DEMCOPEM- 2MW

Demonstration of a combined heat and power 2 MWe PEM fuel cell generator and integration into an existing chlorine production plant

DEMCOPEM 2MW

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Programme Review Days 2018

Brussels, 14-15 November 2018

PROJECT OVERVIEW

- **Call year:** 2013
- **Call topic:** SP1-JTI-FCH.2013.3.5 Field demonstration of large scale stationary power and CHP fuel cell systems
- **Project dates:** 01/01/2015 – 31/12/2018
- **% stage of implementation 01/11/2017:** 71% (36 months vs the 48 planned)
- **Total project budget:** 10,524,200 €
- **FCH JU max. contribution:** 5,466,525 €
- **Other financial contribution:** n/a
- **Partners:** Nouryon (formerly AkzoNobel Industrial Chemicals B.V.); Nedstack Fuel Cell Technology B.V.; MTSA Technopower B.V; Johnson Matthey Fuel Cells Limited; Politecnico di Milano

PROJECT SUMMARY

DEMCOPEM-2MW - Demonstration of a combined heat and power 2 MWe PEM fuel cell generator and integration into an existing production plant

- The main project objective was to design, build and operate a 2MW power generator fully integrated in an existing chlorine production plant
  - Contribute to the FCH JU goals of installed power (>5MW @3000€/kW 2015, >50MW @1500€/kW in 2020)

- The DEMCOPEM system is the world's current largest PEM fuel cell stationary power plant

- Possible application of the technology is the chlor-alkali industry and the "power-to-power" (P2P) market

Installation at Ynnovate site, Yingkou, China

PROJECT SUMMARY

Construction and shipment of the plant in mid 2016

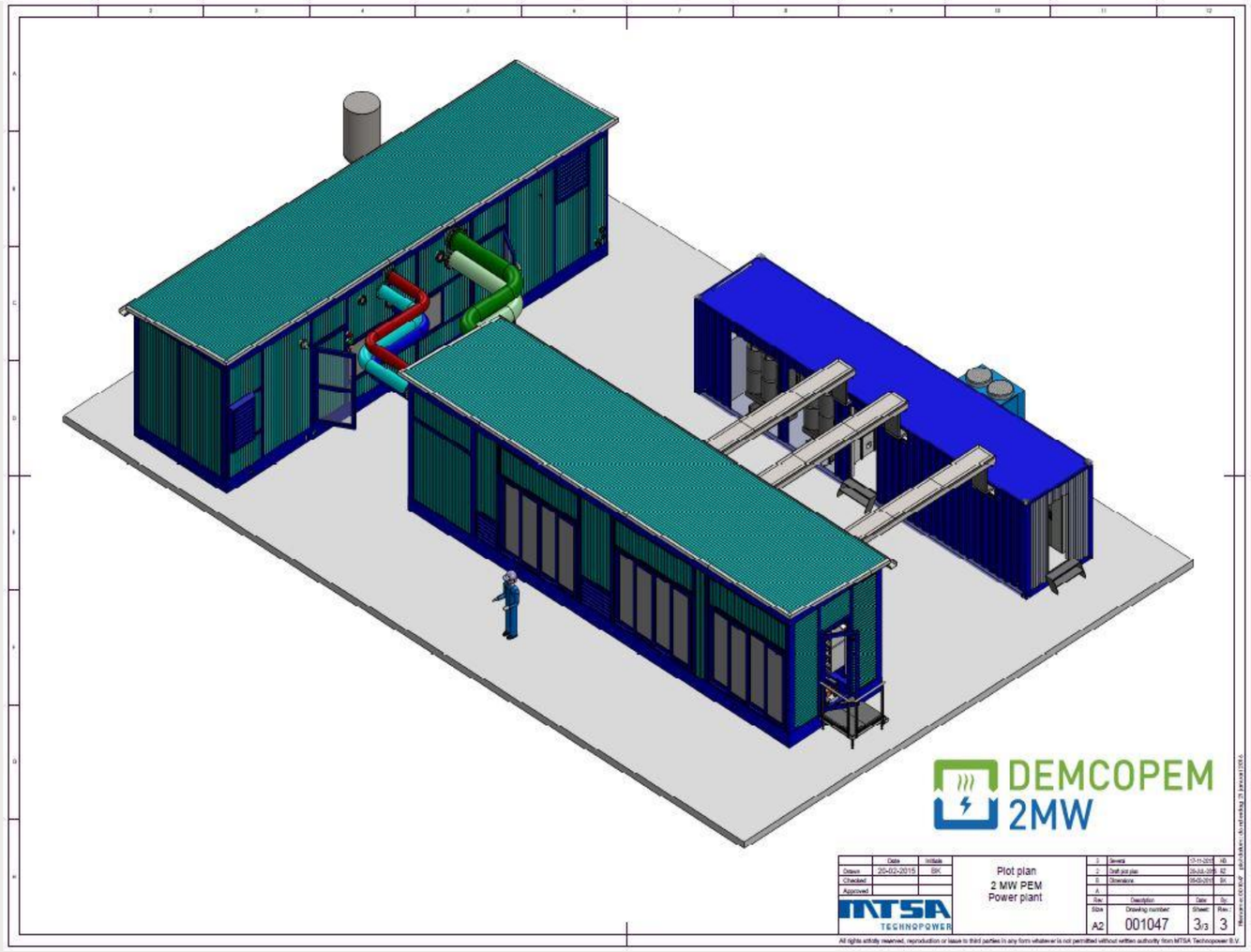
Opening ceremony on Oct. 14, 2016 at plant location of Ynnovate Ltd in Yingkou, China

