ERA ENERGY RESEARCH ACCELERATOR

NET-ZERO HEROES

@EnergyRA #energyleaders

Christmas Special: Wednesday 14 December 2022

During this Net Zero Heroes webinar each of the ERA Universities will highlight the research, innovation and commercial developments in green energy that have taken place at their institution during 2022

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Aston University
Patricia Thornley

Supergen Bioenergy Hub

Supergen | Bioenergy

Biomass-to-hydrogen *Policy Briefing*

SBH-Biomass-to-hydrogen-briefing-1.pdf (supergen-bioenergy.net)

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Cranfield University

Highlights include:

- [HyPER](#) construction underway and completing 2023 – project build photos are now on the web site.
- Hydrogen showcase
- PIRI (Peterborough Integrated Renewables Infrastructure) project completed
- H2-BECCS – joint industry/university Hydrogen research workshop
- C-DICE training events for Post-docs and end stage PhD students.

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Keele University
Charles E. Creissen

Sustainable Electrolysis

Fuels from Waste using Renewable Electricity

Dr. Charles E. Creissen

@ccreissen

CreissenLab.com

Keele UNIVERSITY

Sustainable Electrolysis

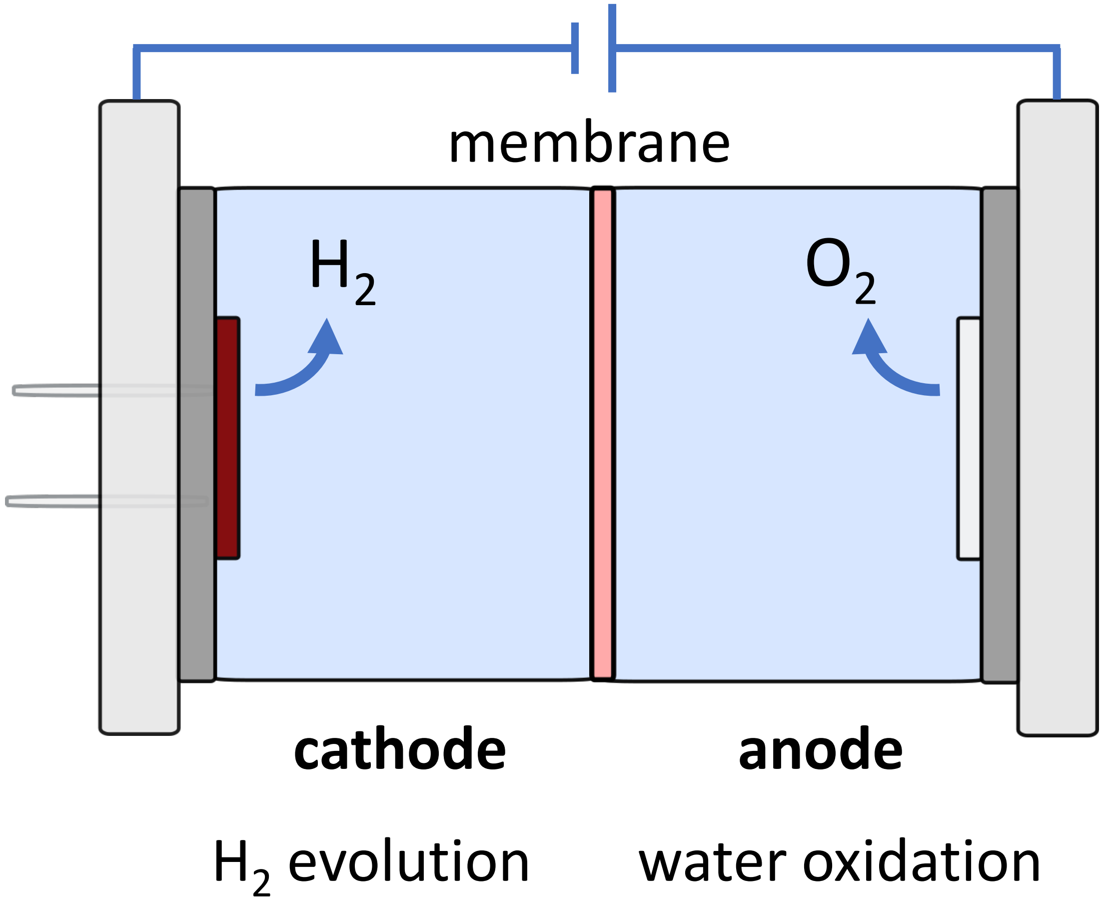
What makes the process sustainable?

1. Renewable
2. Lower Emissions
3. Continuous

Electrochemical CO_2R Cell

Green Hydrogen Production

- ◎ **Green H_2** is a fantastic fuel formed from water and **renewable electricity**
- ◎ Can be stored, transported, and converted to electricity
- ◎ Rate of production = **current**
- ◎ Electricity input = **voltage**



Electrochemical CO_2R Cell

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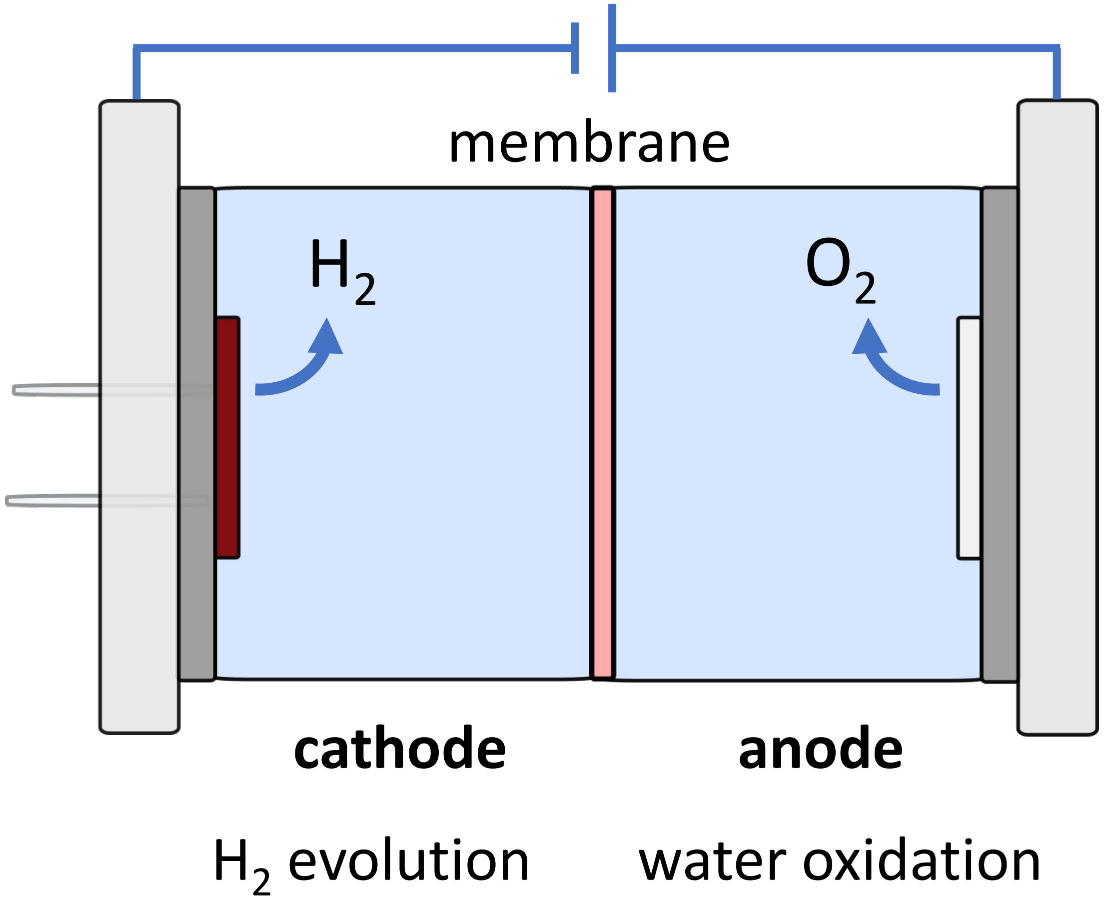


The **high voltages** for common water electrolysers **increase the cost** of operation

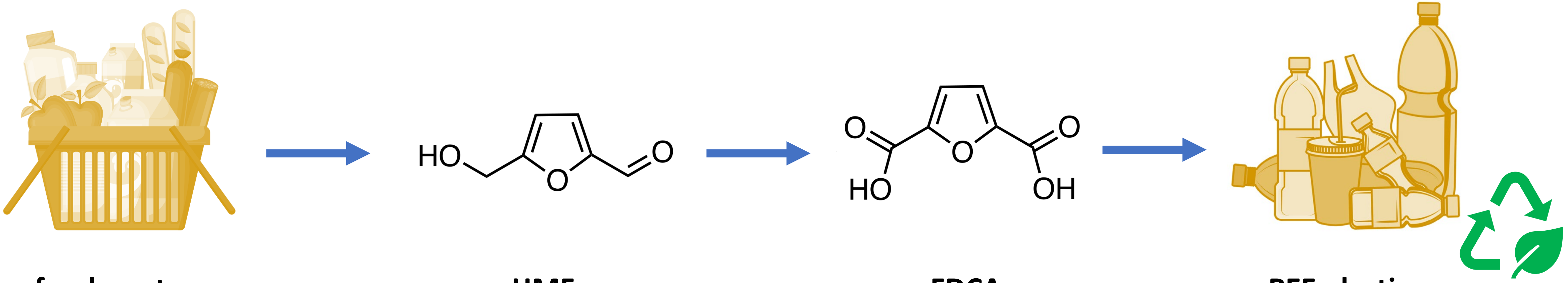
Electrochemical CO_2R Cell

Waste Oxidation

- ◎ The cause of the **high voltage** is oxygen evolution which also generates **low value oxygen** which is typically vented

- ◎ Can replace oxygen evolution with waste oxidation – one example is HMF

- ◎ HMF oxidation to **FDCA** (a bioplastic precursor) occurs with **lower voltages**

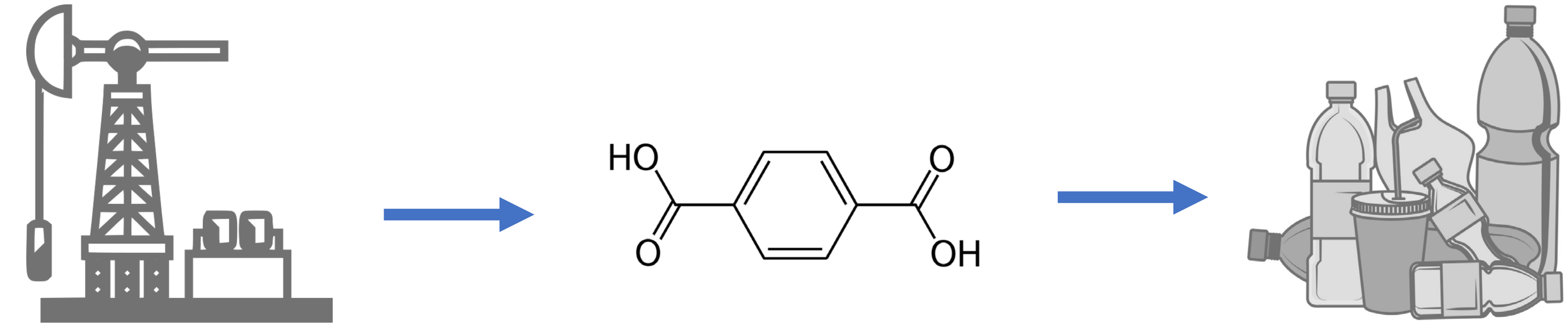


food waste **HMF** **FDCA** **PEF plastic**

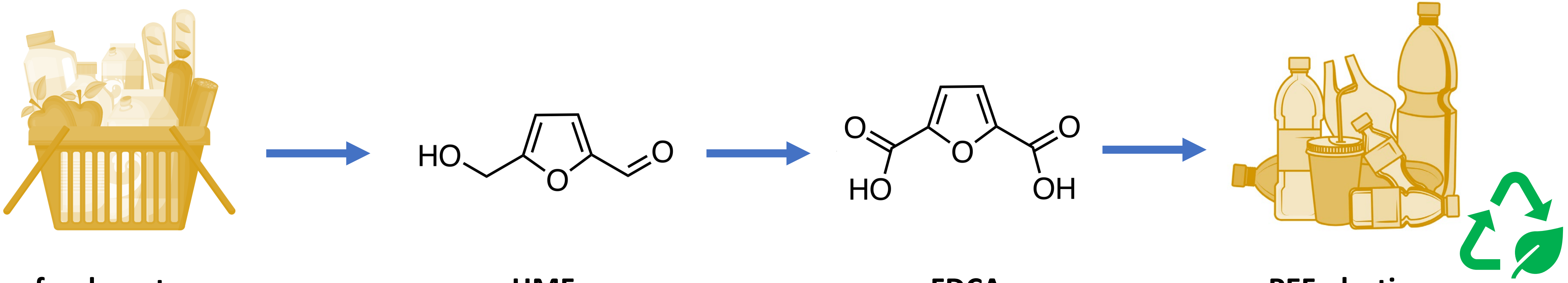
https://www.staffordshire.gov.uk/Waste-and-recycling/Types-of-waste/Food-waste.aspx

