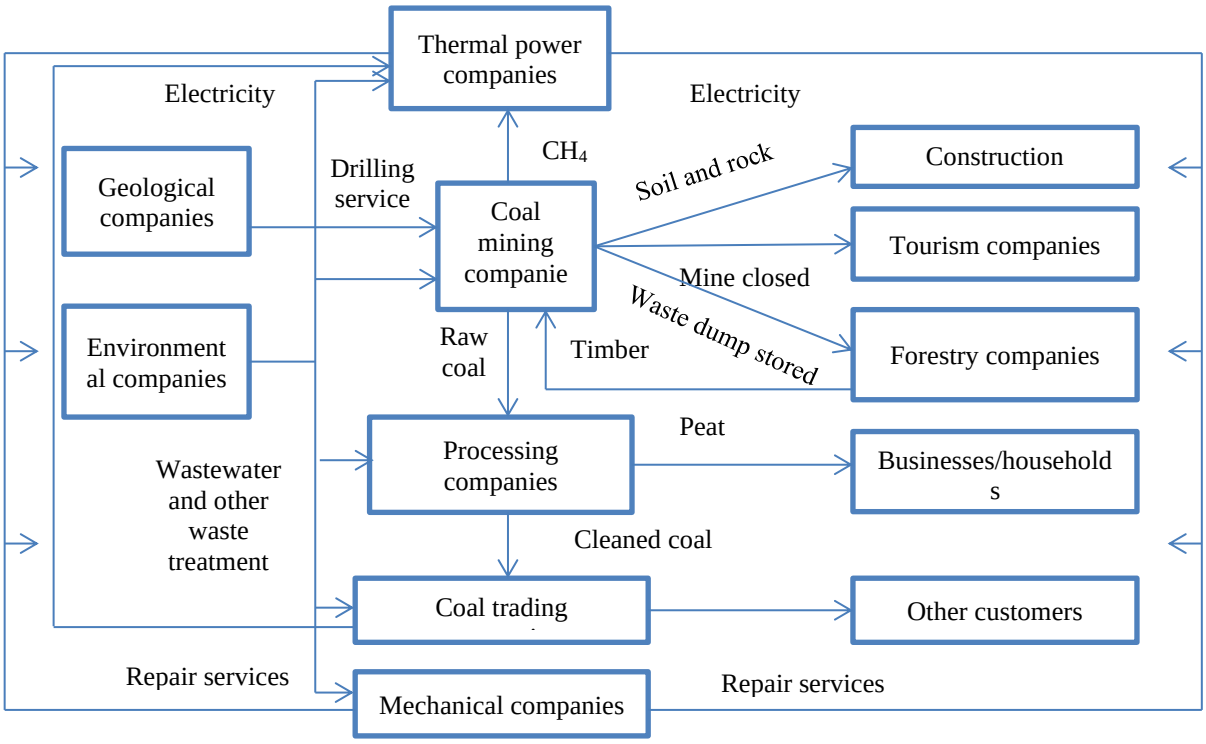

Fig. 3. The circular economy model applied to the Vietnamese coal mining industry.

- Coal mining companies supply raw coal to processing companies; provide soil and rock waste for construction companies (traffic works, ground leveling, sea encroachment, etc.); supply methane gas for thermal power companies. The restored waste dump could allow forestry companies to plant forests and buy timber from these companies for production. Mine after closing could be used for tourism.

- Processing companies supply cleaned coal for coal trading companies; provide peat (be salvaged of processing) to businesses/households.

- Mechanical companies provide repair services, restoration, and upgrading the production capacity of the equipment to other companies; thermal power companies supply electricity to other companies.

4.2. Enterprise-level model (for coal mining companies)

At the enterprise level (for coal mining companies), the authors propose the circular economy model shown in Figure 4.

According to this model, the recovered materials after each operation process and other unwanted outputs will be processed to continue for the future production cycle.

- For materials recovered after each operation process, companies will evaluate, repair, and restore to continue putting into future production; or reuse the parts and details of them as spare parts.

- The soil and rock waste will be used as ground leveling materials (for sea encroachment projects, traffic works, etc.). The rest is sent to the waste dump.

- The wastewater is treated to ensure standards of domestic water for workers and production water for dust suppression, road watering, watering plants, etc.

- The methane gas is recovered for electricity production.

