Power-to-Gas

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Hydrogenics is a leader in water electrolyzers and hydrogen fuel cell power systems

Onsite Generation
Electrolysers

Power Systems
Fuel Cell Modules

Industrial hydrogen
Hydrogen fueling
Stand-by power
Mobility power

Energy Storage
Power-to-Gas
What if we broke down the energy silos?

Transport Fuels: 36%
Natural Gas: 35%
Electricity: 19%
Other: 10%

Source data: National Energy Board secondary energy demand forecast, Rethinking Energy Conservation in Ontario, May 2010 report
Power-to-Gas converts clean generation when it is not needed into renewable fuel, power or heat where and when it is needed.

**Power-to-Gas Solution**

**Integrate Renewables**
- Wind Power
- Solar Power
- Surplus Power

**Renewable Gas Options**
- Clean Fuel
- Natural Gas Grid
- Industrial H2
- Dispatchable Power
- H2/NG Blend
- Low Carbon Heating
30 Power-to-Gas demonstration projects launched in Europe to date

- Power-to-Gas Applications
  - Direct Injection
  - H2 Fueling
  - Biogas Methanation
  - Industrial H2 Feed

- Hydrogenics has supplied electrolysers for 8 projects and 4 of 5 projects 1MW or larger

- Currently most projects are in pre-startup or early operation phase

Source: DNV KEMA. “Systems analyses Power to Gas: A technology review”. June 20, 2013
E.ON inaugurated first Power-to-Gas plant to inject hydrogen into natural gas grid last August

2MW Power-to-Gas Demonstration Plant in Falkenhagen, Germany
Only hydrogen can provide seasonal storage capacity by charging consecutive days or even weeks without needing to discharge

Hydrogen storage far exceeds the capacity of competing storage technology

This much could be fed into an underground hydrogen reservoir (2 M m³ salt cavern):

600,000 MWh

Source: KBB underground

Source: GM presentation, Freese, May 13, '09

Pumped Hydro Storage Potential

CAES Potential for 2 Mm³ Salt Cavern
Hydrogen fueling stations using electrolysis have excellent customer reach

- Safe and meet SAE and local standards
- Can be located in densely populated urban areas
- Provides clean fuel – 99.999% purity
- Scalable – incremental fueling capacity added as required

130 kg/day (Stuttgart, Germany)  
65 kg/day (Santa Monica, CA)
The real time dynamic response that makes Power-to-Gas ideally suited for providing an ISO balancing service.

Note: Ontario IESO signal test completed June 2011
The value proposition for Power-to-Gas is compelling

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Power-to-Gas developers need to monetize three core benefits for a robust business model

1. Integrate Renewables
2. Energy Produced
3. Value of Renewable Hydrogen
For example, operating the PEM electrolyser 12 hours a day would accommodate a wide range of fueling demand and provide a useful band for CAISO.
Hydrogenics is working with Enbridge to develop the first Power-to-Gas Pilot Project in North America

P2G Demonstration Project Objectives

**Integrate Renewables**
- Demonstrate Ancillary Services with IESO
- Performance Monitoring and Reporting

**Electrolyser**
- PEM Electrolyser
- Define Contracting Path

**Renewable Gas Options**
- Set Gas Inter-Operability Standards and Metering
- Optimize Operations
Our next generation PEM stack has the same capacity as 12 of our pressurized alkaline stacks.
Power-to-Gas pilot plants today will drive commercial scale deployments in the future

**Today…**
Among the most proven and utilized technology

**Needs…**
Tailored for large scale energy storage

**Future…**
Advanced MW-scale GEN3 technology plant solutions

- 2 MW Alkaline
- 1 MW PEM
- 40 MW Plant
Power-to-Gas will be an important part of the hydrogen technology roadmap, but much work remains to be done

Remove Barriers to Energy Storage

- Power-to-Gas proponents need to join the efforts of energy storage associations to smooth adoption of energy storage technologies
- Includes wholesale power input prices, provision of ancillary services, ITCs, procurement targets

Get Credit for Renewable Gas

- Encourage holistic energy policy thinking breaking down silos
  - California’s procurement of 33% renewable HRS
  - Broadening RFS2 Renewable Fuel Standards to include renewable H2
  - Renewable natural gas market or tariff mechanism

Facilitate North American Gas Inter-Operability Standards

- Needed for Direct Injection P2G application for GWh scale energy storage in natural gas grid