

Power2**METHANE**

Project Goals

Luis Miguel Madeira

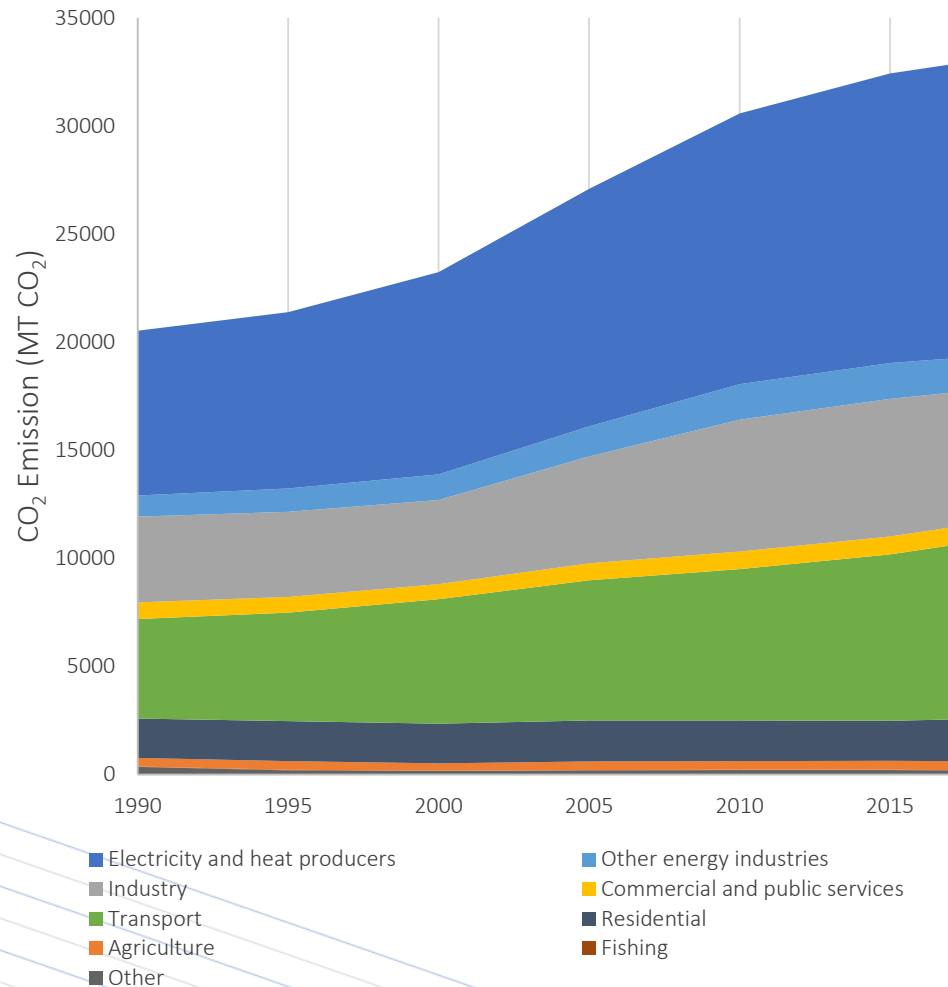
Department of Chemical Engineering
LEPABE – Faculty of Engineering, University of Porto

P2M ^{1st} WEBINAR | 5th June 2020

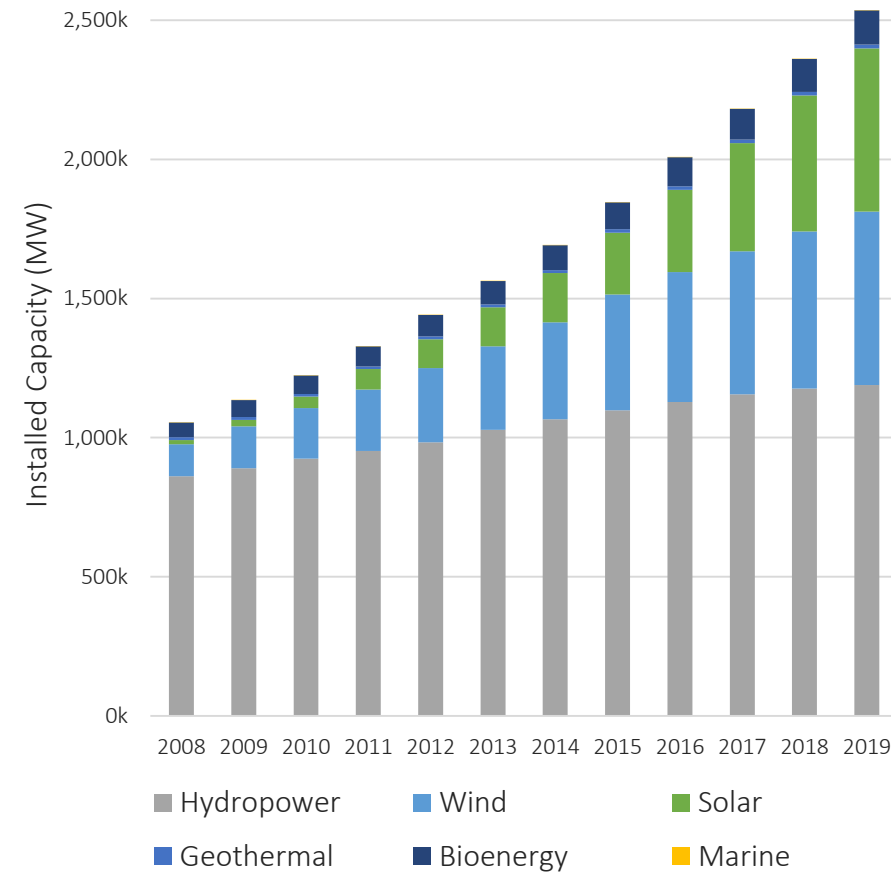
Power-to-Methane Concept

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World CO₂ emissions by Sector



