H2GEO

New technology for hydrogen and geopolymer composites production from post-mining waste

Deliverable 1.3

The comprehensive public overview of the project

Grant agreement No: 101112386

December 2023

Co-funded by the European Union

PROJECT INFORMATION

TITLE: New technology for hydrogen and geopolymer composites production from post-mining waste

ACRONYM: **H2GEO**

PROJECT NO: 101112386 (RFCS-2022)

PROJECT BUDGET: 2 549 585,75 Euro

PROJECT DURATION: 36 months

START TIME: 01/07/2023

END TIME: 30/06/2026

H2GEO PROJECT GOAL

The aim of the H2GEO project is to develop a ***comprehensive technology for the management of post-mining dumps in line with the circular economy***. The project assumes the use of separated energy fractions to obtain hydrogen through gasification and mineral fractions and fly ash for the production of geopolymer composites.

Mine waste dumps created as a result of hard coal production degrade the environment and pose many threats, including: fires and the related release of gases polluting the atmosphere (carbon monoxide and carbon dioxide), as well as contamination of surface and ground waters by leaching chlorides and sulphates from dumps

The post-mining waste processing technologies, developed as a part of the project, will enable the gradual liquidation of the existing dumps at the maximum use of the waste stored there. The idea is therefore consistent with the vision of a circular economy in which waste generated during the production phase can be recycled and thus become a resource.

The most important activity in the project will be the development of a new technology for processing of mineral waste and fly ash with the use (utilization) of CO2 for the production of geopolymer composites. The versatility of the technology will enable its use in other EU countries, where mine waste dumps cause environmental and social problems. The work in this scope will be supported by the LCA analysis and determination of methods of using the produced composites.

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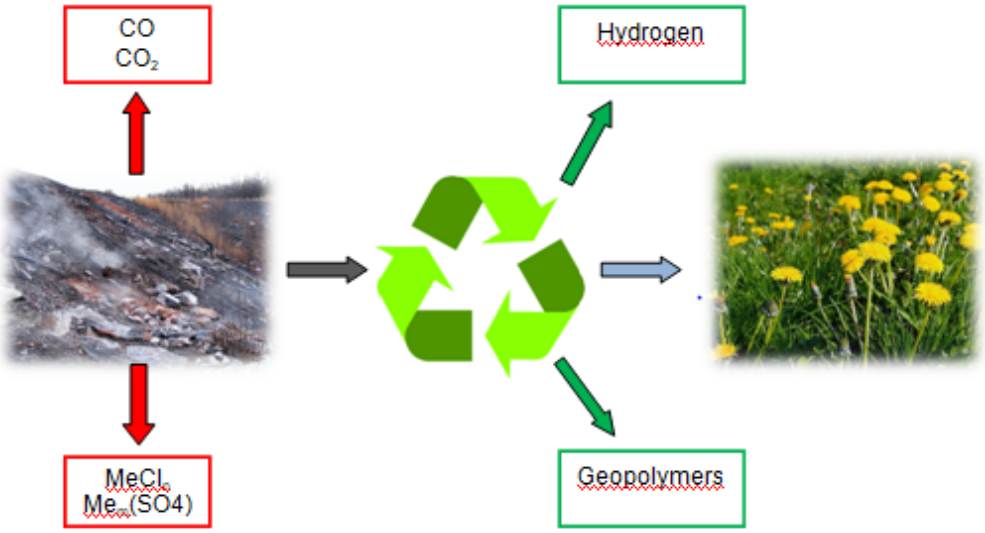
The project will define the directions for the management of the energy fraction separated from waste. Research will be carried out to develop an effective method of hydrogen production from synthesis gas obtained from a gasification of carbon-bearing fractions. Moreover, on the basis of the results obtained from the combustion of coal concentrate in terms of the emission of hazardous substances into the atmosphere, the possibilities of its use in the energy sector will be determined.

In order to obtain high-quality materials from mine waste for further processing, the concept and documentation of a mobile mine waste separation system will be developed based on the analysis of the possibility of using selected beneficiation processes and the performed laboratory tests. Developed mobile unit will be equipped with the innovative control system, which will enable a very effective separation of waste material. This process will guarantee obtaining high quality ecological products.

Based on the results of laboratory tests of mining waste beneficiation process and the physicochemical and mechanical properties of the beneficiation products, other directions for the use of mine waste will also be determined. The possibilities of using waste from the beneficiation process as building and road materials, for environmental engineering and mining, agriculture and land reclamation will be analyzed and some guidelines will be formulated.

The project will enable the creation of environmentally friendly and economically justified installations using material from a post-mining waste dumps. Achieving the final goal will be possible thanks to the implementation of the partial goals set in the project, including the development of technologies dedicated to the production of geopolymers and hydrogen.



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ROLE OF CONSORTIUM PARTNERS IN H2GEO PROJECT

1. Instytut Techniki Górniczej KOMAG (KOMAG):

Project Coordinator; leader of WP1 (Project Management and Coordination), WP3 (Use of gravitational processes for recovery of raw materials from mine wastes) and WP6 (Evaluation of new technology for hydrogen and geopolymer composites production from post-mining waste); participation in physicochemical analyses and mechanical property tests of raw materials (WP2); development a technology of soil reclamation, after the end of the processing of the dump, using for this purpose bio-waste and REE separation tests from mine waste using electrostatic and magnetic separators (WP5).

2. Główny Instytut Górnictwa (GIG):

leader of WP2 (Critical analysis of mine waste dumps) and WP5 (Development of methods for managing mineral waste generated in the process of jig enrichment); participation in physicochemical analyses and mechanical property tests of the separation products (WP3); participation in development of new technology concept and in environmental, social and legal aspects hydrogen and geopolymer composites production from waste dumps (WP6).

3. Ustav Stavebnictva A Architektury Slovenskej Akademie Vied VVI (USTARCH):

participation in physicochemical analyses and mechanical property tests of raw materials and the separation products (WP2, WP3); participation in research on geopolymer composites synthesis with CO2 and fly ash used (WP5); participation in in development of new technology concept and in economic aspects of hydrogen and geopolymer composites production from waste dumps (WP6).

4. Instytut Technologii Paliw i Energii (ITPE):

leader of WP4 (Development of thermochemical methods of management of energy fraction of waste from jig beneficiation process to hydrogen generation); participation in physicochemical analyses and mechanical property tests of raw materials and the separation products (WP2, WP3); participation in tasks on the manufacture and testing of geopolymer composites (WP5).

5. VSB - Technical University Of Ostrava (VSB-TUO):

participation in participation in inventory of active and recultivated mine waste dumps and in development of the database system (WP2); research on H2 production by plasma gasification of coal-enriched fractions (WP4); participation in in development of new technology concept (WP6).

6. Politechnika Wrocławska (PWR):

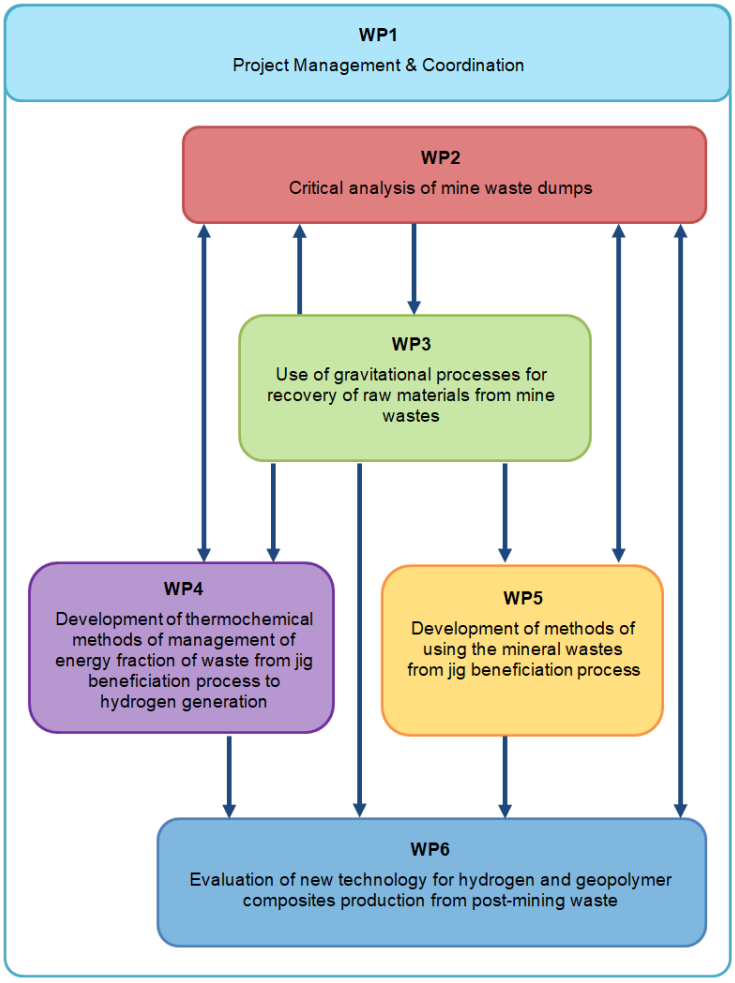
participation in development of the database system (WP2); participation in economic, environmental, social and legal aspects hydrogen and geopolymer composites production from waste dumps (WP6).