Electrochemical CO_2R Cell

Waste Oxidation



crude oil — terephthalic acid — PET plastic



food waste — HMF — FDCA — PEF plastic

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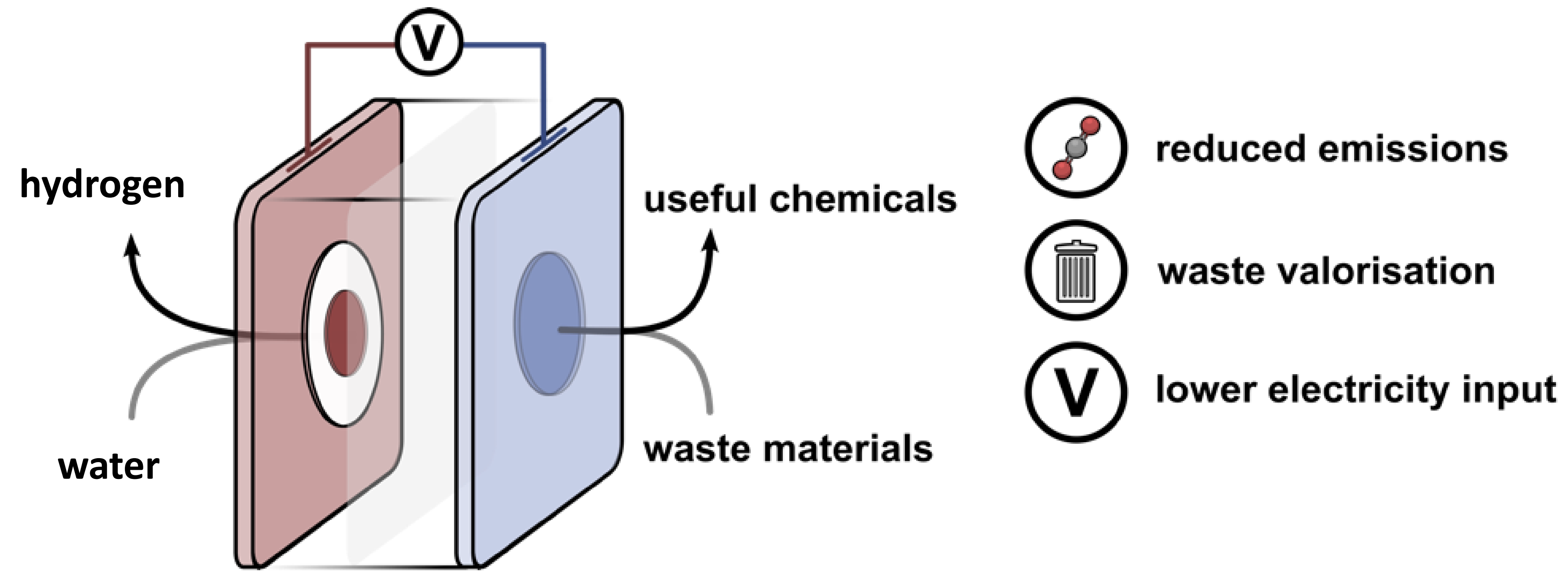
Electrochemical CO_2R Cell

Sustainable Electrolysis



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Keele
UNIVERSITY

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Loughborough University

Michael Walls

Solar in the UK and progress with Anti-Reflection and Anti-Soiling coatings for solar modules

Michael Walls

CREST, Wolfson School of Mechanical, Electrical and Manufacturing Engineering
Loughborough University ,UK

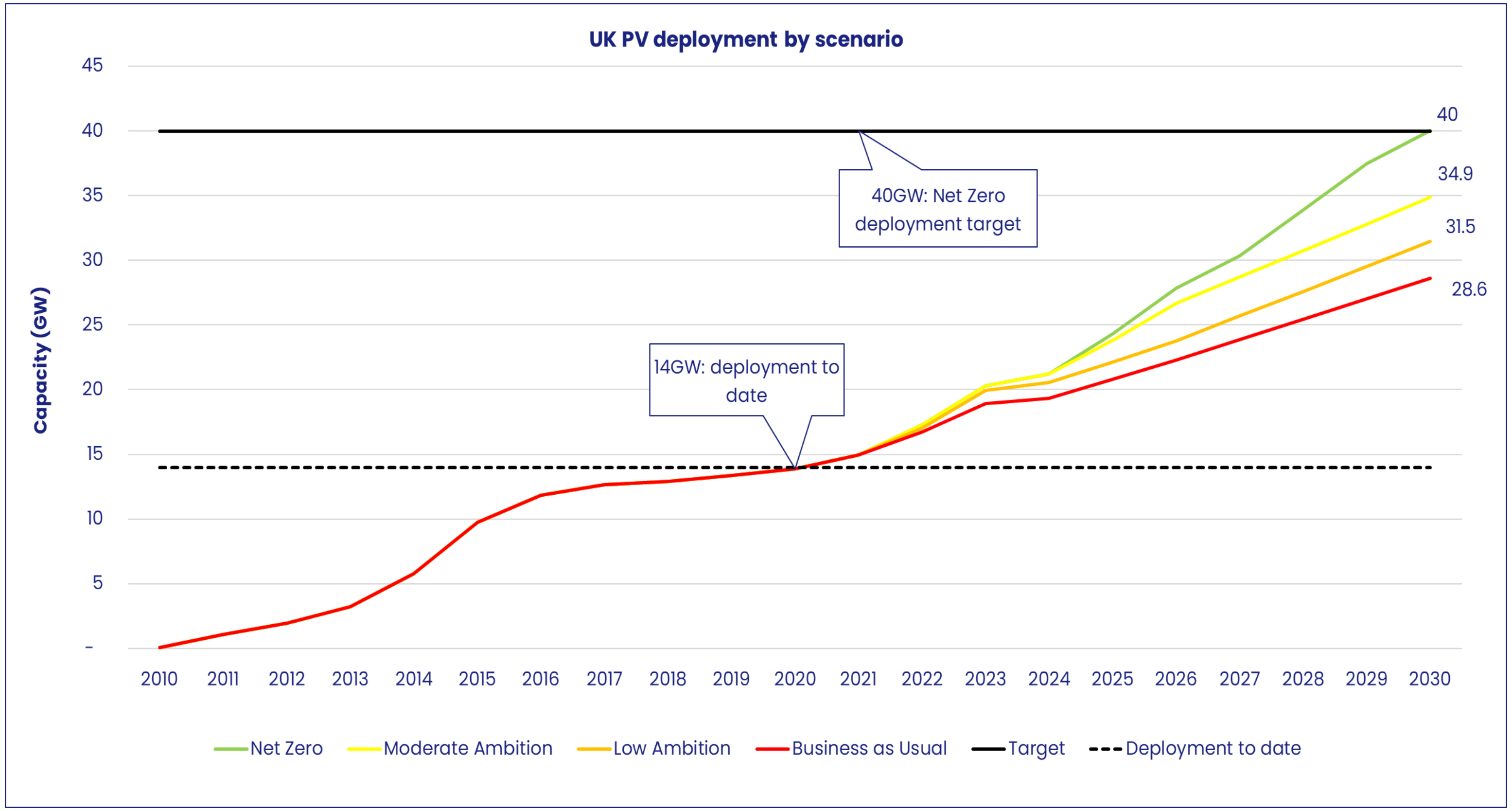
j.m.walls@lboro.ac.uk

Whistle stop tour, 14th December 2022

SUPERGEN SuperSolar

Loughborough University

Solar Energy UK 2030 Scenarios



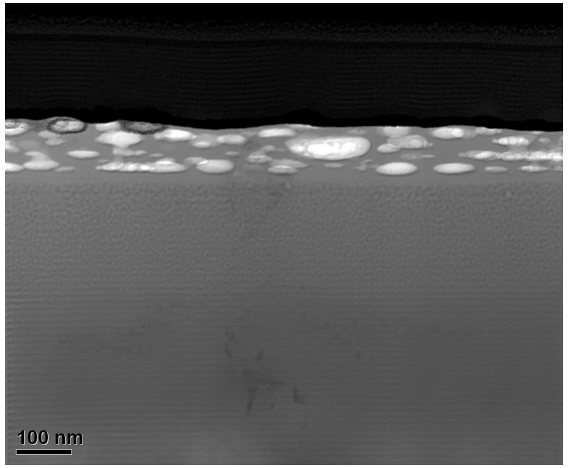
Industry scenarios BEFORE the energy price crisis were to reach 40GW by 2030

British Energy Security Strategy now anticipates up to 70GW by 2035

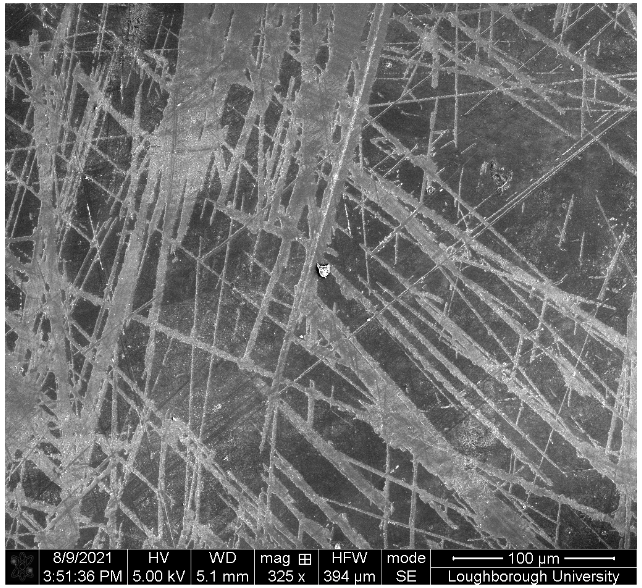
If global gas prices stay high then this trajectory is more than possible

Reflections reduce power output from solar modules

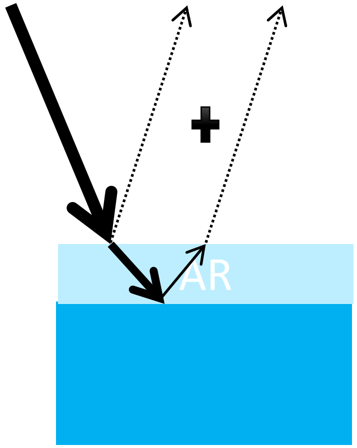
- Reflection from the cover glass surface reduces power output by ~4.1%
- Coatings are exposed to outdoors 24/7
- Solar modules are subject to regular cleaning and maintenance causing wear and tear.

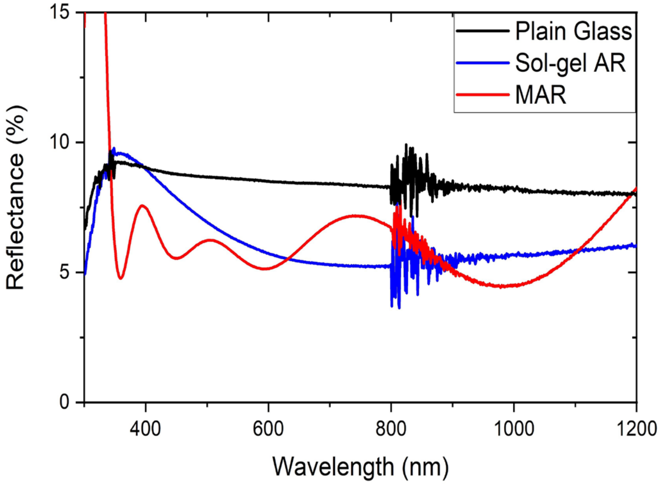


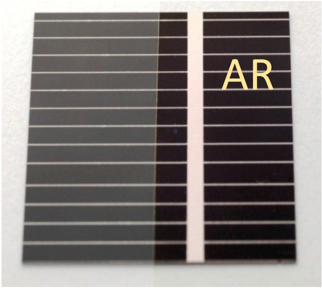
Single layer porous silica

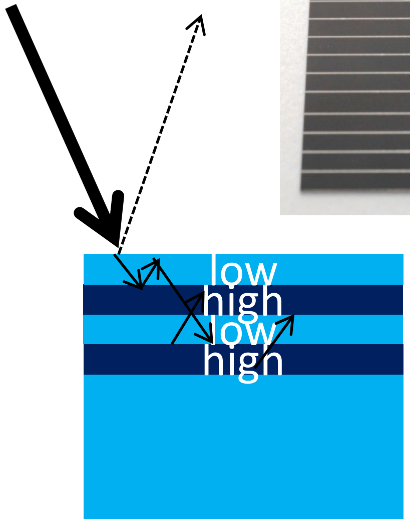


Damaged coating after ~6 years

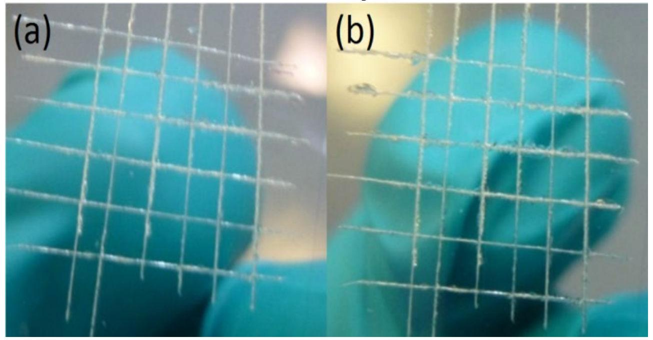








Broadband Multilayer SiO2/ZrO2



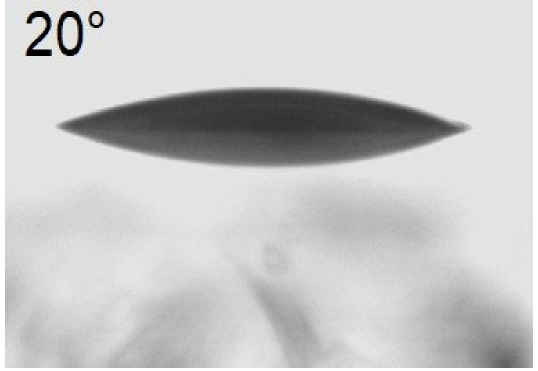
cross-hatch test

Weighted Average reflectance:

a) **Uncoated 4.1%**
b) **Single layer porous silica 1.9%**
c) **Broadband multilayer 1.7%**

