FuelCell Energy

# FuelCell Energy Platforms for Hydrogen Production

## US Department of Energy Bulk Storage of Gaseous Hydrogen Workshop

February 10, 2022

# Safe Harbor Statement

This presentation contains forward-looking statements within the meaning of the safe harbor provisions of the Private Securities Litigation Reform Act of 1995 regarding future events or our future financial performance that involve certain contingencies and uncertainties, including those discussed in our Annual Report on Form 10-K for the fiscal year ended October 31, 2021 in the section entitled "Management's Discussion and Analysis of Financial Condition and Results of Operations”. Forward-looking statements include, without limitation, statements with respect to the Company’s anticipated financial results and statements regarding the Company’s plans and expectations regarding the continuing development, commercialization and financing of its fuel cell technology and its business plans and strategies. These statements are not guarantees of future performance, and all forward-looking statements are subject to risks and uncertainties that could cause actual results to differ materially from those projected. Factors that could cause such a difference include, without limitation: general risks associated with product development and manufacturing; general economic conditions; changes in interest rates, which may impact project financing; supply chain disruptions; changes in the utility regulatory environment; changes in the utility industry and the markets for distributed generation, distributed hydrogen, and fuel cell power plants configured for carbon capture or carbon separation; potential volatility of commodity and energy prices that may adversely affect our projects; availability of government subsidies and economic incentives for alternative energy technologies; our ability to remain in compliance with U.S. federal and state and foreign government laws and regulations and the listing rules of The Nasdaq Stock Market; rapid technological change; competition; the risk that our bid awards will not convert to contracts or that our contracts will not convert to revenue; market acceptance of our products; changes in accounting policies or practices adopted voluntarily or as required by accounting principles generally accepted in the United States; factors affecting our liquidity position and financial condition; government appropriations; the ability of the government and third parties to terminate their development contracts at any time; the ability of the government to exercise “march-in” rights with respect to certain of our patents; our ability to successfully market and sell our products internationally; our ability to implement our strategy; our ability to reduce our levelized cost of energy and our cost reduction strategy generally; our ability to protect our intellectual property; litigation and other proceedings; the risk that commercialization of our products will not occur when anticipated or, if it does, that we will not have adequate capacity to satisfy demand; our need for and the availability of additional financing; our ability to generate positive cash flow from operations; our ability to service our long-term debt; our ability to increase the output and longevity of our platforms and to meet the performance requirements of our contracts; our ability to expand our customer base and maintain relationships with our largest customers and strategic business allies; changes by the U.S. Small Business Administration or other governmental authorities to, or with respect to the implementation or interpretation of, the Coronavirus Aid, Relief, and Economic Security Act, the Paycheck Protection Program or related administrative matters; and concerns with, threats of, or the consequences of, pandemics, contagious diseases or health epidemics, including the novel coronavirus, and resulting supply chain disruptions, shifts in clean energy demand, impacts to our customers’ capital budgets and investment plans, impacts to our project schedules, impacts to our ability to service existing projects, and impacts on the demand for our products, as well as other risks set forth in the Company’s filings with the Securities and Exchange Commission. The forward-looking statements contained herein speak only as of the date of this presentation. The Company expressly disclaims any obligation or undertaking to release publicly any updates or revisions to any such statement contained or incorporated by reference herein to reflect any change in the Company’s expectations or any change in events, conditions or circumstances on which any such statement is based.

The information set forth in this presentation is qualified by reference to, and should be read in conjunction with, our Annual Report on Form 10-K for the fiscal year ended October 31, 2021, filed with the SEC on December 29, 2021, our Form 10-Q for the three months ended January 31, 2022, filed with the SEC on March 10, 2022, and our earnings release for the first fiscal quarter of 2022, filed as an exhibit to our Current Report on Form 8-K filed with the SEC on March 10, 2021.

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# FuelCell Energy: A Global Leader in Fuel Cell Technology – Operating Since 1969

## COMPANY OVERVIEW

A global leader in **decarbonizing power** and **producing hydrogen** through our proprietary fuel cell technology

FuelCell Energy is working to:

- **Produce** low- to zero-carbon power
- **Capture** carbon and greenhouse gasses while simultaneously generating power; Negligible NOx or SOx emissions
- **Supply** green or blue hydrogen power
- **Store** energy from intermittent renewables by converting excess power to hydrogen – then converting hydrogen back into power when it's needed or delivering to other applications

## COMPANY HIGHLIGHTS[1]

| | | |
|---|---|---|
| **HQ** Danbury, Connecticut | **~380** Employees | **>50** Plants Installed Globally — **3** Continents |
| **FCEL** Listing: NASDAQ | **>220 MW** Capacity in Field | **>12** Million MWh's generated with SureSource Patented Technology |

## GLOBAL CUSTOMERS

**Demand for Clean, Reliable Electricity Driving Adoption of Fuel Cell Technology**

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[1] As of the year ended October 31, 2021 [2] Percentages of FY21 revenue

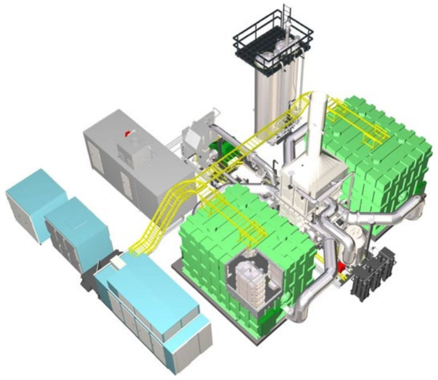
# Technology Overview

## High Temperature Fuel Cell and Electrolysis Solutions

- Fuel cells cleanly and efficiently convert energy in hydrogen rich fuels into electricity and high-quality heat
- A fuel cell stack is comprised of many individual cells grouped together. Stack modules can have one or more stacks
- Fuels are converted to hydrogen in the stack by reforming using water and heat produced by the fuel cells
- Hydrogen not used in power generation can be exported to hydrogen users
- Fuel cell stacks can also operate in electrolysis mode – producing hydrogen from steam and power

## Carbonate

- Large stacks provide economies of scale in MW-scale power generation applications
- Uniquely suited to operate with on-site renewable biogas
- Produces hydrogen through internal reforming or electrolysis/reforming combination



## Solid Oxide

- Compact, lightweight and scalable stack design
- Can operate with natural gas, biogas, or hydrogen fuel
- Can produce hydrogen through internal reforming or electrolysis
- Can alternate between fuel cell and electrolysis modes in hydrogen-based energy storage systems

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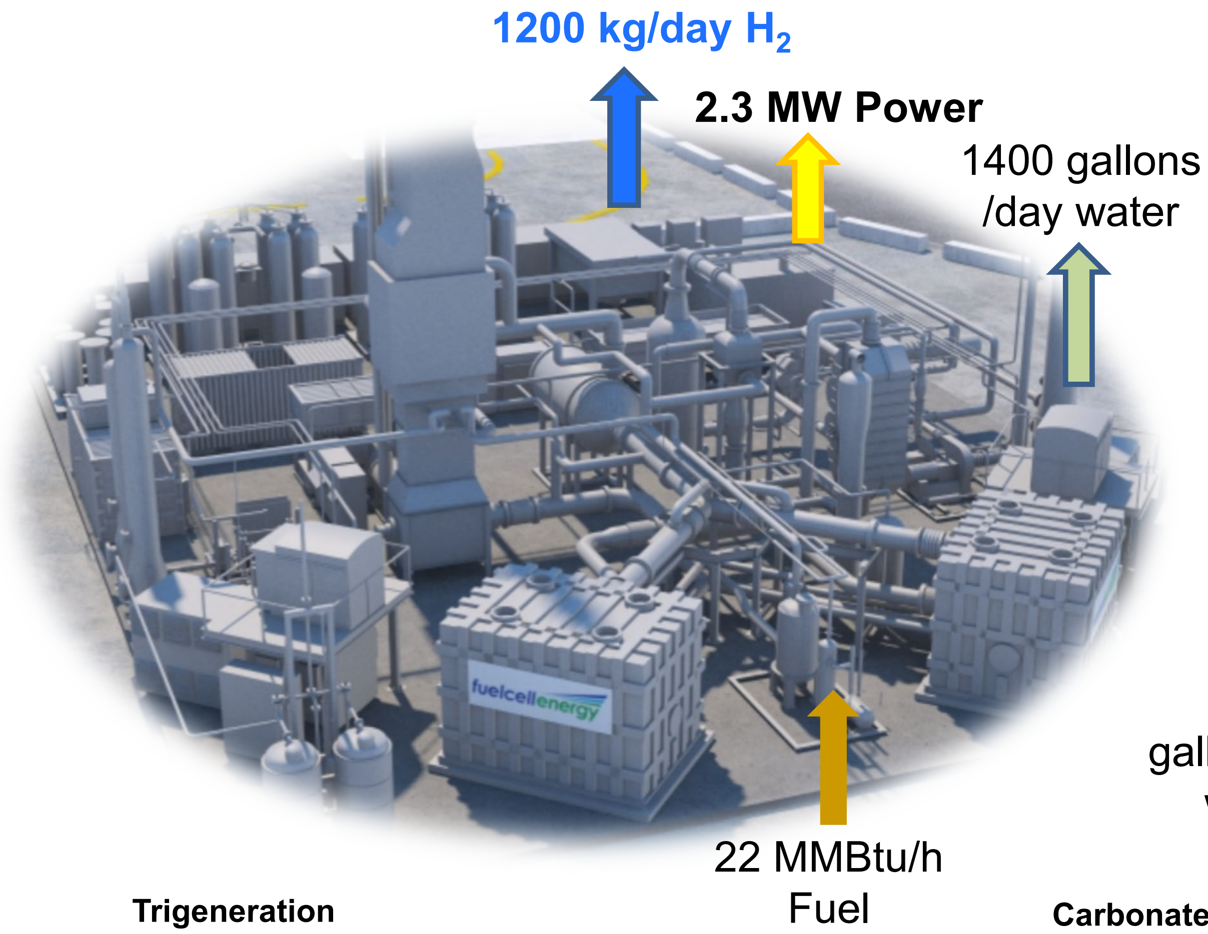
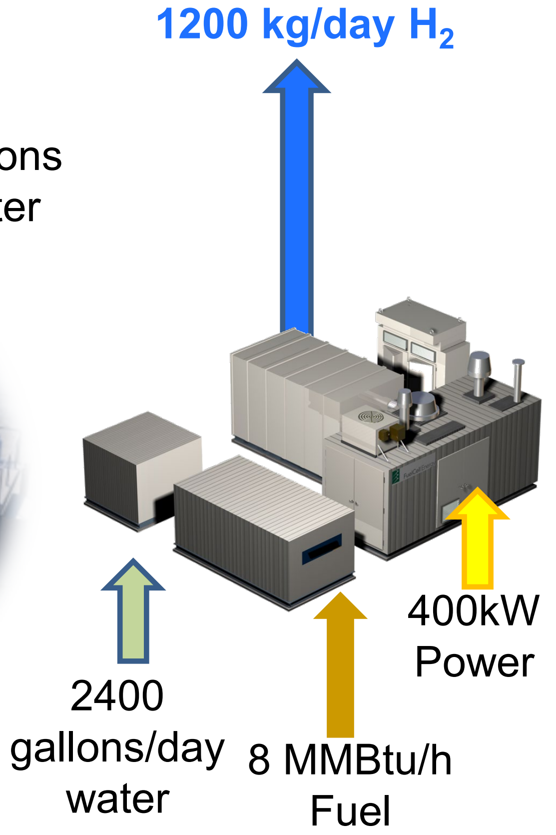
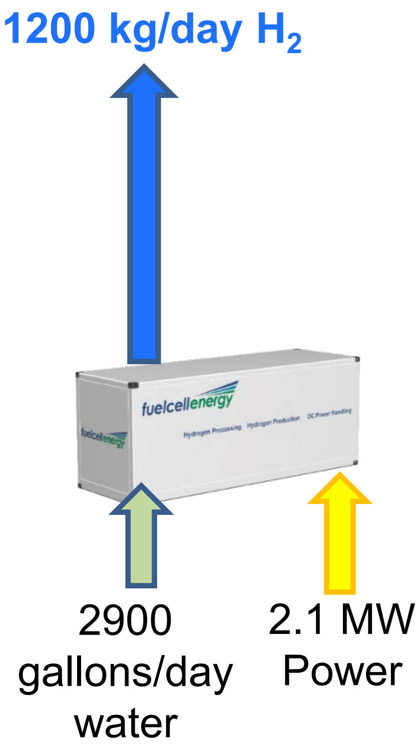
# FCE Hydrogen Solutions Compared at 1200 kg/day $H_2$




**Trigeneration**
- Two 4-stack Carbonate Modules
- Power and Hydrogen revenue streams
- Net water producer



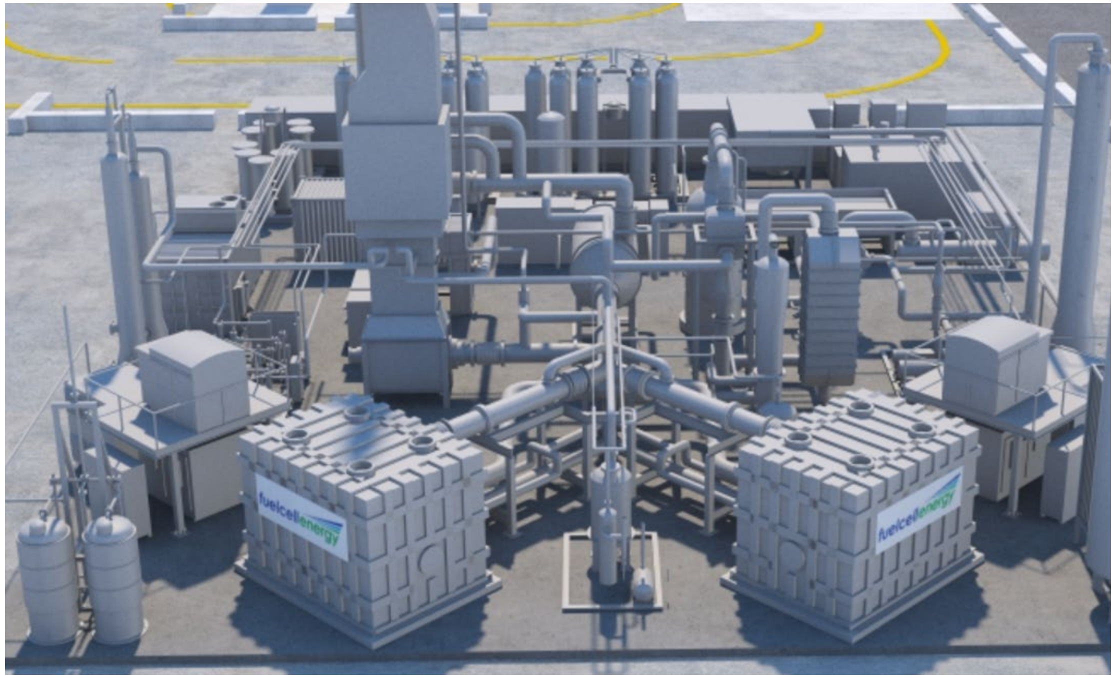

**Carbonate REP**
- One single-stack Carbonate Module
- Consumes fuel, power and water




**Solid Oxide Electrolysis**
- 48 compact stacks in two modules
- Consumes power and water

# Carbonate Trigeneration System

Natural gas or renewable biogas fuel



**2.35 MW Clean and green power – 18 GWh/year**

- 1200 tons per year avoided grid $CO_2$ emissions with natural gas fuel
- 10,000 tons per year avoided grid $CO_2$ emissions with biogas fuel
- 5 tons per year avoided NOX

**0.5 MMBtu/h thermal energy**

- 290 tons per year avoided boiler $CO_2$ emissions
- 200 lbs per year avoided NOX

**1270 kg/day hydrogen**

- 1700 tons per year $CO_2$ reduction vs SMR
- 4200 tons per year $CO_2$ reduction vs SMR with biogas fuel
- 700 lbs per year NOX reduction vs SMR
- 2 million gallons less water used per year vs SMR

**1400 gallons / day water**

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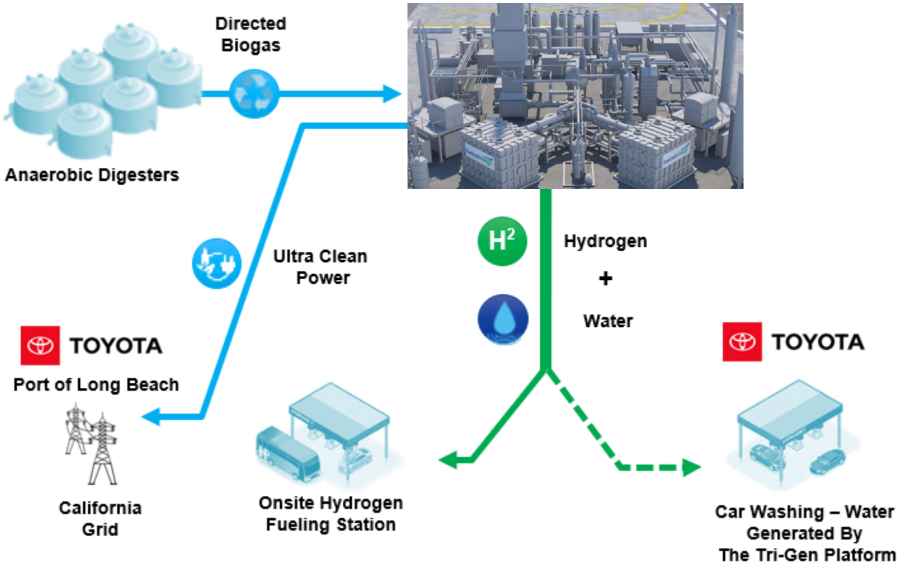
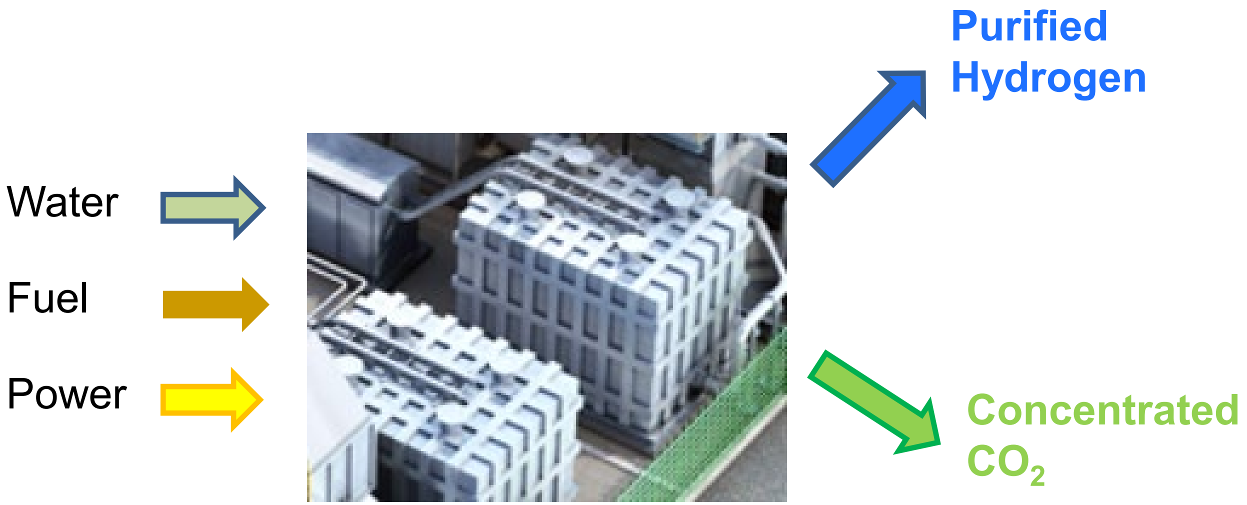
# Toyota Tri-generation Project

- Project supports Toyota vehicle fueling activities at the Port of Long Beach, where Toyota is importing fuel cell passenger vehicles and operating fuel cell trucks
- Fueled with directed biogas, project will produce renewable power and renewable hydrogen, plus clean water for car washing operations
- The system will generate 2.3MW of electricity, 1200kg of hydrogen, and 1400 gallons of water per day
- Enough to power ~ 2,250 average-sized homes and meet the daily driving needs of nearly 1,500 vehicles

# REP: Reforming / Electrolysis / Purification

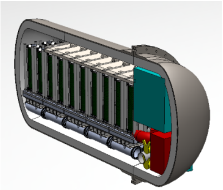
- Combination of reforming and electrolysis, using standard carbonate fuel cell stacks operating in reverse mode: electrolysis vs power generation
- Uses less fuel than pure reforming and less power than pure electrolysis
- Fuel is reformed to hydrogen and $CO_2$
- Electrolysis produces additional $H_2$ and transfers $CO_2$ to concentrated stream
- Concentrated $CO_2$ stream facilitates extraction for $CO_2$ capture to produce blue hydrogen



# Solid Oxide Applications

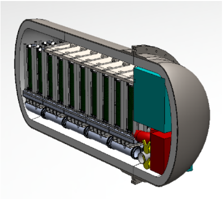
**SOFC Stack**


7 kW DC Power Generation
36 kW DC / 25 kg $H_2$/day electrolysis
350 cells, 17” height

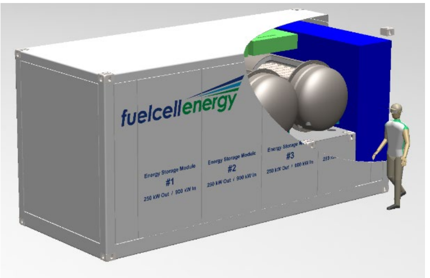


**Power Generation Stack Module – Only runs in power generation mode on a wide range of fuels, including natural gas, biofuels, propane, and hydrogen**

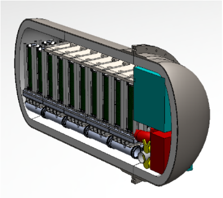
***200kW Power Generation System***



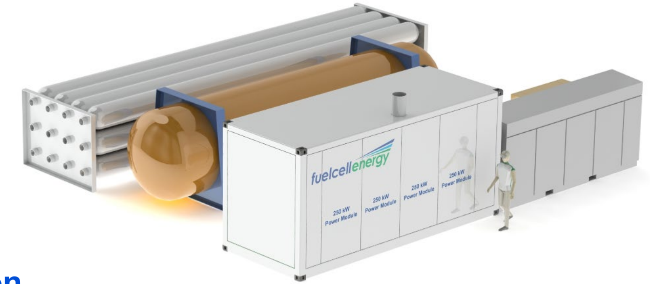
**Electrolysis Stack Module – Produces hydrogen from steam with power input**




***Electrolysis***
***4,000 kg/day H2 from 7.3 MW***



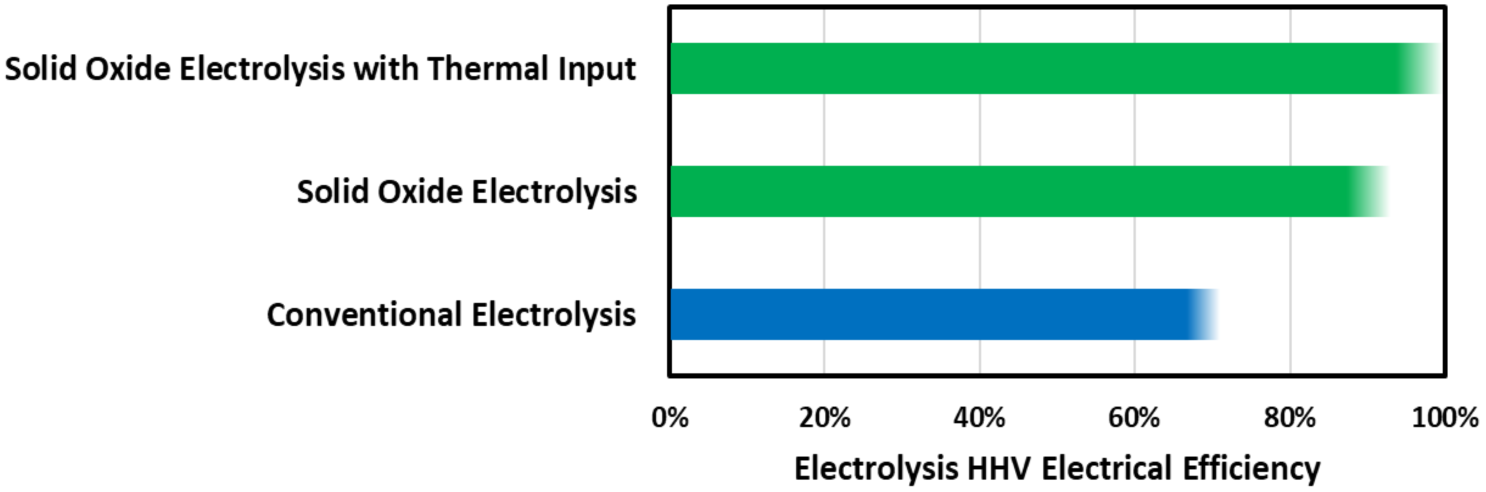
**Energy Storage Stack Module – Alternates between power generation on hydrogen fuel and electrolysis producing hydrogen from water**




***Energy Storage System***
***1MW 8 MWh***

# FCE Solid Oxide Electrolysis Performance Advantage

- **High current density, low weigh stacks** = lower stack cost needed for given hydrogen production rate
- **Low electrolysis voltage** = less power needed for given electrolysis rate: **Higher Electrical Efficiency**
- Lower stack hardware requirement and lower power requirement = **30 to 50% lower cost per kg for hydrogen depending on power cost**
- At low current densities, Solid Oxide Electrolysis Cells (SOEC) are **more than 100% electrically efficient** and need thermal energy input to maintain temperature
  - Provides opportunities for **waste heat utilization in hydrogen production**
  - Allows high round trip energy efficiency in **energy storage systems** with thermal energy storage




***High hydrogen production electrical efficiency can be increased further with use of waste heat***

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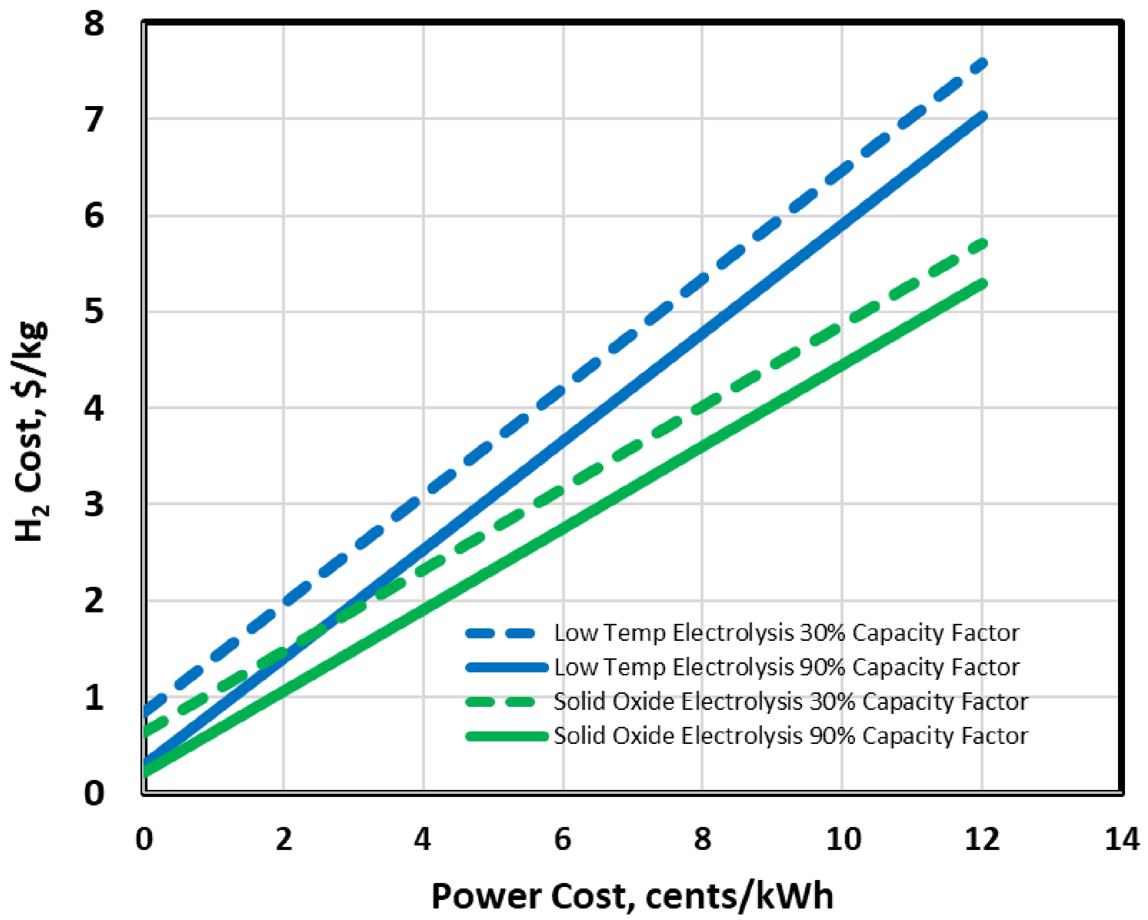
# High Efficiency Drives SOEC Cost Advantage

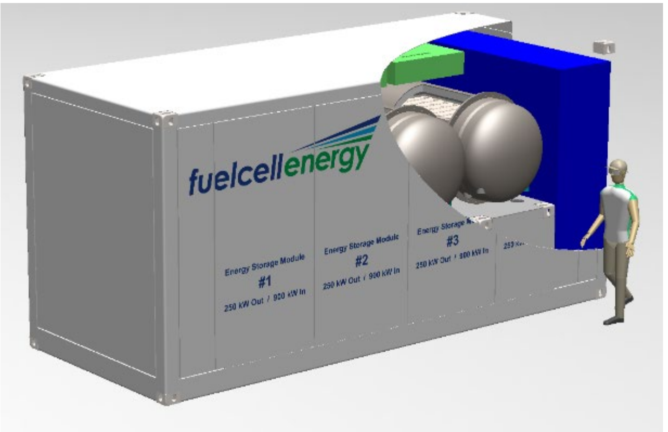
Comparing cost of hydrogen vs cost of power for low temperature and solid oxide electrolysis systems, with these future cost and performance assumptions:

| | Low Temp | SOEC |
|---|---|---|
| Installed Cost, $/kW | 300 | 300 |
| Annual Maintenance, % of capital | 5% | 5% |
| Efficiency, % HHV | 70% | 92% |
| Efficiency, kWh/kg | 56 | 43 |

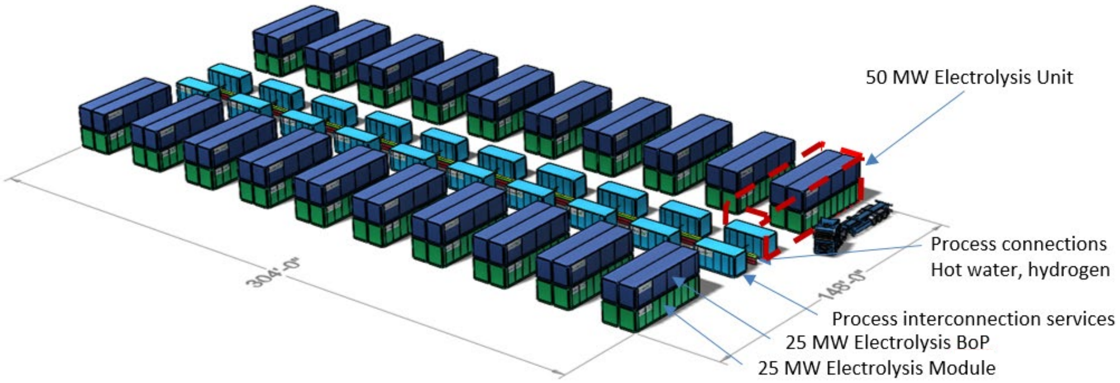
- Low-cost curtailed renewable power will be available for a small percentage of time, driving low capacity factor utilization
- Higher capacity factor operation will typically see higher average power cost



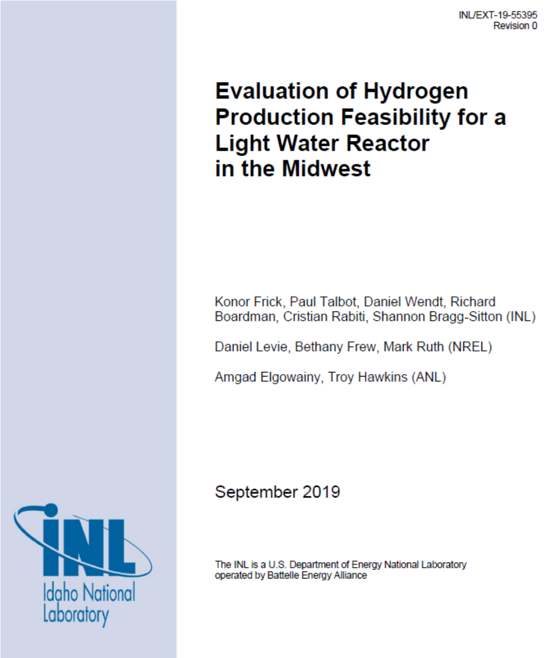
# Wide Range of Electrolysis Applications




***Distributed Electrolysis***
***4,000 kg/day H2 from 7.3MW***




***GW-scale electrolysis system for converting off peak nuclear power to hydrogen***



INL/EXT-19-55395
Revision 0

**Evaluation of Hydrogen Production Feasibility for a Light Water Reactor in the Midwest**

Konor Frick, Paul Talbot, Daniel Wendt, Richard Boardman, Cristian Rabiti, Shannon Bragg-Sitton (INL)

Daniel Levie, Bethany Frew, Mark Ruth (NREL)

Amgad Elgowainy, Troy Hawkins (ANL)

