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Research Fund for Coal & Steel

waste2CRM

Determination of the potential for sourcing critical raw materials from mining wastes, and development the method for their effective recovery

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Project acronym	Waste2CRM
Project title	Determination of the potential for sourcing critical raw materials from mining wastes, and development the method for their effective recovery
Grant Agreement N°	101157810 — Waste2CRM — RFCS-2023

Deliverable - D1.1

COMPREHENSIVE OVERVIEW OF THE PROJECT

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Deliverable number – D.1.1	
Due date of deliverable	28th February 2025
Deliverable responsible partner	ITPE has overall responsibility for the deliverable.
Dissemination level	Open access
Work-package	WP1 – Project Management, Coordination, Dissemination and Exploitation
Task	Task 1.4. Results dissemination.
Authors	Michał Rejdak, Małgorzata Wojtaszek-Kalaitzidi, Bartosz Mertas, Instytut Technologii Paliw i Energii (Poland) Agnieszka Klupa, Magdalena Cempa, Aleksander Wrana, Główny Instytut Górnictwa - PIB (Poland) Łukasz Skrzypiec, IMN - Łukasiewicz Research Network - Institute of Non-ferrous Metals (Poland) Stavros Kalaitzidis, UP Patras (Greece) Amanda Gomez Marfil, Systra Subterra (Spain)

Table of contents

1. Introduction

The Waste2CRM project is a comprehensive initiative designed to address the critical need for sustainable sources of critical raw materials (CRMs) within the European Union, while simultaneously contributing to the just transition of coal-dependent regions. The project focuses on extracting valuable critical raw materials, particularly rare earth elements (REEs), from the vast quantities of coal mining waste currently accumulating in heaps and backfill areas across Europe. This innovative approach tackles two significant challenges simultaneously: securing a reliable supply of CRMs for the EU's strategic industries and mitigating the environmental and socio-economic impacts of abandoned and transitioning coal mining sites.

The Waste2CRM project, idea of which is presented in Figure 1, aims to explore the use of coal mining waste as an alternative source of critical raw materials and to develop effective recovery methodologies. Focusing on waste from hard coal and lignite mining, the project seeks to address the need for EU countries to access critical elements through recycling of existing mining waste. It includes resource inventory, drilling, sampling, and detailed analysis of valuable elements, alongside technological development for their recovery.

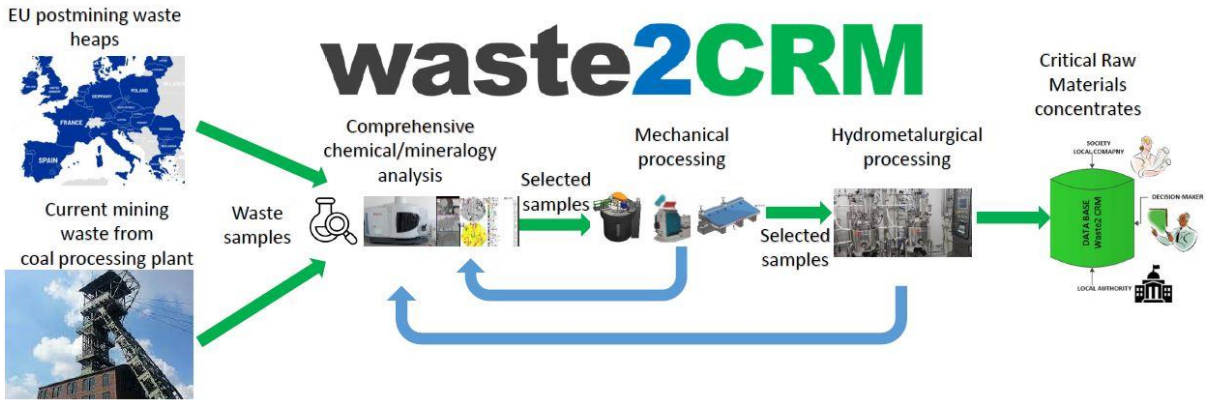

Figure 1. Idea of Waste2CRM project.

