

# IPHE Infrastructure Workshop

## Workshop Proceedings



**February 25-26, 2010  
Sacramento, California**

## Acknowledgements

---

The International Partnership for Hydrogen and Fuel Cells in the Economy would like to thank the workshop steering group members for their efforts to plan and scope the workshop: Catherine Dunwoody and Chris White (CaFCP), John Garbak and Fred Joseck (DOE), Klaus Bonhoff and Steffi Rode (NOW-Germany), and Marc Melaina (NREL). IPHE would also like to thank NREL for their help in producing the hypothetical business case scenarios (especially Marc Melaina and Darlene Steward, with help from Mike Penev and Angela Costanzo). Energetics Incorporated provided assistance in planning and conducting the workshop, including the breakout group facilitation. Breakout group facilitators included Matt Antes, Jan Brinch, Shawna McQueen, and Richard Scheer. Kristen Deason, Stacey Young, and Elvin Yuzugullu (SENTECH, Incorporated) also provided valuable support for workshop planning and logistics. The workshop proceedings were prepared by Samantha Jacoby and Shawna McQueen of Energetics. Finally, very special thanks are extended to the workshop presenters and participants, who gave their time and knowledge to inform and enliven the workshop discussion.

Cover photo: Shell fueling station at a busy intersection in West Los Angeles, California includes both gasoline and hydrogen dispensers. Compressed hydrogen is produced onsite via renewable energy-powered electrolysis, and all hydrogen production and storage equipment is mounted on the roof of the station canopy to minimize the footprint.

## Contents

Executive Summary.....	i
Introduction .....	1
Workshop Purpose and Format.....	2
Purpose .....	2
Workshop Format .....	4
Discussion Summary .....	5
Plenary Presentations .....	5
United States.....	5
Germany .....	5
Japan .....	6
South Korea.....	6
Business Case Scenarios and Summary of Focus Group Results .....	6
Breakout Discussion Sessions .....	7
Starter Station Business Model.....	7
Policies and Incentives.....	7
Information/Education Campaigns and Training.....	8
Other Risk Reducing Strategies.....	8
Ways to Boost Hydrogen Demand.....	9
Novel Business Models .....	10
Conclusion.....	11
Appendix A – Agenda .....	A-1
Appendix B – List of Participating Organizations .....	B-1
Appendix C – Online Focus Group with Large Fuel Retailers.....	C-1
Appendix D – Business Case Scenarios .....	D-1
Appendix E – Detailed Outputs from Breakout Groups.....	E-1

## Tables and Figures

Table 1. Summary of Breakout Group Discussion Results .....	ii
Figure 1. Fuel Retailer Focus Group: Summary of Results .....	3

# IPHE INFRASTRUCTURE WORKSHOP

## Executive Summary

Assuring adequate fueling infrastructure for customers is one of the biggest barriers to hydrogen fuel cell vehicle commercialization. Fuel retailers lack the financial incentive to build new hydrogen stations, because demand is likely to remain too low in the near-term to achieve an adequate return on investment. Consumers, however, need reassurance that convenient fueling infrastructure will be available, or they will not purchase fuel cell vehicles.

Automakers worldwide are honing in on a 2015 date to begin commercialization of fuel cell vehicles in targeted markets. Key early markets include Germany, California (particularly Southern California and the San Francisco Bay area), Japan, and Korea. To be successful, the commercial launch of fuel cell vehicles must be synchronized with the availability of enough retail-ready hydrogen fueling stations to satisfy customer needs in these areas. Because there are few retail-ready stations now, a large number of stations must be built in the next five to ten years.

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) has recognized the importance of this challenge and has taken on "accelerating the market penetration and early adoption of hydrogen and fuel cell technologies and their supporting infrastructure" as a strategic priority. The February 25-26, 2010,



At Chevron's hydrogen station in Chino, California, hydrogen is produced onsite via natural gas reforming.

IPHE Infrastructure Workshop was held in Sacramento, California to explore the market implementation needs for hydrogen fueling station development. This interactive workshop was coordinated by IPHE, the U.S. Department of Energy (DOE), and the California Fuel Cell Partnership (CaFCP) to engage stakeholders in developing creative and practical solutions for establishing hydrogen infrastructure in the near-term. More than 80 professionals representing a wide variety of stakeholders and expertise participated.

