



Hydrogen Infrastructure Market Readiness Analysis



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**National Renewable
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Peer Evaluation Meeting**

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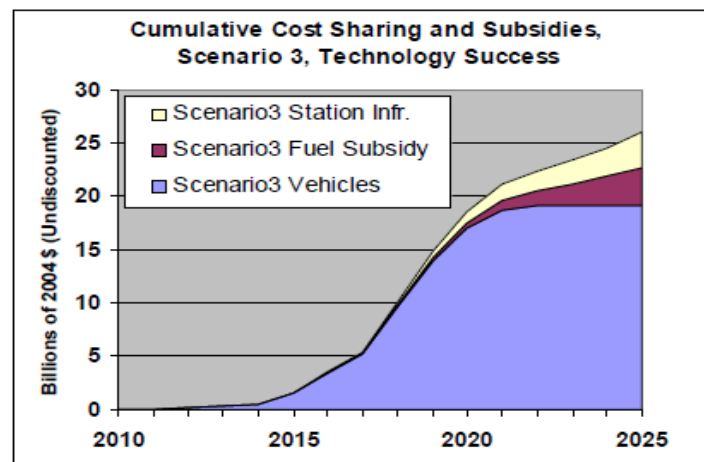
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Project Overview

Timeline	Barriers
<p>Start: October 2010 Finish: August 2010</p> <ul style="list-style-type: none">• Complete: 40%	<ul style="list-style-type: none">• Future Market Behavior [4.5.A]• Inconsistent Data, Assumptions, and Guidelines [4.5.C]• Unplanned Studies and Analysis [4.5.E]
Budget	Partners
<p>Total Funding: \$150K</p> <ul style="list-style-type: none">• 100% DOE-funded• FY10 funding: \$50K• FY11 funding: \$100K	<ul style="list-style-type: none">• Energetics• IDC Energy Insights• DRG, Inc.• California Fuel Cell Partnership• General Motors• Plug Power• Nuvera Fuel Cells

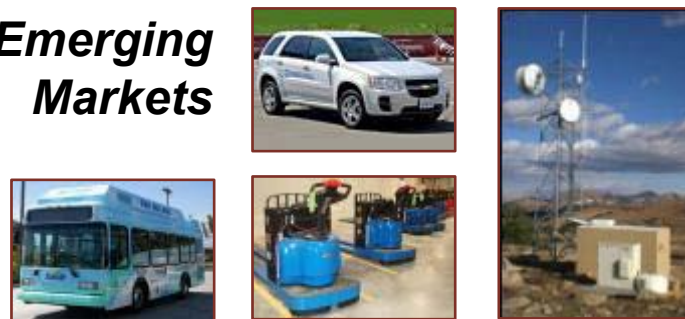
Relevance: Early Infrastructure Costs Are Uncertain and Changing Rapidly

- Past transition studies have used costs for near-term infrastructure components
- Given the rapid change in technological progress, and the demand generated by emerging markets such as material handling and telecom, near-term cost models must be updated
- Updated cost and performance data can contribute to a more accurate understanding of near-term hydrogen infrastructure development challenges



Cumulative government fuel costs are ~\$8B by 2025 (Greene and Leiby 2007)

Emerging Markets

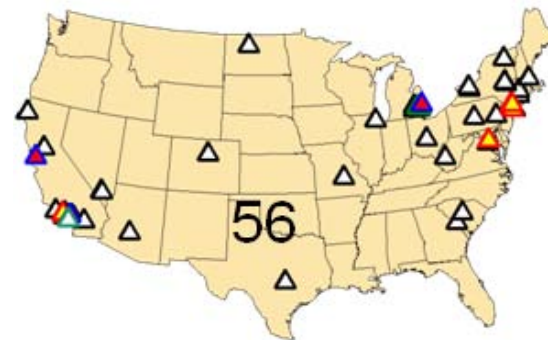


Emerging markets have resulted in improved hydrogen infrastructure technologies, perhaps with lower costs

Relevance: Project Objective Is Identification and Quantification of Cost Reduction Opportunities

- The objective of this project is to identify and collect feedback from key stakeholders on the following:
 - Cost reduction opportunities from economies of scale (e.g., station standardization, number and size of installations) and learning-by-doing resulting from growth in material handling equipment (MHE), backup power, transit bus, and light-duty vehicle markets.
 - Cost reduction opportunities from focused R&D areas and priorities.
 - Specific examples through which early markets, such as MHE, backup power, and transit buses, can provide increased demand and reduce hydrogen infrastructure costs.

