GINER ELX
Giner ELX Inc., 89 Rumford Ave, Newton, Ma. 02466

Demonstration of Integrated Hydrogen Production and Consumption for Improved Utility Operations

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2019 Fuel Cell Seminar & Energy Exposition
H2@Scale Initiative
Long Beach, CA., Nov 05th, 2019

Company Profile

- Giner, Inc., Founded in 1973
- Specializing in development of PEM based electrochemical technologies and systems
  - Key driver: Manufacturing of PEM electrolyzers to OEMs
  - Global leader in Polymer Electrolyte Membrane (PEM)-based electrolyzers
  - Highest efficiency technology for commercial applications
- Core Mission: Provide Innovative PEM Technologies with the Highest Efficiencies at the Lowest Costs to Developing Hydrogen Markets
- In April 2017, **GINER ELX**, Inc. was created to focus on commercial development and manufacturing of large scale electrolyzer stacks & systems

Electrolyzer Stacks & Systems

Overview

Our next generation commercial electrolyzer stack. Designed specifically for our lab scale hydrogen generator OEMs using the latest technologies developed for our larger products. Also popular with academic institutions and for use in specialty water electrolysis applications.

- 50 cm^2 nominal active
- 450 sccm – 1800 sccm
- Higher flow rate stacks available
- Differential or balanced pressure
- CE Mark
- In stock

Overview

The R&D version of our G5 comes available with cell voltage tabs and customizable MEA's. We are able to produce single cell to 20-cell Pemisewassett stacks that perfectly mimic the operation of our larger platform stacks at a fraction of the cost. Rated at up to 250 Amps this device has been a workhorse for our internal electrolysis development as well as NASA, DOE, and DoD programs.

- 50 cm^2 nominal active cell
- Single-cell to 20-cell stacks
- Custom MEAs
- Up to 290 psig (20 bar)
- Individual cell voltage tabs available

Overview

Giner has a leading position in aerospace regenerative fuel cells (RFCs) through its collaborations with NASA, DARPA, US Navy and a broad range of industrial clients. Our electrolyzer stack offers extraordinary efficiency, power density and pressure capability that facilitate RFC systems to capture design wins where even the most advanced batteries fail to deliver. These stacks are unsurpassed in their efficiency and performance metrics.

Specifics

- Dual feed, cathode feed, anode feed capability
- 0 to 1200 psig (82.7 bar)
- Diffferential or balanced pressure
- Weighs 83% less than other commercial stacks
- Production energy cost of 44 kw-hr/kg-H_2
- Individual cell voltage tabs available

Overview

The largest commercially available stack currently on the market. This device offers unprecedented operating efficiencies at high current densities to provide the optimum price performance for our customers. The Merrimack offers world-class lifetimes with stable operating voltages. High operating temperatures and pressures minimize the size of heat exchangers, and post electrolysis compression equipment. Turn-down ratios of 10:1 and rapid ramp times enable demand management to the millisecond scale.

Specifics

- 300 cm^2 active area
- To 66 kg/day (160 KWe nominal input)
- 0-40 bar (580 psig)
- Differential or balanced pressure
- CE Mark with PED and ASME BPVC

Overview

New for 2016, Giner proudly introduces our megawatt scale stack. The Allagash platform offers the best-in-class price-performance in the production range from 30 Nm^3/hr to 400 Nm^3/hr within an extremely compact single assembly. The break-through rectangular pressure vessel design optimizes our material utilization while maintaining our market leadership in stack performance. Boasting a cell active area over four times larger than our Merrimack platform and fluid handling capabilities to match, we have not just broken but have shattered the $1,000/kW price barrier. The Allagash offers an exceptional combination of price, efficiency, scale, durability and packaging. Already subject to many thousands of hours of laboratory testing, we anticipate that this stack will lead the hydrogen refueling station, power-to-gas, and power-to-product demonstration markets in the near term.

Specifics

- 1250 cm^2 active area
- To 900 kg/day ($2ME_e$ nominal input)
- 0-40 bar (580 psig)
- Differential pressure operation
- CE Mark with PED and ASME BPVC

Overview

We are developing a range of large electrolyzer stacks to address the nascent power to gas and Power 2 Mobility™ markets. Giner's Kennebec stacks span the range from 60 kg/day to 2200 kg/day (5 MW nominal input). Giner is driving PEM electrolyzer technology forward to meet the needs of tomorrow's green hydrogen economy.

