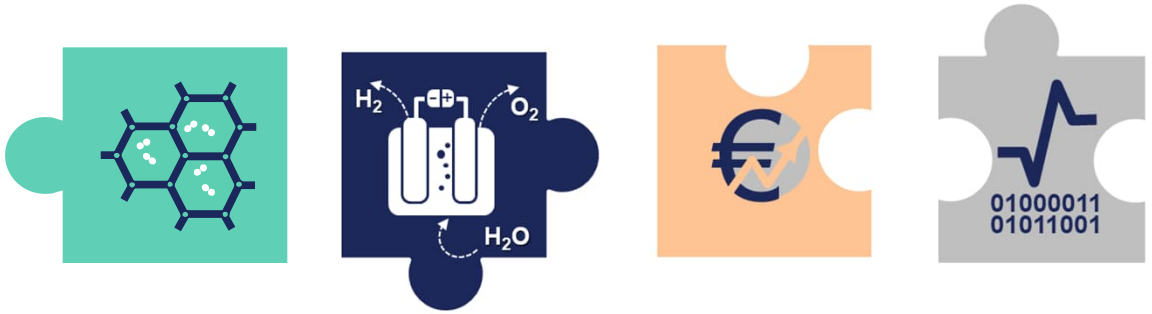

All About HyPER

Hydrogen Production and Storage as an Enabler of Industrial Renewal in Central Finland (HyPER)

Bajamundi Cyril (cyril.bajamundi@vtt.fi), Kärki Janne, Lappalainen Mikko, Kauppinen Juho, Luukkonen Aaro (VTT)

Haukka Matti, Honkala Karoliina, Lahtinen Manu (JyU)

01.10.2024

Hydrogen and Carbon Value Chains in Green Electrification (HYGCEL) Seminar

Co-funded by the European Union

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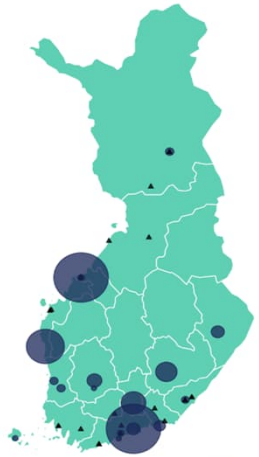
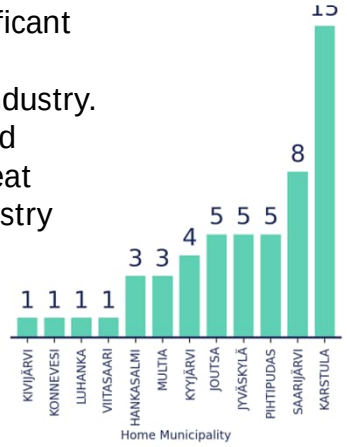
Background and Motivation of HyPER

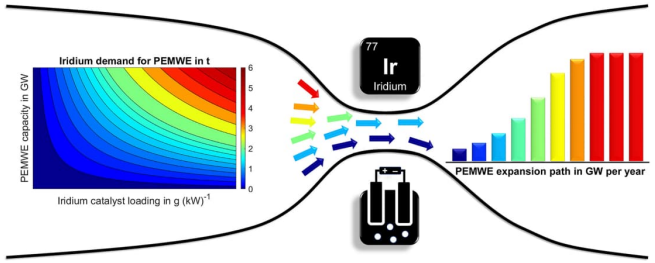
- The hydrogen economy is compatible with the 2030 carbon neutrality target of Central Finland and could contribute to addressing the dwindling peat industry



- By 2030 the utilisation of peat in Central Finland is only 10% of 2019 values; this will bring a significant economic blow to 52 local companies engaged in the industry. Regional hydrogen infra could support the transition of peat workers to future-ready industry



- Majority of the electrolysers being considered in Finland and the EU are reliant on Iridium; the availability of supply of iridium all over the world is not enough to support the ballooning demand; AEMEL technology can offer a solution.