Today's 56 hydrogen stations for LDVs represent only a fraction of the hydrogen infrastructure serving early markets (figure from Wipke 2011, AMR tv001)



Key stakeholders are those who have been directly involved in the planning, funding, and installation of hydrogen stations

Relevance: Impact on Barriers

<i>Barrier</i>	<i>Impact</i>
Future Market Behavior [4.5.A]	<ul style="list-style-type: none">• The study will improve our understanding of the technologies to be deployed in near-term markets, as well as dynamics between suppliers, system integrators and multiple hydrogen end users
Inconsistent Data, Assumptions, and Guidelines [4.5.C]	<ul style="list-style-type: none">• The feedback from stakeholders, on costs and others issues, is being collected in a consistent manner with input from multiple stakeholder types
Unplanned Studies and Analysis [4.5.E]	<ul style="list-style-type: none">• This study is responding to technological changes due to recent market dynamics, in an attempt to analyze opportunities for cost reductions

Approach: Project Plan (3 Parts)

1 Stakeholder Market Readiness Workshop

- A 1.5-day invitation-only expert workshop held in conjunction with FCHEA 2011 (Fuel Cell and Hydrogen Energy Association)
- Planned workshop with input from planning team, including members from the *U.S. Department of Energy, California Fuel Cell Partnership (CaFCP), General Motors, Plug Power, Nuvera, Energetics*
- Focus on key questions addressing cost reduction opportunities
- 3 breakout groups, facilitated by *Energetics*

2 Early Station Cost Calculator

- Circulated to key stakeholders for review
- Responses compiled anonymously
- Managed by *IDC Energy Insights* and the *Dieringer Research Group (DRG, Inc.)*

3 Coordination With Related Activities

- CaFCP Roadmap and Working Group



- ✓ Energetics
- ✓ IDC Energy Insights
- ✓ DRG, Inc.
- ✓ Nuvera
- ✓ California Fuel Cell Partnership
- ✓ General Motors
- ✓ Plug Power

Approach: Milestones and Timeline

One AOP milestone specific to the project

<i>Milestone</i>	<i>Date</i>	<i>Status</i>
Complete Market Readiness Report (2.1.3)	July 2011	On track

Summary of timeline for completion

- Complete planning for workshop Feb 2011
- Conduct workshop Feb 2011
- Distribute final cost calculator April 2011
- Compile and report calculator results June 2011
- Complete draft report July 2011

Approach: Market Readiness Workshop

Multiple stakeholder types

- Industrial gas companies
- Government agencies
- Energy companies
- Automotive companies
- Analysts and researchers

Presentations

- Panel #1: Early Market End User Experiences
- Panel #2: Outlook for Infrastructure Cost Reductions

Key Questions posed in breakout groups:

1. What are the biggest opportunities to reduce the costs of hydrogen fueling stations over the next 2-5 years?
2. What can we DO to achieve the high-priority cost reduction opportunities?
3. Who needs to do what when? What kind of help is needed? Is information sharing or coordination needed?

WORKSHOP AGENDA

Day 1

Panel #1 (1.5 hrs)

Panel #2 (1.5 hrs)



Day 2

Presentations (2 hrs)

Breakout Group #1 (2 hrs)

Breakout Group #2 (2 hrs)

Report back & discussion (1.5 hrs)

Approach: Early Station Cost Calculator

Four hydrogen station cost types

1. State-of-the-art
2. Early commercial
3. More stations
4. Larger stations

Inquires about timing, volume, and detailed cost breakdown

- Can complete calculator with various levels of detail

Direct feedback on \$/kg

- Calculator uses inputs to generate \$/kg results for each station type
- Calculations are based upon H2A discounted cash flow

Distributed anonymously

- IDC and DRG distribute the calculator and compile aggregate, anonymous results

The image displays a complex spreadsheet interface for the 'Early Station Cost Calculator'. It is organized into several vertical sections, each containing a table with columns for 'Station Type', 'Volume', 'Timing', and 'Cost Breakdown'. The tables are filled with numerical data, and some cells are highlighted in yellow. The interface includes various input fields, dropdown menus, and a summary section at the bottom right. The overall layout is professional and data-intensive, typical of a financial modeling tool.