The project will also conduct technical, economic, and environmental assessments for potential industrial implementation. The findings will contribute to the European knowledge base on critical raw materials and inform decisions for their recovery from mining waste.

2. Project Objectives and Scope

The primary aim of Waste2CRM is to develop and validate a cost-effective and environmentally sound technology for recovering CRMs from coal mining waste. This ambitious undertaking includes several key objectives:

1. **Comprehensive Waste Characterization:** The project will begin with a thorough inventory and characterization of coal mining waste resources across diverse geographical locations in Poland, Greece, and Spain. This crucial first step involves detailed analysis of waste composition, including the identification and quantification of CRMs, along with the assessment of physical and geotechnical properties. Different types of waste will be considered taking into account their spatial distribution within waste heaps and backfilled areas. This detailed characterization is essential to optimize subsequent processing steps and maximize CRM recovery.
2. **Optimized Pre-Concentration Methods:** To enhance the efficiency and cost-effectiveness of downstream hydrometallurgical processing, the project will focus on developing and optimizing effective pre-concentration techniques. The project will investigate a range of physical separation methods, including gravity separation, magnetic separation, electrostatic separation, and sensor-based sorting. These methods will be carefully selected and combined to produce pre-concentrates enriched in CRMs, thereby minimizing the volume of material requiring further, more intensive and costly processing. The selection of optimal methods will depend on the specific characteristics of the waste material being processed.
3. **Efficient Hydrometallurgical Extraction:** The pre-concentrated materials will undergo further processing using advanced hydrometallurgical techniques to extract the target CRMs. This stage will explore and compare various leaching methods (acid leaching, alkaline leaching, etc.) and optimize parameters such as reagent concentration, temperature, and reaction time. The choice of hydrometallurgical techniques will be guided by the results from the pre-concentration stage, aiming for maximized CRM recovery and minimal environmental impact. The exploration of innovative approaches, such as microwave-assisted leaching, which may offer superior efficiency or reduced energy consumption, will also be considered.

4. **Techno-economic and Environmental Assessment:** A comprehensive techno-economic assessment (TEA) and life cycle assessment (LCA) will be conducted to evaluate the overall feasibility and sustainability of the developed CRM recovery technology. The TEA will consider capital and operating costs, profitability, and scalability of the technology for different scales of implementation (demonstration plant and full-scale industrial plant). The LCA will assess the environmental footprint of the entire process, from raw material acquisition to final product disposal, considering energy consumption, greenhouse gas emissions, and waste generation. These assessments are critical for ensuring the environmental and economic viability of the proposed technology and for informing decision-making regarding industrial-scale deployment.
5. **Dissemination and Exploitation:** The project's findings will be actively disseminated to a wide range of stakeholders, including coal mining industries, policymakers, researchers, and the general public. This will involve publications in peer-reviewed journals, presentations at international conferences, and the development of accessible communication materials (e.g., brochures, website). The project also has an exploitation strategy to ensure the results are translated into commercial applications and benefit the relevant sectors.

3. Expected Impacts

The successful completion of the Waste2CRM project is expected to yield significant impacts across various sectors:

- **Economic Impacts:** Creating new economic opportunities in coal-mining regions through the development of a new industry based on CRM recovery, generating jobs and revitalizing local economies. Ensuring the supply of CRMs to support the EU's strategic industries, reducing reliance on imports.
- **Environmental Impacts:** Mitigating the environmental impact of coal mining waste by transforming it into a valuable resource, reducing landfill needs and improving site remediation. Reducing reliance on primary CRM extraction, minimizing the environmental burden associated with mining operations.
- **Social Impacts:** Supporting the just transition of coal-mining regions by creating employment opportunities and promoting economic diversification. Improving public awareness regarding the potential of waste resources.

The Waste2CRM project represents a significant step towards a more sustainable and resilient future for the EU's CRM supply chain and its coal-mining regions. Its integrated

approach, encompassing scientific research, techno-economic evaluation, and strategic communication, positions it as a leading example of effective innovation in the circular economy. The strong partnership between research institutions, industry, and government ensures the project's findings will have a tangible impact on the transition towards a more sustainable and resilient future.

