Hydrogen Enabling Renewables Working Group

Update for the HTAC

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Purpose

Examine the various ways in which hydrogen might serve as an enabler for high penetrations *(>50% nationally, on an energy basis – See appendix)* of variable renewable energy in the United States.

Summarize the opportunities and challenges of using hydrogen as an enabler for renewables in "white paper(s)" for DOE executive management.

Potential Applications

- Energy storage
- Supplement to Natural Gas System
- Energy transmission & distribution
- Improved renewable resource utilization via vehicle fuel production

Initial Focus Area

- **Grid energy storage application**
  - Integration of variable renewable resources (ramp rate controls, time shifting from off-peak to on-peak, reserve margins, etc.)
  - Reduction of variable renewable energy curtailments due to baseload bottoming and/or transmission and distribution system constraints
- **Basis**
  - Analysis of this application can be leveraged in the analysis of other applications
  - DOE interest in energy storage for integrating renewables

Presentation of Results

Energy Storage Modeling

- Simple Model: Sandy Thomas (Consultant)
  - Direct comparison of energy storage technologies
  - Identified competitive opportunities
- Community Energy Model: Darlene Steward (NREL)
  - Explored potential for small scale hydrogen energy storage to support grid and hydrogen vehicles
  - Compared results to comparable/competitive energy storage system supporting grid and electric vehicles

Simple Model

Sandy Thomas (Consultant)

Community Energy Model

Darlene Steward (NREL)

High Level
Summary of Findings

Simple Model Conclusions

Hydrogen is competitive for scenarios where:

- **Large amounts of otherwise "spilled" energy** from renewables (>24 hrs) must be captured
- **Fast ramping** is desired in addition to the energy

Multi-day energy storage will likely be necessary in a high renewables penetration scenario

System economics work only if there is more **value placed on otherwise curtailed renewable resources**:

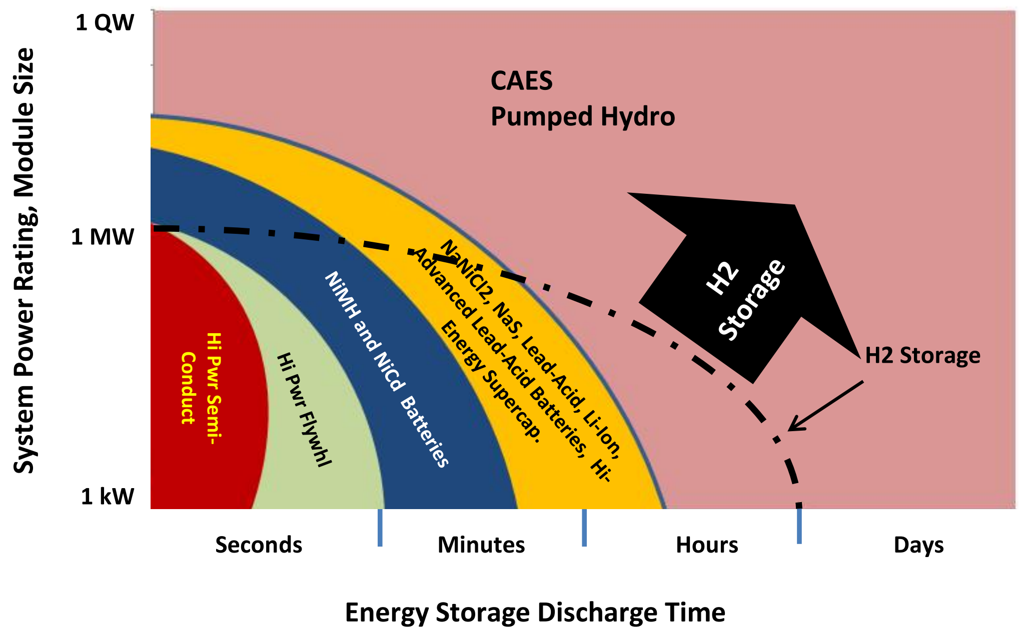
- Higher Renewable Portfolio Standards
- Carbon Dioxide Emission Controls

H2 Storage Has Unique Competitive Characteristics That Can Add More Value

- **Scalable** energy storage can be deployed wherever needed (not limited to cavern)
- **Greater flexibility** for discharging stored energy
  - As clean power
  - As low carbon heat
  - As hydrogen fuel for transport
- If hydrogen injected into the natural gas system
  - **Seasonal** storage potential
  - The energy can be **discharged anywhere** on the gas or electric network

Conceptual Range of Scale For H2 Energy Storage

Energy Storage Technologies Power Rating and Capacity



Source: The data for the figure was obtained from EPRI's ***Electricity Energy Storage Technology Options*** *A White Paper Primer on Applications, Costs, and Benefits*

Community Energy Conclusions

- Though system **allows for fully renewable vehicle fuel**, no compelling story for hydrogen system benefits over electric battery system equivalent
- **Surprisingly good match** between building load, PV system peak capacity and number of vehicles served
- **Hydrogen system more flexible** for dealing with seasonal variability and inconsistent fueling events (due to increment of additional kWh of hydrogen storage is less than that for battery electro-chemical storage)

Recommendations

Energy Storage

- Determine if there are national policies being considered that would significantly increase renewable penetrations.
- Conduct system analyses including and excluding long-term storage using policy scenarios identified above.
- Estimate the value of hydrogen energy storage to the overall system
- Determine what value to assign otherwise “spilled” renewables to make multi-day scale hydrogen (and other) energy storage economical.

Recommendations

Community Energy Storage/Transportation System

- Conduct sensitivity analyses to determine what conditions are necessary for a hydrogen system to compete with electric battery system for fueling FCV and EV vehicles, respectively, with solar PV energy.

Many Thanks!!!

- **Sandy Thomas** – Architect and driver of the Simple Model (on personal time!)
- **Darlene Steward** – Hydrogen energy storage subject matter expert and lead for grounding our work in reality
- **HTAC and other Non-HTAC Members** – experts and thought leaders

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Daryl Wilson	Maurice Kaya
Fred Joseck	Peter Bond
Monterey Gardiner	Rob Friedland
George Sverdrup	Bob Shaw
Jason Marcinkoski	Todd Ramsden
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HTAC Feedback

Next Steps

- Incorporate HTAC Feedback on these two topics and issue “white paper” with Energy Storage “Simple Model” results, with recommendations to DOE for further R&D
- Begin exploring energy storage in gas pipelines and use of hydrogen for heat

Appendix

Characteristics of a future US combined electric grid and transportation sector powered with >50% renewables

- Large amounts of variable off-peak renewable energy "spillage"
- Renewables used to power both grid and transportation sectors would count toward total energy produced (denominator) and total renewable energy produced (numerator)
- Reductions in the cost of renewable energy versus traditional energy sources due to high volume production and technological advances
- Baseload power plants with lower turndown capabilities and better load following performance
- Large wind resources will not be near large load centers, requiring significant transmission investments
- Environmental concerns and transmission constraints will limit large scale central solar facilities. This will influence more distributed scale solar, using existing urban and suburban open spaces, including paved lots. This resource will be interconnected to the distribution grids, and will produce more power than is used by the facilities associated with the solar resource.
- Distributed energy such as stationary fuel cells may be more economical and more efficient (both from energy conversion and CO_2 perspectives) than utility scale thermal resources.