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Contemporary Economic Issues in Asian Countries: Proceeding of CEIAC 2022, Volume 2

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Contents

Circular Economic Model Applied to the Mining Industry in Vietnam

Dinh Chieu Le, Thi Bich Dong, and Nga Nguyen

Abstract The circular economy is designed to produce no waste or pollution. In the model, the waste is recycled to be a secondary resource that returned to provide the next production cycle. Therefore, applying the economic model couldn't only lengthen the value chain of industries but also reduce environmental pollution. Nowadays, many countries around the world, including Vietnam, have been transiting from the linear economic model to the circular economic model. The mining industry plays an important role in economic development because it provides mineral materials for many other industries. However, too much waste (including solid, liquid, and gaseous waste) of the industry has polluted for both the geological environment and human living environment; it is necessary to apply the circular economy model into the industry. Through this chapter, we reviewed the theory of circular economy model; analyzed the need and potentials of applying the circular economy model in the mining industry in Vietnam; and proposed the circular economic model for Vietnam's mining industry, and some measures to promote the application of the economy model to the industry.

1 Introductions

The circular economy is the economy which products, materials, or resources are researched to reuse or recycle for the next production progresses in order to create more value for society and businesses, and contemporaneous with minimizing emissions causing environmental pollution (Nguyen, 2021). In essence, the circular economy is the economic model that the waste (unwanted output) of each production process is researched to recycle and reuse for the next production processes. In other words, the circular economy is the economic model that aims to prolong the life of products, materials and eliminate negative impacts on the environment (Ellen MacArthur Foundation, 2013).

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The circular economy model has currently been promoted in developed and developing countries around the world. The European Union (EU) adopted the action plan about the Circular Economy in 2015, including solutions for accelerating transition to the circular economy, increasing global competitiveness, promoting sustainable economic growth, and creating more new jobs (Nguyen, 2021) The Swedish government tries to change the citizens and enterprise perception, and building legal institutions toward to environmental protection such as high taxes on waste, and giving preferential policies in using renewable energy sources or clean energy (Bui, 2020; Nguyen, 2021). Since 2013, the Dutch government has implemented a series of programs and projects to make the country become the circular center of Europe (Bui, 2020; Nguyen, 2021). In Asia, Singapore early became one of the typical evident in promoting the circular economy. Since the 1980s, Singapore has developed technology to turn the waste into energy and turn the rest of the waste (about 10% of the total waste) into the artificial garbage island, which known as the first one in the world. China is also the typical country that approaching the circular economy model after using natural resources excessively for a long time, which further caused many environmental issues. China has built three stages to develop the circular economy, including small circle (implemented at the scale of factories and industrial zones); medium cycle (scales up more); and large cycle (performs across the entire economy) (Nguyen, 2021). The gradual transition from the linear economic model to the circular economic model is applied in the developed and developing countries in the world, because the application of the model has many benefits including macro level and micro-level.

In Vietnam, after decades of transitioning to the market economy, besides the achievements; Vietnam is facing with many problems related to resource depletion, environmental pollution, and climate change. In such a context, Vietnamese Government has not only advocated to gradually apply but also replace the circular economy model with the linear economic model. The policy is shown in some documents such as the document of the 13th Communist Party Congress that identifies building the circular economy model is one of development orientations of Vietnam in the period of 2021–2030 (Tran, 2021); The Agenda 21 of Vietnam (decision 153/2004/QD-TTg) has shown that sustainable development that based on ensuring the harmony of three aspects of economy, society, and environment is the inevitable path of Vietnam (Vietnamese Government, 2004); the Law on Environmental Protection 2020 has specific regulations on waste management and control of pollutants; and the issues of response to climate change (Vietnamese Parliament, 2020). These documents are considered as important legal bases for the circular economy model implementation.

