



Examples of Initial Capabilities Under H2@Scale Consortium

Keith Wipke

Fuel Cell & Hydrogen Technologies Program Manager

H2@Scale Review Meeting

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NREL Fuel Cell & Hydrogen Technologies (FCHT) Program

Major Research Topics

- Hydrogen Production
- Delivery/H2FIRST
- Storage
- Fuel cells
- Fuel cell manufacturing R&D
- Technology validation
- Market transformation
- Safety, codes and standards
- Systems analysis



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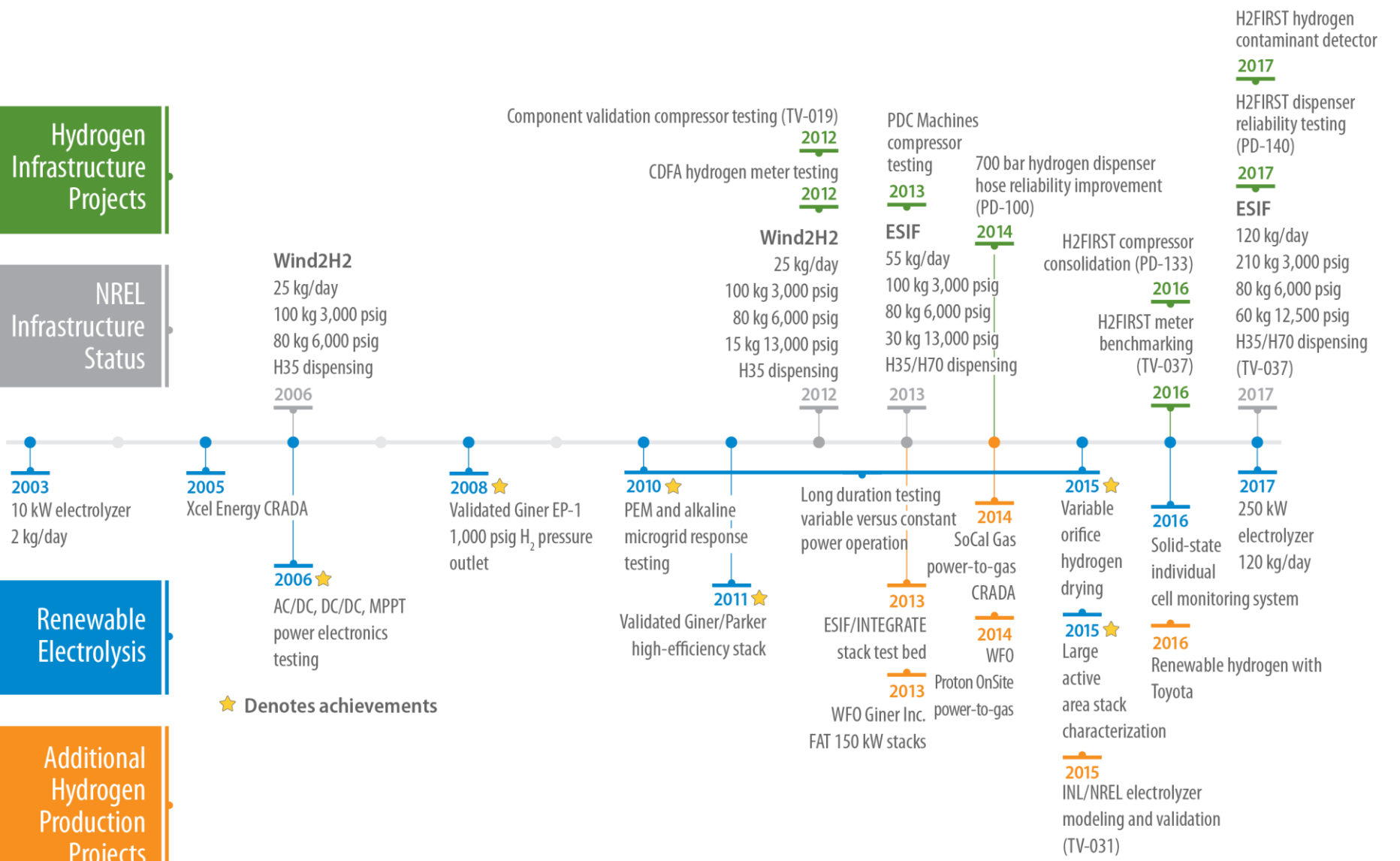
Hydrogen R&D Timeline

