WHEC 2018
22nd World Hydrogen Energy Conference
June 17-22, 2018
Rio de Janeiro, Brazil
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Keynote C2K2

Lifetime assessment of novel membranes for water electrolysis technology providing grid services

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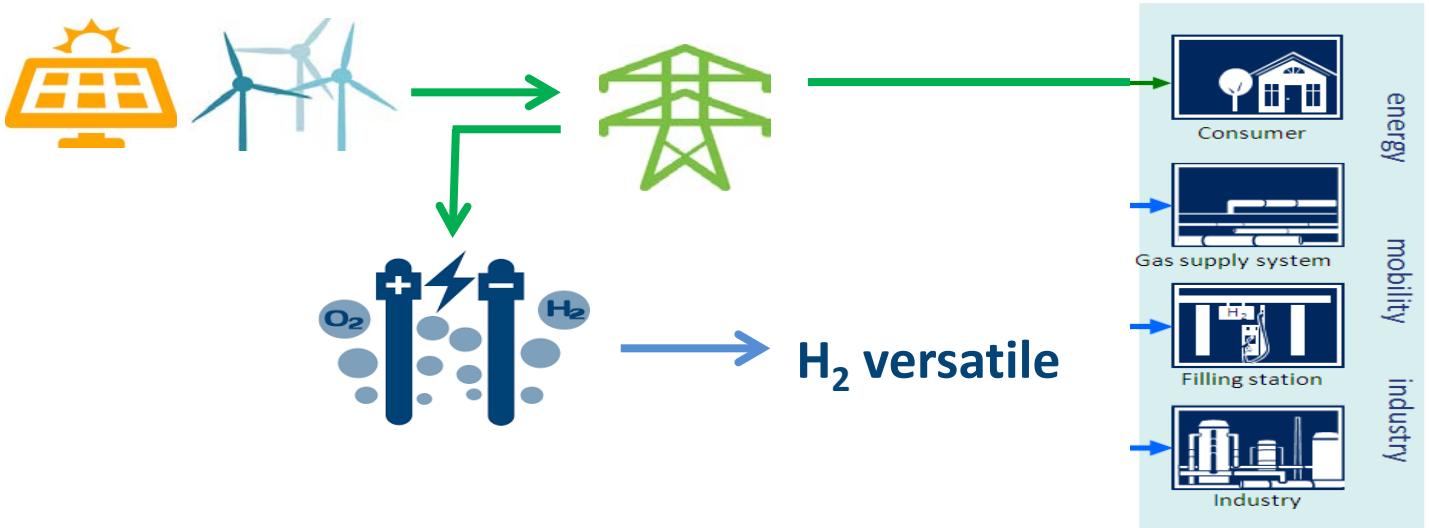
Water electrolysis technology

- Optimal use of renewable energy electricity (H_2 production from excess REs)
- To stabilize the electricity grid (additional revenue stream for green H_2)



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Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications

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Key challenges

- Performance (load flexibility)
- Cost competitiveness (low OPEX, electricity prices)

- ✓ Stack cell development (new materials and topology)
  - → Performance improvement in a broad range of electrolyzer load
- ✓ Balance of plant (BOP) optimization
  - → Analysis of the BOP components and streams decreasing system costs

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Objective

Lifetime assessment of **novel membranes**
for alkaline water electrolysers providing **grid services**

Test protocols for accelerated in situ degradation
of alkaline water electrolyser under dynamic operation conditions

Why do we need accelerated stress tests?

- Degradation as a slow process → investigation of long term durability = **€€€**
- New materials for cheap and efficient stacks (broad range of load)
  → unknown behaviour

→ **Fast** screening of these new materials by **low cost** method

Design of AST protocols

Stressors defined by operating conditions:

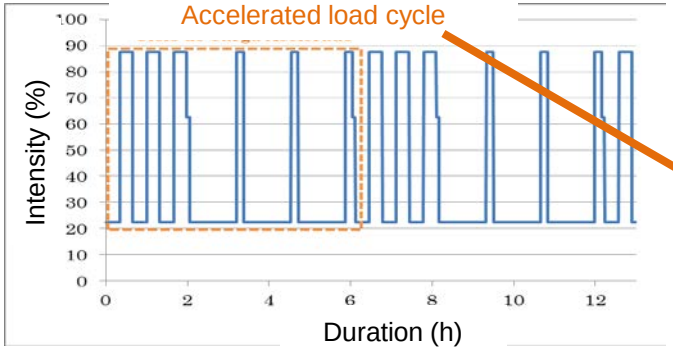
- Grid service
- Power of electrolyzer (minimum/maximum)
- Operating conditions (T, P, KOH flow, ...)