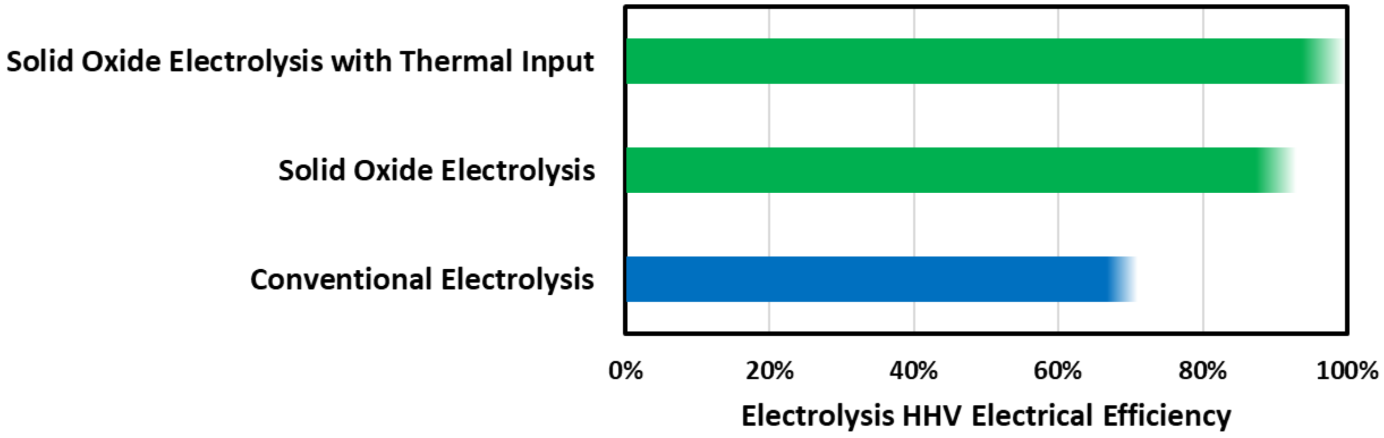
September 2019

INL Idaho National Laboratory

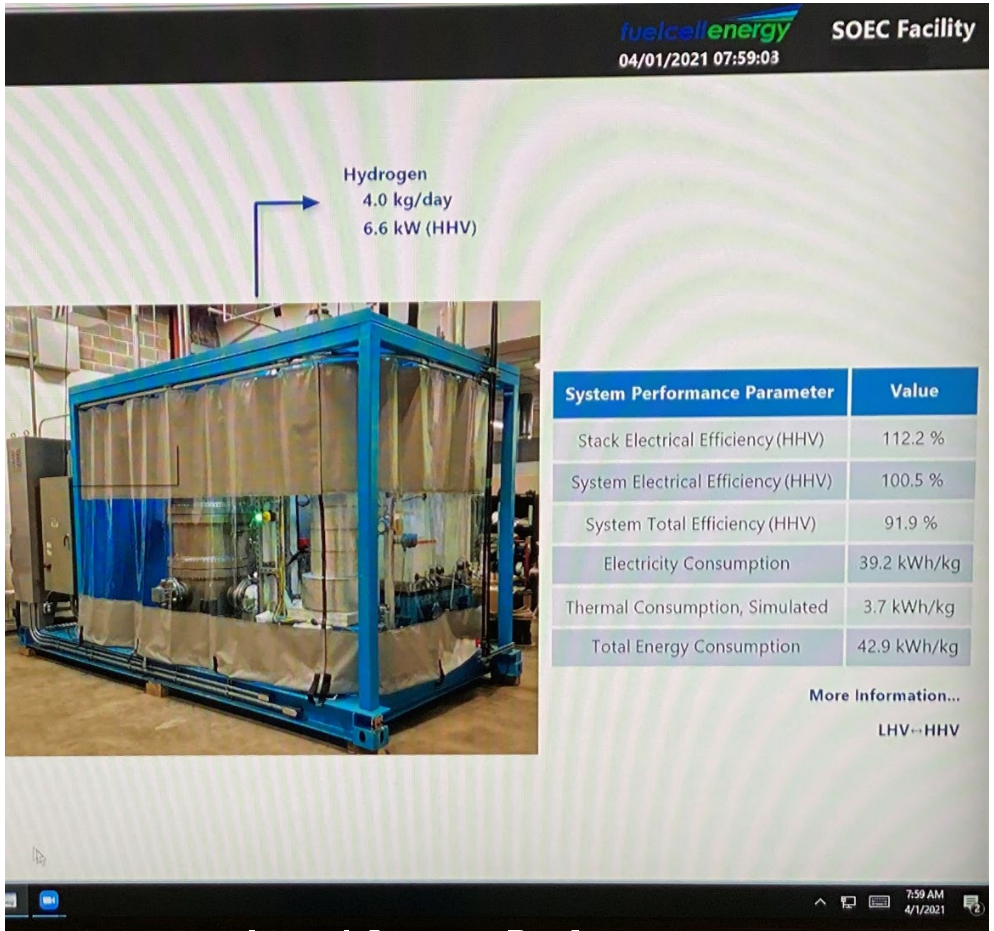
The INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance

***Electrolysis will be deployed in distributed and large-scale applications***

# Electrolysis Demonstration in Danbury




**Efficiency Projection**




**Actual System Performance**

- *Will be converted to energy storage system later this year to develop storage control and system technology ahead of first storage prototype systems*
- *This demonstration of the technology has developed and optimized control approaches and process improvements which will be used in the 250kW INL Demonstration*

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# 250kW Demonstration System

- 150 kg/day Hydrogen production from 270kW (or 250kW with thermal input)
- Demonstration of high efficiency prototype system at Idaho National Laboratory (INL) at nuclear plant operating modes, including thermal energy support for ultra high efficiency electrolysis
- Will demonstrate high efficiency without thermal input, and up to 100% efficiency with thermal input


***Packaged prototype of module repeated in larger systems***

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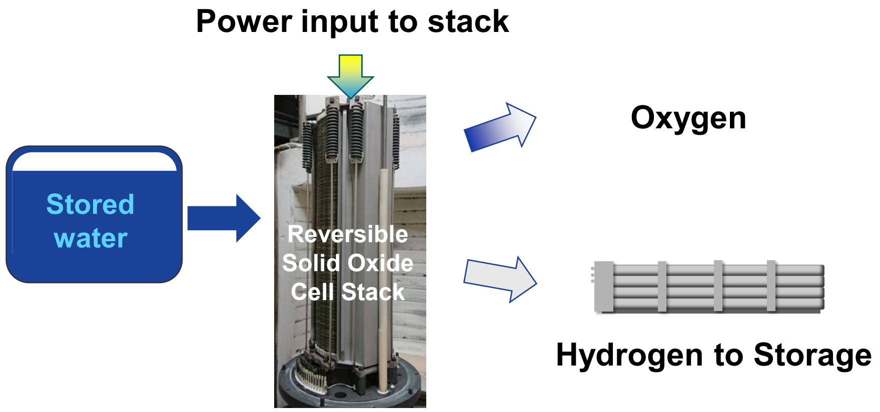
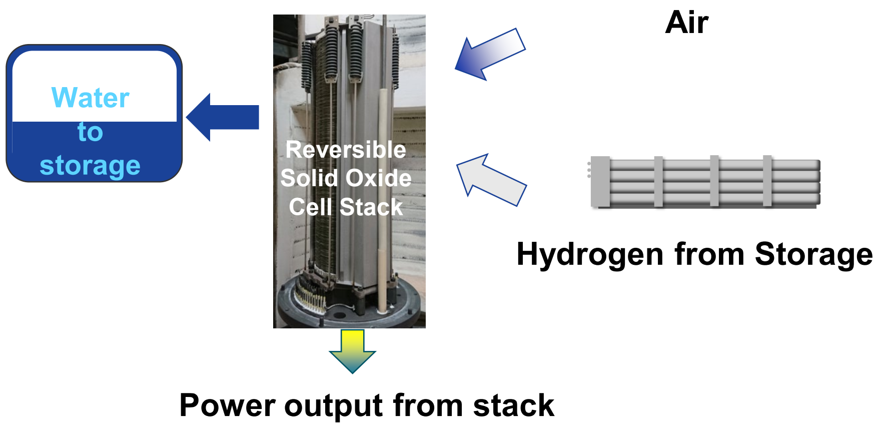
# Solid Oxide Hydrogen Based Energy Storage