World Renewable Energy Installed Capacity



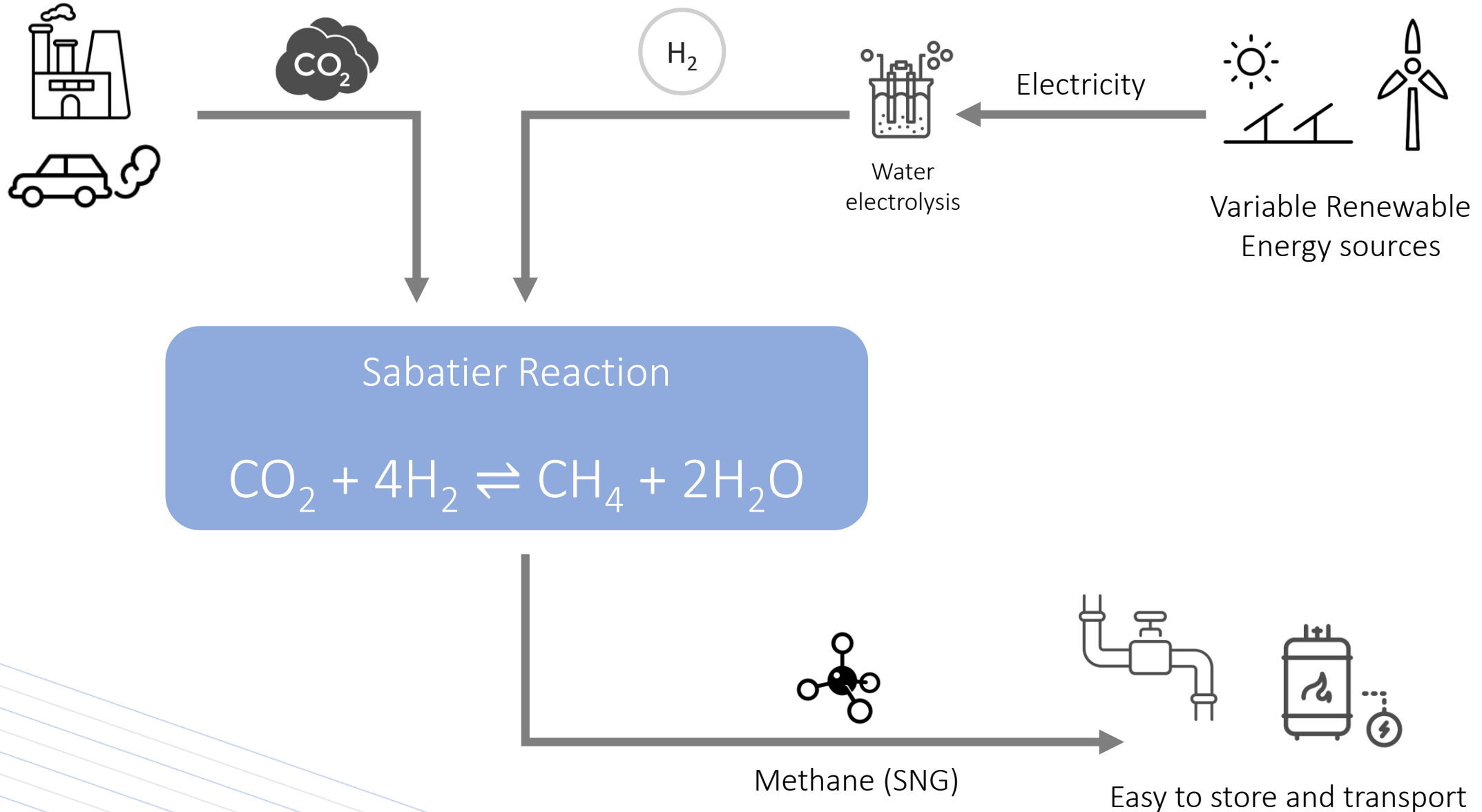
Team

Project
Tasks

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