The workshop discussion sessions were informed by the results of a Fuel Retailer Focus Group, organized and conducted in late January 2010 by the CaFCP, DOE and the National Renewable Energy Laboratory (NREL). The on-line focus group included some of the largest fuel retailers in the United States and Europe, who answered questions about the fuel business in general, alternative fuels, and some hypothetical hydrogen business cases developed by NREL. Though many of the fuel retailers who participated in the focus group knew little about hydrogen, they were interested in learning more, and most were open to the idea of selling hydrogen if the capital cost and station size can be reduced.

The workshop itself included both plenary presentations and breakout sessions, in which attendees had the opportunity to work in small groups to brainstorm and develop new ideas. The majority of the time was devoted to workshop discussion, and the results of these discussions are summarized in Table 1 on the next page. Workshop participants agreed that actions taken in the next five years will be essential for the hydrogen and fuel cell industry, both in the United States and around the world. The dialogue that was started at this workshop must be continued, and additional stakeholders engaged, to build on and carry out these ideas so that FCVs can become a viable clean-transportation choice for consumers.

# IPHE INFRASTRUCTURE WORKSHOP

**Table 1. Summary of Breakout Group Discussion Results**

Idea	Outcome	Responsible Parties	Next Steps
<b>Develop low-cost, 100 kg/day starter-station model</b>	<ul style="list-style-type: none"> <li>• Faster construction and siting</li> <li>• Lower capital cost</li> <li>• Minimize impact on business and provide operating experience</li> <li>• Increase mobility, flexibility, and replicability of stations</li> <li>• Easier to coordinate rollout</li> </ul>	<ul style="list-style-type: none"> <li>• CaFCP and local governments</li> <li>• DOE and NREL</li> <li>• Advocacy groups</li> <li>• Station component manufacturers</li> <li>• H<sub>2</sub> fuel providers</li> </ul>	<ul style="list-style-type: none"> <li>• Develop or solicit ideas for starter-station designs</li> <li>• Get feedback from retailers on their particular needs</li> <li>• Build demonstration stations</li> </ul>
<b>Encourage supportive policies, including tax incentives, subsidies, gas/carbon tax, low-cost financing, and regulations</b>	<ul style="list-style-type: none"> <li>• Lower cost of hydrogen</li> <li>• Shorter time for return on investment</li> <li>• Lower risk for station owner</li> <li>• Increase number of stations in early years</li> <li>• More rapid transition to hydrogen</li> </ul>	<ul style="list-style-type: none"> <li>• Federal, state, and local governments</li> <li>• Industry advocates</li> <li>• Trade associations</li> <li>• Academics and policy analysts</li> </ul>	<ul style="list-style-type: none"> <li>• Continue to engage policymakers</li> <li>• Present compelling case for hydrogen to persuade policymakers</li> <li>• Engage in rigorous policy analysis</li> </ul>
<b>Launch information and education campaigns for legislators and the public</b>	<ul style="list-style-type: none"> <li>• Increase public and political support for hydrogen and fuel cells</li> <li>• More rational decision-making by consumers and politicians</li> </ul>	<ul style="list-style-type: none"> <li>• CaFCP, National Hydrogen Assoc., US Fuel Cell Council</li> <li>• Governments at all levels</li> <li>• High-profile industry advocates</li> </ul>	<ul style="list-style-type: none"> <li>• Build website with unbiased comparison of fuels</li> <li>• Develop and launch community engagement campaign</li> </ul>
<b>Implement risk reducing strategies, such as public-private partnerships, insurance pool, cost-share, automaker commitments</b>	<ul style="list-style-type: none"> <li>• Reduce risk for station owners</li> <li>• Improve confidence in vehicle deployment</li> <li>• Reduce costs of insurance for station owners</li> <li>• Prove business case</li> </ul>	<ul style="list-style-type: none"> <li>• Industry: infrastructure providers, automakers, fuel retailers</li> <li>• Government</li> <li>• CaFCP</li> </ul>	<ul style="list-style-type: none"> <li>• Identify infrastructure providers willing to operate stations in California</li> <li>• Negotiate terms and conditions of partnerships or risk pools</li> </ul>
<b>Explore innovative ways to boost H<sub>2</sub> demand, such as target fleets and other fuel cell applications, leverage natural gas industry, increase competition</b>	<ul style="list-style-type: none"> <li>• Higher demand, higher H<sub>2</sub> sales</li> <li>• More favorable investment environment</li> <li>• Faster transition to profitability</li> </ul>	<ul style="list-style-type: none"> <li>• Local governments</li> <li>• CaFCP</li> <li>• H<sub>2</sub> fuel providers</li> <li>• Trade associations</li> <li>• Auto companies</li> <li>• Energy companies</li> </ul>	<ul style="list-style-type: none"> <li>• Energy and auto companies seek procurement commitments</li> <li>• Engage “big box stores,” natural gas companies, and highly visible industry partners</li> </ul>
<b>Promote novel business models that utilize new methods of financing, leverage existing H<sub>2</sub> industry, etc.</b>	<ul style="list-style-type: none"> <li>• Improve hydrogen business case</li> <li>• Attract private capital</li> <li>• Increase visibility of hydrogen</li> <li>• Recruit new players to the industry</li> </ul>	<ul style="list-style-type: none"> <li>• H<sub>2</sub> fuel providers</li> <li>• DOE, California Energy Commission, and other state energy commissions</li> <li>• Trade associations and hydrogen advocates</li> </ul>	<ul style="list-style-type: none"> <li>• Approach potential investors with sound business case and economic analysis</li> <li>• Find celebrity advocates</li> <li>• Identify existing H<sub>2</sub> infrastructure that can be easily expanded</li> </ul>

