Advanced MEMBranes and membrane assisted procEsses for pre- and post- combustion CO_2 captuRe

MEMBER

https://member-co2.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 760944

Duration: 4 years. *Starting date: 01 January 2018*

Budget: € 9 596 541,50 *EU contribution: €7 918 901*

Contact: joseluis.viviente@tecnalia.com

The present publication reflects only the author's views. The Commission is not responsible for any use that may be made of the information contained therein.

Outline

1. Summary
2. Partnership
3. Project Objectives
4. Overall approach and methodology
5. Expected results

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

1. Summary

The key objective of the MEMBER project is the scale-up and manufacturing of advanced materials (membranes and sorbents) and their demonstration at TRL6 in novel membrane based technologies that outperform current technology for pre- and post-combustion CO_2 capture in power plants as well as H_2 generation with integrated CO_2 capture.

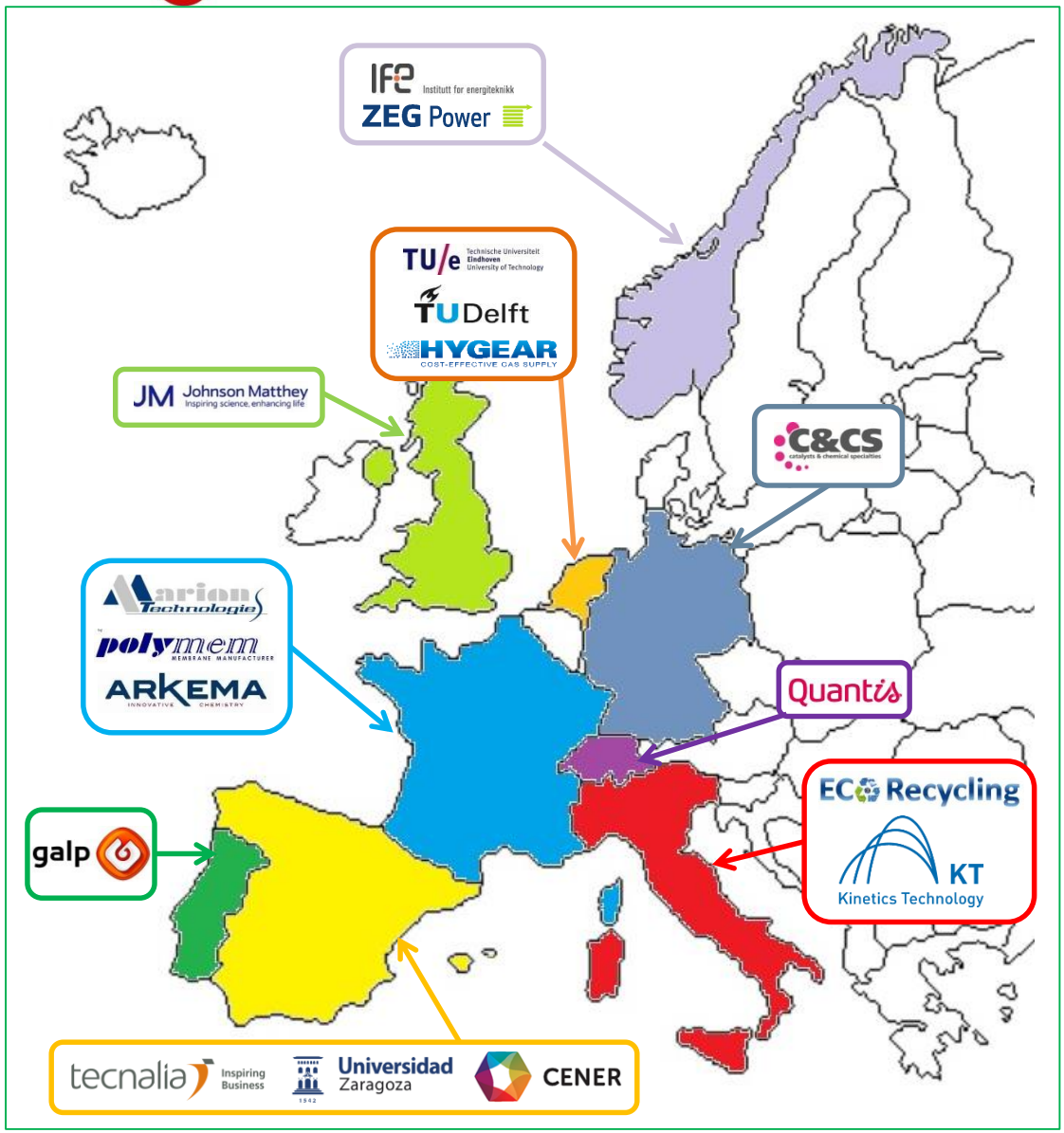
Two different strategies will be developed and demonstrated at three different end users facilities to achieve CO_2 separation:

- A combination of Mixed Matrix Membranes (MMM) for pre- and post-combustion,
- A combination of metallic membranes and sorbents into an advanced Membrane Assisted Sorption Enhanced Reforming (MA-SER) process for pure H2 production with integrated CO2 capture

In both cases, a significant decrease of the total cost of CO_2 capture will be achieved. MEMBER targets CO_2 capture technologies that separate >90% CO_2 at a cost below 40€/ton for post combustion and below 30€/ton for pre-combustion and H_2 production.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

2. Partnership



- Multidisciplinary and complementary team.
- 17 partners from 9 countries.
- Industrial oriented (65%):
  11 SME/IND + 6 RTO/HES
- 7 SMEs (41%) & 4 IND (24%)

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

2. Partnership

1 TECNALIA, RTO, Spain
2 TUE, HES, Netherlands
3 TUDELFT, HES, Netherlands
4 IFE, RTO, Norway
5 UNIZAR, HES, Spain
6 CENER, RTO, Spain
7 MTEC, SME, France
8 C&CS, SME , Germany
9 POLYMEM, SME, France
10 HYGEAR, SME, Netherlands
11 ECOREC, SME, Italy
12 ZEG, SME, Norway
13 QUANTIS, SME, Switzerland
14 KT, IND, Italy
15 GALP, IND,Portugal
16 ARKEMA, IND, France
17 JM, IND, United Kingdom

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

2. Partnership: Consortium synergies

MEMBER gathers the entire value chain:

- Commercial actors in Materials development, processing and supply (JM for MOFs, ARKEMA for polymers, C&CS for catalysts and MTEC for Sorbents)
- one industrial partner focused on membrane manufacturing (POLYMEM),
- two engineering companies focused on system design and integration (HYGEAR and KT),
- 4 partners for the demonstration of the technologies (CENER and GALP for MMMs for pre-and post-combustion respectively and IFE-HYNOR H_2 Technology Center under the supervision of ZEG POWER for MA-SER concept),
- one SME focused on sustainability and recyclability of materials produced (ECORECYCLING)
- one SME for Life Cycle Assessment (QUANTIS).
- industrial partners supported by recognized research organizations experts in the fields of material development (IFE, TUDELFT and UNIZAR), membrane development (TECNALIA) and process engineering (TUe).

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives

The key objective of the MEMBER project is the **scale-up and manufacturing of advanced materials** and their demonstration at industrially relevant conditions (TRL6) in **novel membrane based technologies that outperform current technologies for pre- and post-combustion CO_2 capture in power plants as well as H_2 generation with integrated CO_2 capture and meet the targets of the European SET plan.**

Three different technological solutions involving advanced materials will be developed and demonstrated at three different end user's facilities:

- Advanced Mixed Matrix Membranes (MMMs) for pre- and post-combustion CO_2 capture in power plants (H_2/CO_2 & CO_2/N_2 respect.)
- A combination of metallic hydrogen membranes and CO_2 sorbent integrated into an advanced Membrane Assisted Sorption Enhanced Reforming (MA-SER) process for pure H_2 production with CO_2 capture.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives

- Prototype A, targeted for **pre-combustion capture in power plants** using MMMs at the 2MWth biomass gasifier of **CENER (Spain) aimed for BIO-CCS demonstration.**
- Prototype B targeted for **post-combustion capture in power plants** using MMM at the 8.8MW CHP facilities of **Agroger (GALP, Portugal).**
- Prototype C targeted for **pure hydrogen production with integrated CO_2 capture** using MA-SER at the **IFE-HyNor Hydrogen Technology Centre (Norway)** under the supervision of ZEG POWER.

Main operation conditions & performance targets for the MEMBER prototypes.