Mining industry is the industry that exploits mineral resources (non-renewable resources), meeting the mineral raw materials needs of the national economy. This industry provides lots of products such as coal (of the coal mining industry); oil and gas (of the petroleum industry); metal ores (of the metal ore mining industry); and construction materials (of the construction material mining industry) (Ngo, 2003). Therefore, the industry provides inputs for many other industries of the national economy such as processing industry (refining and petrochemicals, metallurgy);

cement industry; fertilizer industry; and thermal power industry (coal power, oil power, and gas power).

Vietnam is considered as the country with diverse mineral resources with more than 5000 mines of more than 60 types of minerals. Many types of minerals have large reserves such as coal (about 48.7 billion tons) (VEA, 2013); petroleum (about 4.4 billion barrels); bauxite (672.1 million tons); apatite (0.778 million tons); titanium (15.71 million tons); rare earths (1.1 million tons); and granite (15 billion m^3) (Tran, 2016). The mining industry makes a relatively large contribution to GDP of Vietnam (Minh, 2015). Mining activities create economic and social benefits; however, they also create large amount of waste. These wastes have the potential to transform from hazardous waste into a useful resource. These are great potentials to apply the circular economy model into the mining industry (Kinnunen, 2019). Besides, applying the circular economy model in the mining industry can bring many benefits such as obtain financial benefits; integrate environmental protection activities; develop the product-oriented approach to waste management; analysis of environmental impacts; and improve the image of the mining industry (Pomykała & Tora, 2017).

2 The Circular Economy

2.1 The Definition and Roles of the Circular Economy

(a) **The definition of the circular economy**

There are many different interpretations of the circular economy. The circular economy describes the industrial economy designed to produce no waste or pollution (Littleboy et al., 2016); The circular economy is a system that is restorative and renewable through proactive design. It replaces the concept of "end of life" of materials with the concept of recovery, shifting toward the use of renewable energy, no use of harmful chemicals that harm reuse and toward reducing waste reduction through the design of materials, products, engineering systems and business models within that system (Ellen MacArthur Foundation, 2013); or the circular economy is regarded as an economic system based on business models that replace the concept of "end of life" by reducing, reusing, recycling and recovering materials in manufacturing processes, distribution, and consumption at the micro-level (products, companies and consumers), intermediate levels (eco-industrial parks), and macro-levels (cities, regions, countries and more) with the aim of realizing sustainable development, based on ensuring environmental quality, economic prosperity and social justice, serving the interests of present and future generations (Kinnunen, 2019).

Therefore, according to above perspectives, this study defined the circular economic model is the economic model that used unwanted output (waste) of production processes effectively, which further become input of the next production processes. It helps increase the value chain and also reduce environmental pollution, toward sustainable development goals.

(b) **The roles of the circular economy**

1. For national economy

Nowadays, the application of the circular economy model is the goal of most developed and developing countries in over the world for many reasons:

- Increasing national income by using business' unwanted outputs effectively in the economy. By considering waste as the resources and researching the method to recycle and reuse them could help to take advantage of value and increase national income;
- Through production activities to solve and recycle waste from production processes in order to create more jobs for working labors. It helps to reduce the pressure of unemployment rate for the Governments.
- Adding secondary resources from the unwanted outputs of each production process, it could contribute to enhancing the resource assurance for production activities, reducing the demand of raw materials of the economy.
- By using resources effectively, especially non-renewable resources (most of which are fossil energy sources such as coal, oil, gas, etc.) will contribute to ensuring safety the national energy security.
- Reducing production processes waste into the environment helps to reduce environmental pollution and also the consequences of environmental pollution for the countries (including reducing greenhouse gas emissions into the environment, reducing greenhouse effect). As a result of it, the process of climate change can be slower and contribute to achieving of the green growth goals.
- Through the application of the circular economy model, products and goods in the process of using will be repaired and maintained in order to prolong their life to avoid wasting resources of national economy.
- Finally, through the motivation to constantly research and apply measures to recycle waste, the application of the circular economy model plays an important role in guiding innovation of people and businesses.

