Hydrogen Research & Innovation Days
24-25 November 2025

CLEANER
- WITH INDUSTRIAL QUALITY H_2

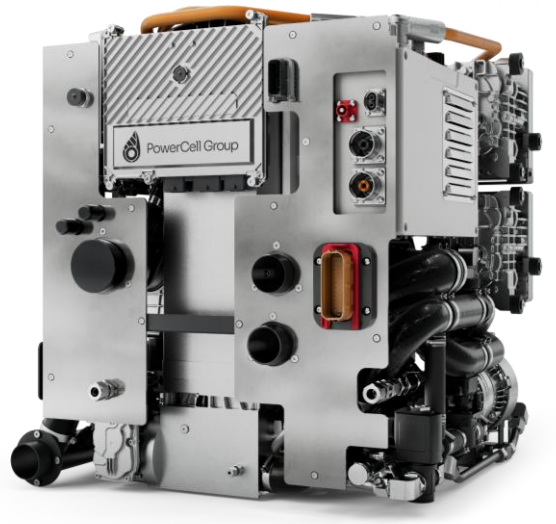
Anders Ødegård, SINTEF

Clean Hydrogen Partnership

Co-funded by the European Union

Project overview (2024-2027)

- **Developing and demonstrating for more than 5000 hours, a >100 kW PEM fuel cell system operating with industrial quality hydrogen.**
- Improve ability to operate on lower quality H_2 by system upgrades
- Increase catalyst tolerance of impurities in hydrogen while reducing the cost
- Reduce TCO through lower cost materials, modelling and increasing efficiency
- Assure economically and environmentally sustainable development



Clean Hydrogen Partnership
SINTEF PRETEXO POWERCELL universität freiburg FONDAZIONE BRUNO KESSLER national gas VTT NAFTOGAZ UKRGASVYDOBUVANNYA FERREXPO Schiphol Amsterdam Airport eurogas
Co-funded by the European Union