	Technology	CO_2 Capture [%]	Capture cost [€/ton]	Demo site
Pre-comb. Power (IGCC)	MMM	> 90	< 30	CENER
Post-comb. Power (Coal)	MMM	> 90	< 40	GALP
H_2 with integrated CO_2 capture	MA-SER	> 90	< 30	IFE-HYNOR

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives: Main Goals and S&T objectives

OBJ. 1: MARKET & BUSINESS OBJECTIVES

- To overcome CCS market barriers with an ambitious set of CCS solutions.
- To take European industrial companies (Materials manufacturers, engineering companies and end users) to a leading position in the CCS market, generating economic growth and job opportunities.

OBJ. 2: ECONOMIC OBJECTIVES

- Compliance with strict cost-effectiveness and performance targets:
  - Pre-combustion Mixed Matrix Membrane system for Power generation
  - Post-combustion Mixed Matrix Membrane system for Power generation
  - Mixed Matrix Membrane materials for MEMBER
  - MA_SER system for pure hydrogen production with integrated CO2 capture
  - MA_SER materials for MEMBER

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives: Main Goals and S&T objectives

OBJ. 3: TECHNICAL OBJECTIVES

- To take to manufacturing development stage (from MRL 4-5 to MRL 6) a portfolio of materials and membranes of MMM technology:
  - Process optimization on pilot production lines (Polymers and MOFs).
  - Scaling production lines for the fine-tuned core material: MOF > 1kg/batch;
  - Scaling up the production of hollow fibres MMMs to >10.000 hollow fibers / batch
  - Scale up the membrane module size to >10 m2
  - Manufacturing of MMM modules for the pre- and post-combustion CO2 capture in Power Plants
  - ……
- Move from MRL 4-5 to MRL 6 a portfolio of materials of MA-SER technology:
  - Scale up production for core material: Sorbents: 50-100 kg/day; catalyst: 50 kg/batch;
  - Scaling up the production of Pd-based H_2 membranes to 8 membranes / batch
  - Lifetime Analysis of MA-SER at TRL6
  - Demonstration of compliance with CCS codes and standards. Installations in experimental demo plants to support and provide additional information on product characterization from qualification testing.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives: Main Goals and S&T objectives

OBJ. 3: TECHNICAL OBJECTIVES

- Development of a software tool to simulate MEMBER components and CO_2 capture energy performance from the earliest design phases:
  - Module/reactor design and process simulation (at large scale) for full integration of the MMM systems for pre- and post-combustion, and for MA-SER for pure H_2 production with integrated CO_2 capture
  - Development of a model of the MA-SER reformer
  - Validation of the models through demonstration in relevant conditions (demo site)

OBJ. 4: DEMONSTRATION OBJECTIVES

- Demonstration of MEMBER systems and related business models in 3 representative demonstration sites across Europe, covering different sectors, membrane based technologies and CO_2 containing streams

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

3. Project Objectives: Main Goals and S&T objectives

OBJ. 5: ENVIRONMENTAL OBJECTIVES

- To quantify the environmental impacts of the proposed holistic solutions through life cycle assessment based on 3 case studies throughout Europe

OBJ. 6: SOCIAL OBJECTIVES

- Job creation and increase awareness and involvement within the whole social & industrial chain: plant owners, manufacturers, installers, authorities, students, CCS organizations, general public, etc.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

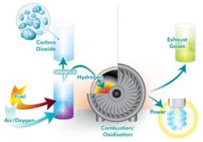
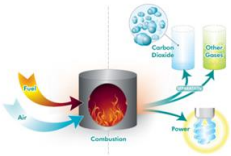
4. Overall approach and methodology

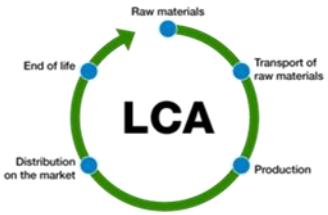
MMM

Material Production and Scale up

Prototype Manufacturing

Demonstration

Core Material	Processing &Scale Up	Process, Quality Control & Recyclability	Module / Reactor	CO_2 Capture System	Application
MOFs   **Polymers**	 **Mixed Matrix Hollow Fibers**	**Process Control:** • Homogeneity • Morphology • Permeation • … **Product Control & Recyclabilit** • Polymer • MOFs • Membranes  			 **Pre-Combustion**  **Post-Combustion**
Johnson Matthey, ARKEMA, TUDelft, Universidad Zaragoza	tecnalia, polymem	Johnson Matthey, ARKEMA, polymem, TUDelft, Universidad Zaragoza	polymem	HYGEAR, TUDelft	galp energia, CENER