Nov. 7, 2018 Final Project workshop including panel discussion

2016-2018: more than one year of plant operation: **data analysis**

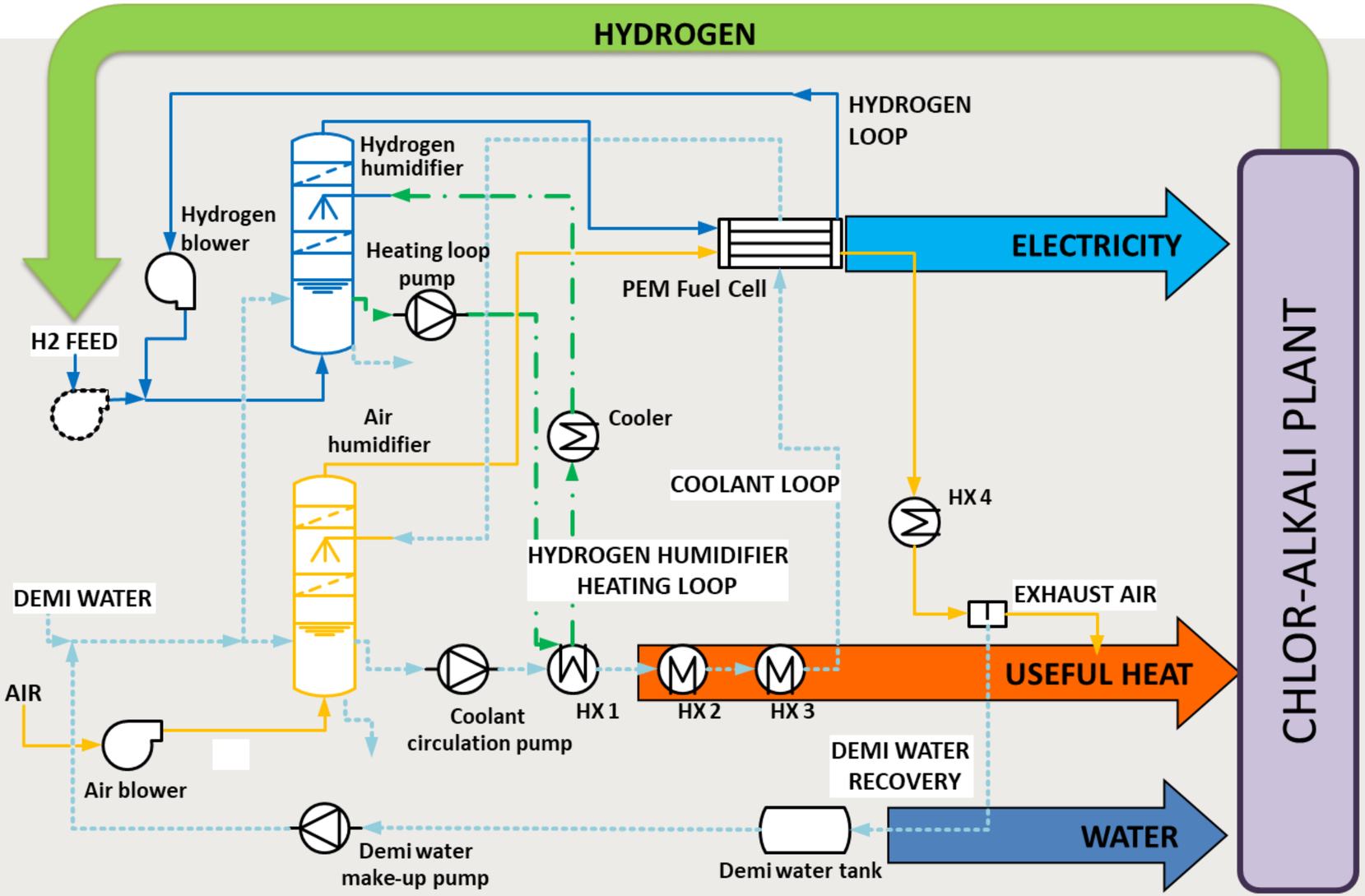
PROJECT SUMMARY / LAY-OUT

- Demonstration project
- Production of electricity
- Specification 2 MWel
- Use hydrogen as energy source
- Hydrogen is a by-product of chlor-alkali production
- Integration in existing industrial production facility
- Use of produced thermal energy
- Fully automated operation and control
- By-product water to be used