- In addition to operation in **electrolysis mode** Solid Oxide Fuel Cells (SOFC) can run in **fuel cell mode**, and can switch between modes, called Reversible Solid Oxide Fuel Cell **(RSOFC)**.
- High efficiency in electrolysis and fuel cell mode enable high round trip efficiency
- RSOFC stacks with hydrogen and water storage are an advanced energy storage approach:
  - High round trip efficiency
  - Long duration achieved by adding low-cost hydrogen and water storage capacity, without the need to add more stacks
  - Inexpensive water is the only reactant – added as an initial fill and regenerated with each discharge cycle

Charging in electrolysis mode:

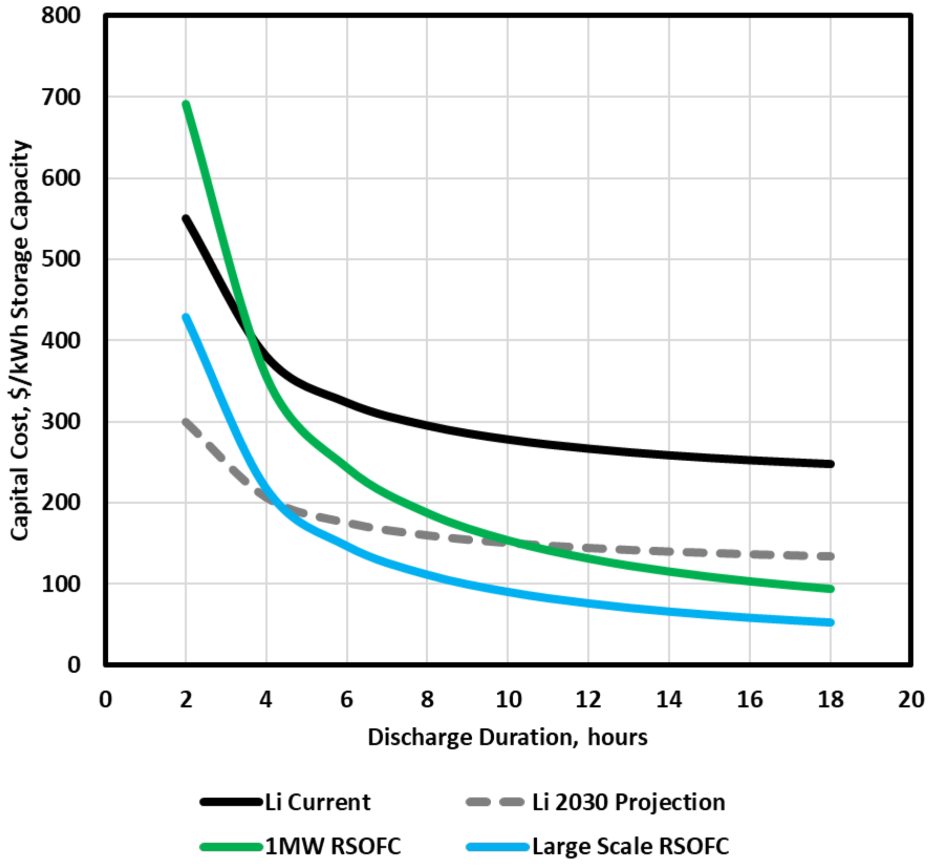


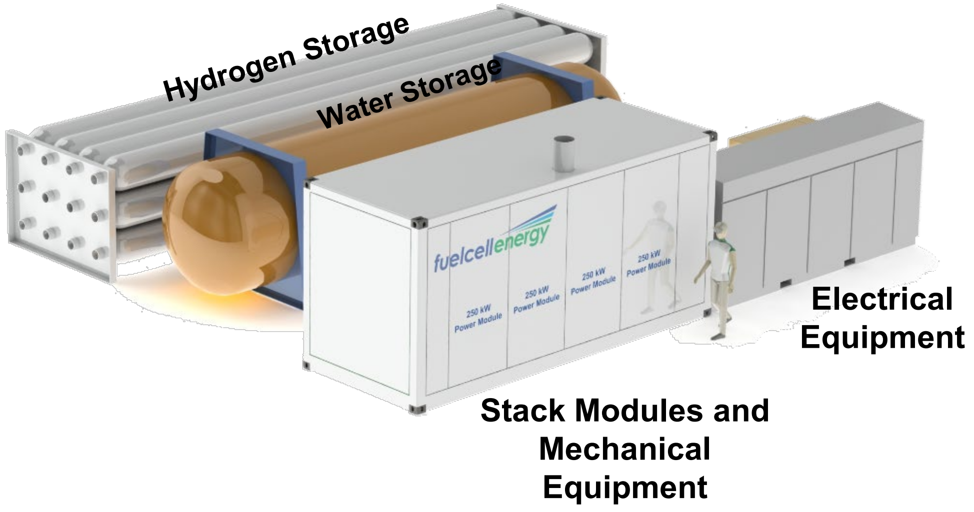

Discharging in fuel cell mode:




***With water as the only stored reactant, hydrogen-based storage has significant advantages for long duration storage***

# Lithium and Reversible Solid Oxide Cost vs Discharge Duration




**RSOFC Energy Storage System**

Discharge duration is increased by adding Hydrogen and water storage – very low $/kWh cost components

**Li projections based on NREL estimates from**
Cole, Wesley, and A. Will Frazier. 2019. Cost Projections for Utility-Scale Battery Storage. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73222. https://www.nrel.gov/docs/fy19osti/73222.pdf

**RSOFC based on company estimates**
1MW projected costs of $1345/kW plus $19/kWh
Large scale applies 80% scaling power factor to $/kW cost and assumes geologic $H_2$ storage, reducing energy cost factor to $5/kWh

***Low $/kWh component of hydrogen-based storage reduces cost of long duration systems***

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# Thank You!