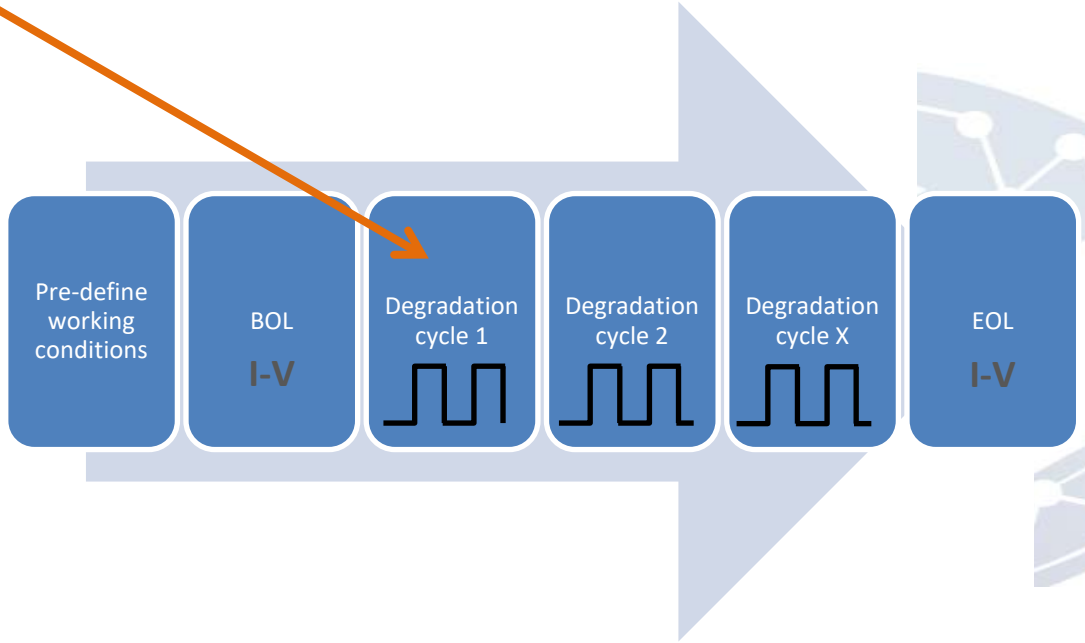
Service constraints:

- symmetrical or separated bids
- minimum bid size (5 MW)
- response time (2 mins)
- tender period (annual)
- times triggered per tender (several times per day)

Mapping Demand Response in Europe

Methodology: AST protocols





ATEX Pilot Scale Test Bench at FHA

- ✓ Up to 60 bar and 95 ºC
- ✓ Up to 25 KW and 3.5 Nm3/h
- ✓ Remote control

Advanced stack ELECTROLYSER (10 kW)

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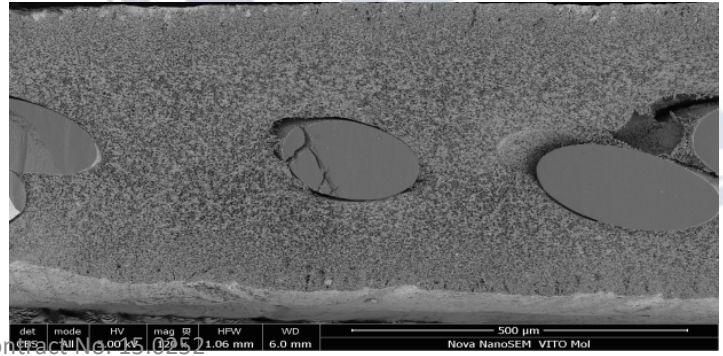
New separator membranes

- Highly porous, compressible separator **membrane**
  - low ionic resistance
  - gas tightness thanks to compression in the electrochemical cell

