Viability of ITM technology for oxygen production; material, system and process aspects

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Presented at the ICOM 2008, Hawaii (USA), July 2008 and

at the ICIM10, Tokyo, Japan, August 18-22, 2008

ECN-M--09-060 May 2009

ECN

Energy research Centre of the Netherlands

Viability of ITM technology for oxygen production
material, system, and process aspects

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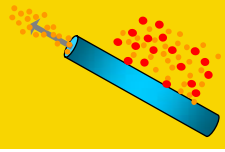
ECN's location



ECN's main features

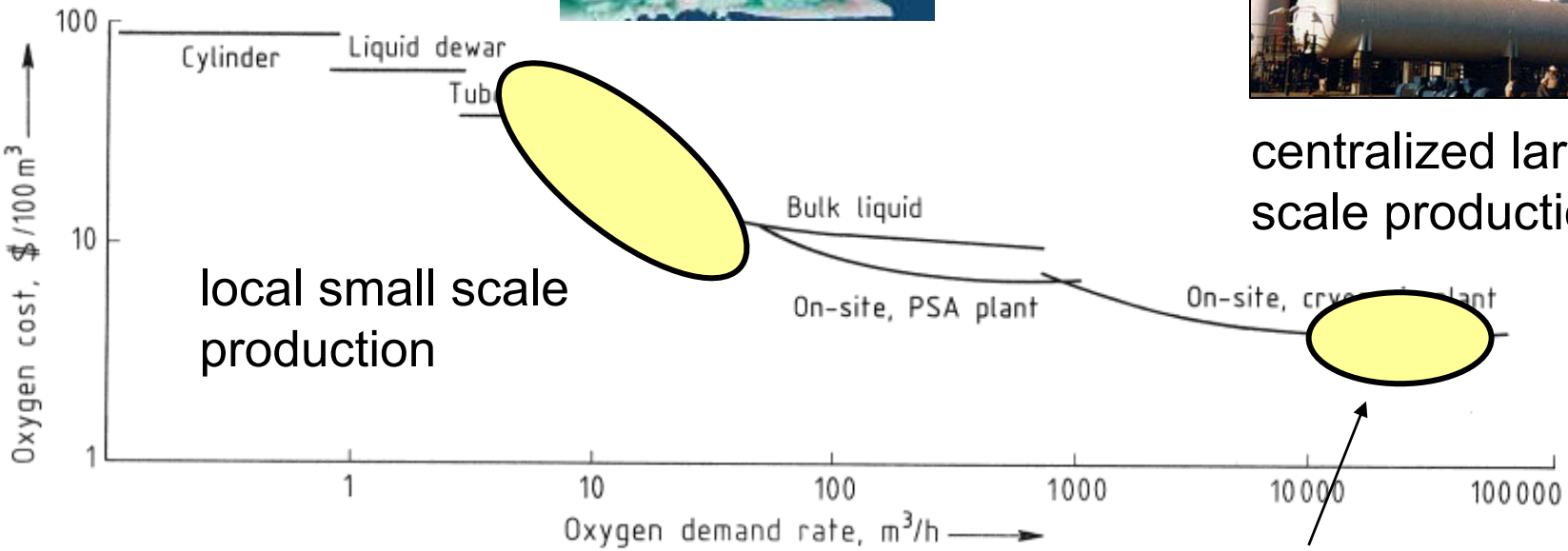
- ECN develops and implements high-level knowledge and technology for the transition to sustainable energy management.

