Hydrogen Financial Analysis Scenario Tool (H2FAST) Updates with Analysis of 101st Station

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DOE Hydrogen and Fuel Cells Program
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This presentation does not contain any proprietary, confidential, or otherwise restricted information.
# Overview

## Timeline

<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>September 2014</td>
</tr>
<tr>
<td>End</td>
<td>September 2017*</td>
</tr>
<tr>
<td>* Annual direction determined by DOE</td>
<td></td>
</tr>
</tbody>
</table>

## Budget

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>DOE Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY16</td>
<td>$100K</td>
</tr>
<tr>
<td>FY17 Planned</td>
<td>$150K</td>
</tr>
<tr>
<td>Total</td>
<td>$250K</td>
</tr>
</tbody>
</table>

## Barriers

4.2 Technical Approach:
- Infrastructure analysis

4.5 A. Future Market Behavior:
- Scenarios to understand vehicle-fuel interactions

4.5 E. Unplanned Studies and Analysis:
- Response to H2USA public-private partnership and infrastructure deployment goals

## Partners

- H2USA Investment and Finance Working Group
- California Energy Commission
- Multiple external and internal subject expert reviewers
- Fuel Pathways and Integration Tech Team (FPITT)
- Independent and in-depth technical review by financial analysis consultant
H2FAST enables detailed infrastructure financial analysis and can interface with multitude of models.

Analysis examines market and financial implications of strategies to support vehicle and infrastructure expansion nationally.

**Analysis Framework**
- Cost estimation
- Scenario development
- Optimization
- Financial analysis
- Data: CaFCP Roadmap trends

**Models & Tools**
- Integrated models
- SERA scenario development capabilities
- H2FAST

**Studies & Analysis**
- Market transformation analysis
- Long-term analysis

**Outputs & Deliverables**
- Recommendations and reports
- Inputs to working groups

Acronyms
- IFWG: H₂USA Investment and Finance Working Group
- CaFCP: California Fuel Cell Partnership
- SERA: Scenario Evaluation and Regionalization Analysis
- H2FAST: Hydrogen Financial Analysis Scenario Tool
- HRSAM: Hydrogen Refueling Station Analysis Model
- LRWG: H₂USA Location Roadmap Working Group
Objectives

- Provide convenient detailed hydrogen infrastructure financial analysis to facilitate investments in hydrogen refueling stations and improve policy-design decisions to support early hydrogen station and fuel cell electric vehicle (FCEV) market development
- Inform multiple stakeholders:
  - Policy and government decision makers
  - Station operators
  - Equity investors
  - Strategic investors
  - Lenders
- Enable transparent incentive analysis
- Provide embedded investment risk analysis

Impacts on FCTO barriers during reporting period

- Enhanced analysis of future hydrogen fueling market behavior (Barrier A)
- Provided timely analytical capabilities to H₂USA partnership and FCTO (Barrier E)
Model framework, inputs, outputs

Model computation framework: Generally Accepted Accounting Principles (GAAP)

- **Income statement** projections (revenues, expenses, taxes)
- **Cash flow statement** projections (cash on hand, capital expenditures, financing transactions)
- **Balance sheet** projections (assets, liabilities, equity)

User inputs

- Capital and Maintenance costs
- Incentives (grants, operating incentives, take or pay contracts)
- Demand profile (e.g., construction time, demand ramp-up)
- Feedstock use (consumption, H2 purchase cost, escalation)
- Retail price of hydrogen
- Financial parameters (e.g. depreciation schedule, interest rates, etc.)

Model outputs

- **Financial performance parameters** (e.g., internal rate of return, pay-back period, break-even price of hydrogen)
- **Time series charts** for all line item parameters
- Per-kilogram **cash flows break-down** (revenues, expenses, financing cash flows)
- Uncertainty distributions (for risk analysis studies)
Model allows for range specification of uncertain variables and computes uncertainty ranges of outputs.

### Overall Financial Performance Metrics

<table>
<thead>
<tr>
<th>Model Feature</th>
<th>Most likely value</th>
<th>5%'ile</th>
<th>95%'ile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leveraged, after-tax, nominal IRR</td>
<td>5.88%</td>
<td>-0.54%</td>
<td>9.50%</td>
</tr>
<tr>
<td>Profitability index</td>
<td>1.35</td>
<td>0.83</td>
<td>1.78</td>
</tr>
<tr>
<td>Investor payback period</td>
<td>10 years</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>First year of positive EBITD analysis</td>
<td>year 2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>After-tax, nominal NPV @ 10% discount</td>
<td>$ (894,655)</td>
<td>$ (2,345,175)</td>
<td>$ (102,307)</td>
</tr>
<tr>
<td>Estimated break-even leveraged price ($/kg)</td>
<td>$ 12.45</td>
<td>$ 10.28</td>
<td>$ 16.42</td>
</tr>
</tbody>
</table>

Break-even leveraged price can be used to yield IRR target.