Separator in un-compressed form

Separator compressed in the cell to ~80% of its original thickness

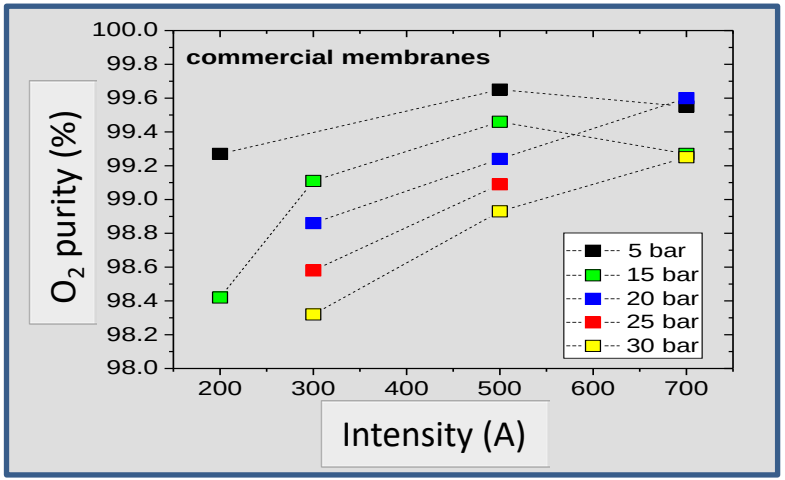
Cross-section of a compressible separator

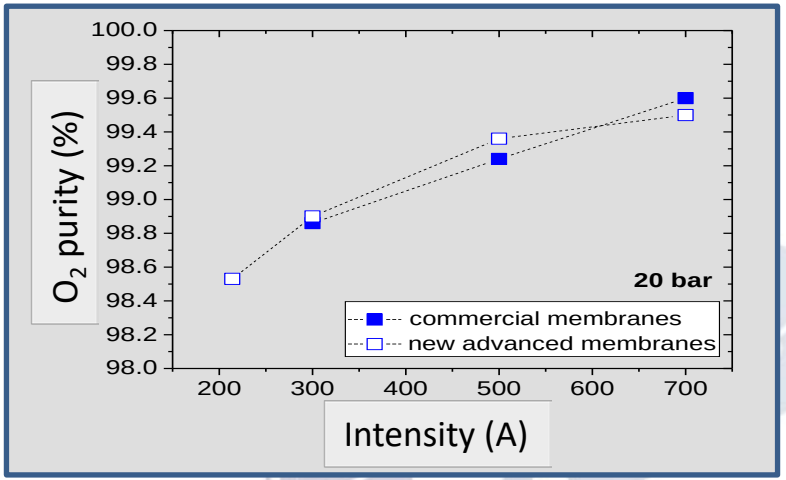


- Mixed matrix (organic-inorganic) composite membrane
- Textile reinforcement
- Pore template (60 nm primary grain size)