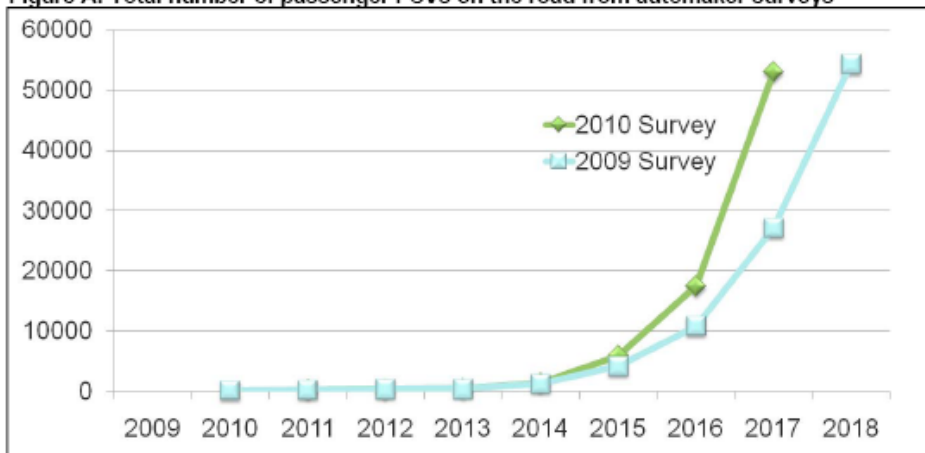
Cost Calculator

Approach: Coordination with Related Activities

Contribute to and learn from update to CaFCP Roadmap Document

- Detailed planning of cluster rollout strategy and matching of station installations to vehicle deployments
- Station-by-station cost analysis, and determination of cash flows based upon revenue from fuel sales
- Sharing of data and analysis with Working Group

Figure A: Total number of passenger FCVs on the road from automaker surveys



Open and Planned Hydrogen Stations in California				
Status		Station	LDV Capacity kg/day	Pressure (H35/H70)
Open		Irvine #1	25	35/70
		Thousand Palms	60	35
		Riverside	12	35
		West Los Angeles #1	30	35
Planned		Burbank	60	35/70
		Los Angeles	60	35/70
		Emeryville	60	35/70
		Fountain Valley	100	35/70
		Harbor City	100	35/70
		Newport Beach	100	35/70
		Torrance	50	35/70
		Westwood	140	35/70
		Oakland (transit only)	0	35
		Santa Monica	100	35/70
		Beverly Hills	100	35/70
		West Los Angeles #2	100	35/70
		Hermosa Beach	100	35/70
		Irvine #2	100	35/70
		Hawthorne	100	35/70
		San Francisco	120	35/70
		Laguna Niguel	100	35/70
		West Sacramento	100	35/70
	Diamond Bar	100	35/70	

