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Corporate Environmental Responsibility within the Circular Economy Context: Opportunities for Development and Sustainability

(the example of Dundee Precious Metals Chelopech EAD)

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Abstract

Environmental responsibility, as one of the constructs of the comprehensive concept of corporate social responsibility, stands out with its own identity and has many similarities with the circular economy idea. The aim of the study is to demonstrate how the results from the environmentally responsible practices implemented in accordance with circular economy principles open up opportunities for development and sustainability. This paper describes the continuous improvement of the environmental responsibility of a leading mining company in Bulgaria – Dundee Precious Metals Chelopech EAD. The study is based on the case study method. The scientific analytical and comparative methods employed are based on environmental performance indicators for the 2011 – 2017 period. The results show that by observing circular economy principles and implementing environmentally responsible practices, the company has enhanced the efficiency of resources used in ore mining and processing (water, fuel, electricity, cement) and increased the degree of water and waste reuse (waste-rock and tailings). This in turn has led to improvement of economic and financial results. The symbiosis between corporate environmental responsibility and circular economy creates additional opportunities for development and sustainability.

Key words: corporate environmental responsibility, circular economy, sustainable development, resource efficiency

JEL: Q50, Q51, Q56, Q58

Introduction

One of the biggest challenges we are currently facing is how to break free from the growth-oriented model in order to meet the community's social needs and replace the historic predatory exploitation of natural resources with a new, more efficient, resource-friendly and environmentally responsible model. Circular economy provides basic guidelines on what should be done to achieve a significant and lasting reduction of the economy's resource dependence and

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head towards overcoming the scarcity of non-renewable natural resources. It is a new way of viewing existing relations between markets and commercial enterprises and reconsidering the concept of waste as a natural resource (Davey, 2008).

In response to the undeniable need for a new model of economic development, the business is implementing environmentally responsible practices mitigating the adverse environmental impact brought about by implemented business activities, created products and facilities used. Corporate environmental responsibility has a significant contribution to the development of the idea of circular economy and it stands out with its own identity as one of the subconstructs of "the responsibility of enterprises for their impact on society," according to the new definition of corporate social responsibility (CSR) by EC (EC, 2011, pp.6). This is a result of the very essence of the corporate environmental responsibility concept, which is directed towards mitigating the environmental impact of the company and can include changes in the company's products, processes and policies, such as reducing energy consumption and waste generation, using environmentally sustainable resources and implementing an environmental management system (Bansal, P. and Roth, K. 2000). Companies implement environmental initiatives to reduce their environmental footprint, applying innovative technological solutions for reducing polluting emissions, rational utilization of resources and energy, recycling more waste and products. Implementing the principles of circular economy related to waste management and reuse, for example, offers efficient alternatives to the problems arising from the rapid increase of waste generated in production (Lisney, Riley and Banks, 2004; Fricker, 2003; Boiral and Croteau, 2001).

Such a transformation of the economy is also a means to generate future prerequisites for growth. This is due to the transition from an extraction- and consumption-based production to more complex development models which would lead to long-term growth strategies. Future competitiveness will be a function of energy efficiency and resource management (Ivanova, V. 2013).

The development of circular economy in the mining industry has a significant impact on solving the problem of mineral resource shortage, waste from resources and environmental pollution, enhancing resource efficiency and the sustainable development of the national economy.

A question of research interest is: "Are there points of contact between corporate environmental responsibility and circular economy principles at the DPM Chelopech mining company – is the company implementing environmentally responsible business practices based on circular economy principles manifested either explicitly or implicitly?"

Methodology

In this paper, corporate environmental responsibility is reviewed in accordance with the circular economy principles, and **the aim** of the study is to demonstrate how the results from environmentally responsible practices implemented in accordance with these principles open up opportunities for the company's development and sustainability.

The object of the study is Dundee Precious Metals Chelopech EAD – a company for extraction and processing of gold-copper-pyrite ores from the Chelopech deposit. It is located in the western part of the village of Chelopech, at the foot of the Balkan Range, 75 km to the east of the city of Sofia. The company is an established leader in the

mining industry, which is why it was selected for the study.

The subject of the study is the environmentally responsible practices of the company.

From the wide range of indicators included in Global Reporting Initiative (GRI), the authors have selected those which they believe measure the results of environmentally responsible practices implemented in accordance with circular economy principles either explicitly or implicitly.

Research goals include:

- To present the corporate environmental responsibility of Dundee Precious Metals Chelopech EAD mining company;
- To analyse the environmental performance indicators reflecting the results from the environmental responsibility implemented by the company in accordance with the circular economy principles for the 2011 – 2017 period.
- To demonstrate the relationship between environmental responsibility and circular economy principles, and the symbiosis between the two, based on the findings.

The working hypothesis to be confirmed is: *Implementing corporate environmental responsibility in accordance with circular economy principles opens up opportunities for company development and sustainability.*

Our research is based on the case study method. The scientific analytical and comparative methods are employed. The in-depth analysis of Dundee Precious Metals Chelopech EAD mining company is based on data from documents published on the company website – written policies, corporate values, code of ethics; sustainable development reports of the parent company Dundee Precious Metals, as well as its financial reports; information in the press and online media on Dundee Precious Metals Chelopech EAD, as well as interviews with company representatives. According to the GRI, electronic or web-based reports and hardcopy versions are suitable and acceptable media for reporting company information.