Model does uncertainty analysis.
Most input values can be varied.
Results reflect uncertainty ranges.
Model allows instant attribution of revenues, expenses and financial cash flows

**Real levelized values ($/kg H\textsubscript{2})**

| Revenue from hydrogen sales | $10.00 |
| Revenue from electricity co-production | $4.44 |
| Inflow of equity | $3.33 |
| Inflow of debt | $1.28 |
| Monetized tax losses | $0.49 |
| Revenue from waste heat sales | $0.20 |
| Cash on hand recovery | $0.04 |

Operating revenues and financing cash inflows are normalized for ease of comparison.

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**Preliminary Example Results**

| Total cash inflows | $19.78 |
| Maintenance expense | $4.79 |
| Dividends paid | $4.21 |
| Equipment cost | $3.14 |
| Cost of natural gas | $1.92 |
| Taxes payable | $1.39 |
| Interest expense | $1.34 |
| Repayment of debt | $0.85 |
| Installation expenditure | $0.70 |
| Road tax | $0.36 |
| Property insurance | $0.27 |
| Credit card fees | $0.25 |
| Sales tax | $0.23 |
| Cost of electricity | $0.17 |
| Cash on hand reserve | $0.06 |
| Selling & administrative | $0.05 |
| Rent | $0.04 |
| Licensing & permitting | $0.01 |

Operating expenses and financing cash outflows are normalized for ease of comparison.

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Model provides instant revenue and expense attribution

DOE-FCTO Webinar on H2FAST was presented and recorded for stakeholders with guidance and examples:
Model was integrated into SERA for national and regional scenario analysis

**Analysis summary**
- Three H₂ infrastructure deployment scenarios
- Contiguous 48 states
- Timeframe: 2015–2050
- Station count and size support urban region H₂ demand growth

**Financial performance drivers**
- Station cost reduction (learning curves)
- Larger stations over time (driven by higher demand per location)
- Faster utilization growth

**Objective of analysis**
- Estimate cross-over point when stations will be financially profitable without incentives

**Approach**
- Model relevant local conditions
- Estimate NPV of every projected station

H2FAST is embedded in SERA
Evaluates financial performance of each projected
Example results: cumulative number of stations built from 2015–2050

<table>
<thead>
<tr>
<th>City</th>
<th>Total Stations</th>
<th>Ave Cap (kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle, WA</td>
<td>248</td>
<td>1,937</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>157</td>
<td>1,896</td>
</tr>
<tr>
<td>Sacramento, CA</td>
<td>138</td>
<td>1,782</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>1,519</td>
<td>1,915</td>
</tr>
<tr>
<td>Denver--Aurora, CO</td>
<td>91</td>
<td>1,853</td>
</tr>
<tr>
<td>Kansas City, MO</td>
<td>27</td>
<td>689</td>
</tr>
<tr>
<td>Minn.-St. Paul, MN</td>
<td>57</td>
<td>1,031</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>366</td>
<td>1,953</td>
</tr>
<tr>
<td>Boston, MA</td>
<td>346</td>
<td>1,880</td>
</tr>
<tr>
<td>New York, NY</td>
<td>1,627</td>
<td>1,959</td>
</tr>
<tr>
<td>Columbus, OH</td>
<td>18</td>
<td>736</td>
</tr>
<tr>
<td>Atlanta, GA</td>
<td>217</td>
<td>1,331</td>
</tr>
</tbody>
</table>

Number HRS: 11,800
Pop. Enabled: 126 M

H2FAST financial analysis was performed for each station

- Capital cost vs. year and size
- Cost of delivered hydrogen
- Price of retail hydrogen
- Cost of energy commodities

Densest markets are populated first
Early markets get most stations and benefit from economies of scale
Example results of Massachusetts station NPV

Observations:

- Poorly performing stations are seen throughout analysis span
- Average station NPV indicates when profits from well performing stations can offset losses of other stations
- Average NPV may be a good indicator of when infrastructure may be self-sustaining
- In this scenario, Massachusetts infrastructure could be self-sustaining after 2033

Annual average new station NPV is used for assessing financial sustainability
Projection of individual states pivot point years

Annual average new station NPV is used for assessing financial sustainability

Preliminary Results

Year = 2049

Ave. NPV < 0, (K$/station)
First year ave. NPV > 0
Model was used for retail stations analysis