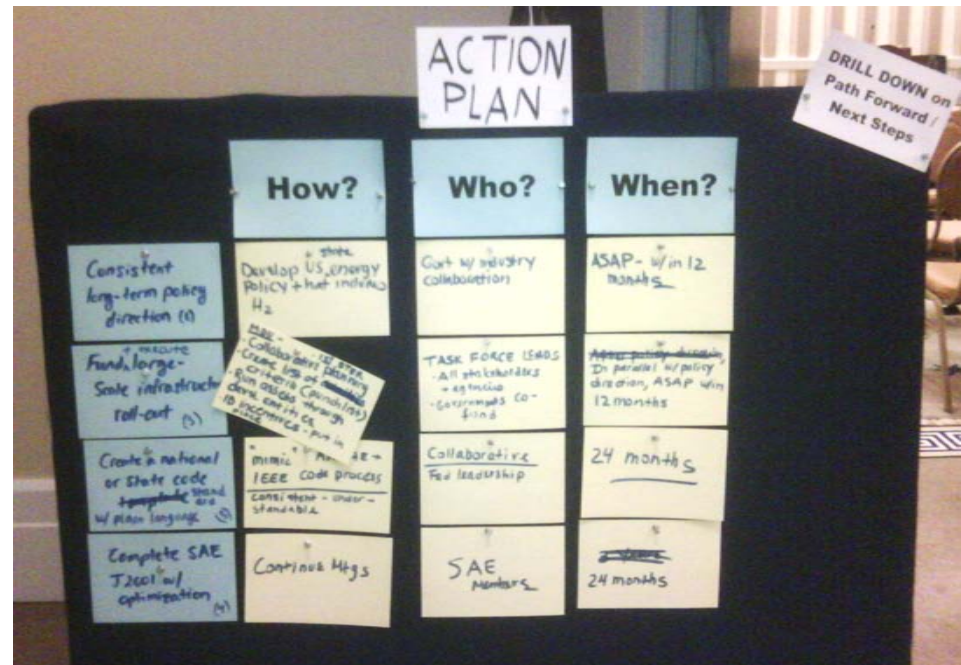
The updated Roadmap will match new stations to expected vehicle deployments (<http://www.fuelcellpartnership.org>)

Feedback from California-specific activities will contribute to improved cost reduction estimates and rollout analysis

Technical Accomplishments: Feedback on Priority Opportunities to Reduce Costs

Categories of Feedback Collected

- System Station Costs (Design, Performance Requirements)
- Component Level Costs
- Reduce dispensing costs
- Economies of Scale and Learning-by-Doing
- Collaborative Actions
- Technology R&D
- Action Plan to reduce costs



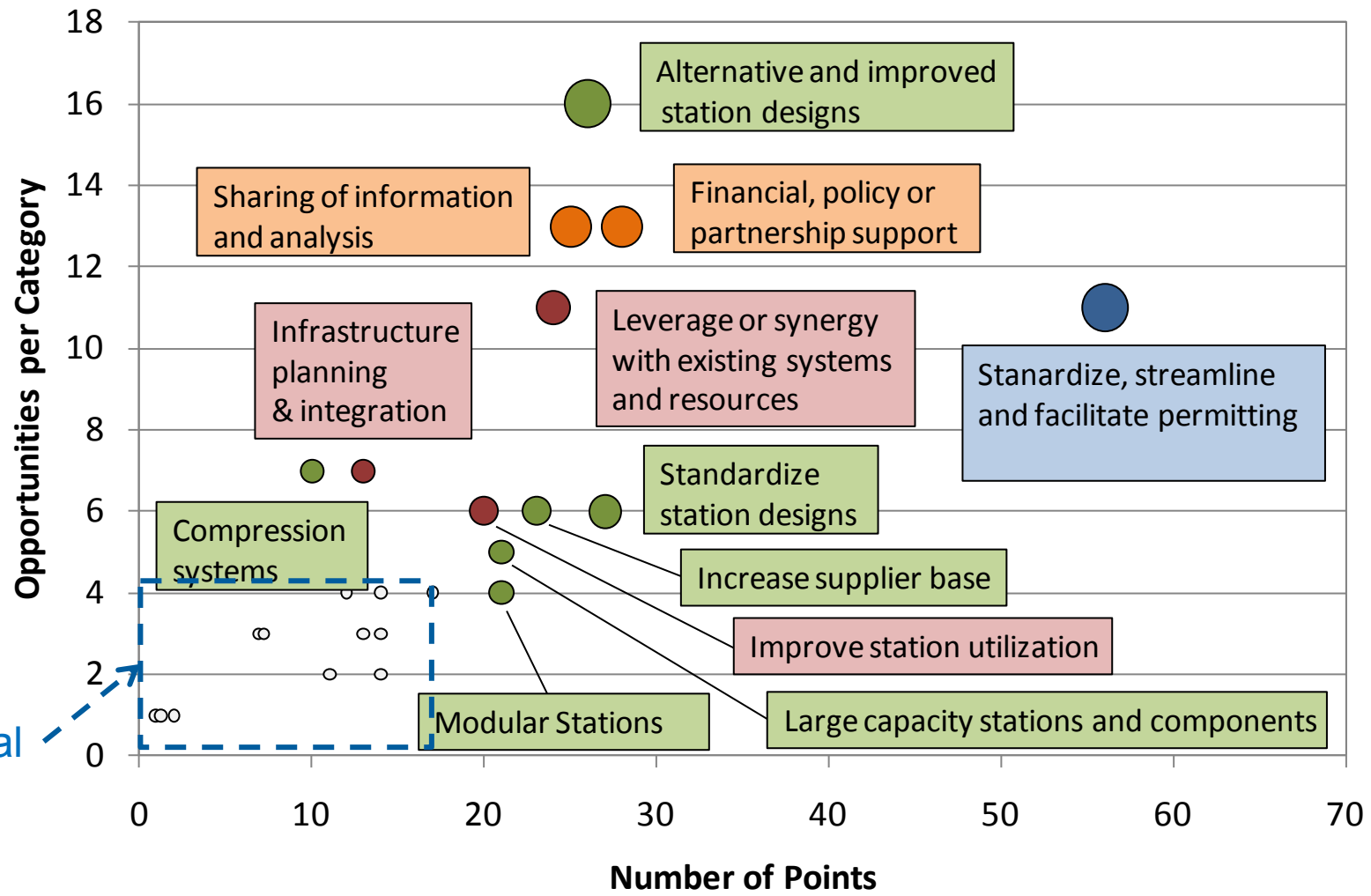
Feedback included ~200 comments on cost reduction opportunities (see supplemental slides)