7. HALDEX Spółka Akcyjna (HDX):

participation in participation in inventory of active and recultivated mine waste dumps (WP2); participation in development of the prototype of mobile system for coal and raw materials separation from mine wastes (WP3); participation in development of the full chain technology concept.

OVERALL STRUCTURE OF THE WORK PLAN

The planned comprehensive goal of the project - development of full chain technology concept of hydrogen and geopolymers production from mine waste dumps - will be achieved as a result of the implementation of many research, conceptual and study works within six WP's.



WP 1 – Project Management and Coordination

T1.1 – Project coordination and cooperation between project partners

To ensure proper implementation of the planned tasks in the project, the KOMAG project leader will be responsible for ongoing project management including: contacts with project partners; archiving all data and documents related to the implementation of the project; evaluation of project implementation; organizing progress meetings to discuss project progress and plan subsequent tasks; control of promotional activities for project results; preparing reports on project implementation.

In November 2023, during the International Scientific and Technical Conference KOMTECH "Mining in the Age of Green Transformation" in Szczyrk, Kick-off Meeting was held to officially start the H2GEO project. During the meeting, a number of issues related to the implementation of the project results were discussed. The activities conducted so far and those planned for subsequent tasks were also discussed.

T1.2– Project promotion and dissemination

This task will include activities aimed at disseminating the project results.

The main activities of the project are:

- preparation of a strategic dissemination plan,
- development and constant updating of the H2GEO project website,
- publication of articles in national and international scientific/technical journals,
- participation in conferences and science fairs and presentation of project results (papers, roll-ups, etc.).
- organizing the workshops and the final international seminar as a separate event or as a special day within an existing conference to present all the results and achievements of the project.

According to the schedule for delivering the project results, in July 2023, the first Deliverable 1.1 "Communication and Dissemination Plan" - was posted on the RFCS portal.

On November 7, 2023, a website dedicated to the H2GEO project - New technology for hydrogen and geopolymer composites production from post-mining waste - was made public. The website is constantly expanded and updated in line with ongoing activities and events.

T1.3 – Lessons Learned and Recommendations document and results dissemination

All partners will be involved in preparing their own aspects of the document, with the WP Outcome Leaders playing a key role. The final report will be prepared in draft form before the end of the project implementation period.

WP2 – Critical analysis of mine waste dumps

T 2.1 Inventory of active and recultivated mine waste dumps

Inventory of mine waste dumps in selected European countries will be carried out, with division into active and recultivated dumps and with regard to the characteristics of deposited wastes and possibilities of using them in the beneficiation process. Basing on the results from inventory, mine waste dumps will be selected, from which samples for laboratory tests will be taken.

In accordance with the project schedule, mine waste dumps located in Poland, the Czech Republic and Western European countries were reviewed (T2.1). For the effective analysis of the information obtained, the criteria for the review were defined. HDX

classified the mining waste landfills located in the Upper Silesian Industrial District in terms of location and surface area and on-site visits to the landfill areas began. VSB-TUO successively obtains information about heaps located in the Czech Republic, while GIG reviews the heaps located in Western European countries. Databases, implemented European projects and scientific articles on mine waste dumps were analysed. Inquiries were sent to the selected organisations in Germany, France and Great Britain.

T2.2 – Testing the physical and chemical properties of mine wastes

It is planned to determine selected physicochemical and mechanical parameters of raw mine waste. A microscopic evaluation of the landfill material will be carried out to determine the deterioration of organic matter and aid material selection. The analysis of trace elements classified as "critical" for the world economy, in order to select them from mine waste dump will be carried out. A biological activity of waste coming from a closed dump in relation to planned reclamation activities will also be assessed.

Three heaps were selected for testing the raw material from mine waste dumps, from which two samples were taken from each heap. Samples were collected and prepared by VSB from the Paskov D dumps in Ostrava and Jan Karel in Karvina (Czech Republic). From the Panewniki heap (facility) belonging to Haldex S.A. in Katowice (Poland), samples were collected by HDX. The samples, after being avaraging in KOMAG, were delivered to the project partners (GIG, ITPE, USTARCH), where the planned tests began.

T2.3 – Development of a database system

A database will be built, in which all relevant, properly measured and calculated parameters will be archived, obtained during the entire project. This system will keep continuous archives of relevant measured and calculated data from project (compositions, parameters, etc.). The database system can be used by all the beneficiaries of the project in real time (on the Internet).