- Annual turnover of 70 million euro
- Approx. 5-10 international patents granted each year
- Approx. 600 reports and publications each year

- (Inter)national co-operation with companies, universities and research institutes

Scales

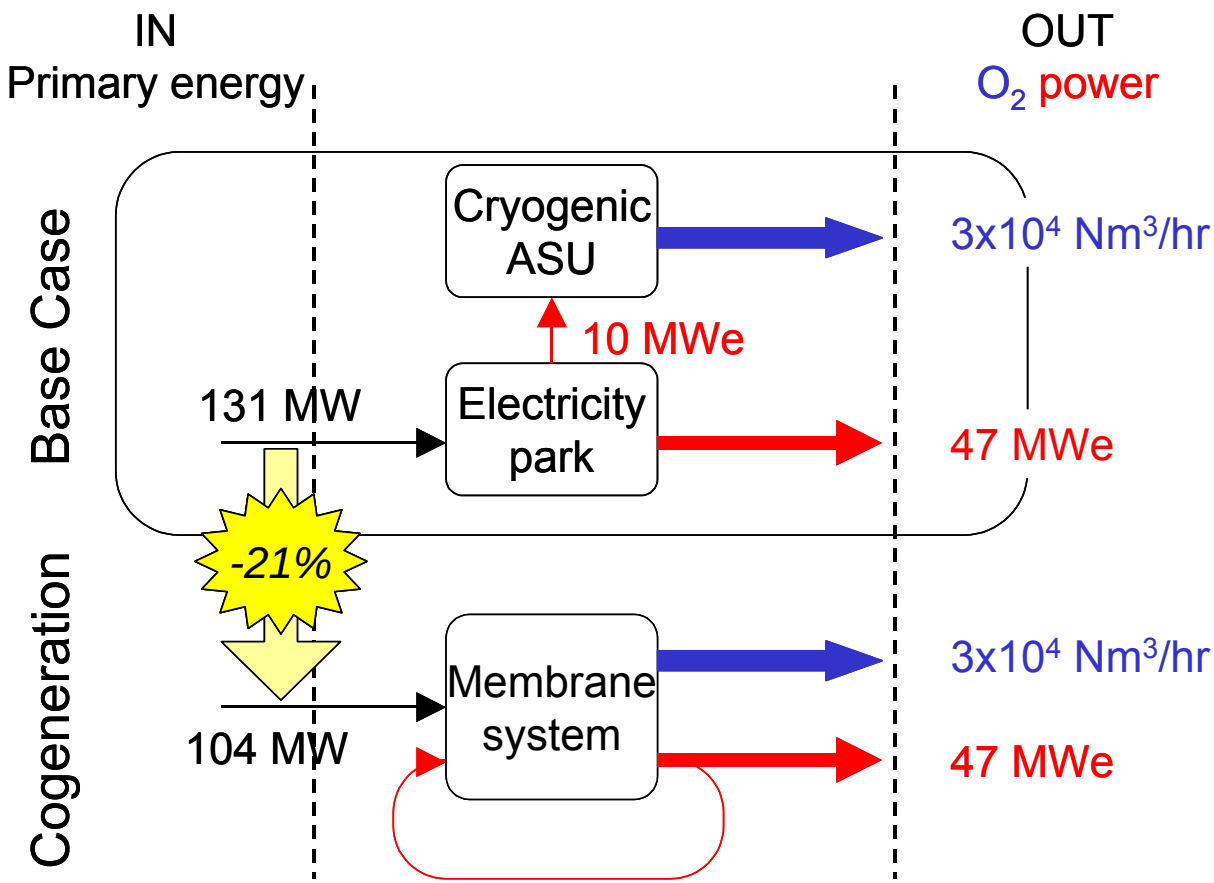
centralized large scale production



local small scale production

ECN emphasis

Energy savings: cryogenic distillation versus ITM

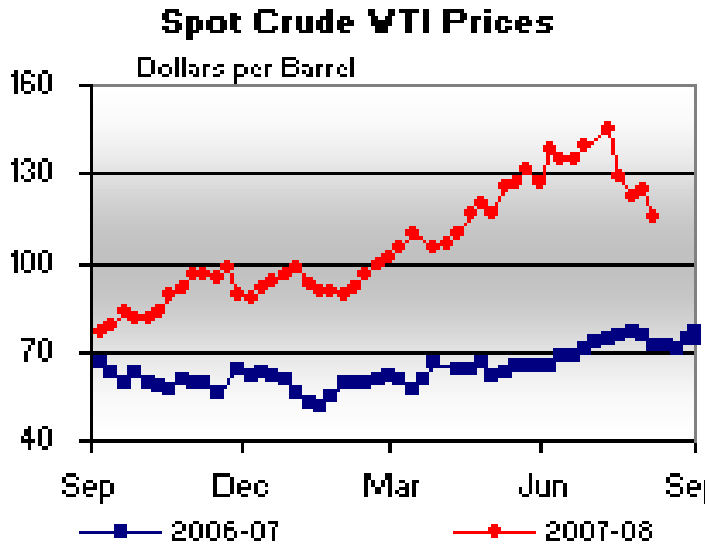


Reduction of energy use when combined with electric power production