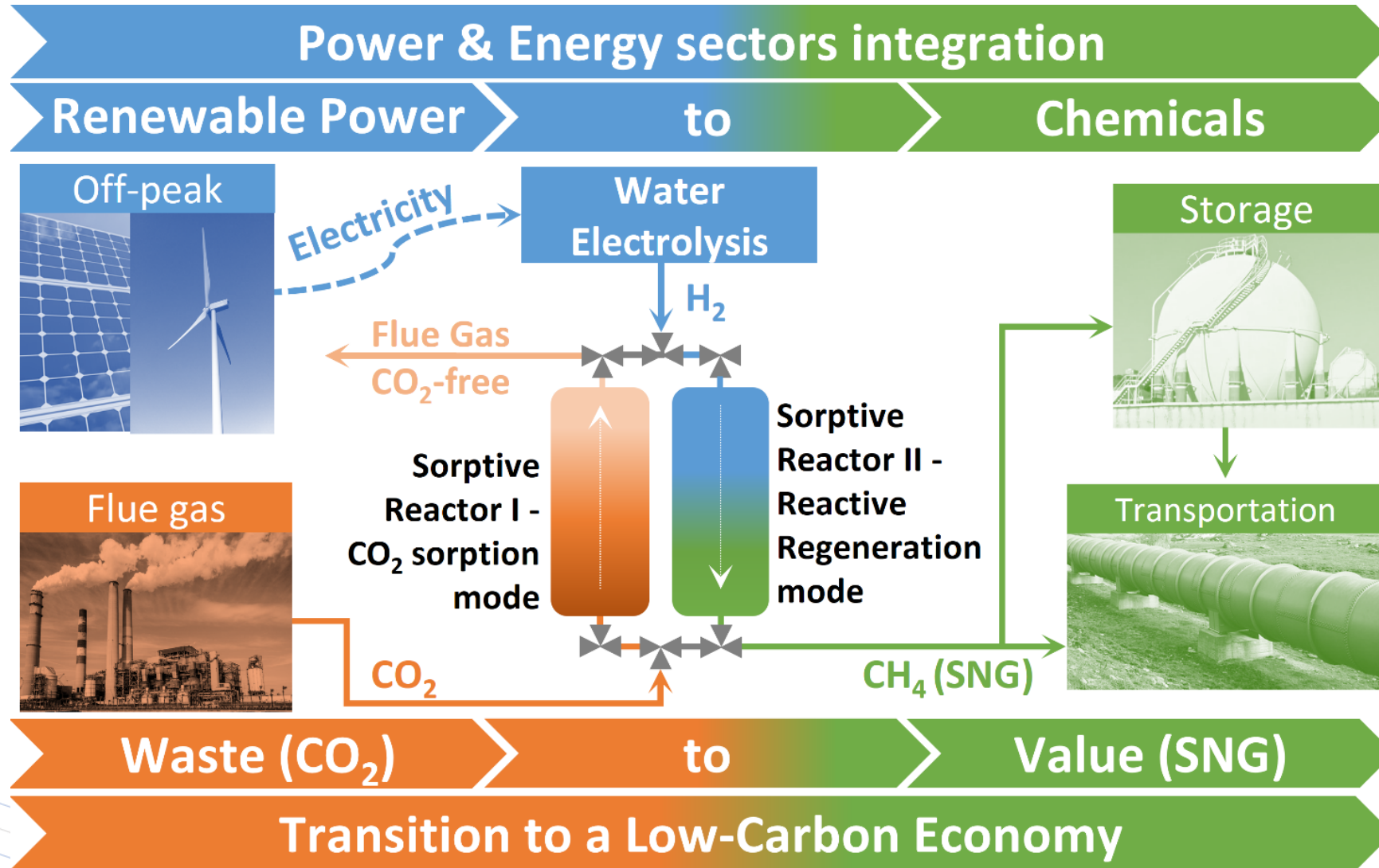
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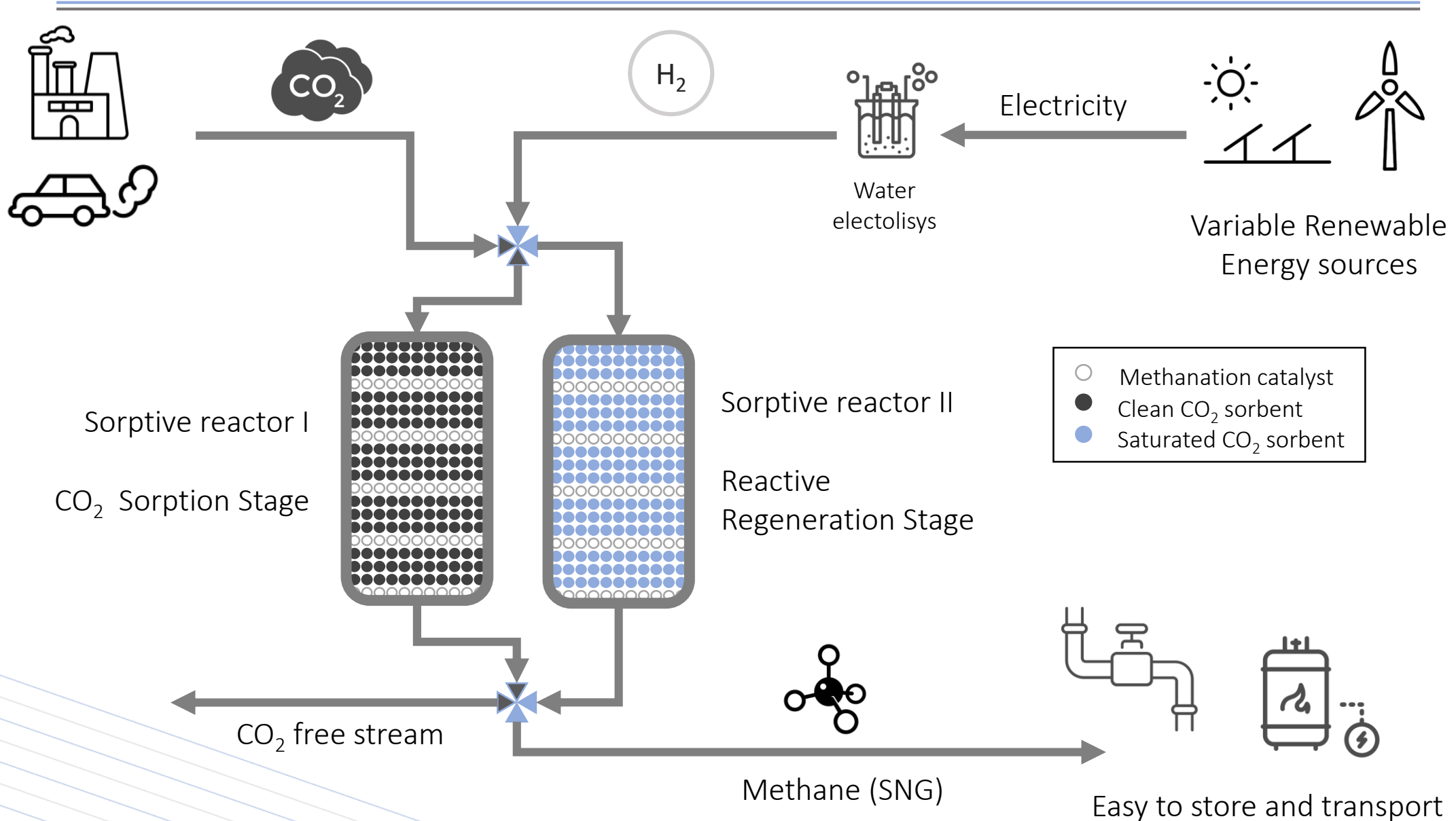