PWR has developed an initial concept for the construction of geodatabases of mine waste dumps, taking into account the advanced spatial analyses planned in the project. Based on the expected area of heap analysis (selected European countries), a scale was selected and the possibilities of obtaining cartographic materials were identified. The required types of data that will be stored in the geodatabase, the method of storage, and the method of their use and maintenance were determined.

WP3 – Use of gravitational processes for recovery of raw materials from mine wastes

T3.1 – Laboratory tests of jig beneficiation

KOMAG will carry out gravity separation tests in a pulsating water medium at the laboratory stand jig. The main goals of tests are:

- verifying the possibility of using the jig beneficiation process for the separation of mine waste,
- obtaining mine heap separation products (energy fraction, mineral fraction), which will be used for analyses in T3.2,
- development of input data for the design of a mobile installation for processing mining waste (in T3.3).

As part of the task, enrichment tests will be performed for selected technological parameters, such as pulsation characteristics, density and grain size distribution of the feed. The enrichment products will be subjected to density and grain analyses, and their ash, sulphur content and calorific value will be determined. The effectiveness of the applied enrichment technology will be assessed based on the characteristic separation parameters in the form of probable dispersion and imperfection index.

As part of the task, in KOMAG, a preliminary actions were started for the planned research work, including purchasing the following: chemical reagents, small laboratory equipment, components of the test stand as well as inspection of measuring equipment. Material from one of the samples taken by HDX will be used for testing.

T3.2 – Physicochemical analyses and mechanical property tests of the separation products

Analyses of the laboratory separation products that enable to determine the directions of their management will be carried out in this task. The work will determine the physico-chemical and mechanical properties and carry out technical analyses of the products. Chemical analyses will include determination of trace element content and of the main elements of which the aluminosilicates are composed. In addition microscopic evaluation of the landfill material to determine the deterioration of organic matter and aid material selection will be carried out.

T3.3 – Development of the prototype of mobile system for coal and raw materials separation from mine wastes

Based on the input data obtained in T3.1, KOMAG will develop assumptions and then technical documentation of selected elements of a prototype mobile mine waste separation system with an estimated capacity of 100 t/h.
The basic element of the system will be a device in which the separation process will take

place in a pulsating water medium. In the device, mine waste will be separated into two products: cleaned aggregate (mineral fraction) and thermal coal concentrate (energy fraction). An integral element of the system will be an electronic control system which, using a predictive algorithm, will enable obtaining appropriate water pulsation characteristics adapted to the feed parameters and will control the receipt of the separated material. Elements of M2M technology will be used to exchange data between system elements.

WP4 – Development of thermochemical methods of management of energy fraction of waste from jig beneficiation process to hydrogen generation

T 4.1 Production of H2 through plasma gasification of coal enriched fraction

Development and optimization of a method for production of hydrogen, through plasma gasification. Tests of gasification of coal-bearing fraction (CBF) in a plasma gasifier, which is part of the CEETe building technology. Determination of optimum process parameters depending on the gas composition. Variable parameters: process temperature, fuel/gasifier ratio, fuel flow rate.

T 4.2 Production of H2 through FB gasification of coal enriched fraction

Development and optimization of a method for production of hydrogen, through FB gasification of the CBF. TG study to determine thermal characteristics and kinetic parameters of steam gasification of CCF. Optimize the conversion through blending other, low-ash feedstocks containing catalytically active elements (Ca, Mg, Fe). Determination of the composition of the blend for FB testing. Development of a method for pretreatment of the blend and to improve its rheological and transport properties (mixing, milling, compaction). Screen the gasification process conditions of the blend in a bench-scale BFB (O2+H2O). Test and analysed statistically the influence of variation of pressure 0-5 bar, temperature 750-950°C, steam-to-carbon ratio 1-3, reactor power, bed depth, bed renewal rate and use of bed additives (CaO), aiming to optimise H2 yield, process efficiency (HGE and CGE, CCE, SCE), reduce contaminants of the syngas and solving technical issues (bed defluidization and sintering, fouling of the reactor). Qualitative and quantitative analyses of all process streams to determine mass and energy balances and process efficiency indices. Verification of the indicated process conditions at the PDU-scale gasification installation with the long-term operation (>72h).

T 4.3 Upgrading and gas separation for H2 production

The hydrogen separation research will be carried out in two cases. In the first case, hydrogen will be separated from the gas obtained from gasification unit without the implementation of the WGS process and in the next case with the retrofitting of the system with WGS unit. Gas directed to PSA unit will be separated using 4 adsorption columns. Tests out with different adsorption beds give information about absorption-desorption procedures. The relationship between the hydrogen purity grade, the efficiency of gas separation and the parameters of the subsequent steps of the PSA process will be determined. The tail gas composition will be determined for further it's management.

