1
H
Hydrogen
1.008

82
Pb
Lead
207.2

Loughborough University

Battery-Electrolyser

Utilising lead acid battery technology as a method of green hydrogen production.

Challenges with renewable energy generation and storage

INTERMITTENCY

Renewable energy generation is variable.

Electrolysers depend on a stable energy source,

LIMATED STORAGE

To account for low energy production, renewables are often over specified by 30%

When battery storage is full, excess energy is curtailed

CAPITAL-COST

Electrolysers require high upfront investment.

Costs can be a barrier for large-scale adoption.

SUSTAINABILE

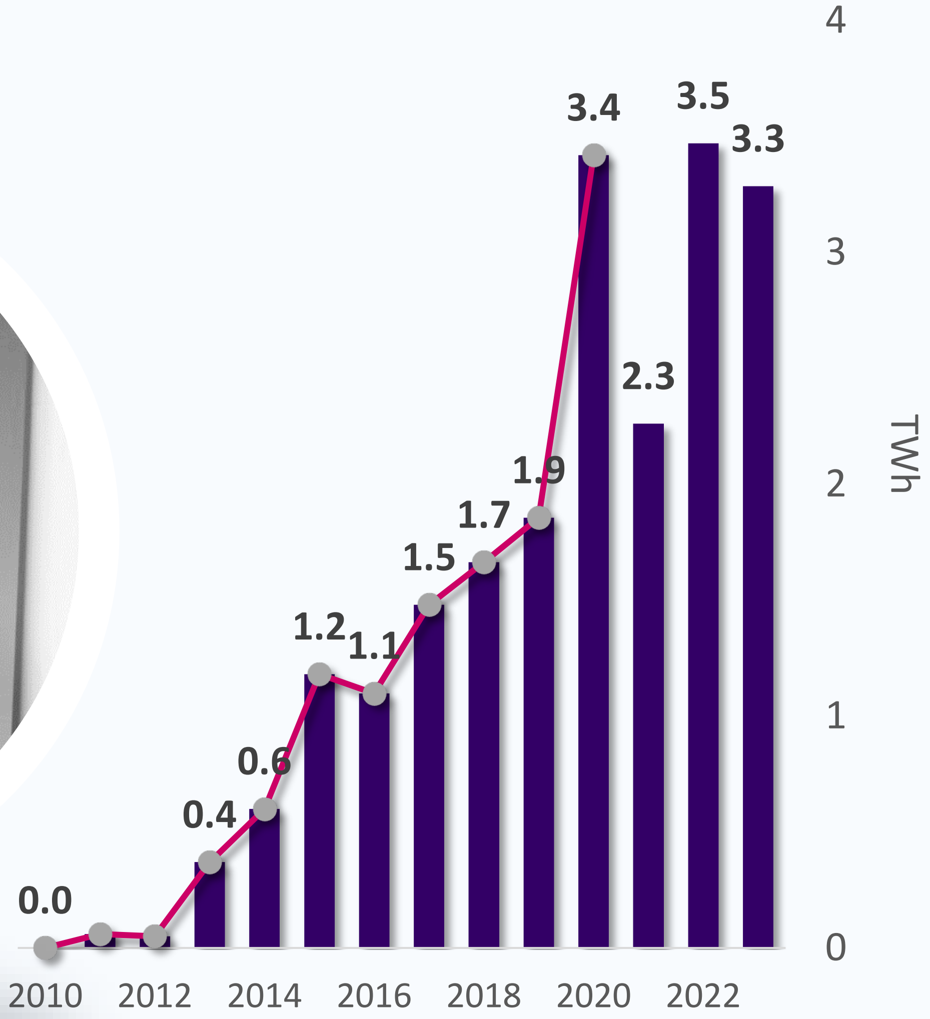
Electrolysers rely on scarce and expensive materials (Pt or Ir)

Mining these materials have high environmental and economic costs.

6.5 TWh of wind power curtailed in the UK

Costing £1.5 billion

resulting in 2.5 million tones of CO_2 emissions



[1]Electric Insights, "Record Wind Output and Curtailment," Q4 2020, available at: https://reports.electricinsights.co.uk/q4-2020/record-wind-output-and-curtailment/ (accessed August 5, 2024)..

Electrolyser – economics of materials required

Element	Approx. Global reserves tons [1]	Cost $/g [2]	CO_2 used in extraction [3,4]
Platinum	69,000	$33	31,700 kg CO_{2e}/kg
Iridium	3,000	$144	27,500 kg CO_{2e}/kg
Lead	4.5 million	$0.002	1.3kg CO_{2e}/kg

Annual production

of Pt and Ir is only able to support 3-7.5GW of electrolyser production annually .

Significant amounts required

to scale up production goes against the government mandate to reduce scarce material utilisation.

Commercialisation

Most electrolysis units are around 1 MW, with a 20 MW trial unit planned, while other methods are still in experimental stages.