This study traces the results from the continuous improvement of environmental responsibility for the 2011 – 2017 period based on environmental performance indicators. The company implements the GRI and data from its sustainable development reports were used. Analytical and comparative methods were applied.

The paper is organized as follows: first, the essence of corporate environmental responsibility, forms of manifestation and benefits of its implementation are clarified, as well as the essence of circular economy, its principles and characteristics; second, an analysis is made of the environmentally responsible business practices implemented by the company and their results, based on the environmental performance indicators; third, the relationship between environmentally responsible business practices and circular economy principles is reviewed. Finally, conclusions are made and areas which require further research are outlined.

1. Corporate environmental responsibility and circular economy

Greening company operations for the purpose of gaining greater competitive advantage and production sustainability is now becoming an inevitable necessity (Bansal, P. and Roth, K., 2000). The main focus here is resource efficiency, which results in a reduction of production costs and growth of productivity. In this respect, the activities related to waste utilization, reuse and actual limiting of waste volumes carry significant potential (Fricker, A., 2003). These processes of greening business operations

for sustainability and development purposes are linked to implementing environmentally responsible business practices and applying circular economy principles.

1.1. Corporate environmental responsibility

Businesses are facing growing challenges related to enhancing care for the environment and climate change, reducing poverty, and the accelerated process of globalization, which are changing the role of the business in society and turning environmental responsibility, as a major subconstruct of corporate social responsibility (CSR), into an important and integral part of the corporate activities of a growing number of companies.

Public expectations of corporate activities through the decades have changed significantly, and the appeal for greater environmental sustainability is at the core of this change. Different stakeholder groups, regulatory institutions and non-governmental organizations, in particular, exert a lot of pressure on corporations to become more environmentally friendly in their activities and operations.

The change in corporate environmental behavior comprises two separate stages, characterized by different driving forces. In the early stage, it is based on the paradigm related to observing the norms, where legal and regulatory considerations are the main drivers of undertaking corporate environmental activities (Li, 2001; Rosen, 2001). This stage is characterized by behavior resulting from the legislation, dictated by considerations related to the command-and-control method or the regulatory regime, and internally justified by cost considerations. During this stage, corporate environmental responses react more strongly to outside institutional pressure, mainly to regulatory pressure from the government (Hart, 1995; Li, 2001), and to some extent, to normative pressure from non-governmental organizations (NGOs) and social groups (Du et al., 2013; Koh et al., 2014).

The second stage is based on the viewpoint related to competitive advantages, which states that economy and ecology are compatible, and superior environmental performance leads to profit generation above the average in the industry (Rosen, 2001; Russo and Fouts, 1997). Environmental sustainability can contribute to both economic profitability and the company's competitive advantages (Porter & van der Linde, 1995). According to this view, corporations with proactive environmental programs have a competitive advantage because they have a better reputation, which has a favorable impact on their relations with different stakeholder groups, both customers and employees, as well as society as a whole (Slavova, I., 2013, Kurucz, E., Colbert, B. and Wheeler, D.,2008). Other factors which contribute to the competitive advantage based on environmental sustainability are innovative technological solutions directed towards lower polluting emissions, smart resource and energy usage, more waste and product recycling (Huang, J., Li, Y., 2017).

The main prerequisite for the second stage is that stakeholders expect companies to take responsibility for the impact they have on the environment and, consequently, it is expected that a market benefit will be obtained for enhanced environmental performance. At this stage, a widely accepted view is that CSR activities, and environmental ones, in particular, which provide benefits both for the company and the society (Porter, Kramer, 2006, 2011) correspond to the organization's goals and its business strategy by contributing to the growth of its competitive advantage (Slavova, I., 2015 a). The environmental aspect of corporate social responsibility and sustainability management play an

increasingly important role in corporate development, formation of the organization's strategy and market performance.

Corporate environmental responsibility has different definitions in academic literature and is viewed as „ … a set of initiatives aimed at mitigating a firm's impact on the natural environment. The initiatives can include changes to the firm's products, processes, and policies, such as reducing energy consumption and waste generation, using ecological sustainable resources, and implementing an environment management system. The concept of corporate ecological responsiveness refers not to what a firm should do, but to the initiatives that reduced the firm's ecological footprint (Bansal, P and Roth,K. 2000, p. 717).

Additional efforts of the companies integrating environmental considerations in their business operations and interaction with stakeholders (Williamson et al., 2006) can reduce the environmental implications of implemented business operations, created products and facilities used. In other definitions the focus is on the voluntary nature of environmental responsibility as a clearly distinguished element of the comprehensive concept of corporate social responsibility – environmentally friendly activities which go beyond mere compliance with legal requirements (Lyon, T. P., & Maxwell, J. W., 2008). These activities are related to "the duty to cover the environmental implications of the company's operations, products and facilities; eliminate waste and emissions; maximize the efficiency and productivity of its resources; and minimize practices that might adversely affect the enjoyment of the country's resources by future generations"(Mazurkiewicz, 2004 p. 2).

