



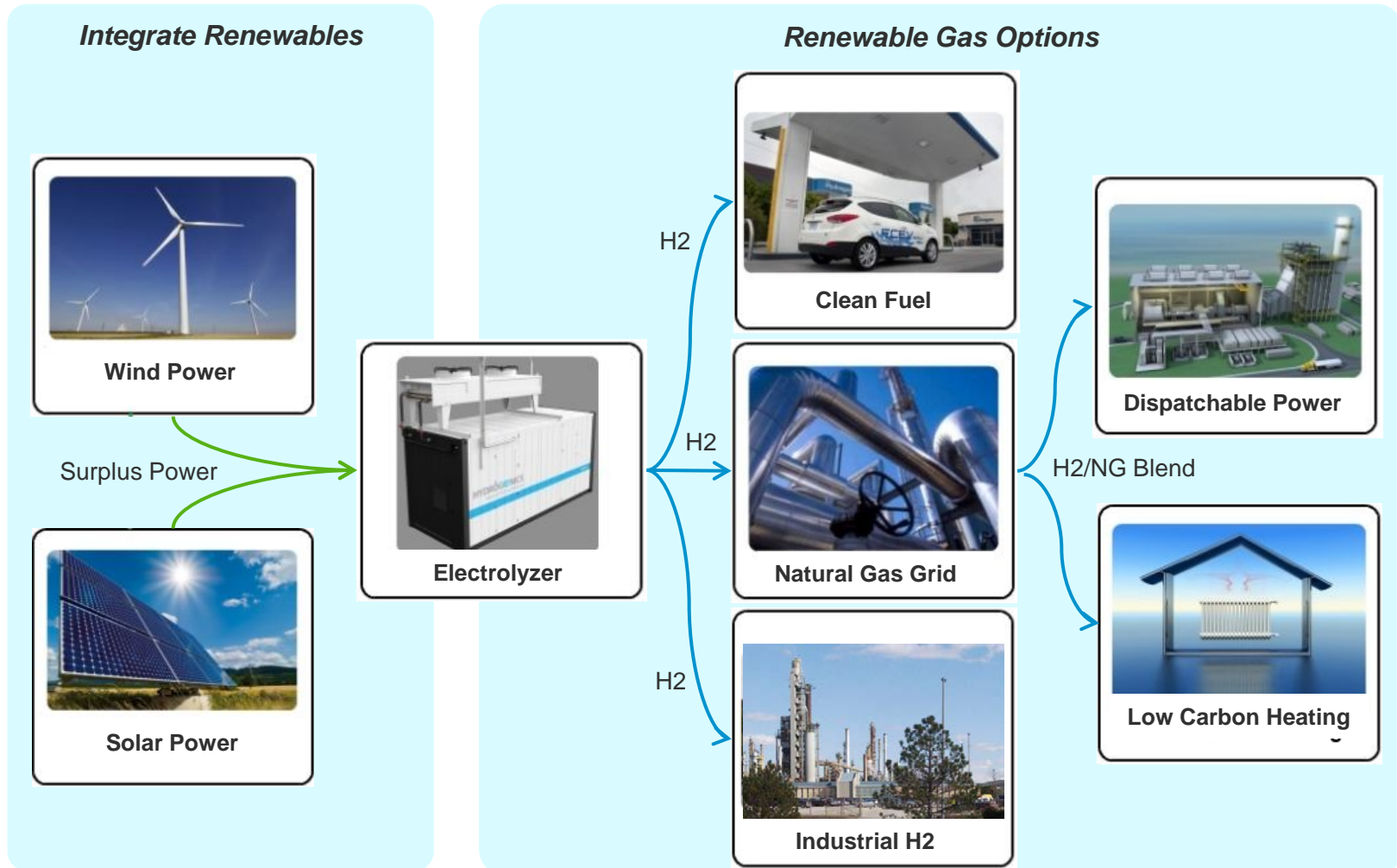
Power-to-Gas for Energy Storage

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DOE Electrolytic Hydrogen Production Workshop
National Renewable Energy Laboratory, Golden, CO – Feb 28, 2014