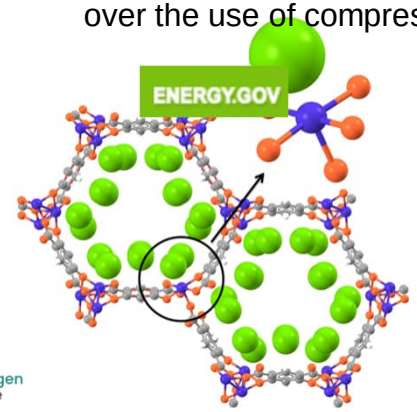


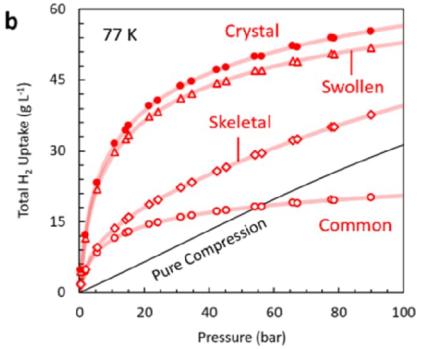
- Potential PFAS ban

”No alternative is foreseen to be able to substitute today or in the near future these highly specialised materials, central to the functioning of the hydrogen value chain”

Hydrogen Europe

- **Hydrogen transport** is a hot topic and technological developments are still needed.
- **Carbon-based** storage and carrier is one promising alternative. Central Finland’s carbon sources could be **valorised** as hydrogen storage media
- The nature of the adsorption process can still offer **volumetric density advantages** over the use of compressed gas storage





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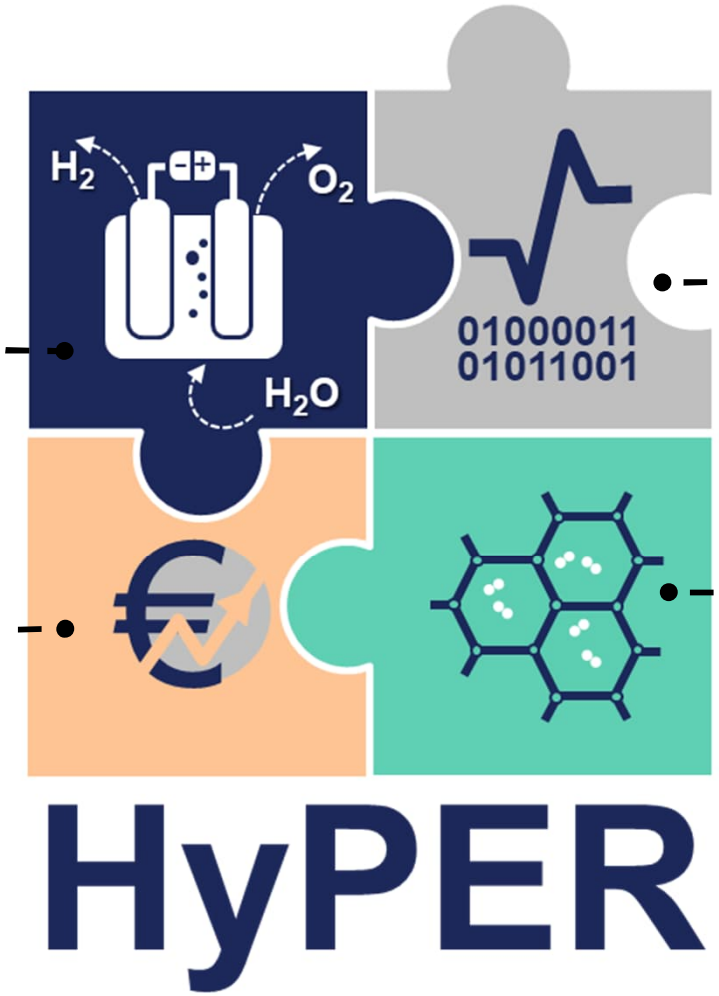
Hydrogen Production and Storage as an Enabler of Industrial Renewal in Central Finland

Anion Exchange Membrane Electrolysis

Digitalization



Business

Hydrogen Storage

Project Duration:

01.01.2024 – 31.12.2025

Contact:
cyril.bajamundi@vtt.fi

Funding:
Just Transition Fund

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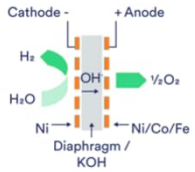
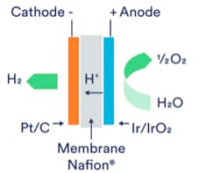
Anion Exchange Membrane Electrolysis

