GINER

DOE Hydrogen Program

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Hydrogen Home Refueling

Status, Key Issues, and Challenges

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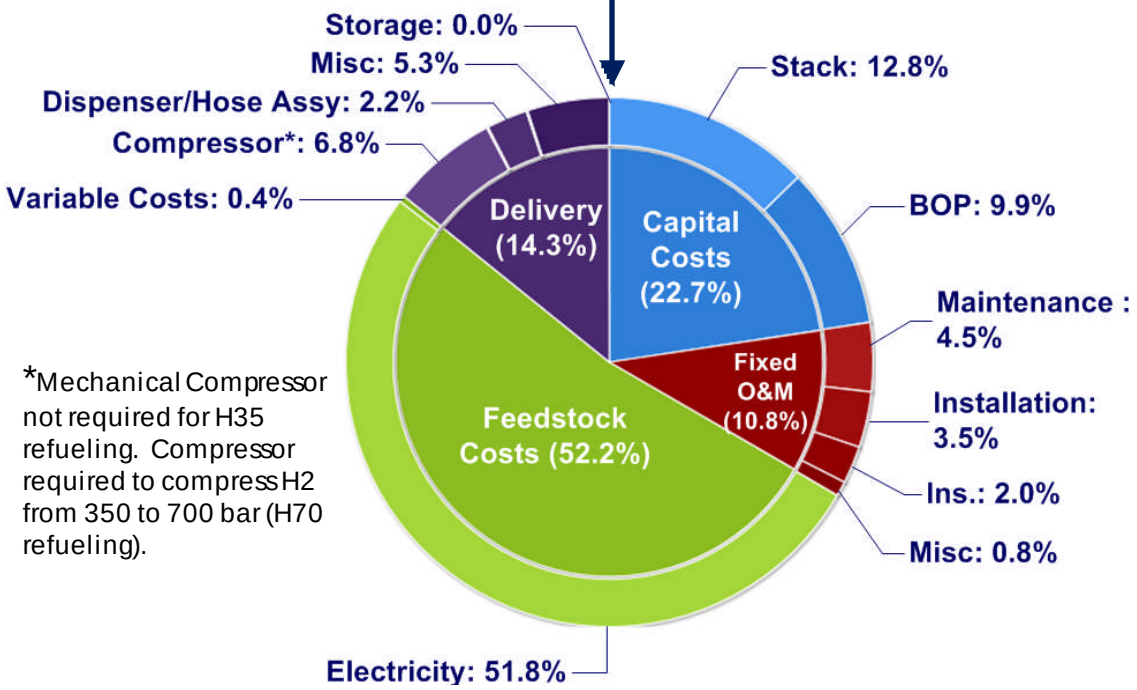
Home Refueling Costs

Based on Forecourt H2A Model (Ver. 3.0)

H_2 Production Cost Contribution	DOE Target (2020)	Home Refueler (2013)
Capital Costs	$0.50	$1.05
Fixed O&M	$0.20	$0.50
Feedstock Costs System Efficiency: 65 kWh_e/kg -H_2	$1.60 **($0.037/kW)**	$2.40 ($0.037/kW)
Other Variable Costs (including utilities)	<$0.10	$0.02
***Total Hydrogen Production Cost* ($/kg)**	**2.30**	**3.98**
Delivery (CSD)	$1.70	$0.66 (5,000 psig output, no Storage or Forecourt Station Requirements)
***Total Hydrogen Production Cost* ($/kg)**	**<4.00**	**4.64**

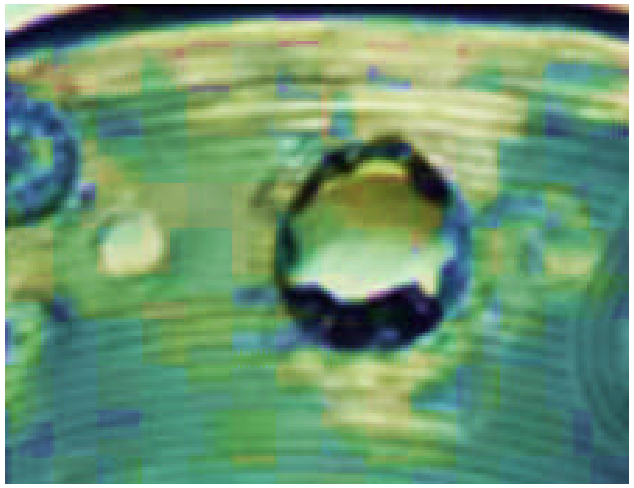


*Mechanical Compressor not required for H35 refueling. Compressor required to compress H2 from 350 to 700 bar (H70 refueling).

