HY2SEPS-2

Hybrid Membrane - Pressure Swing Adsorption (PSA) Hydrogen Purification Systems (Contract No 278538)

Theophilos Ioannides
FORTH/ICE-HT

New Energy World JU
fuel cells & hydrogen for sustainability

General Overview

Project full title: Hybrid Membrane - Pressure Swing Adsorption (PSA) Hydrogen Purification Systems

Duration: 01/11/2011 – 31/10/2013

Total Budget: 1,606,279.00 €

FCH contribution: 825,321.00 €

Partnership

FORTH (GR): Study of membrane materials

UPORTO (PT): Study of sorbents and PSA separation systems

PSE (UK)) Design and optimization of membrane separation systems

HYGEAR (NL): Construction and testing of hybrid separation system

CTI (FR): Design and manufacturing of ceramic supports and membranes

HY2SEPS-2 Summary

Main project goal

Design and testing of hybrid separation schemes that combine membrane and Pressure Swing Adsorption (PSA) technology for the purification of H_2 from a reformate stream that also contains CO_2, CO, CH_4, and N_2

Focus

Small systems operating at pressures < 10 atm

Approach

Membrane & adsorbent development, Process modeling & optimization, Pilot unit testing.

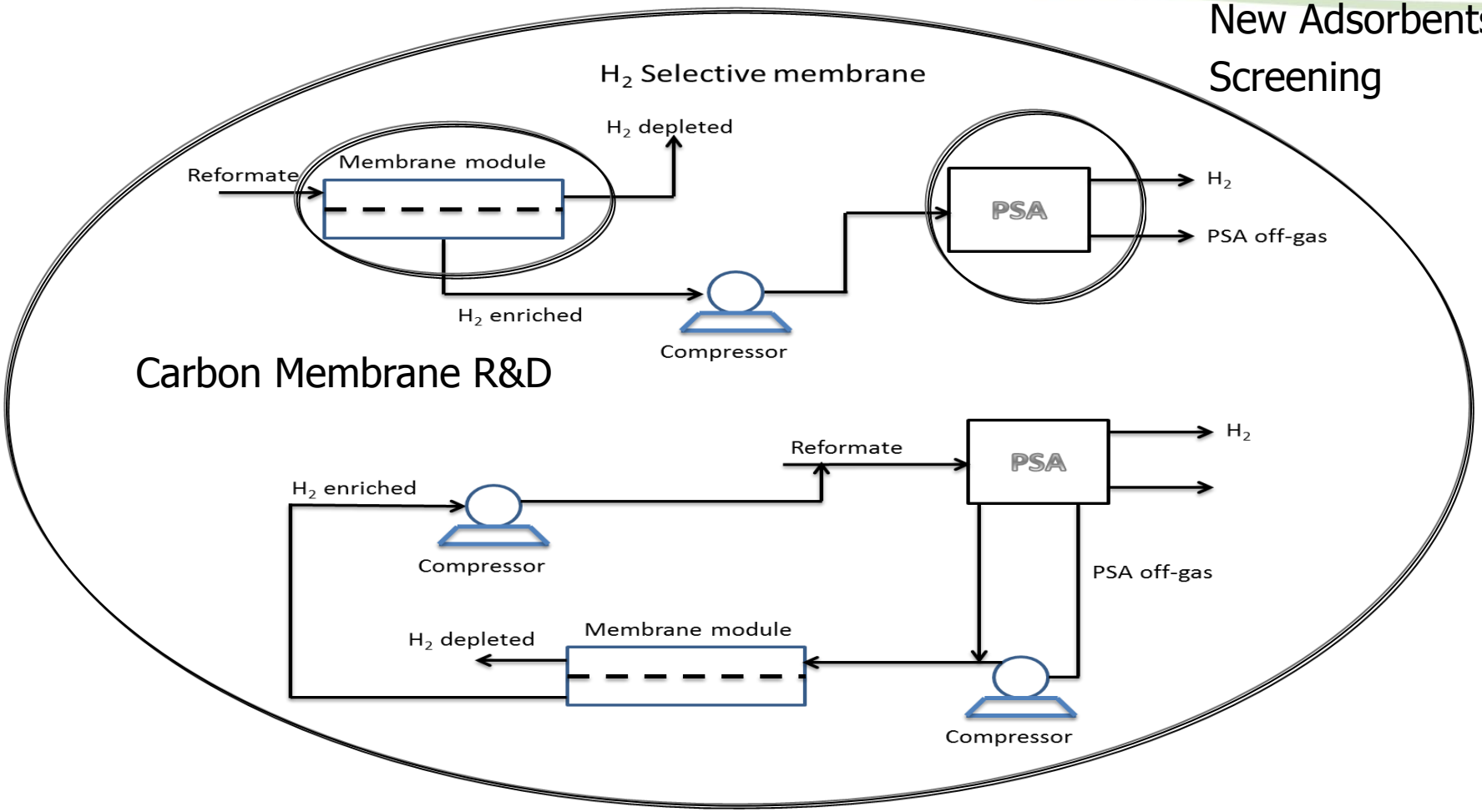
Expected Outcome

Hybrid process with lower operating cost and enhanced H_2 recovery compared to present situation.

HY2SEPS-2: Design alternatives

Process Modeling & Design

New Adsorbents Screening



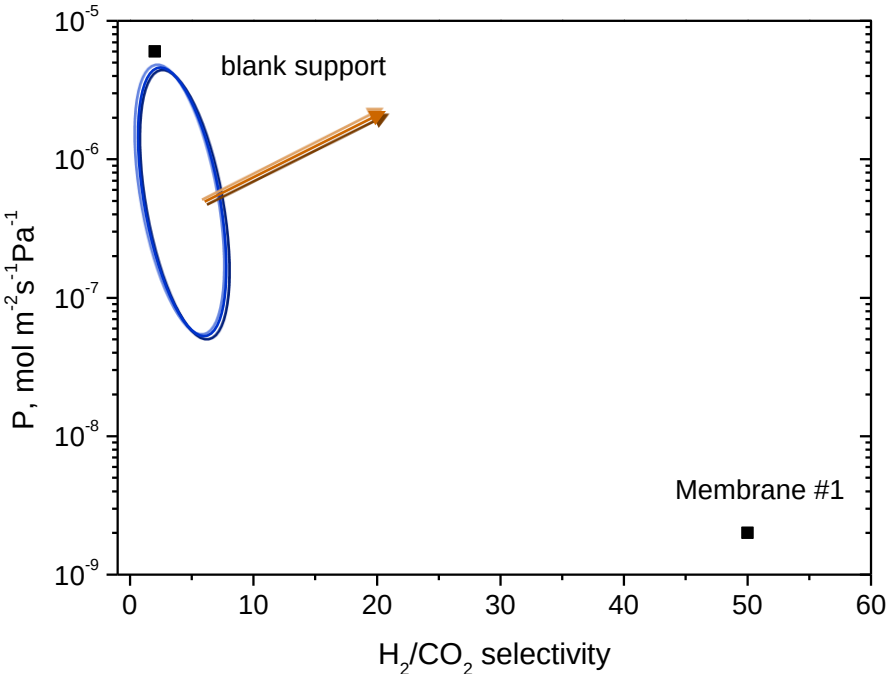
HY2SEPS-2: Membranes (1/2)

Carbon membrane development on ceramic supports

H_2/CH_4 & H_2/N_2 selectivity obtained through molecular sieving

Surface diffusion of CO_2 lowers H_2/CO_2 selectivity

Focus: reduce the number of preparation steps, tune CO_2 behavior



Deliverables

Results on carbon membranes synthesis - characterization and testing (M12)

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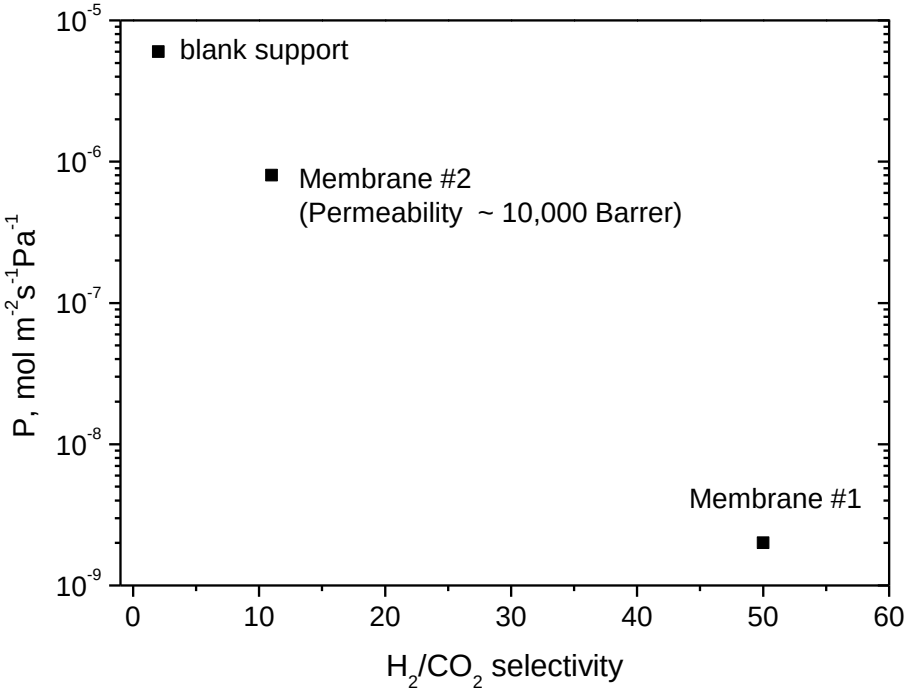


