"Next Generation PEM Electrolyser for Sustainable Hydrogen Production"

Contract no. 245262

Dr. Magnus S Thomassen
SINTEF Materials and Chemistry
Trondheim, Norway

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Objectives

NEXPEL main objectives:

Develop and demonstrate a PEM water electrolyser integrated with Renewable Energy Sources (RES):

75% Efficiency (LHV), H_2 production cost ~ €5,000 / Nm^3h^{-1}, target lifetime of 40,000 h

Jan 2010 - Dec 2012

Total Budget: € 3,353,549

www.nexpel.eu

Overview
NEXPEL consortium

New Materials Development (Electrocatalysts & Membranes)

Component development and testing

Stack and system design

System integration and testing with RES

University of Reading

fumatech
Funktionelle Membranen und Anlagentechnologie

Fraunhofer ISE

Statoil

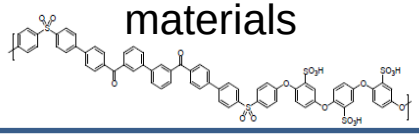
SINTEF

cea

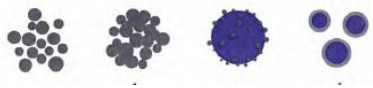
HELION
HYDROGEN POWER

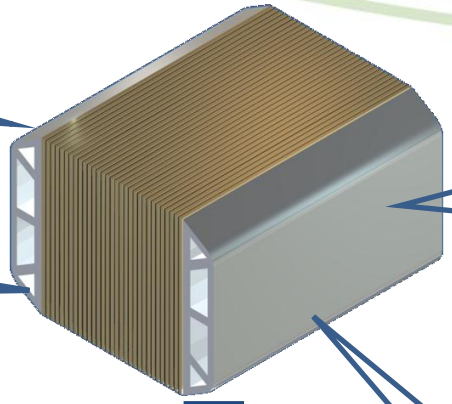
1. Project achievements
Approach

WP2 New membrane materials

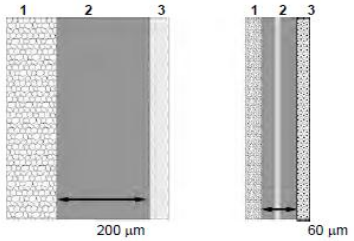


WP3 New catalysts

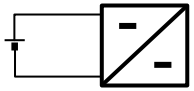




WP4 Improved MEAs

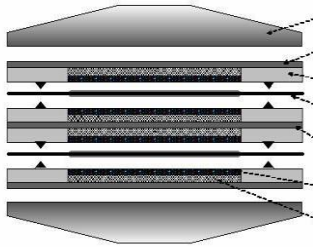


WP7 Improved DC-DC converter



WP7 Integration with RES

WP5&6 Novel stack design and new construction materials



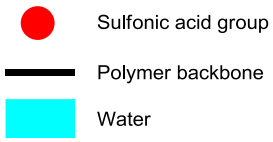
1. Project achievements
NEXPEL milestones

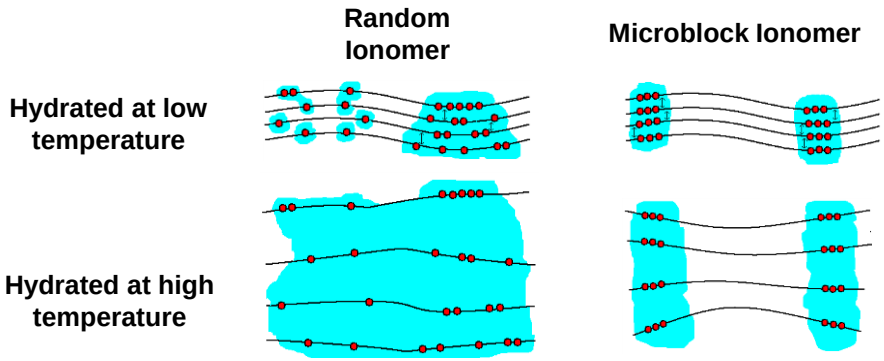
Month/Year	Milestone	Status
Mar-2010	Milestone 1: Kick-off meeting	**Achieved**
Dec-2010	Milestone 2: Key parameters for design and operation of NEXPEL stack determined.	**Achieved**
Aug-2011	Milestone 3: Novel MEA demonstrated using low cost membrane and reduced noble metal loadings	**Achieved**
Feb-2012	Milestone 4: PEM electrolysis short stack assembled and function tested	**Achieved**
Jun-2012	Milestones 5&6: PEM stack and DC/DC converter integrated in test site for demonstration with RES	**Partially achieved**