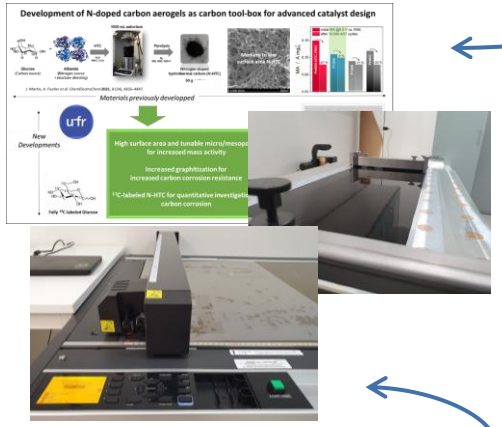
Project activities

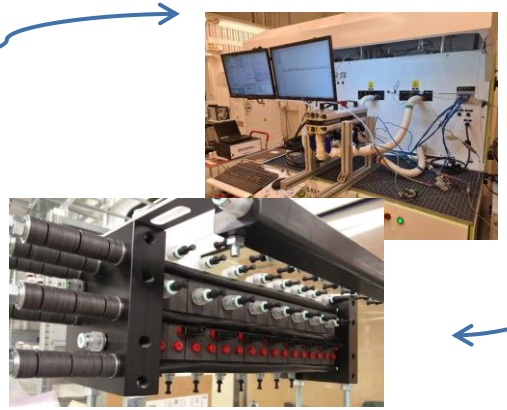
Catalyst, membrane, MEA development

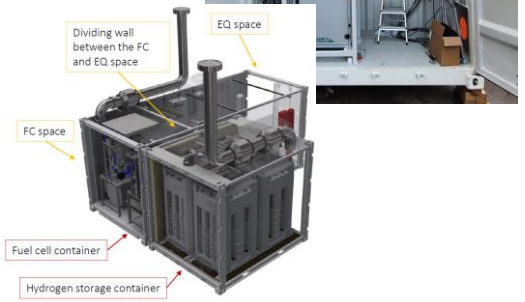
Cell and stack testing

System improvements

System testing and validation







Modelling, techno-economic and environmental user-case analysis

Communication and dissemination

Clean Hydrogen Partnership

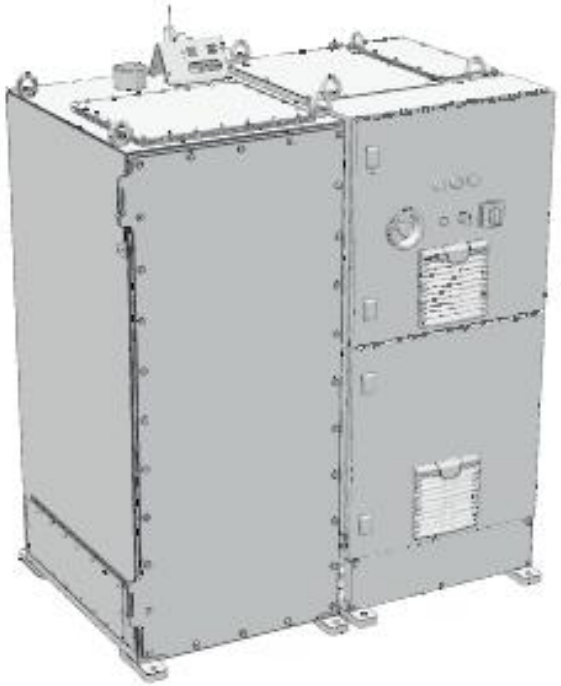
Co-funded by the European Union

PowerCell System - Phase 1

PowerCell has designed and developed a fuel cell system delivering more than 100 kW electrical power. The system is manufactured, has passed all factory acceptance tests, and is ready for the first test campaign at VTT.

The focus areas in the system design were:

- **High durability** to limit degradation during long-term operation.
- **Stability of the anode recirculation loop** to reduce the purge frequency and increase the fuel utilization.
- Strengthening **contamination resilience** by introducing an air bleed into the hydrogen line to mitigate the impact of carbon monoxide, a potential impurity in the hydrogen stream.



Full size system testing

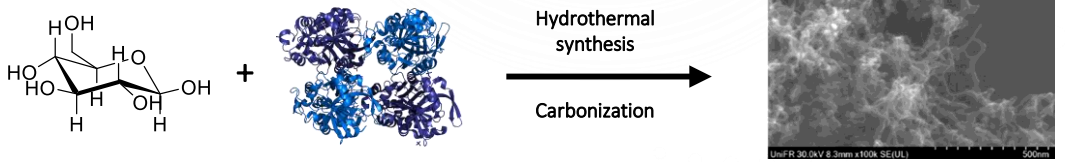
- VTT developed and tested containerised test platform for > 100 kW fuel cell system with impurity feed connected in H_2 supply.
- Impurity tolerant PowerCell developed fuel cell systems will be tested in the test platform for total of 5000 hours
  - Impurities, e.g. CO, supply adjustment at 0.5 – 20 ppm concentrations in H_2
  - Anode exhaust will be monitored with a micro-GC

UFreiburg Carbon Supports and Pt/C Catalysts

- PEM fuel cell catalyst development, aiming for
  a) enhanced carbon corrosion stability and improved tolerance against hydrogen impurities
  b) advanced carbon corrosion monitoring
- In-house synthesized hydrothermal carbon aerogels (**HTC**)
  - 3D microstructure, N-doping, tuneable meso-/micropores
  - scalable synthesis from glucose and ovalbumine
  - ^{13}C carbon isotope labelling → diagnostic carbon twins

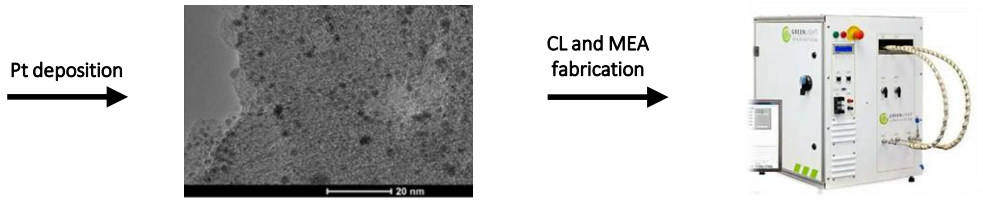
→ Fully ^{13}C-labelled fuel cell catalysts for advanced carbon corrosion monitoring implemented within the catalyst layer

HTC support development [1]