Various aspects for economic viability

External Factors:

- CO_2 penalty
- Legislation
- Other technologies
- Energy (oil) price (now $115 / barrel)

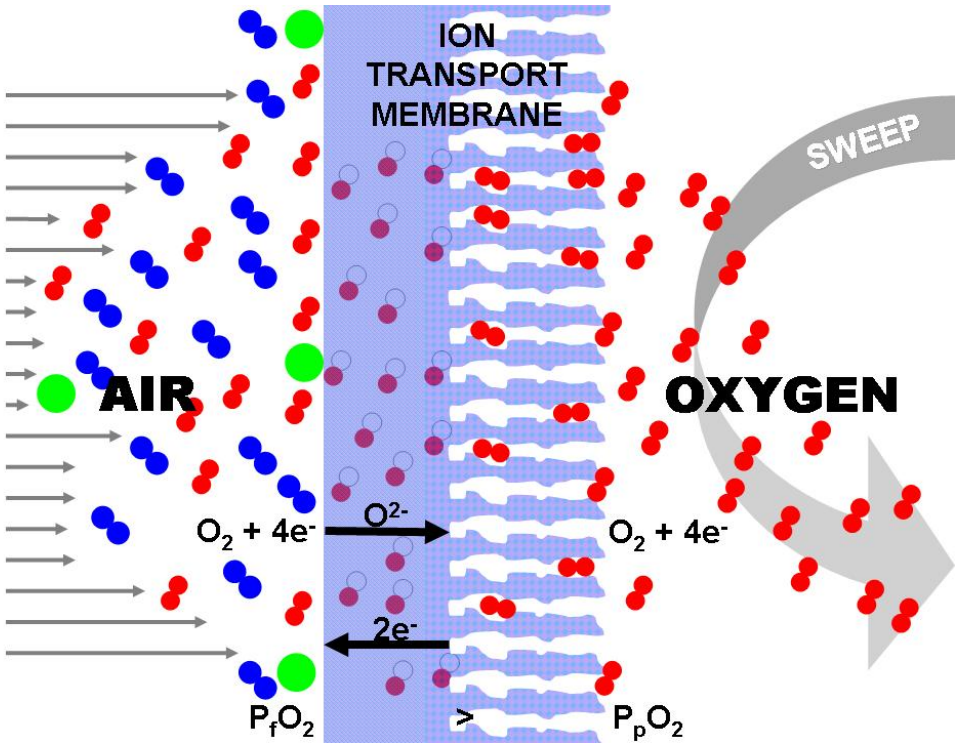


Source: tonto.eia.doe.gov/oog/info/twip/twip.asp

Technological Factors:

- Membrane configuration & module design
- Higher permeance → smaller membrane area; stability issues?
- Include heat intergration options
  - Partial oxidation
  - Iron ore reduction

