FuelCell Energy Advanced Technologies - Power Long Term Growth At FuelCell Energy

June, 2020

Agenda

i. Addressing Energy's Biggest Challenges

ii. Can Batteries Alone Get The World's Energy Grid Firm | Balanced?

iii. Transformation of the Energy Grid

iv. Fuel Cell Energy Overview

v. FuelCell Energy Advanced Technologies

Enable the world to live a life empowered by clean energy

Purpose Statement

Enable the world to live
a life empowered by clean energy

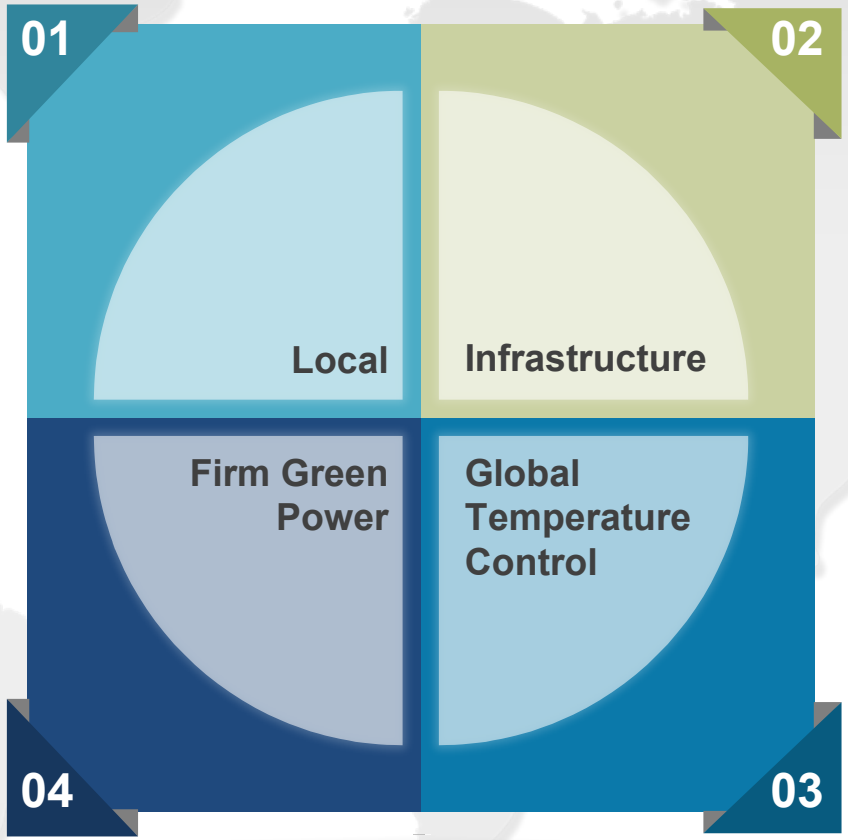
FuelCell Energy Differentiated Green Technology Addressing The 4 Major Energy Challenges

Distributed Generation

- ❑ Multi-Fuel
- ❑ Microgrid
- ❑ CHP
- ❑ Sub-MW through Large MW Scale
- ❑ Resiliency | Reliability
- ❑ Limited Space Requirements
- ❑ Low decibel level
- ❑ Avoids transmission costs and losses

Electrolysis & Hydrogen Energy Storage & Hydrogen Power Generation

- ❑ High efficiency electrolysis and power generation
- ❑ High round trip efficiency storage
- ❑ Low-cost long duration storage
- ❑ Scalable for large-scale bulk storage without battery raw material supply and disposal issues



Distributed Hydrogen

- ❑ Hydrogen co-produced with power and heat
- ❑ Low carbon footprint with natural gas
- ❑ Zero carbon footprint with biogas
- ❑ No water consumption
- ❑ Hydrogen production near users – low transportation cost, avoided transportation emissions

Carbon Capture

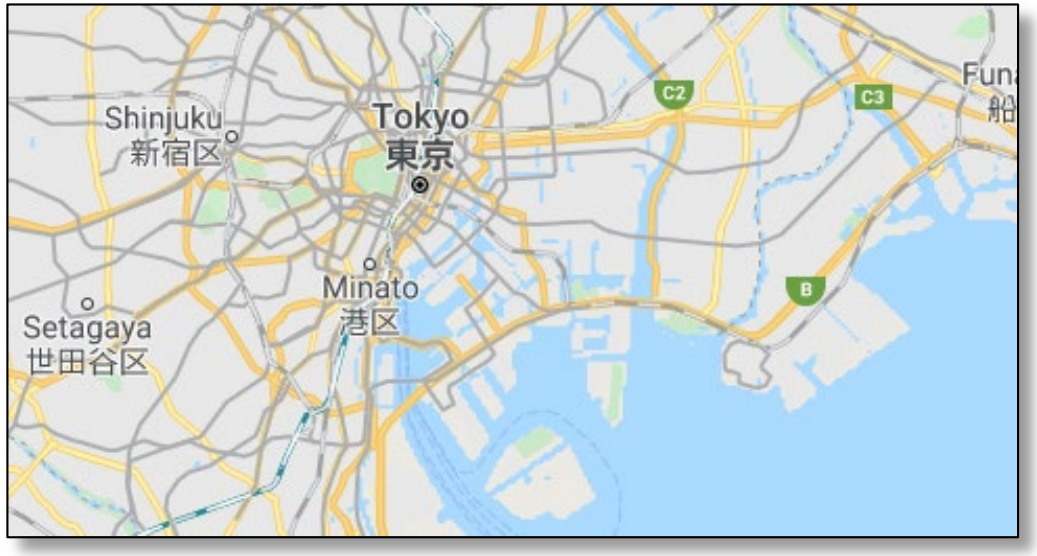
- ❑ Only technology which produces power while capturing carbon
- ❑ Increases output of host plant instead of decreasing output
- ❑ Power revenue stream reduces cost of CO_2 capture

Hydrogen Based Energy Storage Advantage

There is not enough lithium battery materials in the world to meet the demand to power large metropolitan areas with intermittent renewable power

Bill Gates from “Inside the Mind of Bill Gates” Documentary:

“Technology like wind and solar won’t single handedly shut off any pipes....We can’t build enough batteries to store power for the entire world....When Tokyo has a cyclone for four days, wind has to shut off, no sun, where is the energy coming from? Just that energy for those four days is more than all the batteries we make.”



