Loughborough University

Battery-Electrolyser

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1
H
Hydrogen
1.008

82
Pb
Lead
207.2

BATTERY-ELECTROLYSER

INTRODUCTION

BATTERY ELECTROLYSER TECHNOLOGY

APPLICATIONS

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600 million lacked access to electricity in sub-Saharan Africa

1 billion rely on polluting fuels for cooking, lighting and heating homes

700,000 premature deaths yearly from air pollution

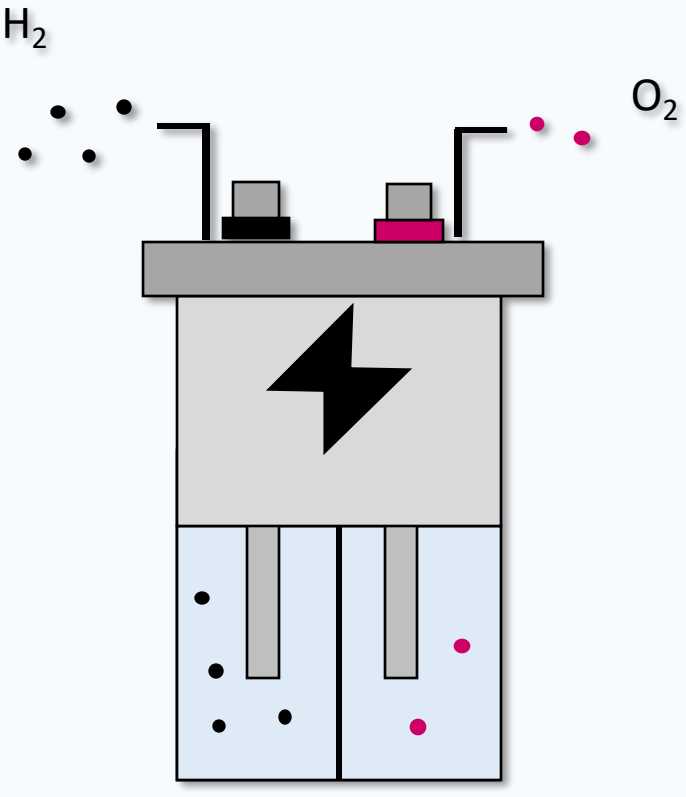
[1]Electric Insights, "Record Wind Output and Curtailment," Q4 2020, available at: https://reports.electricinsights.co.uk/q4-2020/record-wind-output-and-curtailment/ (accessed August 5, 2024)..

Combined battery –electrolyser function

LEAD ACID BATTERY

technology allows the cell to charge and discharge as a battery

01



02

ELECTROLYSIS

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

HYDROGEN GAS

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

03

04

RENEWABLE ENERGY

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

EUROPEON HORIZON PROJECT: LoCEL-H2

- The battery and electrolyser, developed as part of the LoCEL-H2 project
- It uses advanced lead batteries and green hydrogen production to deliver a new source of clean, reliable, and sustainable energy storage for off-grid communities in Africa

PILOT PROGRAMS

- Pilot programs located in Zambia and Ivory Coast
- Providing electricity for approximately 30 households (per community)
- **This program will provide each location with a sustainable and flexible renewable energy!**

OUR TEAM

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RÉSEAUX HYDROGÈNE DÉCARBONÉ

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HOPPECKE
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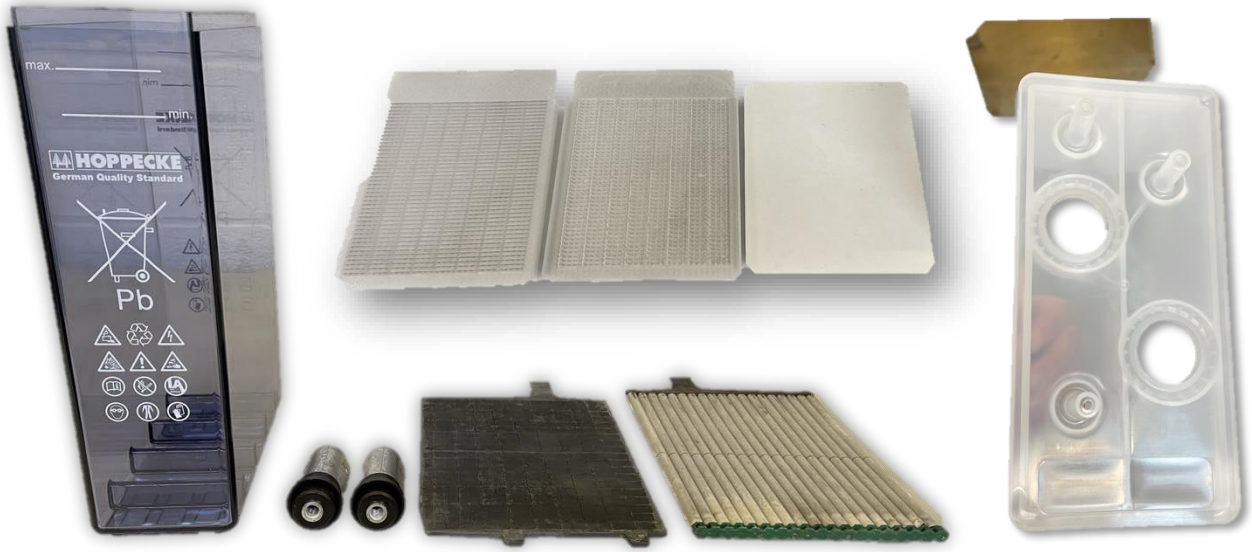
OFF THE SHELF COMPONENTS:
Lead-acid battery electrolyser

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.



Electrolyser – economics of materials required

Element	Approx. Global abundance mg/L [1]	Cost $/g [2]	CO_2 used in extraction [3]
Platinum	0.005	$27	12,500kg CO_{2e}/kg
Iridium	0.001	$196	8,860kg CO_{2e}/kg
Lead	14	$0.002	1.3kg CO_{2e}/kg

Annual production

Annual production of Iridium & Platinum only able to support 3-7.5GW of electrolyser production annually [4].

Significant amounts required

Using significant amounts of these materials to scale up production goes against the government mandate to reduce scarce material utilisation.

Commercialisation

Most electrolysis units are manufactured at around 1MW, however, there are plans for a 20MW trial unit. Other methods are at trial stage and not close to commercialisation

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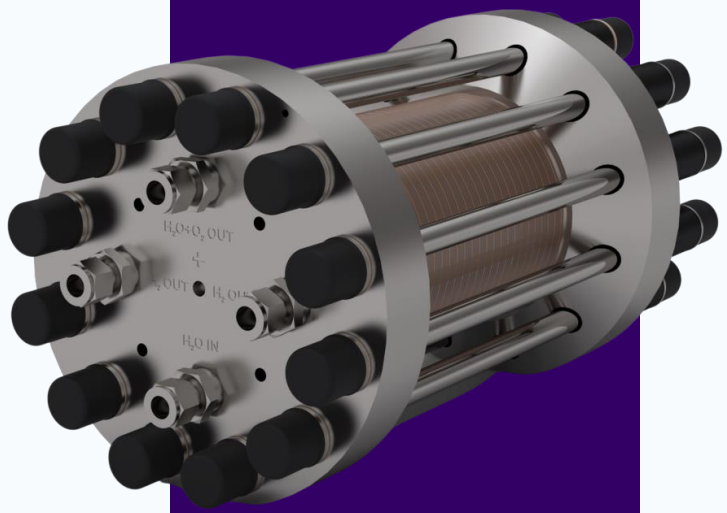


LEAD-ACID BATTERY ELECTROLYSER TECHNOLOGY

Key risks to overcome for successful development

01

Hydrogen Purity

A purity of >99.8 % must be achieved for use in a hydrogen cooker.

02

Battery durability

The cell must before well as a normal lead acid battery for electrical energy storage from solar generation.

03

Efficiency

Charge efficiency and electrolysis efficiency should challenge that of existing lead acid batteries and electrolysers

04

Hydrogen production rate

The rate of hydrogen produced from the cells must be sufficient to provide fuel for clean cooking for a village.

05

Maintain low cost

The materials used to modify the lead acid battery to allow electrolysis must remain low

Results achieved so far

>99%

Hydrogen purity, even at low load factor

71.3 %

Electrolyser efficiency

80.1 %

Charge efficiency

40 $Lmin^{-1}$

Flow rate of Hydrogen from 160 cells at max power

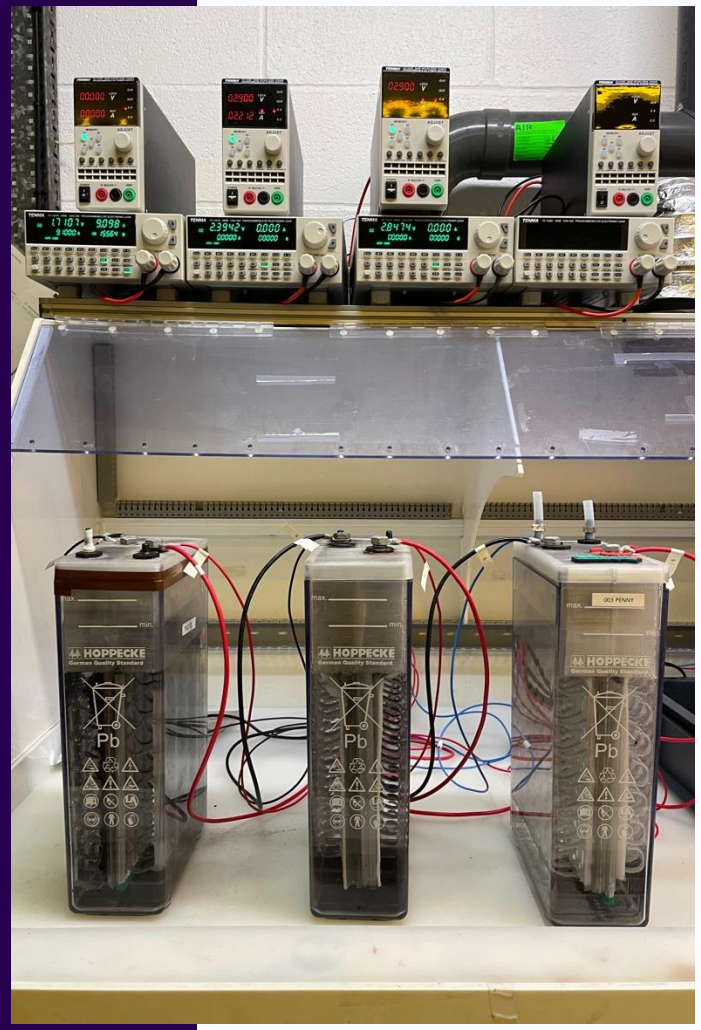
£53

Cost of materials per cell, including 3D printed lid.

Proof of concept – laboratory validation testing

We currently have cells on test in the laboratory operating under three different functions.: battery, electrolyer and battery-electrolyser

The tests are continuously undergoing cycling, with cell 02 and cell 03 undergoing programs that mimics the operation of the cells in the field.



01 Battery

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

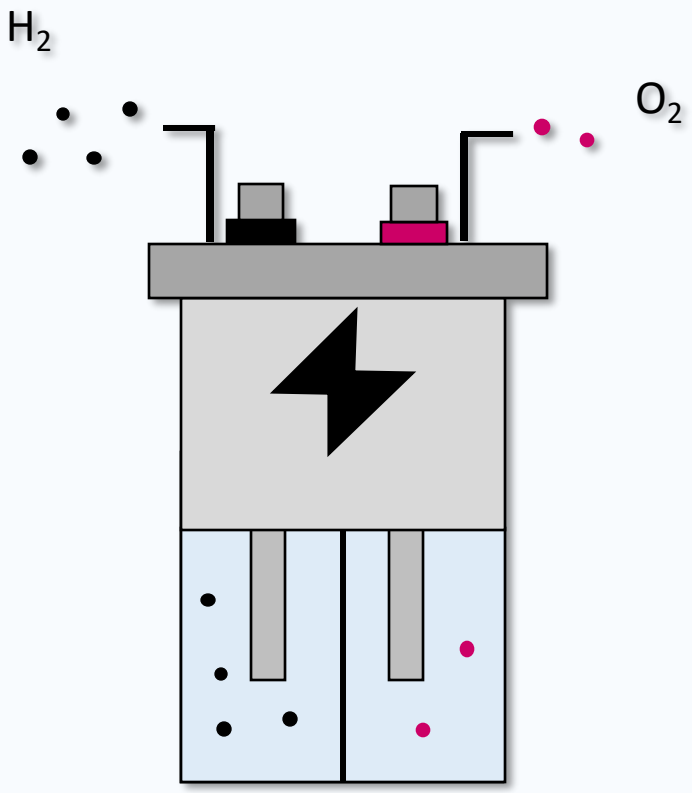
02 Battery – electrolyser

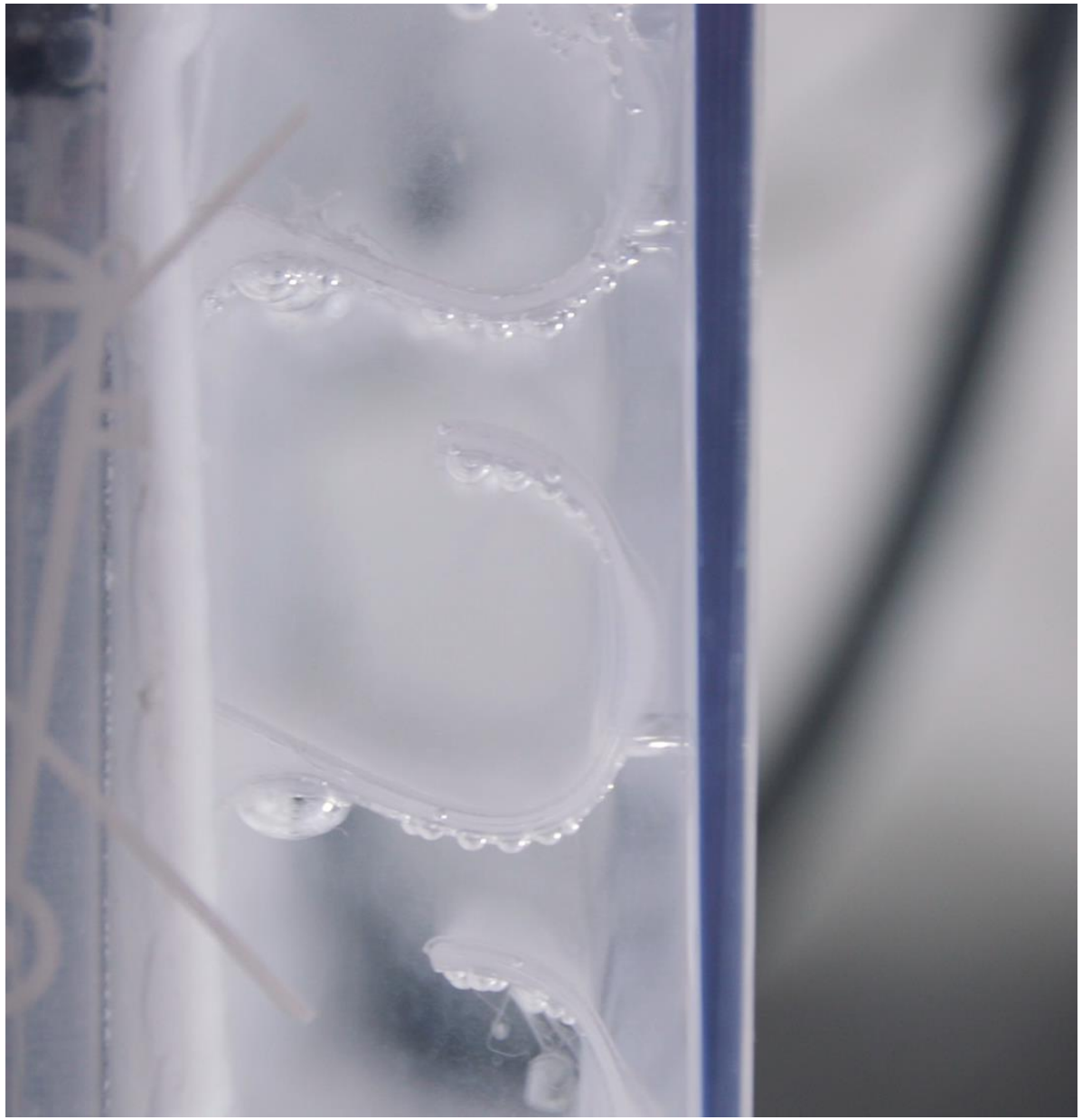
Undergoing cycling as a battery and also operation as an electrolyser

03 Electrolyser

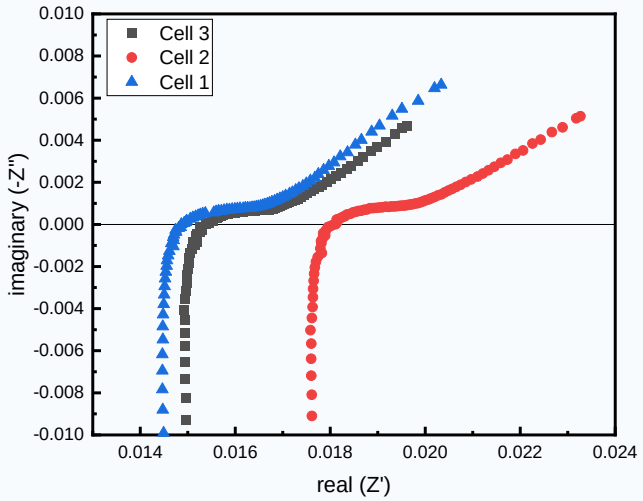
Only electrolysis is performed using this cell, no discharge cycles.

BATTERY ELECTROLYSER - VIDEO





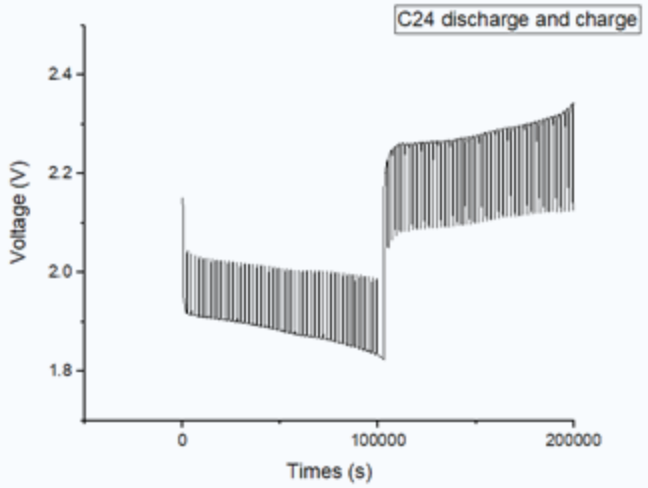
Quality assurance after manufacture



Electrical Impedance

Electrical impedance spectroscopy is performed to measure internal resistance

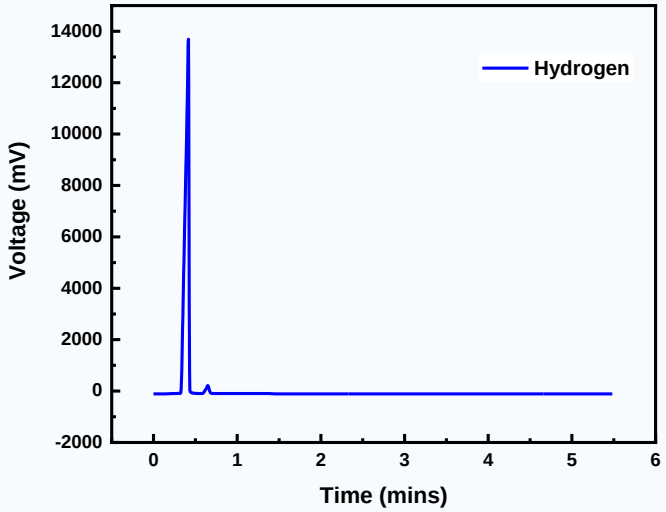
01



Capacity test

A capacity test at c5 using a current of 9.1 A is performed after manufacture

02



Hydrogen purity

Hydrogen and oxygen samples are analysed using gas chromatography..

03

Timeline of our progress

Apr 2022

Flow lab setup

July 2022

First porotype concept

Sep 2023

Design iterations of cell

March 2024

First string of 20 cells

Aug 2024

Arrival of parts for 4 containers

Timeline of our progress

Jan 2023

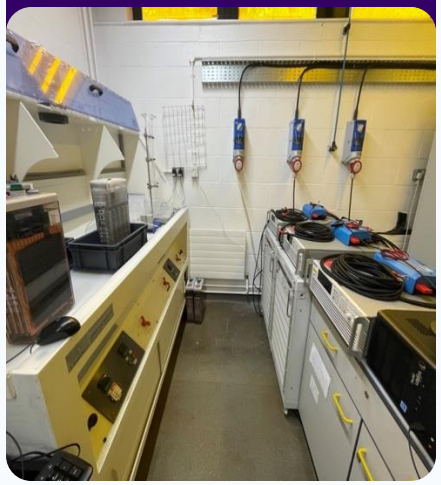
Empty lab

March 2023

Fumehoods arrived

July 2023

3 phase power sockets installed



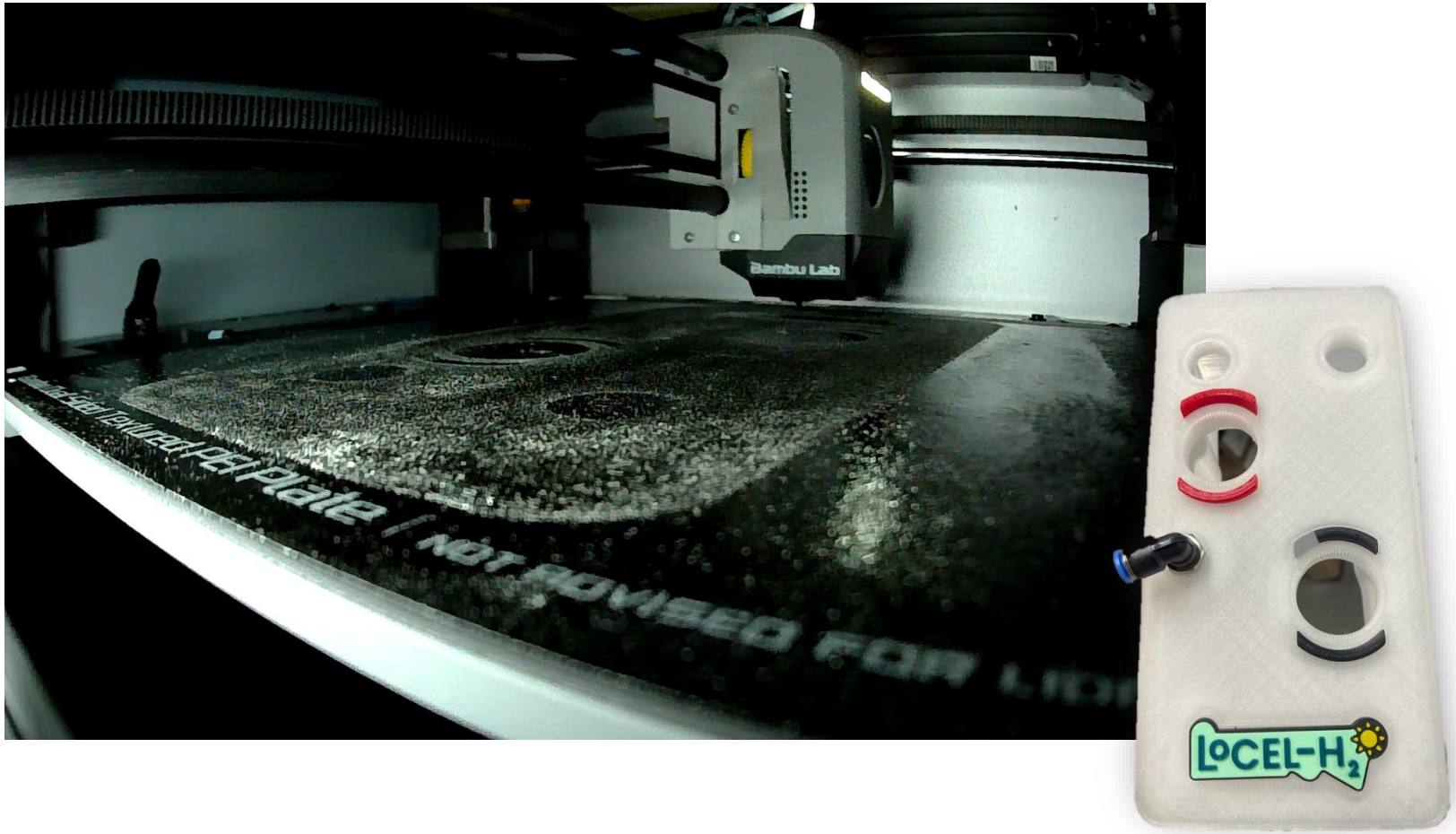
Feb 2024

First string of 20 cells

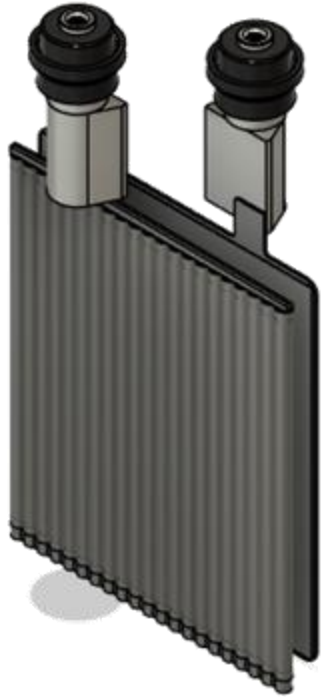
Aug 2024

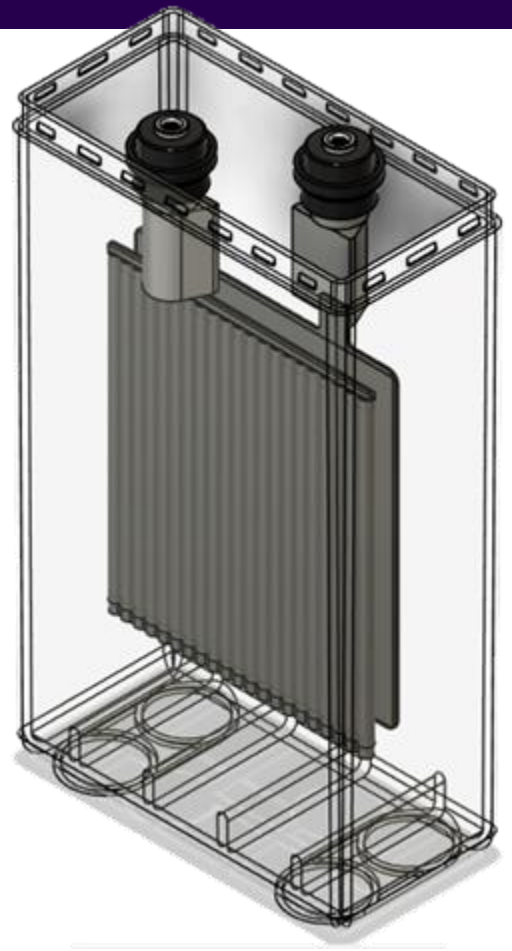
Two 20ft containers

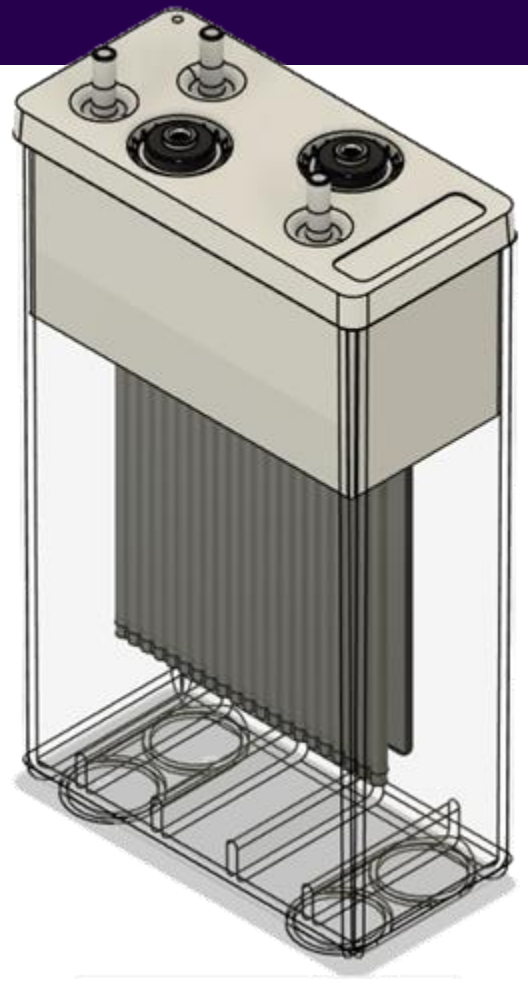
3D printed – Lid design Iterations



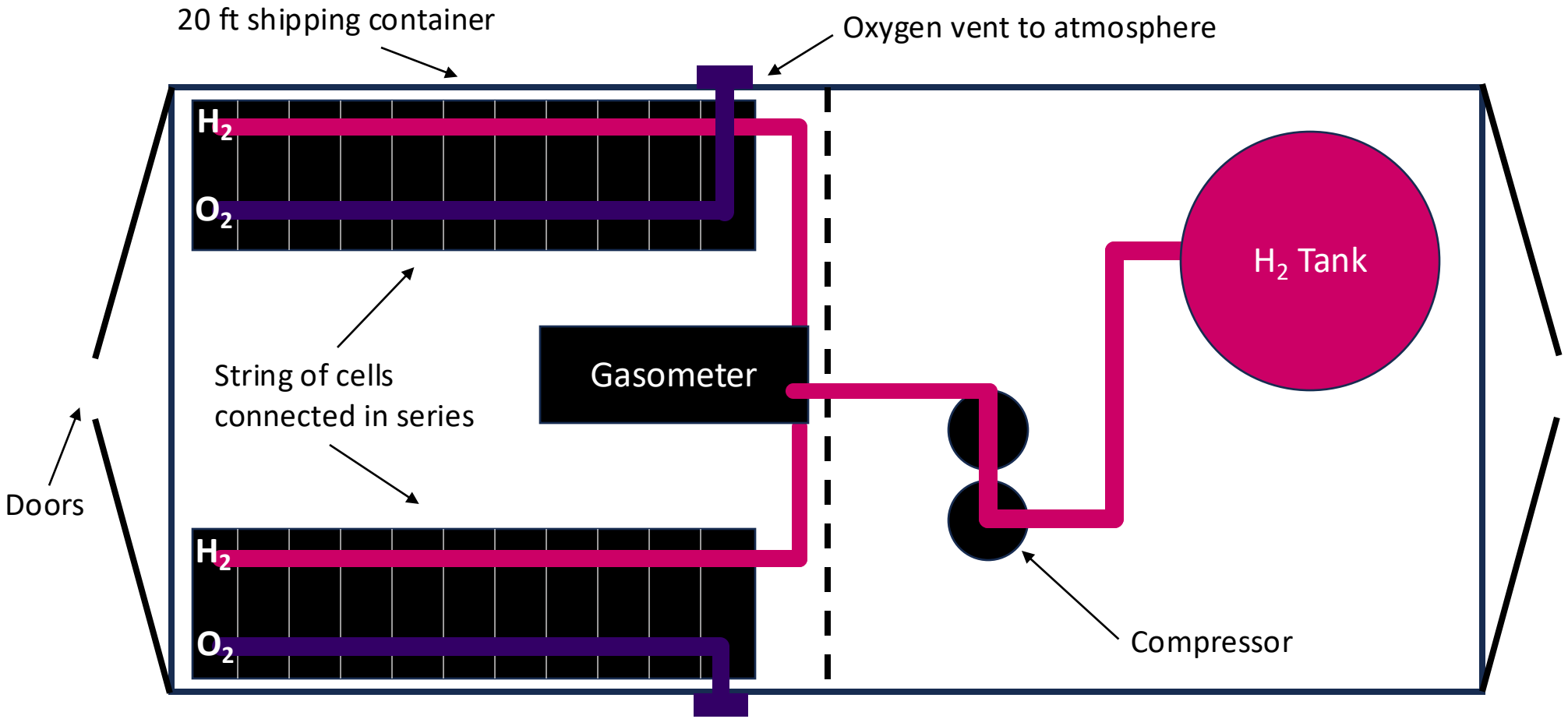
Injection molded lid







Container layout



Current projects demonstrating lead acid battery electrolyser technology

LoCEL-H2

These cases are perfectly simple and easy to distinguish. In a free hour, when our power of choice is untrammelled and when nothing prevents our being the other hand, we denounce with righteous indignation and dislike men who are so beguiled and demoralized by the charms of pleasure.

MESCH

When our power of choice is untrammelled and when nothing prevents our being the other hand, we denounce with righteous indignation and dislike. Cannot foresee the pain and trouble that are bound to ensue.

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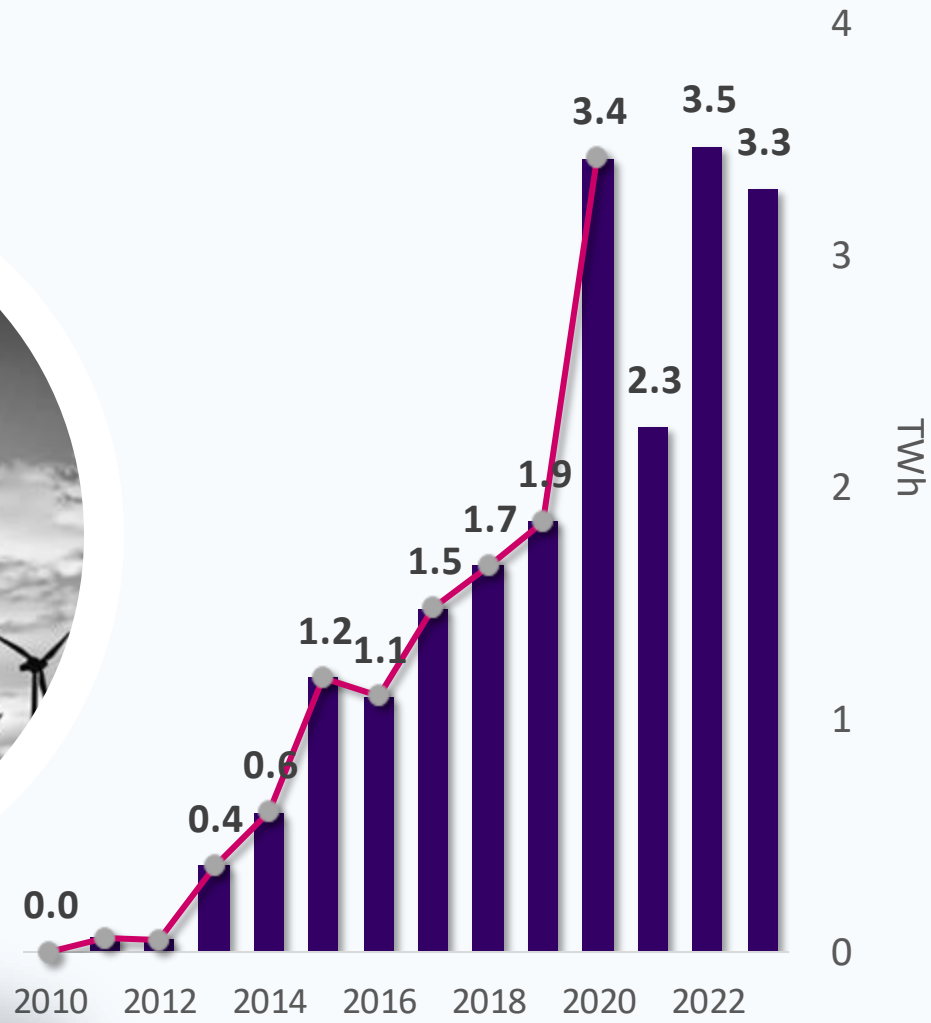
Cannot foresee the pain and trouble that are bound to ensue; and equal blame belongs to those who fail in their duty through.

These cases are perfectly simple and easy to distinguish. In a free hour when.

6.5 TWh of wind power curtailed in the UK

Costing £1.5 billion

resulting in 2.5 million tones of CO_2 emissions



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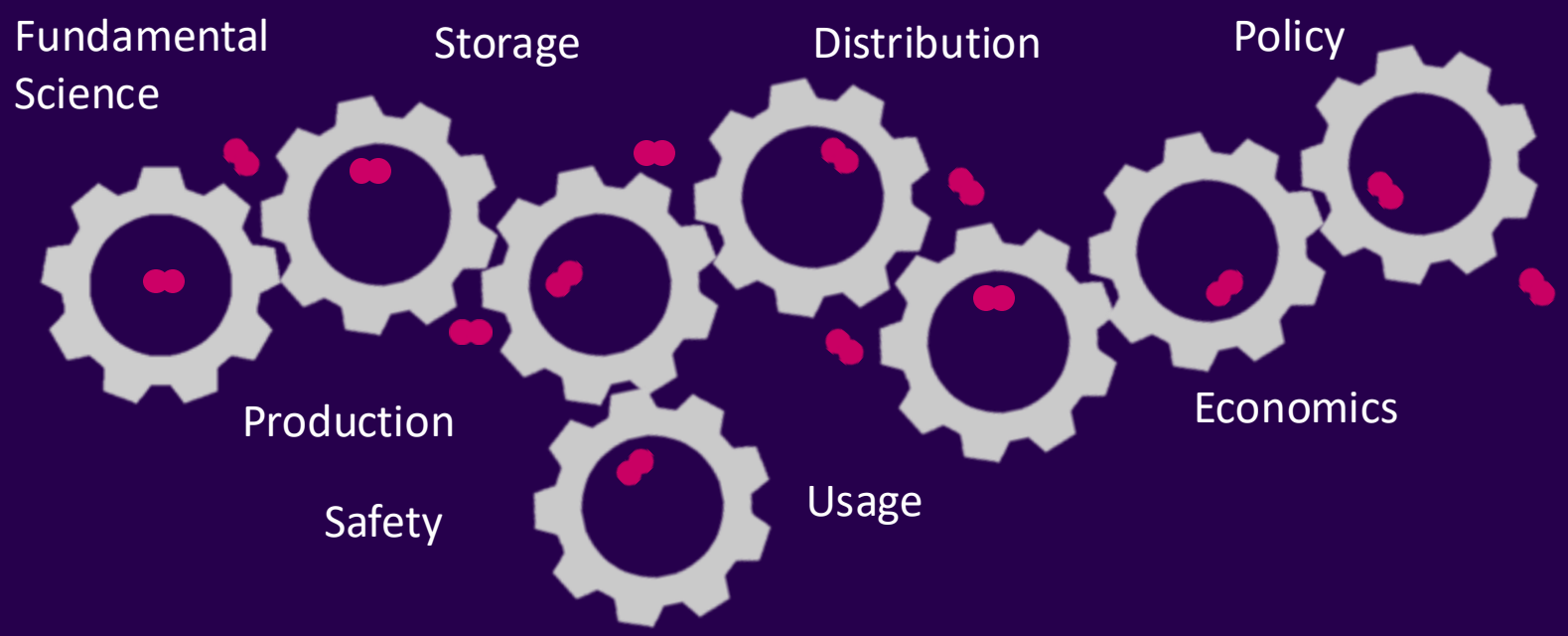

Fundamental Science
Storage
Distribution
Policy
Production
Safety
Usage
Economics

Meet
The Battery-Electrolyser Team

These cases are perfectly simple and easy to distinguish. In a free hour, when our power of choice is untrammelled and when nothing prevents our being.

Professor Dani Strickland

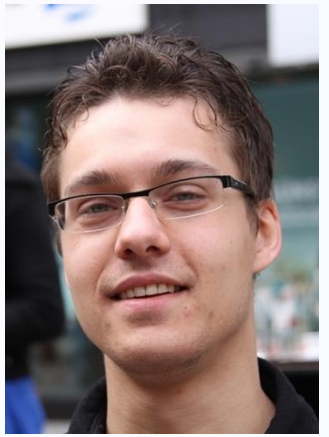
Professor or Electrical Power Engineering

Dr Jonathan Wilson

Lecturer in System and Mechanical Engineering

Dr John Barton

Senior Research Associate



Dr Martin Bliss

Senior Research Associate

Dr Elizabeth Ashton

Senior Research Associate

Dr Richard Wilson

Research Associate

Matthew Brenton

PhD Researcher

Professor Paul Holland

Professor of Hydrogen Metrology

THANK YOU

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