Principle ion transport membranes



Characteristics

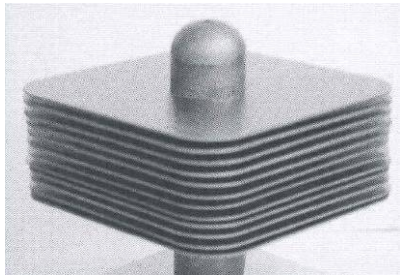
Intrinsically very high selectivity

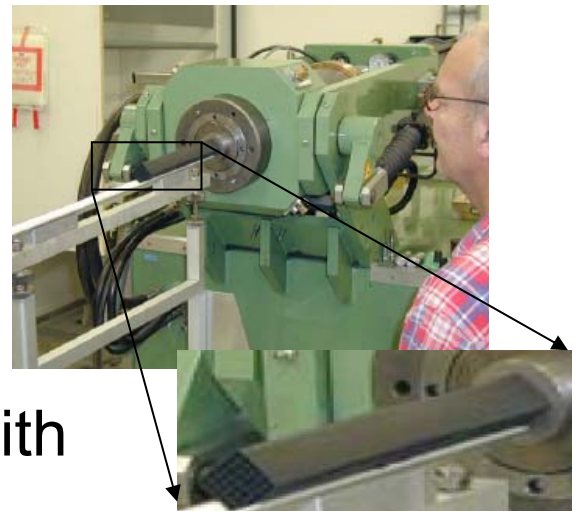
High application temperatures

Membrane geometries

-Tube-plates

(Air Products)





- Multi-channel monolith

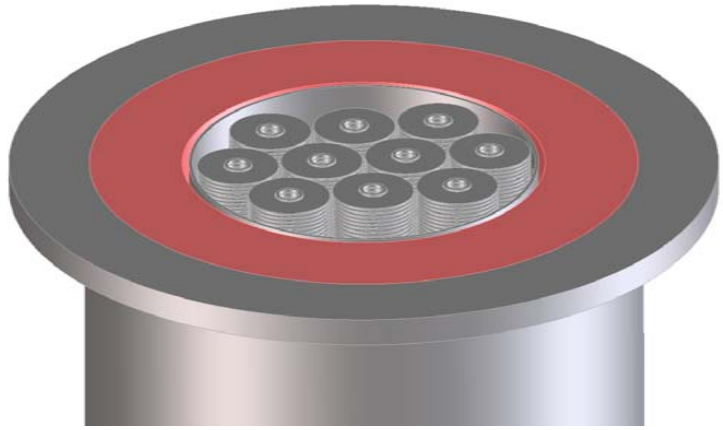
(Hydro Oil + Energy)

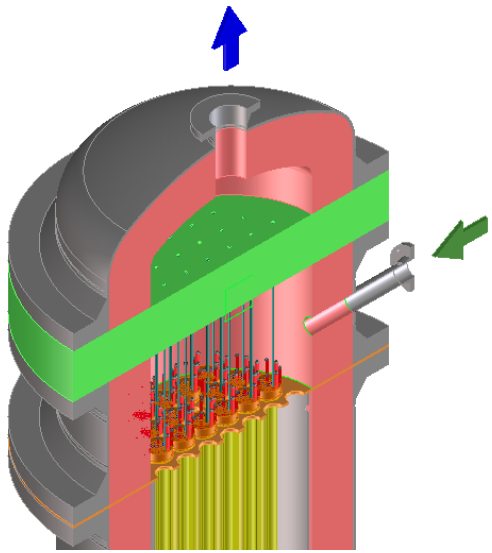
- Single hole tubes / hollow fibers

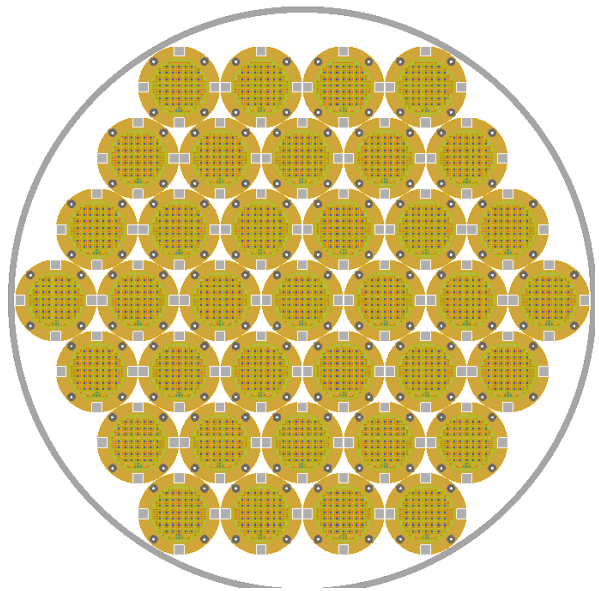
(Praxair)

Dimensional limitations

- Only part of the volume of the module can be used
- because of tubular arrangements
- space required for manifolding, heat insulation etc.