Hydrogen Infrastructure Projects

NREL Infrastructure Status

Renewable Electrolysis

Additional Hydrogen Production Projects



★ Denotes achievements

Near-term Infrastructure Concept R&D

Capabilities

700 bar
Refueling
Current/Future
Protocols

Real Time
Monitoring and
Analysis

Customizable
Station
Operation

High
Throughput
Vehicle
Refueling

Hydrogen
Quality
Evaluation

Green Hydrogen
for FCEV Use

Applications and Industries

Energy Storage, Novel
Station Design and
Operation, Quality
Control and
Assurance

Protocol and
Regulation
Development,
Future Station
Configurations and
Operation

Station Developers, Hydrogen Production
Companies, Auto OEMs, Government
Regulations, C&S Committees



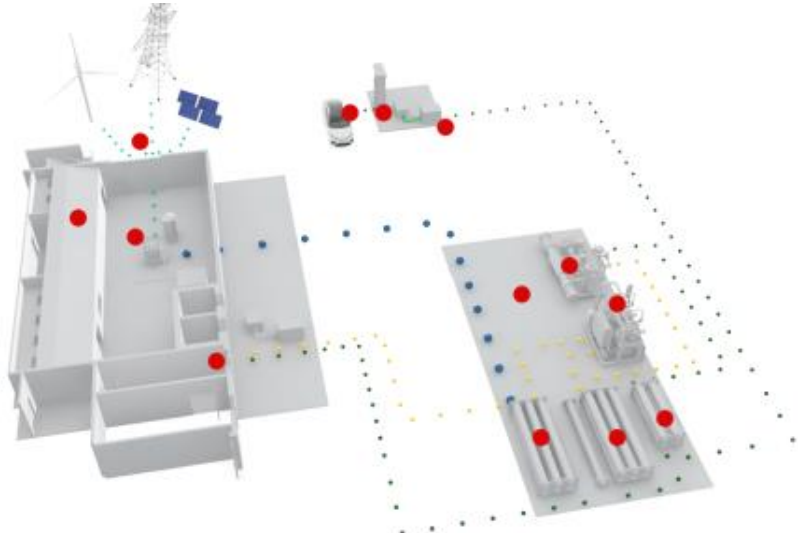
Innovating Hydrogen Station Components

Capabilities

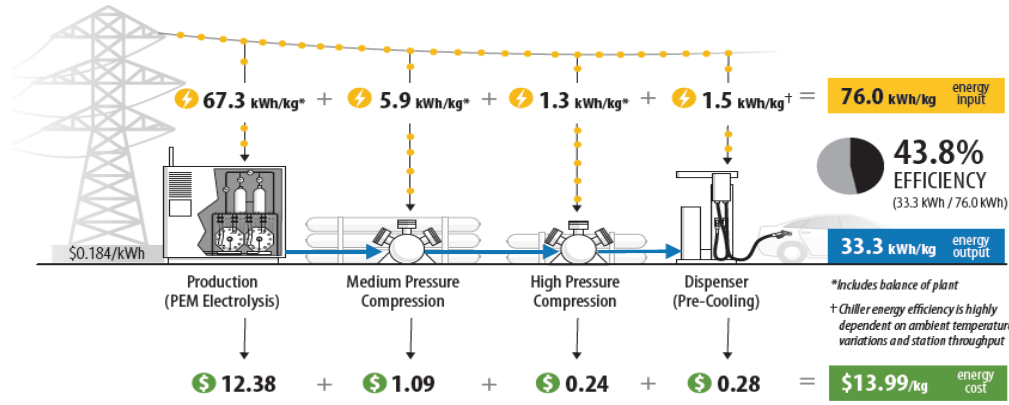
Robotic and Destructive Testing	Highly Accelerated Life Cycle Testing	High Flow, High Pressure, Pre-Chilled Testing
Hydrogen Meter Testing	Power and Energy Monitoring	Deep Dive Failure Analysis

Applications and Industries

Early Detection of Failures, Root Cause, Improving Material Selection and Manufacturing Processes	Meter Accuracy, Station Operating and Maintenance Cost, Safety Research
Station Operators, Component Manufacturers, C&S Committees	



ENERGY required to produce and dispense 1 kg of H₂



For more information contact Mike.Peters@nrel.gov or visit http://www.nrel.gov/hydrogen/facilities_hitrf.html