As much as the definitions of corporate environmental responsibility differ, in general they focus on activities specific for the company, both compatible and preventive, which restrict the company's adverse impact on the environment (Rahman, N., Post, C., 2012). It is manifested in different ways: environmentally responsible practices; implementation of certified international environmental management systems; participation in local environmental initiatives; supporting environment-related causes aiming to contribute to local community development, improving the quality of life, promoting and improving human welfare and achieving environmentally friendly management.

Environmentally responsible business practices are business practices in which the corporation adopts and demonstrates a method of work and investments which reduces adverse environmental impact (Kotler, F., Lee, N., 2011). They are characterized by activities which are not required by law or other types of regulation and are not something to be expected from simply observing moral and ethical standards.

Most initiatives related to environmentally responsible business practices concern changing internal procedures and policies, such as product range, facilities design, production processes related to innovative solutions. Such environmentally responsible business practices implemented by corporations include:

- Designing buildings in a way that complies with or even exceeds safety and environmental protection requirements, such as higher energy efficiency.
- Improvements in production processes – these could be practices, such as prohibiting the use of hazardous waste materials; reducing the amount of waste; enhancing resource efficiency, etc.
- Implementing innovative technological solutions in manufacturing which reduce natural resource consumption and environmental impact.

- Selecting suppliers according to their willingness to implement or maintain sustainable environmental practices, supporting and rewarding their efforts.
- Selecting the most environmentally-friendly raw and packaging materials, taking into account the goals of reducing waste, using renewable resources and reducing or eliminating carbon emissions/greenhouse gases released into the atmosphere.
- Measuring, monitoring, reporting and disclosing measurable objectives and activities, including the good and the bad news.
- Taking decisions for locating/re-locating production activities, improving their economic impact on society and reducing their adverse environmental impact.

The companies which embrace environmentally responsible business practices gain various benefits, and there is a rising tendency for efforts in this direction to be linked to positive financial results. Financial gains are associated with reduced operational costs, monetary incentives from the regulatory bodies, enhanced employee performance and employee retention; achieving a high standard of healthy and safe working conditions, which reduces costs and risks. It has been established that proactive environmental practices lead to cost and risk reduction (Berman et al, 1999; Hart, 1995; Shrivastava, 1995).

CSR activities in the form of policies for equal employment opportunity, as well as environmental commitment, help increase the long-term value for shareholders by reducing costs and risks (Smith 2003).

Corporate responsible business practices can also create marketing advantages due to the potential for a better attitude from society, creating brand preference, brand positioning, improving product quality and higher respect for the corporation. They also create opportunities for building relations with external partners, such as regulatory bodies, suppliers, local authorities and non-governmental organizations.

The company has to regularly inspect and undertake new, or change existing, business practices to reduce adverse environmental impact and improve the quality of life, while creating financial, operational or marketing advantages. Since the impact of corporations on the environment varies, the environmentally responsible initiatives also vary depending on the industry within which the company operates and its geographical scope (Lee et al., 2014; Koh et al., 2014). A defining role in the selection and implementation of environmentally responsible business practices is played by the main competences and institutional capacity of the company, as well as its ability to stand out with its environmental responsibility in accordance with its strategy.

In the last decade, a change has been observed in the adoption of more responsible business practices as a result of regulatory requirements, customer complaints and pressure from special interest groups, towards proactively seeking corporate solutions to environmental problems and introduction of new business practices to support them (Boeva, B., 2015; Gangi, F., D'Angelo, E., 2017). In response to the absolute necessity for a new economic development model, the business is implementing environmentally responsible practices based on the circular economy principles, creating opportunities for business development and sustainability.

An important issue related to environmental responsibility is accounting and disclosing company results directed towards achieving the economic, social and environmental goals, following the famous "triple bottom line" approach (Elkington, 1994), which directs the

planned activities and operations undertaken by the company.

Pressure from stakeholders affects companies in two different ways – companies are not only expected to efficiently manage their environmental results, they should also take responsibility for this performance. As a result, a growing number of companies disclose environmental data, and many of these disclosures are in the form of environmental reports (Sethi, S., Martell, T., Demir M., 2017).

In order to provide a continuous guideline for dissemination of environmental information, several environmental accounting standards have been established, including the GRI (the most common and widely used by companies). However, their recommendations for corporate environmental management have many features in common (Wagner, R., Seele, P., 2017). These common characteristics include an environmental protection policy to manage operations, environmental system for turning policy into practice by integrating environmental problems in different organizational and functional processes, a commitment to improve environmental results through continuous study of best practices and re-evaluation of operations, requiring subcontractors and suppliers to meet environmental standards, and open communication to encourage dialogue with different stakeholder groups (ISO 14001, CERES, ICC, GRI).

It has been accepted that corporate environmental results are usually derived from content analysis of environmental reports (Clarkson et al. 2008; Morhardt et al. 2002) and on corporate websites (Jose and Lee 2007). According to the GRI, electronic or web-based reports and hardcopy versions are suitable and acceptable media for reporting company information.

The study covers environmentally responsible practices based on circular economy principles, and the results of their implementation are measured by indicators included in GRI. Similar to CSR, manifested either explicitly or implicitly (Matten, D., Moon J.,(2008), we believe that in implementing their environmental responsibility, companies utilize circular economy principles whether this is stated explicitly in their company policies, or not.

1.2. Circular economy

The essence of circular economy lies in the aggregation of different production methods and practices, hierarchically arranged depending on their impact and aiming to optimize consumption of raw materials and energy (Mathews and Tan, 2011, Europesworld, 2014).