4. Project workplan

The Waste2CRM project is structured around five work packages (WPs), each with specific objectives and deliverables designed to achieve the overall project goals (Figure 2)

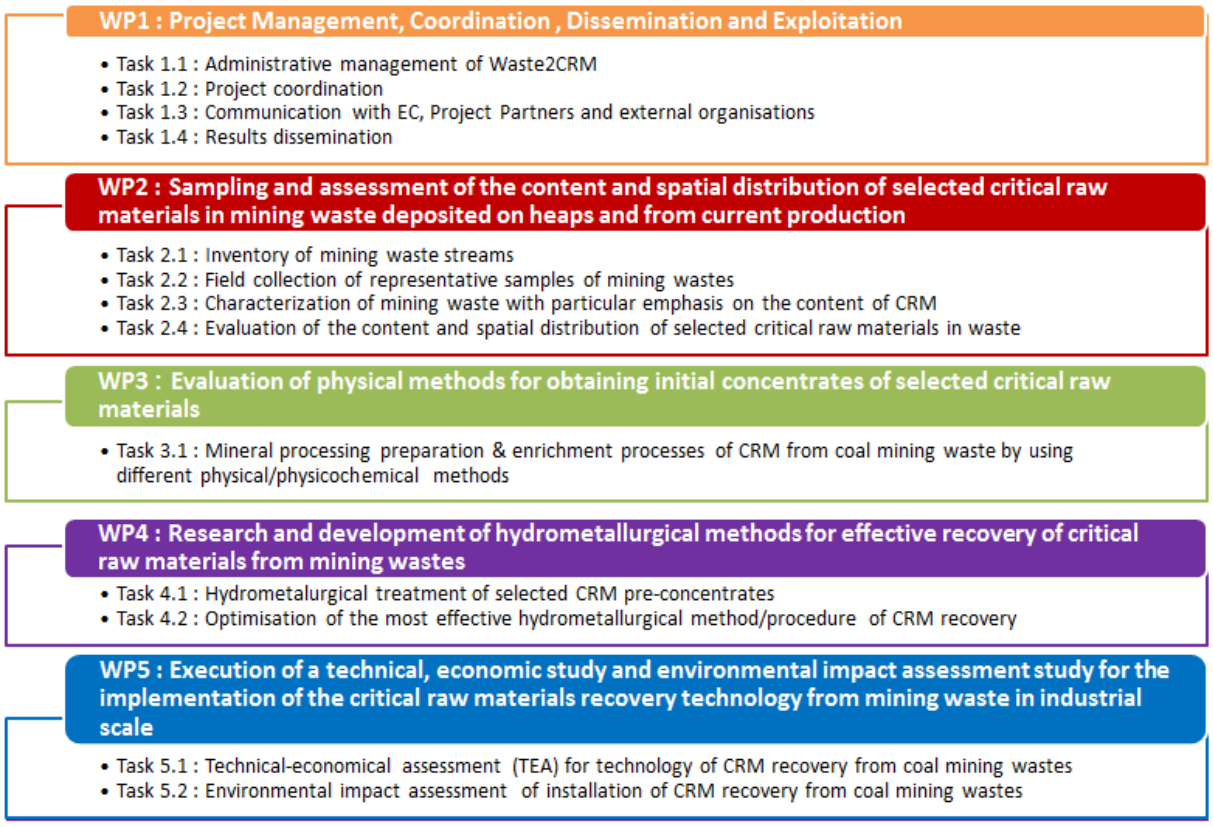

Figure 2. Waste2CRM project structure.

Work Package 1: Project Management, Coordination, Dissemination, and Exploitation

WP1 covers the management and coordination activities for the project. Key objectives include:

- **Project Management:** Implementing efficient administrative and financial processes, ensuring compliance with EU regulations, and overseeing timely project execution within budget.
- **Coordination:** Facilitating communication among partners, addressing conflicts, and ensuring all partners fulfill their responsibilities through regular meetings and data sharing.
- **Dissemination:** Creating and executing a communication plan to share findings with stakeholders, including publishing articles, presenting at conferences, and maintaining a project website.
- **Exploitation:** Formulating strategies to utilize project results post-duration, such as licensing technologies and forming partnerships for commercializing CRM recovery technology.