2. For enterprise

From the micro-perspective, applying the circular economy model also plays an important role for enterprise:

- Increase the value chain by taking advantage of unwanted outputs and turning them into inputs for further production processes. Through that activities, it could create more revenue and profit for the enterprise.
- Cost savings through the utilization of materials used many times and also repairing and maintenance to prolong the life of machineries and equipment.
- Reduce both economic losses and negative impacts on working labor's health that caused by emission activities in order to improve the employee commitment and loyalty to the companies.
- Show corporate social responsibility of enterprise to improve the reputation and competitive advantages; sustainable development the customer relationships in the

context of increasing awareness and requirements for environmental protection of citizens.

In the context of resources depletion and environmental pollution, the application of the circular economy model is an important solution to help countries and enterprises achieve sustainable development goals.

2.2 The Need of Transiting from the Linear Economy Model to the Circular Economy Model

The linear economic model is regarded as the economic model that has been applied in most countries in the world. This model is applied in the early stages of the development processes that characterized by trade-off development, accepting environmental damage to pursue economic growth goals. However, applying this economic model for a long time could have serious consequences:

- *Resource depletion.* For non-renewable resources, overexploitation leads to resource depletion; for renewable resources, the extraction rate exceeding the regeneration rate would also lead to resource depletion. Pursuing the linear economic model that maximum exploitation of natural resources and ignore sustainable development goals has led to resource depletion. In the context of the resource depletion, the limited resources could not be guaranteed for everyone, thereby leading to injustice, war, and conflict.
- *Loss of biodiversity and losing ecological balance.* The exploitation of resources, production progress and human living activities has damaged to nature, narrowed the living space of species. It leads to many species of animals and plants becoming extinct or in danger of extinction, reducing biodiversity and losing ecological balance.
- *Environmental pollution.* Human activities (mining, production and human living) have released a large amounts of waste into the environment (land, water, and air environment), exceeding the environment assimilation threshold, which further leads to environmental pollution, and this situation is becoming more and more serious.
- *Causing climate change.* Along with the development of human society, greenhouse gases (CO_2, CH_4, N_xO, CFCs) are increasingly being released into the atmosphere that causes the greenhouse effect—main cause of climate change with main manifestations such as increasing temperature; the sea levels are rising because of sea ice melting, rising the number of negative weather phenomena and difficult to predict, etc.
- *Threatening human health and life.* The negative impacts on the environment such as environmental pollution and climate change could negatively impact to human life. Natural disasters, epidemics, and diseases directly threaten to human being.

Facing the negative consequences of the linear economy and the requirements of sustainable development, and gradually responding and solving the above consequences, it is necessary to transit to the circular economy model. Nowadays, the transformation has been gradually implemented by many countries, including Vietnam.

3 The Necessity and Potentials of Applying the Circular Economy Model into the Mining Industry in Vietnam

3.1 The Necessity of Applying the Circular Economy Model into the Mining Industry in Vietnam

In recent years, under the pressure of economic growth, modernization, and urbanization, the demand for raw materials and fuels is increasing. It leads to increasing sharply production scale of the mining industry, causing depletion of mineral resources, environmental pollution, and contributing to climate change.

As a developing country, Vietnam still needs to base on exploiting mineral resources for developing. However, mineral resources are finite and non-renewable and mining activities always cause negative impacts on the environment. Therefore, it is necessary to ensure mineral exploitation to serve the demand of current socio-economic development while minimizing risks of environmental pollution and degradation. It is so important to have effective solutions to reduce material consumption, reduce resource loss, especially recycling and reuse of wastes in the process of mining and mineral processing.

Tables 1 and 2 show the expected volume of solid and liquid waste from the coal mining operation.

To achieve that goal, one of the strategic solutions is researching to apply the circular economy model into the mining industry.