According to the UN definition "circular economy is a system of production, exchange and sharing enabling social progress, the preservation of natural capital and sustainable economic development"[1]

According to the definition provided by the Environment and Energy Management Agency (ADEME2014) "circular economy is an economic system for exchange and production which, at all stages of the product life cycle (goods and services), aims to increase the efficiency of resource use and reduce the impact on the environment, while enabling people to live well."[2]

This is also the working definition adopted in the present study.

Circular economy is a model aiming at preserving and increasing the value of resources used in production and consumption, while reducing their impact on

[1] https://www.economiecirculaire.org/data/sources/users/901/septpiliersec.png

[2] http://www.ademe.fr/sites/default/files/assets/documents/fiche-technique-economie-circulaire-oct-2014.pdf

the environment, during the whole life cycle of the products (ACR+report, 2015).

Circular economy can be viewed as an integral part of the concept of sustainable development, since it very closely correlates with each of the dimensions – economic, social and environmental.

This is a practice-oriented concept. The manufacturing of products designed for long-term use is fundamental in this model (Ellen MacArthur Foundation, 2012). They should be designed so as to be suitable for refurbishment, also guaranteeing production of spare parts for them. Products should be suitable for reuse, shared use and with maximum length of service life (Geng et al., 2014). Last but not least, circular economy requires the manufacturing of decomposable products whose components or subsystems can be reused as components in the manufacture of new products (Frondel et al., 2004). Recycling (as far as possible) of parts which cannot be reused or refurbished plays a key role in a circular economy model.

Drivers of circular economy transition can include:

- Reducing use of hazardous or hard to recycle materials;
- Creating products with better features and longer service life;
- More efficient production processes which turn waste into resources using new technologies.
- Designing products which are more easily refurbished, upgraded and recycled;
- Providing incentives for reducing waste.

The transition to a circular economy shifts the focus onto reuse, refurbishment and recycling of existing materials and products. On the one hand, this requires reducing the amount of generated waste, and on the other, a change in the behavior model of manufacturers related to the supply of a new type of products which can be reused (Matete and Trois, 2008). Advances in eco innovations provide new products, processes, technologies and organizational structures which enable a transition towards business models based on refurbishment, reuse or recycling of products or their components (Geng and Doberstein, 2008, Naustdalslid, 2014). This is without doubt a new opportunity for small and medium-sized enterprises.

The ultimate aim of circular economy is to disconnect economic growth from the depletion of natural resources by creating innovative products, services, and business models, taking into consideration all flows throughout the life of the product (EC, 2012). At the same time, the concept presupposes implementation of adequate public policies focusing on new models of production, consumption, extending the service life of products, their reuse and components recycling.

Circular economy creates new added value for companies while resources are reused for as long as possible. This has a twofold effect – better waste management, on the one hand, but more importantly, enhanced company competitiveness and development. When a product completes its main function, it is returned to the company, where it is dismantled into reusable parts (Harribey et al., 2011). The final stage in circular economy is recycling. It allows waste (industrial or household) to be reused in the manufacturing of products as raw materials.

Circular economy principles

In order to meet modern economic challenges related, on the one hand, to scarce, finite and increasingly expensive resources, and to environmental needs, on the other, circular economy is based on three fundamental principles (Declic, 2016). They are summarized in Figure 1.

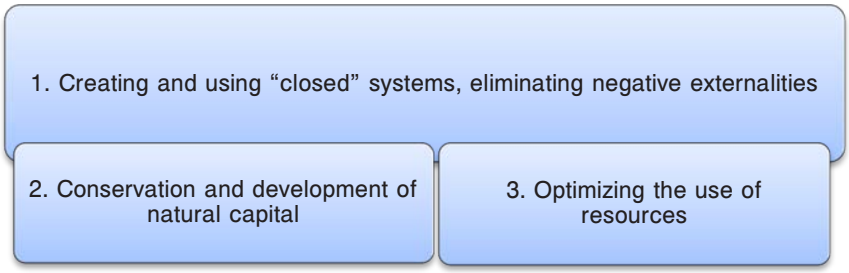

Figure 1. *Principles of Circular Economy*

Observing each of these principles leads to economical, responsible and efficient resource use. Preservation and development of natural capital is carried out by controlling finite stocks and balancing renewable resource flows. The focus is on dematerializing utility whenever possible and careful selection and promotion of technological processes enabling renewability of resources with the highest possible efficiency. In the circular economy model of natural capital, suitable conditions are created for regeneration and recovery of ecosystems (Rotillon, 2010).

Circular economy characteristics

In order to be defined as circular, an economy must meet the following four characteristics:

A) **Systematicity** –understanding the interconnectedness and interdependence of individual components within a whole is probably the most significant characteristic of circular economy (Costa et al.,2010). Each economic unit should be perceived as an integral part of its social and environmental context. Since the majority of subsystems in the economy function as non-linear, interconnected and more or less interdependent, it is crucial that the idea of the complex interdependencies and multitude of possible interactions be adopted, i.e. the idea of circularity(Preston, 2012).

B) **Cascading** in functioning – similar to ecosystems, the subsequent, cascading use of products and materials is an inexhaustible source of added value in production too. Going through the various transformation stages before materials are finally destroyed and turned into energy creates a number of opportunities to optimize and fully use resources (Hours and Lapierre, 2013).