Quantis

4. Overall approach and methodology

MA-SER

Material Production and Scale up

Core Material Manufacturing & Scale up

Sorbents

Membranes

Catalyst

Process, Quality Control & Recyclability

Process Control:

- Homogeneity
- Morphology
- Permeation
- …

Product Control & Recyclability

- Catalyst
- Sorbents
- Membranes

Prototype Manufacturing

Module / Reactor

CO_2 Capture System

Demonstration

Application

Hydrogen production with integrated CO_2 capture for industrial sectors

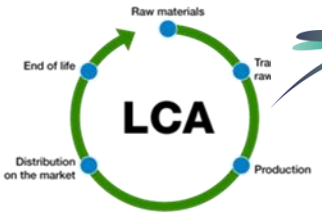
Marion Technologie
tecnalia
C&CS catalysts & chemical specialities
IFE

Marion Technologie
tecnalia
C&CS catalysts & chemical specialities
ECO Recycling

KT Kinetics Technology
TU/e

KT Kinetics Technology
TU/e
IFE

Hynor Lillestrøm
IFE
ZEG Power



Quantis

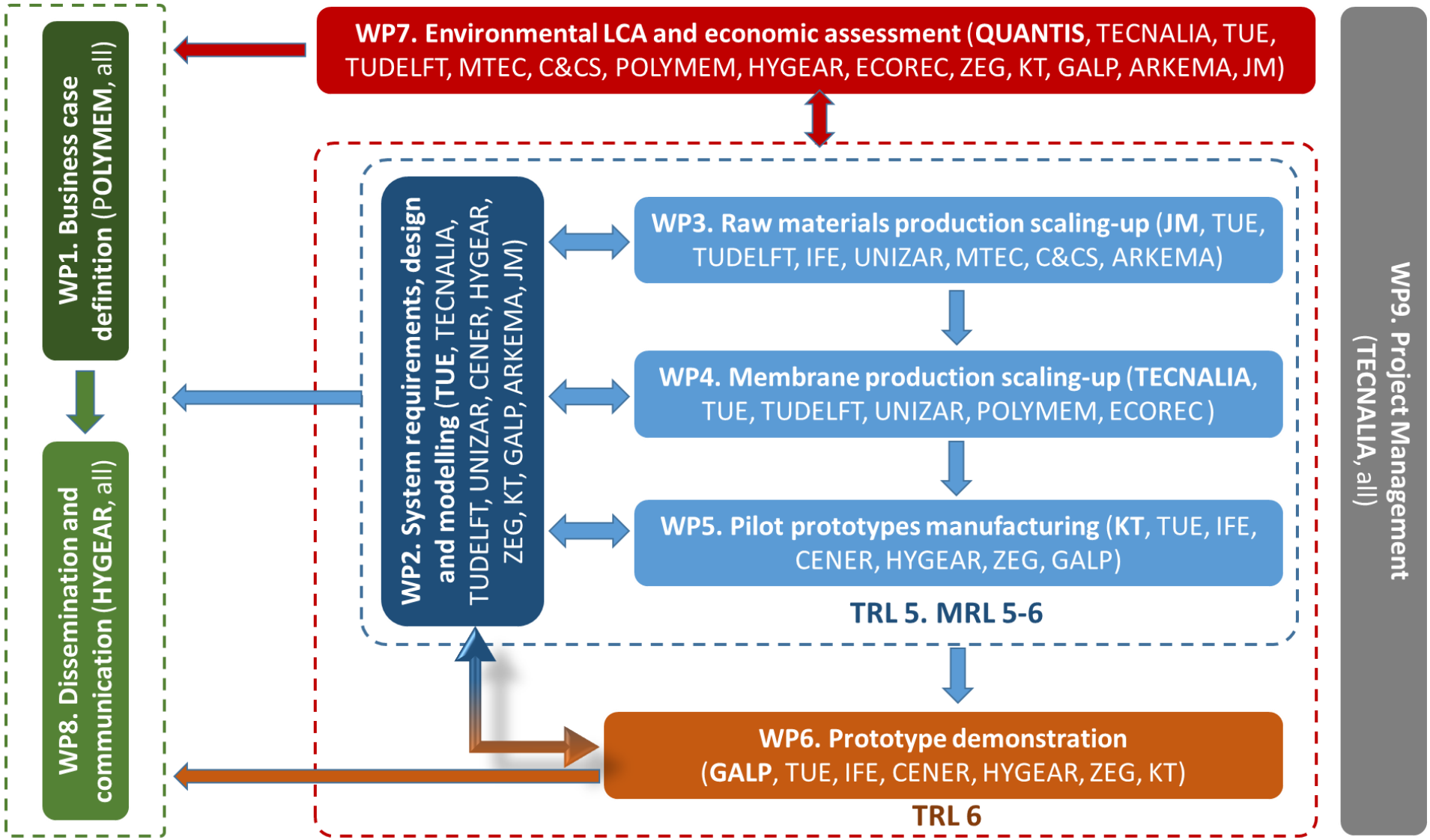
4. Overall approach and methodology

The technical content of the project is divided on different work packages representing key developments in the chain of value.

WP No	Work Package Title	Lead Part. Name
1	Business case definition	POLYMEM
2	System requirements, design and modelling	TUE
3	Core materials production scaling-up	JM
4	Membrane production scaling-up	TECNALIA
5	Pilot prototypes design, construction & testing	KT
6	Prototype demonstration	GALP
7	Environmental LCA and economic assessment	QUANTIS
8	Dissemination and communication	HYGEAR
9	Project Management	TECNALIA
10	Ethics requirements	TECNALIA

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

4. Overall approach and methodology



(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

4. Overall approach and methodology

- **WP1: Business case definition,** will set the foundation for effective development and exploitation of results into the market.
- **WP2: System requirements, design and modelling,** will define a coherent set of specifications for the membrane based CO_2 capture systems as well as defining the requirements of the different materials and their scale up.
- **WP3 Core materials production scaling-up**, will scale-up the production processes of the core materials required for the three CO_2 capture solutions.
- **WP4: Membrane production scaling-up,** will tackle the production of the membranes for the three CO_2 capture prototypes.