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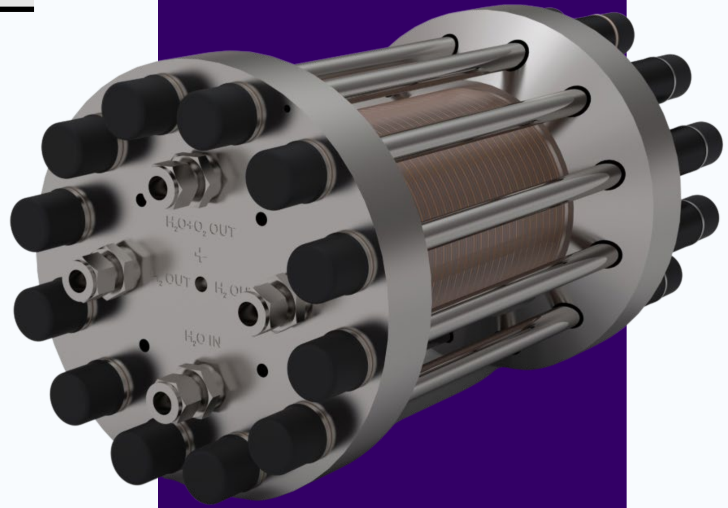


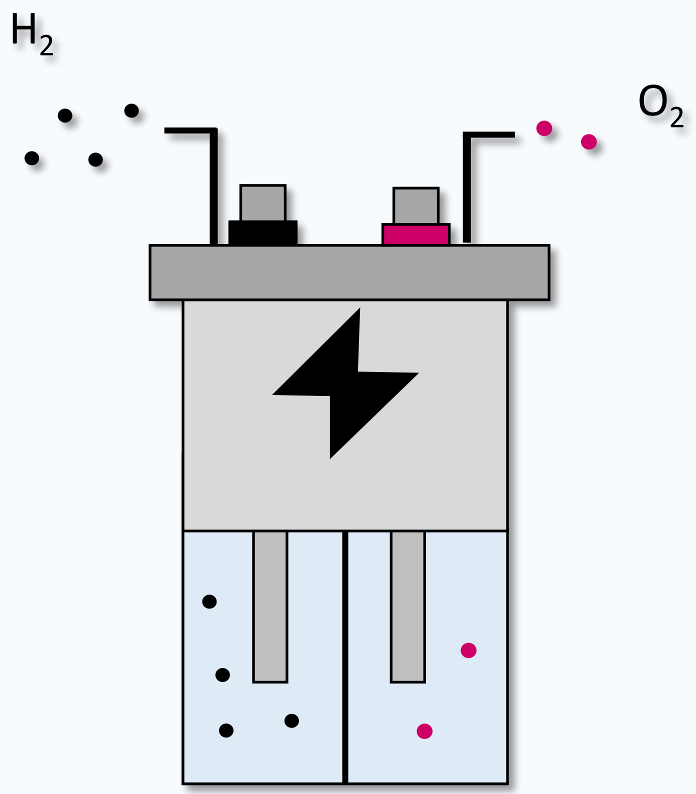
Ref: [1] U.S. Geological Survey. Mineral Commodity Summaries 2024; Iridium.[2] Source: IPA-LCA Study 2017; upstream data from 2022 (GaBi database) [3] Statista. Average prices of platinum worldwide from 2012 to 2024. Statista. (accessed September 7, 2024).[4] Price of iridium worldwide from 2011 to 2024. Statista (accessed September 7, 2024).

Combined battery –electrolyser function

LEAD ACID BATTERY

01

technology allows the cell to charge and discharge as a battery



ELECTROLYSIS

02

occurs when the cell is over charged – splitting water from the electrolyte into H2 and O2 gas.

HYDROGEN GAS

03

is collected at the negative electrode as a method of chemical energy storage during excess renewable energy production

RENEWABLE ENERGY

04

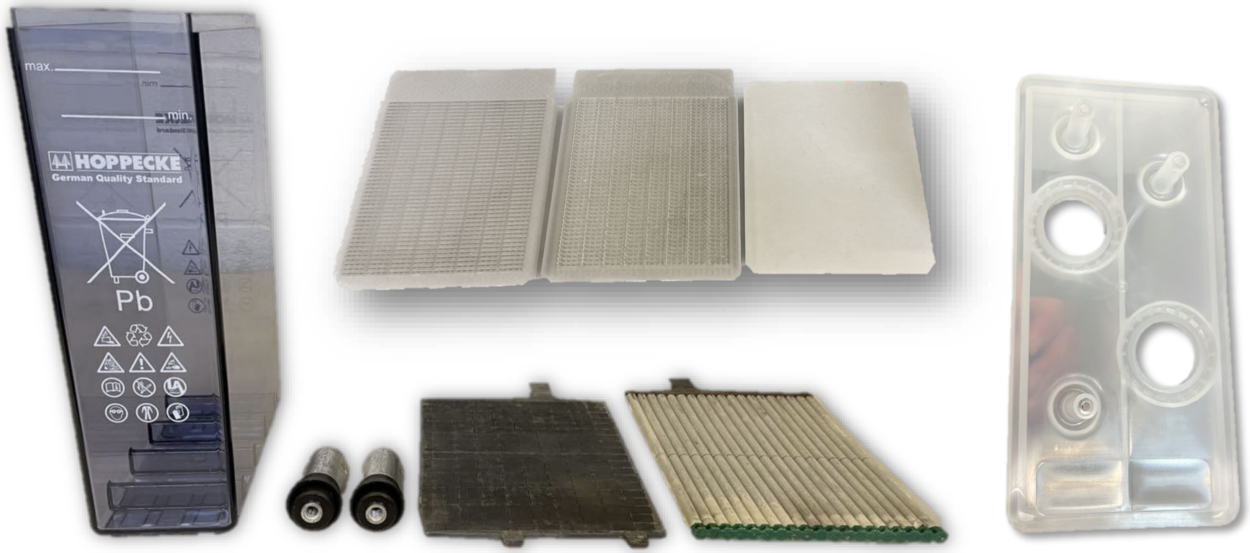
is stored either as electrical energy in the battery or chemical energy as hydrogen gas

OFF THE SHELF COMPONENTS:
Lead-acid battery electrolyser

Cheap and available materials!

- Plates, terminals and boxes are provided by Hoppecke
- Separator materials is provided by Hollingsworth and Vose

- 3D printed components are the gas separator and cell lid, both made from recyclable materials.



RISKS

Key risks for successful development

01 Battery durability

02 Hydrogen Purity

03 Efficiency

04 Safety

05 Cost vs revenue

Results achieved so far

>99 %

Hydrogen purity, even at low load factor

71.3 %

Electrolyser efficiency

80.1 %

Charge efficiency

20 $Lmin^{-1}$

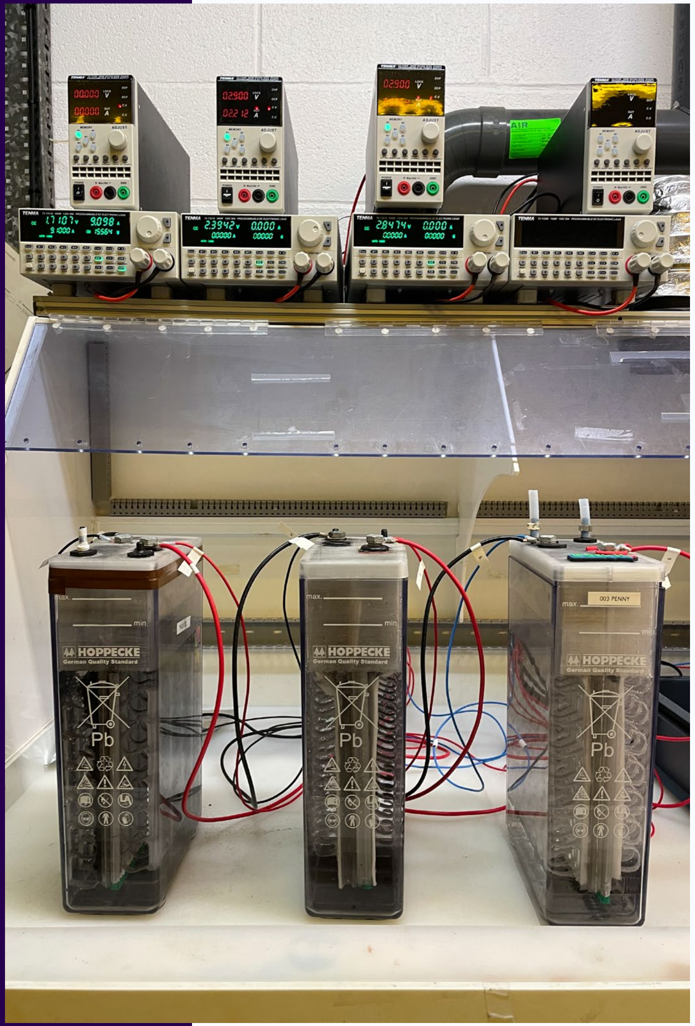
Flow rate of Hydrogen from 160 cells at max power

£23

Cost of materials per cell, including IM printed lid.

Durability – laboratory validation testing

Durability tests are continuously cycling, with programs that mimic the operation of the cells in the field.



01 Battery

Operated as a battery for comparison to standard lead acid battery.

02 Battery – electrolyser

Undergoing cycling as a battery and also operation as an electrolyser

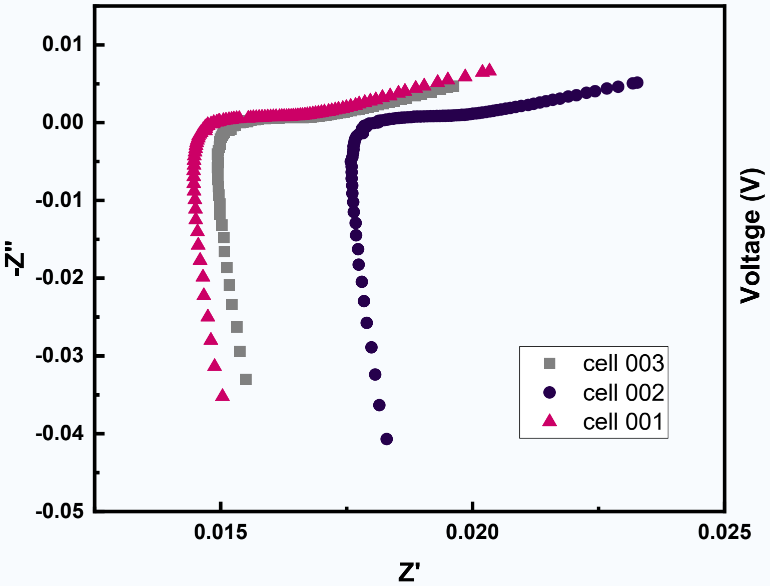
03 Electrolyser

Only electrolysis is performed using this cell, no discharge cycles.

Cell manufacture – scale up

BATTERY ELECTROLYSER CELL

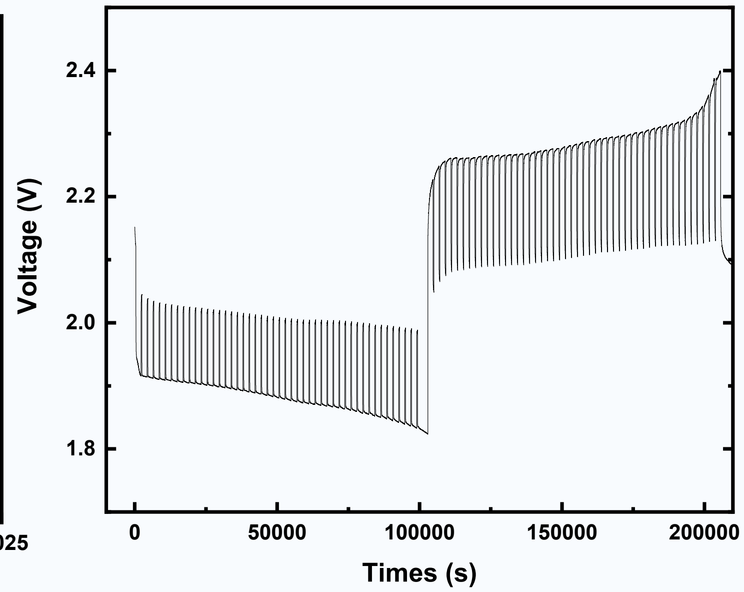
Post manufacture test



Electrical Impedance

Electrical impedance spectroscopy is performed to measure internal resistance

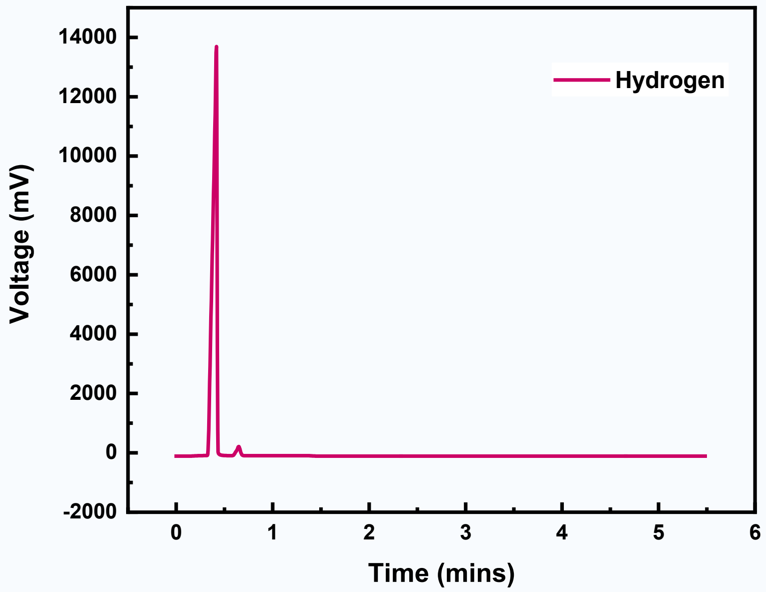
01



Capacity test

A capacity test using a current of 9.1 A is performed after manufacture

02



Hydrogen purity

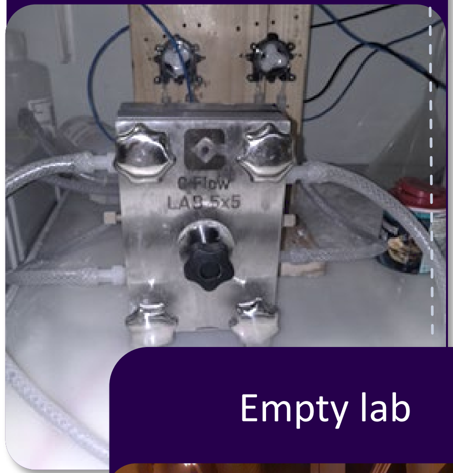
Gas chromatography with a TCD or chemiluminescence detector

03

Timeline of battery-electrolyser progress

July 2022 | **Sep 2023** | **March 2024** | **Aug 2024** | **Today**

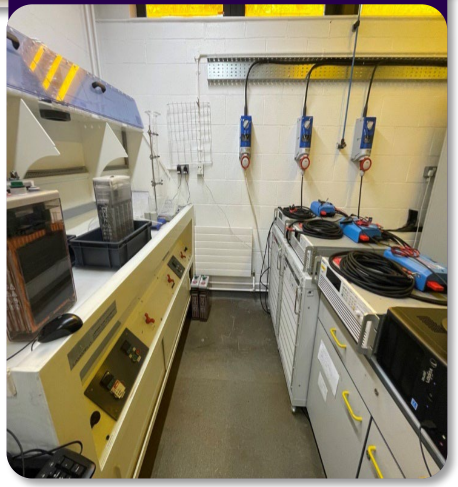
Flow lab setup



Empty lab

Cell design iteration

Lab ready

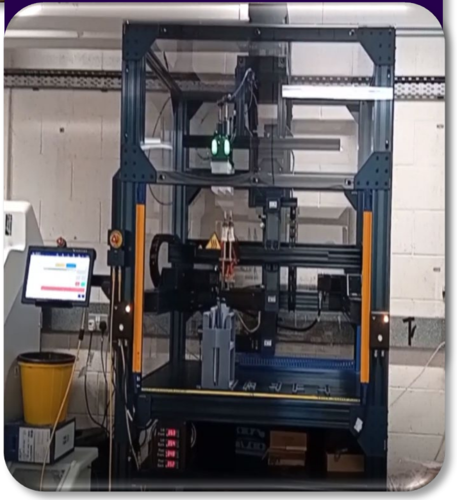


First string of 20 cells

20ft containers

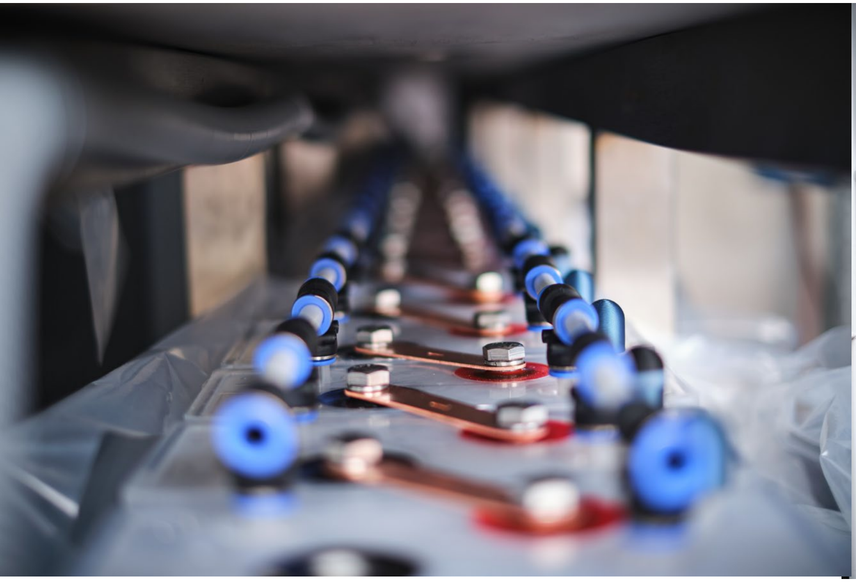
Arrival of parts

Manufacturing



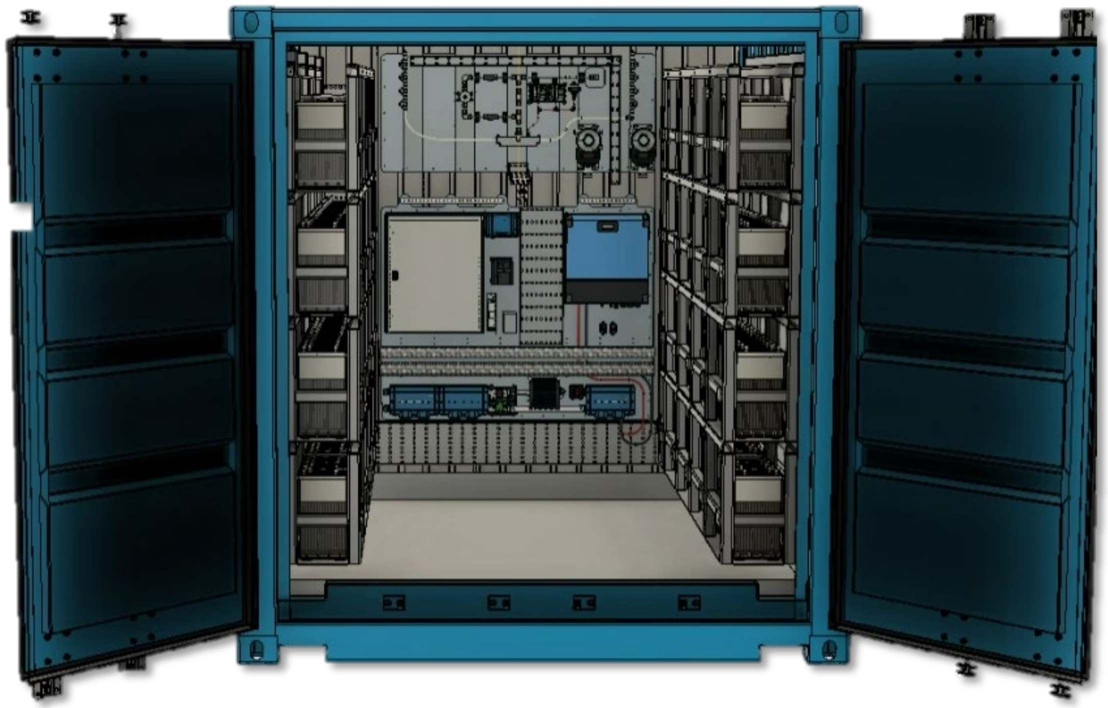
Project build

DEMONSTRATOR MANUFACTURE UNDERWAY



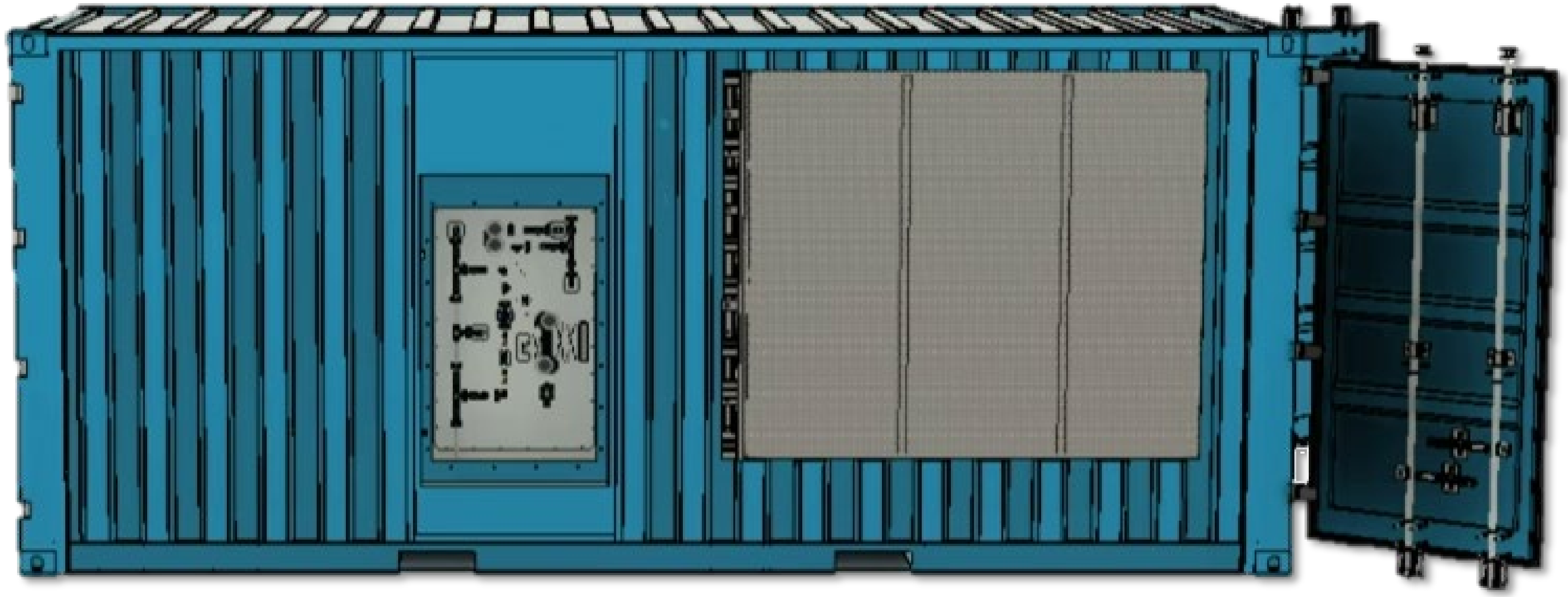
Internal hazop and design review

- P&IDs (cells, electrics, safety control, gasometer, compressor etc)
- Failure points
- Safety compliance to BS EN IEC 60079-10-1:2021 and IGEM SR-25
- Control hatch
- Commissioning (nitrogen purge)
- Bunding
- Zones – (DSEAR, ATEX, SIL, ventilation)



Internal hazop – zoning and ventilation

- Container side 1(low pressure) likely a zone 2 of negligible extent
- Container side 2(5Bar pressure) likely a zone 1 rating. All equipment in this side of the container needs to be ATEX rated.



Current projects demonstrating lead acid battery electrolyser technology

MESCH

LoCEL-H_2

Loughborough University

Current deployment timeline

May 2025	Nov 2025	Feb 2026	June 2026
MESCH	LoCEL-H_2	LoCEL-H_2	Loughborough University
Malawi	Zambia	Côte d'Ivoire	Loughborough

MESCH

MESCH

1

Collection of solar energy

Solar panels will capture and convert sunlight into renewable electrical energy.

2

Battery-electrolyser

Electricity will be stored in the battery-electrolysed for use when grid electricity is unavailable.

3

Generation of clean fuel

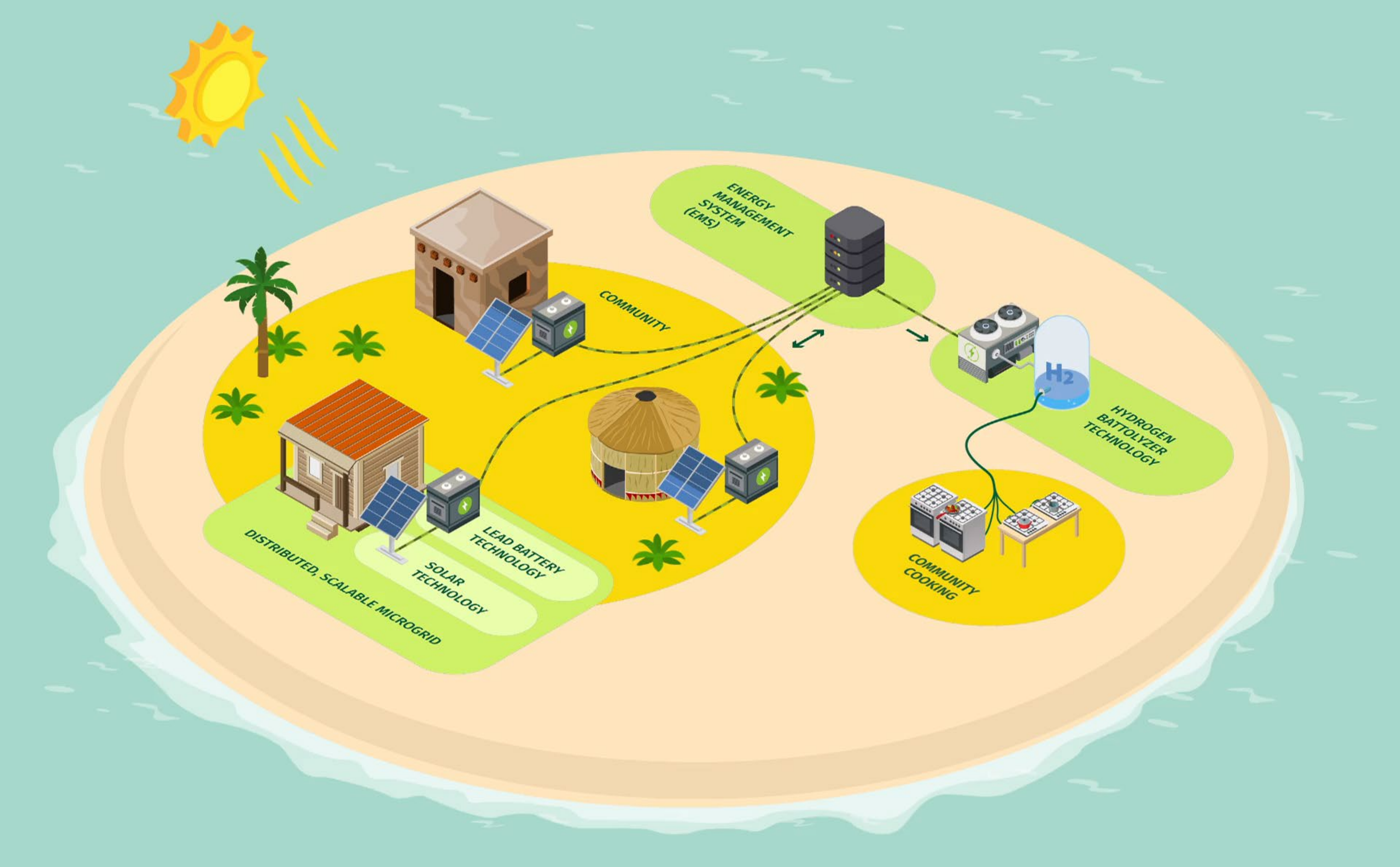
Battery-electrolyser will also convert excess electricity into clean hydrogen fuel.

4

Replacement of diesel and conventional cooking fuels

Hydrogen will be used as a low-cost and clean cooking fuel. The batteries will power the critical building if grid power is interrupted.

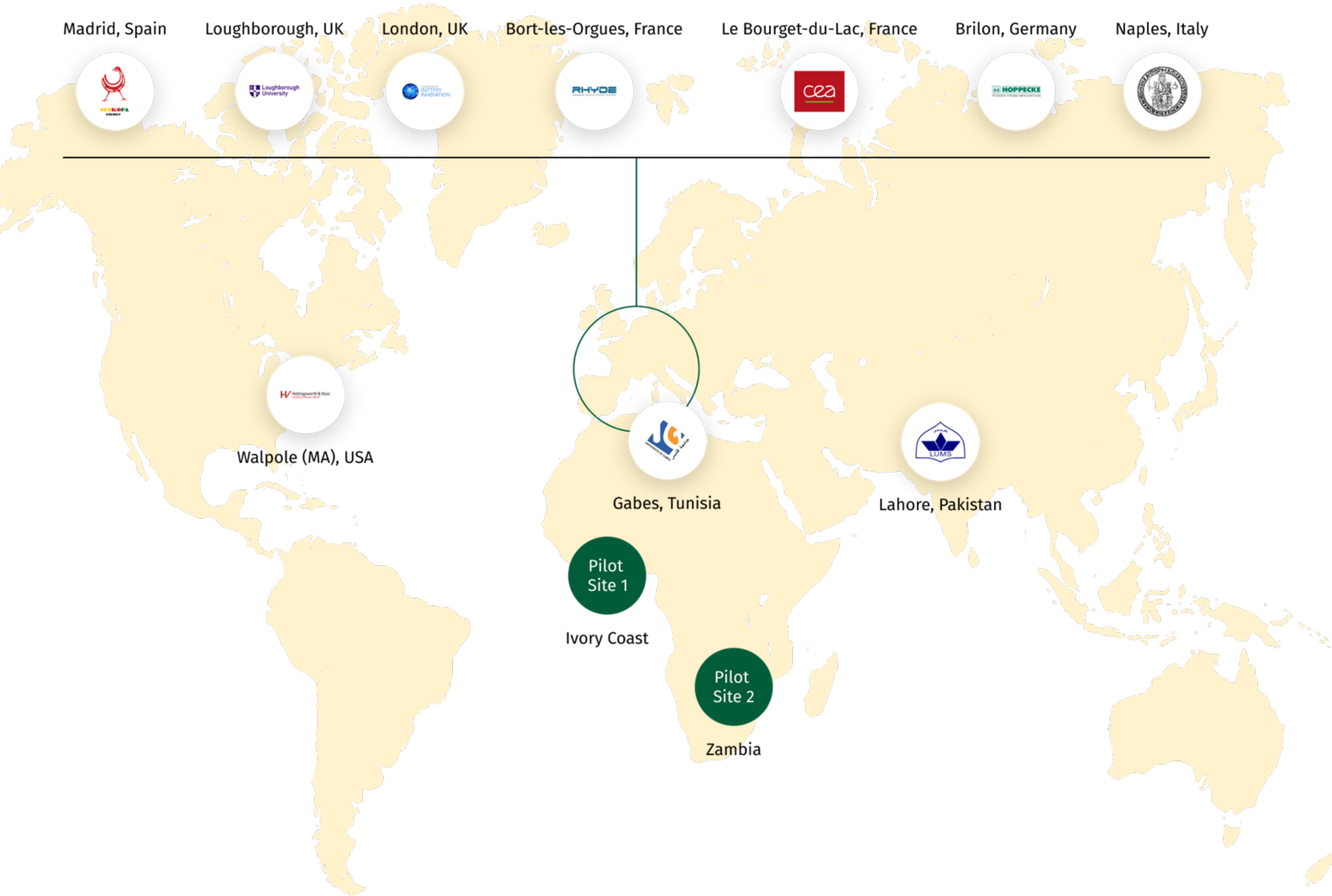
LoCEL-H2



ENERGY MANAGEMENT SYSTEM (EMS)
COMMUNITY
HYDROGEN BATTOLYZER TECHNOLOGY
COMMUNITY COOKING
LEAD BATTERY TECHNOLOGY
SOLAR TECHNOLOGY
DISTRIBUTED, SCALABLE MICROGRID
H2

OUR TEAM


Global Presence
LOCEL-H2
IN THREE WORDS...
Connection
Opportunity
Challenging
Electricity
Hydrogen
Innovation
Prosperity
Innovative
Hope
Reliable
Prospective
Renewable
Safe
Love
Empowerment
Revolutionary
Worldwide
Independence
Impactful
Power
Human
Sustainable
Clean
Share
Integrated
Energy
Green
Affordable
Community
Co-funded by the European Union
ENERGY CONNECTION HOPE
INNOVATIVE INTEGRATED IMPACTFUL
EmPOWERment Prosperity Sustainability
COMMUNITY EMPOWERMENT
Renewable Reliable Revolutionary
HYDROGEN + ELECTRICITY = LOVE GREEN
INNOVATIVE CHALLENGING PROSPECTIVE


Madrid, Spain
Loughborough, UK
London, UK
Bort-les-Orgues, France
Le Bourget-du-Lac, France
Brilon, Germany
Naples, Italy
Walpole (MA), USA
Gabes, Tunisia
Lahore, Pakistan
Pilot Site 1
Ivory Coast
Pilot Site 2
Zambia

East midlands Free port

Loughborough University

EAST MIDLANDS FREEPORT

University of Nottingham UK | CHINA | MALAYSIA

UKRI Research England

A new facility for hydrogen production training and testing

- Solar farm interface
- Battery-electrolyser
- Hydrogen pipework, compressor and storage
- Hydrogen safety system and sensor test bed
- Hydrogen user acceptance area

A practical showcase area to demonstrate capability and attract partnerships.

Conclusions on Technology

1 Battery technology

2 Green H_2

3 Manufacture

4 Demonstrator scale

- **Battery technology:** Using lead acid battery technology, we have successfully developed a combined battery and electrolyser.
- **Green H_2:** excess renewable energy can be used to generate H_2 via electrolysis when over charging the battery cell.
- **Manufacture**: We have developed the combined battery and electrolyser cell design from lab scale to full scale, using off the shelf and bespoke 3D printed and IM parts.
- **Demonstrator scale:** We are now in the process of manufacturing the next cells for testing, before deploying the containerised system in Zambia and the Ivory Coast.

THANK YOU

Loughborough University

EAST MIDLANDS FREEPORT

University of Nottingham
UK | CHINA | MALAYSIA

UKRI Research England

MESCH

MONBAT BATTERIES

INFLO

ENERGY CATALYST

CONSORTIUM FOR BATTERY INNOVATION

Ultima Forma

RENEWABLE MALAWI

UKRI Innovate UK

LoCEL-H_2

Co-funded by the European Union

Hollingsworth & Vose® Creating a Cleaner World™

HOPPECKE POWER FROM INNOVATION

CONSORTIUM FOR BATTERY INNOVATION

LUMS
A Not-for-Profit University

RHYDE
RÉSEAUX HYDROGÈNE DÉCARBONÉ

cea

UNIVERSITE DE GABES جامعة قابس