1. Project achievements
Technical progress

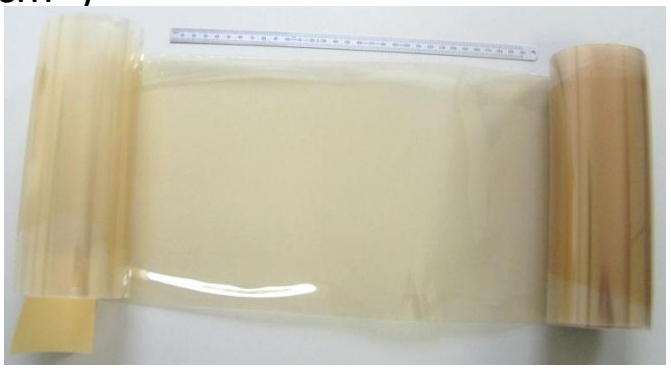
Novel membrane and catalyst materials

- Microblock polyaromatic ionomers
- Reduced swelling in water
- Lower gas crossover



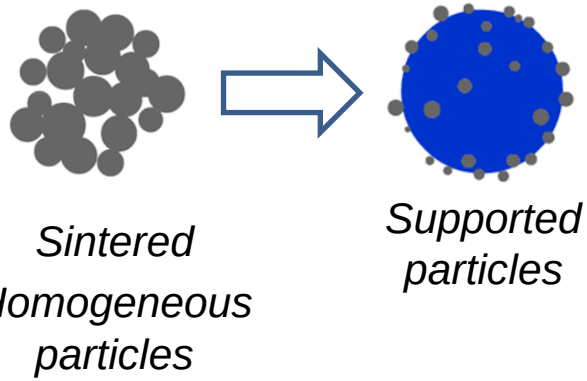


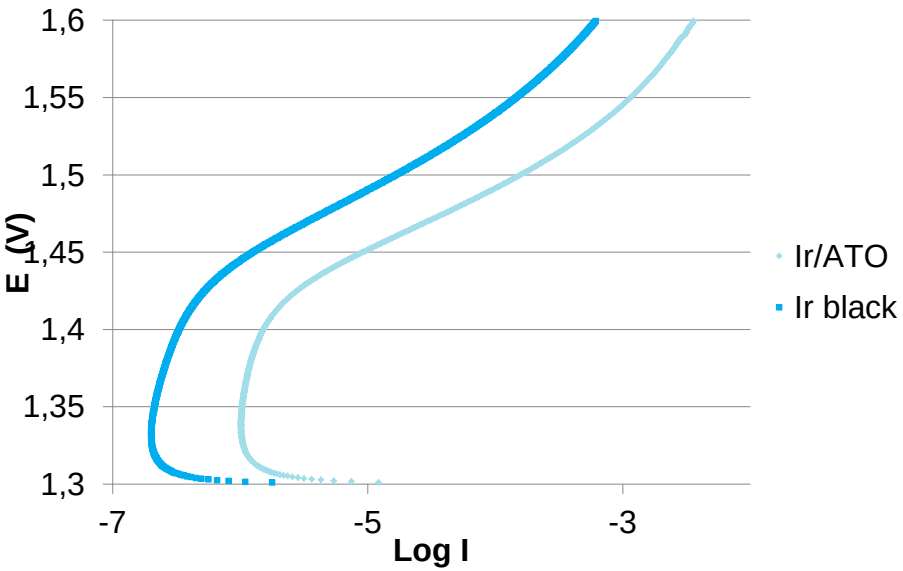
- A series of polyaromatic materials has been prepared
  - Proton conductivity of > 40 mS cm^{-2} (Nafion ~ 100 mS cm^{-2})
  - High mechanical stability (> 120 °C)
  - 10 g scale of ionomers produced
  - 5.5 m^2 membrane cast on continuous production line.