Electrolyzer Stack Performance Testing

Capabilities

Electrolyzer
System and BoP
Test Bed

Simulating Grid
with
Renewables
and Demand
Response

Single Cell
Monitoring

Multiple Stack
& Large Active
Area Stack
Testing

Power
Hardware-in-
the-Loop &
Remote Control

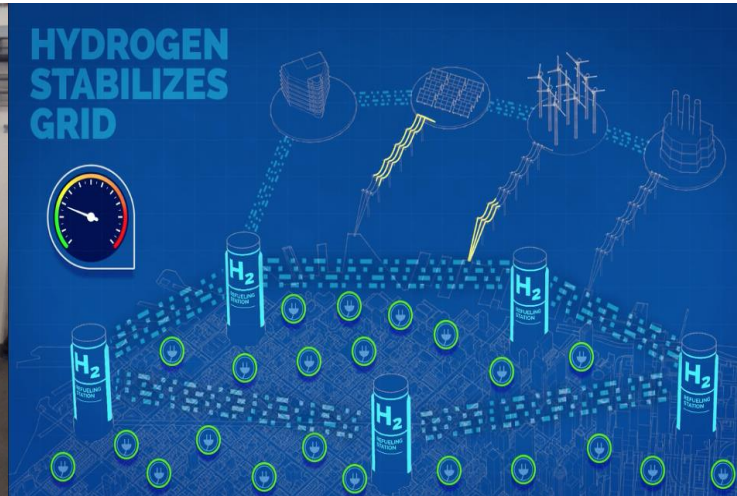
Variable Profile
Operation for
Life-Cycle
Analysis

Applications and Industries

Renewable Hydrogen
Production Integrated
with Hydrogen
Fueling and Other
End Uses

Energy Storage,
Grid Balancing,
System
Optimization,
Product Validation

Electrolyzer companies, power producers,
utilities, independent gas companies, station
operators, component manufacturers



For more information contact Kevin.Harrison@nrel.gov or visit http://www.nrel.gov/hydrogen/renew_electrolysis.html

Renewable Electrolysis – Systems Integration

Capabilities

Applications and Industries

Electrolyzer Stack & BoP Test Facility @ 70 bar, 85°C

Power Conversion & Renewable Energy (RE) Integration

In Situ High-Speed Cell, Stack and BoP Performance Monitoring

Renewable Hydrogen Production Integrated with Energy Storage, Transportation and other End Uses

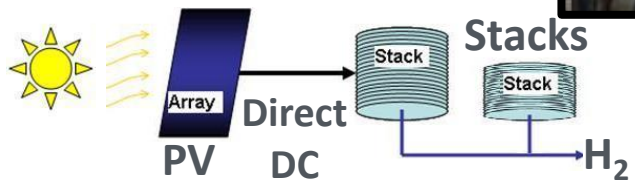
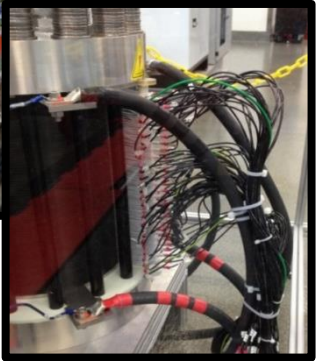
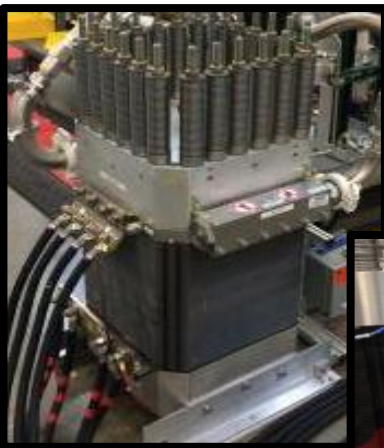
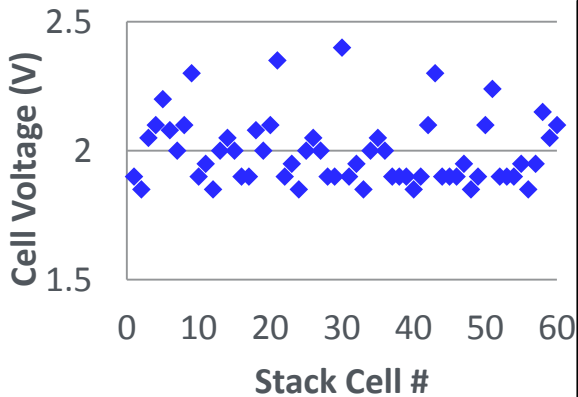
Grid Interoperability, Systems Optimization and Product Validation

Large Active Area & Multi-Stack Performance Validation

Hardware-in-the-Loop & Real World Systems Demonstration

RE Variable (AC & DC) Power Operation & Analysis

Electrolyzer & Stack Manufacturers, Utilities, System Developers, H₂ Component Manufacturers, States and other Stakeholders