T 4.4 Modelling of the H2 production process

Development of computational models (mass and energy flows & engineering models for main reactors) for the production of H2 through the gasification of the coal-bearing fraction and validate it against the experimental results. The model will consist of all unit operations and processes adding up to the whole process, from acquiring the fuel, transportation, storage, feeding, gasification, gas cleaning, upgrading, separation of H2, heat integration, auxiliary systems and valorisation of all process secondary streams. The modelling will be performed by ITPE using its own codes as well as the Chemcad software, while Partners will provide input data and consulting.

WP5 – Development of methods for managing mineral waste generated in the process of jig enrichment

T 5.1 Advanced waste treatment for geopolymer composites preparation

Raw mineral-rich samples will be subjected to thermal processing in a pressurized fluidized bed reactor. Mineral waste will be thermally processed in an air, and CO2/O2 atmosphere (70–80 v.% CO2 and 20– 30% O2) under elevated pressure 2 bar), and temperature of 800°C, and time (10–30 min).

T 5.2 Research on geopolymer composites synthesis with CO2 and fly ash used

Mineral part separated from a coal mine waste dump (in raw form and after thermal treatment), fly ash from lignite fired boilers and carbonates based on fly ash will be transferred for testing to partners responsible for geopolymerization processes. The quantitative and qualitative impact of raw materials on the geopolymer composites forming process and properties will be determined. Compressive and flexural strengths, water absorption, will be tested and SEM-EDS, XRD XPS analysis of geopolymers will be carried out.

T 5.3 Use of mineral wastes from jig beneficiation process in building and road construction materials, environmental engineering, mining industry

Development of recipes and testing of aggregate mixtures for use as a material for filling post-mining voids in hard coal mines will be carried out. The tests will include determining the physical properties of the mixtures, such as: density, flow, uniaxial compressive strength, excess water content, freeze-thaw, compressibility, water permeability, setting time as well as radioactivity and the content of chemical impurities in leaching tests Recipes for concrete will be developed, which will include waste and cement. The impact of aggregate from mining waste on the strength of structural materials obtained will be determined. The impact of mining waste in concretes on the environmental impact will be investigated.

T5.4 – Use of mineral wastes from jig beneficiation process in agriculture and in land recultivation

Development of recipes and testing of new materials for the production of anthropogenic soils and biological reclamation of post-industrial areas, based on mining waste, energy waste and other, eg. from mining and processing of minerals and biological waste. Development a technology of soil reclamation, after the end of the processing of the dump, using for this purpose bio-waste.

T5.5 – Recovery of minerals and chemicals from products of mine wastes jig beneficiation process

A study will be carried out for the development of preliminary technological assumptions for the possibility of recovering critical raw materials. The method for recovery of minerals and chemicals with initial evaluation of its profitability will be developed.

WP6 – Evaluation of new technology for hydrogen and geopolymer composites production from post-mining waste

T6.1 – Development of the full chain technology concept of hydrogen and geopolymers production from mine waste dumps

The aim of this task is to develop the concept of full technology chain of hydrogen and geopolymers production from the processing of the mine waste dumps on a commercial scale, including:

- recovery of the energy part (coal) and mineral part from the mine waste dumps,
- geopolymerization (with raw material preparation / mineral part of the mine waste dumps),

- gasification plasma and FB process (with fuel preparation, purification and conditioning of process gas for the production of hydrogen),
- production of hydrogen.

T6.2 – Economic aspects of hydrogen and geopolymer composites production from waste dumps

In this task, the directions for the management of segregated mine waste dumps and geopolymer composites and hydrogen will be specified including market environment and sales market forecast. Economic analysis will be carried out for the full chain technology concept of mine waste dumps.

It will also be estimated:

- the amount of potential mineral resources possible to obtain from waste (increasing the resource base of minerals),
- estimation of the land volume and the decrease or increase of value of the reclaimed land in relation to its original value.

T6.3 – Environmental, social and legal aspects hydrogen and geopolymer composites production from waste dumps

An LCA analysis will be carried out to comprehensively examine the impact of the project product - full chain of hydrogen and geopolymers production from the processing of the mine waste dumps - on the environment and natural resources Legal aspects related to the use of post-mining waste for the production of geopolymers will be analysed. The analysis will also specify the requirements related to the collection and transport of waste in Poland. The local community involvement will also be assessed. The legal acts necessary for the investment related to the use of waste will be analysed.

Main person involved in the project:

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