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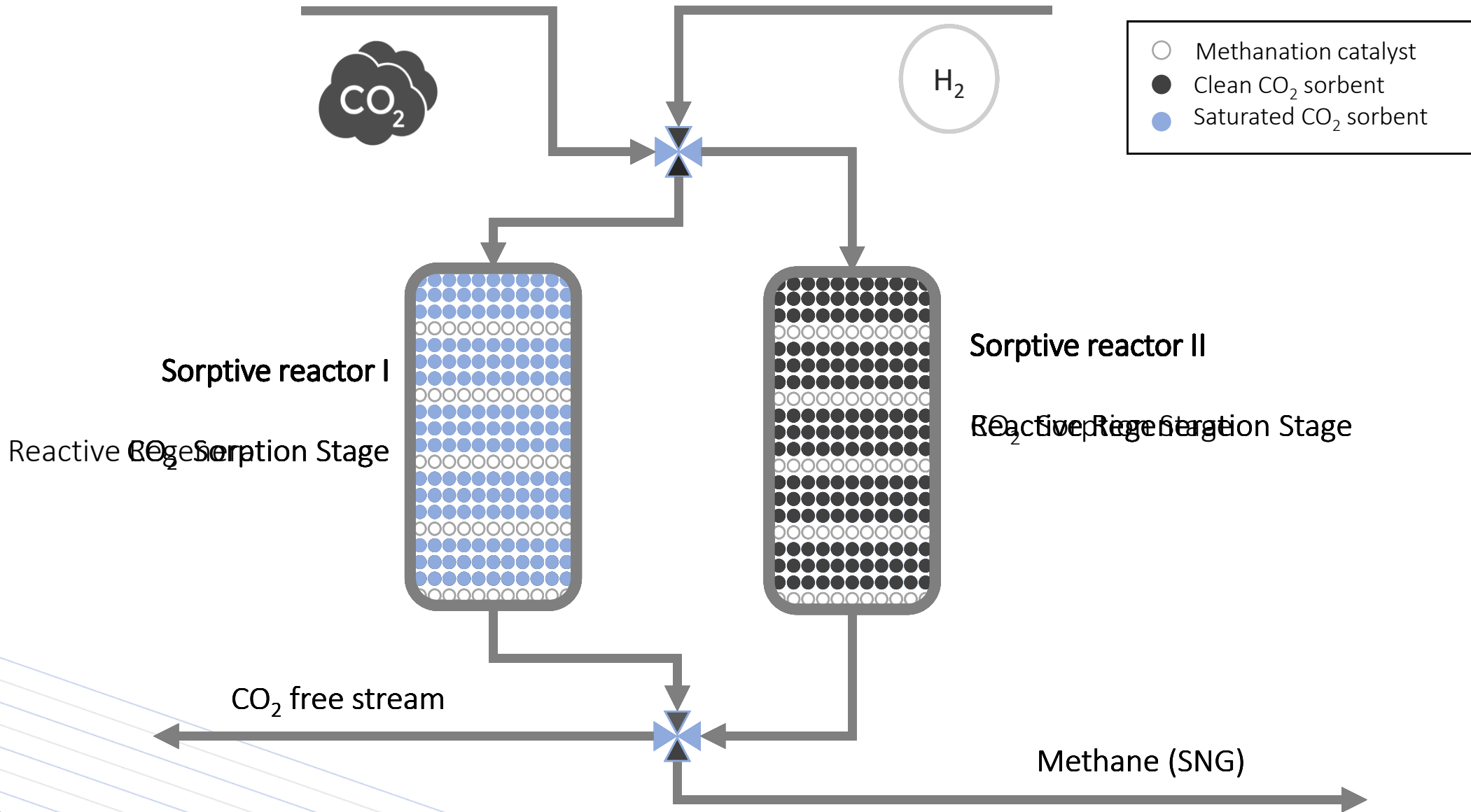
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Power2**METHANE** Team