Deliverables

Results on carbon membranes synthesis - characterization and testing (M12)

HY2SEPS-2: Membranes (2/2)

Scale-up of carbon membrane synthesis and design of membrane module (M18)

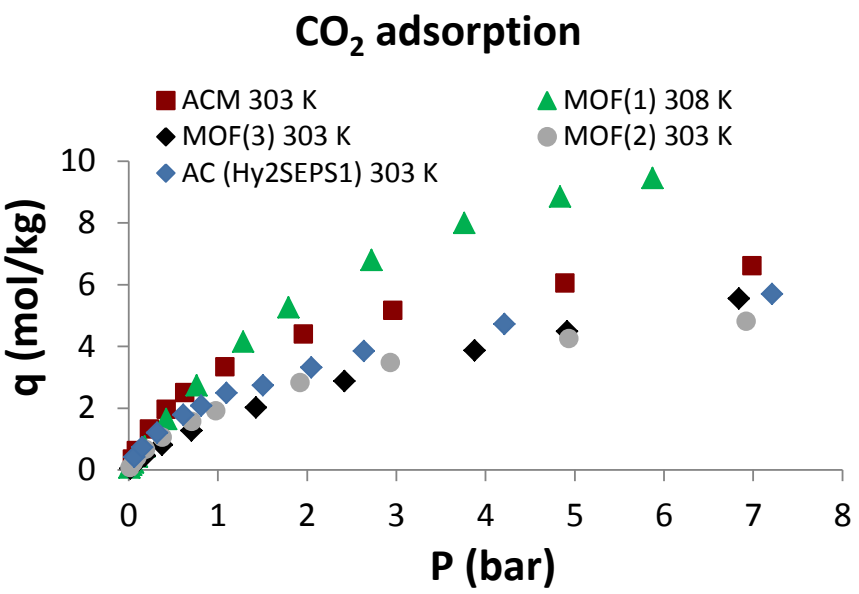
Initial development is carried out on single porous ceramic tubes with a characteristic porous layer ranging from 15 kD to 0.8 µm.

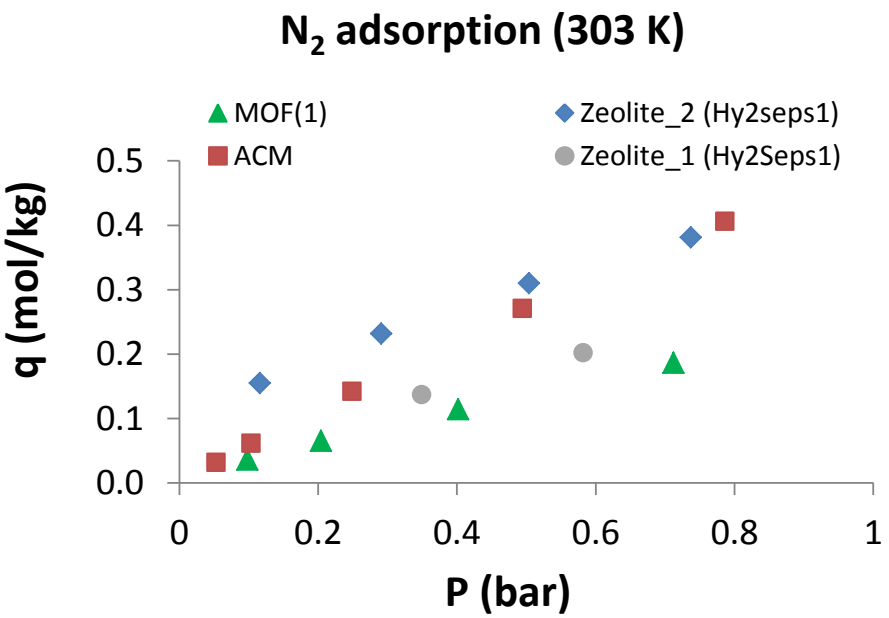
Next step: scaling-up to multi-channel tubes to improve surface/volume ratio.

