Impact of Large-Scale Hydrogen Liquefaction in the Northwest

Jacob Leachman, Ali Mehrizi-Sani and Ken Casavant

Presented at the WSU Energy Systems Innovation Center Advisory Board Meeting, 2014
Impact of Large-Scale Hydrogen Liquefaction in the Northwest

1) Motivation & Background
2) Expected Deliverables

Jacob Leachman (MME), Ali Mehrizi-Sani (EECS), and Ken Casavant (SES)
ESIC Seed Grant
4/22/2014

HYPERdrogen properties for energy research
Recent Hype about Hydrogen

Popular Mechanics

The Hydrogen Car Is Back—Again

Honda, Hyundai, and Toyota are rolling out new hydrogen-fuel-cell vehicles for 2014. So are we finally at the dawn of the hydrogen age? Not so fast.

By Basem Wasef  2/25/2014

So, is Hydrogen Happening?

"When you have several major carmakers saying we're going to invest in this, that's significant," Baum says. But vehicles are just one piece of the puzzle. Every other player in the hydrogen supply chain, such as the service station industry, needs to invest heavily. Until then, refueling options and vehicle choices will remain extremely limited, with no guarantee of expansion. Which is to say that hydrogen-fuel-cell cars will be a minor footnote in terms of overall vehicle sales for the foreseeable future. For all but the earliest of adopters, hydrogen as a prominent fuel alternative remains somewhere on the horizon.
2014 H2 Student Competition

- Design a modular, 700 bar H2 fueling station
- System reduced station cost by 55%
- Lowest cost to station owners
- Hydrogen dispensed for ~$12/gge
Cryo–Hydrogen Distribution Stats

• LH₂ tanker trucks delivered 80-90 % of total small merchant H₂ in 2010.¹

• Cryo-H₂ densities are superior.²
  ▪ LH₂ 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

• Cryo-H₂ fill rates are substantially faster than gas.
  ▪ No on-board cooling required

• Big downside: 30 % of usable energy lost to liquefaction.¹
  ▪ Liquefaction energy can be recouped via autogenous pressurization
  ▪ Many cryo-challenges remain

² REFPROP v. 9.1 NIST (2013)
Cryo-Hydrogen Distribution Network

- 8 LH2 plants in North America
- Gasoline WTW->11 kgCO$_2$/gal
- Not co-located with renewables, little excess cap.

<table>
<thead>
<tr>
<th>Location</th>
<th>GHG Emissions (gCO$_2$e/kWhe)</th>
<th>GHG Emissions (gCO$_2$e/kgLH$_2$)</th>
<th>Liquefaction Capacity (ton/day)</th>
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<tbody>
<tr>
<td>California</td>
<td>380</td>
<td>4.5</td>
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</tbody>
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1 Elgowainy, A., Tecnoeconomic Analysis of H2 Transmission & Distribution, DOE Workshop (2014)
Anticipated Deliverables: LH$_2$ in Northwest

• Feasibility report
  ▪ Current renewable energy capacity & strain
  ▪ Leading site locations
  ▪ Economic impact forecast

• Budget
  ▪ Summer EECS Graduate Student Support: $6,000
  ▪ Consultation with Industry Experts & Stakeholders: $1,500
  ▪ Travel to discuss with program managers (Bullitt, DOE, and NSF): $2,500

Thank You!