Luís Miguel Madeira (PI)
Associate Professor



Alírio Rodrigues (Co-PI)
Emeritus Professor



Carlos Miguel *
Junior Postdoc Researcher



Miguel Angel Soria
Junior Postdoc Researcher



Ana Catarina Faria **
PhD Student



Joana Martins
Project Researcher

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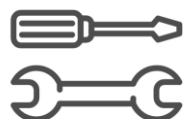
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Project Tasks (3 years)



TASK 1

Management and Dissemination



TASK 2

Prototype Assembling



TASK 3

Synthesis and Characterization
of Sorbents and Catalysts



TASK 4

Prototype Testing and Optimization



TASK 5

Techno-Economic Analysis

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PROJECT SCHEDULE:

1.06.2018 – 31.05.21 (36 months)

Project Tasks

TASK 1 | Management and Dissemination

- PhD and MSc Theses (3 MSc + 1 PhD);
- Publications in peer-reviewed scientific journals;
- Communications in International Conferences;
- Workshops/Seminars;
- Website (<https://power2methane.fe.up.pt/>).

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Project Tasks

TASK 1 | Management and Dissemination



catalysts
an Open Access Journal by MDPI

IMPACT FACTOR 3.444

Novel Materials and Reactor Concepts for CO2 Conversion into Methane, Methanol and DME

Guest Editors
Dr. Carlos V. Miguel, Prof. Luís Madeira, Prof. Dr. Alírio E. Rodrigues

Deadline
31 December 2020

Special Issue
Invitation to submit

[mdpi.com/si/37966](https://www.mdpi.com/si/37966)

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For more detailed information, please visit:

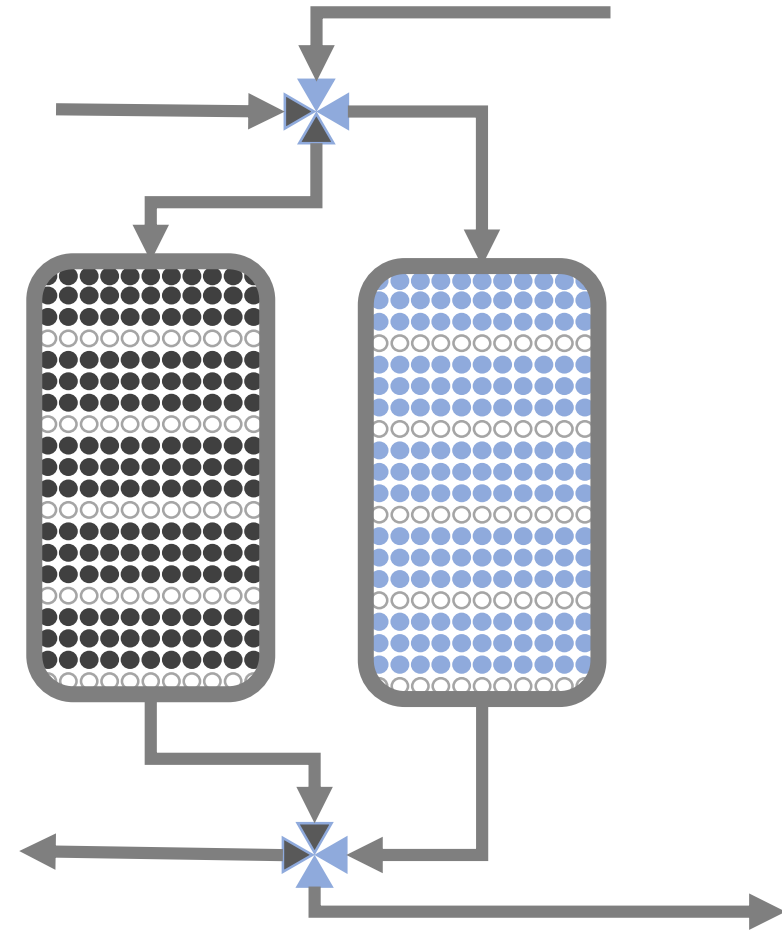
[https://www.mdpi.com/journal/catalysts/special issues/CO2 Conversion Methane](https://www.mdpi.com/journal/catalysts/special%20issues/CO2%20Conversion%20Methane)

Project Tasks

TASK 2 | Prototype Assembling

Prototype for integrated CO₂ capture and conversion into methane (continuous SNG production).