- There are currently 4 main electrolyser technologies

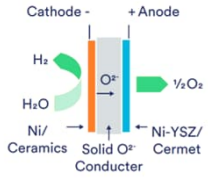
AEL - Alkaline Electrolyser



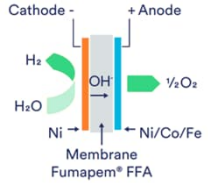
PEMEL - Polymer Electrolyte Membrane Electrolyser



SOEL - Solid Oxide Electrolyser

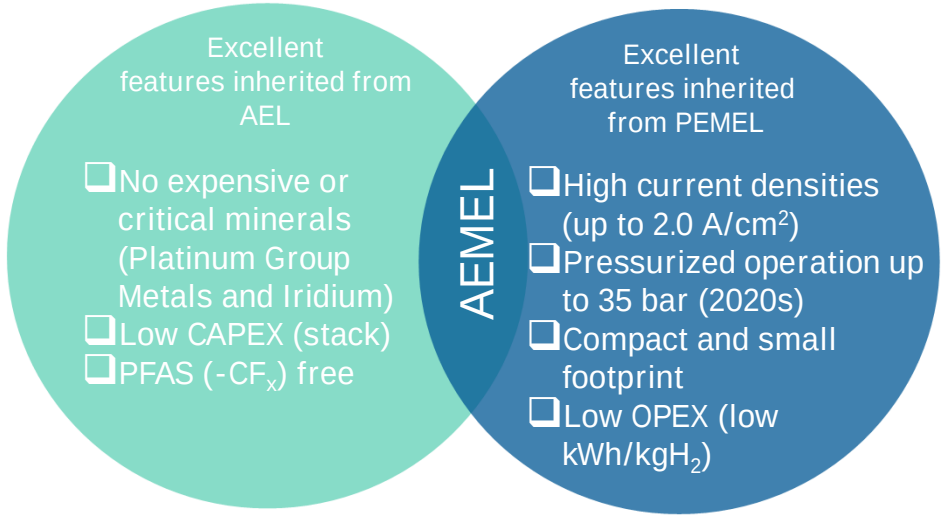


AEMEL - Anion Exchange Membrane Electrolyzer

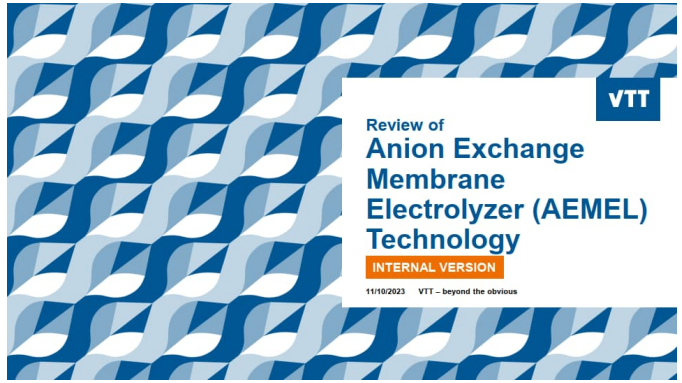


- Each technology has its risk and potential
  - Scarcity of supply of iridium (Ir)
    - EU ban on Per- and polyfluoroalkyl substances (PFAS, -CF_x)

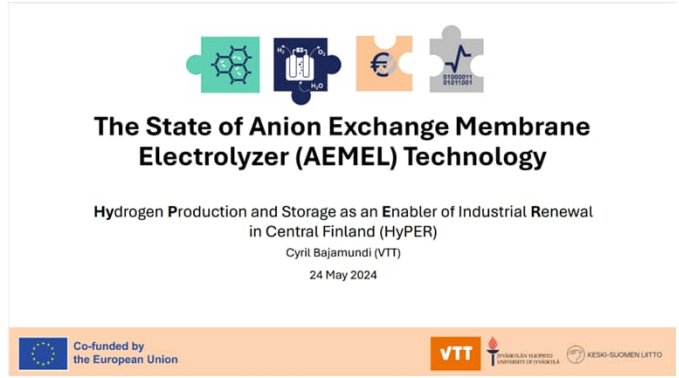
- AEMEL is a hybrid technology that combines the merits of PEMEL and AEL while mitigating many of the risks associated with current low-temperature electrolysis technologies.