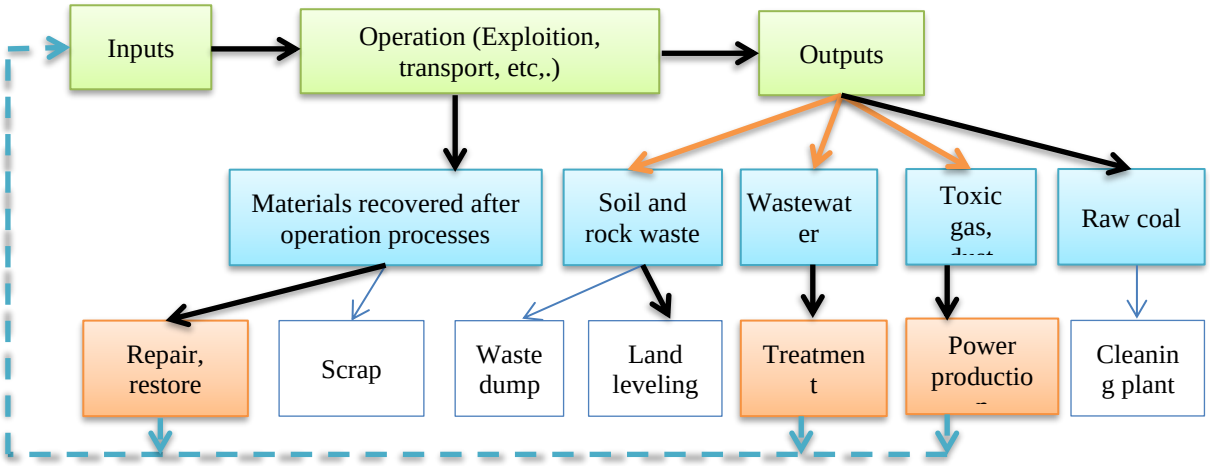

Fig. 4. The circular economy model is applied to coal mining companies.

Currently, some activities in the models (including industry-level model and enterprise-level model) have been performed at the companies in the industry. Such as using soil and rock waste for leveling, planting trees on waste dumps, etc.; some ideas have also started to be mentioned, such as using mines after closure for tourism; or reusing materials in the companies. However, these activities are carried out individually, without a systematic approach. The models in the paper systematized and closely linked the activities of the closed system. It helps to clearly define the outputs of each stage and visualize the recirculation of unwanted ones to minimize waste to the environment. This model also helps managers to establish development strategies for the industry towards sustainable development.

Besides Vietnamese coal mining industry is implemented by Vinacomin and Dong Bac Corporation (concentrated in Quang Ninh Province) and some small mines in other provinces. The models could be fully applied to the companies in Quang Ninh province (organized into concentrated industrial zones in the mining areas). For small mining areas in other provinces, depending on specific conditions, reduced models could be built from the models. For the future mining areas (Coal mining areas in the Red River Delta), the models could be used for master planning towards sustainable development.

5. Some solutions

Applying the circular economy model helps to use the unwanted outputs of production processes to create more value for businesses and society. It minimizes environmental pollution by reducing emissions into the environment. The paper suggests some solutions to able to apply the model to the Vietnamese coal mining industry.

- The Government needs to have the policy and orientation for developing the circular economy model and also has strict sanctions for using resources wastefully or causing environmental pollution.

- Companies must research or transfer modern technology from developed countries to apply in operations. This could be considered the most important solution because it is necessary to have modern technology to reproduce the unwanted outputs.

- The Government and also companies need to promote propaganda and education to raise the awareness of using natural resources reasonably and protecting the environment among people, businesses, and employees.

- Using waste for recycling could have low economic efficiency. However, it is effective in environmental protection and sustainable development. Therefore, the Government must apply at high levels the natural resource taxes and environmental protection taxes to get the budget and subsidizes for recycling waste.

6. Conclusions

The paper has synthesized the theory of the circular economy and the circular economy model; study some typical cases in the reuse of unwanted outputs of operations; and also analyzes some forecasting data on solid waste and wastewater of coal mining, processing, and trading activities in Vietnam in the

future. Based on those analyses, the paper proposes the Vietnamese coal mining industry's circular economy model (including industry level and business level). However, the paper mainly builds the management model. It is essential to research more specifically about technical-technology issues to apply the model to the industry effectively.

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