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# Fostering circular economy approach in extractive industry-related study programs – the CIRCEXTIN project

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**Abstract.** Extractive industry is an industry where large volumes of waste are generated. Solid waste from mining and quarrying is the second largest stream of waste in European Union. Extractive industry and higher education programs related to it such as mining, mineral engineering, raw materials, and applied earth sciences need to put an emphasis on this context and include this concept in the existing curricula and/or create new study programs or short courses that will include circular economy (CE) approach. In 2020 project CIRCEXTIN funded by the Erasmus+ Strategic partnerships Key Action 2 was started. The objective of this project is to create a strategic partnership between Universities and companies developing a comprehensive training platform that will help to modify existing study programmes related to the extractive industry and knowledge of proper waste management incorporating a circular economy approach. This article presents major assumptions and result of the project as of September 2022.

## 1. Introduction

Many natural resources are and need to be used in a smarter, more sustainable way. The European Commission's Circular Economy Action Plan, adopted in 2015, sets many ways how to "close the loop" of product lifecycles [1]. The extractive industry is the industry where large volumes of waste are generated. This includes not only solid waste from mine extraction but also liquid waste in the oil & gas industry and gaseous waste (eg. greenhouse gas emissions from mines). Solid waste from mining and quarrying is the second largest stream of waste in European Union after construction and demolition waste [2]. The Circular economy act published by the EU puts a major emphasis on finding new, innovative means to move away from a 'take-make-dispose' culture and to develop new methods, technologies, and also approaches to recycling and re-using products. In this context extractive industry



and higher education programs related to it such as mining, mineral engineering, raw materials, and applied earth sciences need to put an emphasis on this context and include this concept in the existing curricula and/or create new study programs or short courses that will include circular economy (CE) approach. Despite the fact that the European Commission adopted an Action Plan for the Circular Economy, the EU legislator has not established yet a legal definition of “circular economy”. A legal definition is provided in Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 [3] where in article 2 it is stated that ‘circular economy’ means an economic system whereby the value of products, materials and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use, minimizing waste and the release of hazardous substances at all stages of their life cycle, including through the application of the waste hierarchy. There are many other definitions and in [4] over 114 definitions were examined and some of them mistake CE as recycling and see a weak link to sustainable development (particularly social equity). Nonetheless, the CE concept needs to be introduced in higher education, particularly to future engineers, in order to change the way students approach problem-solving. As mentioned before, this is specifically important in industries where large streams of waste are generated and the extractive industry, at any level, is a good example.

In 2020 project CIRCEXTIN “Strategic partnership for fostering circular economy approach in extractive industry related study programmes” (grant no. 2020-1-PL01-KA203-082089) funded by the Erasmus+ Strategic partnerships Key Action 2 was started. The objective of this project is to create a strategic partnership between Universities and companies developing a comprehensive training platform that will help to modify existing study programmes related to the extractive industry and knowledge of proper waste management incorporating a circular economy approach. The project is realized for a period of 36 months by 7 partners.

## 2. Consortium of the project

The consortium of the CIRCEXTIN project consists of 5 universities and 2 companies from 5 EU countries. There are many important reasons why this particular transnational consortium of universities was formed. The major one is the fact that every partner in the consortium has experience with different resources. Silesian University of Technology (Politechnika Śląska) from Gliwice, Poland for many years has been educating in the field of underground mining of coal and metallic ores. Montanuniversität Leoben’s (Leoben, Austria) study programmes are related to mining technology and mineral resources engineering, as well as mineral economics. Technische Universiteit Delft (Delft, Netherland) has a long experience in education related to environmental-based mining, geothermal, oil and gas industry and cooperation with major energy companies. Moreover, in the past years, TUD-GSE (Geoscience & Engineering Department) is taking a leading role in research related to the energy transition. The Department of Geology at Tallinn University of Technology in Tallinn, Estonia (TalTech) offers programs in geology and mining related to oil shales. The Technical University of Madrid in Spain (Universidad Politécnica de Madrid) with its School of Mining Engineering of Madrid is the oldest mining university in Spain offering study programs in mineral and energy resources mining.