Table 1 Estimated amount of soil and rock waste from coal mining activities

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

Source Vietnamese Government (2016)

Table 2 Estimated amount of wastewater from coal mining in Vietnam

Criteria	Unit	2021 ÷ 2025	2026 ÷ 2030
Amount of raw coal produced	Million tons/year	52,5	57,5
Average amount mine wastewater	m^3/ton	2	2
Amount mine wastewater	Million m^3/year	105	115

Source Vinacomin Industry Investment Consulting JSC (2018)

3.2 Analyzing the Potentials of Applying Circular Economy Model into the Mining Industry in Vietnam

The potential of applying the circular economy model is seen from the following specific angles:

(a) *Regarding policies*

The issue of circular economy development in Vietnam is reflected in the policies of the State. The State has promulgated many policies and laws related to the circular economy, including the Law on Environmental Protection, the Law on Minerals, the Law on Water Resources, the Law on Land, and many decrees and sub-law documents. In addition, the contents related to the circular economy are also reflected in the Vietnam Sustainable Development Strategy for the period of 2011–2020; the Strategy for Environmental Protection to 2020 and the Vision to 2030; the Green Growth Strategy, etc.

Currently, the legal basis for implementing the circular economy model is the Law on Environmental Protection in 2020. In which, Article 142 clearly defines the circular economy definition and stipulate the responsibilities of ministries, ministerial-level agencies, and provincial-level People's Committees (implementing circular economy integration right from the stage of developing strategies, master plans, plans, programs, projects, and development scheme; management of reuse and recycling of waste) as well as the responsibilities of business in the implementation of the circular economy. Article 142 also defines that the Government stipulates criteria, schedule, and mechanism to encourage the implementation the circular economy model in accordance with socio-economic conditions of the Nation (Vietnamese Parliament, 2020). This policy is detailed by the Government through Decree 08/2022/ND-CP, in which, Article 138 is the general regulations about the circular economy, Article 139 refers to the schedule and responsibility for implementing the circular economy, and Article 140 stipulates a mechanism to encourage the implementation of the circular economy (Vietnamese Government, 2022a, b).

In particular, the Government signed the decision No. 678/QD-TTg on the promulgation of the project of circular economy development in Vietnam. The specific objective of the project is to contribute to concretizing the target of reducing greenhouse gas emission intensity per GDP by at least 15% by 2030 compared to 2014, toward the goal of net emissions to "zero" by 2050 (Vietnamese Government, 2022a, b (2)).

With specific policies as mentioned above, it could be seen that the State has oriented the schedule for developing the circular economy, considering circular economy development as inevitable. This is the important basic to develop the circular economy model in Vietnam.

(b) *About the activities to reduce environmental pollution of the mining industry*

Vietnam already has some of circular economy model approaches such as cleaner production model in small- and medium-scale industrial production. Although there are many limitations, such as causing environmental pollution, but these models have also initially approached the content of the circular economy. In each mining activity, there have been effective activities to reduce environmental pollution.

- *Coal mining activities in Quang Ninh*: Over the past years, Vinacomin has implemented many activities to overcome the negative impacts of coal mining on the environment, such as implementing a series of projects to renovate large dumping sites with high risk of landslides (Sidewalks 7–8 Ha Tu, Chinh Bac, Nam Lo Phong, Nam Deo Nai); building some mine wastewater treatment stations to meet the requirements of standard mine wastewater treatment for coal mining companies; invest in building 21 specialized transportation routes with a total length of 131 km; over 1500 ha of forests could be planted to cover waste dumps, renovate and restore the environment; and boosting capacity of industrial hazardous waste treatment plant in Cam Pha–Quang Ninh, etc. (VINACOMIN, 2017).
- Bauxite mining, alumni processing, and aluminum smelting at Tay Nguyen: Using the pits after bauxite mining as storage for tailing sludge to both have materials for leveling the mining terrain and take advantage of the ingredients clay and nutrients to improve and restore soil on pits; using red mud as the raw material for the production of building materials to help reducing landfill costs and safely controlling red mud, gradually reducing and eliminating the area of red mud landfills; make the most of the ash and slag of thermal power plants, lime kilns to reduce waste dumps and turn them into useful materials (Luu, et al, 2020).
- Apatite mining activities in Lao Cai: The field of ore mining at the mining sites is directed and implemented to ensure compliance with technical measures and processes, minimizing of smog and dust that causing environmental pollution; the processing plants well handle the emission of noise; the non-hazardous solid wastes are buried and dumped into the landfill; the wastewater system is treated and put into a centralized wastewater lake; oil and grease in the process of repairing machinery and equipment are classified, collected and thoroughly treated; conducting environmental reclamation and restoration for the entire process of mineral exploration, mining and processing (Xuan, 2020).