C) **Restricting waste generation** – in the ideal case, circular economy is a completely waste-free system since it enables the integration of product components into a new biological or technological cycle (EC, 2014, Wrinkler, 2011). However, this requires that they are designed so as to be decomposed and reused. For biological products, composting is the easiest way. For the rest, eco design allows their quick reuse at minimum energy consumption and preserving their technical features and properties (Brown and Stone, 2007). Recycling is the last stage, where the original product is turned into a secondary raw material fed back into the manufacture of new products.

D) Based on the use of **renewable energy** – circular economy is defined by low energy consumption, restricting the use of conventional fuels and self-sustaining its need for renewable energy sources (Senge et al, 2010).

For the business, the transition to a circular business model is attractive for its economic benefits and the jobs it creates, but that is not sufficient for this transition to take place.

Realizing the fact that the circular economy transition is turning from a voluntary choice into a fundamental necessity can significantly shorten the time required to implement this transformation and channel the efforts of all parties involved – the government, local authorities, companies, NGOs, customers.

2. Results and Discussion

2.1. The corporate environmental responsibility of Dundee Precious Metals Chelopech EAD

Ore mining in the Chelopech mine began in 1954, and its development underwent various stages, including its closure by the Bulgarian government in 1990 due to the relatively high arsenic content in the copper concentrates in Chelopech. By virtue of a privatization agreement with the Bulgarian government, Chelopech mine became the property of Navan and after its bankruptcy in 2003, on 30 September 2003, Dundee Precious Metals (DPM), through some of its wholly-owned subsidiaries, completed the purchase of the Bulgarian mining assets from Navan and Deutsche Bank AG, London, including the Chelopech mine. Annual processed ore production increased from 523,810 tonnes in 2004 to 2,218,717 tonnes in 2017. DPM owns the land upon which the facilities are constructed and operates under a concession agreement that was granted by the Republic of Bulgaria in 1999 for a period of 30 years.

DPM has invested close to 90% of its profits to transform the mine from an undercapitalized operation into a modern and viable one that meets international standards for worker safety, environmental protection and sustainable development.

Environmentally responsible business practices

The very nature of the production process – extraction and processing of copper and gold-containing ore – has an adverse environmental impact. This is why environmental protection is a major priority in the company activities and one of their main goals.

The continuity of environmental protection activities carried out by the leading mining company is evidenced by the growing investments in new environmental projects, as well as the environmental results achieved, which are shown in Table 1 and Table 2 (reduced carbon emissions, reduced consumption of natural resources, reduced water contamination, reduced amount of generated waste, etc.).

The corporate environmental responsibility implemented by the management of Dundee Precious Metals Chelopech EAD is manifested in diverse ways: environmentally responsible business practices; implementation of certified international environmental management systems; involvement in local environmental initiatives and others. In accordance with the research goals of the study, this paper analyzes only the environmentally responsible business practices implemented in accordance with the circular economy principles in the mining industry and the results of their implementation are analyzed using environmental performance indicators.

Corporate environmentally responsible business practices related to the improvement of the production process (expansion and modernization) along with the whole value chain, through which the company significantly enhances energy and resource efficiency and reduces its environmental footprint, include:

- *Implementation of a new ore mining system which results in more effective ore mining, while significantly reducing negative impact on the environment and subsurface resources*

In 2005, the sub-level caving system, employed as the main mining method for

more than 40 years, was replaced with the long-hole stoping with fill method, due to the conditions in the Chelopech mine. In the new system, mining waste (waste rock which in the past were hauled onto the surface as a type of mining waste) is used for stope backfilling directly underground and is hence fully utilized on the site where it is generated.

This innovative system is recommended and implemented as the best available technology worldwide, enabling more effective ore mining while significantly reducing negative impact on the environment and subsurface resources.

This method preserves ground stability, fully utilizes waste rock as a backfill material, and reduces the relative volume of tailings in the tailings management facility (TMF), while preventing regress of surface runoff into the mine.

The benefits for the environment and landscape are irrefutable, the most significant of which include: about 40%-per-tonne-mined reduction in flotation tailings in the TMF 2004 – 2017 (from 0.92 t. flotation/ tailings per tonne mined in 2004, it is reduced to 0.52 t. waste per tonne mined in 2017), thorough utilization of waste rock as backfill material, prevention of surface cavings and waste rock stockpiles above ground, and environmental protection for both surface and groundwater.

- *Improvement and optimization of the stope filling process – reduction of the amount of cement used per tonne ore mined*

The innovative solutions introduced by the company management for enhancing resource efficiency replaced the hydraulic fill plant commissioned in 2008 with a new paste fill plant in 2010. Paste backfill consists of the same components as hydraulic fill (the backfill comprised tailings, reclaim water and cohesive substance – cement), but it allows more thorough utilization of the flotation waste, better quality control, slower backfill transportation and, last but not least, lower amount of cement used.

Data show that in the 2012-2013 period, the amount of cement used in the backfill was reduced by about 50% per tonne mined compared to 2009 (43 thousand t. per tonne mined), and after 2011, when production was increased to over 2 Mt/y, the quantity of cement used per tonne mined was within 17-18.5 thousand t. (2011-2017). According to experts, this is the result of improvements in production processes based on expertise and experience acquired so far.