Specifics

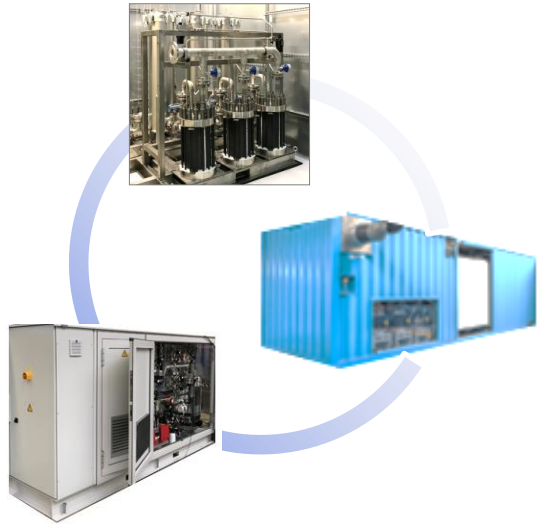
- 3000 cm^2 (nominal) active area
- 40 years of satisfied customers
- To 2350 kg/day
- 0 to 225 psig (15.5 bar)
- Customizable

Giner ELX electrolyzer systems incorporate our world-leading PEM electrolyzer stack technology. They deliver pure hydrogen (99.9995%) safely, cleanly, noiselessly and efficiently at pressures up to 40 barg or 580 psi.

Applications include:

- Energy storage: storage of surplus electric energy—particularly of stranded solar or wind energy—as hydrogen for later use:
  - to power fuel cell vehicles or hydrogen turbines
  - as an industrial gas
  - by blending into the natural gas supply network
- Hydrogen fueling stations (for fuel cell powered buses, cars, trains, trucks, fork-lifts....and trains!)
- On-demand hydrogen production for industrial users:
  - Electric turbine cooling
  - Hydrogenation for food manufacturers
  - Float glass processing
  - Semiconductor fabrication
  - Gas chromatography and other laboratory devices

30S: 30Nm³/h System	60S: 60Nm³/h System	90S: 90Nm³/h System	200S: 200Nm³/h System
20-foot container	20-foot container	30-foot container	40-foot container
150 kW System	300 kW System	450 kW System	1,000 kW System



Commercial Hydrogen Stacks & Systems

www.GinerELX.com

Integrated Hydrogen Production and Consumption for Improved Utility Operations

Project Objectives

- Develop integrated system incorporating PEM-based electrolysis for H_2 production/storage and H_2-fuel for refueling of FCEVs
- Electricity generation with site-specific PEM-based stationary fuel cells
- Develop/Optimize dispatch models based on grid-level optimization controls

Impact

- Deployment of **Grid-Integrated Hydrogen assets** creates a system capable of leveraging intermittently available low-cost electricity to produce hydrogen for use in FCEVs, back-up power, and grid operational use cases
  - Ensures that the hydrogen is produced at the lowest electricity cost, and then consumed for the greatest possible value
  - Develops business models for OUC or other utilities, where the utility provides both electricity and hydrogen fuel, either as a grid asset of to support the transportation sector