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



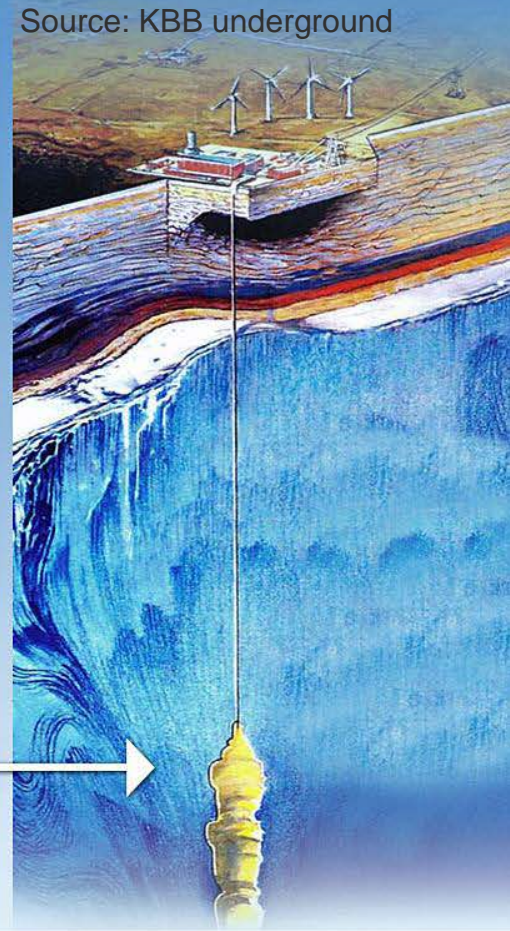
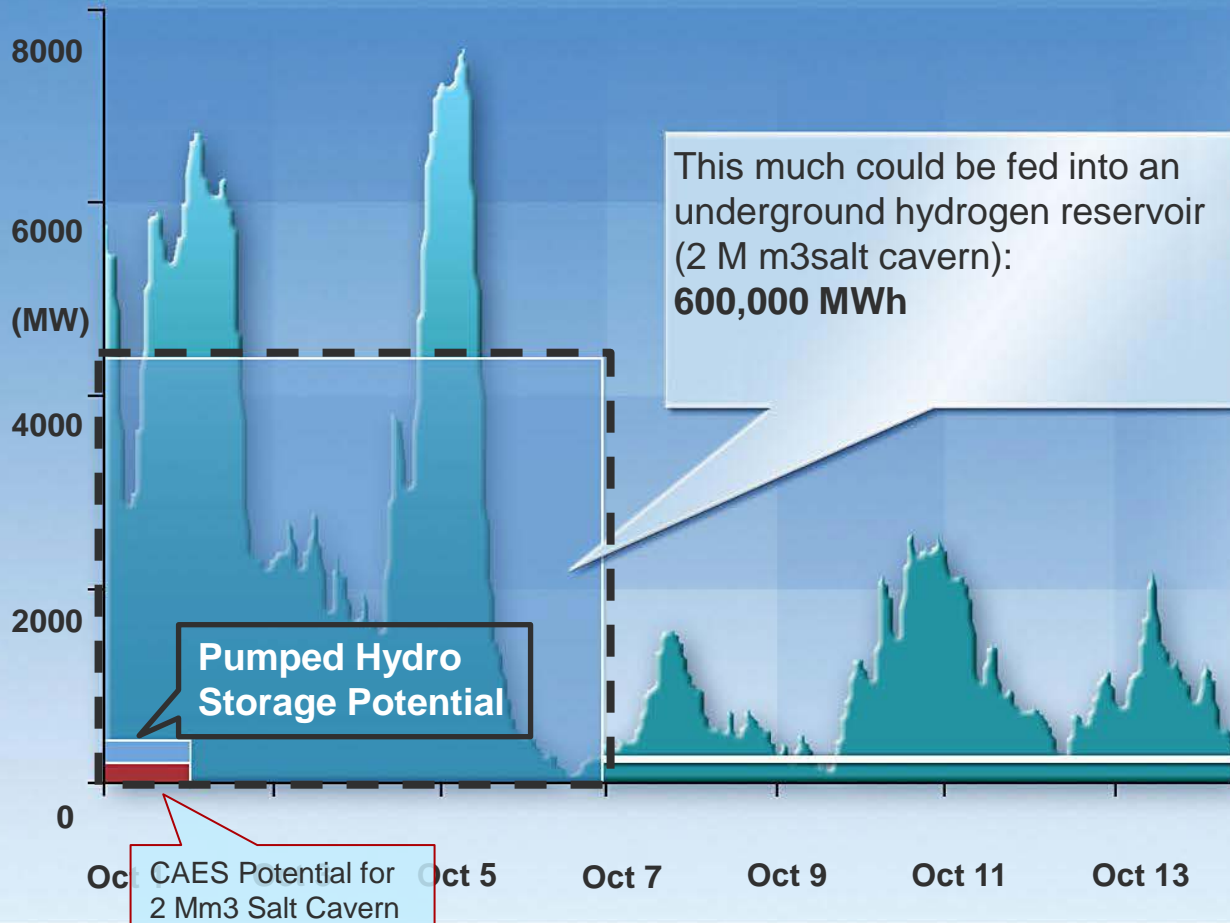
The value proposition is compelling