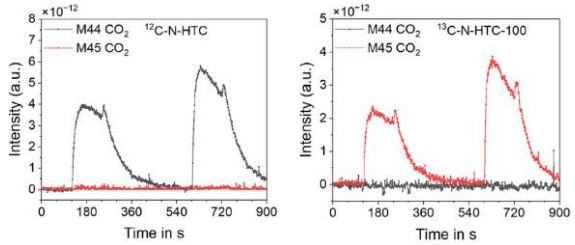
Glucose + Ovalbumin → N-doped HTC support

Pt/HTC catalyst synthesis and PEM fuel cell testing



Pt/HTC catalyst → Single-cell, multi-cell, and stack testing

^{13}C isotope HTC and Pt/HTC twins [2]



→ Detection of carbon corrosion *via* distinct CO_2 peaks

1 J. Martin, A. Fischer *et al*, *ChemElectroChem*, **2021**, *8*, 4835-4847.
2 N. Ortlieb, J. Martin, J. Ihonen, A. Fischer *et al*, *Adv. Energy Mater.* **2025**, *15*, 2406164.

Clean Hydrogen Partnership
Co-funded by the European Union

Hydrogen impurities – review report

- What is industrial quality hydrogen?
  - We identified impurities from across the value chain and categorised them as low, medium, or high risk for PEMFC end-use
- Frequently occurring impurities were:
  - N_2, hydrocarbons including CH_4, CO_2
- Key impurities identified:
  - *High risk:* CO
  - *Medium risk:* N_2, CH_4, CO_2, hydrocarbons, odorant

Report presented in webinar, recording available on project website

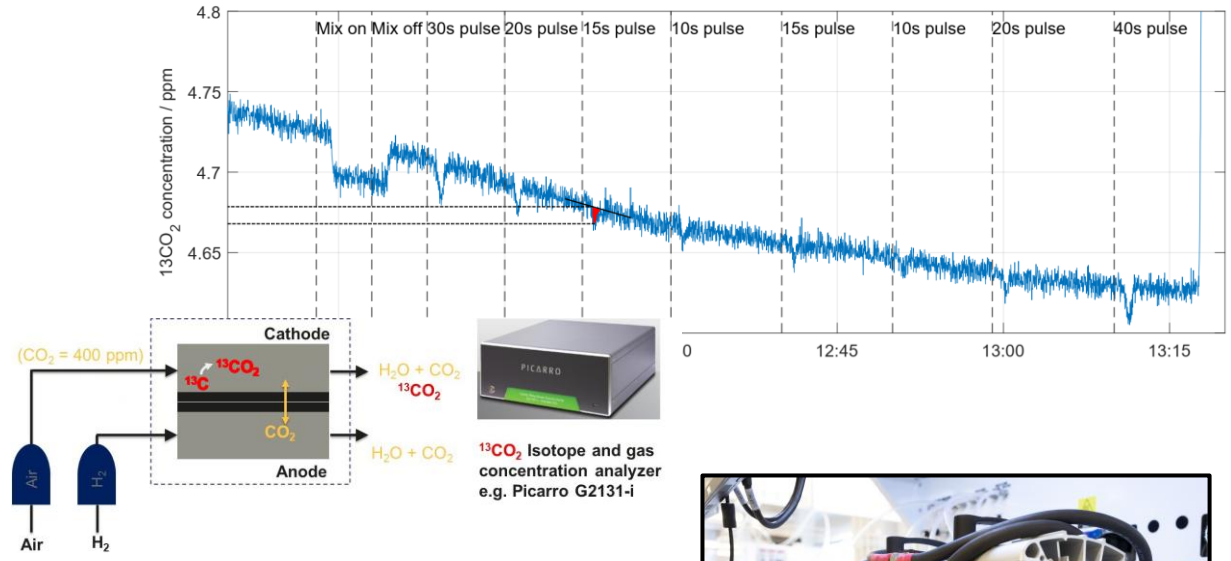
Clean Hydrogen Partnership

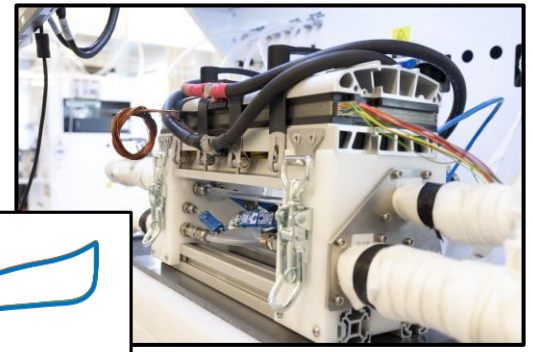
Co-funded by the European Union

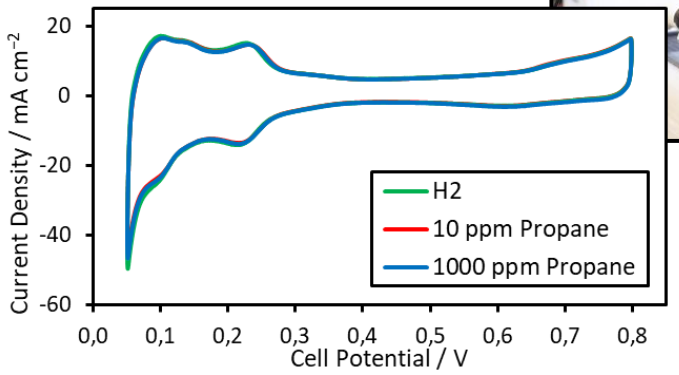
1. doi.org/10.1016/j.ijhydene.2023.09.305

Cell and stack testing

- Development of methods for CO poisoning research with a multi-single cell setup.
- Preparing capabilities of $13CO_2$ detection for carbon corrosion monitoring at low levels of corrosion.
- Selected impurities are evaluated to determine their impact on PEMFCs:
  - Propane initially selected due to its presence in repurposed gas pipelines[1] and depleted fields
  - Showed no poisoning effect on the catalyst or membrane during single cell testing, short-stack performance will be evaluated





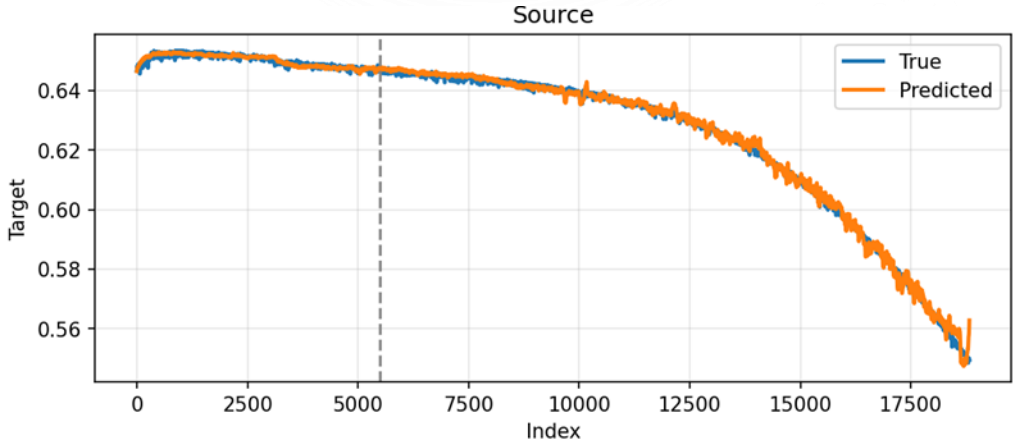


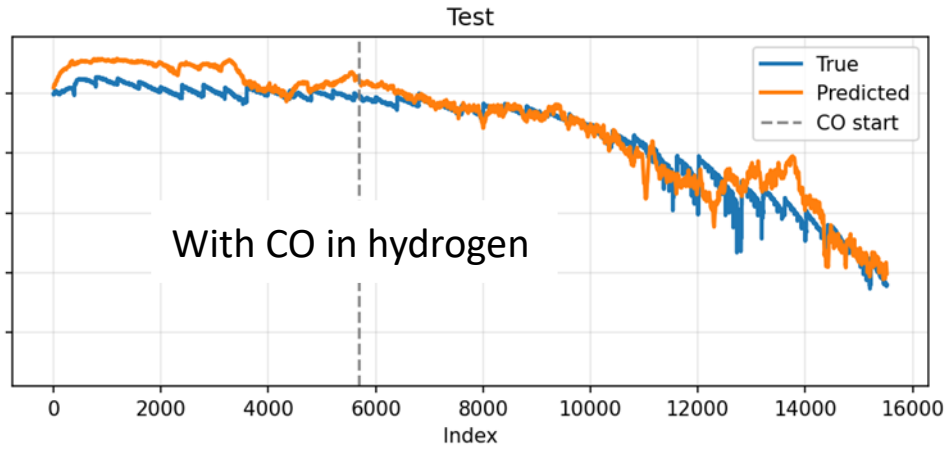
Clean Hydrogen Partnership

Co-funded by the European Union

CO induced degradation modelling

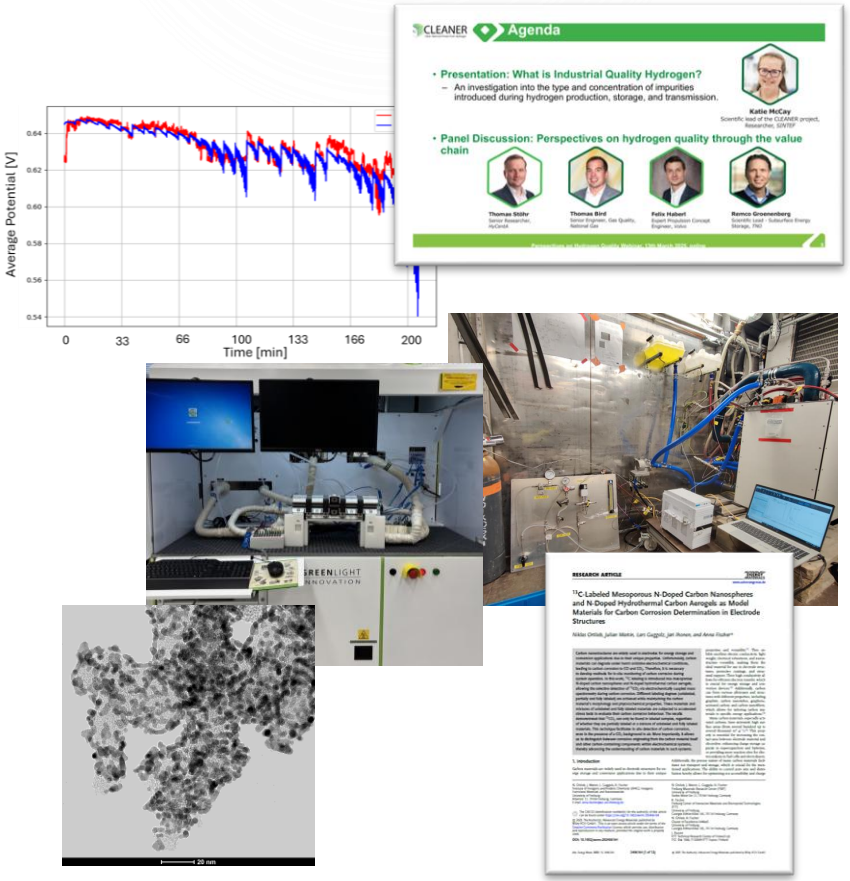
- Artificial Neural Networks, employing domain adaptation techniques to improve generalization capability from source to target datasets.
- Developed and tested on available data-set, with and without CO in hydrogen





Summary

- Frequently occurring impurities in "industrial" hydrogen:
  - N_2, hydrocarbons including CH_4, CO_2
  - *High risk:* CO
- Mitigations incl. both new material and system design
- Fuel cell testing combined with modelling required to reveal impact and understand mechanisms
- 100 kW PEMFC system built and ready for 5000 hours operation on hydrogen with impurities



Acknowledgements

- The CLEANER project is supported by the Clean Hydrogen Partnership and its members under grant agreement No 101137799.
- Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Hydrogen JU. Neither the European Union nor the granting authority can be held responsible for them.

national gas
NAFTOGAZ UKRGASVYDOBUVANNYA
FERREXPO
VTT
Schiphol Amsterdam Airport
eurogas
SINTEF
PRETEXO
POWERCELL
universität freiburg
FONDAZIONE BRUNO KESSLER

Clean Hydrogen Partnership

Co-funded by the European Union