Capabilities

100- and 700-L
Pressurized Gas
Fermentation
Bioreactor

Systems
Optimization,
FMEA, Safety,
Monitoring &
Controls

Grid-Scale End-to-
End Systems
Validation and
TEA

Input and
Product Gas
Quality Analysis

5 kg per hr H₂
Production with
300+ kg of
Storage

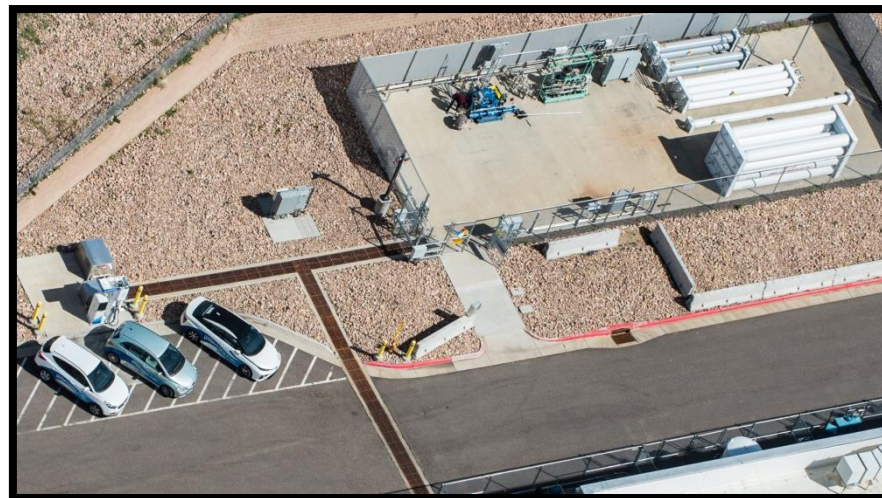
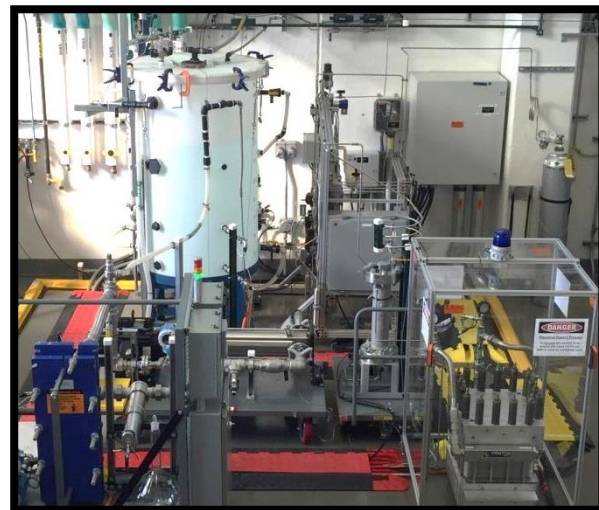
Design for
Sustainable
Variable System
Operation

Applications and Industries

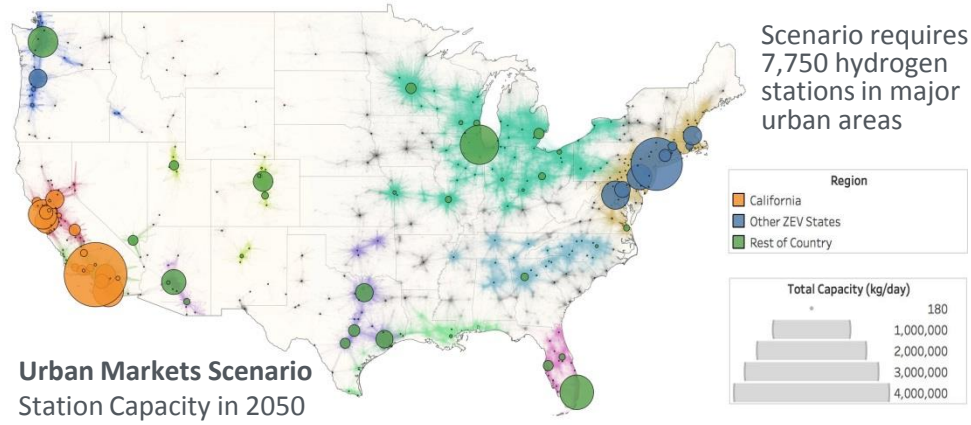
Flexibility to Integrate
Equipment from
Partners into End-to-
End Pilot Process