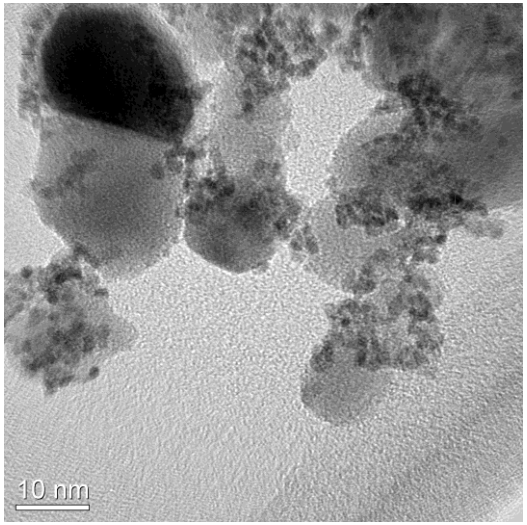


Oxygen evolution catalysts

- Highly active oxygen evolution catalysts developed
  - 2 nm Ir particles on ATO support (20wt% Ir)
  - 200% higher activity than state of the art catalysts (0.94 Acm^{-2} at 1.65 V and 80 °C)
  - Scaled up synthesis (~30g catalyst batch size)



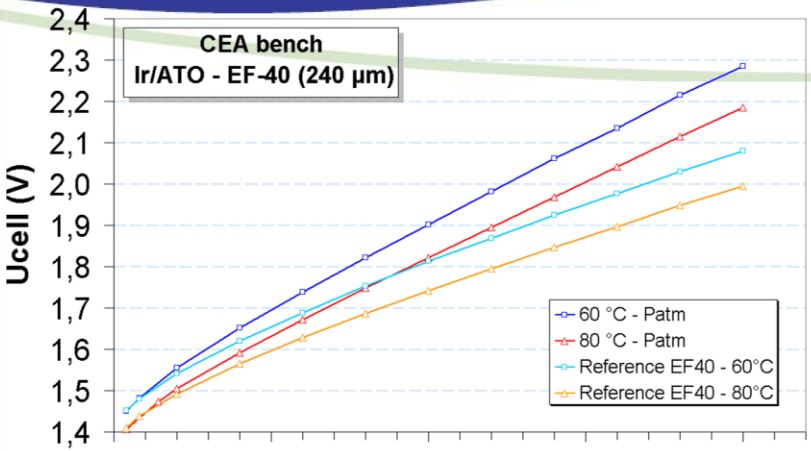


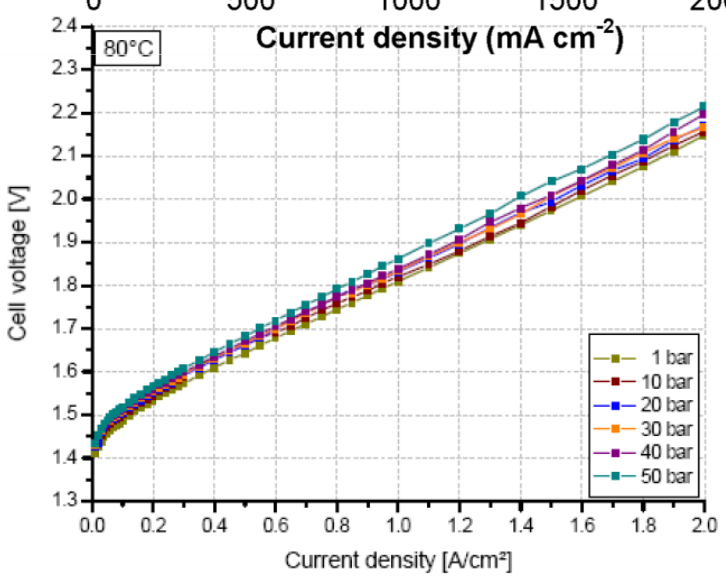


1. Project achievements
Technical progress

MEA/CCM development

- State of the art CCMs
  - Fumatech reinforced membranes
  - High gas purity (<0.5% H_2 in O_2) and high operating pressure
- Incorporation of new materials
  - Ir/ATO catalysts are utilized in final demonstrator stack
  - Optimisation of coating procedures and catalyst loading
  - Comparable performance to state of the art CCMs with 40% of Ir (anode) loading.

