CCS-CCU TECHNOLOGY FOR CARBON FOOTPRINT REDUCTION USING BIO-ADSORBENTS

Contract No. PPI/APM/2019/1/00042/U/00001

PROJECT TEAM

COORDINATOR

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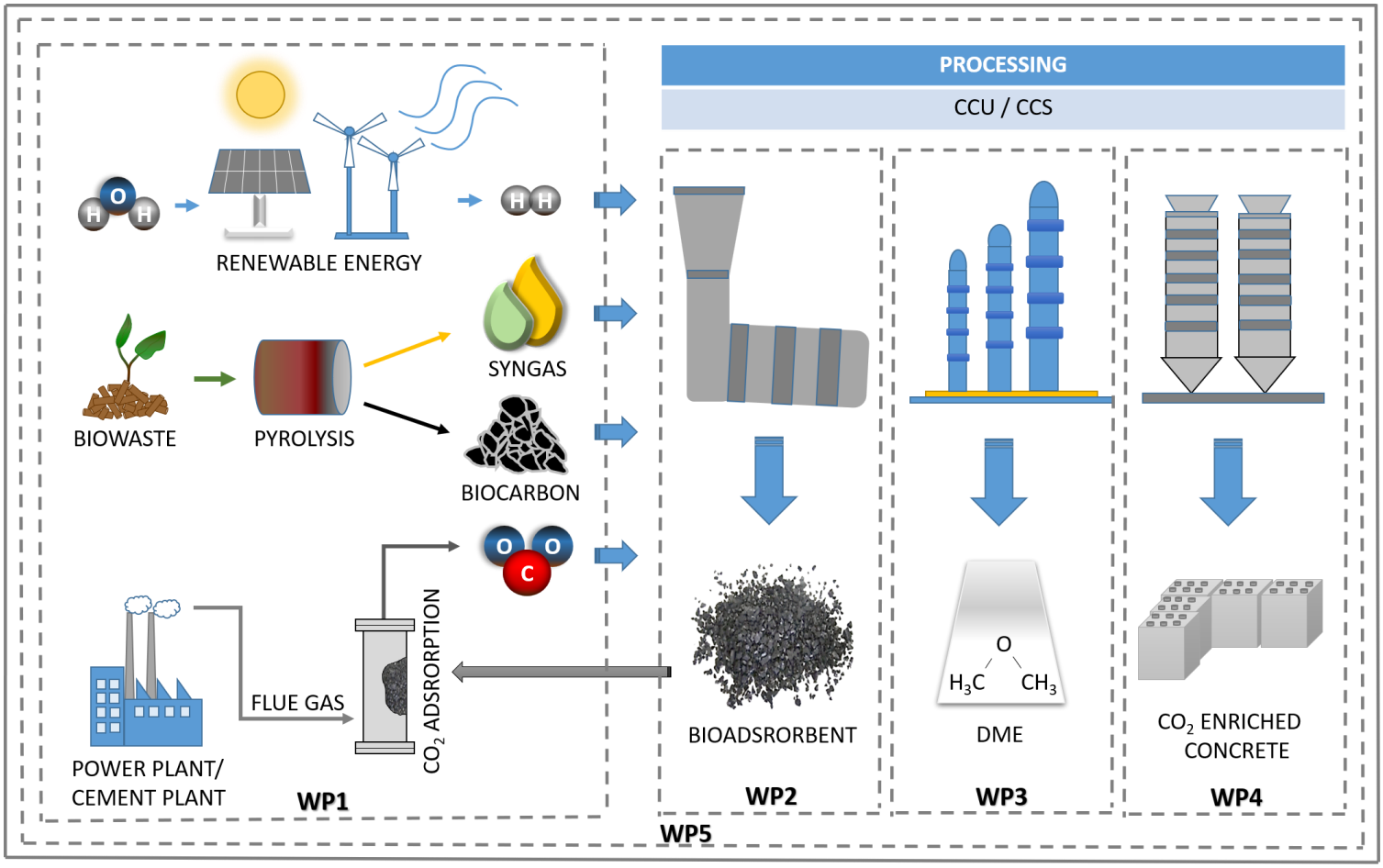
PROJECT PURPOSE

OBJECTIVE OF THE PROJECT is to undertake long-term scientific cooperation carried out as part of an international academic partnership established by Czestochowa University of Technology from Poland with universities and research institutes from Spain, Italy and Portugal, promoting the best practices and innovative solutions in the field of reducing carbon dioxide emissions.

PROJECT CONCERNS the establish of the international academic partnership in the field of reduction of the carbon footprint by utilizing carbon dioxide, coming from the energy and cement sector, as well as the waste biomass and the production of useful products using renewable energy.



PROJECT ACTIVITIES have been divided into five work packages:

WP1 CCU-CCS technology analysis

WP2 Bio-adsorbents engineering

WP3 Utilization of CO_2 – DME production

WP4 Utilization of CO_2 – concrete production

WP5 Carbon footprint analysis

CZESTOCHOWA UNIVERSITY OF TECHNOLOGY

Czestochowa University of Technology is the largest state university in the region composed of six Faculties: Civil Engineering, Electrical Engineering, Mechanical Engineering and Computer Science, Production Engineering and Materials Technology, Infrastructure and Environment, Management.

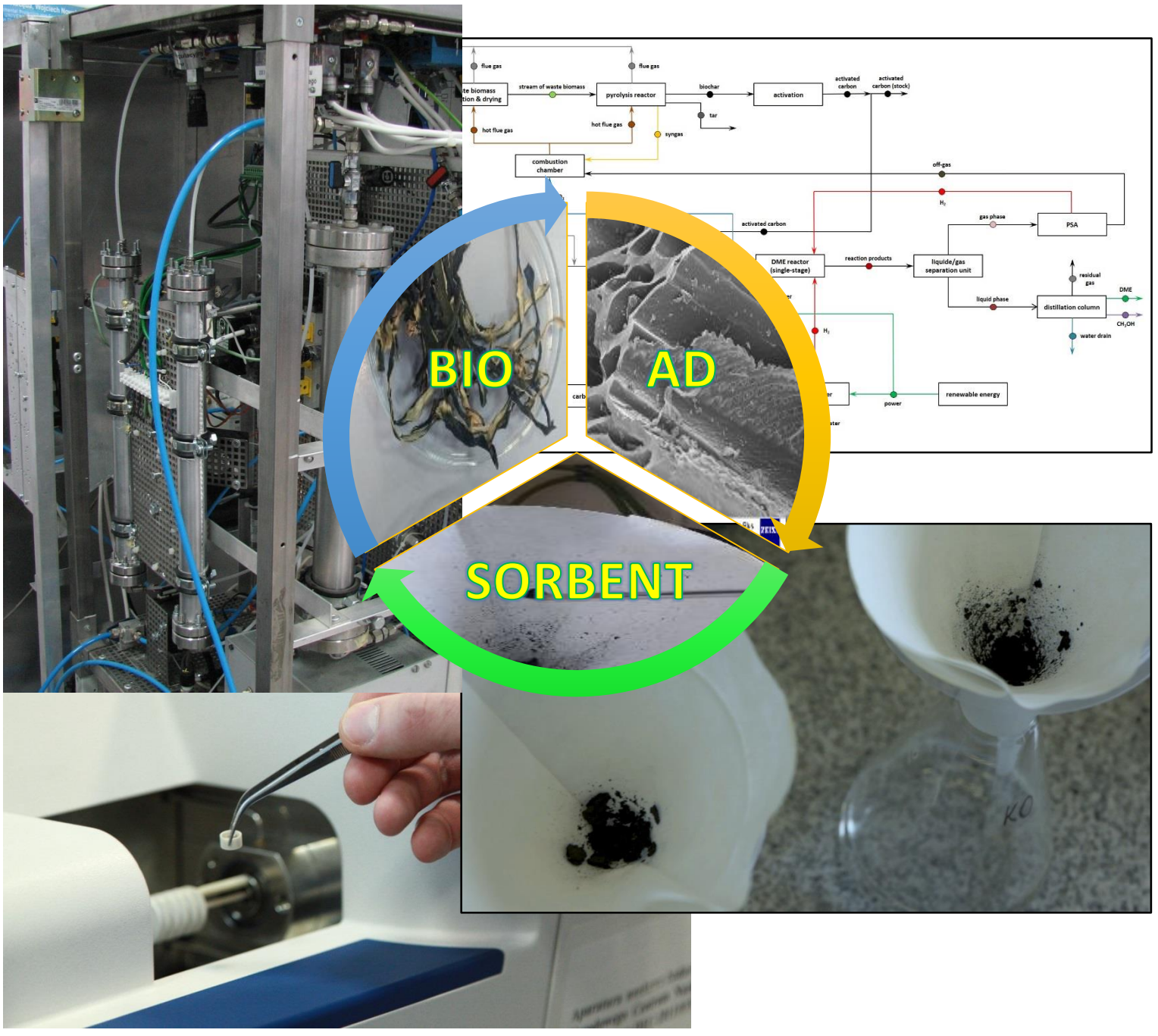
The research activity of the Department of Advanced Energy Technologies at the Faculty of Infrastructure and Environment is focused on: clean coal technologies, new energy technologies, oxygen carbon combustion technologies, renewable energy sources and energy storage technologies. The Institute cooperates with other scientific and research units, both at home and abroad, which results in the implementation of many international and domestic projects. The cooperation with the industry has contributed to the construction of innovative pilot plants for demonstrating oxygen combustion technology, oxygen production from the air and CO_2 separation from flue gases using the DR-VPSA method.

During its activity, the Institute received 28 patents, submitted 15 inventions and obtained 7 implementations, implemented 30 research projects as grants, commissioned and development projects.

WP1 CCU-CCS TECHNOLOGY ANALYSIS

The analysis of the proposed CCS / CCU technologies will be carried out, with attention to production of dimethyl ether from CO_2 and H_2 as well as CO_2 enriched prefabricates.

This stage includes the identification of the necessary data for the complementarity of the entire processes. The main substrates necessary for the utilization / storage of carbon dioxide as well as the requirements and parameters of the process will be determined. It is also planned to make some investigation of selected adsorbent. The collected data will be the base to calculate the carbon footprint as well as energy flow analysis.

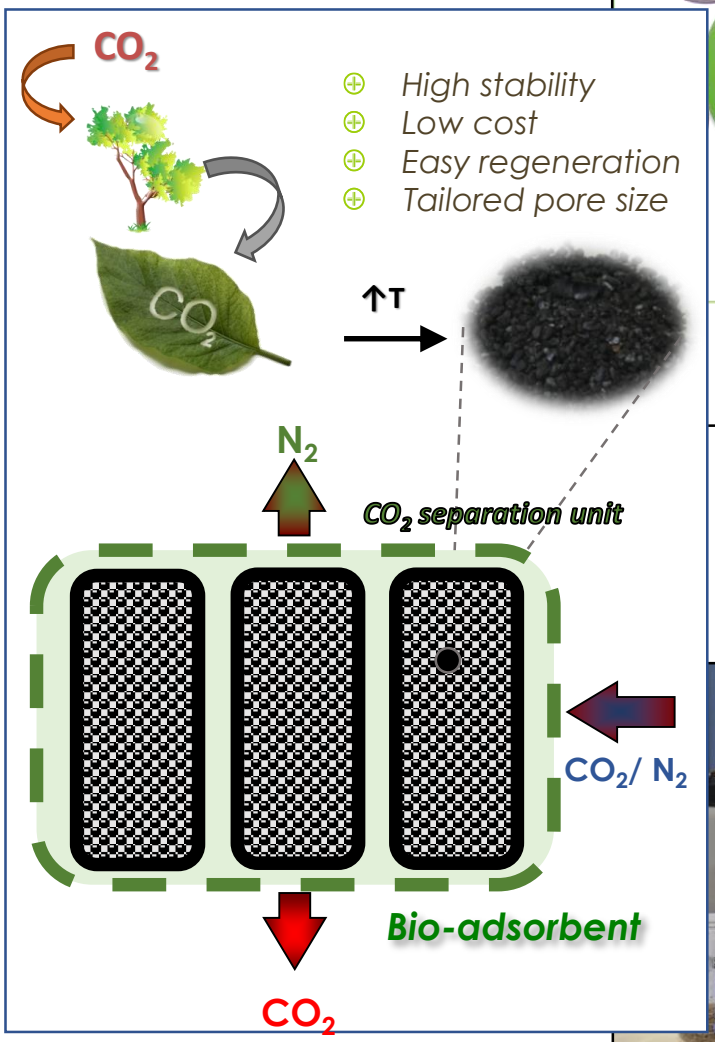


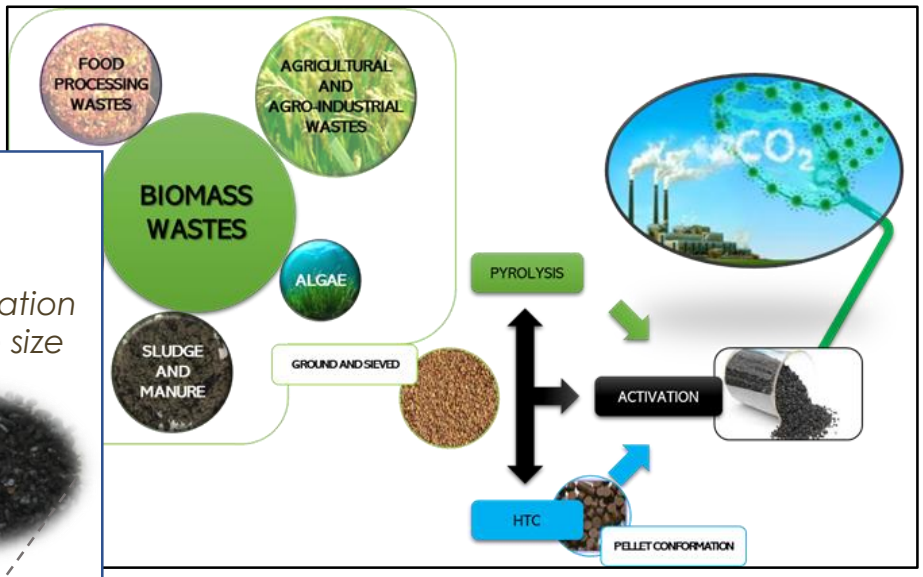
AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS

CSIC is a major player in the development of the European research area and therefore a significant contributor to the European integration process. The Instituto de Ciencia y Tecnología del Carbono (INCAR), that belongs to the CSIC, is the partner in the BIOCO2 project. CSIC-INCAR has focused its scientific and technical activities on two main research lines: the development of high-performance carbon materials for energy and the decarbonisation of industrial sectors, with particular emphasis on CO_2 capture. CSIC-INCAR will contribute to the project from the Energy Processes and Emission Reduction (PrEM) Group. Over the last fifteen years, their team members have consolidated a strong background in the research of technologies of CO_2 capture and H_2 production by the reforming process of biomass-based materials. The group has also a broad experience in the fields of combustion and gasification of biomass and coal/biomass mixtures in different types of reactors (fixed, fluidized and entrained flow), on the post and pre-combustion CO_2 capture by adsorption processes (PSA, VSA and TSA) and oxy-fuel combustion.

WP2 BIO-ADSORBENTS ENGINEERING

A bio-adsorbent with suitable properties for application to CO_2 capture as well as other industrial gas separations will be engineered. The envisioned material will be produced by activation of biochar from waste biomass under optimized conditions that guarantee proper bio-adsorbent structure (activated carbon). This will proceed through environmentally-benign and low-cost methodology developed within the team of Instituto de Ciencia y Tecnología del Carbono, equipped with the appropriate devices and installations for this purpose. The study also includes the determination of the basic properties of the activated carbon (e.g., chemical composition, textural characteristics, equilibrium capacity, etc.).





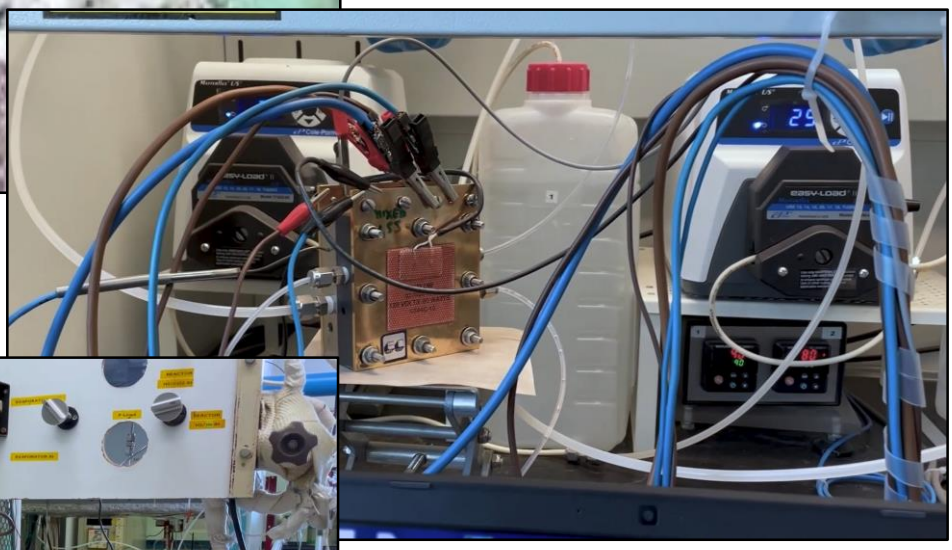
CONSIGLIO NAZIONALE DELLE RICERCHE

The Institute for Advanced Energy Technologies "N. Giordano" (ITAE), located in Messina, is one of the Institutes of National Research Council of Italy (CNR).

The role of ITAE in the energy sector mainly consists in the development of innovative, highly efficient and green technologies and processes, spanning from fundamental to applied research. The main research pillars include the realization of fuel-cell stacks, the production of hydrogen and environmentally-friendly fuels as well as the integration of energy systems with renewable energy sources. The participation in many EU and extra-EU research projects, joined to an effective dissemination and communication action, allowed CNR-ITAE to gain over the years an international leadership, as demonstrated by a market-oriented scientific production and several patents linked to project outcomes. Peculiar skills are related to the preparation and characterization of catalysts and smart materials, as essential components of devices for power generation, transformation or energy storage. The experimental tools and routines suitable for the testing of systems and prototypes in lab-scale facilities provide the basis for further development at higher technological readiness levels both in stationary and mobile energy sectors or biofuels applications.

WP3 UTILIZATION OF CO_2 – DME PRODUCTION

The feasibility of the direct catalytic conversion of CO_2 (captured from large sources of CO_2 emissions) in presence of H_2 (as a renewable energy source electrochemically generated from water electrolysis) into dimethyl ether (DME) will be carried out. This green fuel represents a very attractive alternative for diesel compression-ignited engines, with the major advantage of much lower pollutants and dusts emission in respect of the traditional diesel fuels. Catalytic data obtained during one-pot hydrogenation of CO_2-to-DME will be compared with data obtained from the conventional two-step process, involving first methanol synthesis and then its dehydration to DME in a second reactor. Evaluation of the obtained results with data from direct catalytic conversion processes of CO_2 will be used to estimate, i.e.: CO_2 conversion, energy demand for electrolyzers.



UNIVERSIDADE DE LISBOA

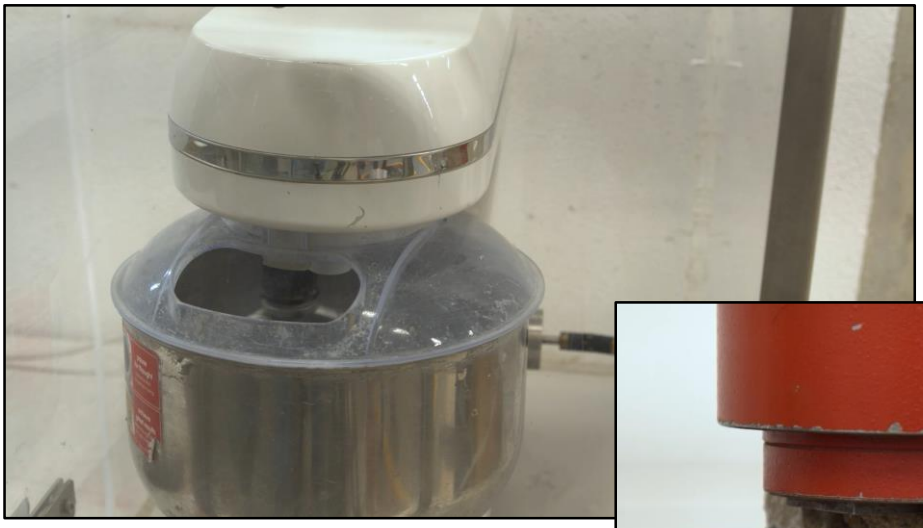
Instituto Superior Técnico, Universidade de Lisboa (IST-UL) is the largest and most reputed school of Engineering, Science and Technology in Portugal. Since its creation in 1911, IST's mission is to contribute to the development of society by providing top quality higher education and research activities.

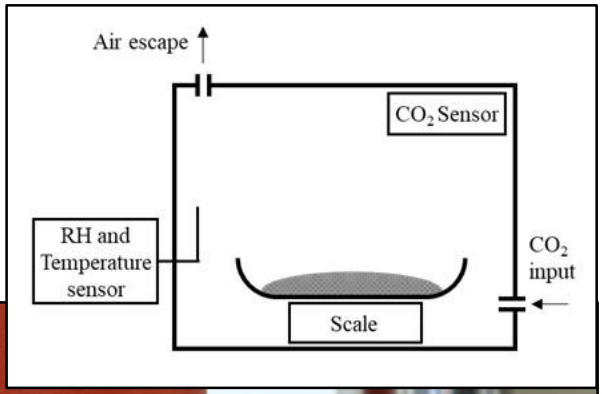
CERIS – "Civil Engineering Research and Innovation for Sustainability" – is an RDI unit of the Civil Engineering, Architecture and Georresources Department of IST-UL. It comprises 115 PhD researchers and around 250 PhD students. CERIS is transversally organized into four thematic strands that directly derive from national and EU directives: Product Development for Industry; Risk and Safety in Built and Natural Environments; Rehabilitation of Built and Natural Environments; Response to Natural and Societal Changes. In the scope of the low-carbon concrete, the main scientific skills of the CERIS research team comprise advanced concrete technology (characterization, performance, durability and lifecycle) and sustainable cementitious materials (incorporating waste, recycled concrete, recycled cement and recycled and lightweight aggregates). The members of the team have published around 100 papers in refereed SCI journals and have participated in 10 national projects in the last 10 years.

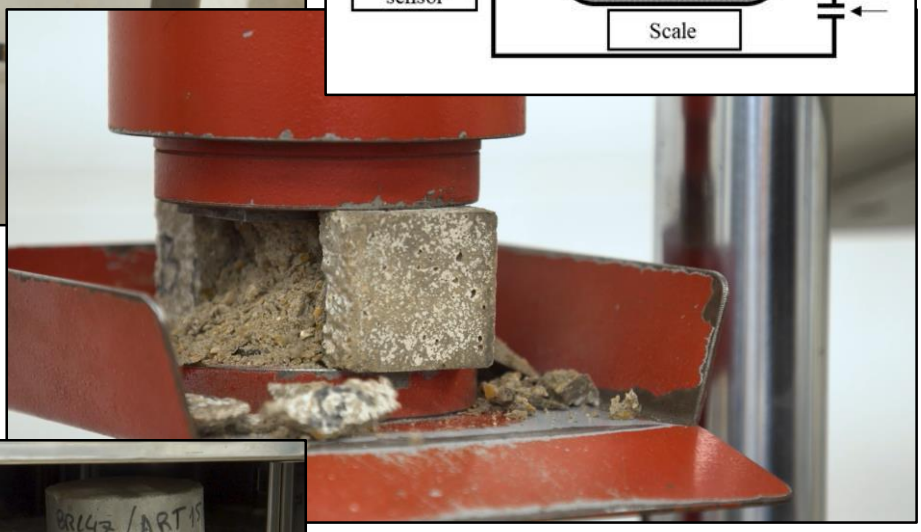
WP4 UTILIZATION OF CO_2 – CONCRETE PRODUCTION

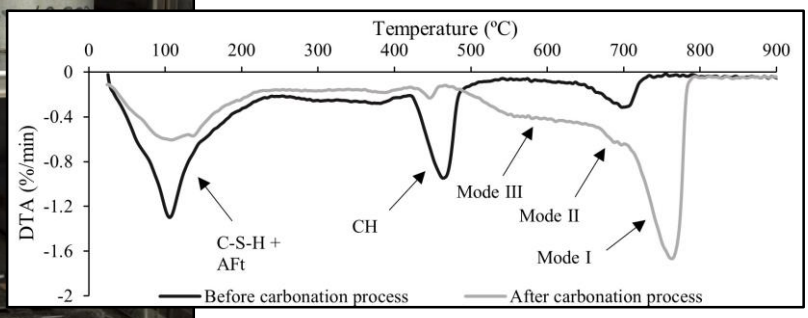
The conditions that can improve CO_2 uptake during the production and curing processes of cementitious mixtures will be studied. Also, recycled cement will be tested under carbonation to improve its performance as a green binding element for concrete.

Different parameters will be tested, namely: CO_2 concentration, mixing time and rotation speed of the mixing pans, water content and particle size. The mixtures will be characterized through micro- and macro-structure analysis in order to investigate the early-age carbonation and hardening mechanisms of cement materials, as well as to assess the influence of the CO_2 uptake on the cement hydration, mechanical behavior and durability.









UNIVERSITÀ CAMPUS BIO-MEDICO DI ROMA

Campus Bio-Medico University of Rome (UCBM) is a young, yet rapidly developing, private academic institution, devoted to undergraduate and postgraduate education, advanced research and provision of high-quality healthcare services. Established in 1992, today the University runs the School of Medicine and Surgery, the School of Engineering (degree in “Industrial Engineering”, “Biomedical Engineering”, “Chemical Engineering for the Sustainable Development”), and PhD in “Integrated Biomedical Sciences and Bioetics” and “Science and Engineering for Humans and the Environment”. The University hosts 40+ multidisciplinary Research Units.

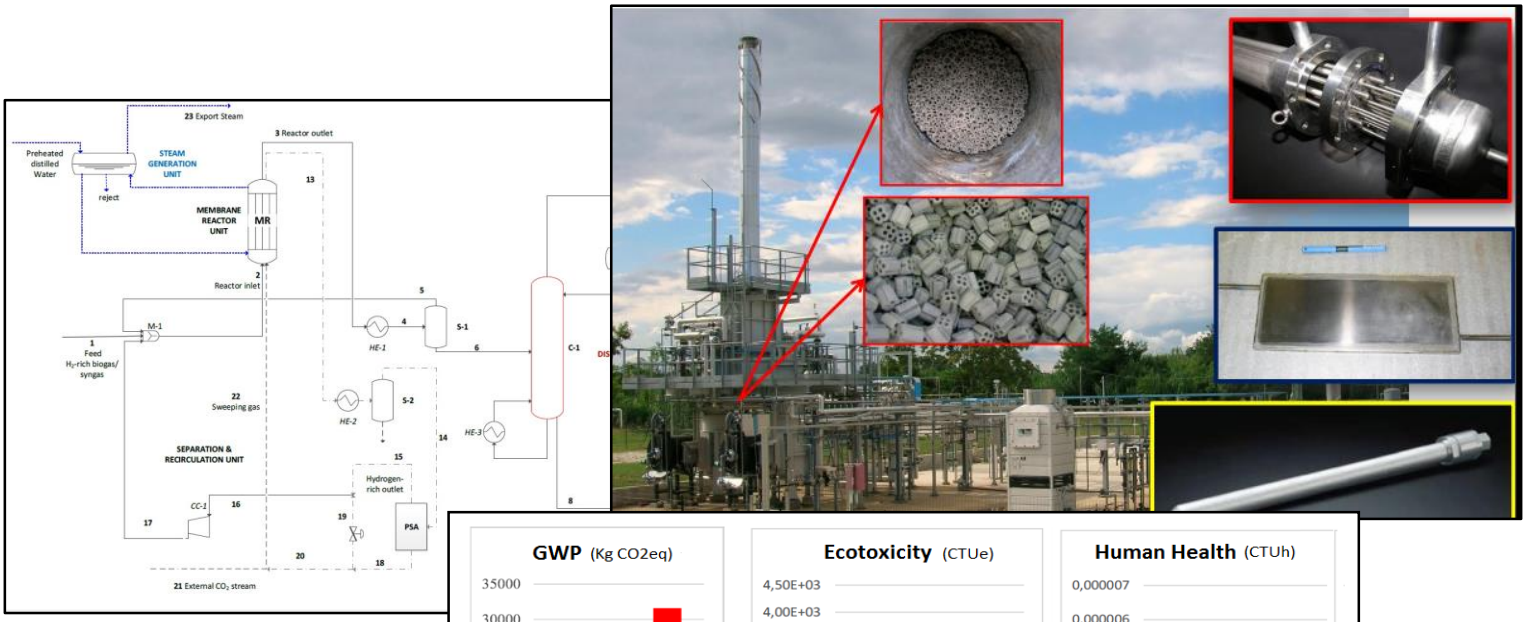
In Italy, UCBM has been systematically top-ranked for the quality of the education provided to a selected group of students. A maximum of about 120 students per year per course are admitted to undergraduate programs after an open, public competition typically joined by hundreds to thousands of candidates.

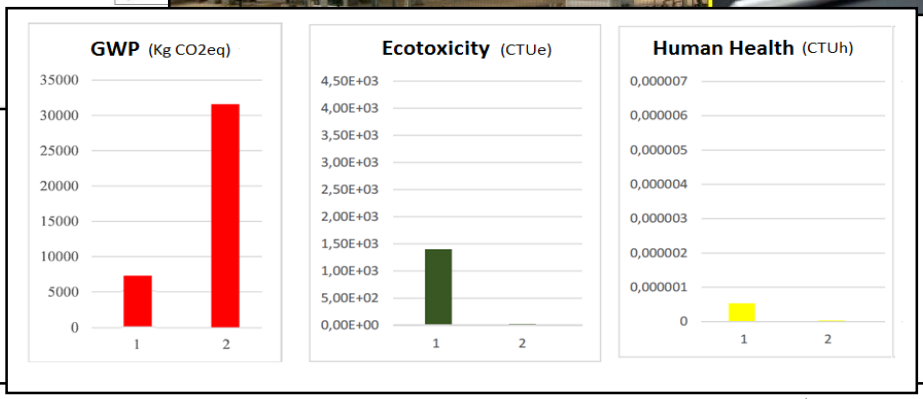
The Research Unit of “Process Engineering” is focused on the development and optimization of new technologies in the following sectors: energy, hydrogen generation, Carbon Capture and Storage, energy thermal storage.

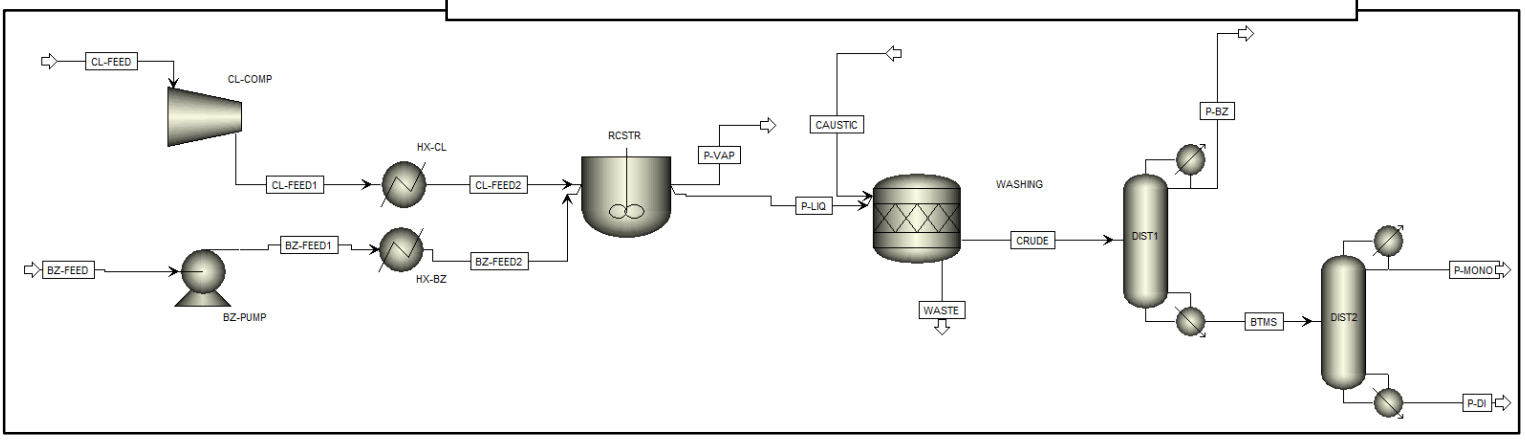
WP5 CARBON FOOTPRINT ANALYSIS

Numerical methods will be used to assess the carbon storage / utilization processes based on the following methodology:

- simulation of the process schemes by software, made together with a sensitivity analysis, comparing the architectures proposed and quantifying the operating condition optimal sets to maximize the performance and the energy efficiency,
- Life Cycle Assessment enabling the quantitative determination of carbon footprints and their derivation,
- exegetics efficiency analysis, aimed to define the energy penalty for each process and where the efforts have to be devoted to improve the global efficiency.







PARTNERS MEETING IN PORTUGAL
Universidade de Lisboa

PARTNERS MEETING IN ITALY
Università Campus Bio-Medico di Roma

PARTNERS MEETING IN ITALY
Consiglio Nazionale delle Ricerche

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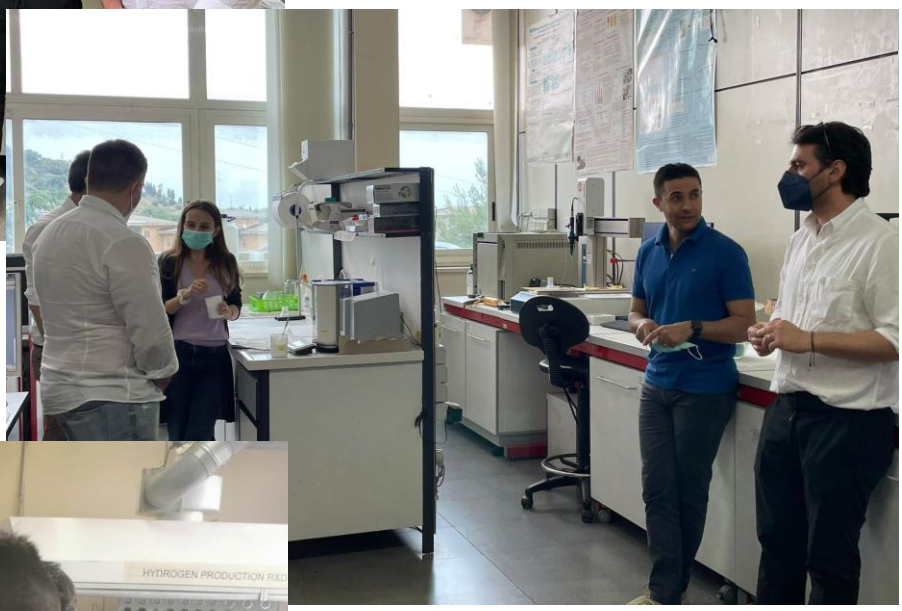
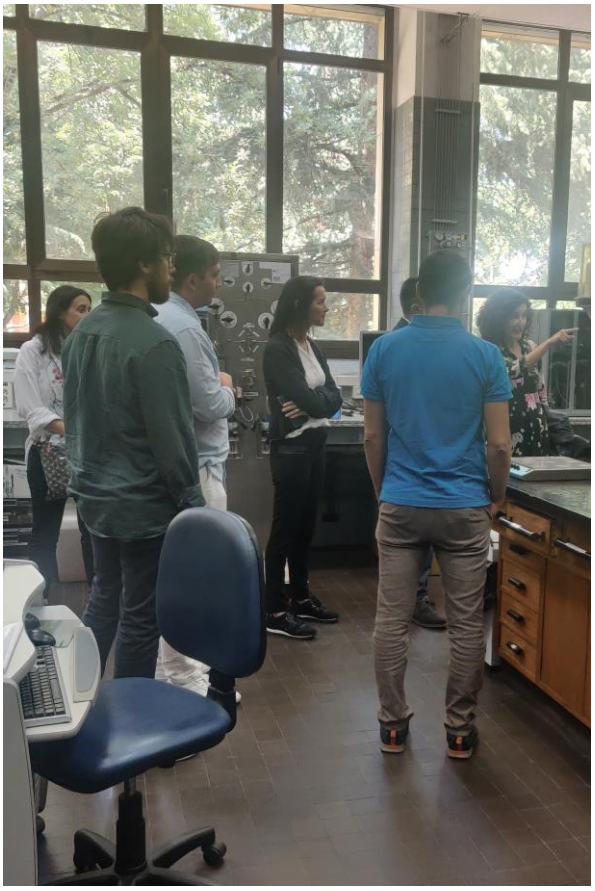


PARTNERS MEETING IN SPAIN
Agencia Estatal Consejo Superior de Investigaciones Cientificas



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POLISH NATIONAL AGENCY FOR ACADEMIC EXCHANGE

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