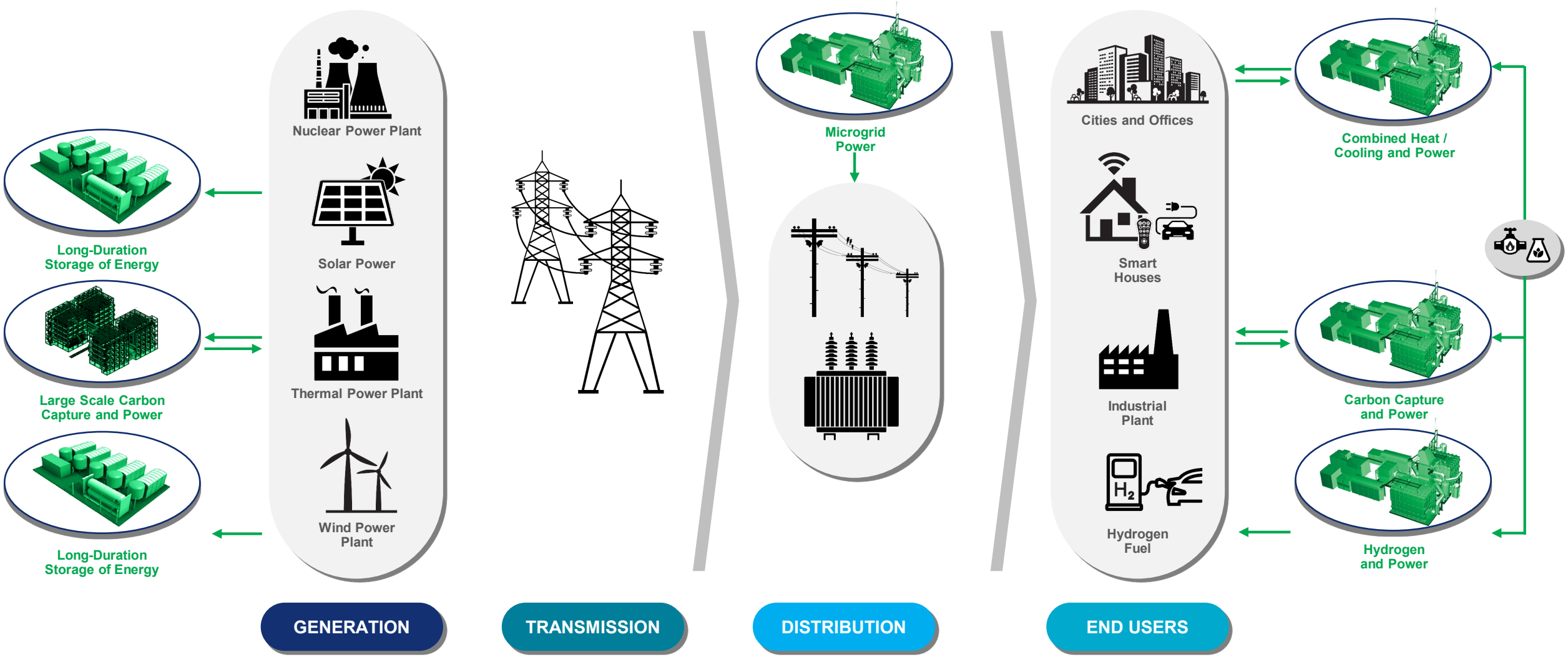
- Powering Tokyo for four days would require 3000 GWh of stored energy
- A lithium battery of this size would require more than 600,000 tons of Cobalt, which is more than twice annual Cobalt production
- Hydrogen based storage would require a one-time fill of ~250 million gallons of water across all systems, a small fraction of the 400 billion gallons of water used annually in Tokyo. And storage could range from pressurized tanks, to pipeline systems as needed.

“Inside the Mind of Bill Gates” Netflix documentary
Tokyo power consumption based on Tepco data for 2019, averaged over the year
Source for Cobalt Consumption: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf

Hydrogen is the only practical option for very large scale energy storage

The Evolving Energy Grid

FUEL CELL TECHNOLOGY A GROWING SOURCE OF CLEAN, RELIABLE POWER FOR MICROGRID SOLUTIONS, CARBON CAPTURE AND ENERGY STORAGE

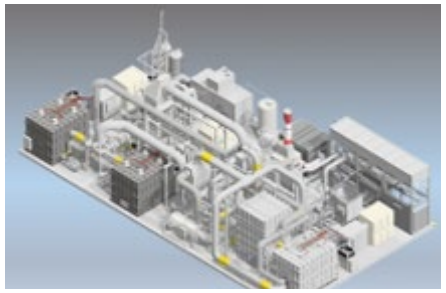


A Global Leader in Fuel Cell Technology since 1969

COMPANY HIGHLIGHTS[1]

Danbury, CT	Headquarters
~300	Employees
3	Continents
57	Global plant installations
>255 MW	Capacity in Field
$60.8M	Total FY 2019 Revenue

REVENUE DRIVERS

SERVICE & LICENSE	ADVANCED TECHNOLOGIES	GENERATION	PRODUCT
			
FY 2019 Revenue			
$26.6M	$19.6M	$14.0M	$0.5M

High Visibility to Recurring Revenue

GLOBAL CUSTOMERS

Pfizer, ExxonMobil, Toyota, City of Tulare, LIPA Long Island Power Authority, University of California San Diego, Central Connecticut State University, City of Riverside, American Electric Power, Pepperidge Farm, Radisson Blu, Clearway, Federal Ministry of Education and Research, Pacific Gas and Electric Company, KOSPO, Southern California Edison, e.on, Avangrid, Connecticut Municipal Electric Energy Cooperative, Friatec, Hartford Hospital Connect to healthier.