- 2 Parallel reactors (0.5 L each);
- 2 automated 4-way valves for an easy shift between CO₂ Sorption and Regenerative Reaction stages;
- Operation up to 350 °C;
- Different feeding options;
- Online gas analyser (CO₂, H₂, CH₄, O₂ and CO) and H₂O probe in the outlet stream.



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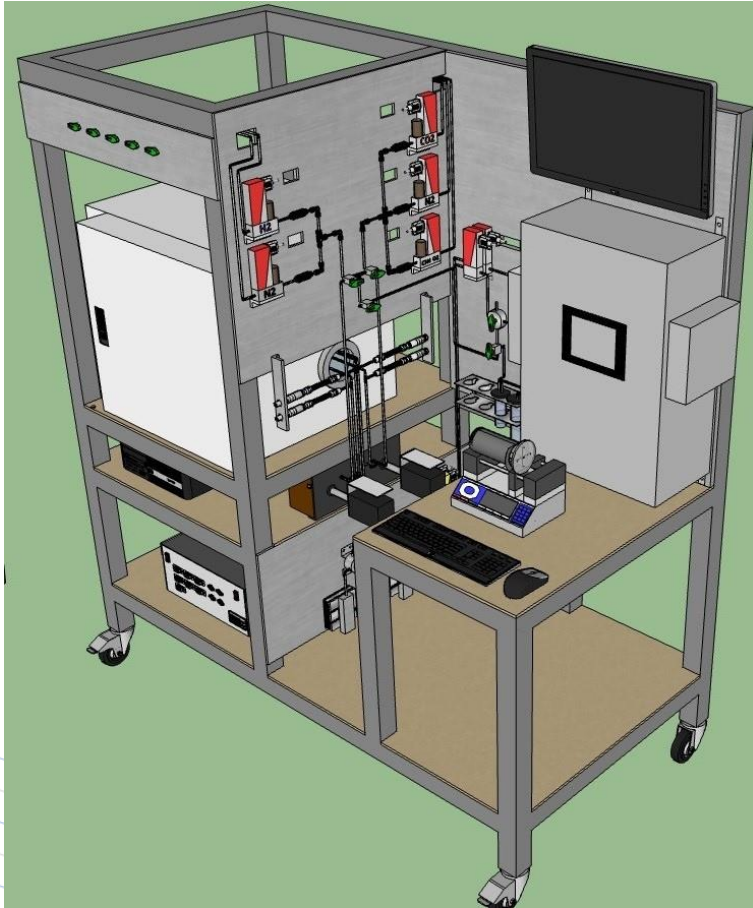
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TASK 2 | Prototype Assembling



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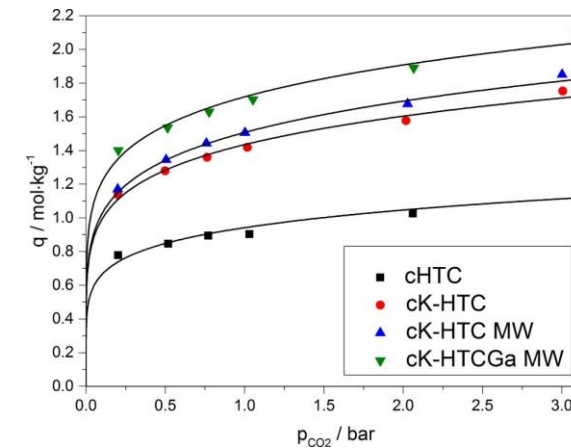
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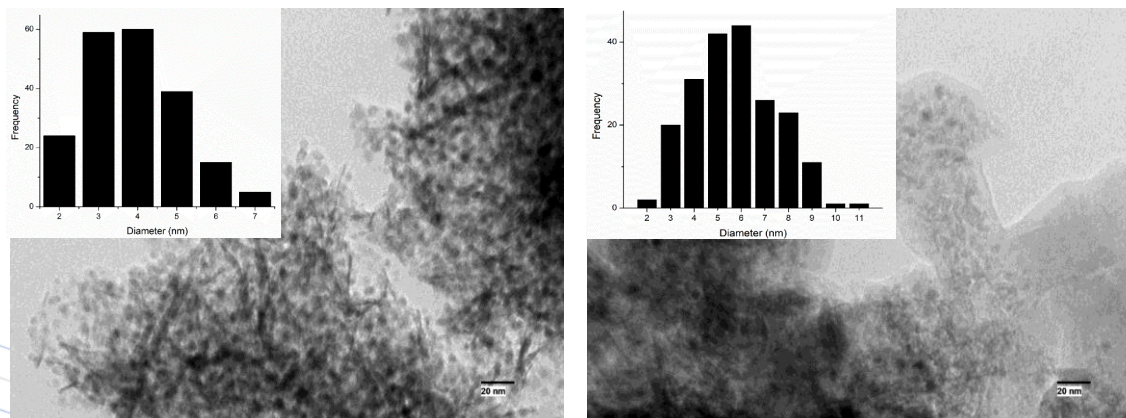
Project Tasks