Power-to-Gas Applications

Value Proposition	Direct Injection	H2 Fueling Station	Industrial H2 Feed	Biogas Methanation	Captive RE
Ancillary Services	●	●	●	●	
Store Energy	●	●	●	●	●
Seasonal Storage	●			●	●
Tx Grid Capital Deferral	◐			◐	●
Renewable H2	●	●	●	●	●

Only hydrogen can provide seasonal storage capacity by charging consecutive days or even weeks without needing to discharge

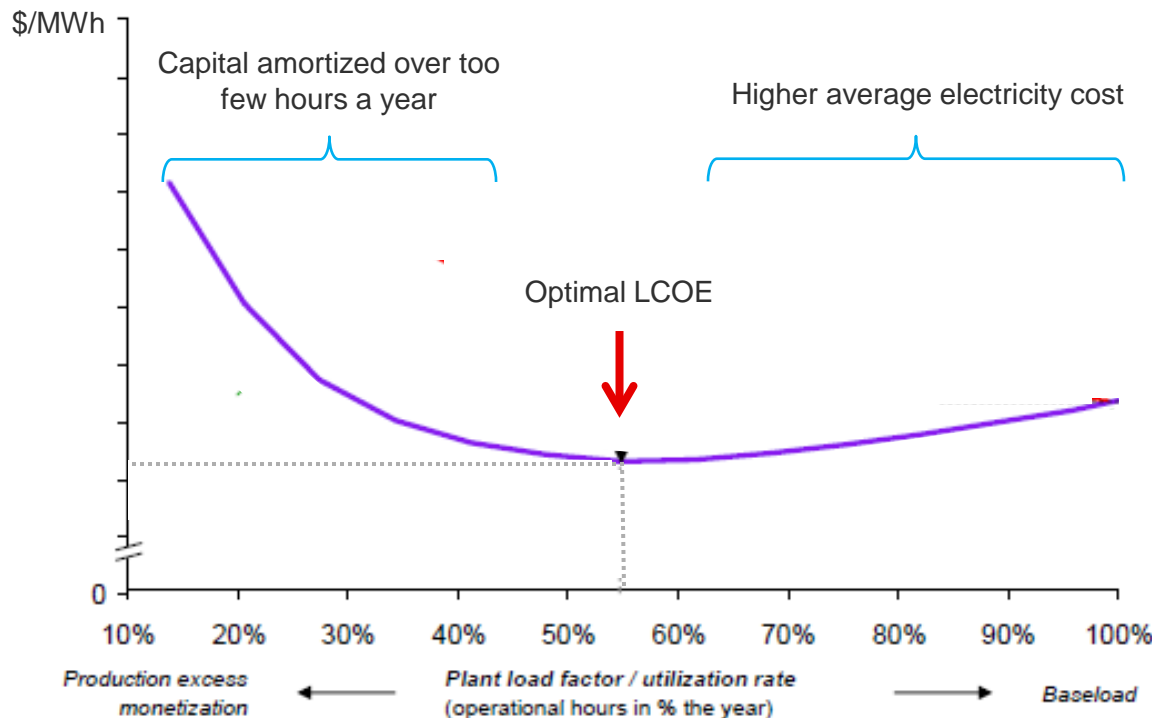
Hydrogen storage far exceeds the capacity of competing storage technology