- Critical Technical Review of AEMEL



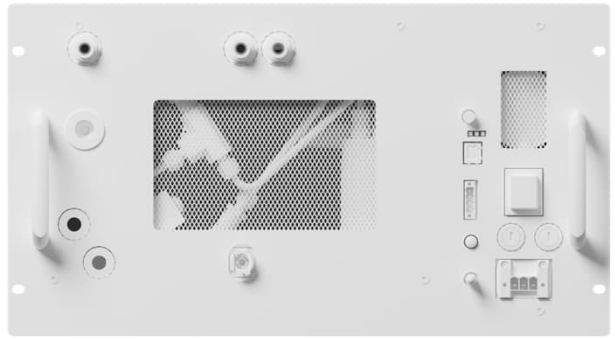
- Top Companies and AEMEL Technology and integration

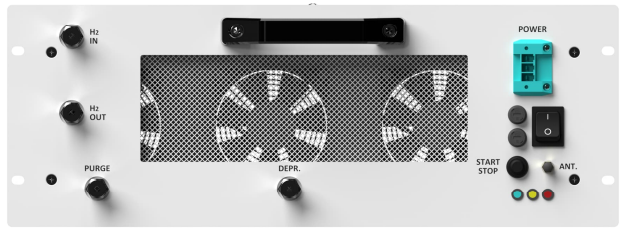


AEMEL Electrolyser Unit

Hydrogen production unit using Anion Exchange Membrane Electrolysis Technology

- Production rage: 1000 NL/h (~1 k/day)
- H_2 output: 99,9 %, 35 bar g (before drying)
- Power consumption: 4.8 kW(nominal)/ 6 kW (peak)
- Liquid cooled system
- Fully automated operation + SCADA for Data Acquisition





Main objectives:

- Understand complete system design of AEMEL based H_2 production.
- Apply best safety practices of H_2 production planning and design
- Understand heat recovery from electrolyser
- Create infra for digitalization and modelling of AEMEL system

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Hydrogen Compression and Storage

Hydrogen compressor plus Storage tank

- Pneumatically driven booster pump
  - Nominal Flow: 4 Nm^3/h
  - Max operating pressure: 55 bar g
  - Head of compressor: 20 bar

- Composite tank for storage
  - Storage pressure: 55 bar g
  - Working pressure: 250 bar g
  - Volume: 612 L

- Enclosed in a 10 ft sea container

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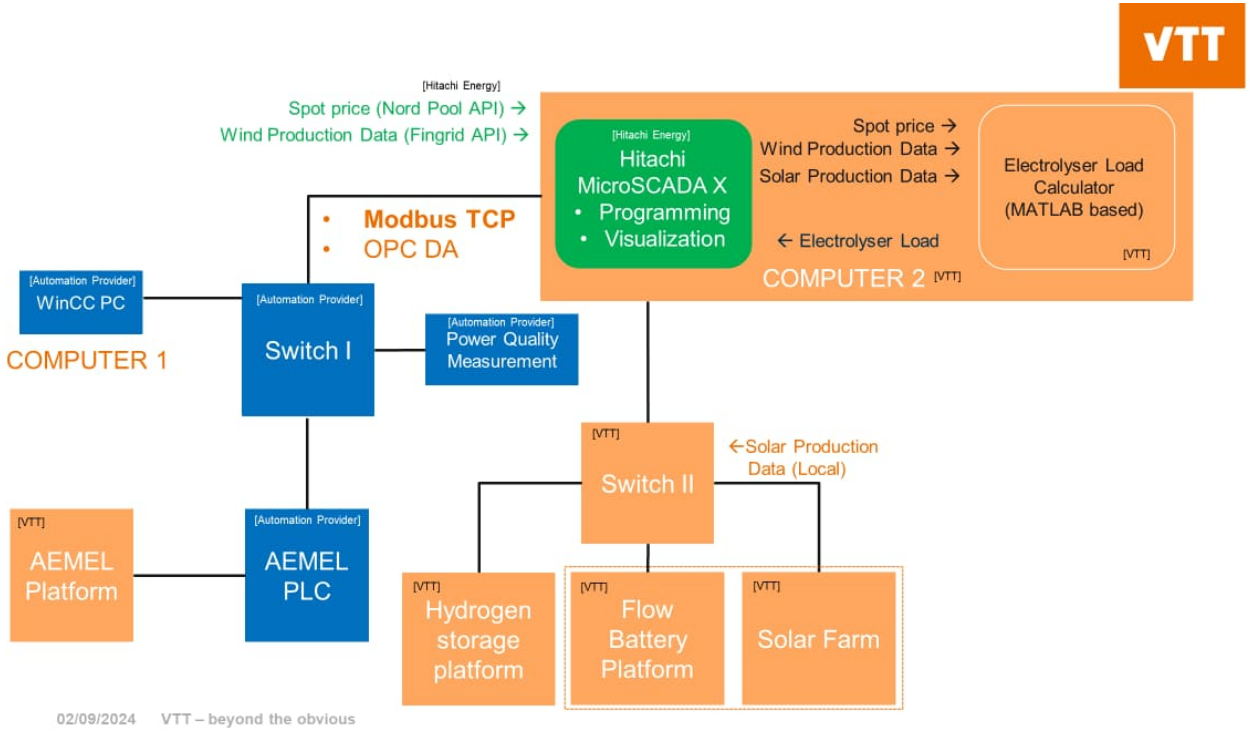
Supervisory control and data acquisition system

