Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies

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Catherine Mertes, RCF
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## Overview

### Timeline

<table>
<thead>
<tr>
<th>Start date:</th>
<th>FY13</th>
</tr>
</thead>
<tbody>
<tr>
<td>End date:</td>
<td>Ongoing project</td>
</tr>
</tbody>
</table>

### Budget

- FY14 DOE Funds: $150k
- FY15 Planned DOE Funds: $200k
  - Including partners

### Barriers

- Future Market Behavior (A)
- Stove-piped/Siloed Analytical Capability (B)
- Inconsistent Data, Assumptions and Guidelines (C)
- Insufficient Suite of Models and Tools (D)

### Funded partners/collaborators

- Argonne National Laboratory
- RCF Economic & Financial Consulting
- Northwestern University
Relevance

Model development

- Develop **consistent framework** to estimate impact of hydrogen (H$_2$) infrastructure investments by FCTO and others
- Develop tool to **address barriers/gaps** in FCTO analysis/modeling portfolio

Analysis

- Evaluate impacts of alternative H$_2$ and fuel cell (FC) infrastructure deployment scenarios
- Provide input for evaluating R&D and deployment targets of FCTO program

Stakeholder support

- Work with stakeholders to develop robust, user-friendly tools with appropriate functionality
- Report analytical results to demonstrate benefits of FCTO program
**Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies**

**Analysis Framework**
- H2A design parameters
- HDSAM/HRSAM parameters
- NREL CDPs
- OEM capital & O&M costs
- Stakeholder experience/data

**Models & Tools**
- H2A
- HDSAM/HRSAM
- RIMS (Regional I-O Modeling System)

**National Labs**
- ANL – HRSAM
- NREL/SNL – H2FIRST

**Stakeholder Analyses** (CAFCP, CCAT, Industry)

**Studies & Analyses**
- Employment Impacts of CAFCP H₂ Roadmap
- U of C Business Case analysis
- Employment Impacts of ARRA FC Deployments

**Outputs & Deliverables**
- JOBS FC 1.1
- JOBS H₂ 1.0
- Uncertainty analysis
- CAFCP rollout report
- EERE Webinars
- Stakeholder webinars

**Approach**
JOBS H$_2$ uses input-output approach

- Input-output methodology converts dollars spent into economic impacts using relationships from USDOC/BEA Regional Input-output Modeling System (RIMS)
- Default or user-input expenditure estimates
  - Reported values
  - Vendor quotes
  - Stakeholder inputs
- User-defined scenarios (e.g., planned rollouts)
- Capture supply chains & induced effects
JOBS $H_2$ models expenditures for many supply chains

As well as ripple or induced effects

Station equipment supply chain

Station planning supply chain

Construction supply chain

Hydrogen supply chain

Output

Earnings

Station O&M supply chain

Approach
**FY 2015 milestones**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Status</th>
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<tbody>
<tr>
<td>Analysis: CAFCP roadmap scenario</td>
<td>✔️</td>
</tr>
<tr>
<td>Modeling: Uncertainty analysis*</td>
<td>✔️</td>
</tr>
<tr>
<td>Modeling: JOBS H2 1.1</td>
<td>9/30/15</td>
</tr>
<tr>
<td>Analysis: Alternative rollout scenario</td>
<td>9/30/15</td>
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*JOBS H2
JOBS $H_2$ estimated impact of CAFCP’s station roadmap

- Modeled development of 100 $H_2$ stations for a specific launch trajectory
- Varied size and utilization of new stations over time
- Modeled operations of new stations over time
- Included operations (but not development) of existing stations
In CA roadmap analysis station development jobs start almost immediately. Operations jobs grow over time.

### Station Development

- **Supply Chain**: [Graph showing job count from 2015 to 2022]
- **Induced**: [Graph showing job count from 2015 to 2022]

Station development is associated with 100–330 jobs/year in CA through 2022.

### Station Operations

Station operation is associated with >1,100 CA jobs at full operation.
Timing & magnitude of impacts on CA earnings and economic output are similar to employment impact

- Total earnings and output modulate peaks in station development
- Earnings peak at $60 million in 2022 then level off
- Economic output peaks at $230 million in 2022 then levels off
- Stations have greatest impact in launch year as development expenses translate into earnings and output, then drop to steady operational level.