- *Modernization of the processing plant – reduction of fresh water consumption in production*

The modernization project for the processing plant, which started in 2010 and was fully completed in 2012, achieved optimization of the reclaim water system with more than 90% of water now recycled back into the process. The new concentrate and flotation tailings thickeners, together with the filter press enable water recovery and recycling at the processing plant, thus cutting down on fresh water consumption and reducing electricity costs of the return water pumps at the TMF.

Once the upgraded processing plant was commissioned, fresh water extraction from the Kachulka Reservoir was cut by more than 50% (2012 compared to 2011 – from 1 149 823l. fresh water consumption in 2011 to 525,063l. in 2012). Water resource efficiency was significantly enhanced – fresh water consumption (cubic metre) per tonne produced was reduced from 0.85l. in 2011 to 0.34l. per tonne produced in 2017. As a result of the optimization of the reclaim water system, the miner achieved 0 (zero) discharge of water from the TMF into the environment.

- *Enhancing energy efficiency and use of renewable energy sources*

Despite the fact that in the 2011-2017 period energy efficiency increased and modern equipment and facilities were used in ore mining and processing, the company still had high electricity consumption.

The data in Table 1 show that the amount of electricity used for the production of one tonne of ore was reduced by approximately 30% – from 72 kWh electricity consumption per tonne mined in 2011 to 48.9 kWh per tonne ore treated in 2017, which is mostly due to the efficient management of the reclaim water system and improvements in the mine's ventilation system.

"The commissioning of the new conveyor system for ore transportation has led to a decrease in the intensity of use of underground diesel transport at the expense of an increase in electricity consumption. As a result, significant reduction in transport-generated air pollutants was achieved."(*Ilia Garkov, Vice President of the company and Executive Director of DPM Chelopech and DPM Krumovgrad, in an interview for* MiningMagazine, November, 10, 2017)

One of the essential innovative solutions for green energy consumption was the commissioning of solar heating collectors installed on the roof of the mine's administrative building.

Table 1. *Efficient use of resources*

Indicators	2011	2012	2013	2014	2015	2016	2017
Ore processed (tonnes)	1,353,733	1,819,687	2,032,002	2,076,112	2,052,138	2,212,340	2,218,717
Cement (tonnes)	not reported	33,725	35,053	38,589	35,876	45,648	38,834
Cement used per tonne ore processed		18,5	17,2	18,5	17,5	20,6	17,5
Water withdrawn – surface water: rivers, dams (cubic meters)	1,149,823	525,063	756,846	778,015	930,579	678,490	756,846
Water withdrawn – surface water: rivers, dams (cubic meters) used per tonne ore processed	0,85	0,29	0,37	0,37	0,45	0,31	0,34
Electricity (Gigajoules)	361,885	364,696	407,963	384,095	390,179	395,443	391,201
Electricity used per tonne ore processed	74,2	55,6	55,7	51,4	52,8	49,6	48,9
Diesel – mine, process plant, light vehicles (liters)	2952, 514	3554815	2,538,081	2,497,735	2,550,919	2,635,976	2,551,666
Fuel consumption (l.) per tonne ore processed	2,18	1,95	1,24	1,20	1,24	1,19	1,15
GHG emissions (tonnes of CO2) – Scope 1,2 and 3	116224	116684	123939	123939	119599	128584	120 099
GHG emissions (tonnes of CO2) per tonne ore processed	85,85	64,12	60,99	59,69	58,28	58,12	54,12

Source: Sustainability *Performance Data Supplement Dundee Precious Metals, 2013, 2015, 2017 and authors own work*

- *Optimization of the transportation system for ore and the end product – reduction in diesel fuel consumption per tonne mined*

Another major resource, besides electricity, in ore mining and processing is diesel fuel. Its consumption in ore transportation was reduced by about 47% per tonne of ore (from 2.18l. diesel fuel per tonne mined in 2011 to 1.15l. per tonne mined), thanks to the underground crushing system and the orepass system. The Underground Crushing and Orepass System constructed in 2012 and commissioned at the beginning of 2013 in the Chelopech mine is unique for Bulgaria, with its solution for safe and sustainable ore mining and care for the environment. This complete system for crushing and belting the ore from the underground mine to the surface ensures integrity of the work process and protection of the environment and human health.

The 2013 optimization of the end product (copper concentrate) transportation process – shortening the distance – has led to an over 50% reduction in the amount of fuel used for copper concentrate transportation, which significantly reduces greenhouse gas emissions, especially carbon dioxide emissions.

- *Reduction of greenhouse gas emissions*

As a result of implemented environmentally responsible business practices and employing the best technologies in ore mining and processing, greenhouse gas emissions have been reduced significantly – the carbon footprint per tonne of ore produced has been reduced by 37% in the 2011 – 2017 period.

Required energy consumption (and greenhouse gases emitted, respectively) has been reduced by current technologies for tailings dewatering, recycling wastewater, utilization of large amounts of tailings for slope filling (paste fill), improvement of the mine's ventilation system, etc. Required fuel consumption has been reduced by the current orepass system, utilization of the restored railway section for loading of copper concentrate, as well as the solar panels installed on the mine's administrative building.