Work Package 2: Sampling and Assessment of Critical Raw Materials in Mining Waste

This work package (WP2) focuses on the comprehensive characterization of coal mining waste resources:

- **Inventory:** Creating a comprehensive database of existing coal mining waste deposits in Poland, Greece, and Spain, including information on location, volume, composition, and accessibility. This involves collating existing data and conducting site visits to supplement and validate existing information.
- **Sampling:** Collecting representative samples of coal mining waste from both historical deposits (heaps, backfills) and current production (various types of waste streams). This requires careful planning and execution of fieldwork, using appropriate sampling techniques to ensure the representativeness of the collected samples.
- **Analysis:** Conducting physicochemical and geochemical analyses of the collected samples to determine the content and distribution of CRMs, particularly REEs, and other valuable elements. This involves advanced laboratory techniques (ICP-OES, XRF, XRD, SEM-EDS), and statistical data analysis to interpret the results and identify areas with high CRM concentrations.
- **Spatial Distribution:** Mapping the spatial distribution of CRMs within the waste deposits to inform the selection of optimal areas for processing. This may involve combining geochemical data with other information, such as geological maps and mining records, to create a detailed spatial model of CRM distribution.

Work Package 3: Evaluation of Physical Pre-Concentration Methods

This work package (WP3) focuses on developing and optimizing physical and physico-chemical methods for pre-concentrating CRMs from coal mining waste:

- **Sample Preparation:** Developing a standardized procedure for preparing the samples for pre-concentration. This includes size reduction (crushing, grinding) and other necessary pre-treatment steps to optimize the efficiency of subsequent separation techniques.
- **Pre-Concentration Techniques:** Testing a range of physical separation techniques (gravity separation, magnetic separation, electrostatic separation, sensor-based sorting) on representative samples to identify the most effective methods for enriching the CRM content. This will involve systematic experimentation to optimize parameters such as particle size, magnetic field strength, and voltage, for each method.
- **Method Optimization:** Optimizing the selected pre-concentration methods to maximize CRM recovery while minimizing energy consumption and waste generation. This involves statistical analysis of experimental results to determine the optimal operating parameters.
- **Pre-concentrate Selection:** Selecting optimized pre-concentrates for further processing via hydrometallurgical methods in WP4. The selection is based on the CRM content and the ease of processing.

Work Package 4: Hydrometallurgical Recovery of Critical Raw Materials

This work package (WP4) focuses on extracting CRMs from the pre-concentrates produced in WP3:

- **Leaching Methods:** Testing various hydrometallurgical methods, including acid leaching, alkaline leaching, and ion exchange, to extract CRMs from the pre-concentrates. This involves systematic experimentation to optimize parameters such as reagent concentration, temperature, time, and pH, using statistical design of experiments (DoE) methodology.
- **Process Optimization:** Optimizing the selected hydrometallurgical methods to achieve high CRM recovery yields while minimizing reagent consumption and waste generation. This involves process modeling and simulation to explore various operational strategies.

Work Package 5: Techno-economic and Environmental Assessment and Dissemination

This work package (WP5) assesses the feasibility and environmental impact of the developed CRM recovery technology, and disseminates the project's results:

- **Techno-economic Assessment (TEA):** Conducting a comprehensive TEA of the proposed CRM recovery technology, considering capital and operating costs, profitability, and scalability for both demonstration and industrial-scale implementations. This will include market analysis and identification of potential investors and users.
- **Life Cycle Assessment (LCA):** Conducting a detailed LCA to evaluate the overall environmental impact of the technology, from raw material extraction to product disposal, including considerations of energy consumption, greenhouse gas emissions, and waste generation.

The Waste2CRM project is characterized by its comprehensive and integrated nature, with each work package designed to contribute to the overall objective of developing a sustainable and economically viable technology for recovering CRMs from coal mining waste.

5. Project Timeline and Budget

The project is expected to last 42 months, the project started on September 1, 2023, and will end on February 29, 2028.