PROJECT SUMMARY / Construction and testing

PROJECT SUMMARY – DEMCOPEM Plant Diagram



PROJECT PROGRESS/ACTIONS – Demonstration

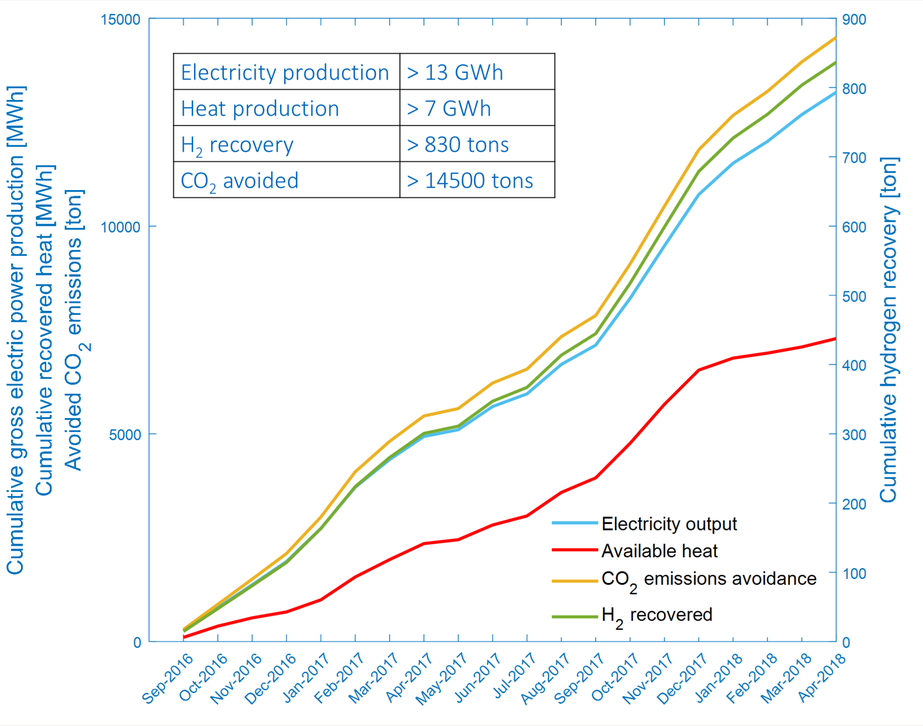
Achievement to-date

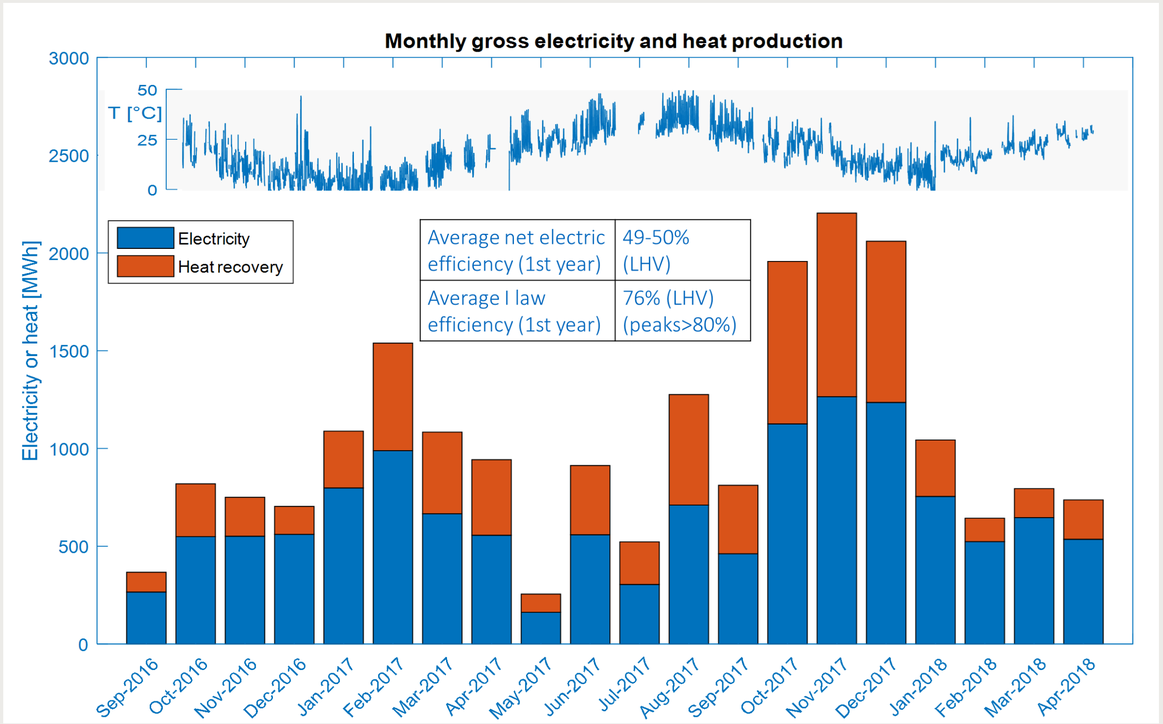
- Implementation and demonstration of the system completed

- Results related to efficiency and availability:
  - The measured BOL electric efficiency was 55%LHV (~56-57%LHV gross in the first project year), aligned with project targets.
  - Additional 26%LHV (average) can be recovered as thermal energy leading to a global efficiency of nearly 76%LHV (peaks over 80%)
  - Since September 2016 the plant has been working for more than 11,240 hours (16,000 targeted).
  - Plant avg availability is high, reaching > 95% end of last year. Further, the plant shows excellent flexibility in terms of part-load, standby operation and on-off control