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

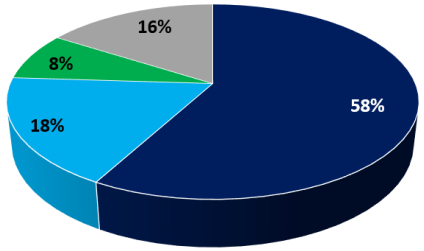
[1] As of year ended October 31, 2019

FuelCell Energy Overview

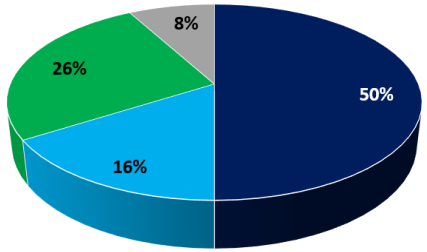
Business Segments & Revenue Mix

Product Sales	Service Offerings	Generation	Advanced Technologies
Sell projects & systems directly to customers	*Long-term service agreements associated with all projects & systems sales*	*Develop and own projects, and sell power to utilities and end-users under long-term power purchase agreements*	*Private & publically funded research activities advancing fuel cell technology*

— FY18 Revenue Mix —



— Illustrative FY23 Revenue Mix —

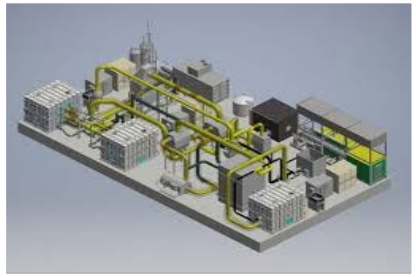


Differentiated Product Offerings

SureSource 250 & 400
250–400KW Production

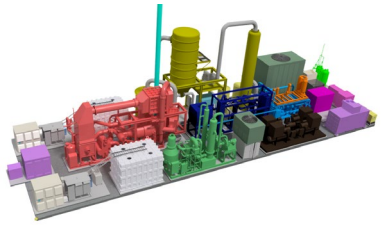
SureSource 1500 & 3000
1.4 – 2.8MW Production

SureSource 4000 – 3.7MW
Production



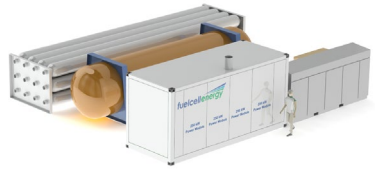
Advanced Technologies

SureSource Carbon Capture (ExxonMobil Partnership)



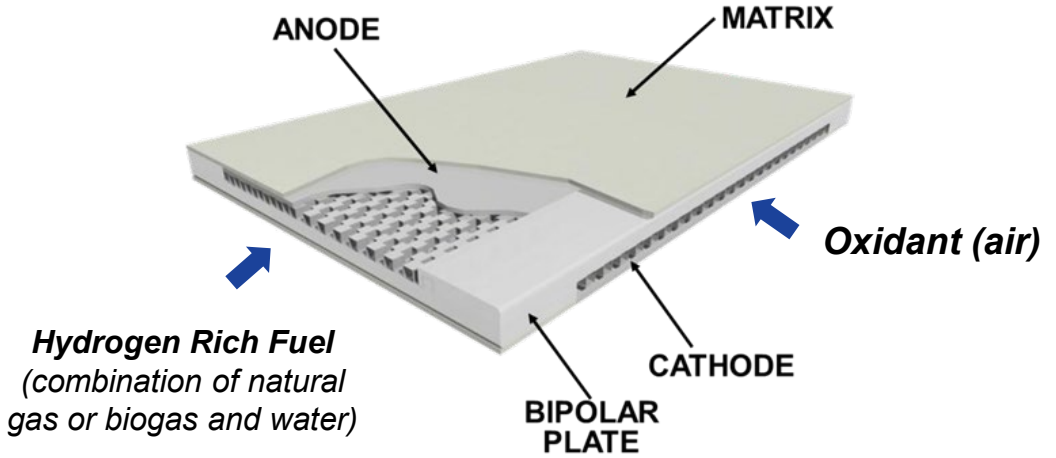
SureSource Hydrogen

Solid Oxide Fuel Cells



Fuel Cell Technology Overview

- Fuel cells cleanly and efficiently convert chemical energy from hydrogen-rich fuels into electrical power and high quality heat via an electrochemical process
  - The process is highly efficient and emits water rather than pollutants. as there is no burning of fuel
- Similar to a battery, a fuel cell is comprised of many individual cells that are grouped together to form a fuel cell stack
- When a hydrogen-rich fuel such as clean natural gas or renewable biogas enters the fuel cell stack, it reacts electrochemically with oxygen to produce electric current, heat and water
- Fuel cells have the ability to continuously generate electricity as long as fuel is continuously supplied
- FuelCell Energy's SureSource power platforms are based on carbonate fuel cell technology
- To produce electricity, carbonate fuel cells generate hydrogen directly from a fuel source, such as natural gas or renewable biogas, via an internal reforming process
  - This approach, which is patented by FuelCell Energy, is a distinct competitive advantage of carbonate fuel cells



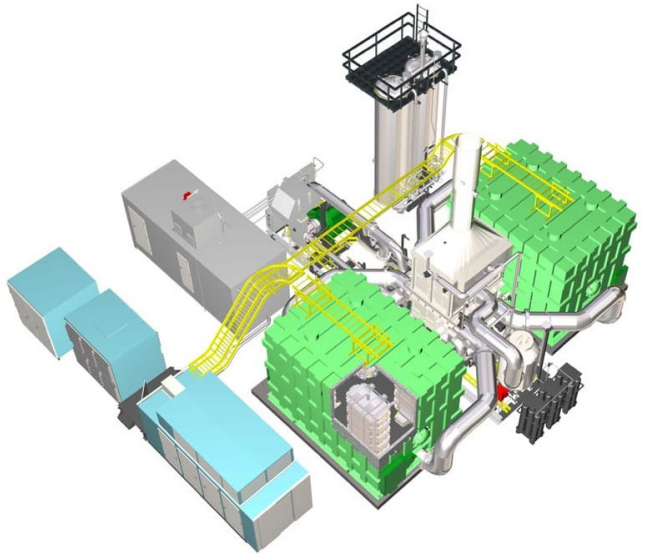


Diagram Description: FuelCell Energy's SureSource 3000 power plant typically is comprised of two fuel cell modules (**green**). One of four fuel cell stacks within each of the modules is visible in the cutaway. The incoming fuel is processed by the mechanical balance of plant (**gray**). The electrical output is processed by the electrical balance of plant (**blue**)

FuelCell Energy Carbonate Fuel Cell Systems

Individual fuel cell &
400-cell fuel cell stack

Single-stack Module
250 – 400kW

Four-Stack
Module 1.4MW

250 - 400kW
SureSource250™
SureSource400™
47% Electrical Eff,
up to 90% Total Eff.