## Introduction

In 2009 leading automakers took a major step towards commercialization of fuel cell vehicles. On September 8, 2009, seven automakers—Daimler AG, Ford Motor Company, General Motors Corporation/Opel, Honda Motor Co., Ltd., Hyundai Motor Company/Kia Motors Corporation, the alliance Renault SA/Nissan Motor Corporation, and Toyota Motor Corporation—issued a Letter of Understanding (LoU) on the development and market introduction of fuel cell vehicles. The automakers recognized that, worldwide, vehicle ownership will continue to grow, along with the need for low- and zero-emission vehicles. These companies are now designing or building next-generation fuel cell vehicles that they feel confident will be able to meet customer demands for performance, durability, comfort, and utility. The LoU signatories “strongly anticipate that from 2015 onwards a quite significant number of fuel cell vehicles could be commercialized” with as many as “a few hundred thousand units” worldwide over the initial products’ life cycle.<sup>1</sup>

The catch? “In order to ensure a successful market introduction of fuel cell vehicles, this market introduction has to be aligned with the build-up of the necessary hydrogen infrastructure.” The seven automakers strongly support the concept of building up hydrogen infrastructure in focused geographic areas, with Germany as the pilot market in Europe, one pilot market in the United States (likely California), and Japan and Korea as additional starting points. However, synchronizing the market introduction of fuel cell vehicles and hydrogen fueling infrastructure is a vexing problem.

Today there are more than 370 hydrogen fueling stations worldwide, but the vast

majority of these were built for demonstration or private use, and are not available or readily accessible to retail users. Enticing private investors to build and operate these retail-ready stations for early markets will require a business case that overcomes the inherent risk factors. In Germany, a landmark agreement among energy companies, industrial gas companies, automakers, and government declared on September 10, 2009, that “a comprehensive nationwide infrastructure for hydrogen refueling will be in place by 2015.” The “H<sub>2</sub> Mobility Initiative” partners now include Air Liquide, Air Products, Daimler, EnBW, Linde, NOW, OMV, Shell, Total and Vattenfall. The partners will work together on standardization of hydrogen fueling stations and development of area-wide station roll-out plans in Germany.

In California, less than a handful of the existing 25+ hydrogen fueling stations are publically accessible today. The state has committed funding to add up to eight new public stations, but many more will be needed to satisfy the potential early market demand promised by the automakers in the Southern California and San Francisco Bay areas. The California Fuel Cell Partnership has estimated that automakers could deploy thousands of fuel cell vehicles in California by 2014, and tens of thousands by 2018. The challenge? Finding ways to engage the private sector in building close to 4,000 kg of hydrogen fueling capacity in these target markets in the next four years, and about 50,000 kg of capacity by 2018. The goal of this workshop was to begin a dialogue on how to meet this challenge, consider models and approaches being taken in different countries, and develop some practical ideas for moving forward that could be applied or adapted for these and other locations.

---

<sup>1</sup> Read the press release here:  
<http://www.greencarcongress.com/2009/09/automakers-fcv-20090909.html#more>

## Workshop Purpose and Format

### Purpose

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), in cooperation with the California Fuel Cell Partnership (CaFCP), U.S. Department of Energy (DOE), and National Renewable Energy Laboratory (NREL), held a two-day interactive workshop on February 25-26, 2010, to explore the market implementation needs for hydrogen fueling station development (see Agenda, Appendix A). The IPHE Infrastructure Workshop brought together more than 80 representatives from different stakeholders in the hydrogen industry—including energy companies; hydrogen equipment suppliers; auto companies; state, federal and international government agencies; non-profit organizations; academia; and research and consulting—to develop creative and practical solutions for establishing hydrogen infrastructure in the near-term (see List of Participating Organizations, Appendix B).