PROJECT PROGRESS/ACTIONS – Demonstration

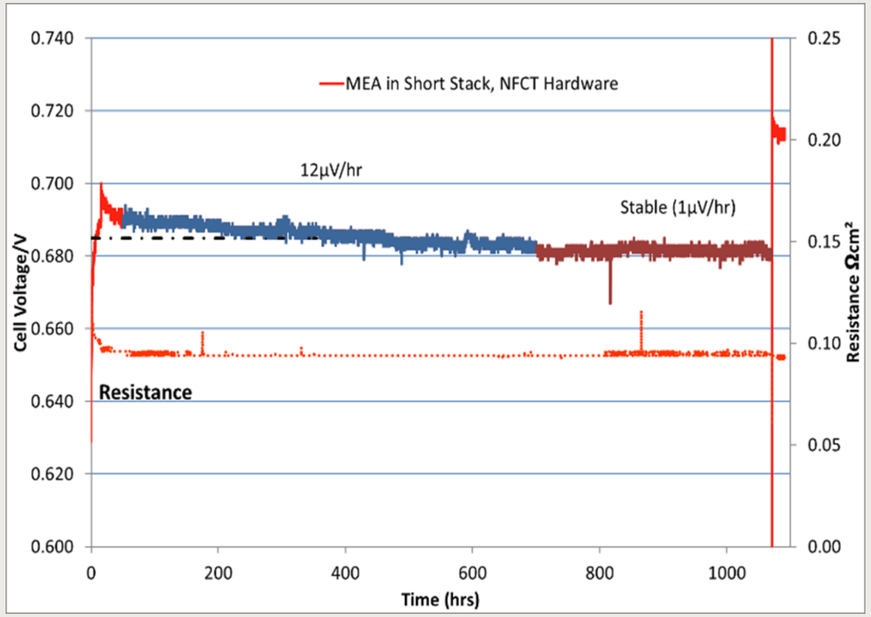
- Globally, the plant produced more than 13 GWh_{el} and made available over 7 GWh of thermal energy at ~65°C.
- More than 830 tons of hydrogen have been recovered, demonstrating an average electric efficiency of 49-50%$_{LHV}$ (ref. first 12 months of operation) and over 14500 tCO_2 emission avoidance.

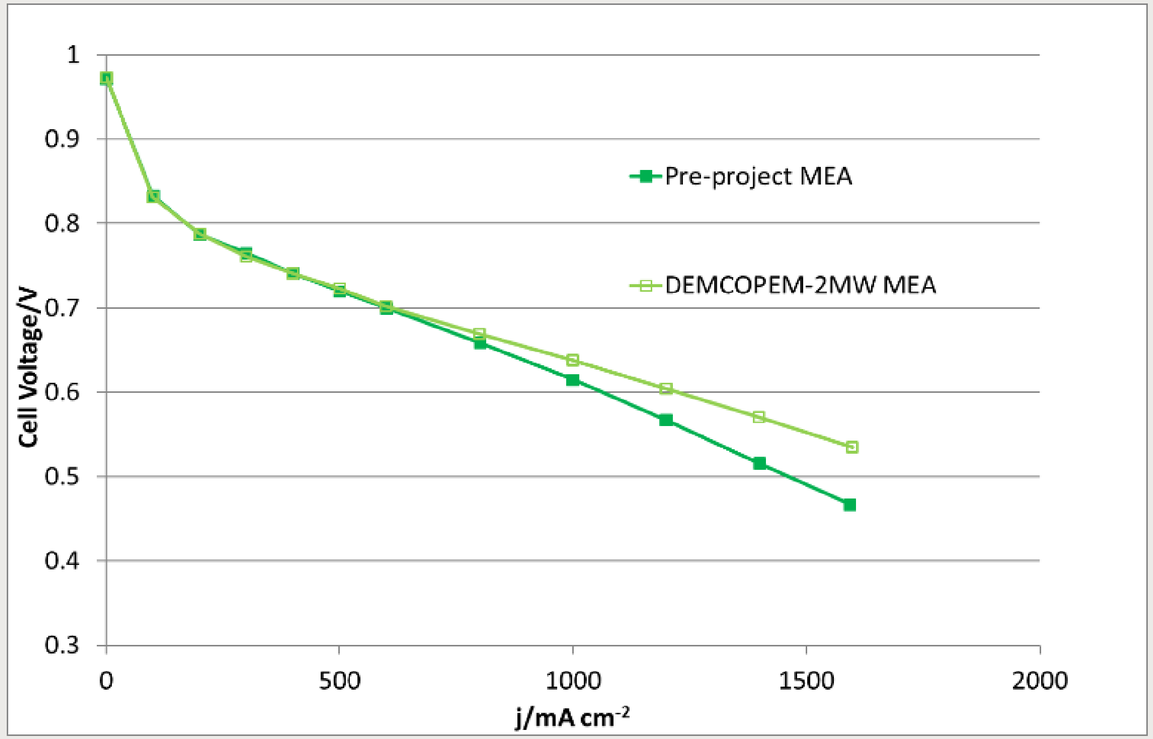




MEA and Stack Development

- DEMCOPEM-2MW long life MEA, made via high volume manufacturing, replacing an earlier stationary power MEA.
- A significant reduction in the number of manual operations was achieved.
- Stable performance over the first 1000h was demonstrated in short-stacks:

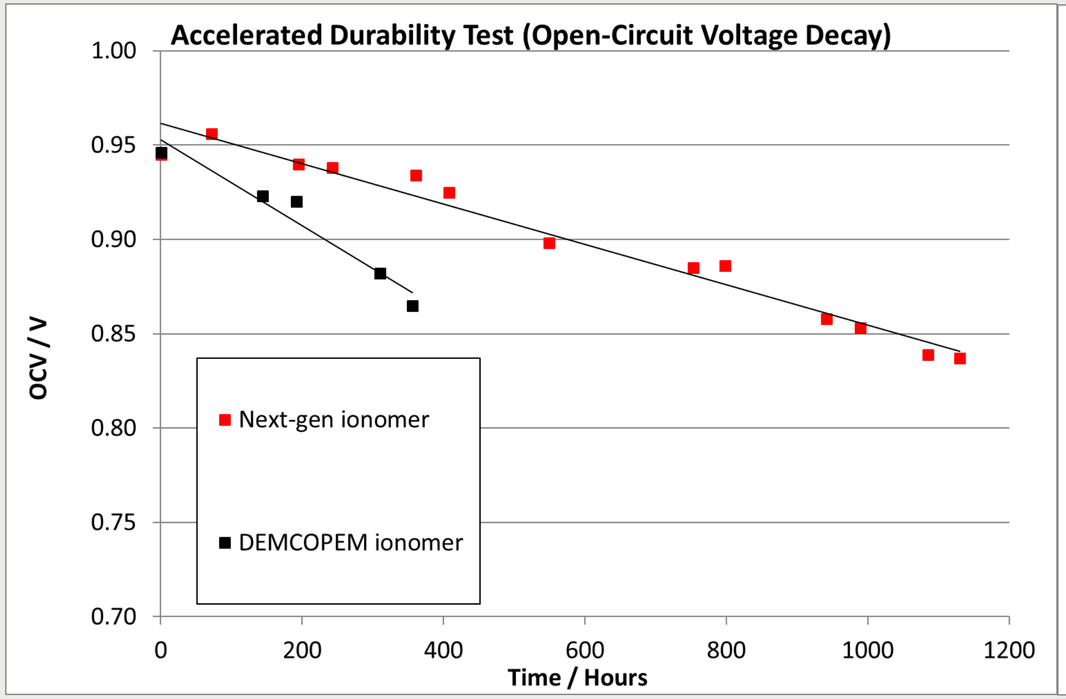


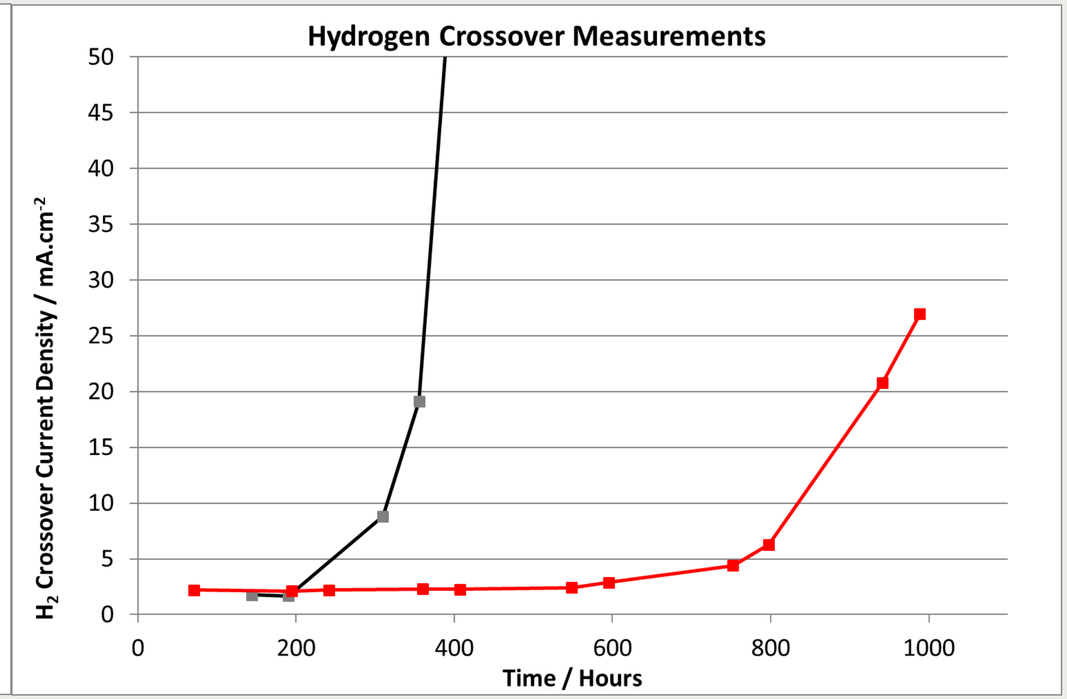


Above: DEMCOPEM MEA polarisation performance compared to pre-existing long life MEA. Left: DEMCOPEM-2MW MEA in short stack, 600 mA/cm²

Cost Savings Associated With Further Improved MEAs

- Further improved MEAs, with a continuous, catalyst coated membrane, offers a lower Pt cost.
- Replacing DEMCOPEM-2MW production MEAs with the lower Pt design could save 80% of the Pt cost per stack.
- Assuming a 98% PGM recovery, recycling the MEAs and replacing them with the CCM design could release around 78% of the Pt cost per stack, depending on Pt price. The Pt cost varied from US$ 800/oz. t, to US$ 1,280/oz. t. over the course of the project.
- Newly developed membrane electrolytes offer longer life, hence savings on stack replacement costs.





PROJECT PROGRESS/ACTIONS – Costs