Total project cost: 2,454,376.70 €; amount of UE co-funding: 1,472,626.02 €

6. Consortium and Expertise

The Waste2CRM project brings together a strong consortium of six partners from Poland, Greece, and Spain, each contributing unique expertise and resources:

- **ITPE (Institute of Energy and Fuel Processing Technology, Poland):** the project coordinator, has been a high-level research institution since 1955. It primarily serves the energy and coke-making industries, waste management, and SMEs, alongside government bodies. ITPE focuses on research and development related to fossil and renewable fuels, biomass, waste processing, and environmental protection. The Institute specializes in thermal processing of fuels through combustion, gasification, and pyrolysis, and it has expertise in energy and mass balance, process modeling, and technical analysis. ITPE has advanced

technological facilities that enable comprehensive testing across a wide range of applications and processes. ITPE has extensive experience in national and international projects, collaborating with over 50 research institutions. The ITPE team will participate in all Work Packages: WP1, WP2, WP3, WP4, and WP5.

- **GIG-PIB (Central Mining Institute, Poland):** one of Poland's largest research institutes, maintains strong ties with coal mining companies and is well-positioned to benchmark the Waste2CRM project within the EU's prominent coal sector. GIG leads efforts in transforming the hard coal mining industry, focusing on risk assessment related to mining hazards and training for transitioning workers. With extensive experience as a partner and coordinator in various European projects (H2020, FP, RFCS, ECSC, Central Europe), GIG currently participates in 16 RFCS projects, three of which it coordinates. The Laboratory of Mineral Processing and Waste Management will lead the work, with the GIG team involved in WP2, WP3, WP4, and WP5.
- **Łukasiewicz Research Network - Institute of Non-Ferrous Metals (Łukasiewicz-IMN), Poland:** has been modernizing Poland's non-ferrous metals industry since 1952. It encompasses all phases of metallic materials production, from ore processing to developing eco-friendly technologies. IMN provides R&D for new technologies, process optimization, and analytical services, benefiting various sectors including SMEs. With strong ties to academic institutions and extensive experience in EU Framework Programs, IMN offers innovative solutions. The Center of Mineral Processing will represent the Institute in the RFCS project and has participated in several EU projects, including BATTERFLAI, FineFuture, NOMECOR, MetNet, and NetFlot. The IMN team will contribute to WP2, WP3, and WP5.
- **UP (University of Patras, Greece):** will be represented by the GeoEnergy Resources Team from the Laboratory of Economic Geology, Department of Geology, University of Patras. This team has extensive experience in coal geology, organic sediment characterization, ore geology, and resource assessment. Their research includes mineralogical and geochemical characterization of coals and metallic ores, supported by facilities for quality control of fossil fuels and geological samples. The head of the unit has experience in the Australian metallurgical coal sector and resource assessments. Since 2015, the team has researched REE deportment in heavy sands, bauxite, and bauxite residues. The UP team will contribute primarily to WP2 and WP5.

- **Systra Subterra (Spain):** is a private engineering company specializing in geological, hydrological, and geotechnical assessments. Actively involved in EU research, SUB has participated in past and ongoing RFCS projects, as well as the H2020 DIG_IT project, which focuses on geotechnical digital twins of active mines, and the Horizon Europe MASTERMINE project. Since 2008, they have provided services including data collection, design, and engineering across all project phases, extending to geotechnical monitoring during construction. SUB's expertise in modeling challenging conditions has been vital for developing techniques to ensure stability during and after mine operations. They are also creating added value from new monitoring systems for various mine structures.

This Waste2CRM project holds significant potential for addressing the EU's need for sustainable CRM resources, promoting a just transition in coal-mining regions, and reducing the environmental impact of coal mining waste. The interdisciplinary collaboration of the consortium enhances its prospects for success.

Co-funded by the European Union

The project is co-funded by the European Commission under the Research Fund for Coal and Steel (RFCS) programme, grant agreement No 101157810

The project is co-funded by the national budget under the programme established by the Minister of Science and Higher Education entitled “Co-financed International Projects (PMW)