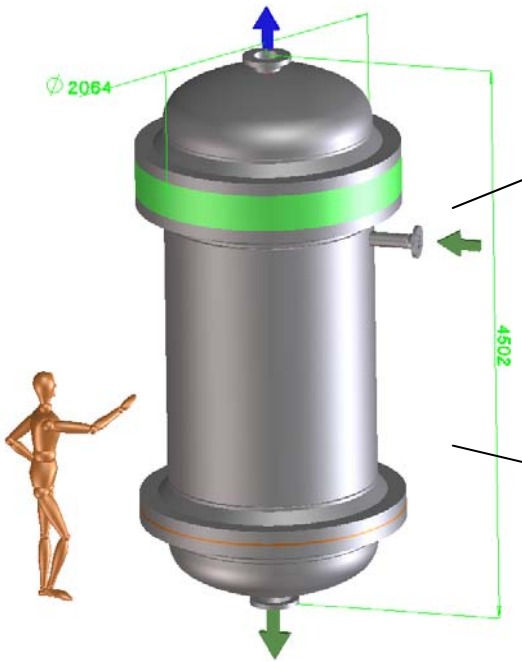


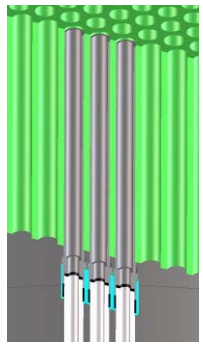


Specific surface area and number of modules

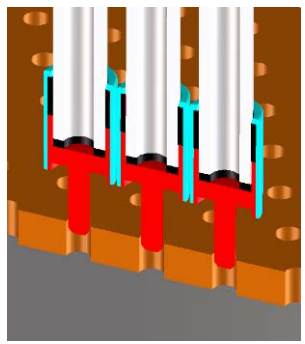
	single-hole tubes		multi-channel monolith		tube-and-plate	
$d_{support}$ (mm)	19	10	100	100	250	70
channels (mm)			2	5		
d_{plate} (mm)					950	240
A_{∞} (m^2/m^3)	81.9	90.7	543.7	232.4	74.0	273.1