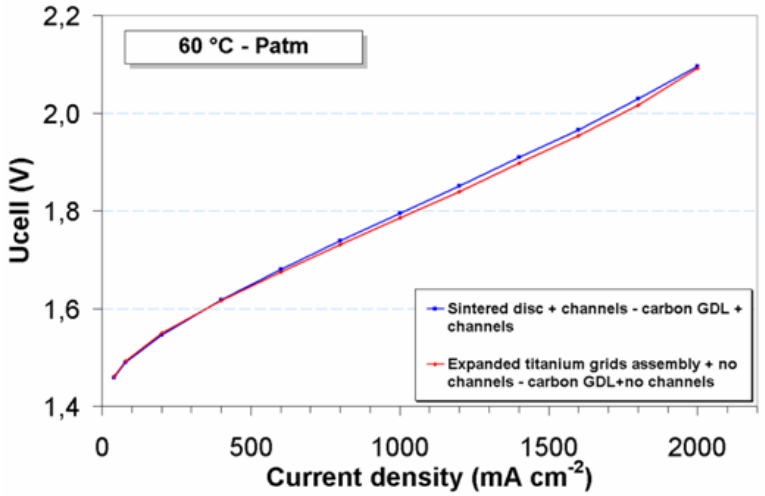




Bipolar plates and current collectors

- Bipolar plates
  - Several Ti grades and stainless steels evaluated in PEMWE representative conditions (several 100h)
- Current collectors
  - Several porous Ti-materials have been tested as current collectors
  - Significant potential for cost reduction identified

150 cm^2 optimized current collectors for 5 cell stack

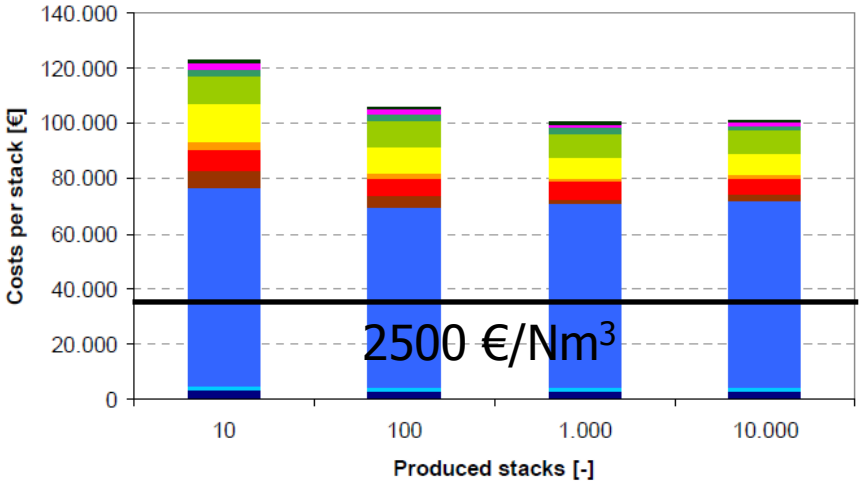


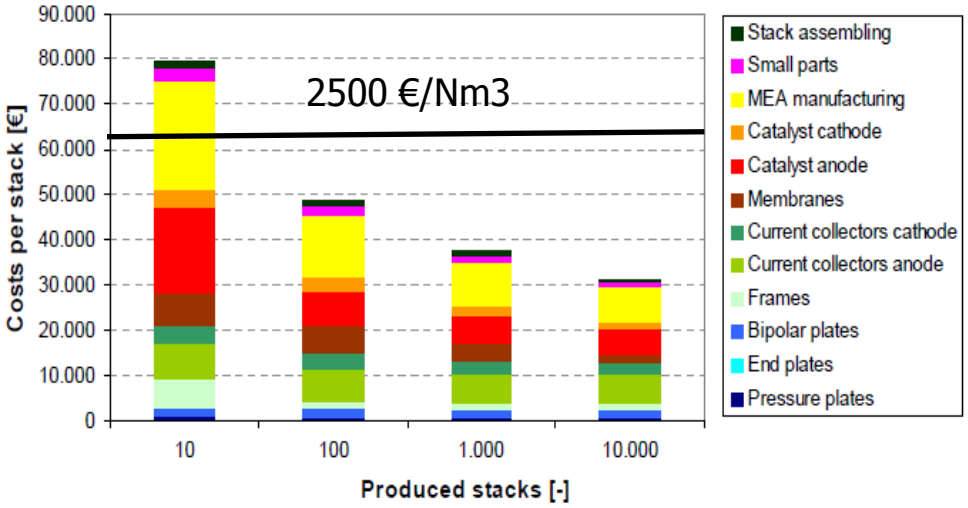
Stack & system design

- Stack design for high pressure operation established
  - New sealing concepts
  - Optimisation of pressure drop and thermal management
  - 2-cell and 5 cell short stacks constructed
  - Passed gas/liquid pressure test of 50 bar.
- Initial system design studies completed
  - Detailed flow-sheets of PEM electrolysis plants of 10 and 100 $Nm^3\ h^{-1}$
  - Cost and performance studies as a function of electrolyser pressure
  - Risk assessments and safety analysis