1.4 MW
SureSource1500™
47% Electrical Eff,
up to 90% Total Eff.

2.8 MW
SureSource3000™
47% Electrical Eff,
up to 90% Total Eff.

2.35 MW
SureSource
Hydrogen™
2.35 MW Power plus
1270 kg/day Hydrogen

3.7 MW
SureSource4000™
60% Electrical Eff.
Up to 80% total Eff

Larger Scale Fuel Cell Parks

Multiple platforms based on a common cell stack technology

Unrivaled Technology to Meet Future Energy Requirements

TECHNOLOGY BENEFITS	ELECTRICAL GRID	COMBUSTION BASED EQUIPMENT	SOLAR AND WIND TECHNOLOGIES	SureSource™ FUEL CELLS	
				NATURAL GAS	BIOGAS
Low CO_2 emissions					
Low criteria emissions					
24x7 Energy output					
24x7 Avoided emissions					
Compact footprint					
Easy to site					
Heat for cogeneration					
Backup power application					
Low cost of energy					
Low cost of capacity					

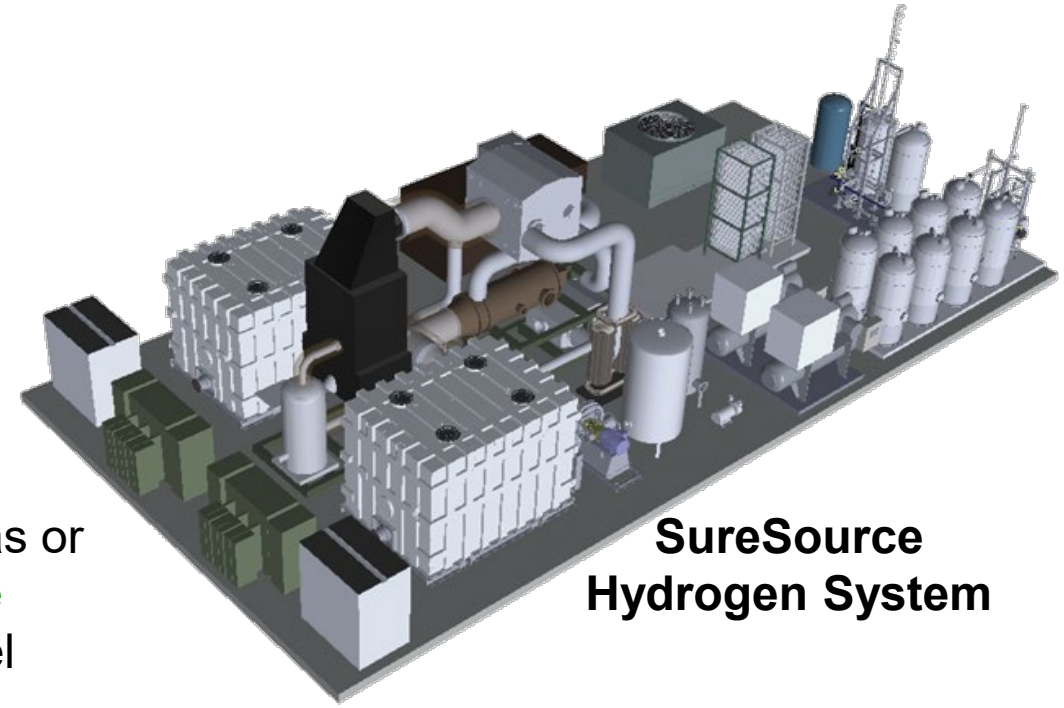
FuelCell Energy Advantages:

- **400x smaller land requirement than Solar** to produce same total energy output; Solar requires 5x generation capacity due to limited sun availability
- **Enhances grid resiliency** and offers a continuous supply of ultra-clean & efficient power for the electric grid
- **Easy to site** in urban and densely populated areas
- **Scalable and cost effective** as high efficiency fuel cells reduce fuel costs and avoids transmission costs