Delivery date: end April 2013.

HY2SEPS-2: PSA adsorbents (1/2)

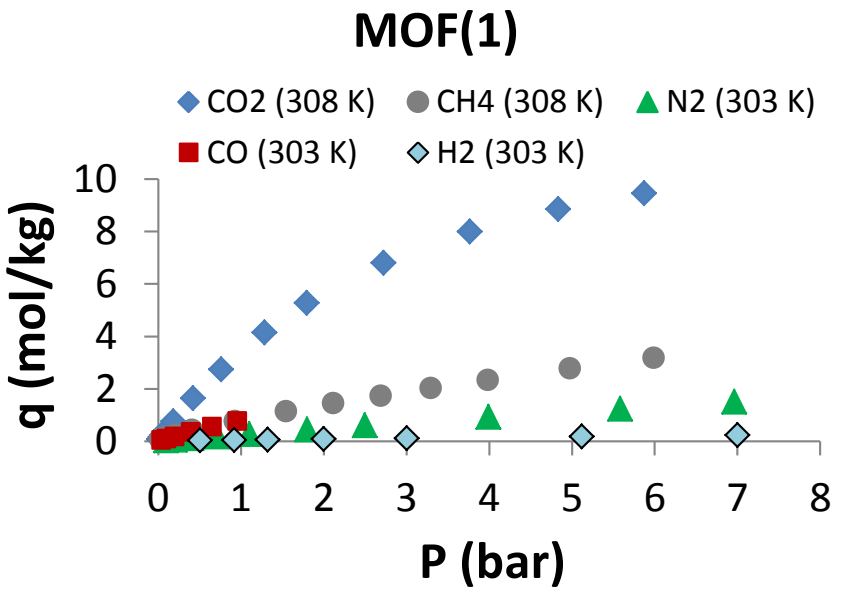
- **Milestone 3: Screening of new adsorbents**
  - MOF(1)
  - MOF(2)
  - MOF(3)
  - Activated carbon monolith (ACM)





HY2SEPS-2: PSA adsorbents (2/2)

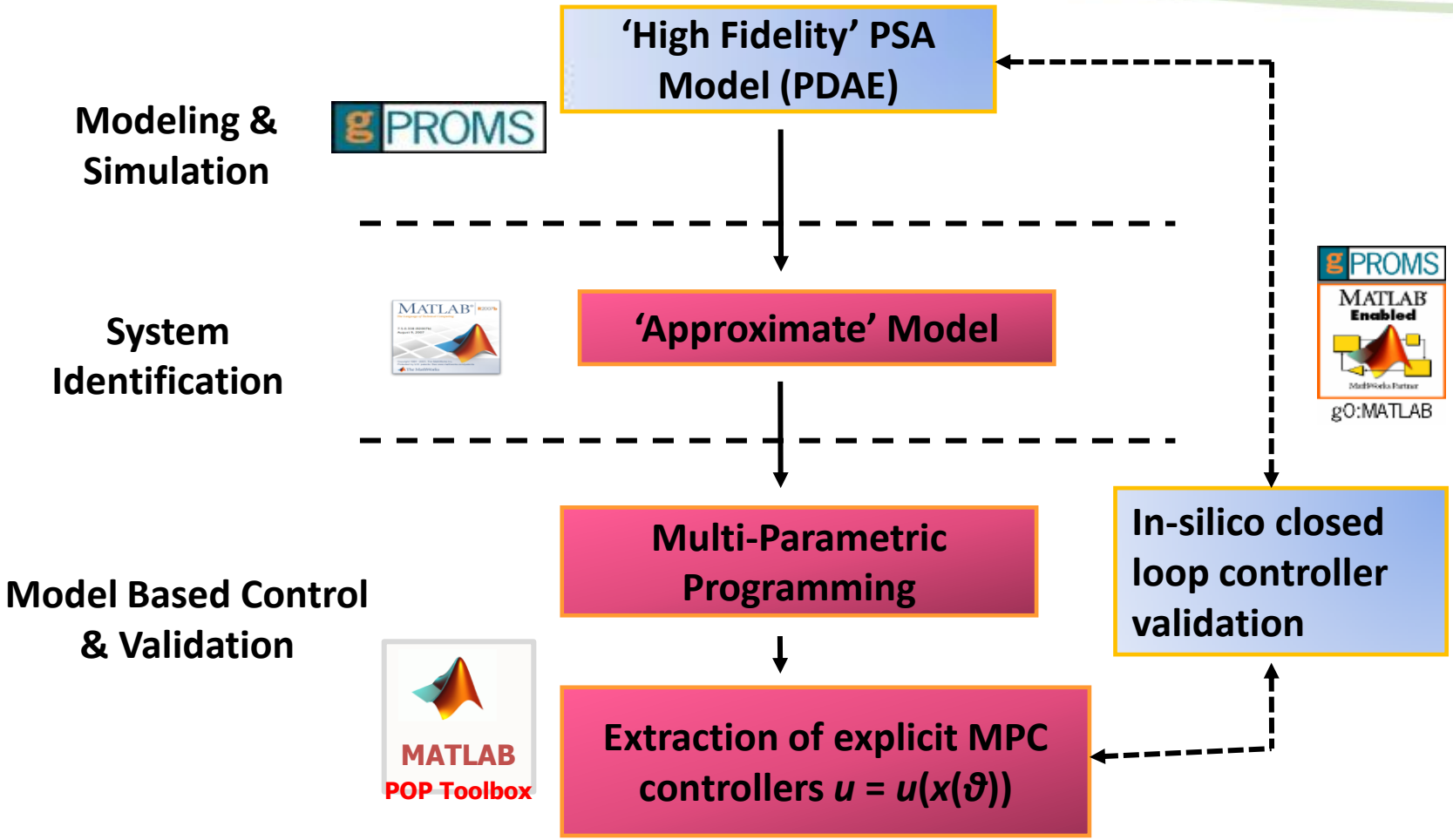
- **Milestone 3: Screening of new adsorbents**
  - Selected material: MOF(1)



MOF(1) has a higher CO_2 working capacity and a higher CO_2/H_2 selectivity than currently employed adsorbents (activated carbon)

HY2SEPS-2: Modeling

Model-based design of hybrid PSA-membrane separation systems



HY2SEPS-2: Outcome

Expected output AIP Topic: SP1-JTI-FCH.2010.2.3 Call: FCH-JU-2010-1		Objectives Project	Status at 50% of the project	Expected revised objectives
Hydrogen recovery improvement		*10%*	N/A	10%
Product gas quality		*99.999 % H_2 & 75 % CO_2*	N/A	*99.999 % H_2 & 75 % CO_2*
Energy consumption of H_2 cleanup (kWh/Nm^3 H_2)	*<0.004*	*<0.004*	N/A	<0.004

Alignment to MAIP / AIP

H – Hydrogen Production & Purification

H03 – Gas purification technologies: *Research and development on gas purification technologies for hydrogen production and quality monitoring in order to address short-term fuelling requirements based on conventional and alternative fuels like bio-fuels. Coordination with H02 is required.*

Several processes and feedstocks will be used to produce hydrogen either in centralised (large scale) plants providing economies of scale or ***distributed (small scale)*** *plants taking advantage of locally available primary energy sources and feedstocks with the benefit of generally improved sustainability and lower distribution infrastructure costs.*

Identify and comment on gaps/bottlenecks in RTD&D proposed by MAIP/AIP documents

No gaps or bottlenecks detected related to hybrid PSA

Training and Education

Foundation for Research & Technology-Hellas, University of Porto, PSE

Dissemination & public awareness

PSE Advanced Process Modeling Forum (16-18 April 2013). Audience: Senior engineers from process industry.

Euromembrane 2012, 23-27 September, London

Website: *hy2seps2.iceht.forth.gr*

- Technology Transfer / Collaborations

Collaboration with adsorbent producers at research or development scale

- Project Future Perspectives
    - Proposed future research approach and relevance
        - *A successful outcome can be readily exploited by participating SMEs*
        - *Collaboration for adaptation of technology to specific hydrogen production units*

Relevance to other projects

CoMetHy: Compact Multifuel-Energy to Hydrogen converter

Steam reforming in a membrane reactor for combined production-separation

NEMESIS2+: New Method for Superior Integrated Hydrogen Generation System 2+

Hydrogen production from diesel/biodiesel. Use of a PSA unit for hydrogen purification.

HyTIME: Low temperature hydrogen production from 2nd generation biomass

ReforCELL: Advanced multi-fuel Reformer for CHP-fuel CELL systems (membrane reformer)