TASK 3 | Synthesis and Characterization of Sorbents and Catalysts

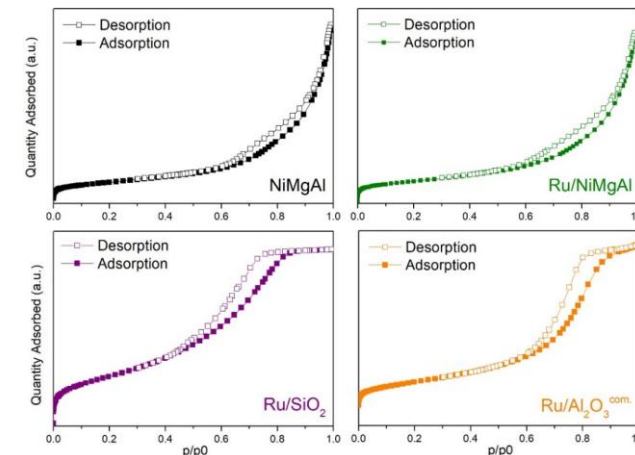
- Synthesis of sorbents for CO₂ capture (hydrotalcites)
- Synthesis of methanation catalysts (nickel- and ruthenium-based)
- Materials characterization and screening (including DFM)
- Pelletization



CO₂ sorption equilibrium isotherms at 573 K on hydrotalcites. Lines correspond to the fitting using the Freundlich equation.



TEM of fresh (left) and spent (right) methanation catalyst NiMgAl.



Adsorption/desorption isotherms of nitrogen over methanation catalysts.

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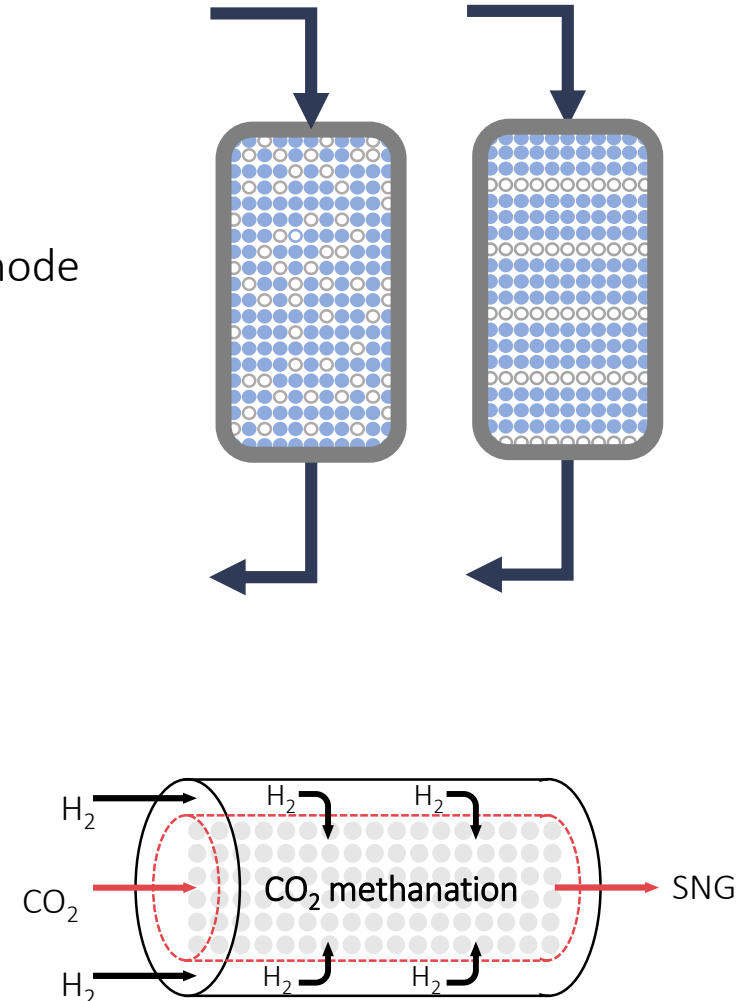
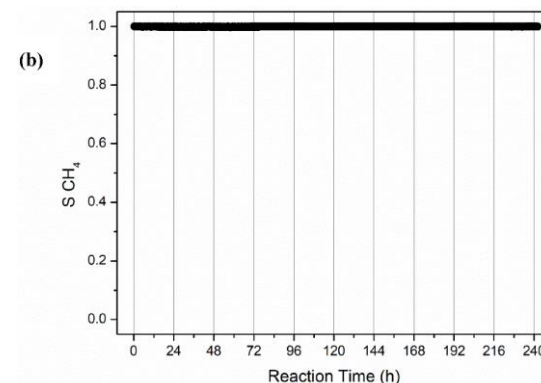
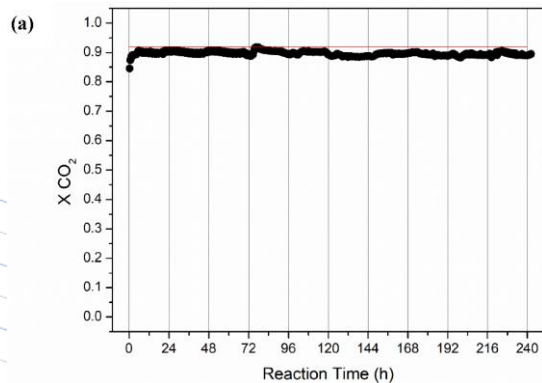
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TASK 4 | Prototype Testing and Optimization

- Study the effect of the sorptive reactor bed configuration
- Study the effect of H₂ feed system (regeneration stream)
 - H₂ delivery under forward or reverse-flow regeneration mode
 - H₂ radial distribution using Pd-based membranes
- Study the effect of the feed composition (e.g. flue gas)
- Cyclic reactor modelling & optimization



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TASK 5 | Techno-economic analysis

Assess the potential of the sorptive-reactor technology, including the strategies of operation considered and materials developed.