Table 2 *Water and waste reuse, waste recycling*

Indicators	2011	2012	2013	2014	2015	2016	2017
Total volume of water recycled and Reused (cubic meters)1	2,518,573	2,015,784	1,906,943	1,765,539	1,538,268	1,560,244	1,701,156
Total volume of water recycled/reused as a % of total water withdrawn	306%	183%	228%	163%	116%	142%	179%
Waste rock mined (tonnes)	378,954	219,399	222,710	207,099	210,911	254,222	202,700
Percentage of waste rock returned underground as backfill	100%	100%	100%	100%	100%	100%	100%
Mill tailings placed in surface tailings facilities (tonnes)	920,653	1,217,767	1,216 0 89	1 151580	1,049443	1,023,595	1,163277
Mill tailings placed in surface tailings facilities (tonnes) per ton ore processed	0,68	0.67	0,60	0,55	0,51	0,46	0,52
Percentage of mill tailings returned underground as backfill	26%	28%	35%	36%	38%	46%	38%
Hazardous waste recycled off-site (tonnes)	not reported	89.0	183	113	113	90	125

Indicators	2011	2012	2013	2014	2015	2016	2017
Hazardous waste sent off-site but not recycled (tons)	not reported	0	6.0	4.3	6.16	10.19	0
Non-hazardous waste treated and disposed of on-site (tons)	not reported	23.0	16,460	2,124	1,709	788	835
Non-hazardous waste sent off-site but not recycled (tons)	not reported	0	261	257	196	216	297

1 Water recycled from tailings management facility.
Source: ***Sustainability*** *Performance Data Supplement Dundee Precious Metals, 2013, 2015, 2017 and authors own work*

- *Modern water and waste management in ore mining and processing*

The results of the implemented environmentally responsible practices related to the modernization and optimization of the whole production process, modern water and waste management are also manifested in the indicators characterizing water and waste reuse (waste rock and tailings), as well as their recycling (see Table 2). For the whole period included in the study, 100% of waste rock are utilized as backfill material underground thanks to the new mining method employed – long-hole open stoping with fill. The relative share of tailings used for backfilling purposes also increased – from 26% in 2011 to 38% in 2017, thus reducing the amount of flotation waste (also known as tailings) generated after ore processing and deposited in the Chelopech TMF. As already mentioned, the amount of waste deposited in the Chelopech TMF per tonne mined was reduced by about 40% in 2017 compared to 2004.

The company implemented a closed-cycle technology as a result of which water is reused (the relative share of reused water, in %, from the total required amount of water is over 100% for the whole period under study) and wastewater is not discharged. Thus the mine does not have to pay the wastewater fee and reduces water/ water extraction costs.

The company also recycles harmful and non-hazardous waste – both on- and offsite (see Table 2).

- *Rehabilitation of land parcels contaminated by ore mining and processing*

The corporate environmental responsibility of Dundee Precious Metals Chelopech EAD is also expressed by the continuous rehabilitation of past environmental damage caused prior to the company's privatization (for example, technological and biological restoration of the landscape following mining activities); as well as in actively looking for alternatives for utilizing rehabilitated tailing ponds. In the 2004-2012 period, the company invested BGN 17.4 million in specific environmental protection activities, achieving compliance with the legislation and rehabilitation of disturbed areas. All shutdown and rehabilitation plans include an analysis of the different options for land use, restoration of the land and buildings, environmental protection and development options for the local communities. Looking for options how the tailing ponds rehabilitated in 2011 can be utilized, DPM implemented a five-year innovative project for growing plants on a land parcel in the vicinity of the Chelopech TMF. The project, initiated and funded entirely by DPM Chelopech EAD, aimed to select the most suitable rehabilitation method for Chelopech TMF, thus providing possibilities for its sustainable utilization. Another positive component of the project is that through sound

planning and the research and tests carried out, after the rehabilitation is completed, the local community will be able to carry out agricultural activities, growing etheric oil crops on such land.

2.2 Discussion

The analysis of the environmentally responsible business practices implemented by DPM Chelopech EAD and the results of this implementation, measured by the environmental performance indicators for the 2011–2016 period, form the basis for answering two questions supporting the hypothesis posed:

- Are there common areas between environmentally responsible business practices and circular economy – is there a symbiosis between them?
- Do implemented environmentally responsible business practices based on circular economy principles create prerequisites for sustainability and development?

The monitoring of the continuous improvement of environmental responsibility via environmental performance indicators shows highly efficient use of resources (water, fuel, electricity, cement) and water and waste reuse. The environmentally responsible business practices implemented to improve production process efficiency – ore mining and processing – have led to a reduction in natural resource costs (water, energy, waste, etc.) and improvement of the environment. The company has reduced its operational costs and environmental pollution not only by reducing the waste generated, but also by recycling waste both on- and offsite.

The immediate goal of circular economy is rational management of all resources (materials, energy, water, land). This directly leads to resource efficiency, important both in term of an environmental and a social and economic aspects. In circular economy, new added value is created for companies, while resources are reused for as long as possible. This achieves a twofold effect – better waste management and, more importantly, higher company competitiveness and development. The potential benefits are not only economic, but also social and environmental. These include:

- less resource consumption and wastage,
- waste prevention (all waste actually being considered as secondary raw material),
- less negative environmental impact

All this corresponds to a great extend with the results of implementing environmentally responsible business practices.

