Vehicle Refueling

ARPA-E NG Vehicles Workshop
Afternoon Breakout

1/26/2012

Opportunity 1: Micro LNG
Session Readout, Group 4: NG Refueling Methods

High Level Solution

- Modular micro LNG production – ~< 5000 GGE/day
- Fills faster, fills full, tanks are cheaper, higher range.
- Combination with LCNG.
- LNG production for ~$0.25 per GGE.

Implications for Technical Areas

- Heat exchangers, must be made smaller. Hard to package in small structure.
- Better refrigeration cycles.
- Better overall process.
- Status quo is not good at liquefying gas at small scale efficiently.
- CO2 cleanup is a big cost driver.
- Does not make sense where LNG can be trucked in easily.

Opportunity 1: Micro LNG
Session Insights, Group 4: NG Refueling Methods

- **Why Micro LNG?**
  - Attractive because of longer range
  - Lighter, cheaper but more complex
    - Better LNG tanks could be a play
  - Mainly suited for medium or heavy vehicles
  - Infrastructure can also be used to provide CNG
  - CO2 and water removal is an issue (they condense)

Opportunity 1: Micro LNG
Session Process, Group 4: NG Refueling Methods

- **How did you come to your solution?**
  - Existing market for LNG
  - Small scale would be easier to deploy
  - There is a cost of trucking associated with centralized plants
- **What was the composition of your team?**
  - Linde, BOC,
  - Chart, Black and Veeach
- **What techno-economic solutions would break paradigm?**
  - LNG generation for $0.25 per GGE at 5000 Gal/daly (rough)

Opportunity 2: Home Refilling
Session Readout, Group 4: NG Refueling Methods

High Level Solution

- Home filling units (based on new advanced compressor designs), advances in materials allow operation at high pressure (3600 PSI) and 1 scfm ($350-500).
- This would allow purchase and installation < $1000.
- Compressor costs could be lower due to lower pressures for sorbent material tank or bi-fuel.

Implications for Tech. Areas

- Disagreement over whether ARPA-E should only fund compressors at 3600 PSI that can reach $500 per unit at 0.5 GGE/hour. Or, if you should also fund < 500 PSI
- Open it up to the different compressor proposals.
    - Due diligence is necessary because is this is very very hard.
    - Cost modeling is important
- A target of $500 for the 10^6 unit is plausible (for 3600 PSI).

Opportunity 2: Home Refilling
Session Insights, Group 4: NG Refueling Methods

- **<u>Why Home Refilling</u>**
  - Stretch target
  - Requires novel concepts and materials
  - Cost target is driven bounded by a $1000-1500 upper cost to product and installation and profit leads to $500/unit.
  - Relies on economics at 10^6 unitsConvenience is big motivator for consumer

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Opportunity 3: Low cost packaged CNG station
Session Readout, Group 4: NG Refueling Methods

High Level Solution

•Low cost island – replacing the gas pump.

•(>10 GGE/min), small footprint comprehensive unit.

•Don't need storage. Better temperature management for high full fill rate CNG. Broker deal to allow for these to be powered by Natural gas.

Implications for Tech. Areas

•Footprint and cost are most important

•Efficiency doesn't matter

•Drop the cost per scfm per minute.

•1 PSI -> 3600 ($200/scfm)

•1000 PSI -> 3600 ($50/scfm)

•Open it up to advanced compressor possibilities.

•Huge challenge local distribution to

Opportunity 3: Low cost packaged CNG station
Session Insights, Group 4: NG Refueling Methods

- **<u>Why Low cost packaged CNG station?</u>**
  - Lower installed cost
  - Permitting becomes easier
  - Target is to not have accompanying storage in an auxiliary tank
  - Firm encapsulation to fit in regulations.
  - Small footprints has many advantages
  - Big challenge to get 1000 PSI

Opportunity 3: Low cost packaged CNG station
Session Process, Group 4: NG Refueling Methods

- **How did you come to your solution?**
  - Dropping the total installed cost, easier to install.
  - Accomplished with integrated solutions
- **What was the composition of your team?**
  - Packagers – ANGI
  - Start-ups
  - Fuel retailer (Shell or a Chevron)
  - Producers (Chesapeake)
- **What techno-economic solutions would break paradigm?**
  - (>10 GGE/min), small footprint comprehensive unit.
  - 1 PSI -> 3600 ($200/scfm)
  - 1000 PSI -> 3600 ($50/scfm)