Stack & system design, market analysis and cost studies

- Cost and market analysis
  - Materials cost based on offers from suppliers / internal cost calculations
  - Production prices based on offers from subcontractors / internal experiences
  - Annual production quantities from 1 – 1000 stacks analysed
  - Stack contributes to 50% of overall system costs
  - NEXPEL stack can reach target costs with production volumes > 100 units.



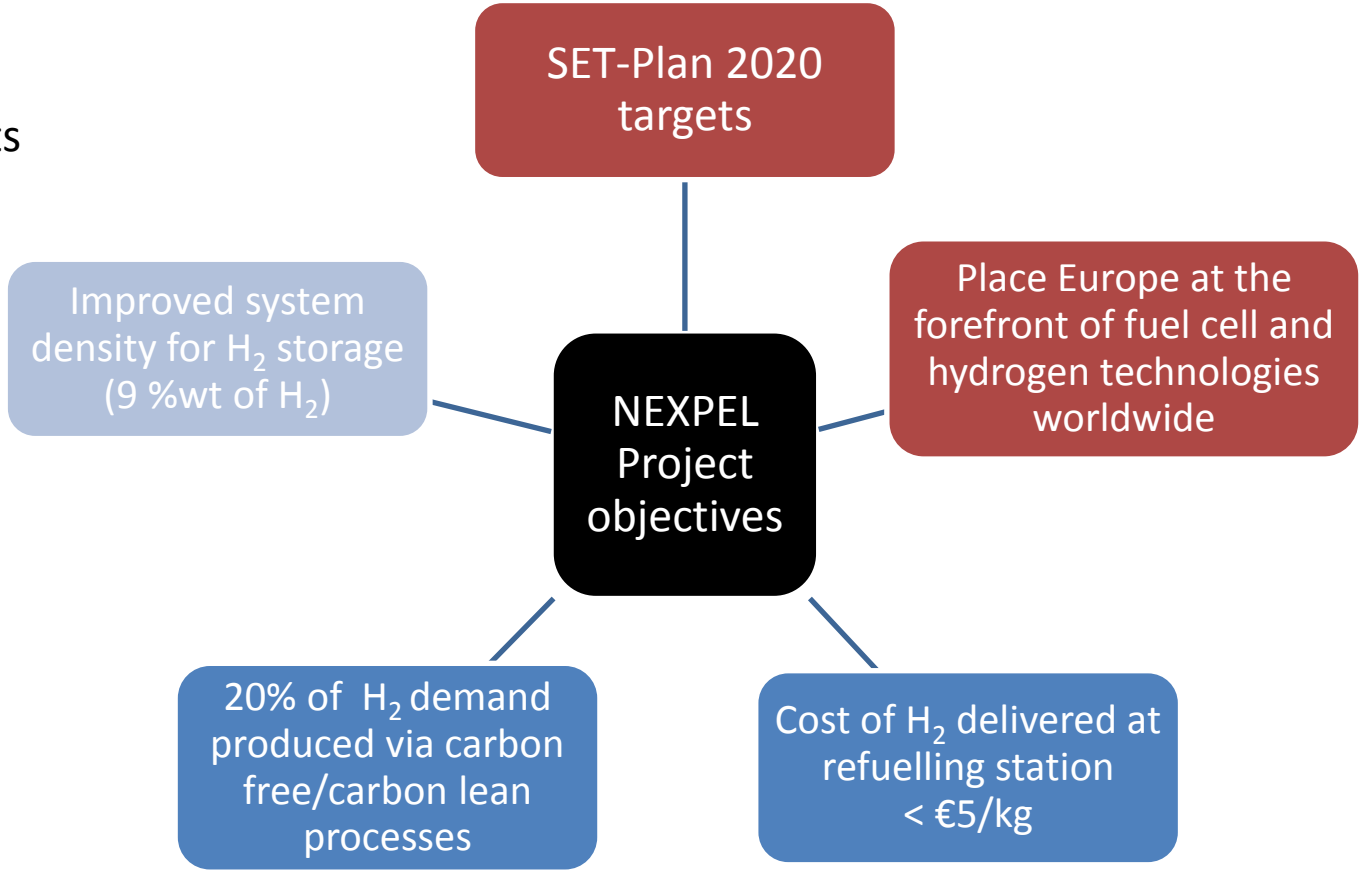


2. Alignment to MAIP

Strategic targets

Technical targets addressed

Technical targets not addressed



2. Alignment to MAIP

Hydrogen production and distribution

"Accordingly, the main emphasis of this application area will be on **research and development of mature production and storage technologies and on breakthrough orientated research of longer term, fully sustainable hydrogen production and supply pathways.** The mature production technologies include (i) reforming (and gas purification) based on bio-fuels as well as conventional fuels; **(ii) cost-efficient low-temperature electrolysers adapted for the large-scale use of carbon free electricity** and (iii) biomass to hydrogen (BTH) thermal conversion.

2. Alignment to AIP2008: Project activities and results

Theme 2.1: Efficient PEM electrolysers

Theme 2.1 project objectives	NEXPEL activities/results match
Research to **increase electrode stability and efficiency**, **development of new catalyst and materials for lowering costs** and improved performance;	**Yes,** improved catalysts with 250% mass activity vs. state of the art demonstrated
Research and development on **advanced power electronics**	**Yes,** DC/DC converter with 98% efficiency under construction
Research to improve materials/components/systems durability/reliability, robustness in order to **reduce costs while optimizing production technologies through design optimization**	**Yes,** Materials research on catalysts and membranes. Stack design for reduced production costs
Development of **low cost, high efficient electrolyser system operating at high pressure**(10MPa = 100bar)	**Yes,** Stack design for reduced costs and high pressure operation (50 bar)
Setting up of field demonstration projects and trials on integration of electrolyser with RES. The work needs to include evaluation of system integration with RES through improvements in modelling tools	**Yes,** Electrolyser will be integrated with wind and solar power. Modelling of RES integration.