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Articles (including Open Access):

- C.V. Miguel, A. Mendes, L.M. Madeira, “An Overview of the Portuguese Energy Sector and Perspectives for Power-to-Gas Implementation“, *Energies*, 2018, 11 (12) 3259. URL: <https://doi.org/10.3390/en11123259> | I.F. 2.707
- J.A. Martins, A.C. Faria, M.A. Soria, C.V. Miguel, A.E. Rodrigues, L.M. Madeira, “CO₂ methanation over hydrotalcite-derived nickel/ruthenium and supported ruthenium catalysts“, *Catalysts*, 2019, 9, 1008. URL: <https://doi.org/10.3390/catal9121008> | I.F. 3.444
- A. Catarina Faria, C.V. Miguel, A.E. Rodrigues, L.M. Madeira, “Modelling and simulation of a steam-selective membrane reactor for enhanced CO₂ methanation”, SUBMITTED
- J.A. Martins, C.V. Miguel, A.E. Rodrigues, L.M. Madeira “Study of carbon dioxide methanation over an industrial nickel-based catalyst”, TO BE SUBMITTED



energies



catalysts

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Communications:

- A.C. Faria, C.V. Miguel, L.M. Madeira “**Modeling and simulation of a CO₂ methanation membrane reactor**”, poster presentation at the [14th International Conference on Catalysis in Membrane Reactors](#), Eindhoven, The Netherlands, July 2019.
- J.A. Martins, A.C. Faria, M.A. Soria, C.V. Miguel, A.E. Rodrigues, L.M. Madeira “**Highly active, stable and selective (Ru)Ni catalysts for CO₂ methanation**”, oral presentation at the [12th European Congress of Chemical Engineering](#), Florence, Italy, September 2019.
- C.V. Miguel, J.C. Gonçalves, A.E. Rodrigues, L.M. Madeira “**Modeling and simulation of a sorptive reactor unit for Power-to-Gas applications featuring CO₂ capture and utilization (CCU)**”, oral presentation at the [12th European Congress of Chemical Engineering](#), Florence, Italy, September 2019.



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Communications:

- A.C. Faria, R. Trujillano, V. Rives, C.V. Miguel, A.E. Rodrigues, L.M. Madeira “Alkaline metal promoted (Na, Cs and K) hydrotalcites for high temperature CO₂ capture from flue gas in cyclic adsorption processes”, oral presentation (accepted) at the [24th International Congress of Chemical and Process Engineering CHISA 2020](#), Prague, Czech Republic, August 2020.
- A.C. Faria, C.V. Miguel, A.E. Rodrigues, L.M. Madeira “A membrane reactor for the methanation of CO₂: Modelling and simulation”, poster presentation (accepted) at the [24th International Congress of Chemical and Process Engineering CHISA 2020](#), Prague, Czech Republic, August 2020.



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- 1 PhD and 2 MSc theses running:



Ana Catarina Faria
PhD Student

Study of a hybrid sorption-reaction process for CO₂ capture and methanation: Power-to-Gas concept



Bárbara Martins
MSc Student

Study of a sorption-enhanced reactor for CO₂ methanation



Igor Iwakiri
MSc Student

Use of membrane reactors for CO₂ hydrogenation reactions

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Webinar - Organizing Committee



Luís Miguel Madeira
Associate Professor



Alírio Rodrigues
Emeritus Professor



Carlos Miguel
Junior Postdoc Researcher



Ana Catarina Faria
PhD Student



Joana Martins
Project Researcher

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Power2METHANE 1st WEBINAR
CO₂ capture and utilization: insights from academia and industry

5th June 2020

10:00
Opening Session and Power2Methane project goals | Luis Madeira

10:20
"Cyclic adsorption/reaction processes in CO₂ capture and utilization" | Alirio Rodrigues

11:15
"CO₂ to methanol in Iceland: Past, Present and Future" | Christiaan Richter

11:55
"Diffusion of energy technology innovations and perspectives for decarbonization in Portugal" | Nuno Bento

14:05
"Power2Methane: outcomes and future perspectives" | Carlos V. Miguel

14:45
"CO₂ recovery and purification from offgas of biogas upgrading and power plants" | Patrick Barcia

15:40
"The NetMIX technology and the CoLAB Net4CO₂ – Perspectives and solutions for the CO₂ climate crisis" | Jose Carlos Lopes

16:20
"Roadmap to a Carbon Neutral Company 2035 – New alternatives to reduce CO₂ fossil emissions" | Nuno Rodrigues

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FEUP | LEPABE

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UNIVERSITY OF ICELAND

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CARLOS V. MIGUEL
CoLAB BIOREF

PATRICK BARCIA
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THE NAVIGATOR COMPANY

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Thank you for your attention and welcome to the

Power2METHANE

1st WEBINAR

CO₂ capture and utilization: insights from academia and industry

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