The important fact is the participation of two extractive industry-related companies. The JSW Innowacje company is the R&D branch of the largest coking coal producer in Europe and is involved in developing cutting-edge technologies related to coal waste management. COBANT Group is an enterprise whose main activity is focused on mine reclamation and waste recovery.

The selection of consortium members ensures that the overall goal of this project can be achieved in almost every resource and reaches far beyond the timeframe of this project. It will allow the creation of an EU platform that can easily be incorporated into the study programs of other universities. This, in turn, will help to educate engineers that are familiar with this concept and know how to apply it for the well-being of Europe. The synergy between universities and enterprises in the CIRCEXTIN project underpins this Strategic Partnership and allows the successful accomplishment of the ambitious goals it sets.

### 3.Objectives of the project

The project aims to strengthen the strategic and structured cooperation between higher education institutions through:

- a) support for various types of cooperation models, including the most ambitious ones such as the European Universities;
- b) contributing to remove obstacles to mobility by implementing automatic mutual recognition of qualifications and learning outcomes, and by embedding mobility in curricula;
- c) support for higher education institutions to implement the Bologna principles and tools to enhance mobility for all and to develop a successful multilingual European Education Area by 2025.

Project objectives will be reached by means of the following activities:

- Exchange of education experience related to the extractive industry in various countries and regions,
- Identifying similarities and differences in curricula related to extractive industry in the Project partners' countries (for various raw materials),
- Determination of similarities and differences in the requirements of the mining industry of various raw materials,
- Determining to what extent the existing education at the Project partners' Universities takes into account the requirements of circular economy,
- Identifying key qualifications and skills for the education of 'future engineers' in the mining industry according to the idea of circular economy and cleaner production,
- Building a common benchmark for educating the 'ideal future engineer' of the European mining industry in a sustainable economy.
- Preparation of an international platform for building education programs and courses,
- Designing a model curriculum related to the circular economy approach in subjects taught at universities where extractive industry-related studies are conducted.
- Building an e-platform for the exchange of experience in the education of "mining engineers" in accordance with the preservation and improvement of the environment and climate.
- Development of a short postgraduate course curriculum for graduate students.
- Development of a Massive Online Open Course (MOOC)
- Establishing a regulatory framework that allows an objective evaluation of the degree of compliance with this indicator

The results achieved during the project will strengthen the cooperation network and allow the maintenance of the e-platform. After finishing the project, participants plan to:

- Develop the operation of an e-platform for building new education programs and courses,
- Conduct the exchange of experiences using the network to improve educational forms for 'mining engineers' while still preserving and improving the environment and climate.
- Conduct further work in new extensive networks and prepare for new projects in the future.

### 4.CIRCEXTIN project intellectual outputs

There are four Intellectual Outputs (IO) foreseen in the project. These are:

1. Development and design of model curriculum
2. Postgraduate short course
3. E-learning course
4. Sustainable regulations associated with the extractive industry

