Impact of Large-Scale Hydrogen Liquefaction in the Northwest

ESIC Board
October 3rd, 2014

In this presentation…
0. Update on H₂ Student
1. Motivation
2. Discussions
3. Refined focus
4. Path forward

Jacob Leachman (MME)
Ali Mehrizi-Sani (EECS)
Ken Casavant (SES)

jacob.leachman@wsu.edu - (509)335-7711 - hydrogen.wsu.edu
Washington State University Wins 2014 Hydrogen Student Design Contest

May 12, 2014 - 12:00pm

The Hydrogen Education Foundation's
Hydrogen Student Design Contest
2013-2014: Designing a Drop-in Hydrogen Fueling Station
www.HydrogenContest.org

2014 CONTEST WINNERS

WASHINGTON STATE UNIVERSITY
Washington State University Wins 2014 Hydrogen Student Design Contest

May 12, 2014 - 12:00pm

Jacob Leachman • School of Mechanical and Materials Engineering
Washington State University Wins 2014 Hydrogen Student Design Contest

May 12, 2014 - 12:00pm
LH$_2$ Will Drive Early Vehicle Market/Economy

- LH$_2$ tanker trucks delivered 80-90% of total small merchant H$_2$ in 2010. Superior costs.\(^1\)

- Cryo-H$_2$ densities are superior.
  - LH$_2$ at NBP is 70.8 g/L
  - Cryocompressed at 440 bar and 30 K is 90 g/L
  - Gaseous at 700 bar and 295 K is 39.7 g/L

- Only 8 LH2 plants in North America

- Not co-located with renewables, little excess cap.

---

\(^1\) Elgowainy, A., Tecnoeconomic Analysis of H2 Transmission & Distribution, DOE Workshop (2014)
1st Expert Consultation: Jeff Richards, Western Sales Manager, Praxair

- Rough large-scale liquefier specifics
  - 30 MW (~60 tonne/day) liquefier runs $30-100 million
  - Load turbine can handle 30% demand fluctuation

- What to look for when siting LH₂ plant:
  - Waste hydrogen (HCl, Caustic chem. products, etc.)
  - Grid proximity: NG, Power, Transportation, Water, etc.
  - Big users: Silicon processing (REC), Biofuel production (NARA), forklifts, distribution centers.

John Day Dam, Columbia River
2nd Expert Consultation: Monterey Gardiner, Technology Manager, DOE FCTO

- Anticipated FOAs: Compact H₂ Liquefiers, Mobile Refuelers
3rd Expert Consultation: Daryl Brown, Energy Economist, PNNL

• Power-to-Gas analysis in Northwest assumptions:
  - Daily spot market electricity prices, April 2012-March 2013
    • Average cost over entire year = $0.0176/kWh
  - Run electrolyzer 8000 hours/yr
  - Electrolyzer efficiency = 78.84% (50 kWh/kg H₂)
  - Average energy cost of hydrogen = $0.88/kg
  - Electrolyzer plant installed cost ~ $1000/kW
  - Assume electrolyzer capital charge = $100/kW/yr
  - H₂ production = 160 kg/kW/yr
  - Capital cost = 100/160 = $0.63/kg
  - O&M = 2% of initial capital per year or $0.13/kg
  - Total H₂ production cost = $1.6/kg
  - Compares to $1.5/kg via NG @ $5/MMBtu
  - Competitive H₂ source, especially if close to customer
Visit to CWREC-Kittitas/Ellensburg: Jim Armstrong, David Bowen, Brian Lenz (PSE)

• Primary Goal: Increase value of Wild horse wind energy
  - 700 MW installed capacity valued at 50 MW

• Opportunity: Dual-use hydrogen to level load and as energy product. Mini Hydrogen Economy!

• End uses: grid-stabilization, REC, forklifts, freeway fueling, biofuel, etc.

• Follow up planned.

• Fund a Master’s thesis?
Student Work & Path Forward

• Ali’s Graduate student: Saleh Ziaeinejad
  ▪ Conducted excess energy analysis to establish incentive

• Undergraduate researcher: Victor Charoonsophak
  ▪ Running JobsH2 & JobsFC, DOE economic models
  ▪ Collecting info on wind-power-to-gas projects

• Considering visit to Bullitt and Energy Authority

• Identified MS student for Wildhorse project

• Target DOE small liquefier proposal 2015