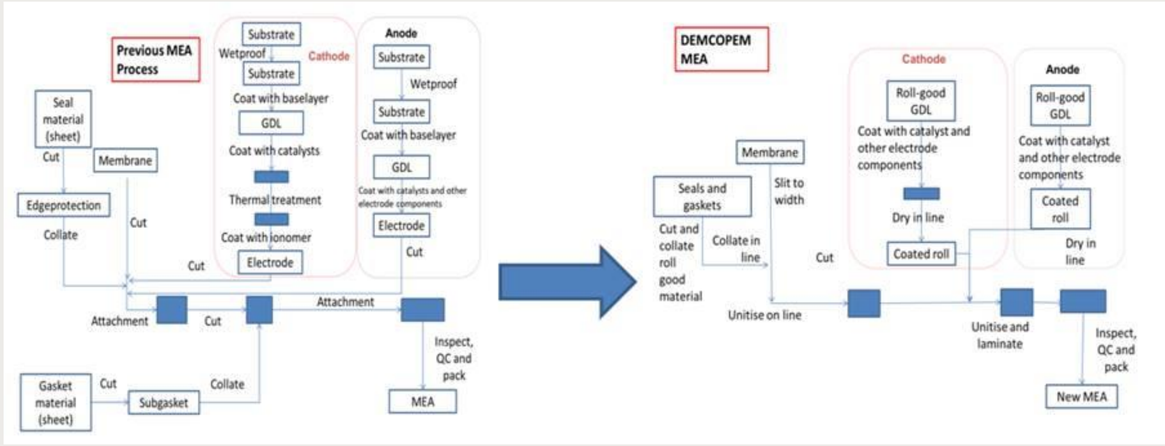
Achievement to date

PROJECT START VALUE → 4,500 €/kW

25% 50% 75%

3,000 €/kW

- Costs (CAPEX and OPEX) related to the possible roll out phase are estimated at 3,200 €/kW, near target.
- In order to reach the target costs, several advanced developments are required. For example:
  - Production of MEAs and fuel cells in large series (e.g. 10 MW volume).
    - Pre-project long life MEA required eighteen manual unit operations; DEMCOPEM-2MW required three manual operations; all other operations automated, continuous, roll to roll volume production methods.
  - Development of fuel cells allowing simpler integration with the Balance of Plant.
  - Development of fuel cell stacks with a higher capacity.
  - Dedicated Balance of Plant components produced in series.
  - Production of PEM fuel cell generators in volume.