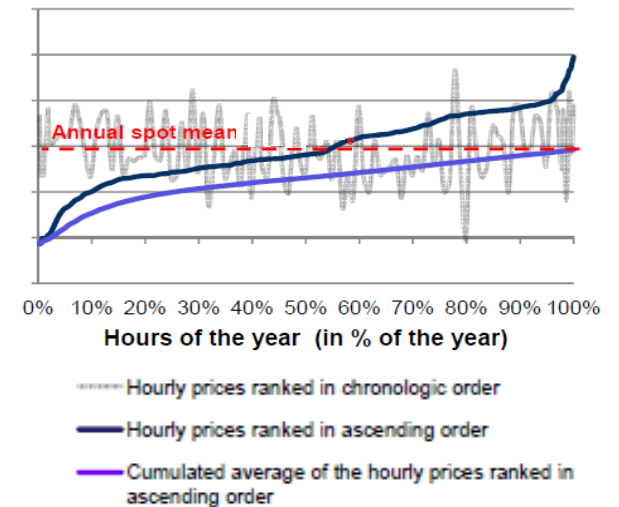
Source: GM presentation, Freese, May 13, '09

An alternative operating model for a Power-to-Gas plant is to capture low-cost power *and* provide ancillary services

LEVELIZED COSTS OF HYDROGEN FOR A GRID-CONNECTED ELECTROLYSIS PLANT



Assumed electricity price distribution (\$/MWh_e)