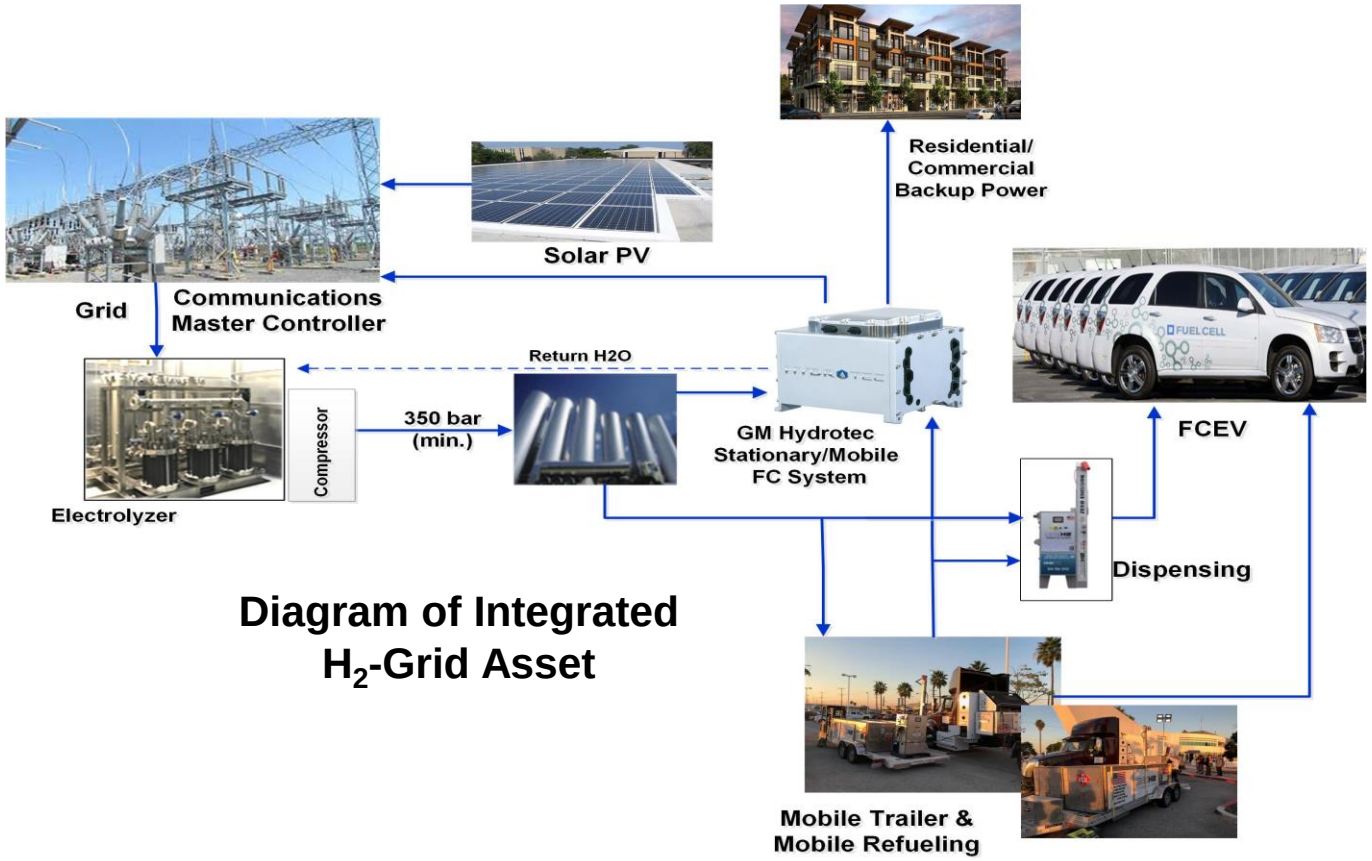


Diagram of Integrated H_2-Grid Asset

Partners

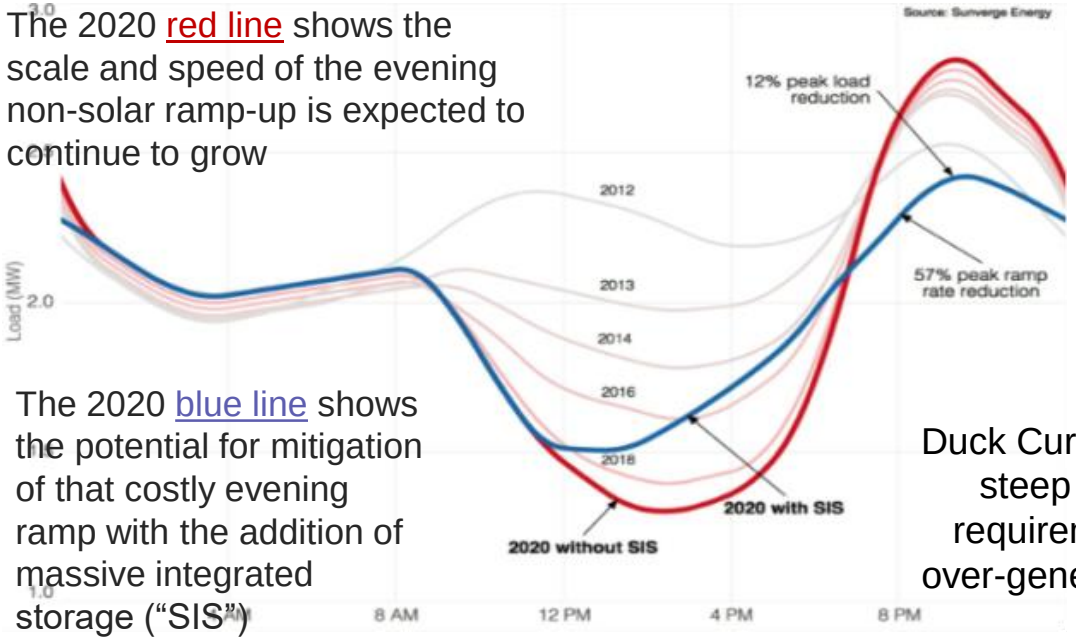
Orlando Utilities Commission (OUC) – Utility Co. / Solar Integration / FC Vehicles
General Motors – Stationary FC Systems
OneH2 – Storage, Compression, & Dispensing
UCF-FSEC – Techno-Economic Analysis, Solar to H2 Optimization
Giner ELX, Inc. – Electrolyzer System Development & Assy

Background

Hydrogen Offers a Green Solution to Intermittent renewables

- Rapid implementation of solar has led to storage needs more quickly than anticipated
- Solution: PEM Electrolyzer with fast response time, and be scalable to TWh
  - Electrolyzers can provide grid services **&** renewably generated hydrogen for mobility with fast response time as a controllable load
- Development of Hydrogen Markets are needed

