Manufacturing Automation and Recycling for Clean Hydrogen Technologies

OxEon Energy
North Salt Lake, Utah

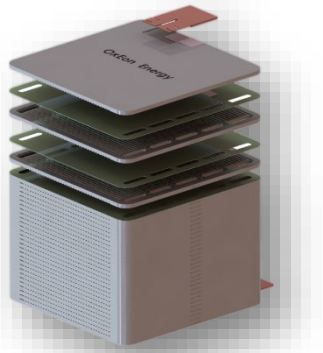
Jessica Elwell

Beyond Current Potential

OxEon Energy, LLC

Utah R&D/ Mfg Facility – Founded 2017 after successful 30-year collaboration of founders

- New 24,000 ft^2 (2230 m^2) office, laboratory, and manufacturing facility
- NASA, DOE, DOD and Commercial Funding
- Tape casting, cell and stack production, and testing
- End-to-end power to synfuels pilot plant in operation

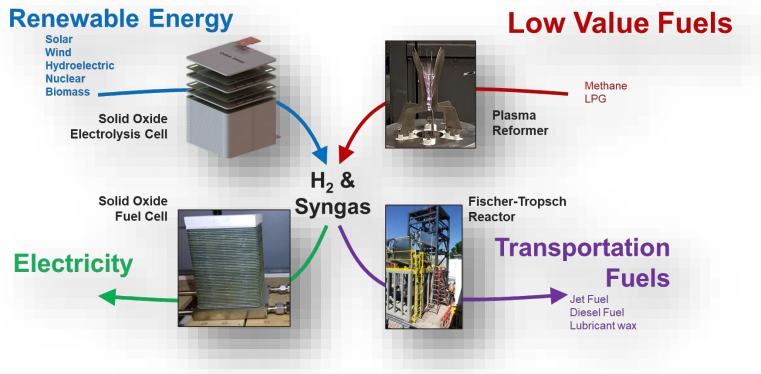


Solid Oxide Fuel Cell and Electrolysis Stacks

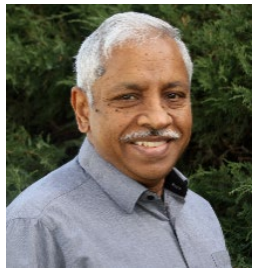
- Longest running solid oxide fuel cell & electrolysis group in world
- Only flight qualified, TRL 9 SOEC unit in history
- 30kW/10kW reversible system test program in process

Fuel Reformation and Generation

- Plasma Reformer – H_2 and Syngas for flare curtailment
- Fischer-Tropsch Reactors – Modular design for transportation fuel production from H_2 and Syngas



OxEon Energy – Executive Team



Dr. S. Elango Elangovan – Co-Chair and Founder

Ph.D. Materials Science, University of Utah; M.S. Materials Science, Caltech
University of Utah (Associate Professor), Technology Research Associate, Inc (Consultant);
Ceramatec/SOFCo (Research Scientist, Program Manager – 30 years)

Joseph Hartvigsen – Co-Chair and Founder

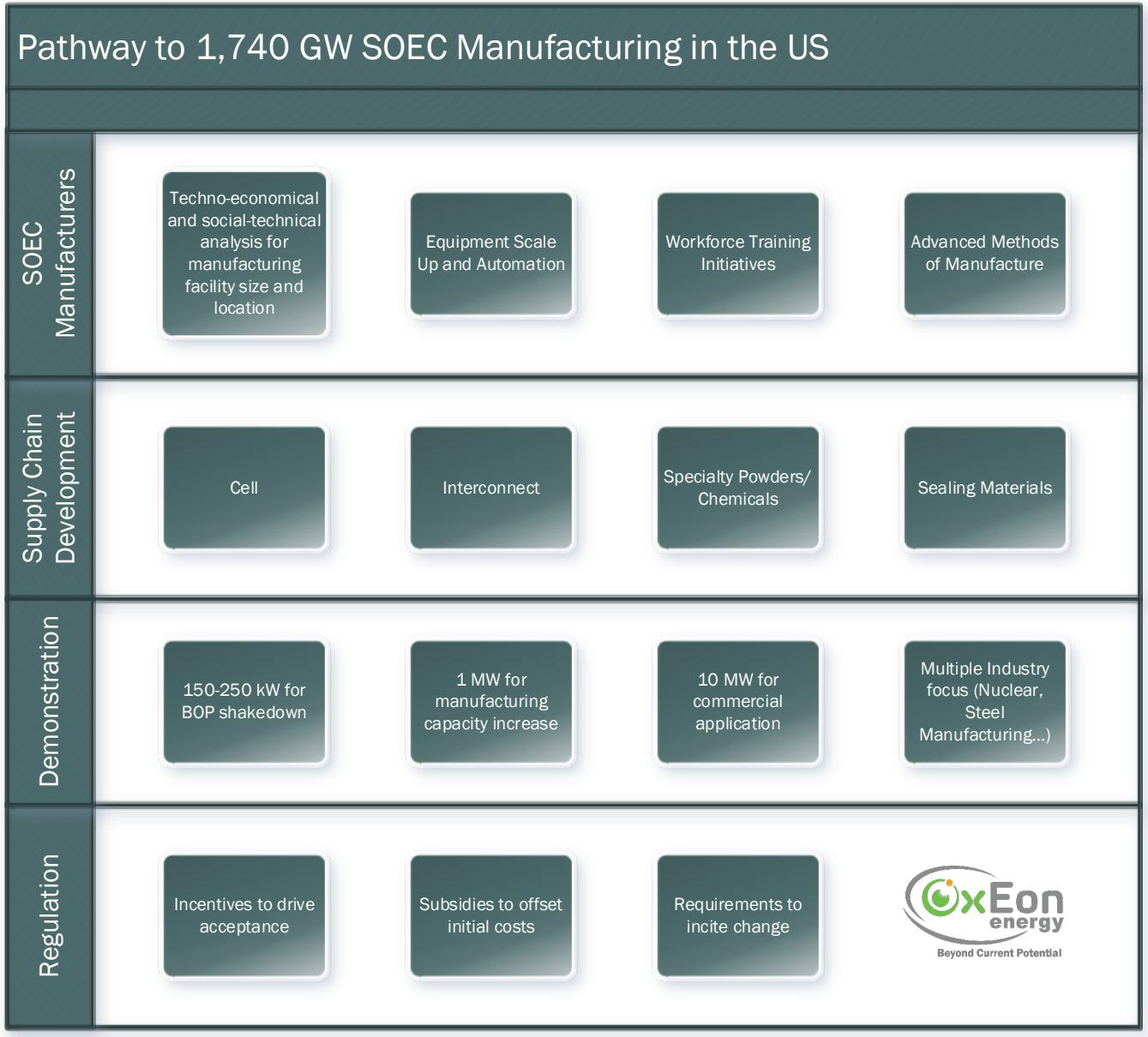
M.S. Chemical Engineering, Iowa State; MOXIE Co-I and Institutional Principal Investigator
Thermal-fluids analyst in defense aerospace (6 Years at Boeing & Hercules)
PI on over 20 years of hydrogen and synthetic fuels research and development
Producer of small hydroelectric turbines, manage 430-acre family farm in Idaho

Jessica Elwell – COO

M.S. Chemical Engineering, Michigan Tech; Program Manager for MOXIE Project; Former Engineering and Compliance Manager for Nammo Defense Systems; 9+ years of Aerospace and Defense Management for Programs, Manufacturing and Business Systems

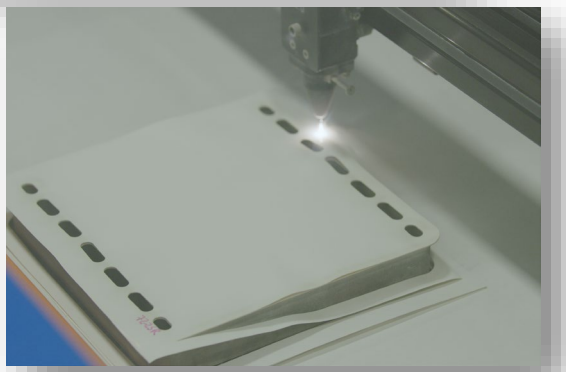
Lyman Frost – CEO and Founder

Babcock & Wilcox (power generation; corporate research); McDermott Inc. (offshore; intrapreneurial); SOFCO (SOFC); Idaho National Laboratory (US DOE; Director Alternate Energy); Field Upgrading (CTO); Western H_2 (H_2 generation - COO); Idaho and Utah Governor's Science Advisory Council; OxEon Energy LLC

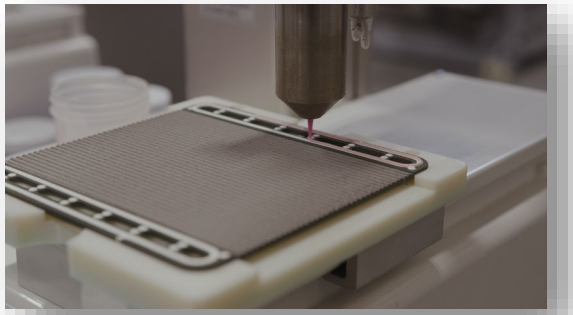

Pathway to 1,740 GW SOEC Manufacturing in the US
SOEC Manufacturers
Techno-economical and social-technical analysis for manufacturing facility size and location
Equipment Scale Up and Automation
Workforce Training Initiatives
Advanced Methods of Manufacture
Supply Chain Development
Cell
Interconnect
Specialty Powders/ Chemicals
Sealing Materials
Demonstration
150-250 kW for BOP shakedown
1 MW for manufacturing capacity increase
10 MW for commercial application
Multiple Industry focus (Nuclear, Steel Manufacturing…)
Regulation
Incentives to drive acceptance
Subsidies to offset initial costs
Requirements to incite change
OxEon energy
Beyond Current Potential

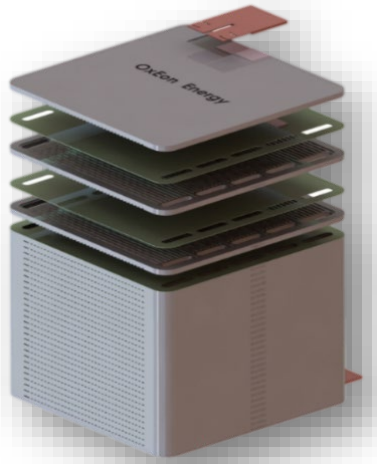
Key Focus Areas

- Thermal Processes:
  - Largest bottleneck in manufacturing process
  - Technologies exist, large equipment investment needed
    - Process adaptation from batch to continuous
- Quality Control/Assurance in Process
  - Correlation to stack results
  - Industry standardization of commonly used metrics
- Cell Process Automation
  - Technologies/Equipment exists, investment in adapting for specific manufacturing processes is needed
- Supply Chain Scale Up
- Product demand to meet production



Stacking Automation





- Stack sealing is a semi-automated and proven process
  - Scaling to MW requires equipment development for robotic feed and decreased cycle time
  - Full automation will be integrated into automated assembly
- Stack assembly automation:
  - Currently a manual process based on demand and production rates
  - Robotics technologies exist that could be adapted to fully automate the stacking process
- Stack joining is an automated and proven process
  - In process quality checks in place

BOP Automation

- Currently building FOK systems
- 100-250 kW system demonstrations will finalize BOP and establish a repeatable module size
- Establishing partnerships to separate BOP manufacturing from Cell/Stack Production
  - Sheet metal fabricators common to appliance industry
  - Thermal refractory manufacturers pre-cut kits to reduce waste
  - Manifold piping bending, welding, differences and similarities to both aerospace and chemical process industries.

Demonstrations to Drive Demand

- 150-250 kW near term to finalize BOP designs and input into manufacturing scale up
- MW scale to justify investment in GW scale plant design and build
- 10s of MW scale to drive industry acceptance

Thank You

OxEon energy

Beyond Current Potential