- H2A Ver. 3 includes higher installation costs and higher pressure requirement for H70 hydrogen refueling
  - Hydrogen pressure requirement 12,688 psig (previously 6,250 psig)
- **Progress inline with achieving *new* 2020 Target of <$4.00/kg-$H_2$**
  - Delivery: No Storage (or *forecourt* station costs)
  - Can achieve <$4.00 kg/$H_2$ for 5,000 psig vehicle refueling
  - Improving stack output pressure to 12,000 psig is required to meet 2020 target for H70 refueling

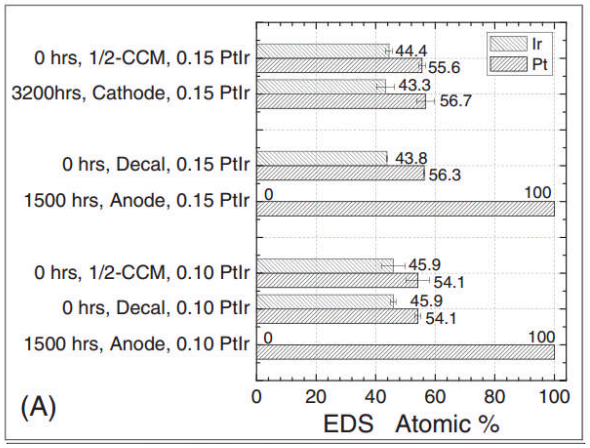
Home Refueling Issues: Technical Challenges

- Components
  - Membrane
    - Permeability
    - Creep (Sealing)
    - Degradation
  - Catalyst
    - Anode Dissolution
  - Separators
    - H_2 Embrittlement
- Safety



Membrane operated under 5000 pisd

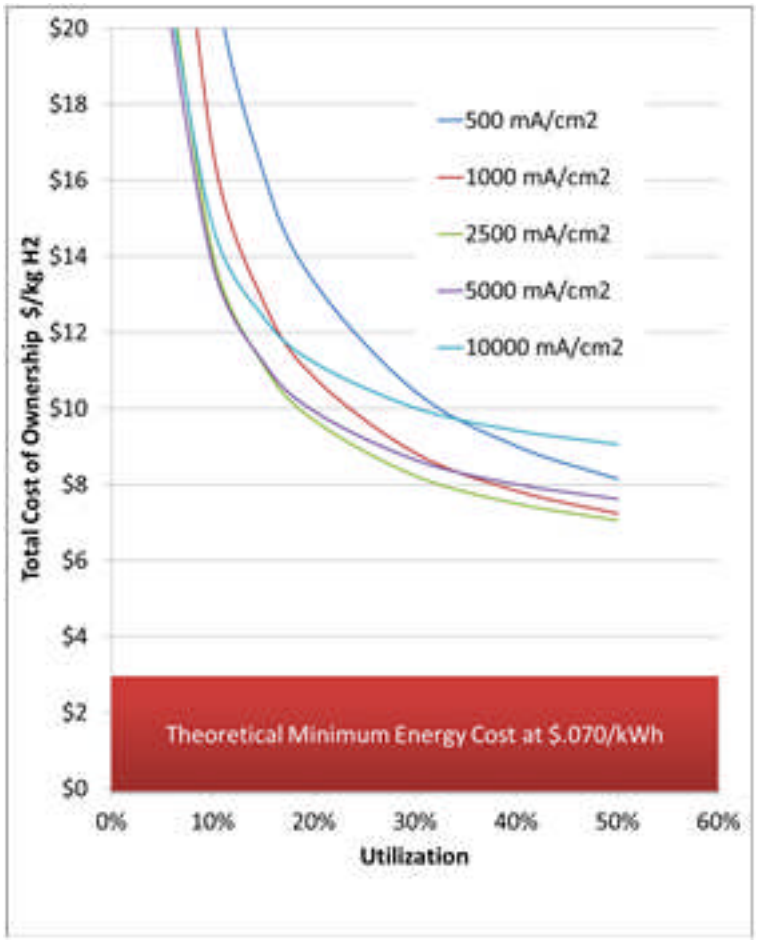
Ir shown to be unstable in NSTF catalysts