3. Cross-cutting issues

NEXPEL contributes to

- Training and Education
  - At least 8 Master students have received training within the project
- Safety, Regulations, Codes and Standards
  - Comprehensive Risk assesment and safety analysis of system and stack design performed as part of NEXPEL project .
  - Field test of NEXPEL electrolyser respect safety regulations on hydrogen filling station site
- Dissemination & public awareness
  - Project achievements are disseminated by annual project folders and via www.nexpel.eu
  - 10 Oral Presentations at international conferences and 1 peer-reviewed paper published (at least 2 papers in preparation)

Dissemination & public awareness

"Water electrolysis and hydrogen as part of the future renewable energy system"

May 10-11, 2012, Copenhagen

Content:

- *Technical overview – International Initiatives*
- *The challenge: Stationary energy storage and energy for transportation*
- *The solution: Hydrogen production by electrolysis*
- *Technical poster presentations*

100 participants from Europe, North America and Asia.

Organized by:

National Danish funded projects:
Medlys (FI 10-093906)
HyProvide the PEM track (EUDP)
Next Generation Alkaline Electrolysis (HT)

4. Enhancing cooperation and future perspectives

- Technology Transfer / Collaborations
  - NEXPEL interacts with several national projects where NEXPEL consortium partners are contributing.
    - Transfer of generic competence (e.g. component testing protocols, safety considerations, etc.)
  - Interfacing with organisations
    - National hydrogen associations; Norwegian Hydrogen Association and NOW
    - IEA Hydrogen Implementation Agreement – Task 24
      - Wind Energy and Hydrogen Integration

4. Enhancing cooperation and future perspectives

- Project Future Perspectives
  - Continuation of the project in FCH-JU 2011 call. (NOVEL)
    - Further development of most promising results
    - Degradation and lifetime issues of PEM electrolysers
  - Two patent applications are being considered
    - Securing IPR for further development / commercialisation
- Need/opportunity for increased cooperation/research
  - Demonstration of cost reduction potential
  - Large scale manufacturing / up-scaling of novel material synthesis
  - Degradation and lifetime issues

Thank you for your attention

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