Completed Task

- Control and Logic Diagrams
- Function Description
- Offer request / Selection of electrical and automation work supplier

- Electrical Cabinet has been modified and ready for testing
- Automation programming on-going
- SAT on mid-October



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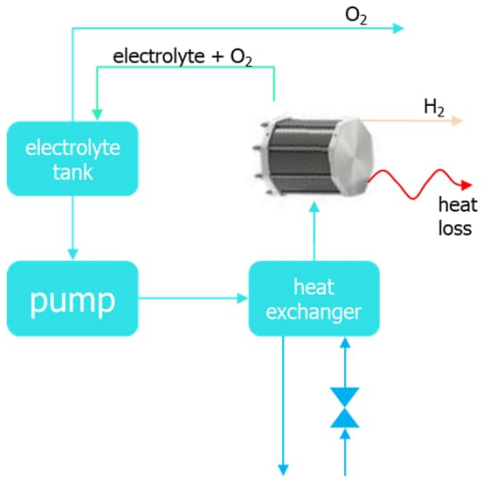
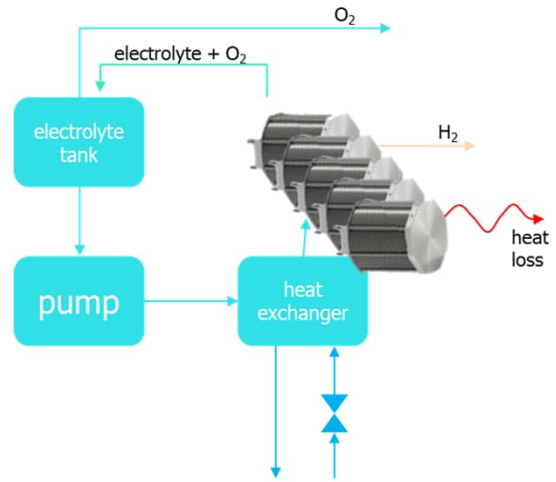
Development of dynamic system model

kW scale



MW scale



Number of stacks	1	420
Nominal power	2.4 kW	1.0 MW
H_2 production	500 Nl/h	210 Nm^3/h
Electrolyte cooling loop	Oxygen electrode	Combined oxygen electrode
Purpose	Model validation	Large scale dynamics

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Future work

- Experimental unit implementation and operation
  → kW unit model validation
  → operation optimization
- Further develop large scale concept model
  - Electrical connection → heat integration
  - Hydrogen processing → dynamics
- Experimental and Apros data for system identification
- Scenario simulations
  - Wind farm connection

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Business case concept analysis
(M8-M21)

Purpose of this task is to evaluate the feasibility of the selected cases.