Retail station analysis (California, California Energy Commission-funded)
• Yielded real world data and examples of infrastructure deployment

Highlighted lesson learned: Cost of electricity for new hydrogen stations
• California blended electricity rate = 15.73 ¢/kWh*
• California stations experience cost of electricity = 50 ¢/kWh**

California stations experience substantially higher cost of electricity than EIA would suggest

* Source: EIA, Table 2.10 Average Price of Electricity to Ultimate Customer by End-Use Sector, by State, 2015 and 2014
Model was used for retail stations analysis


Rate structure source: First Element Electricity bills, with permission of Tim Brown, COO
Model was used for retail stations analysis


<table>
<thead>
<tr>
<th>Station</th>
<th>Energy capacity factor</th>
<th>Service charges</th>
<th>Demand charges</th>
<th>Energy charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truckee</td>
<td>5% cap. factor</td>
<td>3.5 times CA ave</td>
<td>10.1</td>
<td>36.2</td>
</tr>
<tr>
<td></td>
<td>55.7 ¢/kWh</td>
<td></td>
<td>15.8</td>
<td>9.4</td>
</tr>
<tr>
<td>Campbell</td>
<td>9% cap. factor</td>
<td>3 times CA ave</td>
<td>26.1</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>47.4 ¢/kWh</td>
<td></td>
<td>15.8</td>
<td>5.5</td>
</tr>
<tr>
<td>LaCanada</td>
<td>13% cap. factor</td>
<td>2.8 times CA ave</td>
<td>32.2</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>44.4 ¢/kWh</td>
<td></td>
<td>5.5</td>
<td></td>
</tr>
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</table>

Demand charges most relevant at low station utilization (@10 kWh/kg = ~$5/kg)

Maximum demand charges are incurred even at minimal utilization

Demand charges should be treated as a fixed operating cost

IEA average commercial rate = $15.73 ¢/kWh

Utility bills source: First Element Electricity bills, with permission of Tim Brown, COO
Model development contributors

- H₂USA Investment and Finance Working Group (IFWG) – provided requirements and review
- Bill MacLeod (Hyundai Motor Group) – provided requirements and review
- Sanjeeva Senanayake (Welford Energy) – provided review and methodology guidance
- Mike Curry, MBA (Curry & Co.) – provided requirements and review
- Mike Levy, MBA (Aaquis) – provided requirements
- Remy Garderet (Energy Independence Now) – provided model review

State and federal government

- H₂USA Investment and Finance Working Group (IFWG) – provided requirements and review
- California Energy Commission – provided review and model utilization
- Tyson Eckerle (California Governor’s Office) – provided model review and incentive framework

Federal laboratory and university

- Ricardo Bracho, MBA and Michael Elchinger, MBA (NREL) – compliance with accounting and finance standards
- Jeff Grover, DBA (CEO, Grover Group Inc.) – line-by-line model review and validation
Apply modeling methodology to explore National and regional scenarios
  - H₂USA, CEC, Northeast, Hawaii

Increase model integration with SERA
  - Integrate hydrogen production scenarios
  - Evaluate transitions to renewable hydrogen

Implement additional features
  - Additional fixed operating costs (e.g., demand charges)
  - More detailed demand ramp-up specifications
  - Ability to provide custom feedstock and retail price profiles

Ongoing maintenance and support
  - Support custom analysis and user base requests
  - Produce model updates as needed

Any proposed future work is subject to change based on funding levels
Summary

Relevance
• Examine FCEV markets and financial strategies to support infrastructure expansion nationally
• Provide convenient detailed infrastructure financial analysis to facilitate investments in hydrogen

Approach
• Use GAAP financial calculations with extensive modeling inputs and outputs
• Include detailed risk analysis to project ranges of financial outcomes

Accomplishments
• H2FAST was incorporated into SERA model
• National scenarios show variable transition to un-incentivized financial profitability for different states
• H2FAST was used to evaluate real-world installations
• Early station operation demand charges were found to be big cost factors

Collaboration
• Model and framework leverages stakeholder
  o Department of Energy Fuel Cell Technologies Office, H2USA, California Energy Commission
• Model is thoroughly reviewed by internal and external reviewers

Proposed future work
• H2FAST scenarios will be further refined to reflect more financial factors for National scenarios
• New H2FAST features, such as fixed operating costs reflective of real-world experience
Questions?

Contact:
Michael.Penev@nrel.gov
Technical Back-Up Slides
Recording of DOE-sponsored H2FAST webinar:


H2FAST Excel version URL:

http://www.nrel.gov/hydrogen/h2fast/

H2FAST documentation URL: