H.F.R.I.
Hellenic Foundation for Research & Innovation

## Description of the funded research project

# 1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

## Title of the research project:
**Integrated Membrane-Adsorption Processes for Efficient Carbon Capture**

## Principal Investigator: Eustathios Kikkinides

## Reader-friendly title: MemAds2Carb

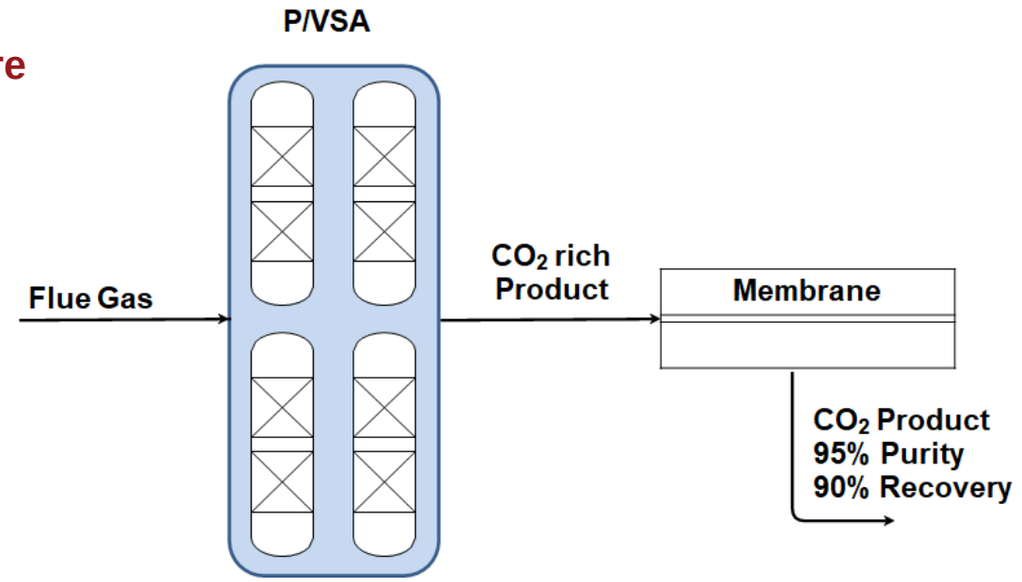
## Scientific Area: Chemical Engineering

## Institution and Country:
**Centre for Research and Technology Hellas (CERTH), Greece**

## Host Institution:
**Chemical Process and Energy Resources Institute (CPERI)**

## Collaborating Institution(s):

## Project webpage (if applicable):




## Budget: 186,784.38 €

## Duration: 36 months

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# Research Project Synopsis

***Driven by great environmental concern and imposed regulations on carbon dioxide ($CO_2$) emissions, the present project offers an integrated material (membrane) and adsorption process development and optimization framework for efficient carbon capture. The resulting technology is expected to reduce significantly the footprint of the capture processes and will be employed to three different industrial case studies that produce $CO_2$ as a by-product in the effluent streams at near atmospheric pressure: (a) coal fired power plants; (b) biomass gasification for combined heat and power generation; (c) production of cement. Within this scope, this proposal is considered to promote leading edge research innovation and opens new dimensions in the area of carbon capture technology due to the following expected technological and scientific achievements:***

- ***Synthesis and development of novel porous membranes for $CO_2$ capture along the course of the project.***
- ***Innovative simulation algorithms for rapid design and optimization of membrane/adsorption processes.***
- ***Integrated process design and optimization combining membranes and adsorption-based processes for different industrial applications of high environmental impact.***

# Project originality

***One attractive feature of adsorption-based processes, such as Pressure/Vacuum Swing Adsorption (P/VSA) is the fact that they only require electricity, making it a simple solution to retrofit to existing plants. A few P/VSA processes have recently been proposed for carbon dioxide ($CO_2$) capture from coal fired power plants, with a total separation energy of 25 kJ/mol compared to 39 kJ/mol for a monoethanolamine (MEA) system, but require vacuum pressures as low as 0.02 bar, which are prohibited for industrial applications. An important advancement in this project will come from the use of integrated membrane-P/VSA configurations, which will allow the increase of pressure at the vacuum pump at least to 0.1 bar, leading to sustainable industrial solutions.***

***Along the course of this project a novel integrated Membrane-Adsorption 2-stage Carbon capture (MemAds2Carb) technology will be developed with which a significant advance from the current best available technologies in terms of its Capital and Operational Expenditure (CAPEX-OPEX) can be achieved. The developments will be guided by three case studies from different industrial sectors and will be validated for these cases demonstrating the proposed approach on gas streams at near ambient pressure that contain $CO_2$ over a broad concentration range (15-30%). This will ensure that the technology developed in this project is general in nature and can be applied to all sectors of the process industries that produce $CO_2$ emissions. Membrane material development will be combined with process modeling and optimization of integrated membrane-P/VSA processes that will be tailor-made to the specific industrial application considered in each case.***

# Expected results & Research Project Impact

***The key challenge to the success of MemAds2Carb is two-fold: (1) a high-$CO_2$ flux porous membrane of moderate to high selectivity will be produced; and (2) an integrated membrane-P/VSA process will be developed to achieve target cost and performance metrics (90 percent $CO_2$ capture with 95 percent $CO_2$ purity). Evidently, the present project addresses challenging problems from a scientific research point of view both at material and process level. Two Ph.D. graduates are expected to come out from this project and be qualified to transfer knowledge and technology directly into industry.***

***<u>Impact on environment and economy.</u> Carbon capture and storage removes $CO_2$ from large industrial sources and stores it safely underground. MemAds2Carb will develop a new $CO_2$ separation technology that will considerably decrease the use of fossil energy and raw material resources. A lower specific energy demand per unit of product will further decrease emissions, water consumption, amount of waste, and dissipation of heat into the environment of the process industry.***

***<u>Impact on technology providers.</u> An important output of the present project will be the new simulation and optimization framework of membrane-P/VSA processes. According to Forbes (2015), the industrial internet is supposed to generate a market of about USD 500 Billion in 2020. Advanced process modeling optimization, simulation tools – applied to energy intensive industries – represent a significant fraction of this market.***

***<u>Social Impact.</u> MemAds2Carb leads to more efficient production and thus, causes lower production cost. This benefits customers by either lower prices or a higher quality of the final consumer products.***

# The importance of this funding

***The project will take place at the Laboratory of Inorganic Materials (LIM) at CPERI/CERTH. LIM has a long-time tradition in the development and application of inorganic porous materials and membranes for gas and liquid separations of industrial or environmental importance. Current funding will help on the continuation of the Lab's active research involvement in the areas of membrane development and carbon capture by adsorption and/or membranes.***

***The research team consists of two collaborating faculty members from Aristotle University of Thessaloniki (AUTH), and two PhD students that will work on the different scientific fields involved along the course of the project. The activities of the research team combine expertise on the development of methodologies for modelling, optimization and integration of adsorption and membrane processes. The PhD students will be financially supported to work on two different but complementary scientific fields (process  and material development) to achieve the current research targets.***

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**COMMUNICATION**

185 Syggrou Ave. & 2 Sardeon St. 2
171 21, N. Smyrni, Greece
+30 210 64 12 410, 420
communication@elidek.gr
www.elidek.gr