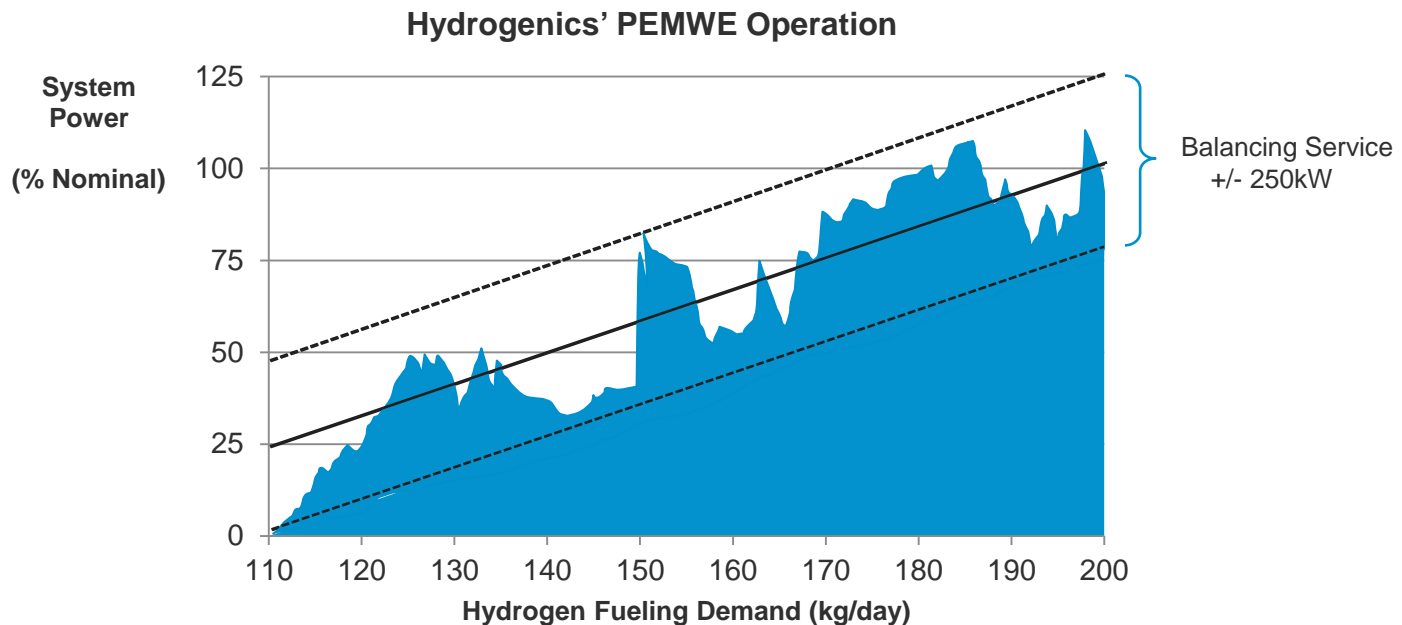
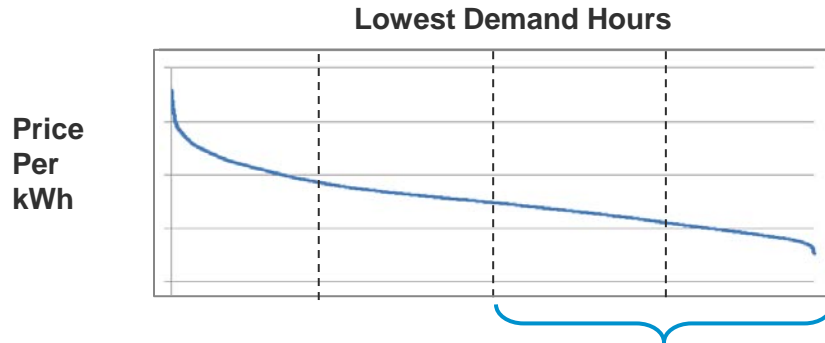


Note: Illustrative example based on SBC Energy Institute simulation based on DOE H2A Model. © 2013 SBC Energy Institute.

Source: Excerpt from presentation by Benoit Decourt entitled *Hydrogen-Based Energy Storage Solutions* at the IEA Hydrogen Roadmap Workshop, Paris – July 10, 2013.

For example, an electrolyzer operating 12-15 hours a day could accommodate a wide range of fueling demand and provide a useful regulation band for the ISO

Illustrative



A number of challenges remain...

Remove Barriers to Energy Storage

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

Testing MW Stacks

- Facilities/resources for product development testing of full size electrolyzer stacks in MW and Multi-MW configurations

Launch MW-Scale Power-to-Gas Pilot Projects

- Need field deployments for different P2G applications
- Demonstration of technology and provision of ancillary services
- Real operating data will lay foundation for contracting commercial projects

Power-to-Gas pilot plants today will drive commercial scale deployments tomorrow

To Date...

Demonstration projects using proven technology



2 MW Alkaline

Needs...

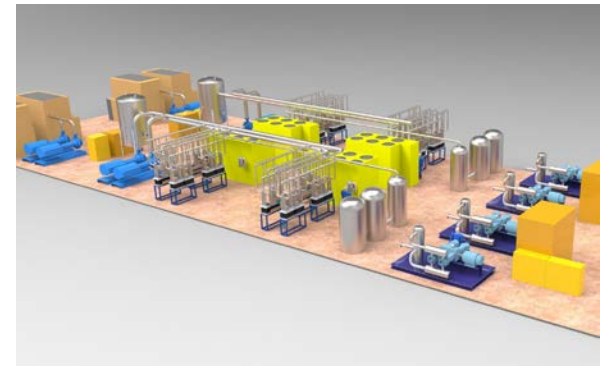
Pilot projects using large scale electrolysis platforms



1 MW PEM

Future...

Commercial scale plants



40 MW Plant