Conceptual module design





pipe-plate



centre-plate

- 160 m^2 membrane area per module

compensation of expansion

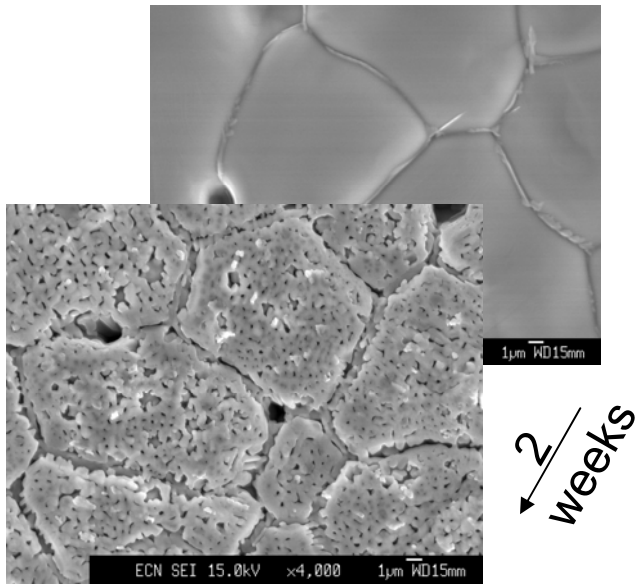
Materials uncertainties

- Creep resistance needs to be improved

- Kinetic phase stability

- Resistance to poisoning

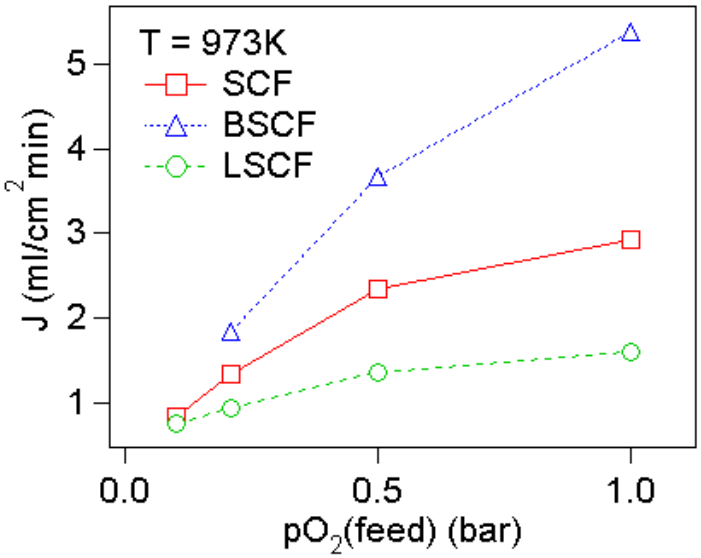
- Long-term performance/reliability

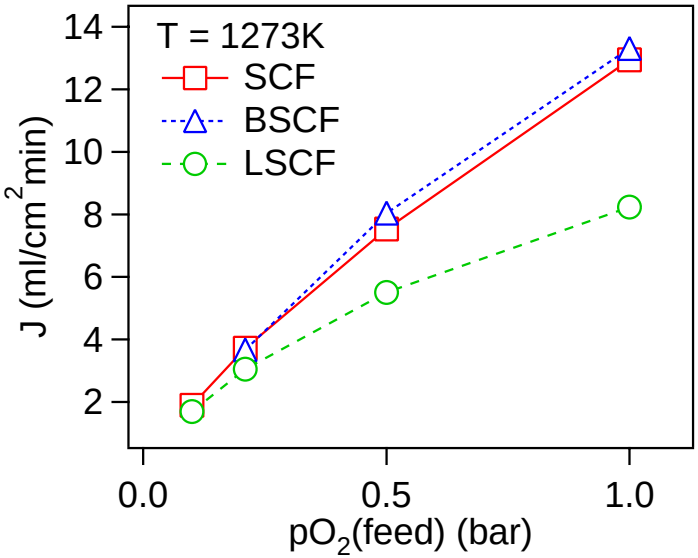


$Sr_{0.5}Ba_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$

→ **Comparative studies required to guide material selection**

Materials selection





(5x5 cm^2 plates, 200 μm thick)