Advanced stack:
new separator membranes, 10 kW power

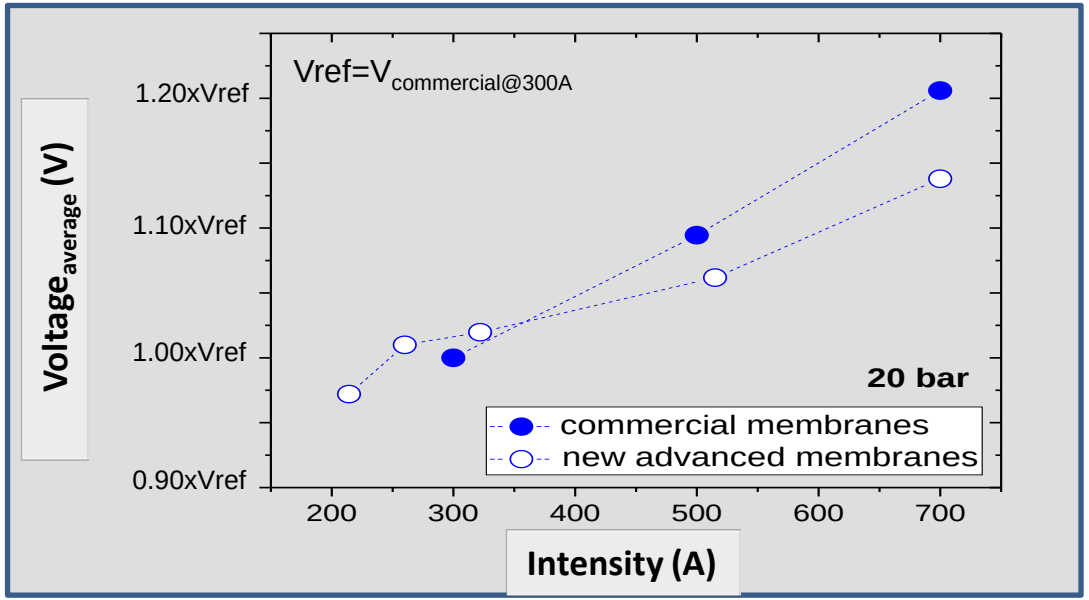
Results: stack characterization





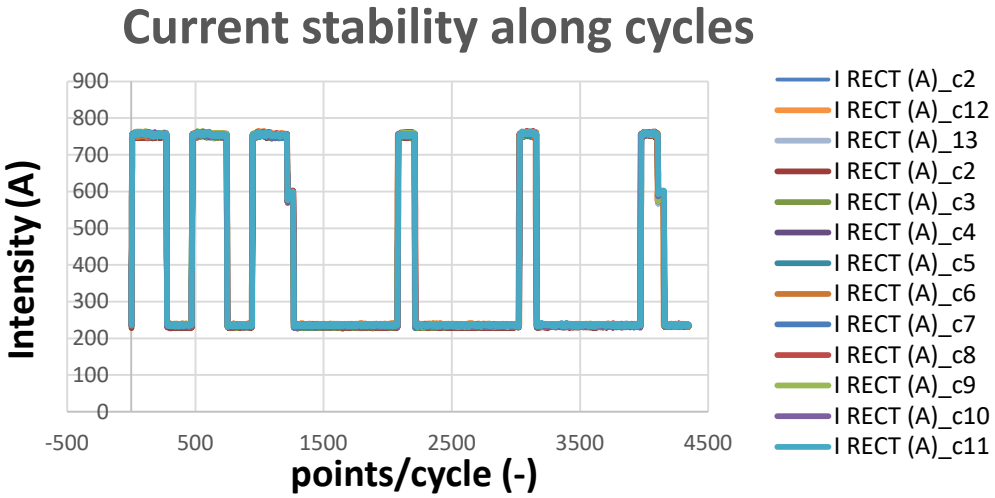
- **Gas purities OK (low/high partial loads)**