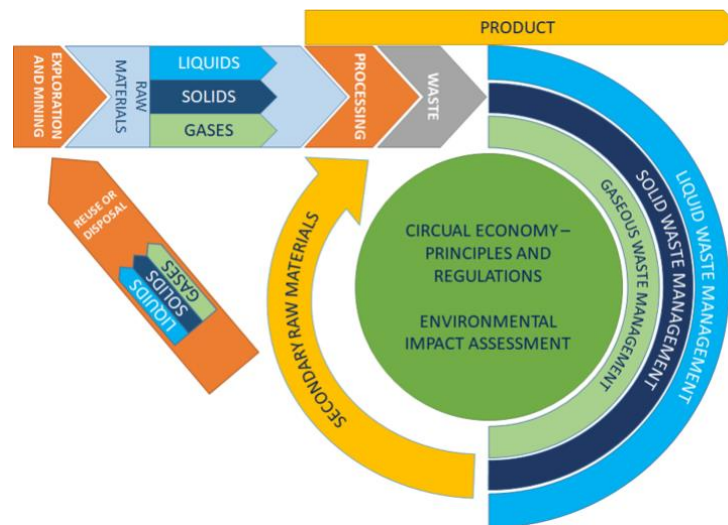
The first IO will help in creating a core structure for the model curriculum related to the circular economy approach in subjects taught at universities where extractive industry-related studies are conducted. Specific topics that should be incorporated into existing study programs of partners have been defined and were related to the focus of the specific fields of each partner. To identify similarities and differences in existing curricula a first online research was carried out to obtain an overview of the individual study programs on mining and geology of the partner organizations. This enabled a number of programs to be identified which, at first glance, partly include the topic and aspects of the Circular Economy. To identify the requirements of the mining industry, key qualifications and skills for the education of 'future engineers' in the mining industry, and the extent of the existing education at the project partners' Universities according to the idea of circular economy and cleaner production an online

survey was conducted. As stakeholders students, academic staff, professionals related to the raw materials industry and professionals working in the extractive industry were identified. For the online questionnaire, the tool Lime Survey was used. A total of 55 different questions out of 7 categories were asked. 126 questionnaires were fully completed by the respective stakeholders. The survey results were analysed quantitatively and qualitatively using IBM SPSS. We achieved in total 126 complete responses. Out of this 68 (54 %) can be assigned to students, 34 (27 %) to academic staff, 6 (4.8 %) to professionals and 28 (14.3 %) to the industry. The KPI of 100 participants was thus achieved. In the survey, the main countries of the project partners are represented, except Estonia. A great number of questionnaires are fulfilled from Polish stakeholders (36,9%). Austrians had the second highest response quote with 21,5%. Also, Spanish (9,2%) and Dutch (8,5) stakeholders completed a high percentage of questionnaires as they are part of the consortium. 15,4% of the survey was fulfilled by other nationalities. As a result, a model curriculum was created providing guidelines for the allocation of ECTS credits, duration and structure of the study programme, learning and teaching content and examination regulations. Below, the structure and outline of the basic module for the MSc programme are given as an example:

- Circular Economy and new business models
  - Circular Economy in mineral processing (result open-ended question)
  - Tools to assess the environmental impacts of the different circularity options. Examples of circular economy in the industry (result open-ended question)
  - Creation of new business models and rethinking of products
  - Shifting from a product to a service business model
- Secondary raw materials
  - [Inceasement of the use of secondary raw materials and by-products (reduce raw materials) out of waste steams]
  - [Creation of a secondary raw material market]
  - [Market Analyses –long-term trends and potential shifts in demand for particular raw materials]
- Cooperation and stakeholder involvement
  - [Cooperation with other industries for a better understanding of material flows and closing loops]
  - [Transparency and engagement with customers and their needs towards circularity (including marketing and sales approaches)]
  - [Stakeholder involvement –cooperation between mining companies, communities, policymakers and consumers]
  - [Supporting policy frameworks]
- Circular economy - Management and Technologies
  - Management
    - [Emission management especially greenhouse gases (GHG)]
    - [Water management (e.g. processing plant)]
    - [Energy management (e.g. electrification of the mine site; providing net benefits to the communities)]
    - Waste management (result open-ended question)
  - Processing Technologies
    - [New processing technologies]
    - [Development of sustainable mining methods and technologies to reduce the environmental impact and impact on local communities]

Second Intellectual Output was intended to create a post-graduate short course for post-graduates. The concept of the circular economy should be developed in the current activity of every company that operates in the extractive industry market. Therefore, there is a need to introduce this concept more deeply to the middle management and engineering staff of such companies. For this purpose, an example full curriculum of a short course was developed. This course was targeted at post-graduates in the field

of mining, mineral resource management, and environmental engineers that deal at any stage with issues related to the extractive industry, Fig. 1.