The next table 3 is an attempt to show the attempted synthesis of the common areas between circular economy principles and the environmentally responsible business practices implemented by the company.

Table 3. *Conformity of DPM's Environmentally responsible business practices with the principles of circular economy*

	Environmentally responsible practices	Indicators	Principles of Circular Economy
1	*Improvement of production process (expansion and modernization)*	• GHG emissions (tonnes of CO2) per tonne ore processed	Creating and using "closed" systems, eliminating negative externalities
1.1	Implementation of a new ore mining system	• Mill tailings placed in surface tailings facilities (tonnes) per ton ore processed	Optimizing the use of resources
1.2	Improvement and optimization of the stope filling process	• Cement used per tonne ore processed	Optimizing the use of resources

	Environmentally responsible practices	Indicators	Principles of Circular Economy
1.3	Modernization of the processing plant	• Water withdrawn – surface water: rivers, dams (cubic meters) used per tonne ore processed	Optimizing the use of resources
1.4	Enhancing energy efficiency and use of renewable energy sources	• Electricity used per tonne ore processed	Creating and using "closed" systems, eliminating negative externalities
1.5	Optimization of the transportation system for ore	• Fuel consumption (l.) per tonne ore processed	Optimizing the use of resources
2	*Modern water and waste management in ore mining and processing*	• Total volume of water recycled/ reused as a % of total water withdrawn • Mill tailings placed in surface tailings facilities (tonnes) per ton ore processed • Hazardous and non-hazardous waste, recycled off site (tonnes)	Optimizing the use of resources Creating and using "closed" systems, eliminating negative externalities
3	*Rehabilitation of land plots contaminated by ore mining and processing*	rehabilitation of disturbed areas (ha)	Conservation and development of natural capital

Source: ***Own*** *work*

As can be seen from Table 3, the environmentally responsible practices implemented by DPM Chelopech EAD are based mainly on two circular economy principles: Optimizing the use of resources and Creating and using "closed" systems, eliminating negative externalities. These principles are manifested implicitly (the company management does not expressly highlight the implementation of a circular economy model in their policies) and based on the implementation of innovative technologies for ore mining and modern management methods.

Environmentally responsible business practices and the application of circular economy principles have their technological support – environmental technologies characterized by lower pollutant emissions, reasonable resource and energy use, recycling more waste and products, and environmentally friendly waste disposal.

Implementing corporate environmental responsibility opens up opportunities for company development and sustainability by reducing costs and risks as a result of reduced resource consumption and enhanced resource efficiency. In addition to reducing environmental impact, the implemented environmentally responsible practices also provide a high standard of health and safety in working conditions by applying modern environmental technologies in the production process (Annual Report, DPM, 2017). This also contributes to reducing costs and risks.

By adhering to circular economy principles and implementing its characteristic technologies and methods, the company has managed to improve its production and financial results. The sustainability of DPM's operations is demonstrated not only by increased production during the period studied (from 1,309,924 mt to 2,232,799 mt), revenues generated from sales (respectively 24,4% growth for 2017*a*.) and increased by 28,9% to Net Profit for the period (data from the annual financial statements of the company), but also by the growing amount of investments in technologies and the environment. Although motivated by economic considerations rather than environmental ones, DPM has managed to achieve sustainable development, which is a determinant for the development and competitiveness of companies in the mining

industry (Columbia Center on Sustainable Investment, UNDP, World Economic Forum, 2016).

The environmentally responsible initiatives implemented by the company also have a social effect, enhance the company image, and improve relations with stakeholders, the local community, in particular. (Slavova, 2015). In order for these practices to become something more than positive exceptions, actual political commitment, supported by specific measures by the state, is required.

Conclusion

The success of business operations depends to a high degree on unpredictable factors, closely linked to the needs of the global community. Whereas in the past some researchers justified the separation of business interests and public interests while others believed this separation to be wrong, at present contrasting economic, environmental and social goals are not only conceptually invalid, but also pragmatically contradictory. Environmentally responsible business practices, integrated in a comprehensive and continuous approach to strategic management employing circular economy principles, help achieve a balance between economic efficiency, social justice and environmental responsibility.

In the past decades the mining industry has made significant progress in mitigating and managing the negative impact and risks of mineral resource mining and processing, improving the methods used by companies to manage their environmental and social impact, protect their workers' health, achieve energy efficiency, and disclose financial and non-financial information about their activities.

In this regard, Dundee Precious Metals Chelopech EAD is a typical example. The analysis of the environmental responsibility, implemented practices and policies shows that DPM Chelopech implements environmentally responsible activities based on circular economy principles, which demonstrate the similarities between the company's economic goals and its environmental and social ones. The company stands out with its long-term programs and campaigns supporting the community and the environment. It applies a strategic approach and integrates environmental responsibility in structures, processes and systems. At the same time, it measures and reports the results achieved – financial, environmental and social.

This study is based only on the analysis of environmentally responsible practices of the company, using some of the environmental performance indicators included in GRI. It illustrates the existence of a direct connection with circular economy principles. Future research would need to include an empirical study of the factors which have an impact on management decision making directed at sustainability in company development, as well as the application of a circular economy model in the mining industry, taking into account the specifics of this sector.

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