Innovative
Processing for
Hydrogen use in
Fuels and Chemicals

Utilities (Gas & Electric), System Developers,
States and Industrial Fuels and Chemicals

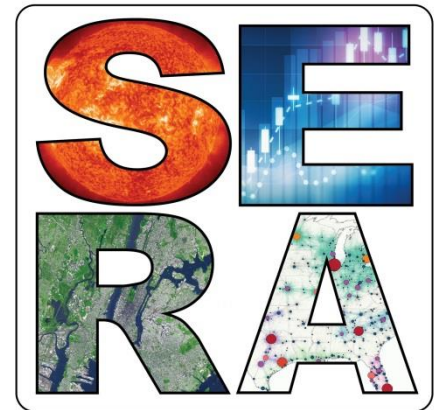


H2USA National Scenarios (FCEV Demand)



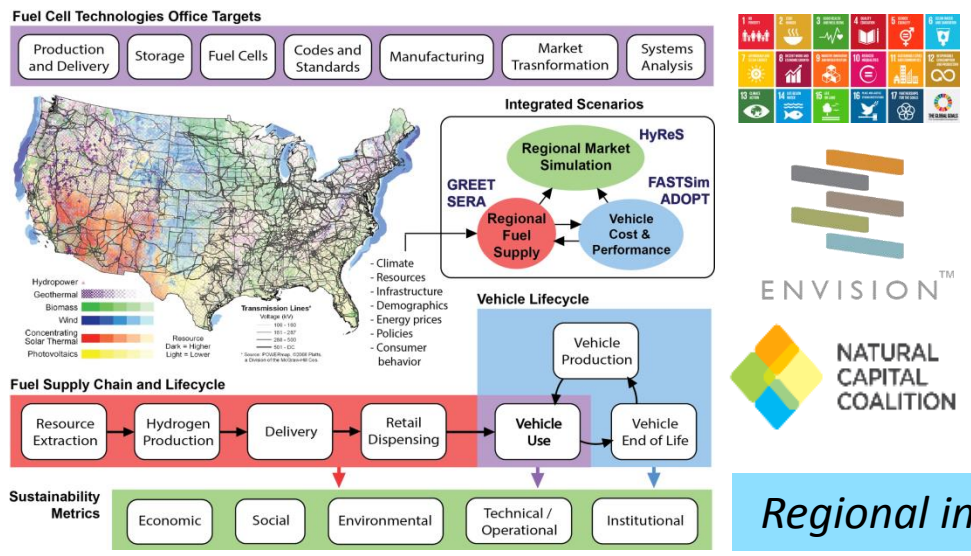
Urban Markets Scenario
Station Capacity in 2050

NREL's **SERA** and **H2FAST** Models provide integrated hydrogen infrastructure financial analysis capabilities



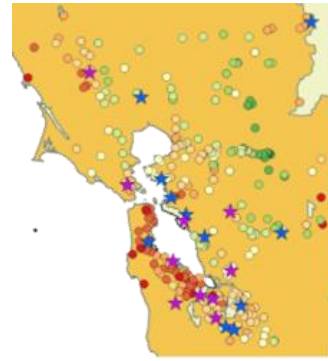
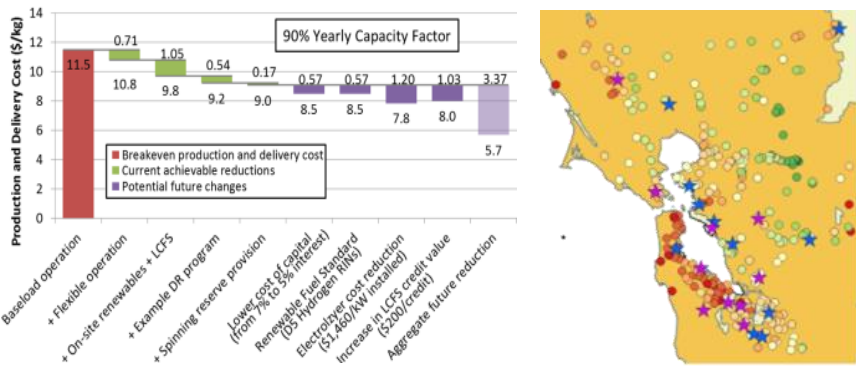
H2FAST www.nrel.gov/hydrogen/h2fast/

Hydrogen Regional Sustainability (HyReS)



California Power-to-Hydrogen

Near-term CA business case for Power-to-hydrogen.
www.nrel.gov/docs/fy17osti/67384.pdf



Regional insights into sustainability and market viability