Thus, there have been many activities of the mining industry to minimize the negative impact on the environment. Although these activities still have certain limitations such as there is no plan for thorough waste treatment; the speed of waste treatment, recycling, environmental restoration, and restoration has not kept pace with the production speed; there is no link between industries in recycling and reuse

of waste, etc. However, these show that the application of the circular economy model in the near future is completely grounded and could be done.

4 Proposing the Circular Economy Model for the Mining Industry in Vietnam

On the basis of the 3R circular economy model (reduce, reuse and recycle), along with the characteristics of the mining industry, the authors propose the circular economic model suitable for Vietnam mining industry as shown in Fig. 1.

According to this model, the operation of the mining industry goes through stages from search and exploration; exploiting; processing (treatment, smelting) and consuming. These stages are performed one after another. The outputs (useful) of the previous stage is the input to the next. However, at each stage, there are unwanted outputs that need to be circular.

– Exploratory drilling activities could determine the structure and reserves of mineral seams. In addition, it is possible to perform drilling activities to remove gas in coal and oil seams, etc., to recover some gases such as CH_4. It could help both reduce toxicity in the mining process, reduce greenhouse gas emissions that cause climate change, and could be used to produce thermal power.

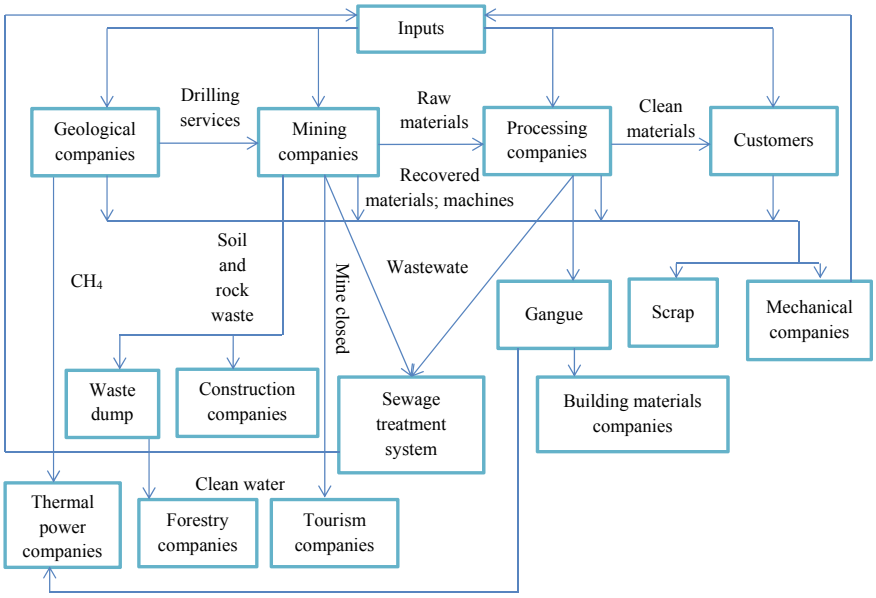

Fig. 1 Circular economy model suitable for Vietnam mining industry. (*Source* Proposal of the authors)