1. Small-scale: H_2 refuelling station

- Jyväskylä is a logistical knot for South-North and East-West traffic making it an obvious location for a H_2 refuelling station
- Hydrogen economy's first steps in Jyväskylä area will be transportation applications

2. Large-scale: P2X

- There are no large-scale utilizers for hydrogen in Central Finland → Hydrogen should preferably be converted into a product that has a market
- We have a lot of *biogenic* CO_2 e.g. from CHP plants in JKL and *waste-heat* can be utilized as district heat making methanol (or methane) an attracting option

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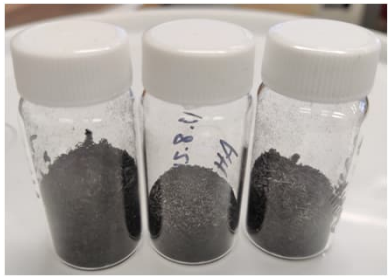
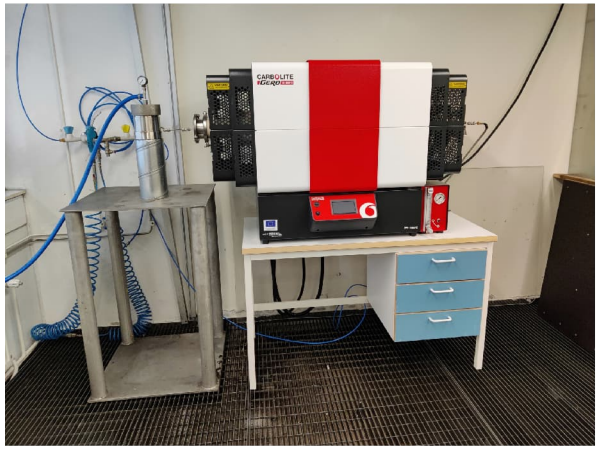
Task 4.1 Porous carbon materials





Task 4.2 Metal Organic frameworks

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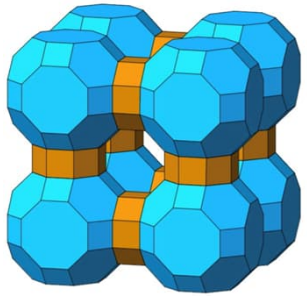
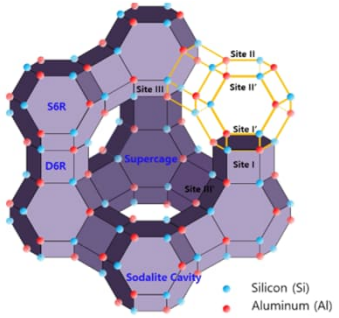
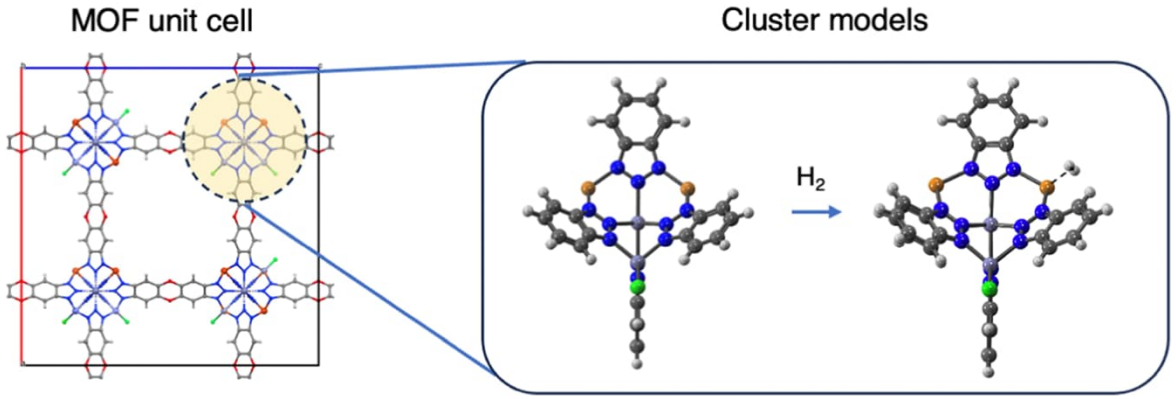
Task 4.3 Zeolites



A-type Zeolite



Y-type Zeolite



- The main objective of the experimental part of the Task 4.3. is to utilize recycled zeolites.
- Computational methods are aimed at determining the key geometric and chemical factors in hydrogen storage that affect hydrogen binding. The goal is to use this information in the search for more efficient storage materials.