Anti-Soiling coatings increase power output from solar modules

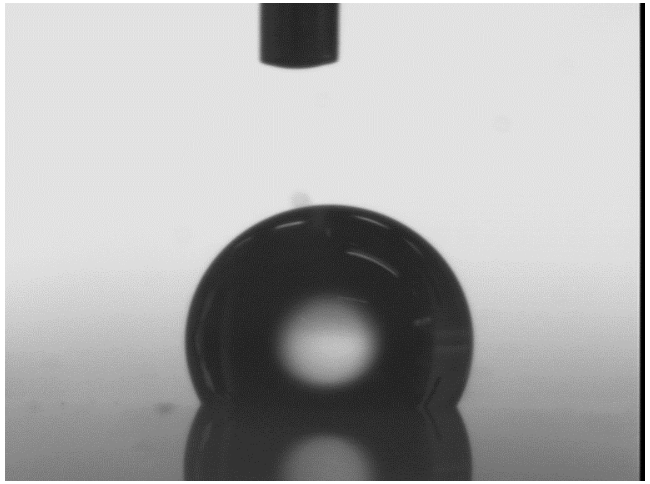
Soiling of module cover glass in a UK solar utility (image courtesy of Solar Farm Cleaning)



Current porous silica AR coatings are hydrophilic (high surface energy)

Solar farm following snowfall- which panel has a hydrophobic coating ?

- Soiling attenuates light into the solar module.
- Causes ~5% losses in the UK and up to 50% in arid regions.
- Proof of principle established for use of hydrophobic coatings.
- Challenge is durability.



Hydrophobic coating with 115^0contact angle and 25^0 roll-off angle

- EPSRC funded project between CREST and UCL to develop a durable inorganic anti-soiling coating.
- Patent application on a UV-resistant polymer

The coated panel has less soiling residues

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University of Birmingham
David Boardman

UNIVERSITY OF BIRMINGHAM

Sustainability
Research that Matters
Education for Sustainable Futures

The Birmingham Energy Institute

Steering the National Conversation with ERA

Creating the Opportunities

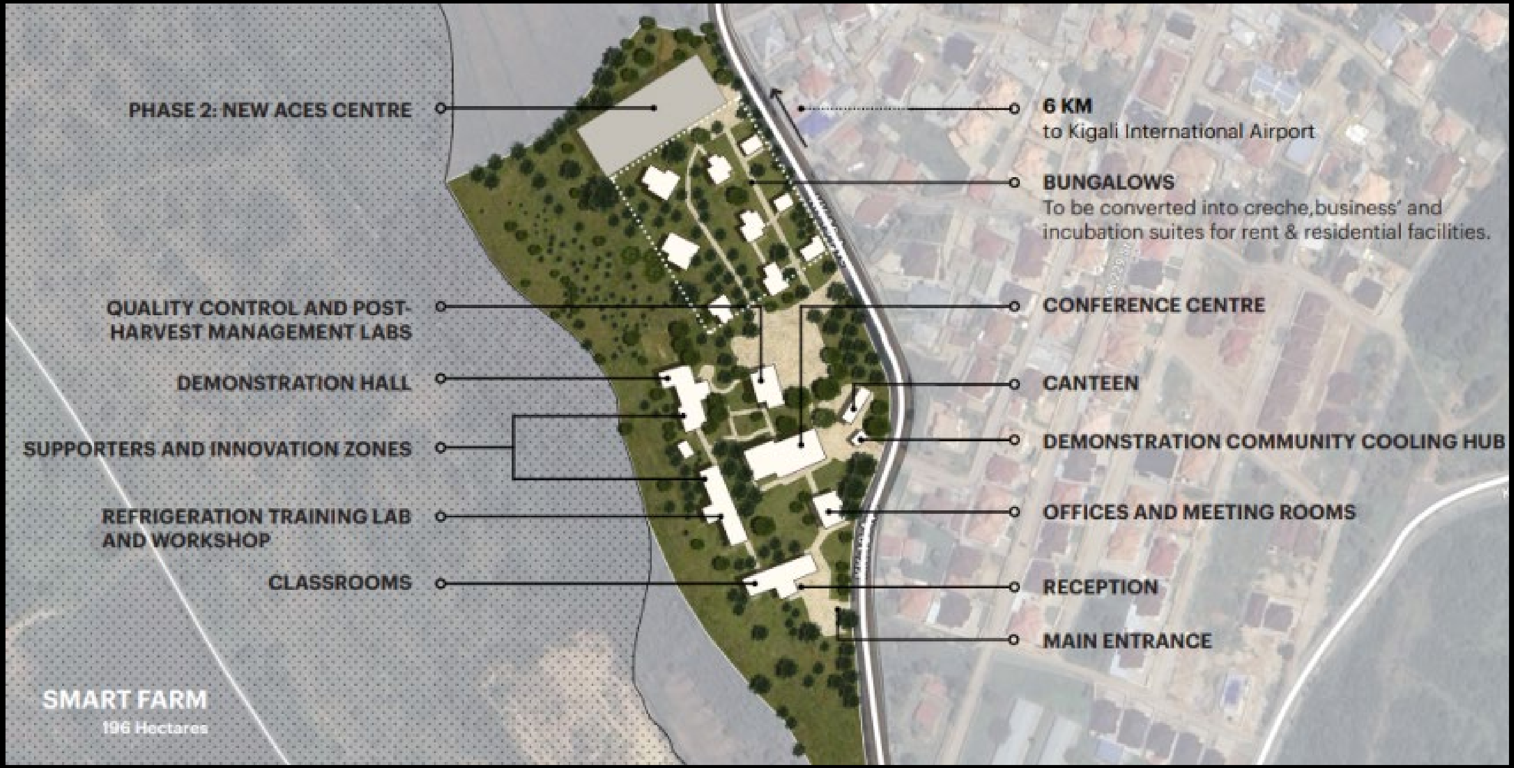
Established Major International Research and Innovation Assets

£6m from EPSRC but closer to £50m true value

Africa Centre for Sustainable Cooling

Consortium led by Birmingham, Cranfield, LSB and Heriot Watt. Now £15m Investment in Africa. University of Rwanda – Rubirizi Campus

Delivering UN SDGs



UNIVERSITY OF BIRMINGHAM

Sustainability
Impacting People and Culture
Education for Sustainable Futures

Transforming Our City and Region
Energy Innovation

Local Growth Fund £7m

Ammonia Cracker £7m

Driving the Electric Revolution £4.3m

HSBC £2m Climate Innovation Programme

Submitted Levelling Up Fund £20m NCDH

UNIVERSITY OF BIRMINGHAM

Civic and Global
Engagement and Impact
Impacting People

Energy Innovation Campus - Living Laboratory

UNIVERSITY OF BIRMINGHAM

Sustainability

Education for Sustainable Futures

Delivering the 2030 Strategic Framework

Research That Matters
Education for Sustainable Futures
Engagement and Impact
Civic and Global
People and Culture
Sustainability

The Birmingham Energy Institute has reached a structural and new growth threshold.
Energy crisis driving the economic downturn creates ideal conditions for the BEI.

The Birmingham Energy Institute

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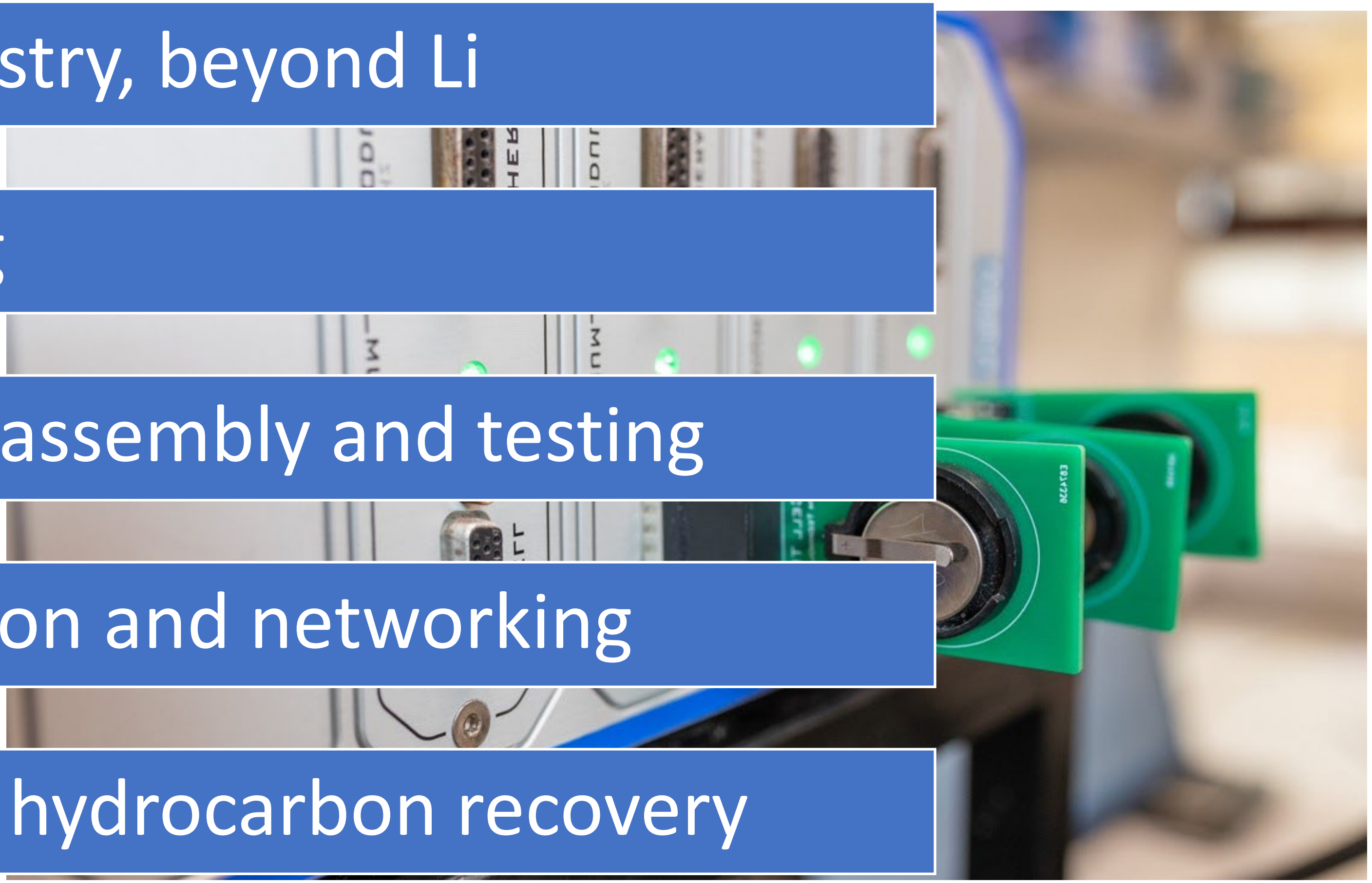
University of Leicester
Karl S. Ryder