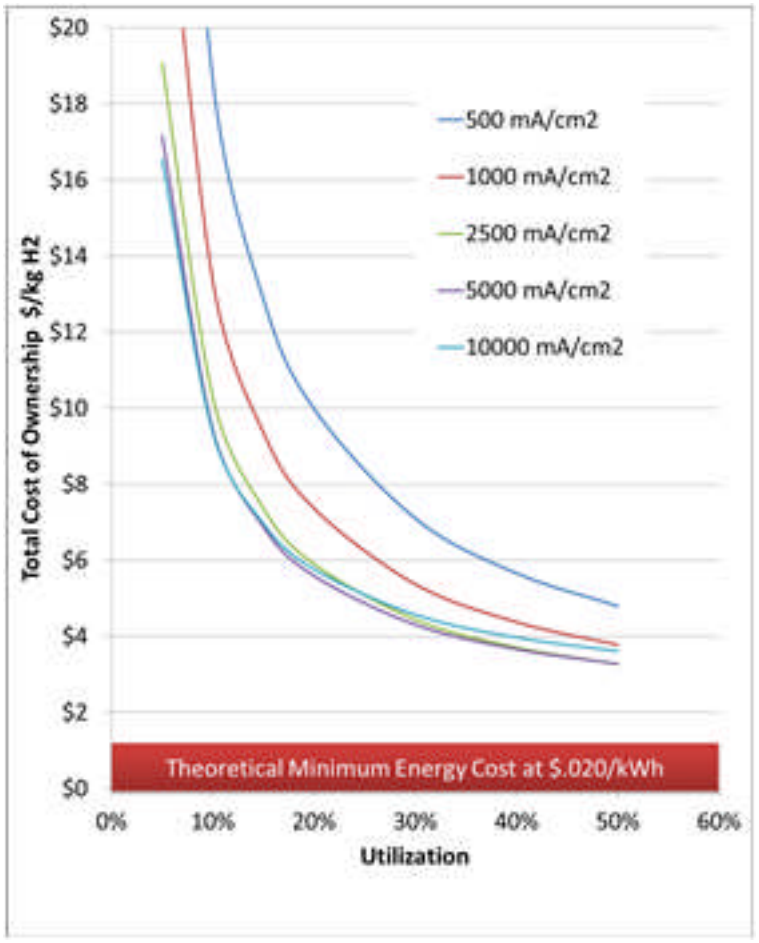


Debe et al. Journal of The Electrochemical Society, 159(6) K165-K176 (2012)

Home Refueling Issues: Cost

0.2 kg/hr System 5000 psi with no further compression





High utilization and energy contracts securing low-cost overnight are essential

Home Refueling: Technical Needs

- Better Membrane
  - PFSA membranes developed for automotive fuel cells are a poor match
  - Permeability is too high
  - Mechanical Properties are too week
  - Low EW not nearly as critical
- Lower catalyst cost
  - Increased Catalyst Activity
  - Higher Temperature
  - More important than in large scale electrolyzers
- Failure Testing
  - Develop methods to reduce, quantify risks
- Accelerated Testing Methods

Home Refueling: Fundamental Questions

In general these things are well qualified for PEM fuel cells, but just touching surface for electrolysis

- How does Temperature effect OER kinetics
  - High activation energy up to 80°C then changes
- Hydrocarbon Membranes
  - Stable in full hydration
  - Better (lower) Permeability?
  - Effect on Electrode Kinetics
- AEMs?
  - Potential of negligible catalyst costs
  - Permeability/conductivity ratio?
- Catalyst Stability Factors
  - Temperature
  - Pressure
  - Voltage Cycling