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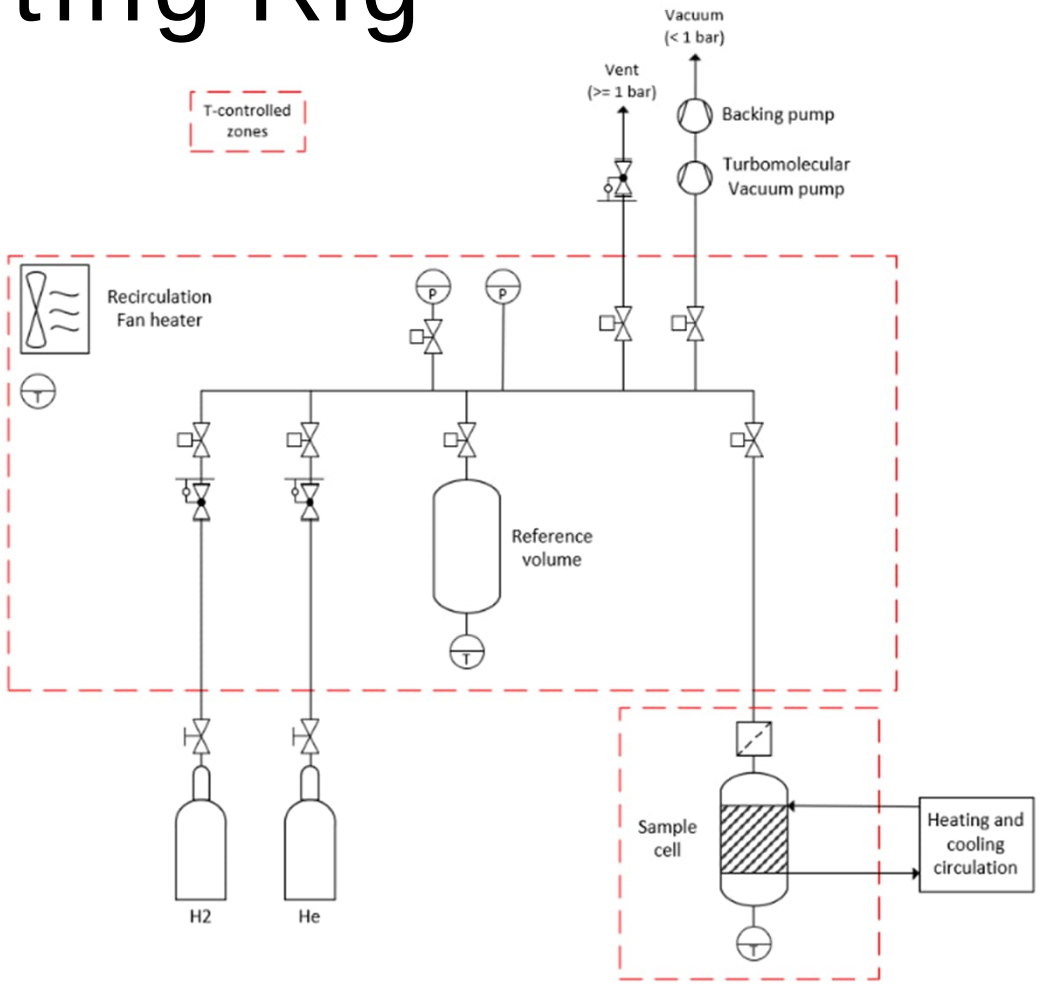
Hydrogen Storage Testing Rig

Device characteristics:

- Gases: Hydrogen (studied gas), Helium (for calibration)
- Samples: Carbon based sorbents, MOFs, zeolites
- Sample capacity: 3-20 g
- Temperature range: -30 to 150 °C
- Pressure range: 0-100 bar
- Measurement principle: Volumetric / Manometric

Main testing objectives for samples:

- Measure H_2 storage capacity in different conditions (T, p)
- Measure storage material durability over time with repeated cycles
- Measure H_2 uptake and release rates