Green energy at Leicester



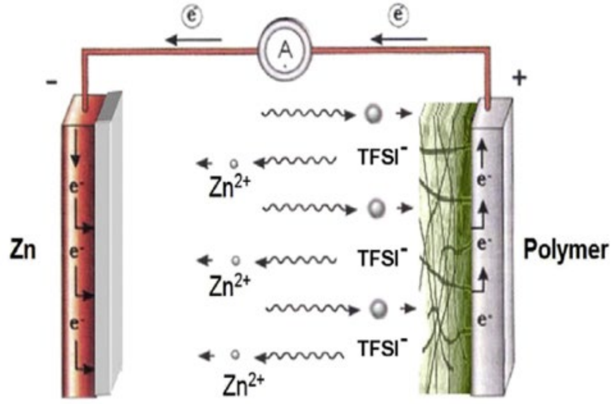

- New battery chemistry, beyond Li
- Battery recycling

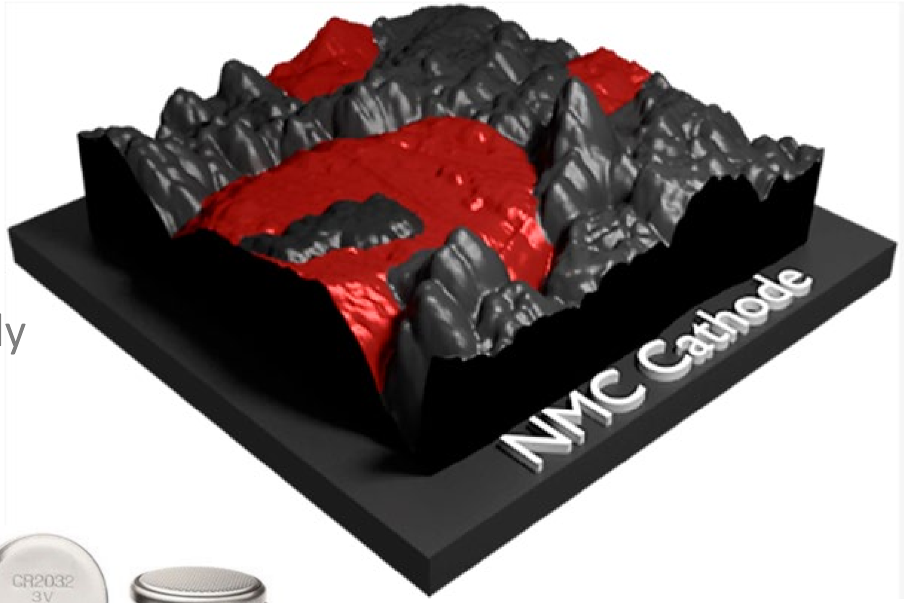

- Small-scale cell assembly and testing


- Energy distribution and networking


- Energy generation, hydrocarbon recovery

Energy storage and novel solvents

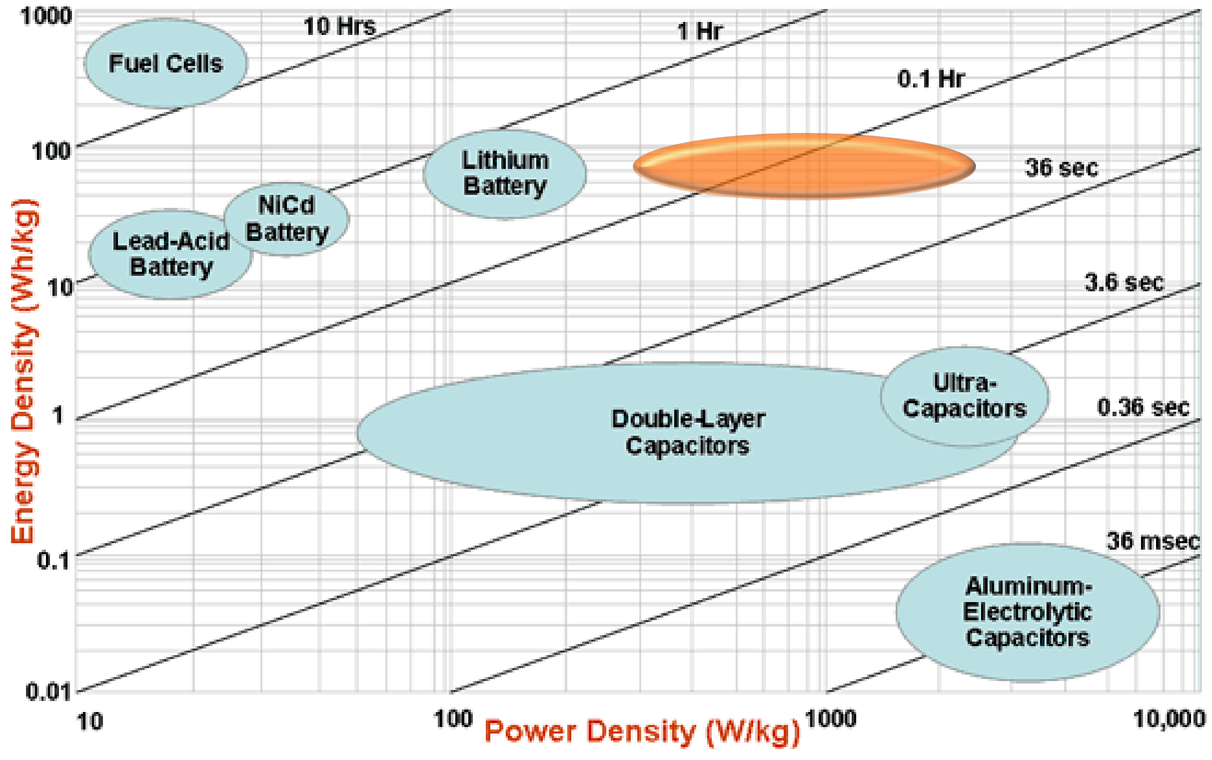




- New battery chemistries
- Cheap abundant materials
- Safe, electrolytes, not environmentally damaging
- Cell development
- Cell testing
- Materials recovery and recycling
- EU and UK Gov. funding

What makes a good battery?

- Energy is the product of voltage and capacity
  How much?
- Power is the product of voltage and current
  How quickly can one delivery it?
- Density factor is the mass of the battery
  How heavy?

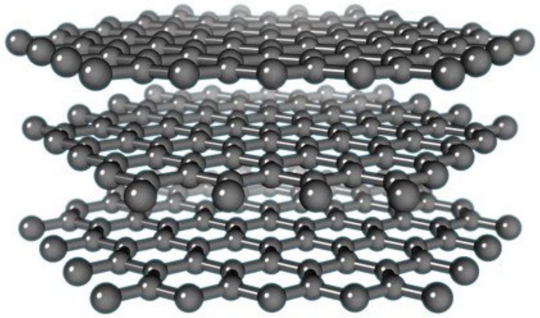


Source US Defence Logistics Agency

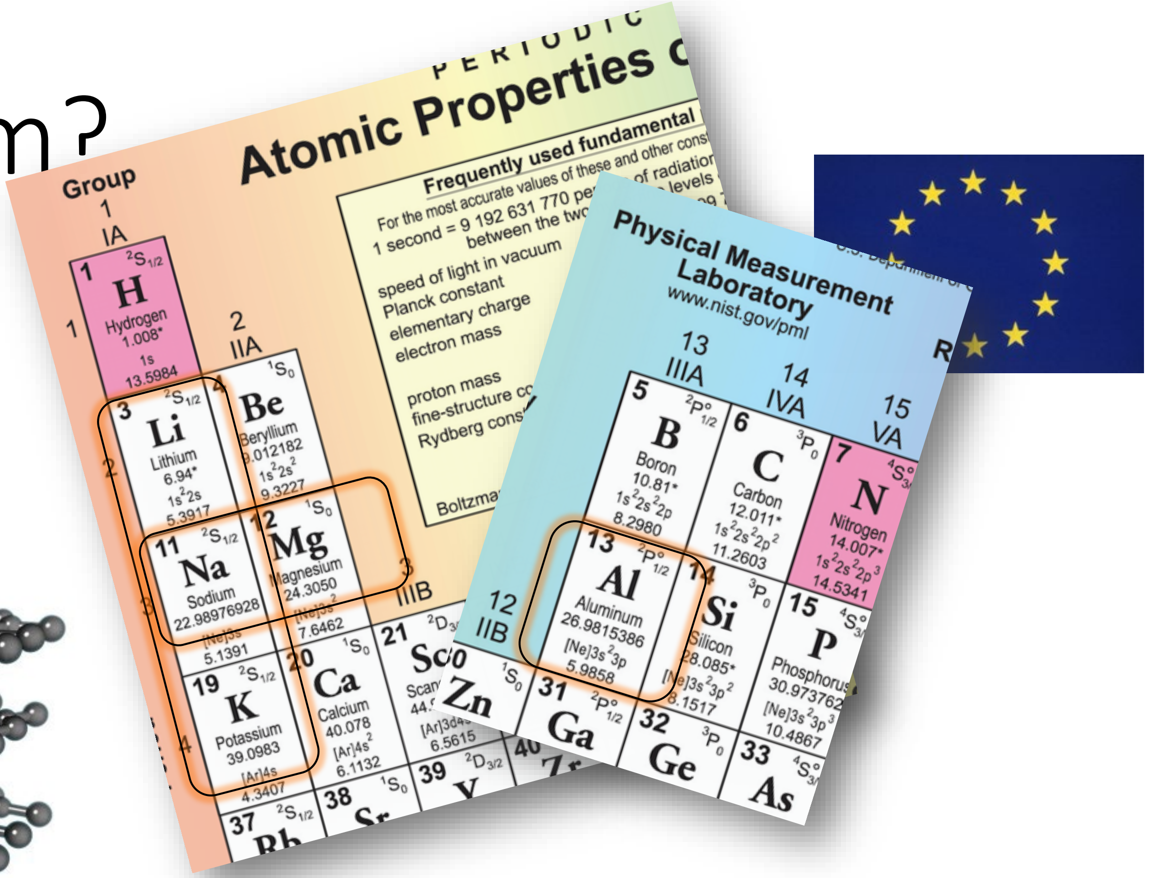
What’s wrong with Lithium?

Li is in limited global supply. Mineral reserves are concentrated in remote regions or areas of geopolitical sensitivity.

We need a technology *beyond Li* for the next generation of batteries



Graphite



Al chemistry is very complex and difficult. Also existing technologies use flammable organic solvents

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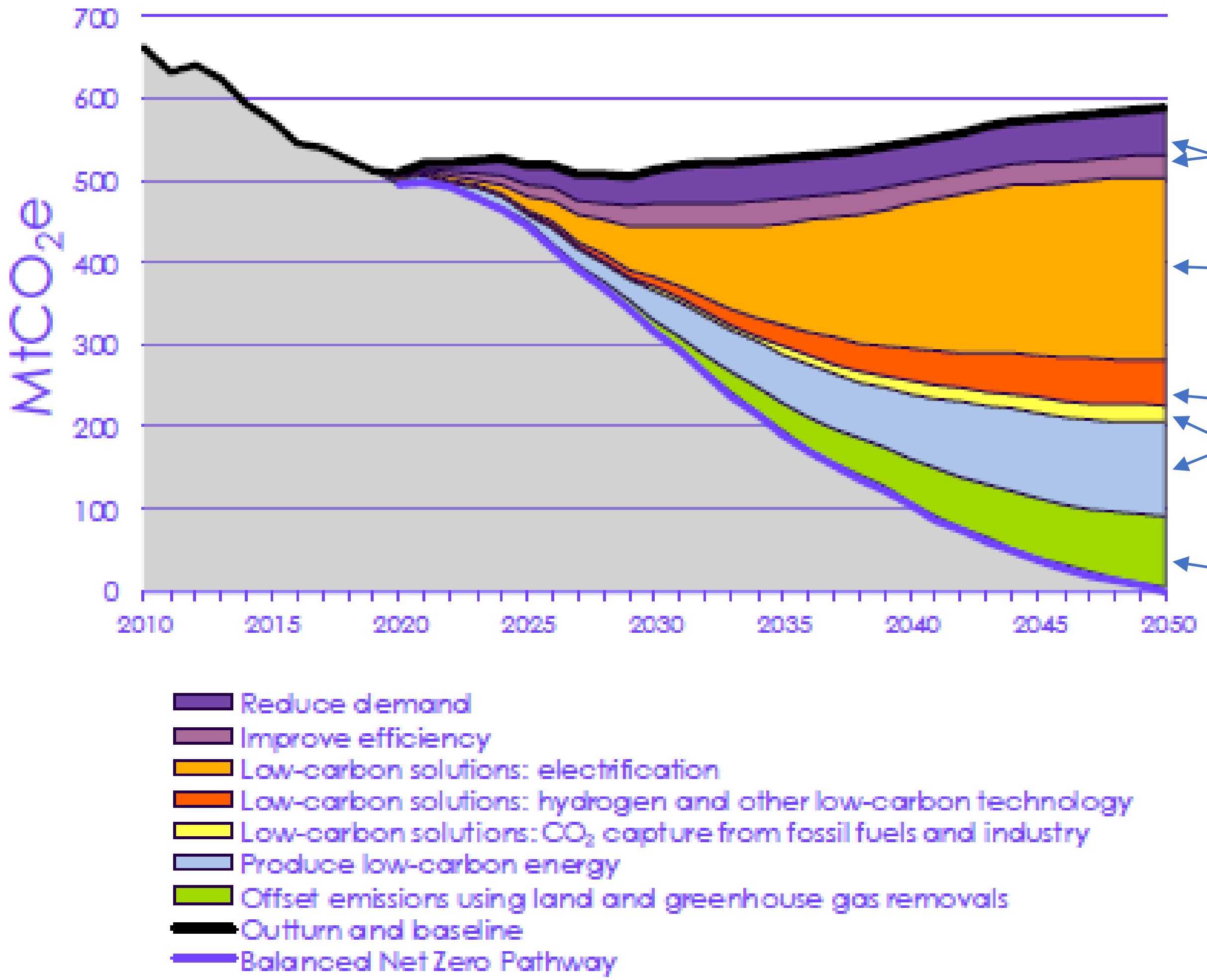
University of Nottingham
Simon Gerrard

Figure 4 Types of abatement in the Balanced Net Zero Pathway



Source: BEIS (2020) Provisional UK greenhouse gas emissions national statistics 2019; CCC analysis.
Notes: 'Other low-carbon technology' includes use of bioenergy and waste treatment measures.
'Producing low- carbon electricity' requires the use of CCS in electricity generation.