**Figure 1.** Infographic depicting idea of the post-graduate short course.

The plan of post graduate short course entitled ‘Circular economy in extractive industry - principles and application’ and its content was created. The course consisted of 6 subjects:

- Circular economy - principles and regulations – 10 h
- Mining waste management and/or circular subsurface CO<sub>2</sub> utilization (incl. geothermal energy) and/or cyclic H<sub>2</sub> storage - 15 h
- Modern solid waste processing methods - 15 h
- Environmental impact assessment - 15 h
- Energy Storage in abandoned coal mines – infrastructure CAES (iCAES) - 15 h
- Waste disposal and Storage - 15 h

The course content was placed on the Remote Teaching Platform of the Silesian University of Technology. By the end of September 2021, the course was ready with all the content on the platform. In order to launch the course at the Silesian University of Technology the budget and the detailed distribution of costs were made.

One of the most important goals of the project is the development of the e-learning course in the Intellectual Output 4 using the course curriculum proposed in Intellectual Outputs 1 and 2, This will be targeted not only to post-graduates in the field of mining, mineral resource management, environmental engineers, mining companies and stakeholders but also to the general public.

The course will be split into several parts/weeks (6-8), and each part will contain modules/topics developed in the IO1-IO2 of the project. At the beginning of the course, the possibility to choose the level of data detailing for participants will be available according to their needs (beginners/advanced). Each part will consist of standardized 5 sub-parts: Overview, Learning Outcomes (what student has to know by the end of the part/week), Learning materials in a form of Presentation and PDF file, State-of-the-art – required and optional readings and links, Testing of studied materials. The preparation of the course is in progress and the course should be ready by the end of 2022 on the canvas.com platform.

The extractive industry needs to introduce the sustainability concept throughout the whole value chain. In this case, it is necessary to establish a regulatory framework that allows an objective evaluation of the degree of compliance with this indicator. The basis of the analysis was carried out on current national regulations. This was the objective of the Intellectual Output 4. The initiative was aimed at establishing a common framework where creativity and communication between industry and future graduates are fostered. The expected impact, therefore, will allow (i) to improve the employability of these students

by increasing their training and work capacity beyond the country of origin. In parallel (ii) the specific training in circular economy applied to the mining industry will facilitate the application of innovative processes that increase the competitiveness of this industry, favouring the incorporation of new leaders in this sector. The sustainability analysis of the mining sector is linked to consolidated parameters such as the SDGs of the United Nations. In the development of a mathematical algorithm for the evaluation of the aforementioned sustainability index, different options of multi-criteria algorithms were considered. Social, Environment and Economic criteria were considered at the first level, and all the SDG described by the UN were described according to measurable criteria (fourth level criteria).

Within the framework of the project one Multiplier event is envisaged. This event will take place in December 2022 at the Silesian University accompanying national mining conference where various representatives of the mining industry will attend. Progress of the project is monitored by the Quality Manager and project meetings take place on regular basis at least twice a year.

## 5. Summary

The CIRCEXTIN project is one of the first attempts on European level to create a common platform that will foster introduction of circular economy approach in extractive industry study programs. The project aims at coordinating the efforts of various universities to not only promote internationalization but, above all, to build coherent learning profiles and bridge gaps in existing curricula. Building the silhouette of "future engineer" is not a local task but a global one. Only an exchange of experience allows the future labour market to remove gaps and mismatches with its requirements. International cooperation between universities will pay off in a cooperation between their graduates, academia and an industry. The more consistent the training and education programs the greater the opportunities to exchange experiences and specialists in the raw materials trading industry. Natural and recyclable materials form the base of a material circulation and designing process in the ideas of a cleaner production and circular economy. For the future of our planet, current university education programs should take into account existing and, above all, future environmental challenges as well as possible climate changes.

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## Disclaimer

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