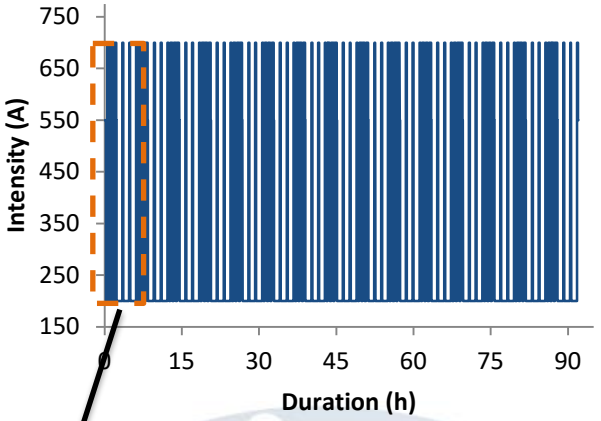
Results: stack characterization

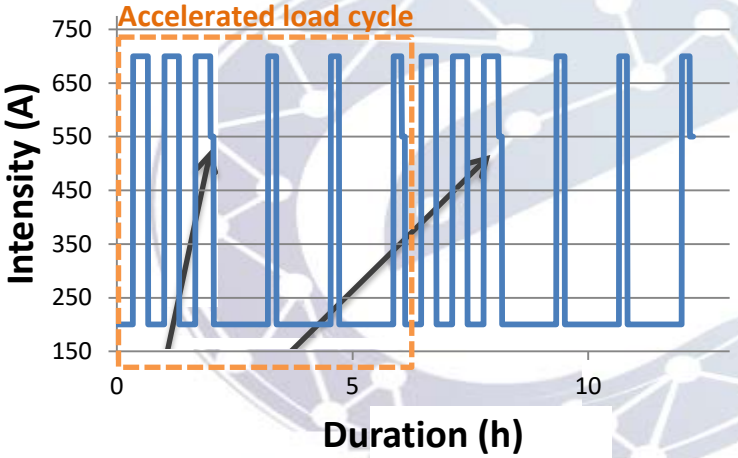


- **Low ionic resistance**

Results: ASTs

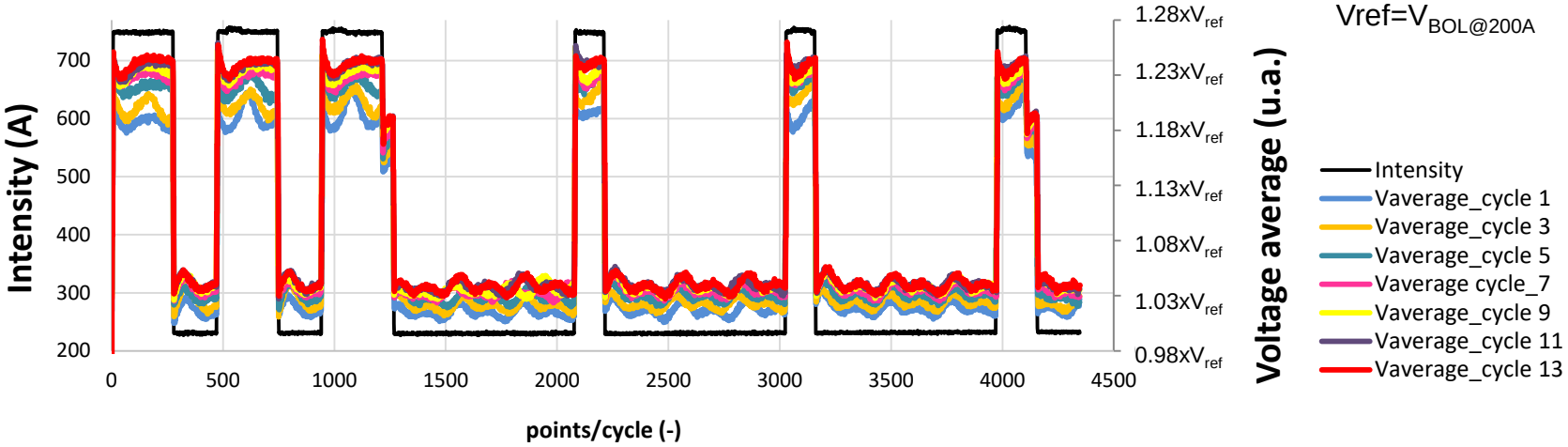






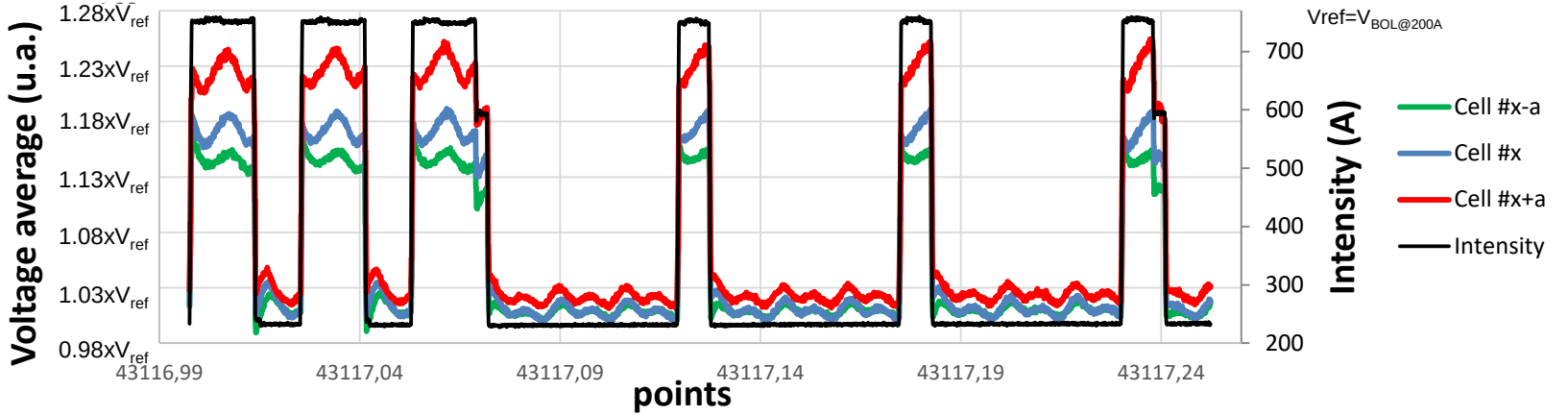
ASTs (high dynamic profiles)

