Systems Analysis Sub-Program Overview

Support a strong foundation of data, build relevant analytical models and execute integrated analysis

Objectives

- Evaluate
  - Technologies and pathways
  - Energy security benefits
  - H2@Scale scenarios and identify needs

- Guide
  - Selection of R&D technology options

- Estimate
  - Potential value of early-stage R&D efforts

- Identify
  - Technology gaps including H2@scale

$ Budget

FY 2018 Appropriation = $3M; FY 2019 Appropriation = $2M

FY 2019 Emphasis:
- Identify gaps and drivers for early stage infrastructure R&D
- Assess early stage R&D impact on energy security
- Integrate analysis to ensure optimization
- Assess targets and metrics for medium and heavy duty trucks
- Conduct H2@scale analysis

Models & Tools

A versatile, comprehensive and multi-functional portfolio:

- Models and Tools
  - Outputs
    - Macroecon. (GDP, Employment)
    - Market Penetration
    - Lifecycle Modeling
  - VISION+, SENA, ANL Jobs
  - MAST, ADOPT, VISION
  - GREET
  - Vehicle Modeling and Simulation
  - Vehicle Technology, Fuel, Infrastructure and Data

Models Description FactSheets Available at: www.energy.gov/eere/fuelsystems/systems-analysis

R&D Innovation

Cumulative H2 and fuel cell patents enabled by FCTO (2018)

- 962 patents enabled by FCTO funds
- 37% of H2 and fuel cell patents

Fuel Cell Vehicle Sales and Station Growth

U.S. Fuel Cell Car Sales Experience Steady Growth

Fuel Cell Cars Sold/Leased in the U.S.

- >6,600 fuel cell cars through March 2019
- In 1 year, Sales increased ~50%

Number of California Retail H2 Stations Increasing

- 40 Retail H2 stations by March 2019

Integration of Advanced On-Board Storage Systems with Hydrogen Delivery

CONTRIBUTIONS TO REFueling COST

- $1.94/kg H2
- $1.23/kg H2 (2016)
- $1.19/kg H2

Low-pressure, near ambient temperature material storage reduce HRS cost

Evaluates impact of onboard hydrogen storage options on refueling cost
- Membrane Hydride (MH) → 100 bar, ambient temperature
- Sorbents → 100 bar, near ambient temperature
- Cryo-sorbents → 100 bar, 94K, and near LiH temperature
- Cryo-compressed Hydrogen → 360 bar, 36K

MH and sorbents near ambient temperature provide the largest potential for refueling cost reduction

Contact reduction ~40%

Most of the cost reduction is attributed to low refueling pressure

Fuel Cell Truck Analysis

<table>
<thead>
<tr>
<th>Scenario Parameters</th>
<th>2016</th>
<th>2025</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCO result in Pacific region.</td>
<td>Lower</td>
<td>Lower</td>
<td>Lower</td>
</tr>
<tr>
<td>FCEV cost driven by fuel ($/gge H2) in this scenario and</td>
<td>$7.6/kg H2</td>
<td>$7.6/kg H2</td>
<td>$7.6/kg H2</td>
</tr>
<tr>
<td>Payload Opportunity Cost</td>
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</tbody>
</table>

H2@Scale Analysis

H2 Cost Target

$16/gge* $13/gge

*Current Low-volume H2 Cost

$7/gge (2016)

< $4/gge (2016)

H2 Cost Target is applied across FCTO

- Target setting
- Subprogram R&D progress gauge

H2@Scale Analysis

Maximum growth potential of hydrogen by 2050 is 16X.

Economic potential for hydrogen is estimated to be 15-50 MMT/yr in 2050

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Collaborations

Collaborations span national and international entities