- Mining operation provides raw materials. The waste of this stage could also be processed for recycling. Specifically, a part of the soil and rock waste is used for construction (levelling activities, production of building materials, etc.); the rest is dumped in the landfill. When the landfill is full, it could be used to provide ground for afforestation. It could help restore and protect the environment, and it could also create wood resources. Wastewater from the mining process is sent to wastewater treatment plants for treatment. Clean water after being treated is brought back to use for production (road watering, misting, etc.), watering plants, human living, etc. In addition, mines after closing could be renovated to become resources for the tourism industry.
- Processing activities create clean materials to meet the different needs of the economy. These activities also create wastes such as wastewater from the process, tail ore. Wastewater will also be sent to treatment centers for cleaning. Tail ore is used to produce thermal power (for coal processing) or produce construction materials (for bauxite, metal ore, etc.).
- In addition, the materials and machines after each production process would be recovered. If they could still be repaired and maintained, these activities will be carried out to prolong the life of them. Materials and equipment that cannot be repaired could be liquidated to serve recycling processes in other companies.

The mining industry discharges lots of waste into the environment (including solid, liquid, and gaseous waste). The application of the circular economy model into this industry contributes to reducing environmental pollution, prolongs the value chain of the industry, making an important contribution to the implementation of sustainable development goals.

5 Some Recommendation to Promote the Application of the Circular Economy Model into the Mining Industry in Vietnam

(a) *About mechanism and policies:*

- The Government shall stipulate criteria, roadmap, and mechanisms to encourage the implementation of the circular economy in accordance with the socio-economic conditions of the nation.
- Develop the circular economy development strategy that is reasonably linked with the other strategies of the mining industry.
- The activities when applying the circular economy model such as waste treatment, resource utilization, etc., could not bring economic benefits to companies. However, these activities are very meaningful to the nation, or even to the global in the context of resource depletion, environmental pollution and climate change. Therefore, the Government needs to have mechanisms,

policies, support activities, and subsidies to promote the application of the circular economy model in the mining industry.

(b) *The implementation of application*

The application of the circular economy model which is offered for the extractive industry should be flexible and adaptive with features of different mineral excavation. In the short term, it needs to be focused on both levels of enterprise and the industry. At the enterprise level, the application includes the utilized excavation of minerals, increasing reuse and recycle of materials to reduce wastes. At the industry level, it is the promotion of an industrial symbiosis model among strong subsectors of the mineral industry, e.g.: the combination of coal–electricity–consumption–construction materials production (from wastes soil of mines, slag of thermal plants), the combination of minerals excavation–processing and metallurgy–recovery and treatment of tailings and sludge (copper, lead, zinc, bauxite, etc.). However, it is necessary for the model to be synchronized with the business model and management mechanism of companies or corporations.

(c) *Training*

Training to improve qualifications for the workforce of the industry, especially a team of experts with in-depth professional knowledge and multidisciplinary understanding of fields related to the mining industry, and also having the ability and conditions to access new scientific and technological achievements, etc.

(d) *About technology and finance*

- Researching and applying new technology in production.
- Strengthening public–private partnership to attract investment capital to develop the circular economy.

6 Conclusions

This research reviews and applies the theory of circular economy model in the mining industry; analyzed the need and potential of applying the circular economy model to this industry in Vietnam; and proposed the circular economy model suitable for the mining industry in Vietnam. On that basis, the authors also propose some solutions to promote the application of the circular economy model in this industry toward the goals of sustainable development. However, the content of this chapter just only build the management model. There are still many specific issues to apply the circular economy model into the mining industry, both management issues, and technical and technological issues. For future research direction, the authors will continue to research or make interdisciplinary links to research in order to continuously promote the application of this economic model in mining activities, contribute to the realization of national goal that transiting from the linear economic model to the circular economy model.

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References

Bui, X. D. (2020). Experience in implementing the circular economy model in some countries and suggestions for Vietnam. *Economy and Forecast Review*, *22*(740).