FuelCell Energy Technology: Winner for Ultra-Clean Baseload Power

Distributed Hydrogen with SureSource Hydrogen Systems

Natural gas or renewable biogas fuel



SureSource Hydrogen System

2.3 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

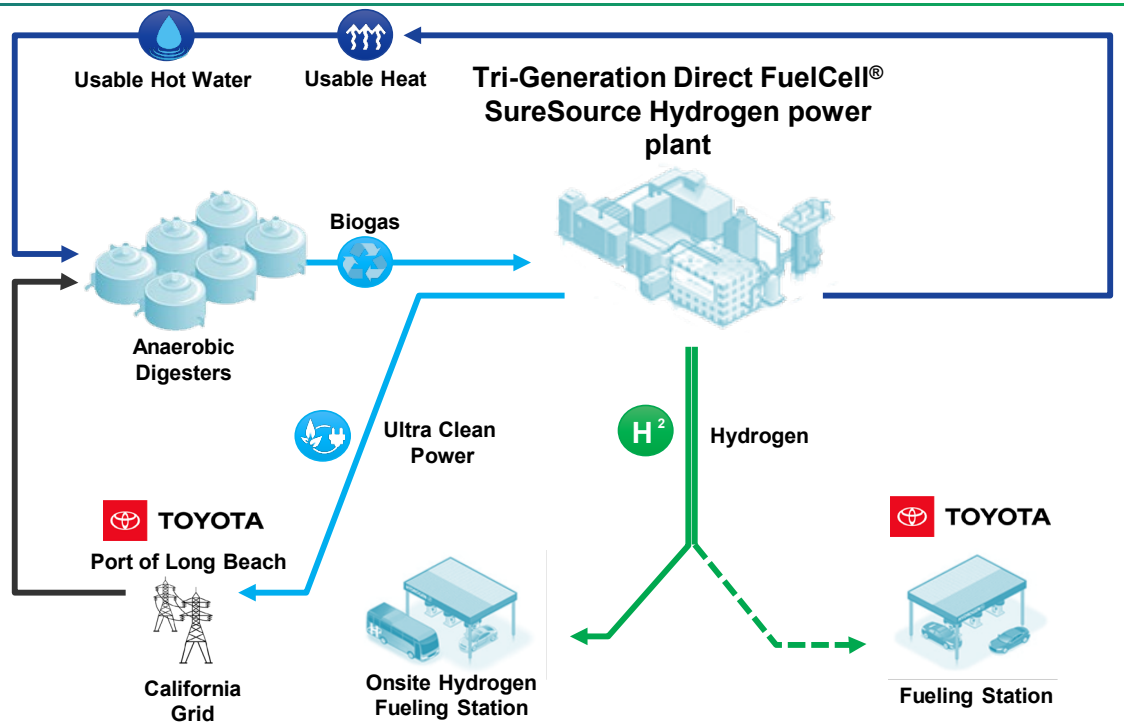
1270 kg/day hydrogen

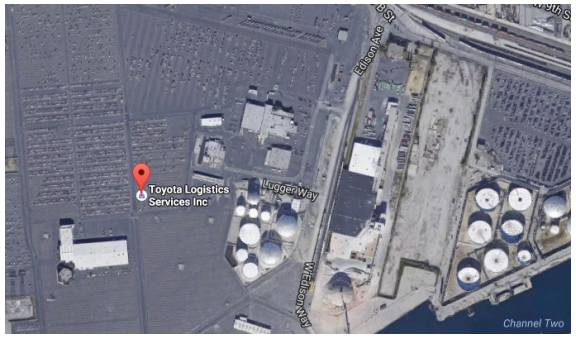
- 1700 tons per year CO_2 reduction vs SMR
- 4200 tons per year CO_2 reduction vs SMR with biogas fuel
- 700 lbs per year NOX reduction vs SMR
- 2 million gallons less water used per year vs SMR

Co-production of power with hydrogen improves economics to produce the most affordable hydrogen

Toyota Port of Long Beach Project

- FuelCell Energy executing a hydrogen generation project with Toyota at the port of Long Beach in Long Beach, California
- Toyota will purchase the hydrogen through a long term purchase agreement, as well as a portion of the electricity generated
- When the plant comes online, the SureSource Hydrogen system will generate approximately 2.3MW of electricity and 1.2 tons of hydrogen per day
- Enough to power the equivalent of about 2,250 average-sized homes and meet the daily driving needs of nearly 1,500 vehicles
- The power generation facility will supply Toyota Logistics Services' operations at the Port, and the location will be the first 100% renewable Toyota facility in North America
- Received favorable opinion from CPUC that confirms project eligibility under BioMAT





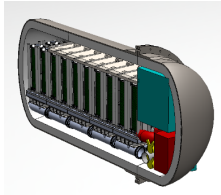
Toyota Port of Long Beach Facility needs Hydrogen to fill light vehicles as they arrive in US and trucks

First commercial scale launch project for SureSource Hydrogen Trigeneration

Solid Oxide Applications

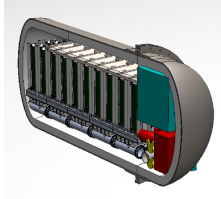
SOFC Stack

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

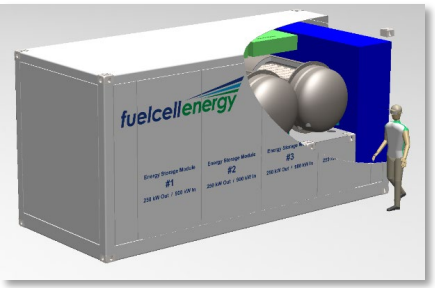


Power Generation Stack Module – Only runs in power generation mode on a wide range of fuels, including natural gas, bio fuels, propane, and hydrogen

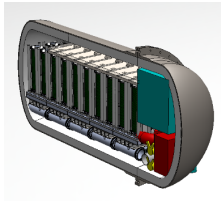
200kW Power Generation System



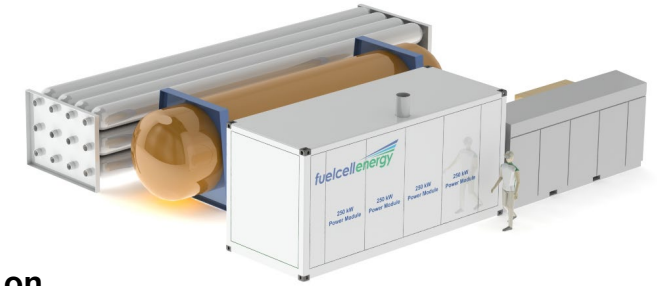
Electrolysis Stack Module – Produces hydrogen from steam with power input



Electrolysis
2,300 kg/day H2 from 4MW



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

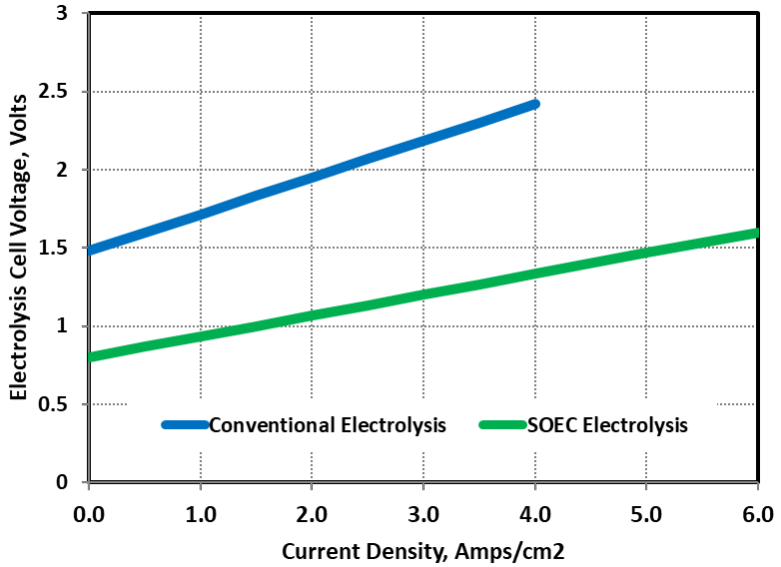


Energy Storage System
1MW 8 MWh

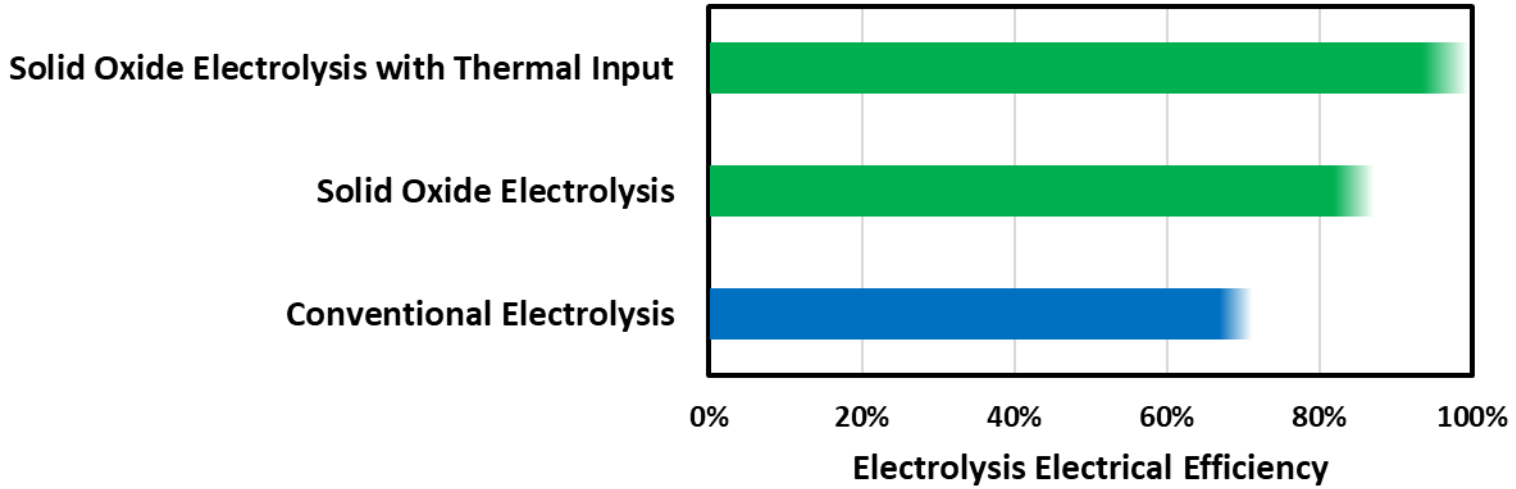
Versatile platform with multiple commercialization paths

Solid Oxide Electrolysis Advantage: Turning Excess Energy Into Hydrogen

Better basic electrochemical performance …



… Leads to improved efficiency and economics

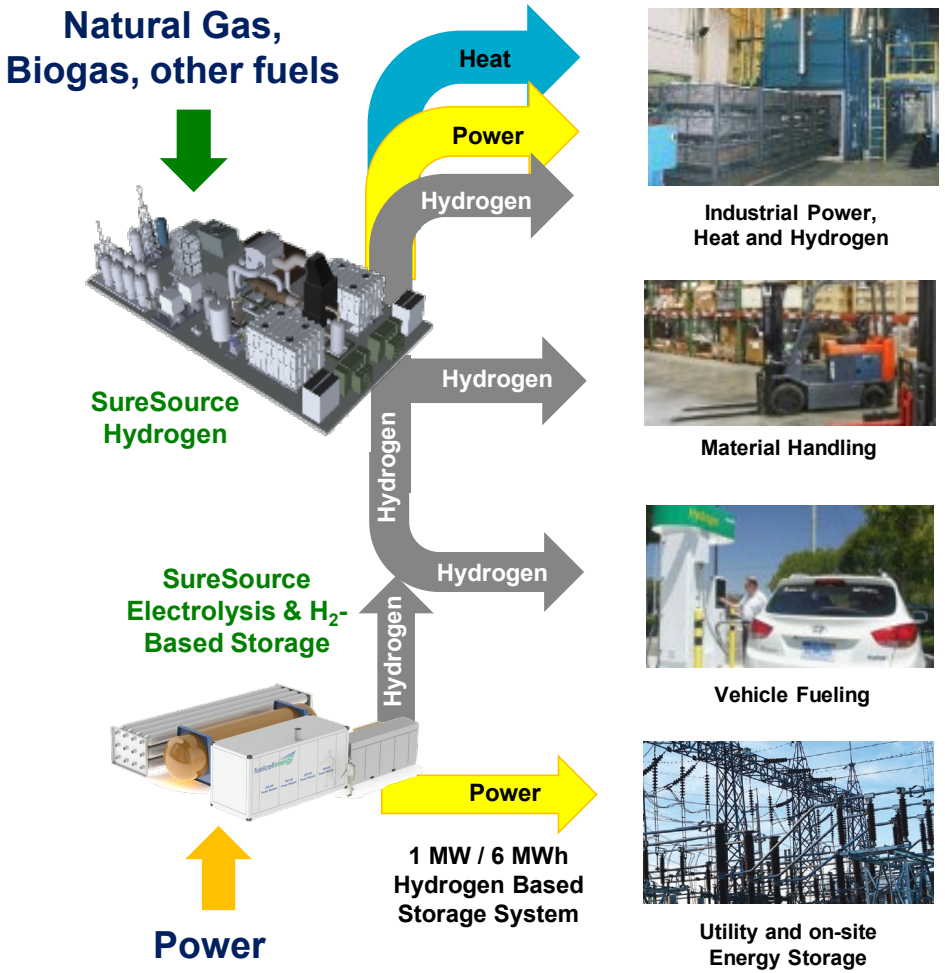


- **High current density** = fewer stacks needed for given hydrogen production rate
- **Low electrolysis voltage** = less power needed for given electrolysis rate: **Higher Electrical Efficiency**
- Lower stack hardware requirement and lower power requirement = **30 to 50% lower cost per kg for hydrogen 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 temperature electrolysis with Solid Oxide cells had demonstrated game changing performance

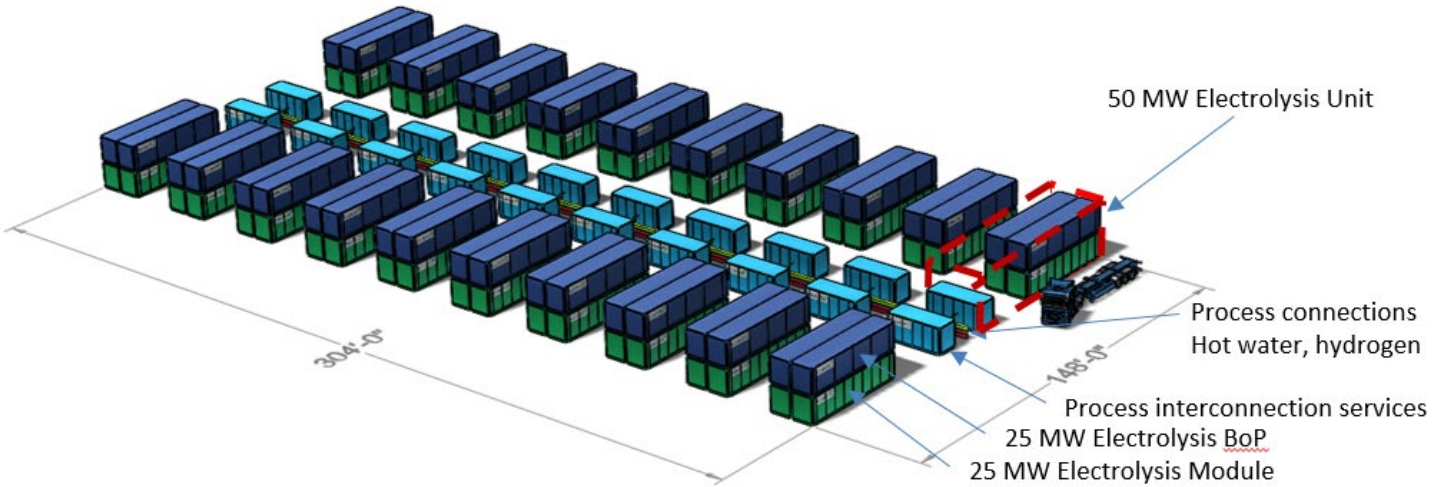
FuelCell Energy Hydrogen Technologies

- SureSource Hydrogen: Clean, efficient power and hydrogen production from multiple fuels:
  - Green Hydrogen from renewable biogas
  - Low-carbon hydrogen from natural gas, propane, associated gas, coke oven gas
  - Blue hydrogen with carbon capture
- SureSource Electrolysis and Storage: Differentiated high efficiency electrolysis and energy storage where input power is converted to hydrogen
- Stored hydrogen can be converted with high round-trip efficiency into power or exported to hydrogen user, e.g. industrial user or vehicle fueling station
- SureSource storage is a closed loop platform which drives the differentiated high efficiency and low react cost

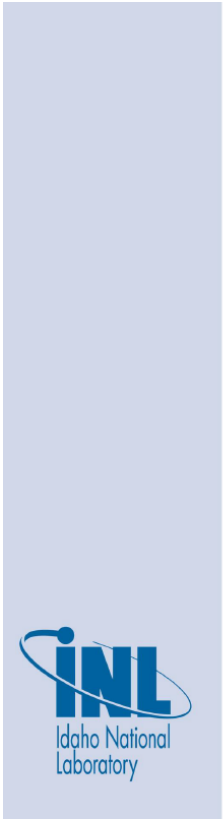


Broad portfolio of hydrogen technologies based on carbonate and solid oxide platforms

Future Application – Large scale electrolysis to manage renewables and nuclear



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

Idaho National Laboratory

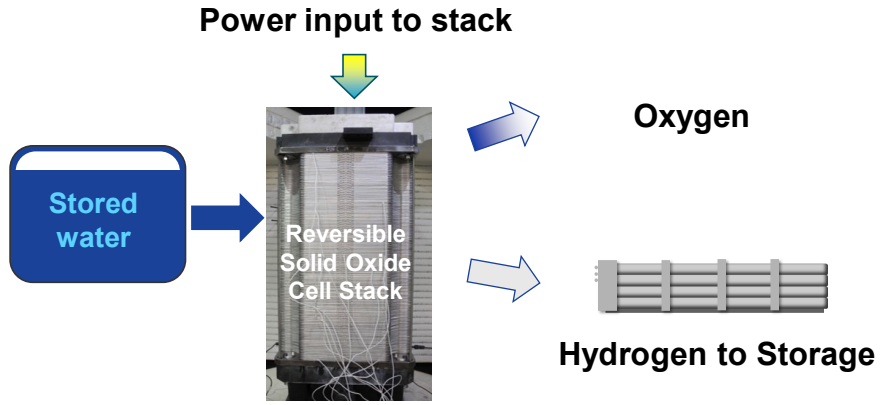
"Two HTSE designs have been discussed thus far in the report. … To keep the capacity payments for the nuclear power plant as high as possible the FuelCell Energy design was selected and will serve as the basis of simulations moving forward."

The ability of Solid Oxide electrolysis systems to use waste heat is an advantage in the nuclear application

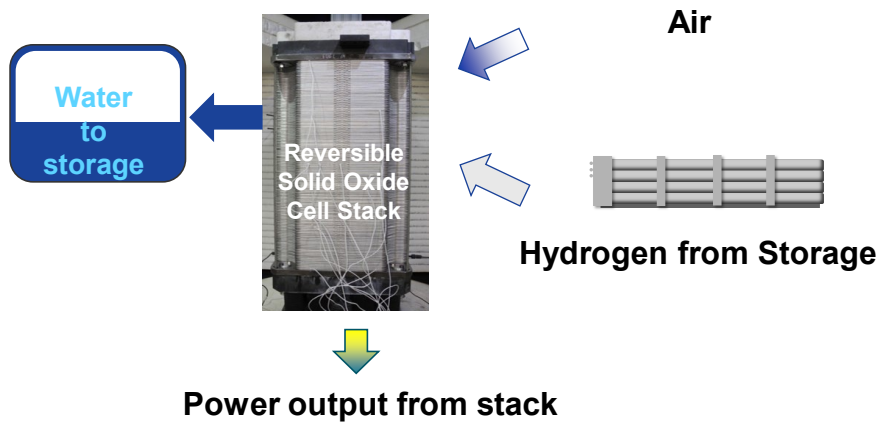
Solid Oxide Hydrogen Based Energy Storage

- Solid Oxide Fuel Cells (SOFC) have demonstrated capability to run in **electrolysis mode** in addition to **fuel cell mode**, and the ability to switch between, called Reversible Solid Oxide Fuel Cell **(RSOFC)** .
- Solid Oxide cells run much more efficiently than conventional electrolysis, and operate with high efficiency in power generation
- 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:



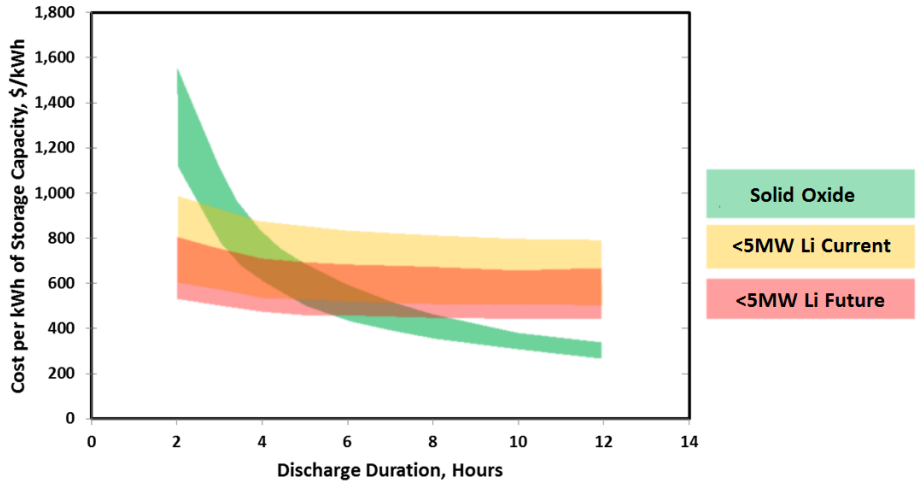
Discharging in fuel cell mode:



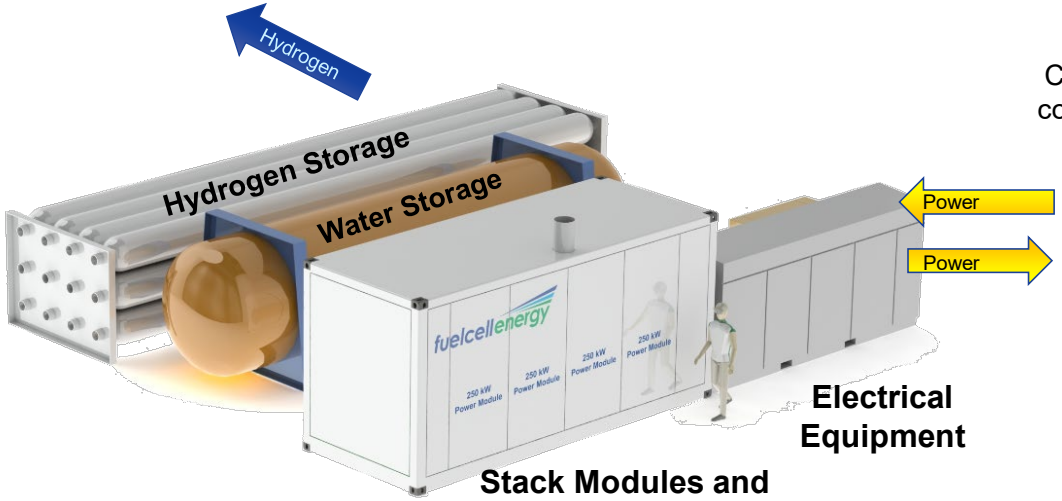
With water as the only stored reactant, hydrogen based storage has significant advantages for long duration

Hydrogen Based Long Duration Energy Storage System - Batteries Can't Compete

- Hydrogen during charge cycle can be used to provide power during discharge cycle or can be exported to hydrogen user
- Geological storage of hydrogen can provide weekly or seasonal storage
- The storage reactant is water, which is regenerated during power generation discharge – does not depend on limited quantities of lithium or cobalt
- Discharge duration is added by adding inexpensive hydrogen and water storage – so cost of storage capacity reduces significantly with longer duration



H_2 can be converted back to power or supplied to H_2 user, enhancing project economics



Charging power is converted to stored hydrogen by electrolysis of stored water

Stored hydrogen is converted back to power and water in fuel cell mode

1MW SOFC/SOEC System with 8 hours of hydrogen storage

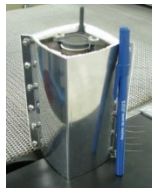
Flexible energy storage approach based on high efficiency conversion of power to hydrogen and hydrogen to power

Solid Oxide Path to Commercialization

Accomplishments

Plan

2009
Reversible SOFC demonstrated in Calgary laboratory



2011
Reversible SOFC cycle life demonstrated in DOE EERE program

2014
Complete energy storage system operated under Boeing DARPA Vulture Program

2015
50kW SOFC Powerplant operation in DOE SECA program

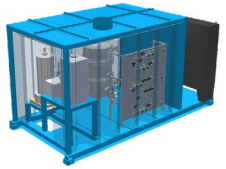
2015
High efficiency, high power density electrolysis demonstrated in DOE EERE program

2018
200kW SOFC Power Plant Operation in Danbury Facility

2019
200kW SOFC Power plant Pittsburgh Demonstration

2020
Subscale packaged electrolysis demonstration system

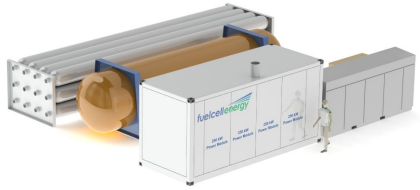
2021
Subscale packaged RSOFC demonstration system

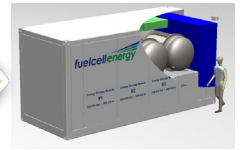


2022
Build and test product prototype systems

2023
Early production units

2024
Commercial Production





Successful Accomplishments Drive Effective Commercialization Plan