PROTON
THE LEADER IN ON SITE GAS GENERATION.



# PEM Electrolysis: Enabling a Decarbonized Energy Future

**Stephen Szymanski, Proton OnSite**

**May 8, 2017**

# Company Overview….for today

- World leader in PEM water electrolysis
- HQ in Wallingford, Connecticut, USA  (1996)
- 2,700 Systems delivered in 75 countries for:
  - Industrial applications
  - Laboratory markets
  - Military customers
  - Fueling and energy storage
- ISO 9001:2008 certified
- ~ 100 employees



# And an exciting new development for tomorrow…

nel

PROTON ON SITE

## Contemplated acquisition of Proton OnSite

*27 February 2017*

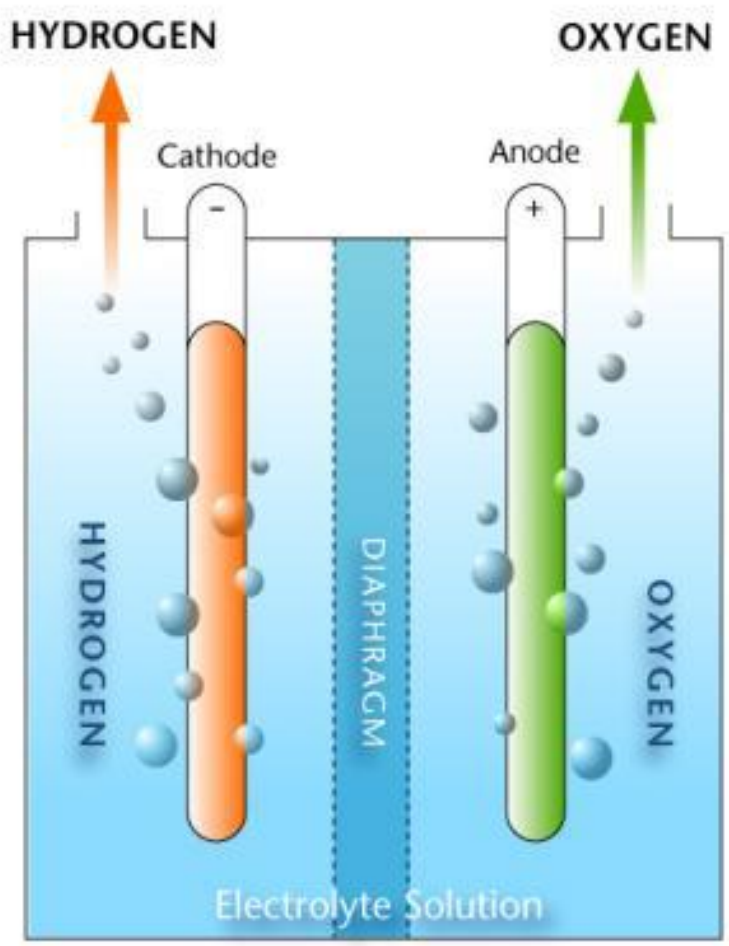
***"Acquiring the world's largest manufacturer of PEM hydrogen electrolysers"***

PRESS RELEASE / OSE FILING

27 February 2017 – Oslo, Norway

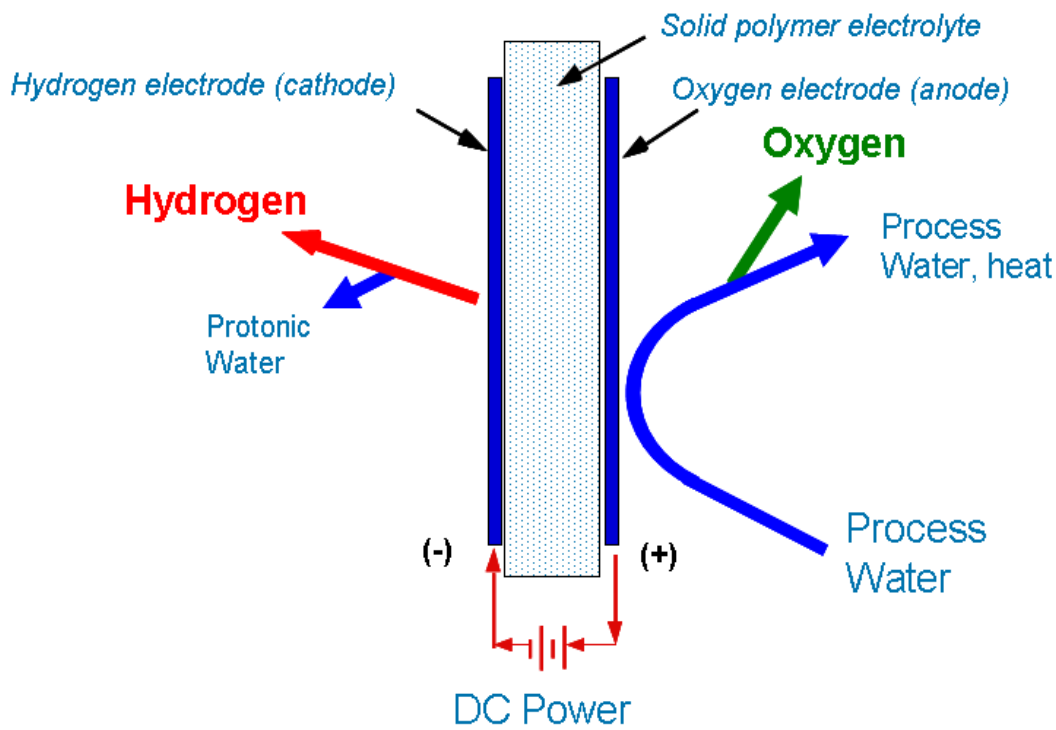
**Nel ASA: Acquires Proton OnSite to create the world's largest electrolyser company and launches private placement**

# Commercial Electrolysis Technologies



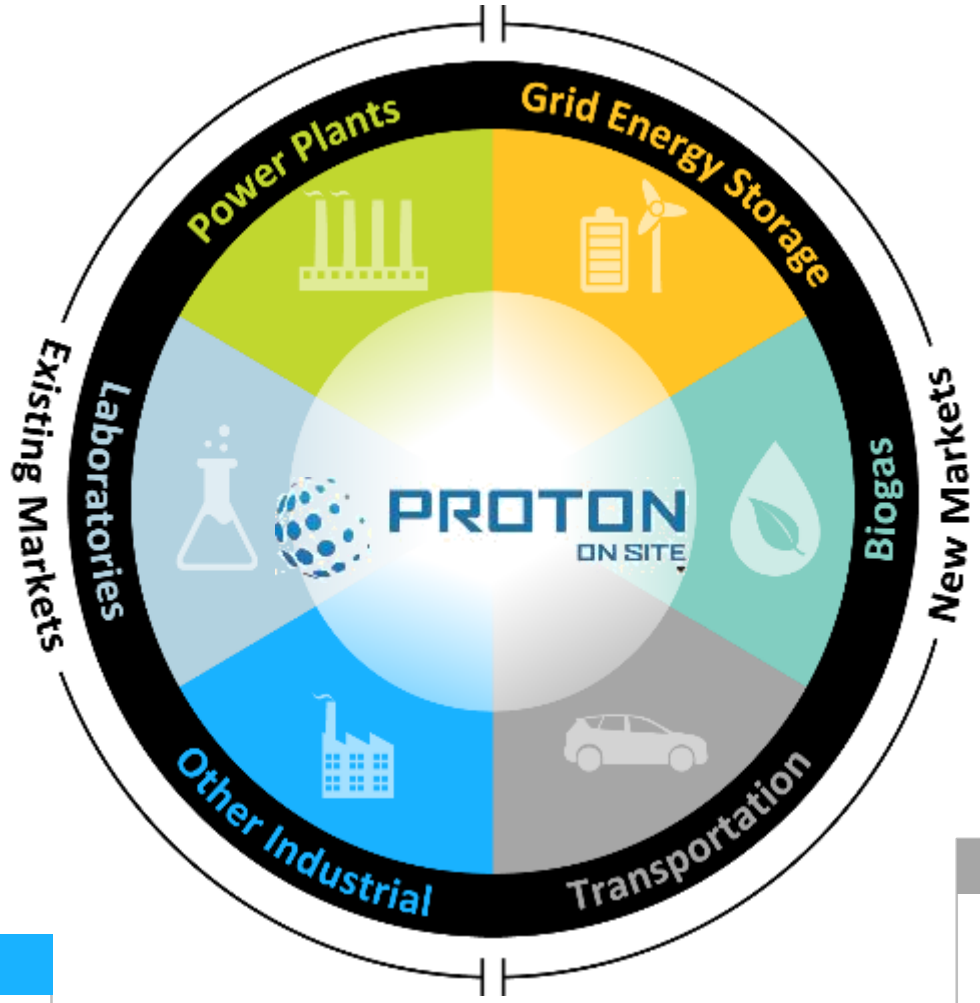

Liquid KOH

- Liquid KOH
  - Corrosive electrolyte
  - Enables non-noble metals
- PEM = solid electrolyte




Proton Exchange Membrane (PEM)

# Where our electrolyzers are used




## Power Plants

Cooling electric generators

## Laboratories

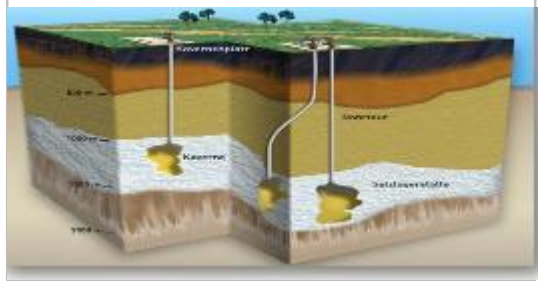
Carrier gas for analytical instrumentation

## Other Industrial

Process gas for semiconductors, heat treatment, and meteorology

## Grid Energy Storage

Storing stranded excess renewable energy



## Biogas

Turning waste $CO_2$ into methane

## Transportation

Fueling fuel-cell vehicles

## Military

Oxygen production and specialty vehicle fueling

# How much $H_2$ can we make?

7 kW

1 day:
2.3 kg

40 kW

1 day:
13 kg

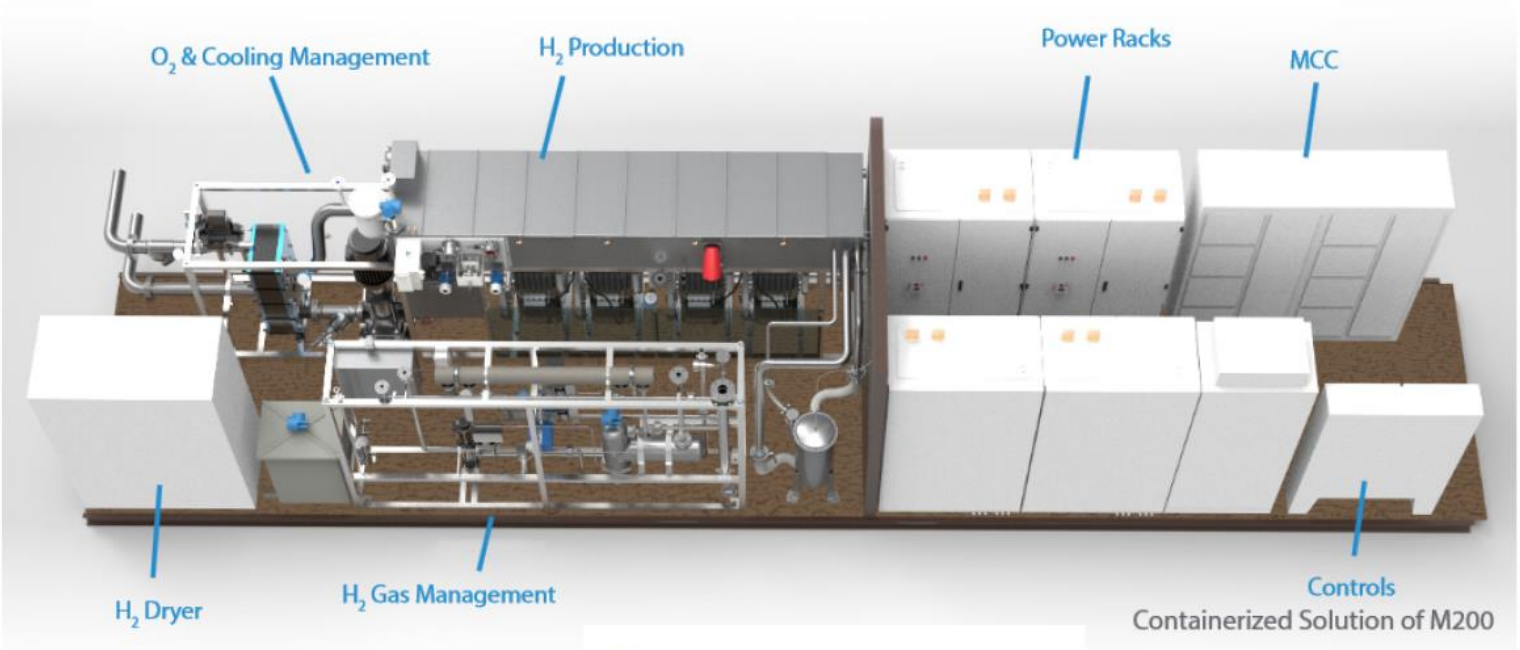
175 kW

1 week:
455 kg

1,000 kW

1 day:
451 kg

# Announcing the largest PEM electrolyzer sale in the world!

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## Proton OnSite Awarded 13 Megawatt Electrolyzers for the Deployment of Fuel Cell Buses in China

ded by FuelCellsWorks, December 20, 2016

Tweet Like 35 Share G+1 6

- World's largest megawatt PEM electrolyzer deal
- Electrolyzers to provide green hydrogen for fuel cell bus fueling in China
- 3 systems released for shipment; balance to ship over next 18 months

# M Series Building Blocks

Process Skid – Stacks, Cooling & $O_2$ Mgt

$H_2$ Gas Mgt Skid – Water Removal

Power Supplies, Power Distribution & Controls

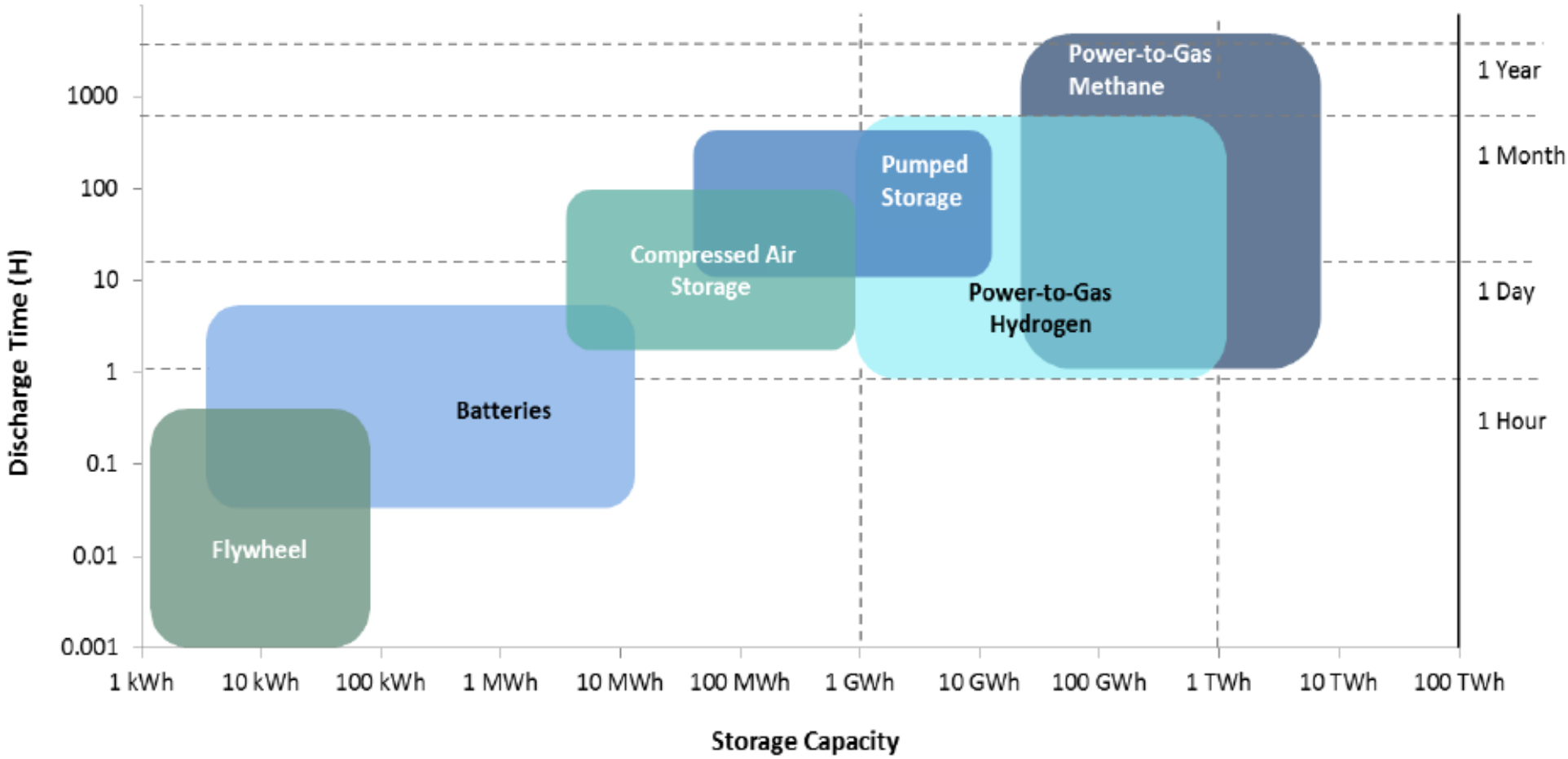
PLC-based HMI Interface

# “P2G”: storing electricity as a gas

# P2G enables bulk/seasonal energy storage:

"P2G Hydrogen": hydrogen is the end-use fuel

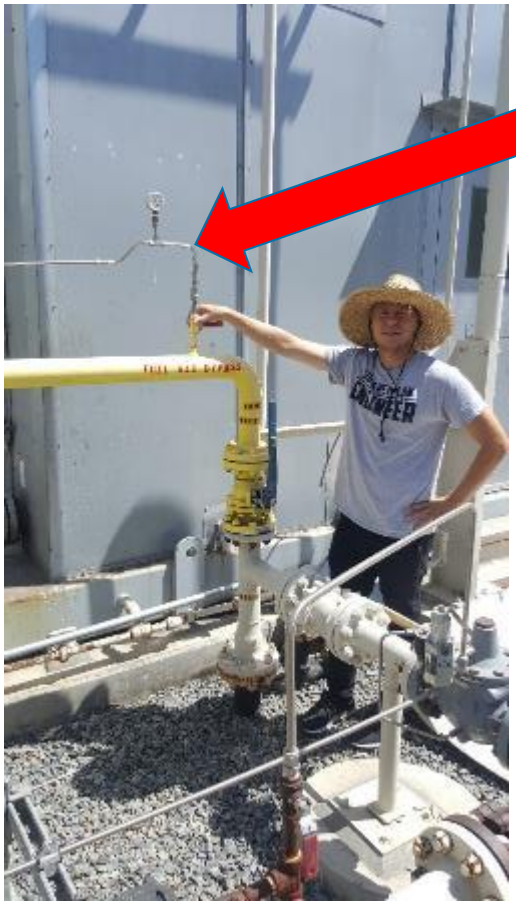
"P2G Methane": hydrogen is converted to syngas




Fraunhofer ISE, 2015

# P2G Demo Project Site: UCI Central Plant

Sponsor:  SoCalGas



Proton's electrolyzer injecting hydrogen into the CNG piping at the UCI Central Plant, feeding their combined-cycle turbine generator.  A first in the U.S.!

# P2G with microbial methanization:

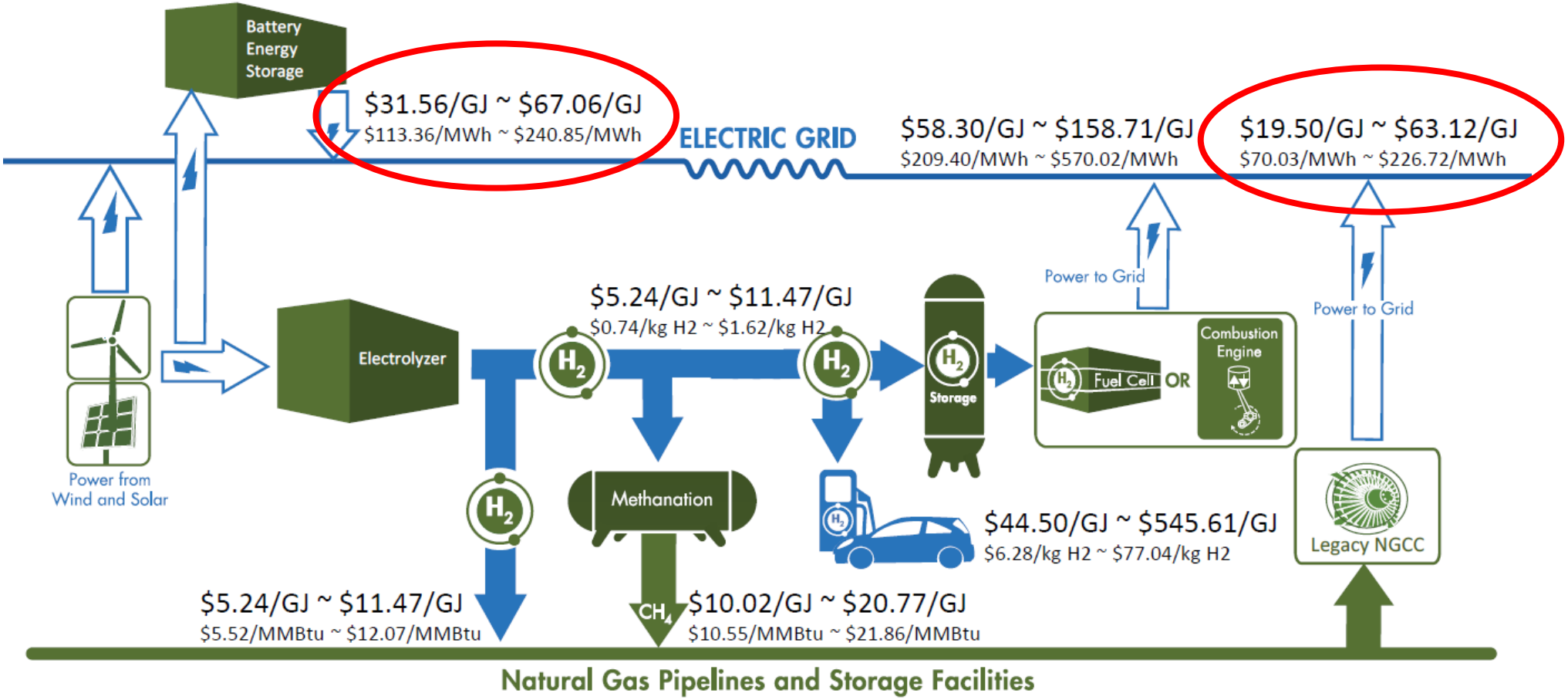
Viessmann (MicrobEnergy), Schwandorf, Germany


- 30Nm$^3$/h Proton PEM electrolyser combined with a methanization process.
- $H_2$ produced from surplus electricity & combined with $CO_2$ from a biogas plant to produce bio-methane ($4H_2 + CO_2 \rightarrow CH_4 + H_2O$).
- Bio-methane is injected into the gas grid, leading to a carbon neutral process.

# “Levelized Cost of Returned Energy”: analysis of P2G use-cases shows P2G can compete with batteries on cost

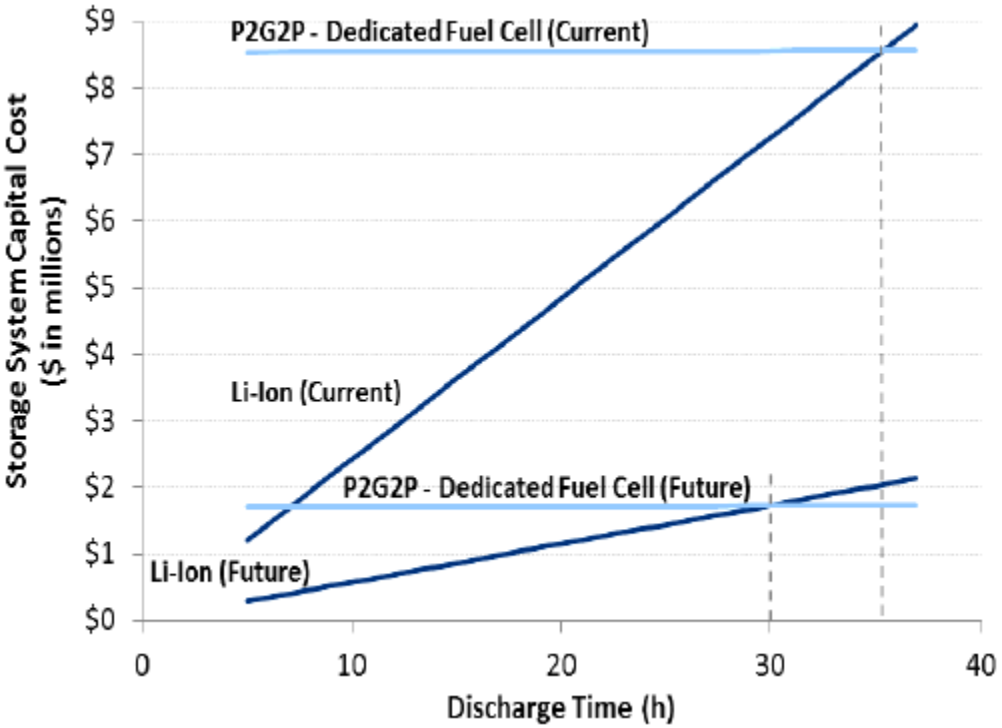
## LCORE Results

CURRENT COSTS & EFFICIENCES
45% Capacity Factor for Batteries;
90% Capacity Factor for All Other Equipment

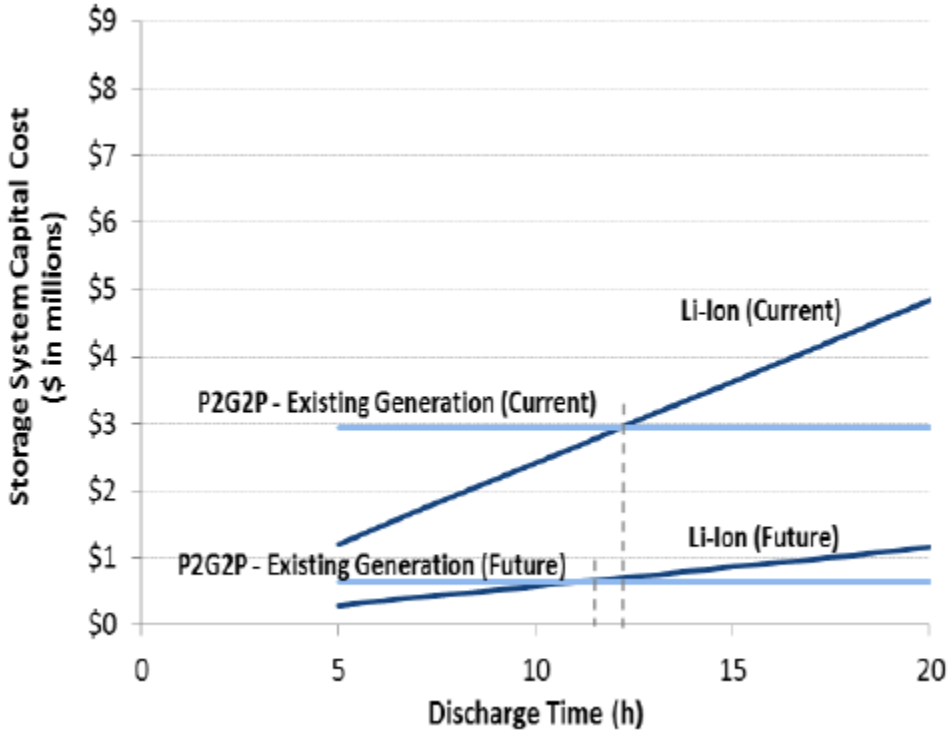


# P2G Costs versus Li-Ion

**Case 1**: Dedicated fuel cell for converting stored energy back to electricity.



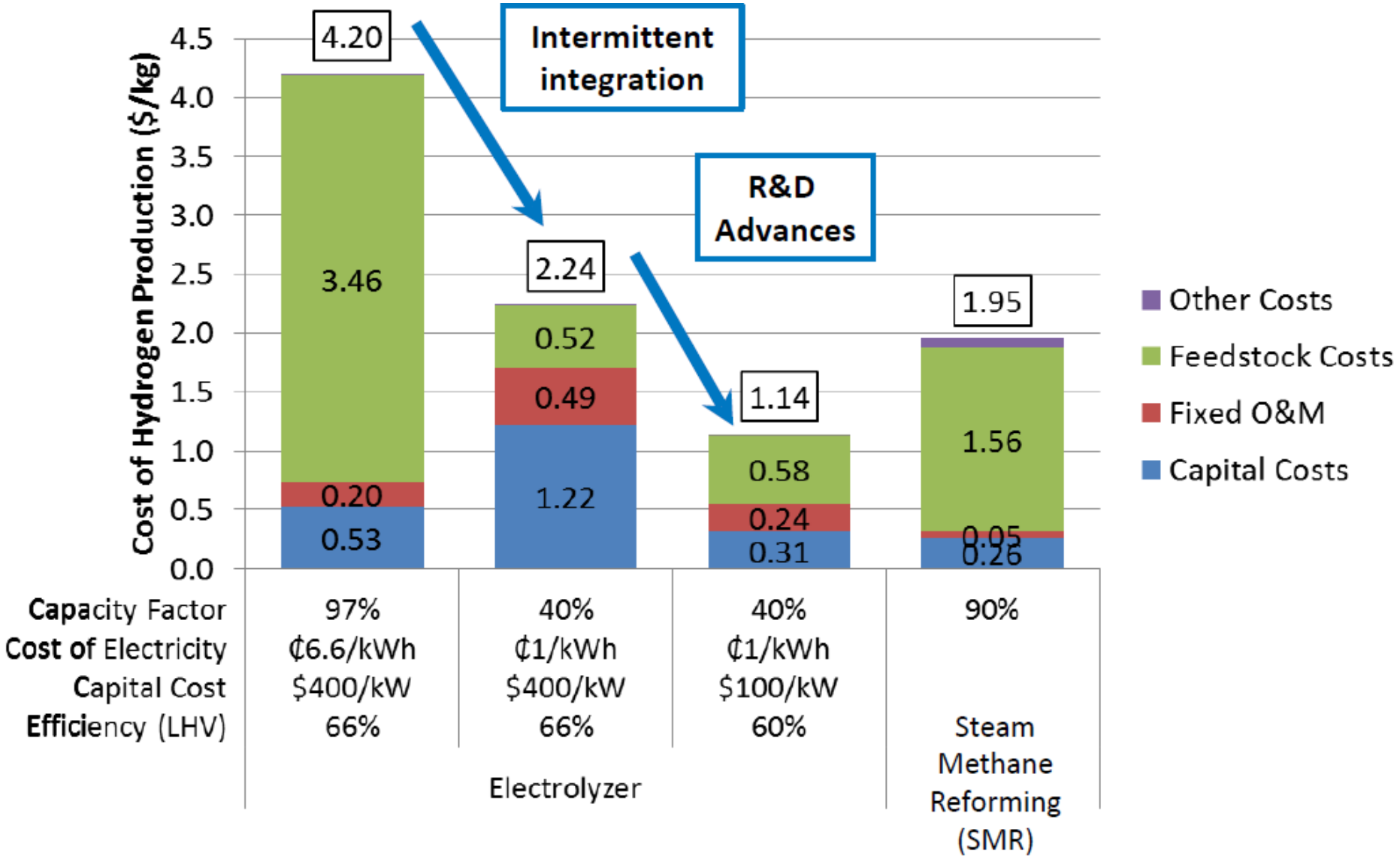

**Case 2**: Hydrogen is transported via CNG distribution system and used in existing generation asset.




CHBC White Paper, Power-to-Gas: The Case for Hydrogen

Key Takeaway:
Even with a dedicated fuel cell for converting the stored energy back to electricity, P2G is cost effective at longer discharge times.

# Improving the economics of renewable H2:




DOE H2@Scale webinar, 7/28/16

# Where do we need to go from here?

- Regulatory and systemic barriers need to be removed: all energy storage is not like a battery!
- Use cases that support a business case need to be developed and proven.
- Some technology work remains:
  - Electrolysis efficiency improvements and cost reduction.
  - Power conversion and controls for renewable electrolysis.
  - Gas blending and end-use conversion devices.
  - Biomethanation, ammonia synthesis, other process development.
- A relevant grid scale demonstration, showing multiple value streams from a P2G system.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# Renewable Electrolysis

## Enabling the Future of an Integrated Energy System


Renewables | Transport | Electricity Grid | **PEM Electrolysis** | $CO_2$ reduction | Biomethane | Gas Network