Effect of ASTs cycles on the lifetime

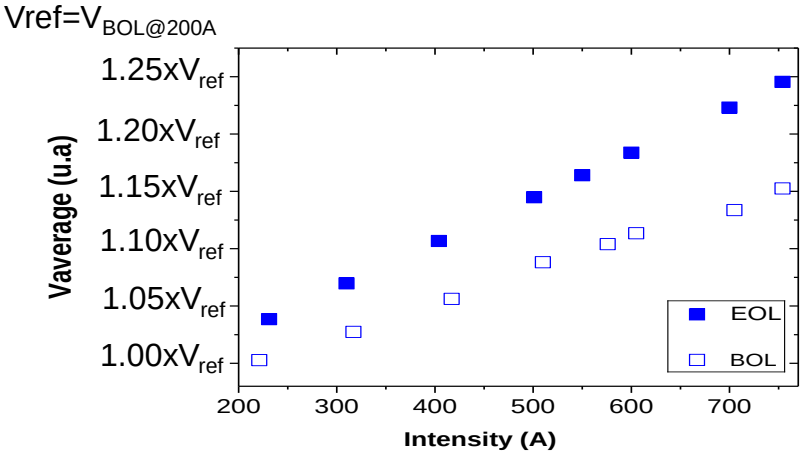


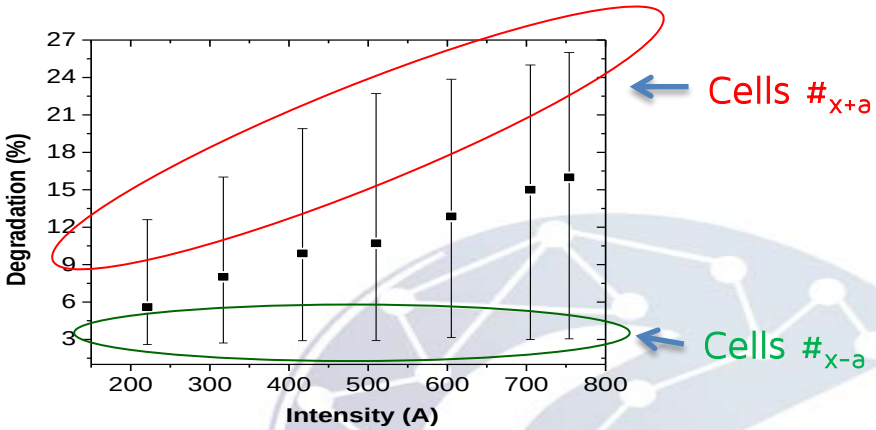
ASTs (high dynamic profiles)

Voltage trend as a function of #cell for a fixed cycle



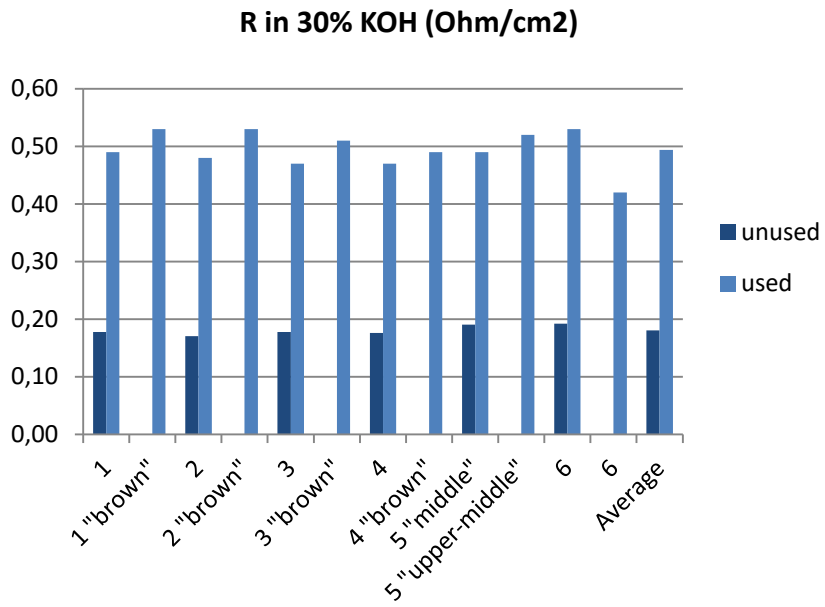
Durability (60 days under very high dynamic profiles)