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HyPER consortium

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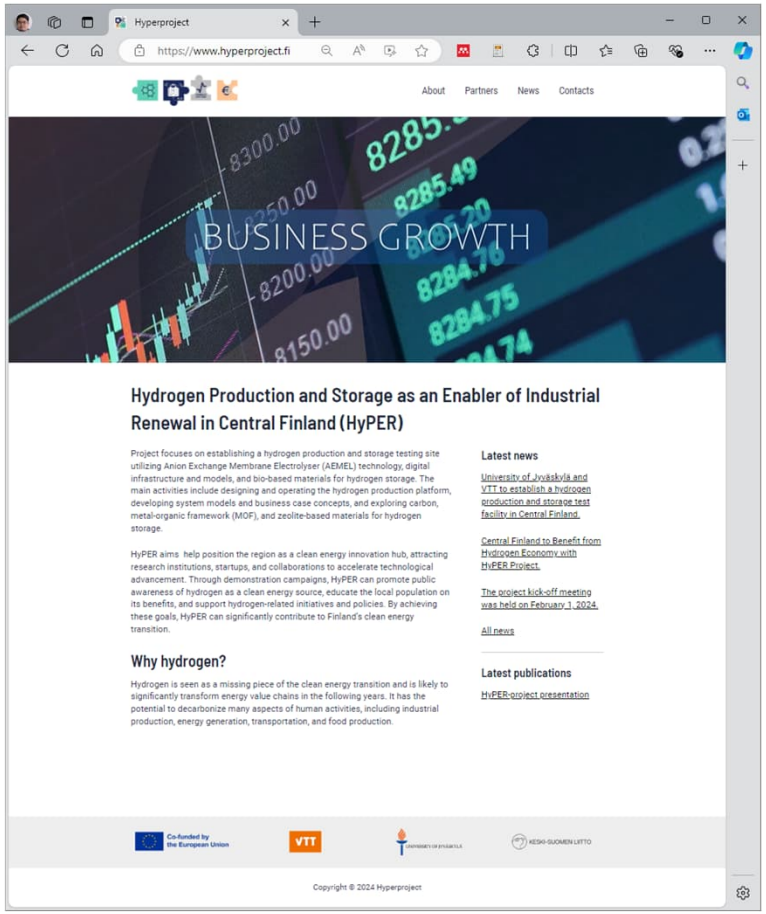
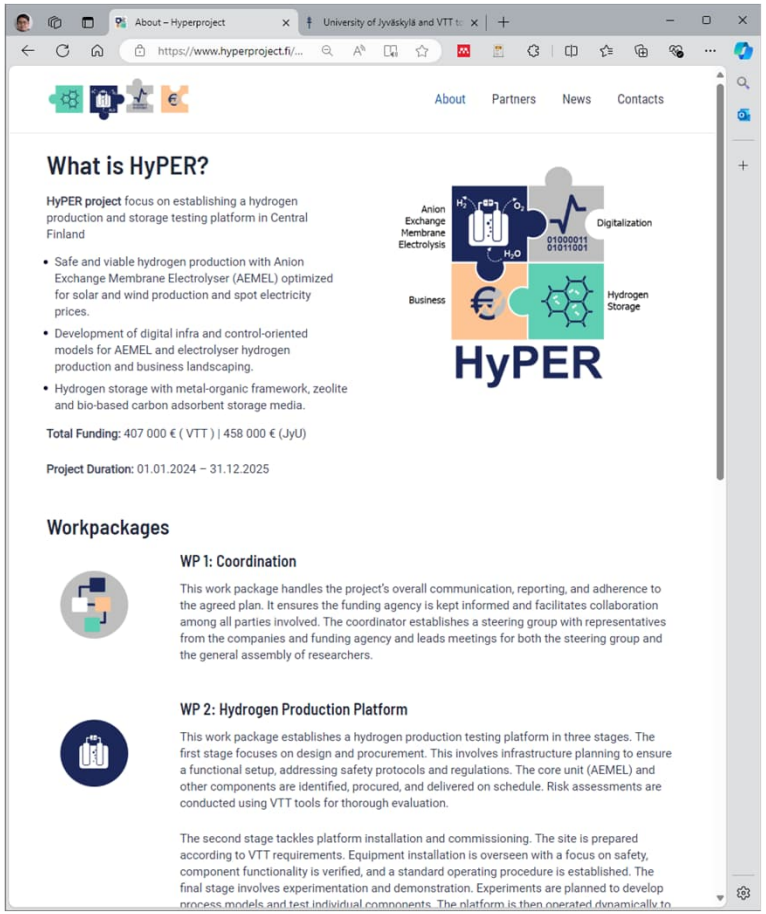
More info:

https://www.hyperproject.fi/





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Thank you!

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