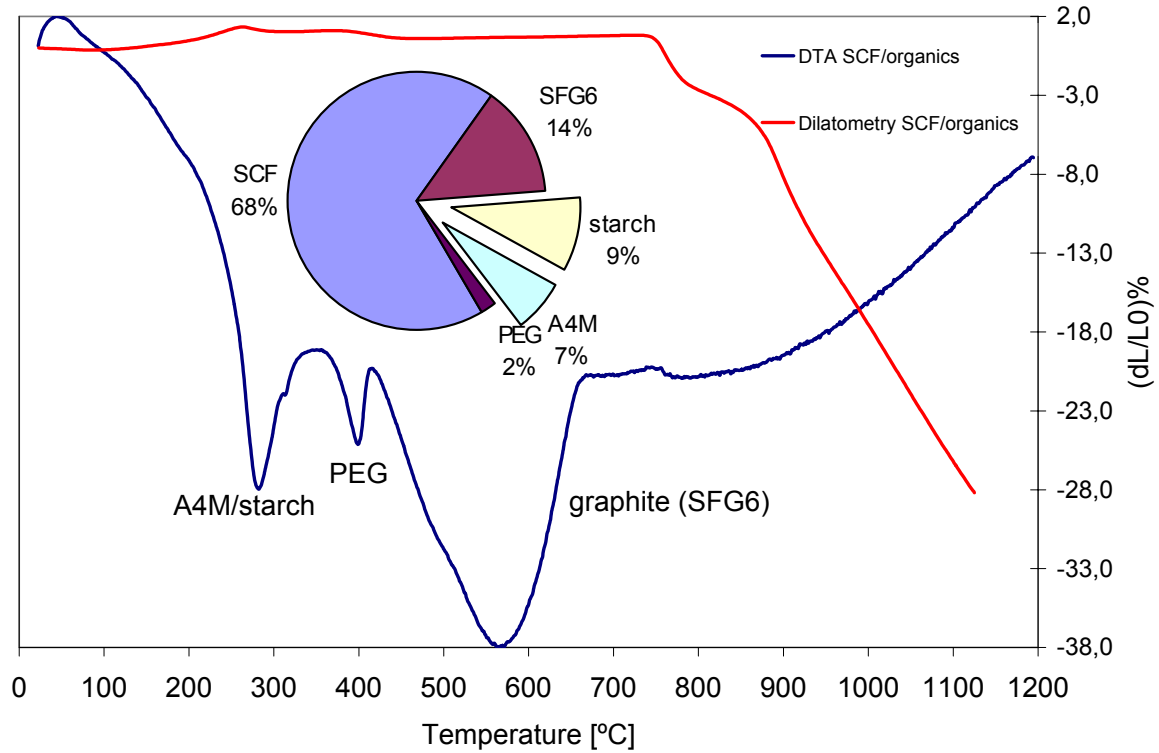
$SrCo_{0.8}Fe_{0.2}O_{3-\delta}$ (SCF) ☺

$Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF) ☺

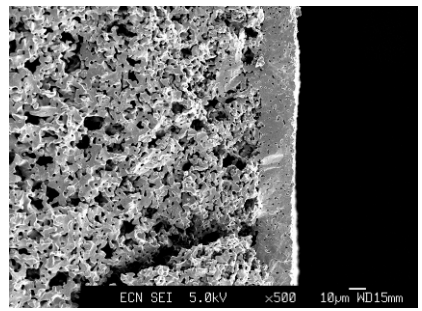
$La_{0.2}Sr_{0.8}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (LSCF) ☹

Membranes fabrication

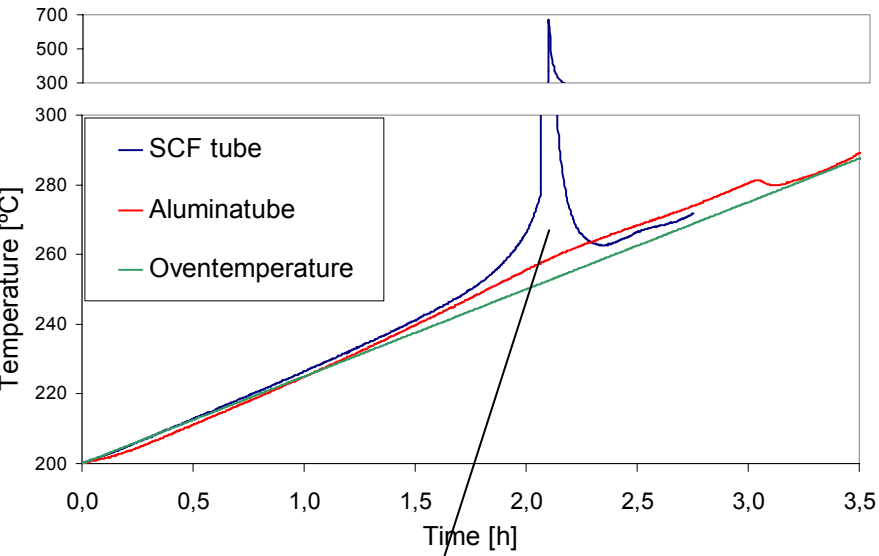
- Extrusion of porous tubes with pore-forming organics

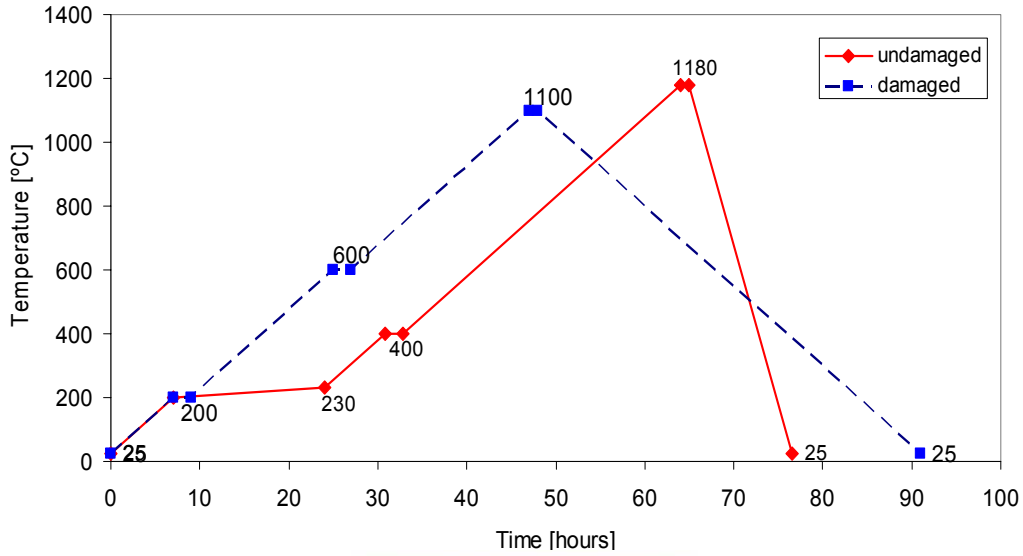


Filmcoating of a
20 μm dense toplayer

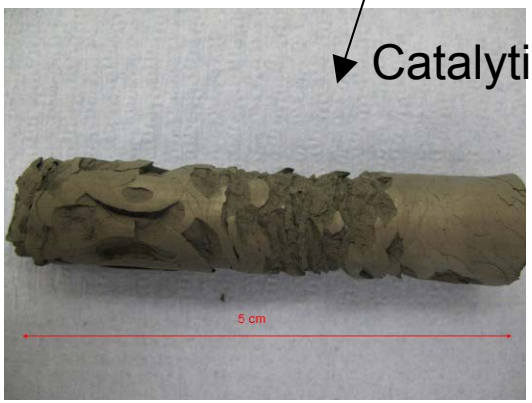


Issues with membrane fabrication

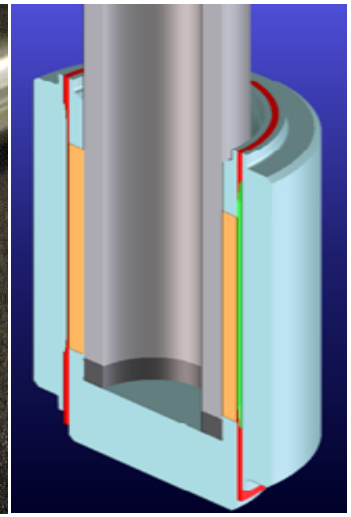


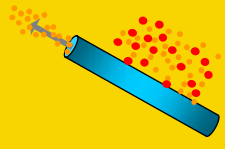


Catalytic burning



Membrane Seal assembly





Towards implementation

If economics are positive!

World wide consensus required on:

- materials selection
- module design
- sealing technology

Followed by orchestrated efforts on:

- creep
- stability
- manufacturing

Impact of twenty years of research is still too limited:
Sharing knowledge and experience is key and crucial

Acknowledgements

The MST group at ECN

Universities of Twente:
Henny Bouwmeester,
Steve McIntosh

Financial support:

SenterNovem
Agentschap voor duurzaamheid en innovatie

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Viability of ITM technology
Inorganic Membranes for Energy and Fuel Applications
Nov 2008, Bose, Arun C. (Ed.) ISBN: 978-0-387-34524-6