- **WP5: Pilot prototypes design, construction & testing,** all the different materials (membranes, sorbents and catalyst) and balance of plant components will be integrated into the prototypes constructed for demonstrating and validating the performance of the materials and associated processes.
- **WP6: Prototype demonstration,** will be focused on the demonstration at TRL 6 of the three CO_2 capture systems developed in MEMBER, each of them being located at different relevant demonstration sites.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

4. Overall approach and methodology

- **WP7: Environmental LCA and economic assessment,** LCA, LCC and techno-economic assessment will be performed, in order to prove the viability of the developed materials and technologies, and to give insights about the further use of the technologies.
- **WP8: Dissemination and communication,** runs throughout the whole project, feeding from the results of previous work packages, and providing support to exploitation of project results through highly focused communication and dissemination activities.
- **WP9: Project Management,** ensures an effective project management all along the execution of the work plan.
- **WP10: Ethics requirements,** will address ethical requirements including Environment, Health and Safety as required in H2020.

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

5. Expected results

#	Main exploitation product/ technologies/ others
1	MMM based system for pre-combustion CO_2 capture
2	MMM based system for post-combustion CO_2 capture
3	MA-SER system for pure H_2 production with integrated CO_2 capture
4	Advanced polymers for post-combustion MMMs
5	Advanced MOFs for pre- and post-combustion MMMs
6	Advanced MMMs for pre- and post-combustion
7	Advanced sorbents for MA-SER
8	Advanced catalysts for MA-SER
9	Advanced Pd-based H_2 membranes for MA-SER
10	Software tool for Membrane reactor and SER design. Membrane separation modules
11	Consulting services on LCA of CO_2 capture

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*

Thank you for your attention

https://member-co2.com/

Contact:
joseluis.viviente@tecnalia.com

Acknowledgement: For the CO2 molecule used in the logo:The original uploader was Frederic Marbach at French Wikipedia [GFDL (http://www.gnu.org/copyleft/fdl.html)

(*Disclosure or reproduction without prior permission of MEMBER is prohibited).*