Technical Accomplishments: Characterization of Cost Reduction Opportunity Priorities

Preliminary Draft Results

Shown in Supplemental Slides



Preliminary priorities appear to be: **1) station designs**, **2) Streamlining of the permitting process**, and **3) systems planning and analysis**.

Accomplishment: Beta Version of Cost Calculator Reviewed, Final Version Administered by Third Parties

- **A beta version of the Hydrogen Station Cost Calculator was circulated for review**
 - Feedback on improvements were compiled anonymously by IDC Energy Insights
 - Comments to improve the Cost Calculator were assessed and used to refine a final version
- **Distribution of the final version is being administered by independent third parties, IDC Energy Insights and DRG, Inc.**
 - Respondents have 4-6 weeks to provide calculator results
 - Component suppliers receive a distinct revised version
- **Aggregate results will be compiled and vetted for inclusion in the final project report**
 - Data collected will be delivered to NREL without association
 - Draft report anticipated by June 2011

Aggregate data on cost reduction opportunities will be used as a reference for updated infrastructure cost models

Collaborations and Future Work

Collaborations

- NREL staff will coordinate with the California Fuel Cell Partnership's Working Group on an updated California Roadmap Document
- Sharing of data, benefits of rollout strategies
- Workshop planning committee will continue to be consulted on improving our understanding of cost reduction opportunities through stakeholder outreach activities



Future Work

- Summary report will be circulated to workshop participants for review
- Will work with ORNL researchers to estimate the implications of cost reductions on market adoption dynamics
- Aggregate IDC Energy Insights results will feed into future U.S. rollout scenario cost analyses

- ✓ IDC Energy Insights
- ✓ DRG Inc.
- ✓ California Fuel Cell Partnership

Summary

Relevance

- ✓ Early infrastructure costs are uncertain and changing rapidly
- ✓ Project objective is identification and quantification of cost reduction opportunities

Approach

- ✓ Market Readiness Workshop
- ✓ Station Cost Calculator
- ✓ Collaboration with ongoing efforts

Accomplishments

- ✓ Collected feedback on cost reduction opportunities through the Market Readiness Workshop
- ✓ Reviewed beta version of cost calculator
- ✓ Distributed cost calculator to collect anonymous input

Collaborations

- ✓ Contribute to and learn from CaFCP Roadmap update
- ✓ Continue interactions with planning committee

Proposed Future Work

- ✓ Summary report will present findings
- ✓ Opportunities will contribute to future scenario analysis