Accomplishments

<table>
<thead>
<tr>
<th>Total Earnings</th>
<th>Total Economic Output</th>
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<tbody>
<tr>
<td>2014 $</td>
<td></td>
</tr>
<tr>
<td>$70,000,000</td>
<td>$250,000,000</td>
</tr>
<tr>
<td>$60,000,000</td>
<td>$200,000,000</td>
</tr>
<tr>
<td>$50,000,000</td>
<td>$150,000,000</td>
</tr>
<tr>
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<tr>
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<td>$50,000,000</td>
</tr>
<tr>
<td>$20,000,000</td>
<td>$0</td>
</tr>
<tr>
<td>$10,000,000</td>
<td>$0</td>
</tr>
<tr>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

Stations in operation 2015
Stations developed in 2015
Stations developed in 2016
Stations developed in 2017
Stations developed in 2018
Stations developed in 2019
Stations developed in 2020
Stations developed in 2021
Stations developed in 2022
Stations developed in 2023
Stations developed in 2024
Stochastic simulation feature added to JOBS $H_2$

Variables simulated:
- Development expenses
- Equipment expenses
- Operational expenses

Probability distribution functions specified

Most probable value assumed to be default value (or user input)

Distribution ranges based on engineering estimates
Two cases demonstrate capabilities and impacts of stochastic module

- Cases based on (not identical to) CAFCP H₂ Roadmap
  - Similar number of new stations (98 vs. 100) deployed
  - Same hydrogen throughput (~36,700 kg/day)
  - Uniform capacity rather than variable capacity stations
  - Constant launch rate (14 stations/year) rather than variable rate
  - Defaults for development and operating costs and local shares rather than Roadmap proposals

- Cases illustrative, not a comprehensive analysis
  - CA case uses CA multipliers & default local shares (i.e., benefits in CA)
  - USA case uses US multipliers & default shares (i.e., benefits in USA)
  - Much higher local shares in US case

- Results differ from CAFCP Roadmap results shown earlier
Accomplishments

USA case has ~2x employment impact of CA case

- Total benefits in both cases accrue throughout period.
- Development benefits begin in year 1 and continue through construction of last stations.
- Operations benefits begin 2 years after initial development and continue through period.
- P10 and P90 results spread relatively evenly around most probable. Most parameter distributions assumed symmetric within range.
Impact on economic output has similar pattern

- Impacts decline in final year in US case because operations jobs added are less than development jobs lost
- Impacts do not decline in final year in CA case because fewer development jobs are in state
QR cards & websites direct users to JOBS models

JOBS Quick Response (QR) Card

Available at
www.afdc.energy.gov/tools
http://jobsmodels.es.anl.gov/main

US DOE/Clean Cities’ Alternative Fuels Data Center tools/calculators page (http://www.afdc.energy.gov/tools)
Collaborators provide key advice/expertise

JOBS H₂ Advisory Group
- California Air Resources Board (CARB)
- California Fuel Cell Partnership (CAFCP)
- Connecticut Center for Advanced Technology (CCAT)
- Fuel and vehicle suppliers
- Researchers

Assistance/role
- Defaults (data/analyses)
- Functionality/granularity
- Future directions/needs
- Beta testing
- Validation

<table>
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<th>Collaborator</th>
<th>FY 2015 Role</th>
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<tr>
<td>Argonne</td>
<td>Management and coordination; engineering data collection and analysis; quality assurance; outreach; stochastic modeling; documentation</td>
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<tr>
<td>RCF</td>
<td>Economic data collection and analysis; quality assurance; code development and application; documentation</td>
</tr>
<tr>
<td>Northwestern U.</td>
<td>Application and upgrading source code; stochastic modeling, quality assurance</td>
</tr>
<tr>
<td>Advisory group</td>
<td>Data/resource acquisition; document review; beta testing</td>
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Select enhancements & analyses planned in FY15-16

Planned model expansions/analyses:
- LH₂, 400+ kg/d
- JOBS FC uncertainty analysis
- Alternative rollout scenarios

Future possibilities (not funded)
- Annual impacts of FC deployments
- Mobile fuelers
- Distributed H₂ production
- Employment detail (skills, industries)
- FC applications in vehicles
Summary

- **Relevance:** Consistent platform to analyze employment and other economic impacts of H₂ and FC investments. Fill gap/barrier in analysis portfolio. Assist DOE and stakeholders with analyses of economic effects of deploying H₂ infrastructure in early markets.

- **Approach:** Input-output modeling in context of user-friendly tools to calculate supply chain and induced employment, earnings and economic output.

- **Collaborations:** Active partnership between ANL & RCF with FY15 assistance from Northwestern University. Extensive stakeholder interaction.

- **Accomplishments and progress:**
  - JOBS H₂ 1.0 launched June 2014 in conjunction with EERE webinar
  - Evaluated impact of CAFCP’s proposed H₂ station rollout
  - Added stochastic module to permit uncertainty analysis in JOBS H₂
  - Tech transfer via AFDC and QR cards ([http://JOBSmodels.es.anl.gov](http://JOBSmodels.es.anl.gov))

- **Future work:**
  - Expand JOBS H₂ to include LH₂ and larger stations
  - Add stochastic module to JOBS FC
  - Analyze additional station rollout scenarios and alternative station options
  - Continue validating and refining defaults and improving model functionality