The 2020 red line shows the scale and speed of the evening non-solar ramp-up is expected to continue to grow



The 2020 blue line shows the potential for mitigation of that costly evening ramp with the addition of massive integrated storage ("SIS")

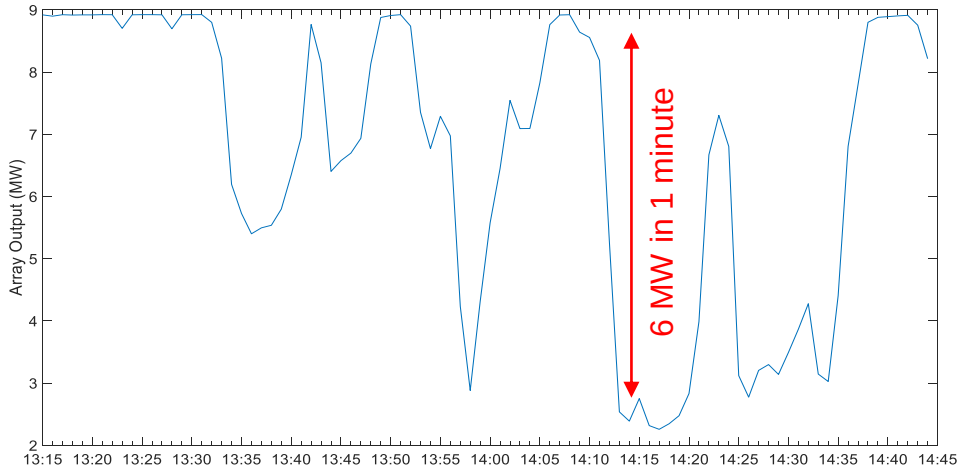
Duck Curve indicates steep ramping requirements and over-generation risk [1]

The "California Duck" Chart:

Non-solar generation required over a 24-hour period (2012 to 2020)

OUC The Reliable One®

- OUC, No. 1 in reliability since 1998[2]
- OUC's solar penetration is <1%, but increasing rapidly to 15% by 2022, plans to integrate 30% solar by 2024+



Output variation from an 8.9 MW_{AC} array[3]

Sources: [1] CAISO. [2] Florida Public Service Commission. [3] OUC.

Hydrogen Markets

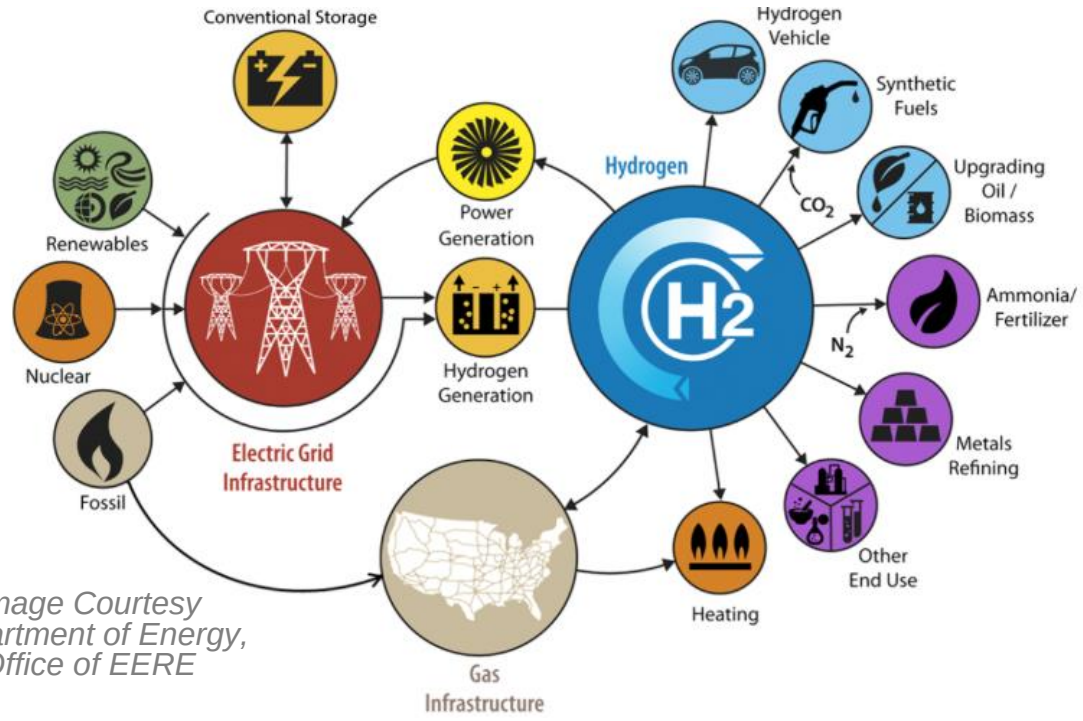


Image Courtesy Department of Energy, Office of EERE

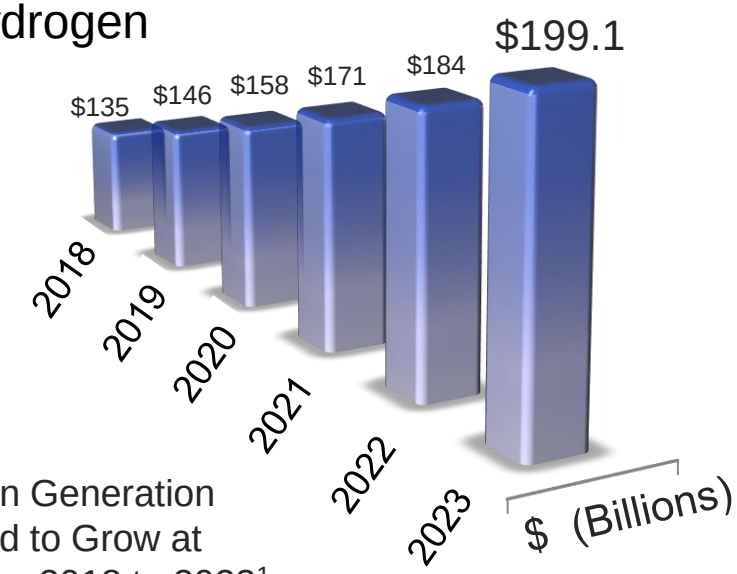
Global Hydrogen Market

PEM Electrolysis Segment of Hydrogen Market

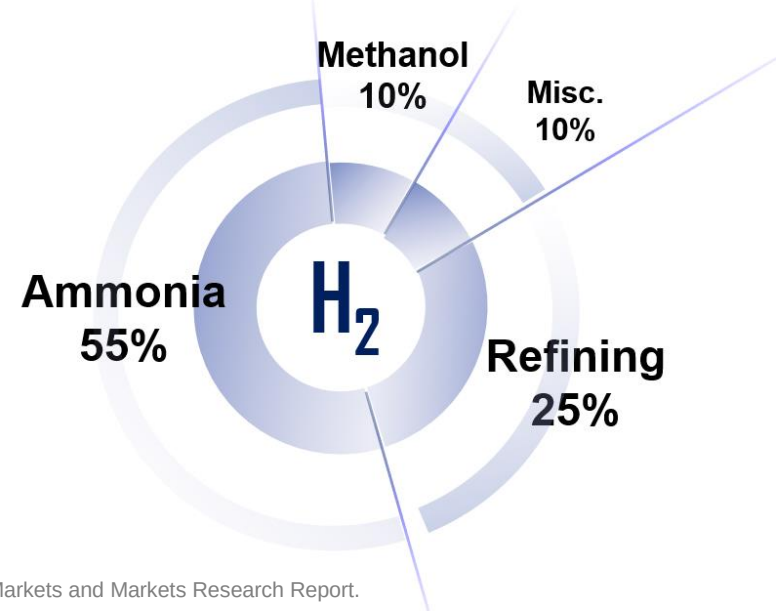
Project:

Integrated H_2 assets enabling renewable energy systems

Global Hydrogen Market



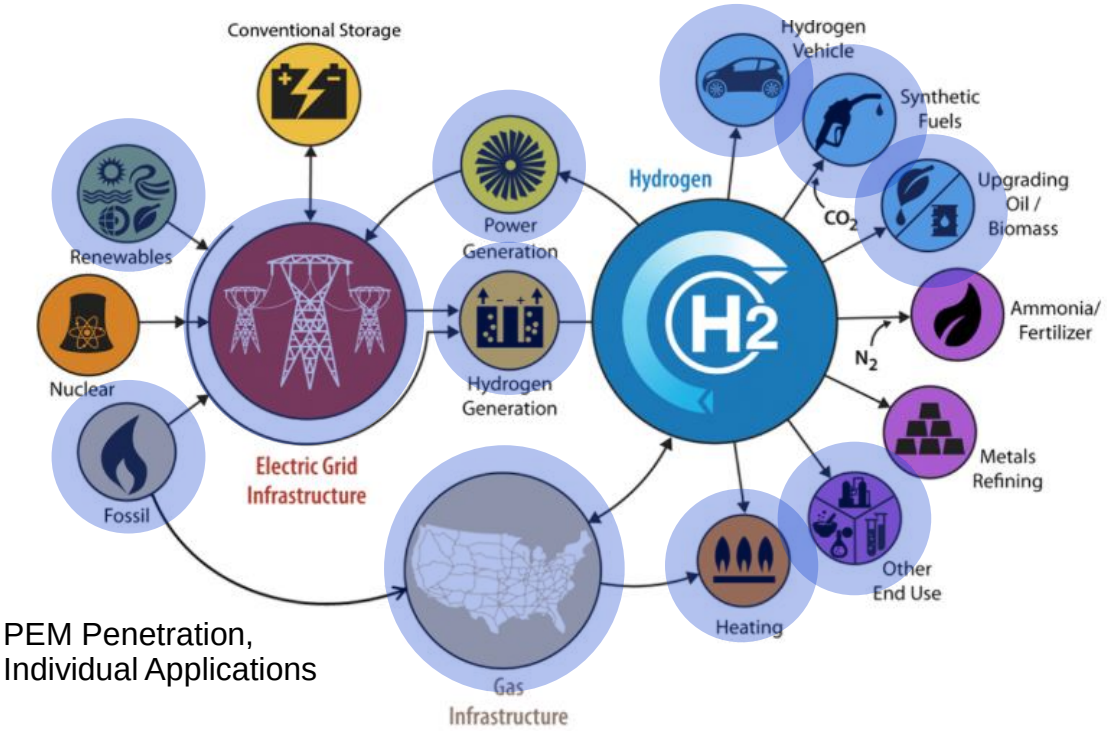
Global Hydrogen Generation Market Expected to Grow at 8.0% CAGR from 2018 to 2023[1]



[1]Source: Markets and Markets Research Report.

Hydrogen Markets

PEM Electrolysis Compliments a Multitude of Industries



PEM Penetration, Individual Applications

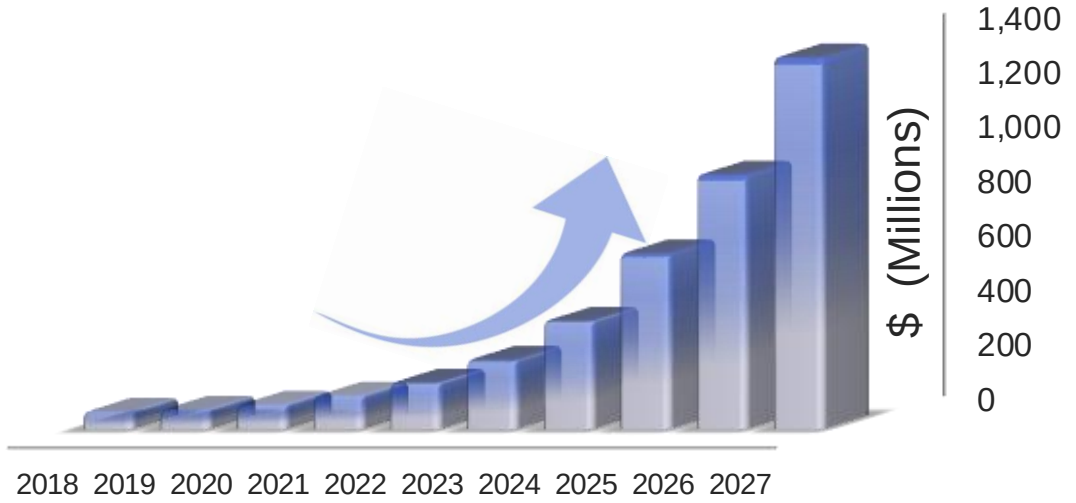
Global Hydrogen Market

PEM Electrolysis Segment of Hydrogen Market

Project:

Integrated H2 assets enabling renewable energy systems

Hydrogen Markets from PEM Electrolysis

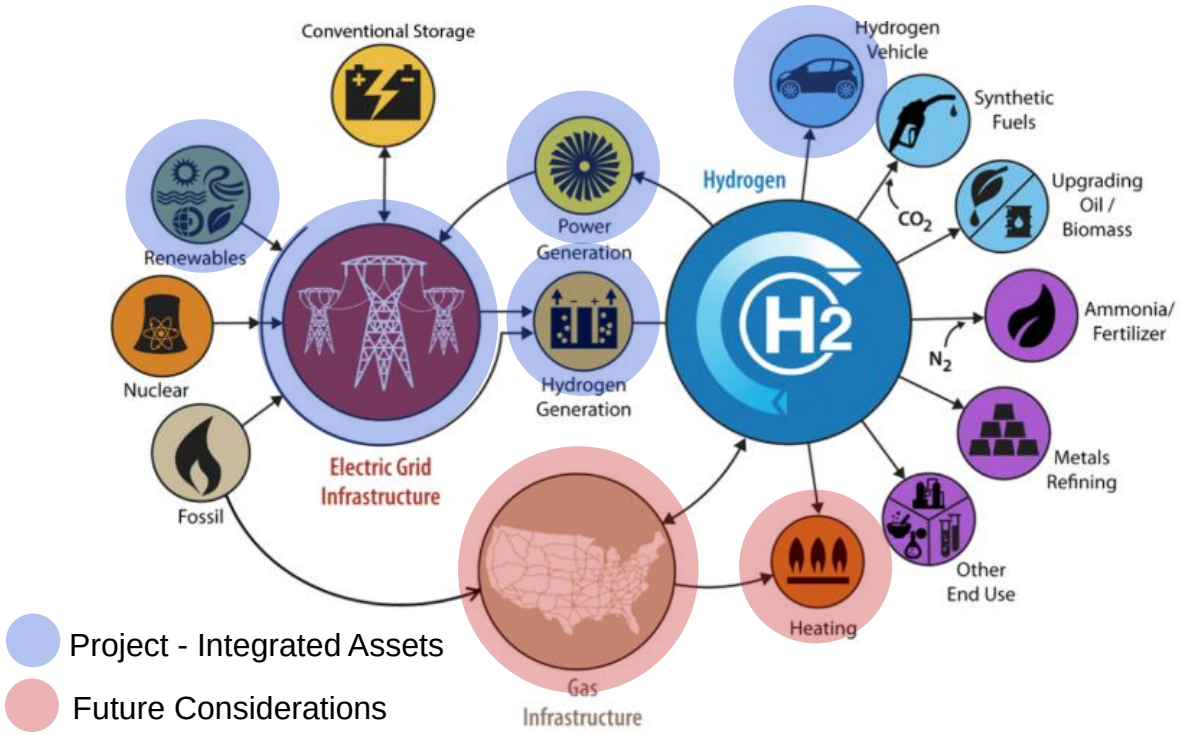


- Global PEM Electrolyzer market, a segment of a larger trend
- PEM market increasing at rapid pace with new market developments and rapid cost reductions
- $1.3 B by 2027[1]
- Hydrogen: Versatile energy carrier enabling renewable energy systems

[1]Source: Future Market Insights and Giner ELX Analysis

Hydrogen Markets

Project: Integrated Utility Operations

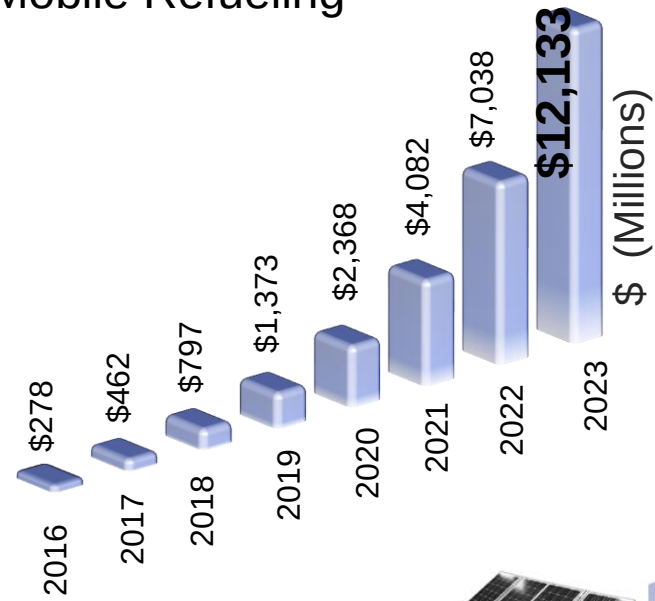


Global Hydrogen Market

PEM Electrolysis Segment of Hydrogen Market

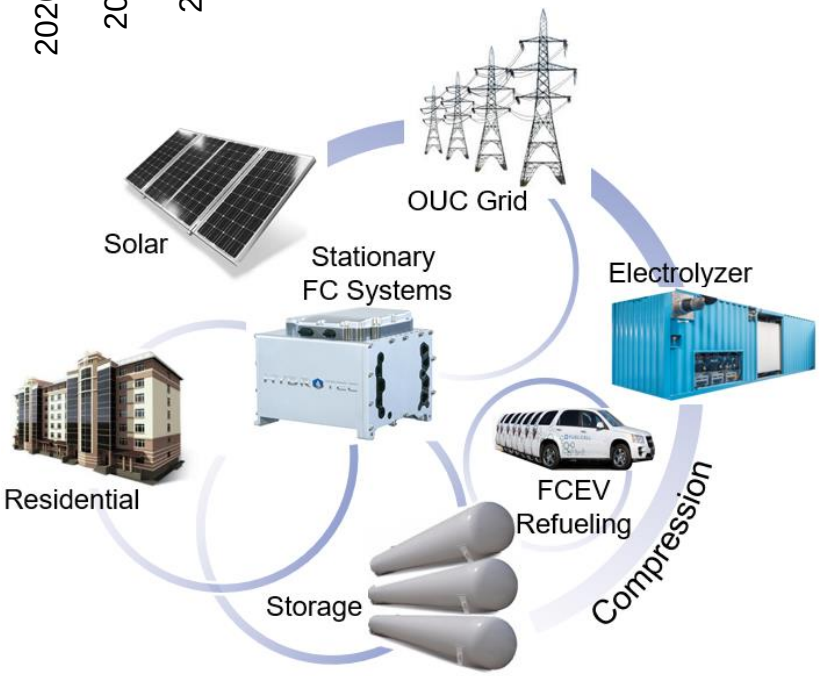
Project: Integrated H_2 assets enabling renewable energy systems

Mobile Refueling



The Global Hydrogen FCEV Market will grow at a CAGR of 72.4% from 2017 to 2023[1]

Controllable loads for overburdened-RES grids have already been marketed at a value of $50/MWh, not including benefits from the sale of hydrogen; an additional financial incentive[2]



Sources: [1]Allied Market Research [2]cleantechnica.com 08/21//2018

Program Tasks

Year 1

- Technoeconomic Analysis
- Develop utility control architecture to dispatch integrated Electrolyzer/Fuel Cell system
- Complete/Optimize design(s) of individual system units (FC, Electrolyzer, PV Array, Storage, Dispensing)

Task No.	Task Title	Description
1	Techno-Economic Feasibility Study	Complete Techno-Economic Feasibility Study. Demonstration path to achieve $2-4/kg.
2	Electrolyzer System Design	Complete preliminary design of Merrimack electrolyzer unit. Delivery: P&ID & PFD diagrams, HazOp studies, layout, manuals for 90 Nm3/hr system
3	Fuel cell-based power generation system Design	Complete optimization/design of fuel cell-based power generation system.
4	Hydrogen Storage, Dispensing Design	Complete sizing of the storage system to meet hydrogen delivery demands, including vehicular and stationary fuel cell applications.
5a	OUC Host Site Design and Preparation	Complete site prep for systems integration
5b	OUC Development of Economic Dispatch Models	Complete Economic Dispatch Models. This information will be used to develop utility control architecture (and will be an ongoing process that will be optimized in Y2).

Year 2

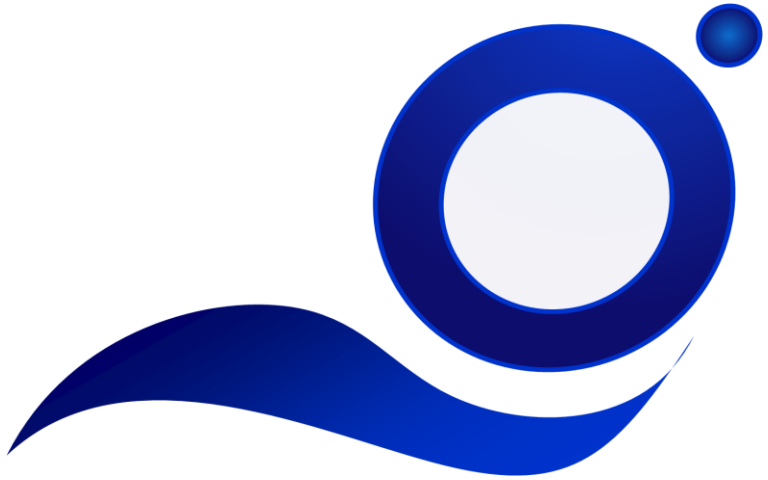
- Complete system unit assemblies
- Integration of individual system units with Utility (OUC Utility)

Task No.	Task Title	Description
6	Electrolyzer Delivery & Integration	Electrolyzer Delivery & Integration
7	Fuel Cell Delivery & Integration	Fuel Cell Delivery & Integration
8	Hydrogen Storage Delivery and Integration	Hydrogen Storage Delivery and Integration
9	Controls Integration and Cybersecurity Assessment	Complete communications/controls integration and cybersecurity assessment
10	Fuel Cell Vehicle Procurement	Fuel Cell Vehicle Procurement

Year 3

- Integrated Operation
- Demonstrate integrated system dispatch with utility
- Complete economic and market feasibility studies, establishing multiple value streams for hydrogen

Task No.	Task Title	Description
10	Systems Operations	Complete test plan detailing operating conditions, the range of parameters to be evaluated, data acquisition requirements and a safety plan.
	Commissioning	Complete commissioning of the integrated electrolyzer, fuel cell, and storage system into OUC host utility grid
11	Techno-Economic Feasibility Study	Initiate operation. Demonstrate integrated system operation couple to OUC grid. Verify Techno-economic studies (conducted in Task 1) with actual operation.
	System Feasibility Studies	Demonstrate grid peak shaving, load shifting, & PV smoothing. Demonstrate multiple usage profiles explored with FCEV, and customer service models such as demand reduction and emergency back-up power.



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Thank You!

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QUESTIONS?