Ellen MacArthur Foundation. (2013). *Towards the circular economy: Economic and business rationale for an accelerated transition.*

Kinnunen, P. (2019). *Towards circular economy in the mining industry: Implications of institutions on the drivers and barriers for tailings valorization.* Tampere University, Faculty of Management and Business.

Littleboy, A. et al. (2016). *The circular economy and its implications for natural resource supply and demand*. UN Centre for Regional Development.

Luu, D. H. et al. (2020). *Building the circular economy model in bauxite mining and aluminum industry in Tay Nguyen.* https://kinhtemoitruong.vn/xay-dung-mo-hinh-kinh-te-tuan-hoan-trong-khai-thac-bauxite-va-cong-nghiep-nhom-o-tay-nguyen-51834.html. Accessed October 19, 2022

Minh, A. (2015) *Mining industry still makes a big contribution to GDP*. https://baotainguyenmoitruong.vn/cong-nghiep-khai-khoang-van-dong-gop-lon-cho-gdp-234640.html. Accessed May 11, 2022

Ngo, T. B. (2003). *Textbook of Vietnam mining industry economics*. HaNoi University of Mining and Geology.

Nguyen, D. D. (2021). *Circular economy: Theoretical and practical issues.* https://tapchinganhang.gov.vn/kinh-te-tuan-hoan-nhung-van-de-ly-luan-va-thuc-tien.htm

PETROVIETNAM. *Introduction of crude oil products.* https://www.pvn.vn/Pages/detailv1.aspx?NewsID=13fa0efa-ec99-4f9d-ba37-af6d4dab8530. Accessed March 10, 2022.

Pomykała, R., & Tora, B. (2017). Circular economy in mineral processing. *E3S Web Conference*, *18*, 01024. https://doi.org/10.1051/e3sconf/20171801024

Tran, H. (2016). *Some overview of Vietnam's mining industry.* https://vietnam.opendevelopmentmekong.net/vi/topics/tieng-viet-mot-vai-net-tong-quan-ve-nganh-cong-nghiep-khai-khoang-viet-nam/#!/story=post-289081&loc=13.2904027,108.4265113,7. Accessed October 3, 2022.

Tran, H. H. (2021). *Developing the circular economy for efficient resource management and using.* https://nhandan.vn/dang-va-cuoc-song/phat-trien-kinh-te-tuan-hoan-de-quan-ly-va-su-dung-hieu-qua-nguon-tai-nguyen-641799/. Accessed February 13, 2022.

Vietnam Energy Association (VEA). (2013). *Vietnam Energy Yearbook 2011–2012.*

Vietnamese Government. (2004). *Agenda 21 of Vietnam (Decision 153/2004/QD-TTG dated September 17, 2004).*

Vietnamese Government. (2016). *Decision 403/2016/QD-TTg*.

Vietnamese Government. (2022a). *Decree 08/2022a/ND-CP*.

Vietnamese Government. (2022b) (2). *Decision No. 678/2022b/QD-TTg.*

Vietnamese Parliament. (2020). *Law on Environmental Protection 2020*.

VINACOMIN. (2017). *Environmental protection solutions in the coal industry*. http://www.vinacomin.vn/tin-tuc-vinacomin/giai-phap-bao-ve-moi-truong-o-nganh-than-201710041510340916.htm. Accessed October 19, 2022

Vinacomin Industry Investment Consulting JSC. (2018). *Project on developing Vietnamese coal market in association with coal production and business following the market mechanism and ensuring national energy security.*

Xuan, Q. (2020). *Vinaapaco synchronously implements solutions to protect the environment and respond to climate change in production and business.* https://www.laocai.gov.vn/1366/95264/70021/530795/tin-tuc-tong-hop/cong-ty-apatit-viet-nam-thuc-hien-dong-bo-cac-giai-phap-bao-ve-moi-truong-ung-pho-voi-bien-doi-khi-hau. Accessed November 5, 2022.