Risks and Challenges

- High risk project both for technical aspects and coordination (collaboration with China) aspects ✓

- Several challenges have been encountered (prior installation)
  - Critical system design and integration
  - Shipment and installation in China
  - Training of Chinese operators
  - Communication and working culture (e.g. perception of good workmanship)

These aspects have been solved by extra effort from consortium partners (mostly NFCT and MTSA) and good communication with the Chinese end user. ✓

- Technical problems encountered in the last year of operation related to stack performances and degradation. Mostly due to non-conformities on site (contaminants present in the utilities and feed streams)

These aspects are currently under investigation by the consortium and end user.

Communication Activities

- Project website (www.demcopem-2mw.eu) and dissemination plan prepared at the beginning of the project and maintained / updated till now.

- Newsletters prepared and distributed during the project lifetime.

- In the last project period main focus on possible new clients and exploitation.
  - Sino-Dutch Joint Venture has been created (Nedstack).

- Two workshops have been organised in China by the project:
  - Launching Ceremony and Project workshop in October 2016 (public deliverable D8.5)
  - Second project workshop in November 2018 (public deliverable D8.6 under preparation)

Communication and Dissemination Activities (2018)

- *Presentation at Chinese Chlor-Alkali conference (March 2018)*
- Presentation at ASME Power & Energy Conference (July 2018)
- Presentation at EuCheMS conference, Liverpool, UK (August 2018)
- “Modelling, Development and Preliminary Testing of a 2 MW PEM Fuel Cell Plant Fuelled With Hydrogen From a Chlor-Alkali Industry”, S. Campanari, G. Guandalini, J. Coolegem, J. ten Have, P. Hayes, A.H. Pichel, *Journal of Electrochemical Energy Conversion and Storage*, under review.

- Project public deliverables :
  - D5.7 Report on system performance, functioning, maintenance and technical improvements
  - D6.8 Report on stack failure causes
  - D7.2 Report on stack performance and repairs
  - D8.1 Project website
  - D8.4 E-newsletters
  - D8.5-D8.6 Workshops

Communication and Dissemination Activities

- Second Project workshop highlights:
  - Project presentations and high level panel discussion
  - Presentation and Booth at Hydrogen Energy & Fuel Cell Technology and Product Expo
  - Introduction of FCH JU (by project officer) at the Hydrogen Energy and Fuel Cell Industry Development Conference (Foshan, China)

EXPLOITATION PLAN/EXPECTED IMPACT

Exploitation

Identified exploitable results:

- New MEAs design and production.
  - Experience of real-world operation in the Chinese chlor-alkali industry.
- Model for plant performance
  - open-source calculation tool for preliminary plant economical assessment.
  - PEM system.

Impact

- A large scale PEM fuel cell system coupled to a chlor-alkali industrial plant for waste hydrogen recovery is demonstrated.
- Plan for roll out phase under preparation.
- MEA optimised for long life, high volume production available as a mature product.
- Real-world estimates of decay rate and lifetime of the new MEA product.

Project Impact

- Roll out of technology
- New projects
- Further international collaboration

- **Current project**

- First plants in Delfzijl and Antwerp

< 2015 — *Proof of concept*

2015 - 2018 — *DEMCOPEM-2MW*

2019 - 2020 — *Market Entry*

> 2020 — *Market Development*

- Self sustained market in PEM FC power plants.
- Collaboration with other technologies using renewable energy sources

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes:

- GRASSHOPPER (GRid ASSisting modular HydrOgen PEM PowER plant) takes the DEMCOPEM MEA design and optimizes it for operation in a 100kW demonstration plant:
  - To reduce costs.
  - Improve dynamic performance.
  - Realise the next generation of modular PEM power plant.

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