

MSIP Technology Update

LERG - Cost-Effective Chemical Synthesis for a Greener Tomorrow

February 20th 2020

Cost-Effective Chemical Synthesis for a Greener Tomorrow

- LERC is developing groundbreaking, patented, proprietary technology using ionically-conducting ceramic materials that facilitate clean, cost-effective synthesis of a variety of essential chemicals and compounds, including hydrogen and ammonia.
- Our SOEC system has preliminarily shown itself to be capable of producing commercially viable amounts of high-purity hydrogen using a proton-conducting ceramic (PCC) membrane (P-SOEC), which allows hydrogen ions to be transported from one side of the membrane to the other at intermediate temperatures and ambient pressure.
- We favor P-SOEC-based electrolysis over oxygen ion conducting-based electrolysis: Ability to produce pure hydrogen and the balance of plant is simpler and has a lower cost to design and build.
- LERC, via its operating subsidiary Low Emissions Resources Global Ltd. (LERG), is located in Dundee, Scotland. At our Dundee location we have a fully-equipped high-tech, protonic-conducting ceramics laboratory and testing facility.

MARKET SIZE AND GROWTH

Across the ammonia, hydrogen and fuel cell universe, LERC's technology represents a rapidly-growing \$183bn market.



AMMONIA

\$50bn
CURRENT
MARKET SIZE

\$71bn
PROJECTED
BY 2025

5.9%
CAGR

H₂ HYDROGEN

\$127bn
CURRENT
MARKET SIZE

\$177bn
PROJECTED
BY 2025

5.8%
CAGR



FUEL CELL

\$6bn
CURRENT
MARKET SIZE

\$18bn
PROJECTED
BY 2025

20.9%
CAGR

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Great Materials Science:

LERG's proton conducting ceramic material, catalysts, and processes enable energy efficient H_2 production through high temperature steam electrolysis.

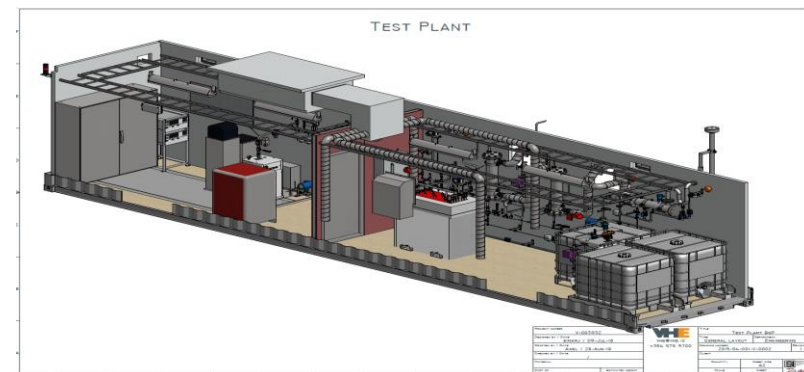
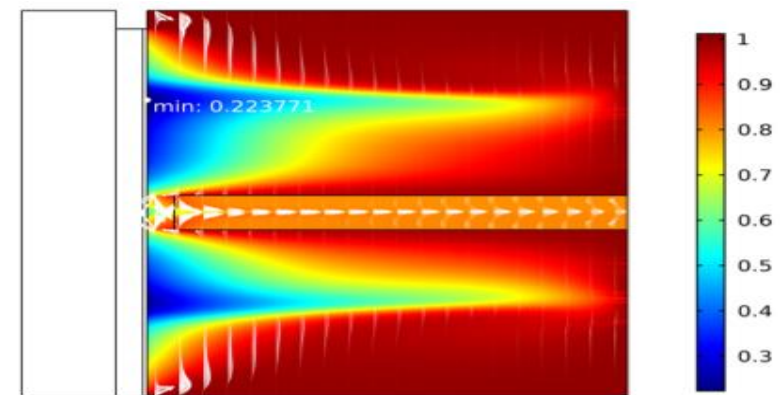
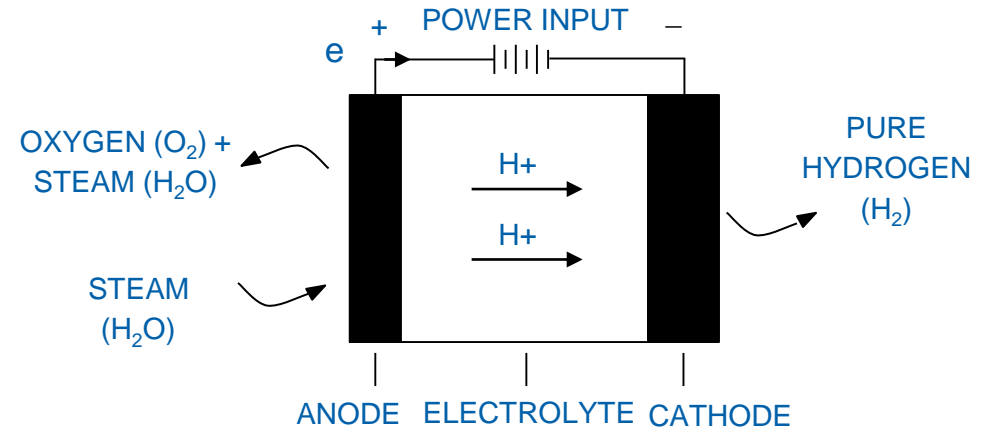
< 45 kWh/kg achieved on single tube/cell in our test reactor.

Pilot Reactors for Optimization

Reacting flow and thermal modeling of electrolysis tubes and stacks ensure stable reactor designs.

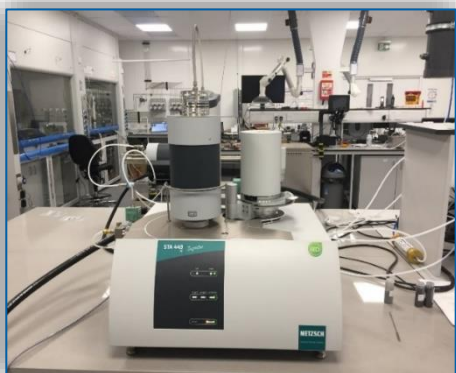
Commercially Scalable Design

Modular stack design grows with customers' H_2 demand.



State of the Art R&D Facility

Simultaneous Thermal Analyzer (STA)



Dilatometer



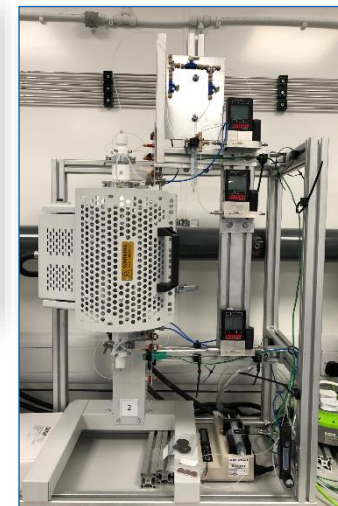
BET Surface Area and Pore Size Analyzer



Gas Chromatography & Mass Spectroscopy



Button Cell Testing



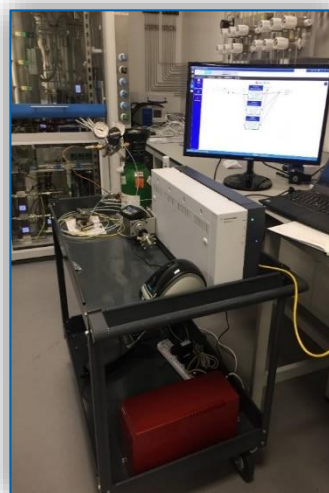
Mastersizer Particle Size Analyzer



Rheometer & Zetasizer



GC – Thermal Conductivity Detector



SEM



Optical MS



Our team has designed and implemented an in house, quick turn R&D process that lends itself to rapid process and technology improvements.

Extrusion



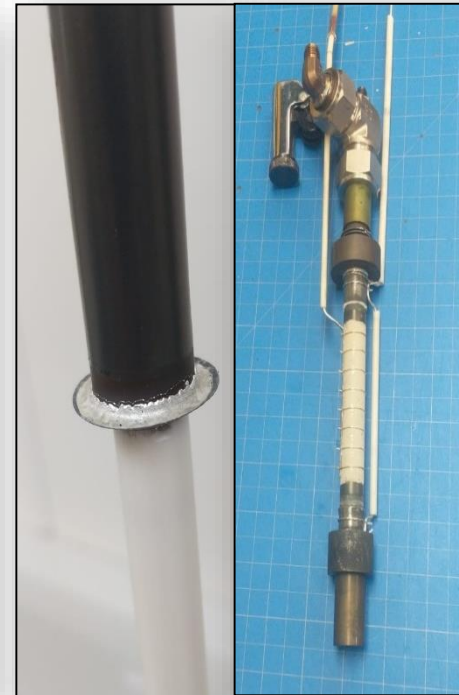
Sintering



Dip Coating



Braze & Interconnect



Test Reactors

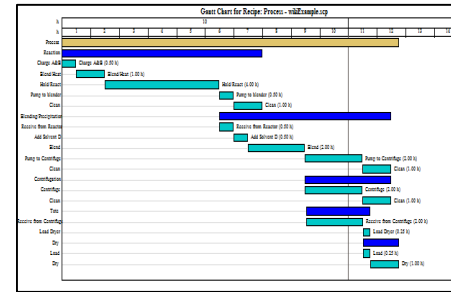


LERG consists of a close knit team with various areas of expertise that compliment the development of our technology.



LERG's Technology Leader:

Mr. Joshua Persky holds a B.S in glass/ceramic engineering from the New York State College of Ceramics at Alfred University. He holds multiple patents in the ceramics field. Joshua is a C-Level Executive and Board Member of LERG.



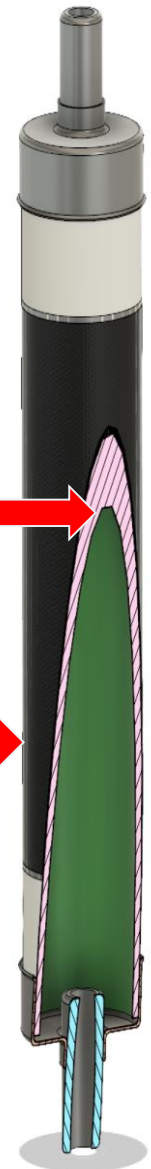
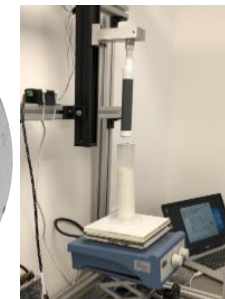
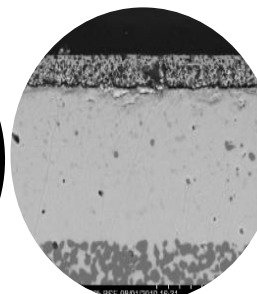
Cathode Support & Single Layer Anode:

Dr. Hwan Kim studied solid state electrochemistry with a focus on Solid Oxide Fuel Cells. PhD from Postech University in Korea.



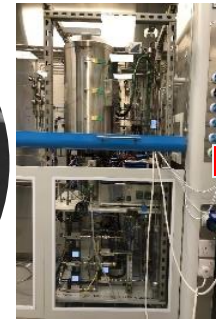
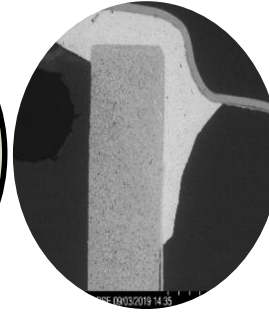
Slurry Formulation and EIS Modeling:

Dr. Berceste Beyribey Price BSc MSc MRSC. She has a PhD in Chemical Engineering from the Yildiz Technical University. The title of the PhD thesis is "Advanced Electrode/Electrolyte Materials for Low and Intermediate Temperature Solid Oxide Fuel Cells" and part of the research was completed in the DTU Energy and supervised by Professor Mogens Mogensen. She has also completed a post doctoral research on fuel cell materials in Professor John Irvine's group at the University of St Andrews.



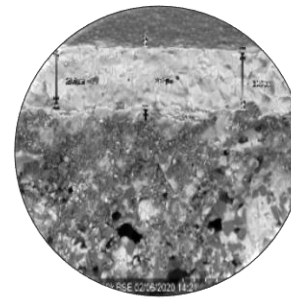
Brazing, Interconnects & Test Infrastructure:

Dr. George Carins MEng PhD is a Mechanical Engineer with a PhD in Chemistry from University of St Andrews. George leads the way in research of the reactor environment in which our cells operate.



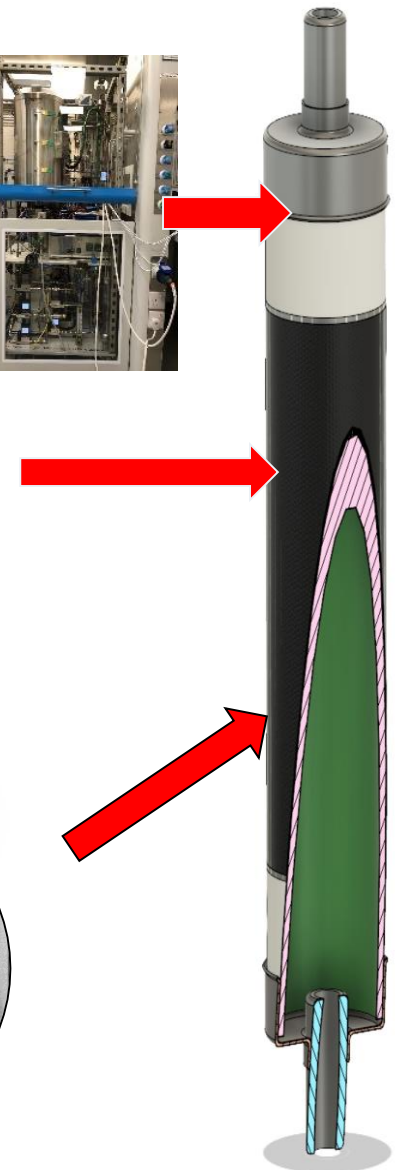
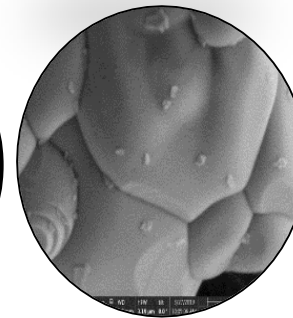
Lead Scientist – overall cell development:

Dr. Zac Dehaney-Steven has a PhD from the University of St Andrews on solid oxide Oxygen Transport Membranes. He also has industrial experience in Solid Oxide Fuel Cell development.



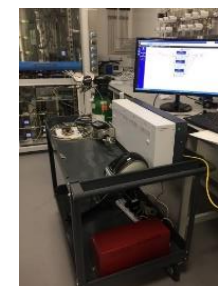
Catalyst Development and Vectoring:

Dr. Alberto Olivo has a PhD in Chemistry (*Doctor Europaeus* label) from Ca' Foscari University of Venice and University of Trieste, Italy, with a thesis on catalysts development for CO₂ photo reduction. His work is focused on the synthesis of innovative catalysts, their characterization and targeted vectoring within SOECs.



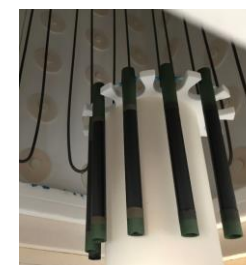
Laboratory Technical Leader:

Dr Gavin Peters has a PhD in Chemistry from University of Strathclyde in Glasgow. Focusing on lab management, chemical and physical analysis, cell production, cell testing and post test cell analysis.



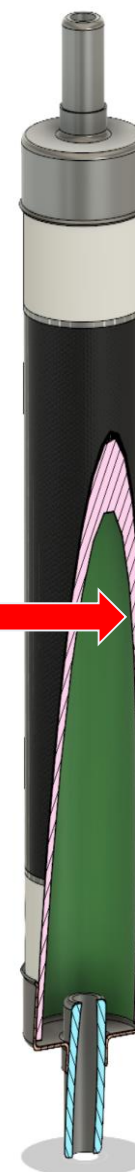
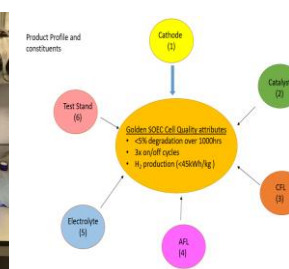
Extrusion, Cell Coating & COSHH Mgmt.:

John Bayne has a HND – Applied Chemistry HNC – Applied Sciences. John brings several years preproduction and lab experience to our team.



Lab Analytics and Quality by Design Program:

Samantha Taylor has a BSc Hons in Pharmaceutical Chemistry from the University of Dundee. Sam has over 8 years industry experience as an analytical chemist.

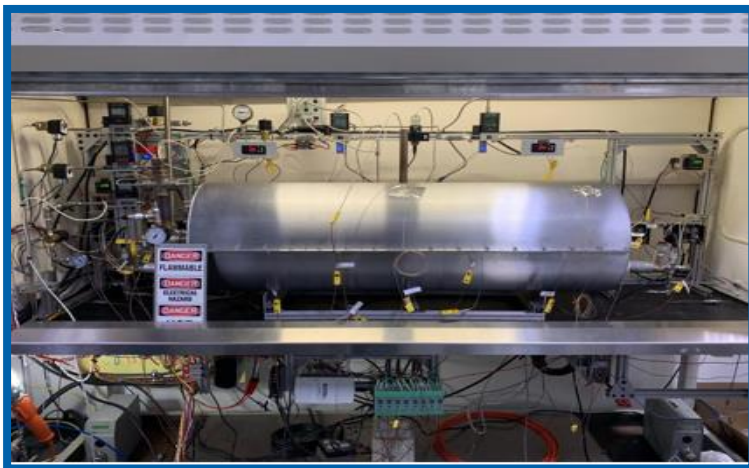


We have partnered with leaders in Ceramics, Electrochemical R&D, Plant Design and Fuel Cell Research



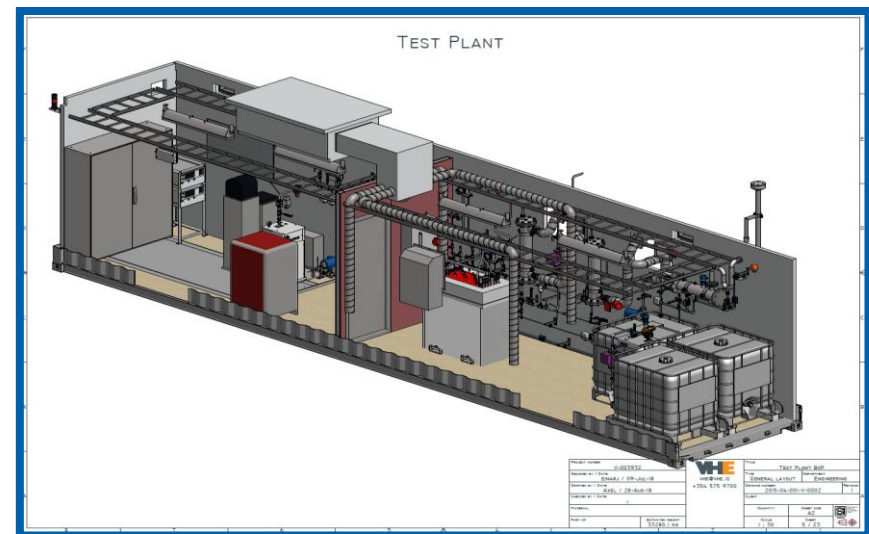
Q2 Goal

- Linear 5 cell module
- Operating in a furnace with lab *BOP*
- Better than 45 kW*hrs/kg at 1000hrs. Extrapolated from 250 hrs
- ~15 inch tubes ~0.625" OD
- Proven Cell Cycling
- Brazed caps and seals
- Verification tests to start April 2020
- Test to reach repeatability target



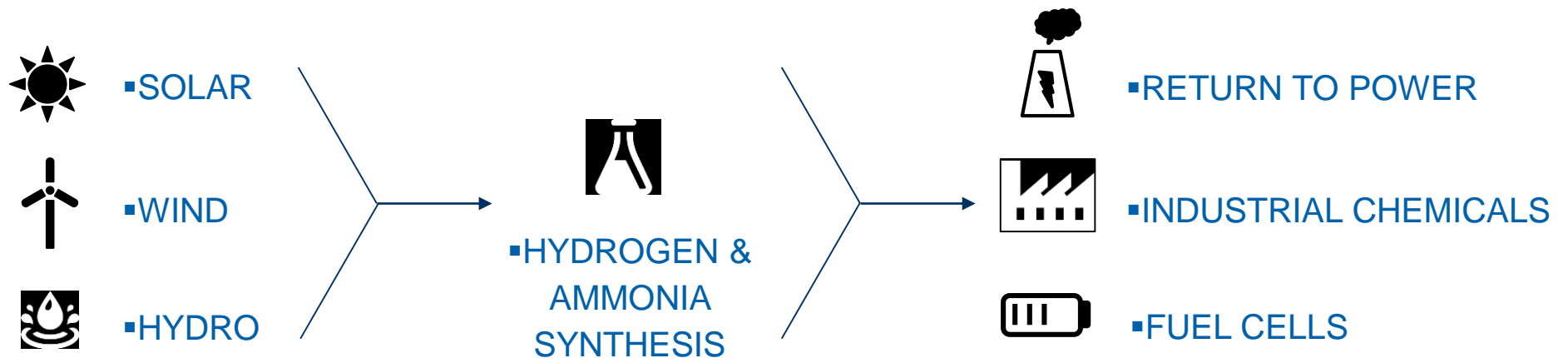
Q4 –Q1 Goal

- 25-50 cell stack operating at partner site
- Completely self-contained micro-plant (40' container)
- 3-4 months lead time after completion of Q2 Goal
 - ✓ Engineering design/redesign
 - ✓ Additional materials procurement
 - ✓ Fabrication
 - ✓ Commissioning



LERG'S TECHNOLOGY WILL ENABLE CONVERSION, STORAGE AND DISTRIBUTION OF CLEAN ENERGY

This is a new and exciting market opportunity. LERG's technology will turn excess power into green energy storage, which can be converted into power for propulsion, heat, air conditioning, etc.



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**We can be reached via the contact
page of our website**

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