- Alkaline water electrolyzer providing grid services:
  - release of power, 5MW
  - response time in 2 mins
  - several times per day

Post-ASTs characterization

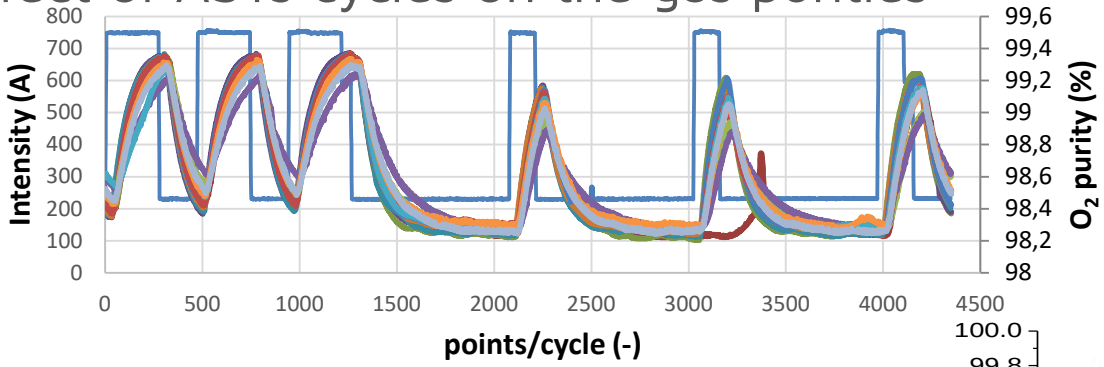


Overview of novel membranes after ASTs

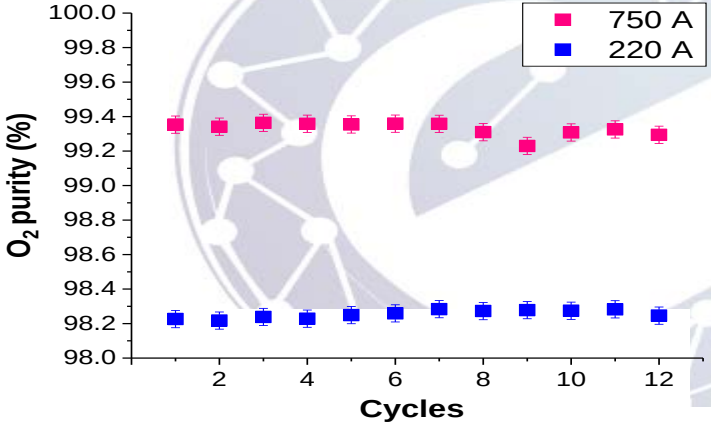
- **Ionic resistance increasing might be the reason for voltage increasing after ASTs?**

Durability (60 days under very high dynamic profiles)

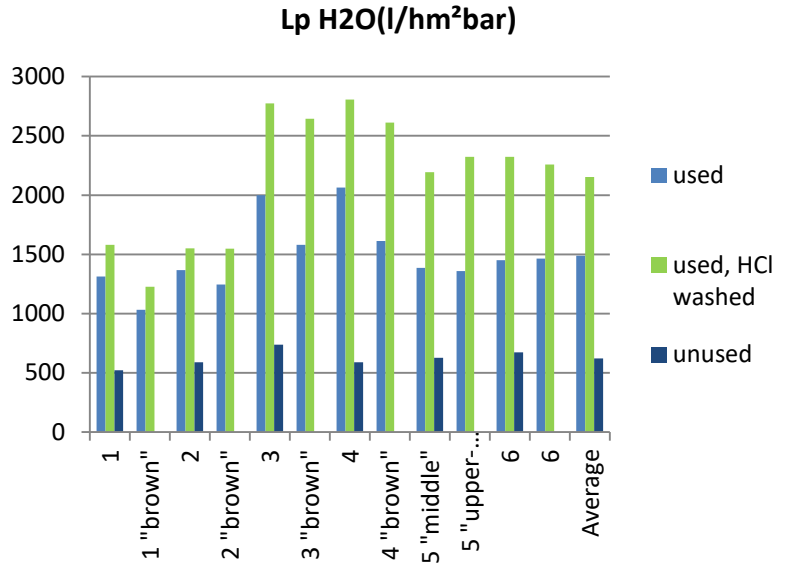
Effect of ASTs cycles on the gas purities

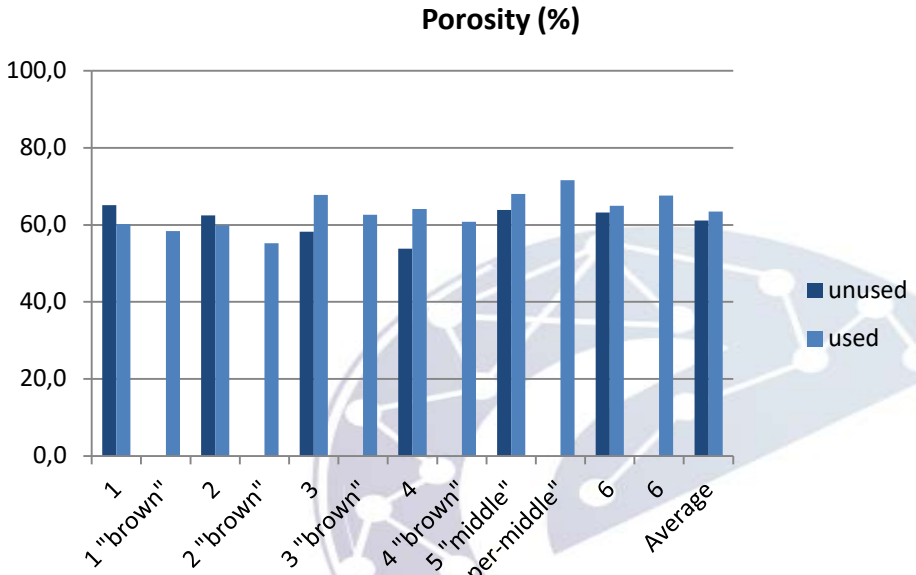


O_2 purity (%)	O_2 purity (%)	Intensity (A)
BOL	EOL	
98.32	**98.25**	220
99.63	**99.51**	750



Post-ASTs characterization





- **Gas purity stability might be explained by permeability increasing**
  →gas diffusion inhibited by lye flow

Post-ASTs characterization

New membrane	thickness (µm)	Lp (l/hm²bar)	MFP (µm)	BP (µm)	R (Ω.cm²)	Porosity %
unused	810	623.5	0.08	0.27	0.18	61.1
used	778	2153.5	#¡DIV/0!	#¡DIV/0!	0.49	63.4
used (% unused new membrane)	96%	345%	#¡DIV/0!	#¡DIV/0!	273%	104%
% change (unused vs used)	-4%	245%	#¡DIV/0!	#¡DIV/0!	173%	4%

Resistance increasing + Liquid permeability increasing → inorganic filler lost???

Other hypothesis kept opened → TGA and/or EDX to be done to conclude

Summary and Conclusions

- New compressible separator membrane developed:
  - gas cross-over reduction: HTO 13% lower than with commercial ones.
  - cell potential similar to commercial membranes.

- Accelerated durability tests: a tool to observe dynamic partial load effect on electrolyzer performance.

- During 60 days of dynamic operation:
  - Some cells present a sharp increase in the voltage degradation rate
  - Some cells the voltage degradation goes down to 3%.

- Gas cross-over contamination is not affected by the dynamic conditions. Gas purities at high and low current densities at 25 bar are constant after 60 days providing grid services (case of study: Finland).

Acknowledgement

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