Social acceptance of new technology spans all approaches

Direct behaviour change

Electrification – supply and end-use

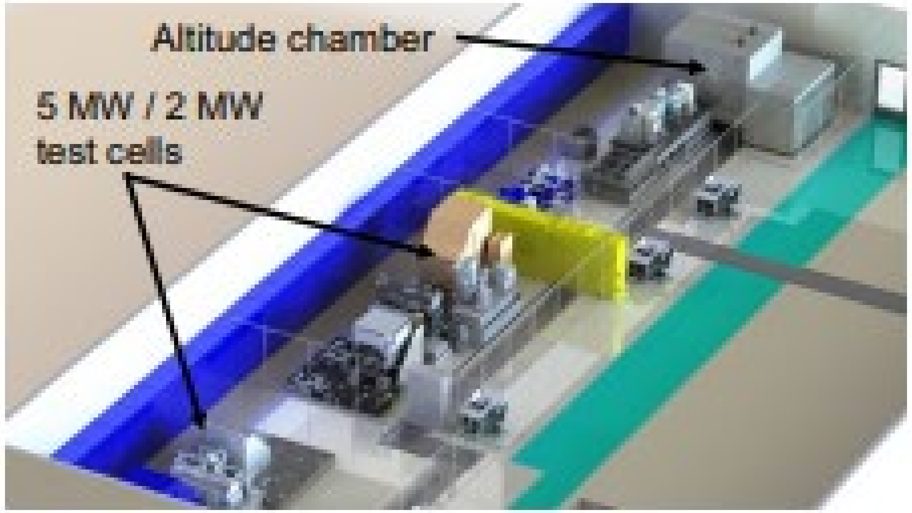
Alternative fuels – H2, NH3 e-fuels etc.

CCUS

Power Electronics and Machines Centre (PEMC)

Enabling translation of capability and technology

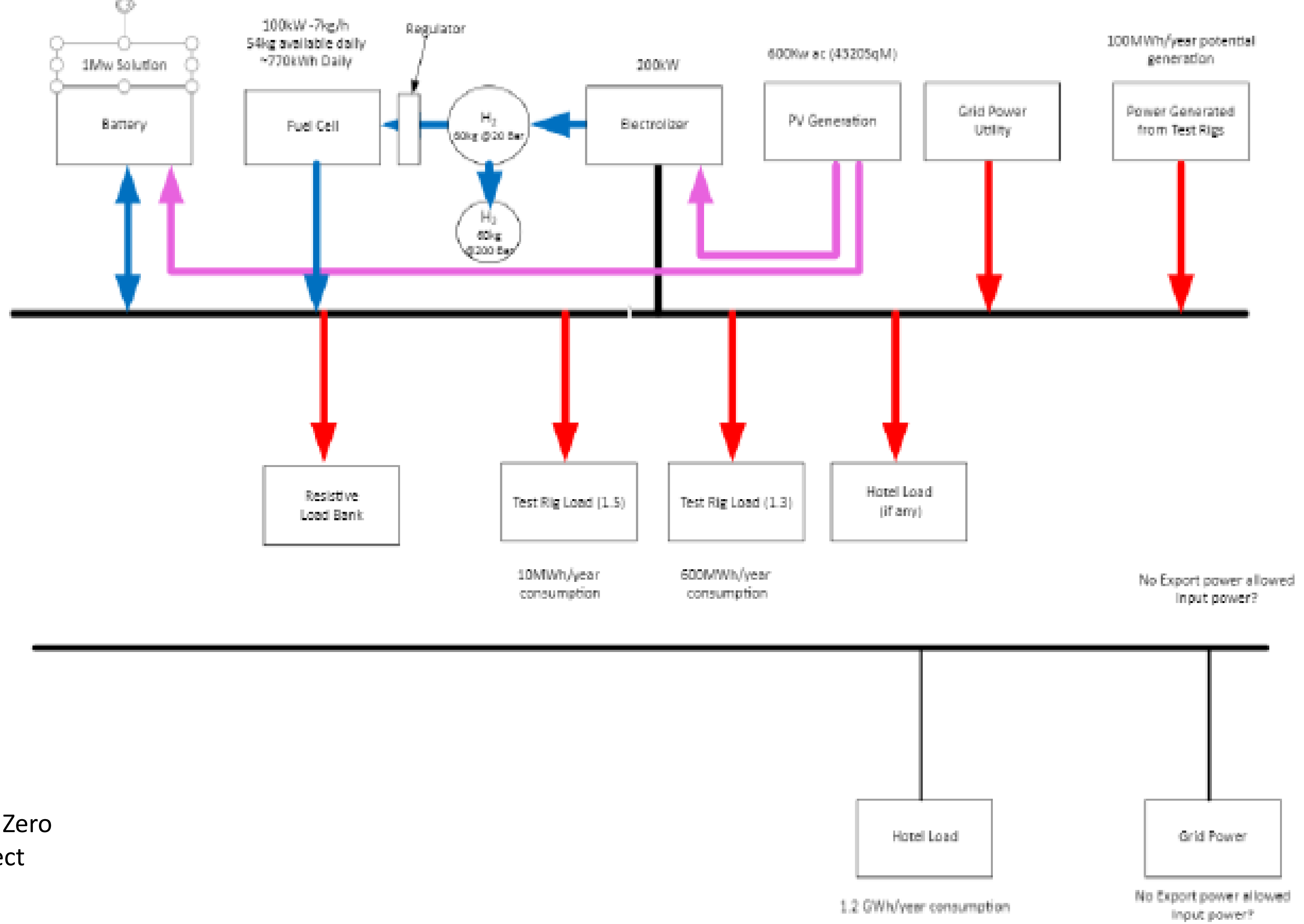
- £40M invested from UoN, DER-IC, D2N2, RPIF, Industry
  for a unique 20MW facility (Regional / Narrowbody aero propulsion scale)
- World's largest academic electrification research group
  21 Academic Staff; 70 Research Fellows; 78 PhD students
- Research, development, manufacturing and test of electrification technologies for automotive, rail, marine and aerospace, for 40+ customers
- 80% of research by funding value is directly or indirectly industry related



Decarbonising the PEMC test facility using a DC microgrid

Scalable, modular, flexible

Wider applications for situations where grid connection is difficult

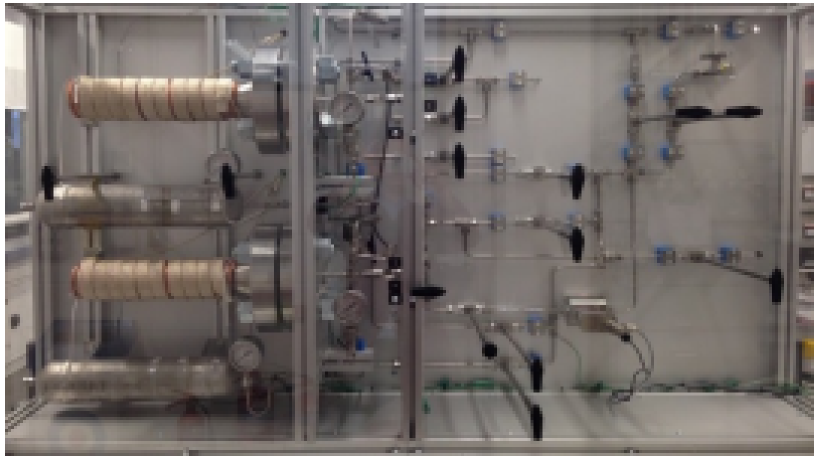


Research England

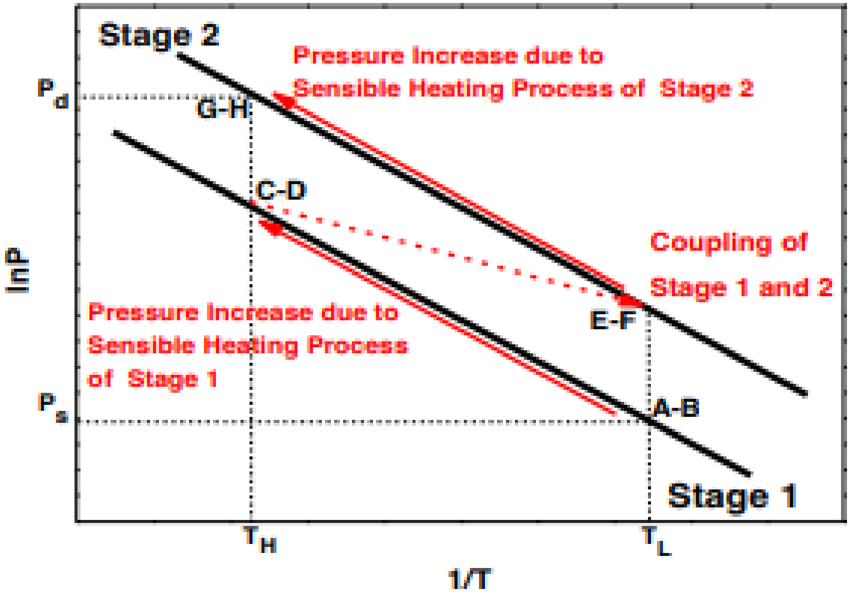
UK RPIF Net Zero Pilot Project

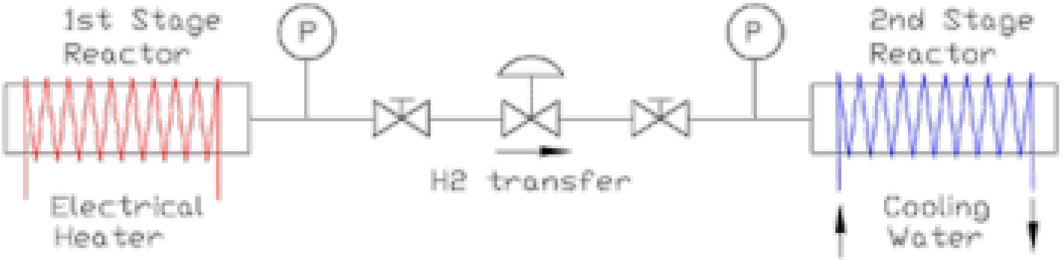
Solid State Hydrogen Compressors (350 bar and 1000 bar)

- Replace mechanical compressor
- No moving parts
- Utilize waste heat
- Only needs modest temperatures 140˚C



Prototype demonstrator





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University of Warwick

Ángeles Rivero Pacho

WARWICK
THE UNIVERSITY OF WARWICK

ERA
ENERGY RESEARCH ACCELERATOR

Christmas Special Net Zero Hero Webinar

Dr Ángeles Rivero Pacho

STET

Sustainable Thermal Energy Technologies

STET team

WARWICK
THE UNIVERSITY OF WARWICK


Jake Locke


Stan Shire


Roger Moss


Zak Tamainot Telto


Bob Critoph


Ángeles Rivero Pacho


Charles Joyce


Sai Yagnamurthy


Steven Metcalf


George Atkinson

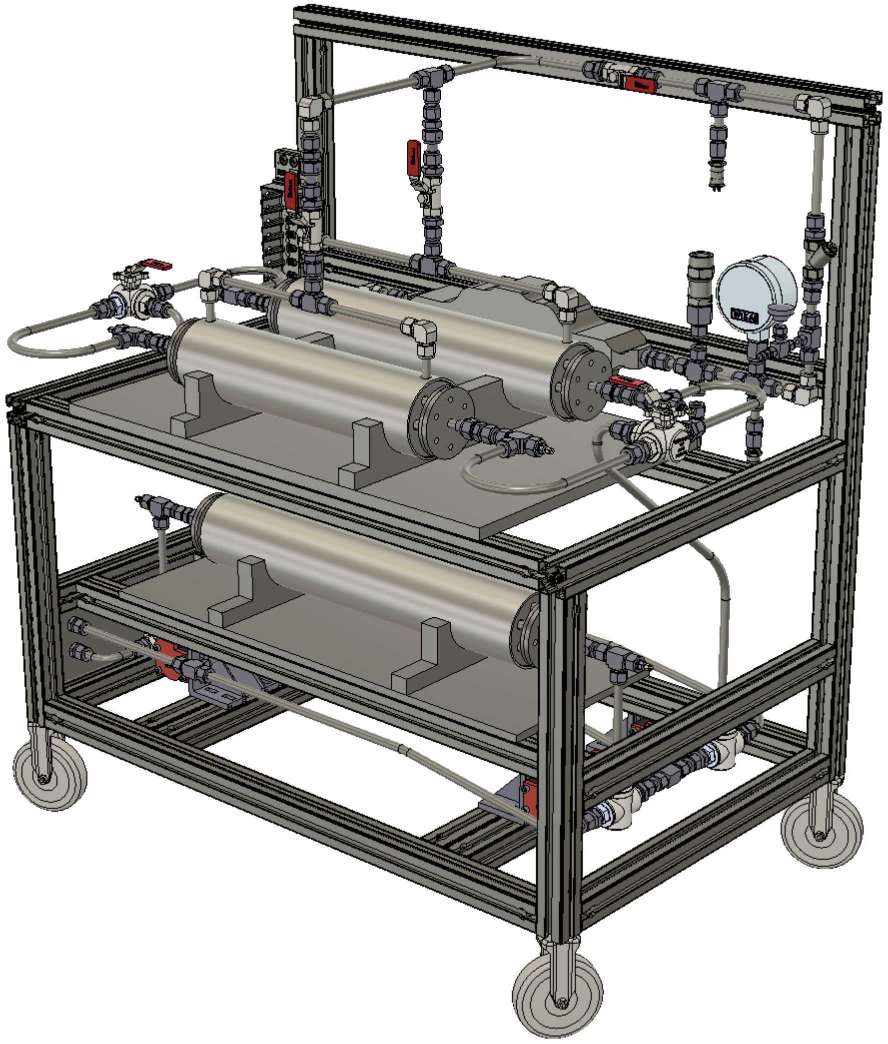
WARWICK
THE UNIVERSITY OF WARWICK

Projects:

- Resorption heat pump (test rig)
- Simulation of a resorption cycle
- HP-FITS (thermochemical heat storage)

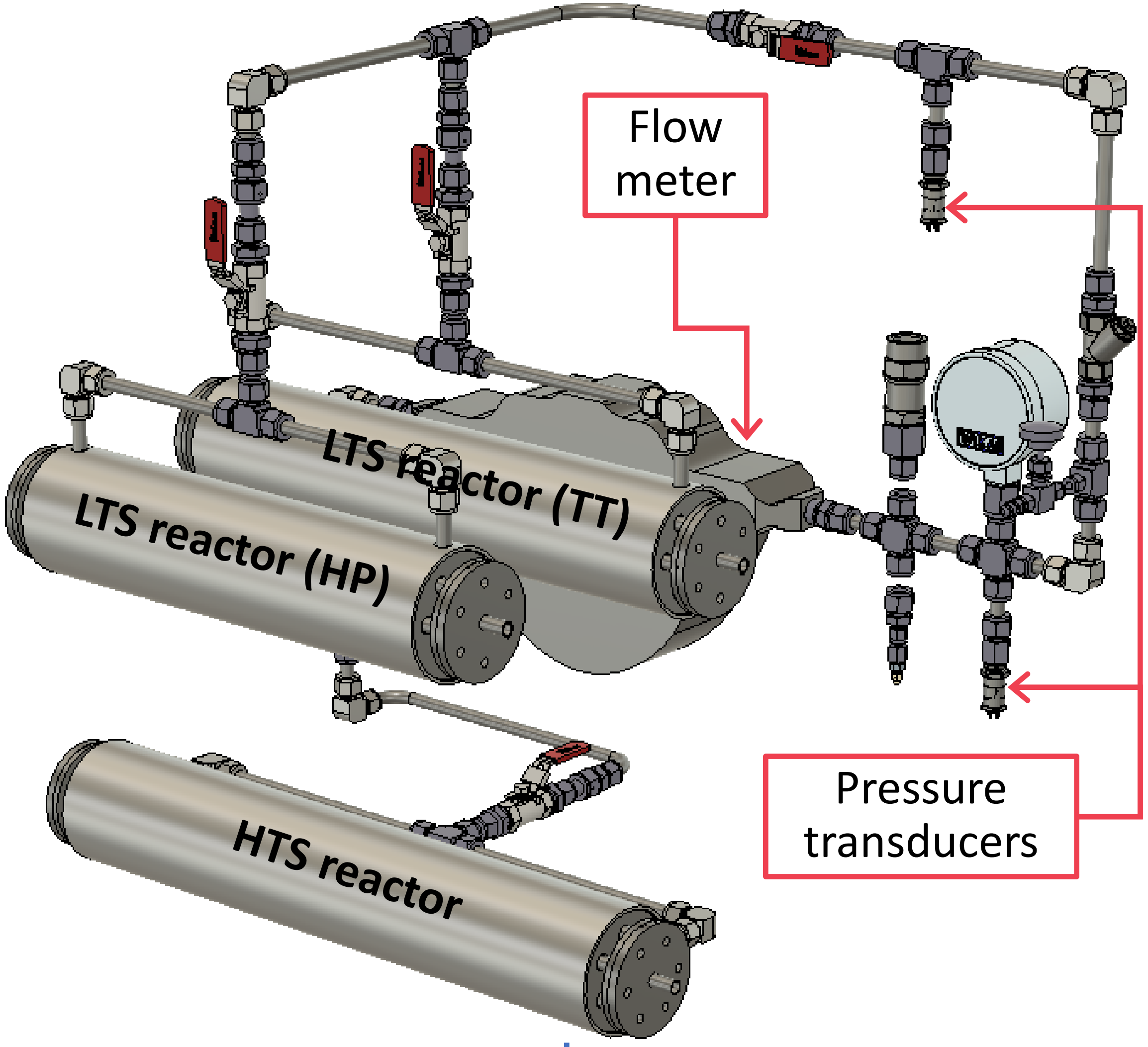
STET Sustainable Thermal Energy Technologies

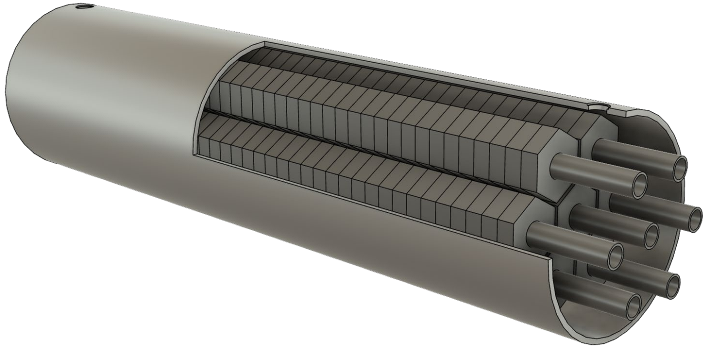
Resorption heat pump



- Shell-and-tube sorption heat exchanger design
- Manganese chloride and sodium bromide salts reacting with ammonia refrigerant
- Simple concept for applications in domestic gas-fired heat pump systems
- Designed in CAD

Resorption heat pump





- Salt impregnated in expanded natural graphite
- Pressurised water in the tube and ammonia in the shell
- Unique reactor manufacture

Resorption heat pump

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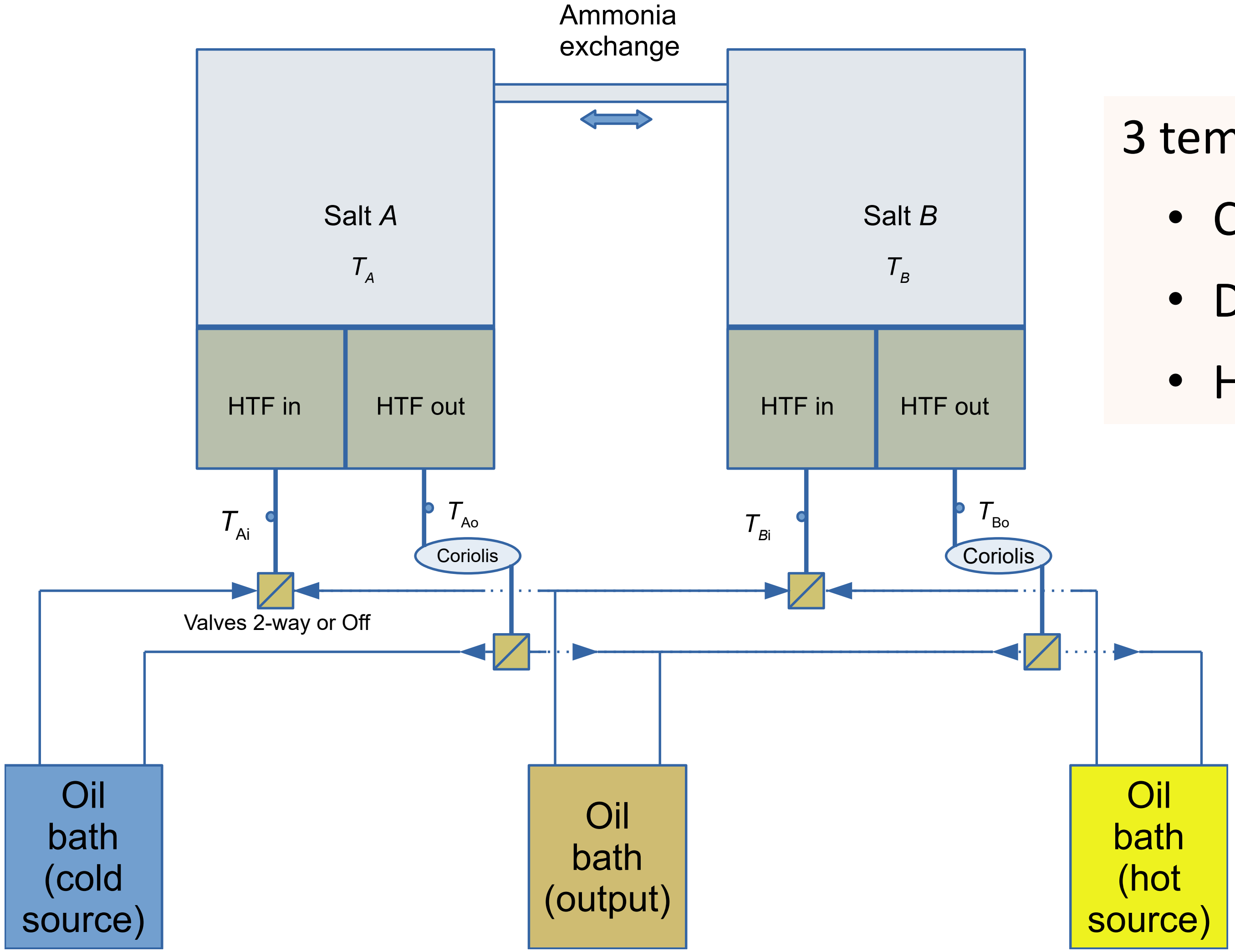
- System design and manufacture is now complete
- Ready for test in the ThermExS facilities at the University of Warwick

Simulation of a resorption cycle



3 temperatures:

- Cold source T_C
- Delivery (output) T_D, T_O
- Hot source T_H

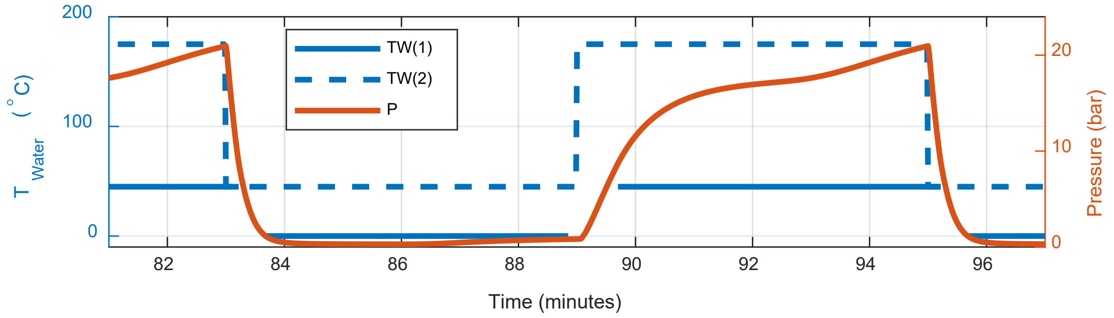
Aims:

- Develop a flexible 2D simulation package
- Assess design options and gain insight into key parameters

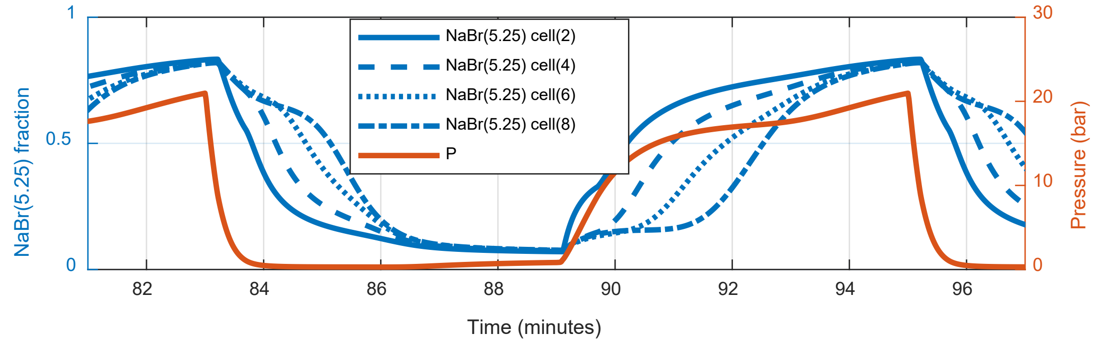
Simulation of a resorption cycle

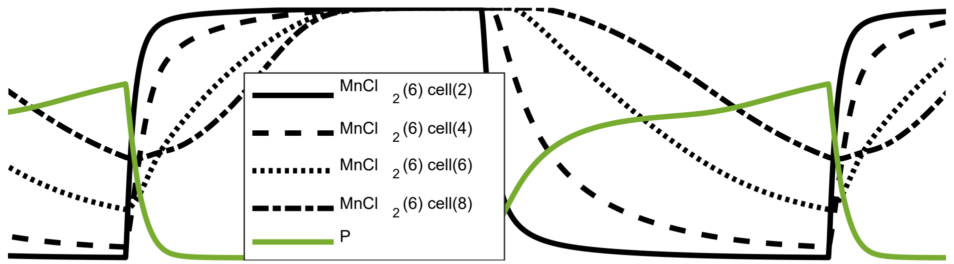
Cycle parameters: temperature, heat flux and ammoniation state

Water temperature & system pressure, showing valve switching



Radial variation in ammoniation state (LTS)

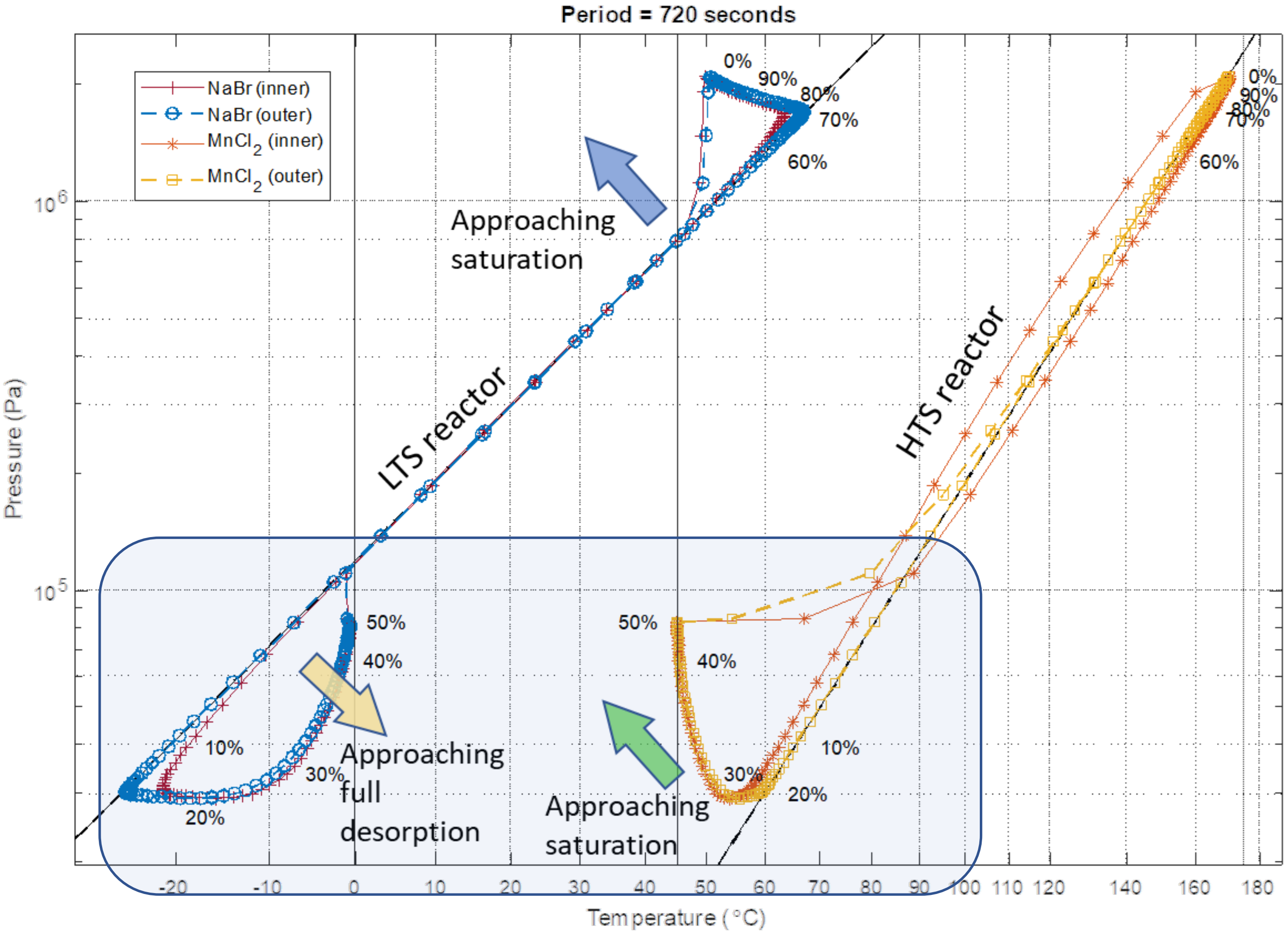




Heat flux

Radial variation in ammoniation state (HTS)

Simulation of a resorption cycle



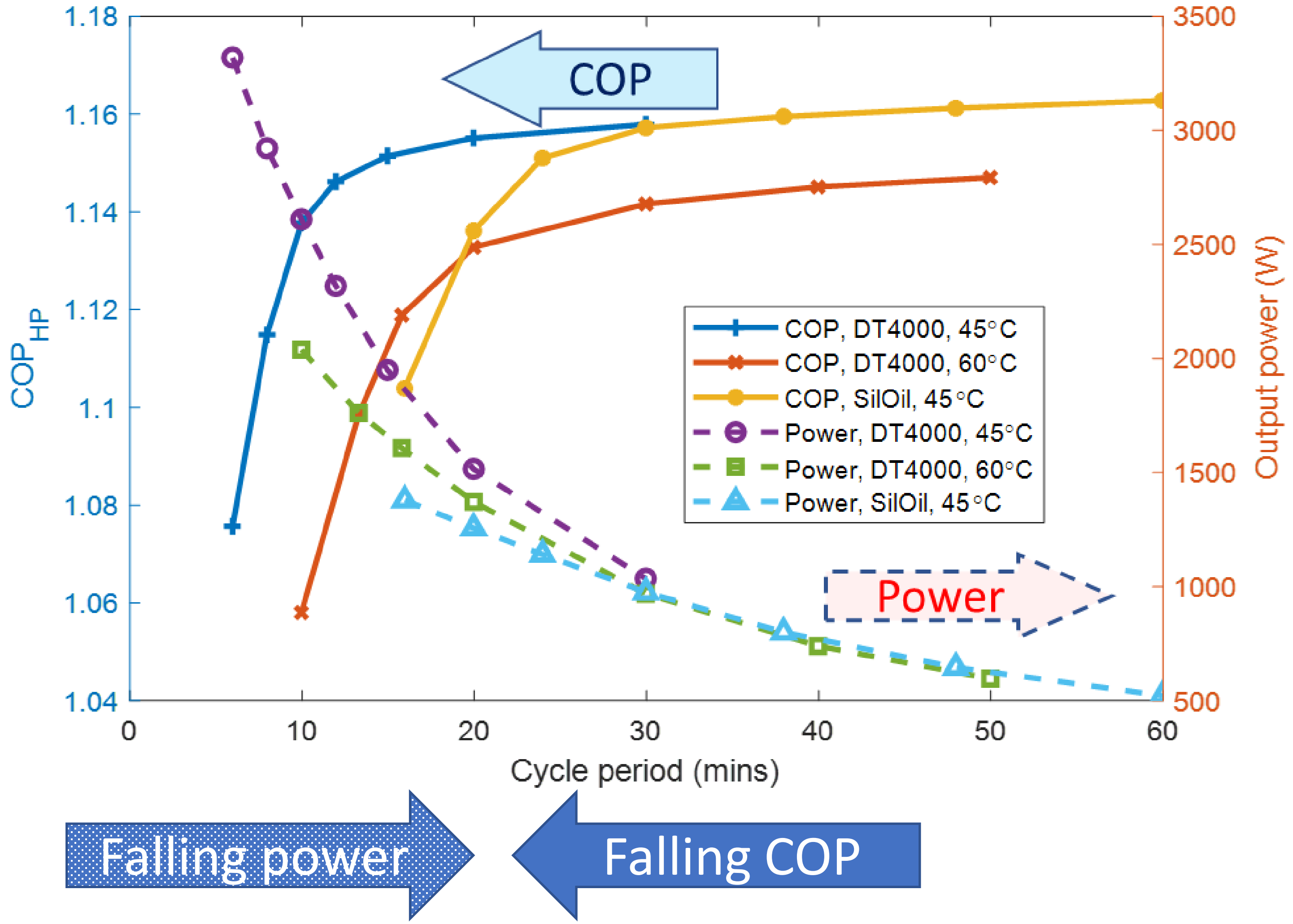
Second half of cycle (heat from **hot** source)

First half of cycle (heat from **cold** source)

Clapeyron diagram for both reactors

Simulation of a resorption cycle

Effect of cycle period on <u>coefficient of performance</u> and <u>power density</u>



Comparison of two heat transfer fluids:

- DowTherm 4000 (water-glycol)
- Huber SilOil 235

Good heat transfer and low sensible heat capacity are essential.

HP-FITS

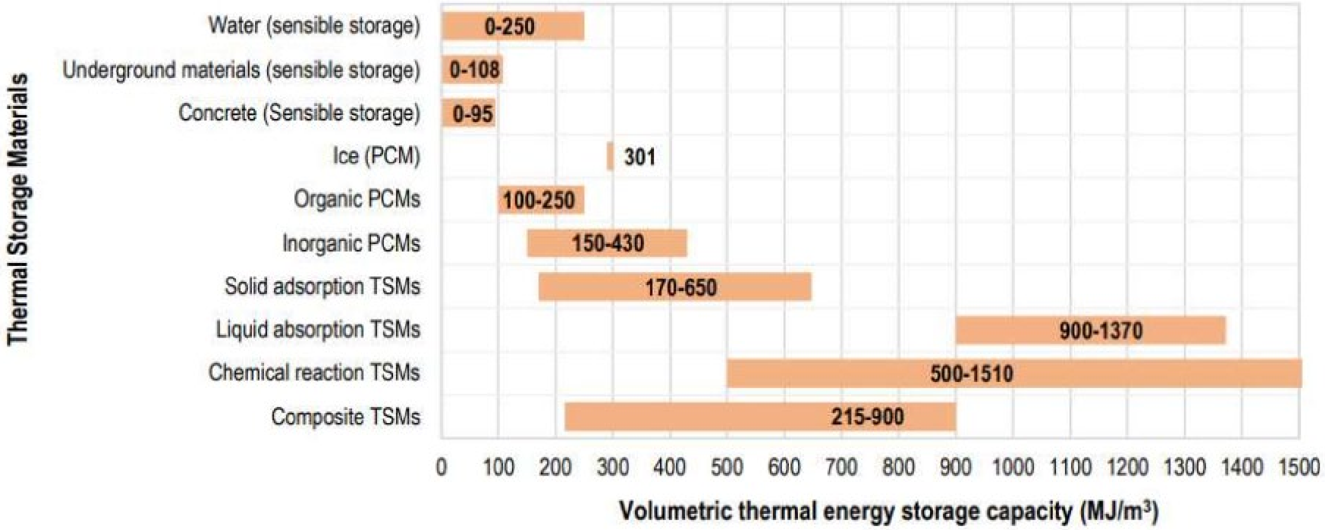
Heat Pump Fully Integrated with Thermochemical Store

Motivation:

- Domestic heating occupies a significant share of heating demand
- Waste heat recovery can help decarbonise heating in buildings
- Thermal storage offsets the demand and waste heat availability

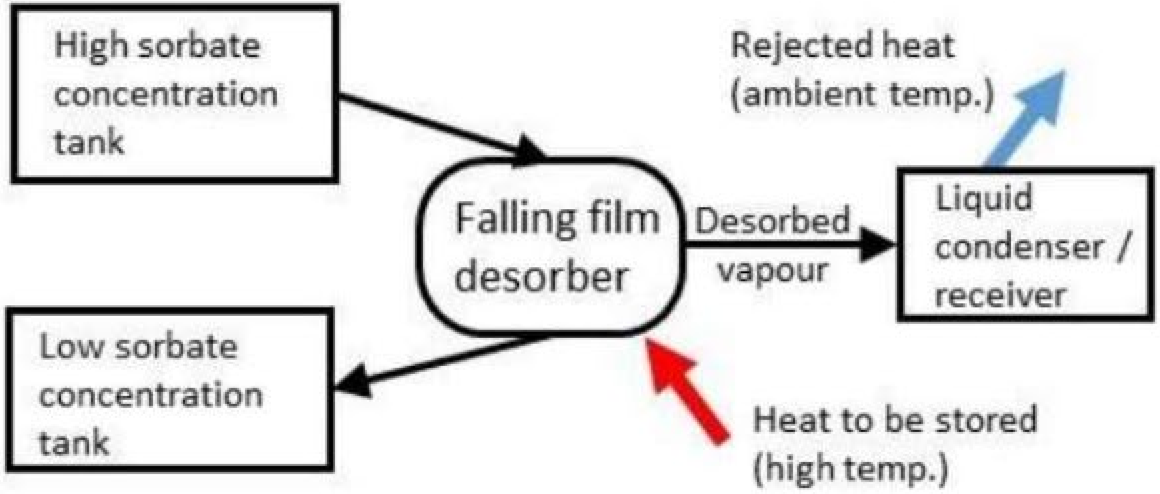
Thermochemical storage(TSM): Highest energy storage density. Lower heat losses and flexibility in storage temperature.

Sodium Hydroxide (NaOH) →
Very high efficiency and low cost

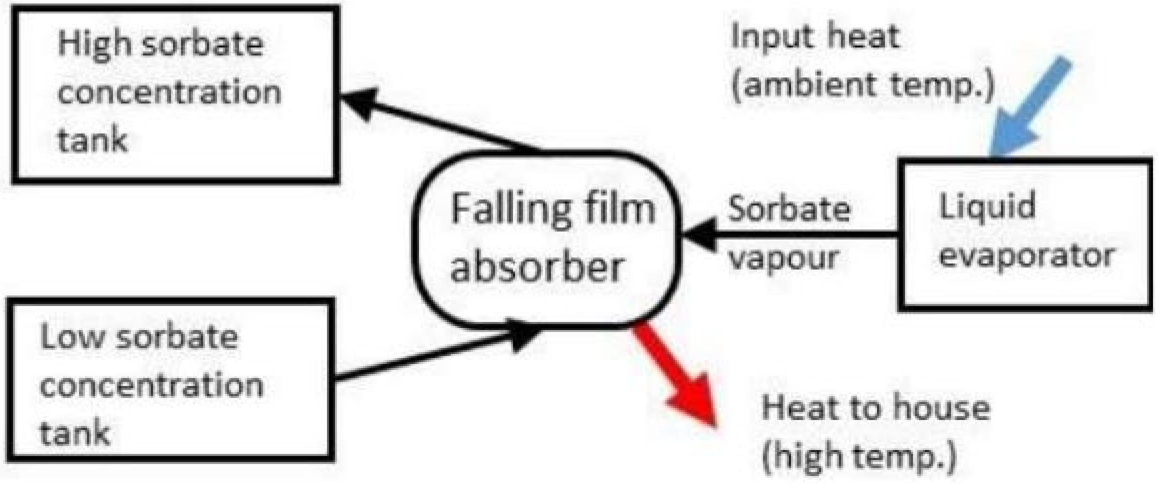


HP-FITS

System description



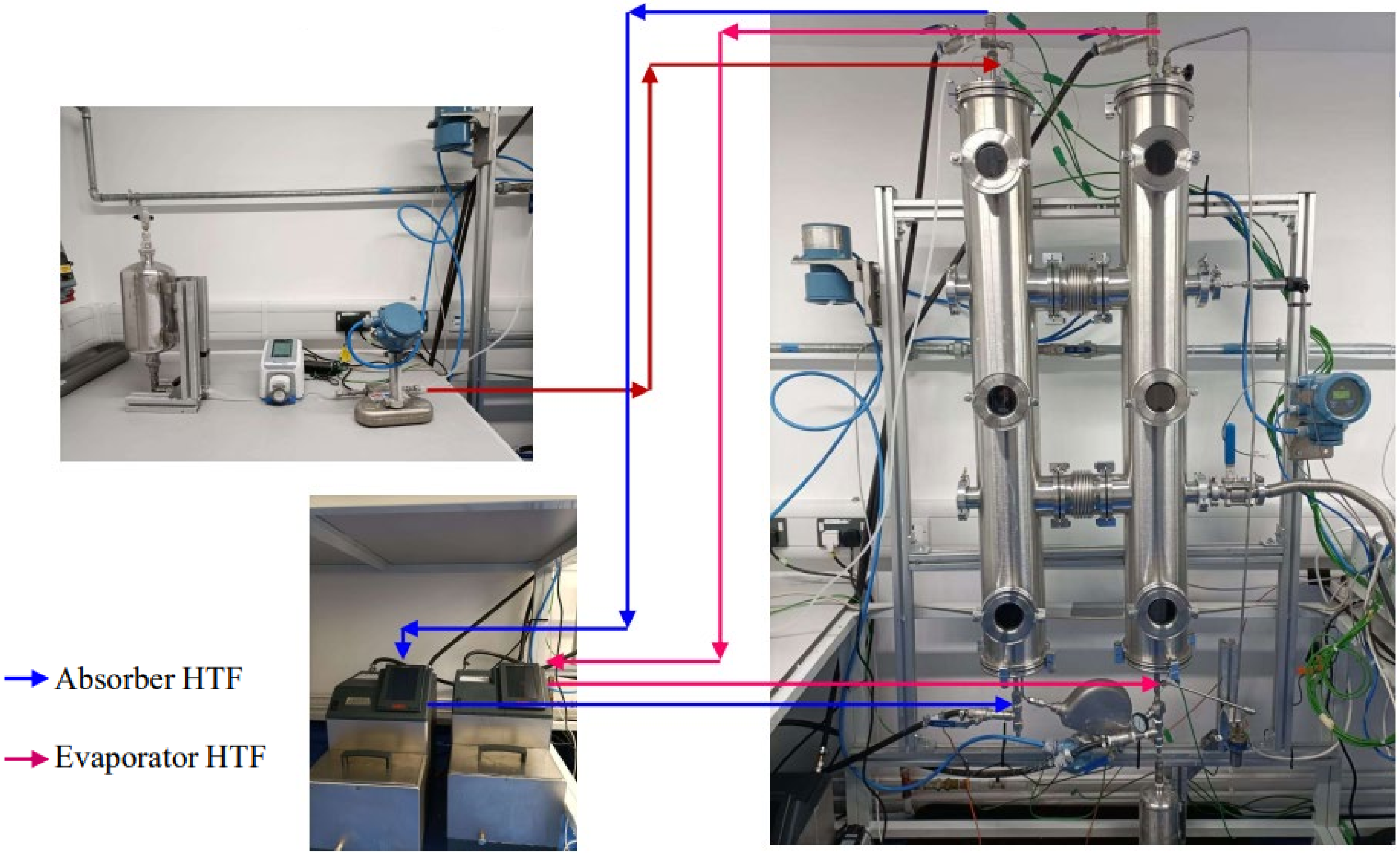
Charging the simple absorption store, flow from high to low concentration tank

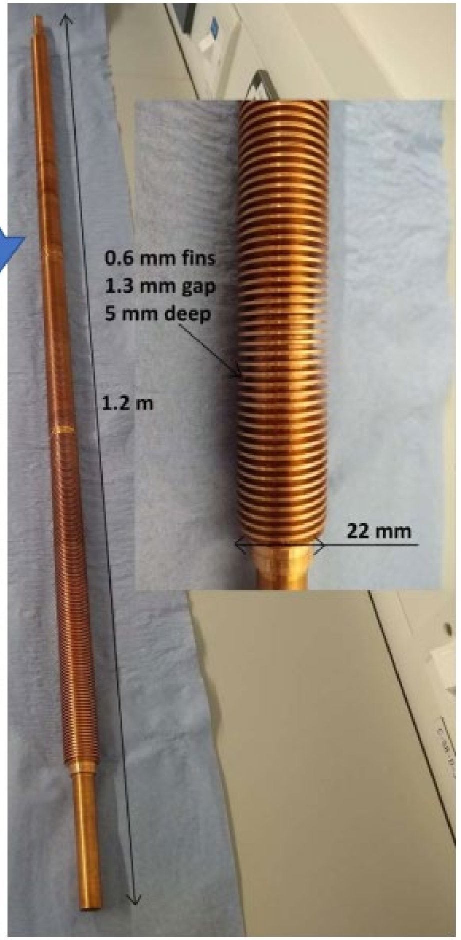


Discharging the simple absorption store, flow from low to high concentration tank

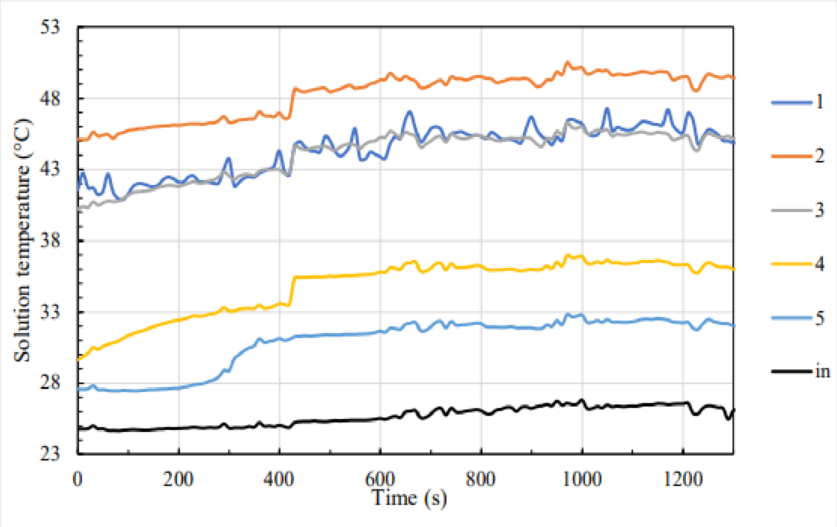
HP-FITS

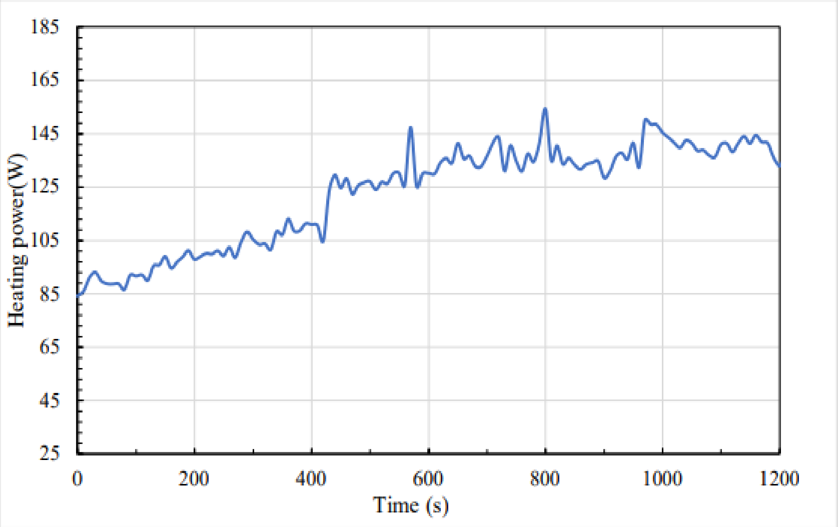
Test rig





HP-FITS





Preliminary test results

- Corrosion of copper tube led to lower absorption and heating power → performance greatly improved with nickel coating.
- Energy storage density of around 2070 MJ/m^3 is observed. It is expected to go beyond 3000 MJ/m^3 with insulation.

Future work

- Parametric study with varying flow rates and operating temperatures.
- Optimal operating point determination.
- Impact analysis of heat exchanger design parameters.
- Exploring alternative heat exchanger designs for performance enhancement.

Thank you!

ERA ENERGY RESEARCH ACCELERATOR

NET-ZERO HEROES

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Coming up in 2023

18 January	Hydrogen use in decarbonisation of transport
15 February	Biofuels and Biotechnology
15 March	Nuclear
19 April	Power grids, digital systems and data
17 May	Energy policy and economics
21 June	Living Labs
19 July	ECR special

If you would like to present at an upcoming ERA Net-Zero Heroes webinar contact Lennie (L.A.Foster@lboro.ac.uk)