Topics addressed in the workshop included:

- Business factors that will motivate, hinder, or prevent investment in hydrogen stations;
- New business cases, financing scenarios, and technical approaches to make hydrogen stations more attractive to fuel retailers;
- Policies, regulations, and incentives needed for a sustainable business case for hydrogen station development;
- Opportunities for international programs to leverage their efforts, including potential areas for further research and development.

In the opening session of the workshop, the CaFCP presented the results of a Fuel Retailer Focus Group, organized and conducted in late January 2010 by the CaFCP, DOE and NREL.

The objectives of the focus group were to gain insight into the business practices of traditional fuel retailers, assess their attitudes regarding alternative fuels and hydrogen, expose them to a variety of basic hydrogen station configurations, and understand their motivations for and opposition to offering hydrogen in an early commercial market. The focus group results were presented at the workshop to guide the attendees as they developed their ideas in the breakout sessions. Though many of the fuel retailers who participated in the focus group knew little about hydrogen, they were interested in learning more, and most were open to the idea of selling hydrogen if the capital cost can be reduced. The sidebar in Figure 1 includes more detailed information about the focus group results (see also Appendix C).



The hydrogen dispenser at this Shell station in Washington, D.C. offers both gaseous and liquid hydrogen.

## Figure 1. Fuel Retailer Focus Group: Summary of Results

The California Fuel Cell Partnership (CaFCP) organized an online focus group of fourteen large fuel retailers to gauge their opinions and perspectives on alternative fuels and hydrogen. The focus group participants were asked questions about the factors that influence their investments in alternative fuels. They were also given five potential business cases for hydrogen fueling stations, and were asked questions about the favorability of these station configurations. Key results from the focus group are summarized below. A more detailed report of the focus group results is provided in Appendix C.

### Fuel Retailers' Business Environment

- In recent years, **traditional fuel retailers have lost market share** to non-traditional fuel retailers, including “big box stores” like Wal-Mart and Costco, who often sell fuel below-cost as a way of attracting customers to their stores. Traditional fuel retailers struggle to compete with these big box stores, and risk losing further market share in the future.
- **Fuel retailers are relying more on profits from their convenience stores** than fuel sales (but profit on fuel sales is still important). The retailers expect this trend to continue.
- Because **transitioning to renewable fuels is expensive**, investment in alternative fuels is somewhat limited. The station owners must achieve a 3-5 year return on investment to justify an investment.
- **Consumer demand and the price of gasoline are the most important factors** in determining investment in alternative fuels. Additionally, government mandates and regulations affect investment in alternative fuels, but the public relations value of “going green” has little impact.

### Advantages and Disadvantages of Adding One or More “Alternative Fuel” Products

- **Advantages:** New fuel sales; acquiring a “green” customer segment; achieving a competitive advantage in a new market; meeting the federal Renewable Fuels Standard.
- **Disadvantages:** High upfront cost; low demand, resulting in unused capacity; negative consumer perception and low education levels; inconsistent demand when the price of gasoline is low; unstable supply.

The participants believe that being an “early adopter” of hydrogen would be beneficial, because it would help boost their visibility and would likely increase sales of conventional fuel, but they cautioned that the capital cost of stations must be low enough for fuel retailers to compete. Most of the focus group participants, however, simply did not know enough about hydrogen, but they would like to learn more.

### Station Configurations and Fuel Retailers' Feedback

The National Renewable Energy Laboratory (NREL) developed five potential 700 kg/day hydrogen station configurations, including high-level information about capital and O&M costs, return on investment, station layout, and hydrogen costs (see Appendix D). The participants had the following reactions to the hydrogen station configurations:

- The **capital costs of all the configurations are too high** without government support.
- Participants worried that **daily delivery of hydrogen could lead to inconsistent inventories**.
- The presumed **additional regulations and liabilities** for station owners could be prohibitive.
- There was considerable **interest in the CHHP system** station, but cost was still an issue.
- **Slowly transitioning a station** by converting one gasoline dispenser to hydrogen and expanding as necessary might be a preferable option. Participants generally agreed that a smaller station, rather than the 1000 kg/day stations, would be preferable in the transition years.

# IPHE INFRASTRUCTURE WORKSHOP

## *Workshop Format*

The two-day workshop featured both high-profile plenary speeches and breakout sessions, in which attendees had the opportunity to work in small groups to brainstorm and develop new ideas.

Plenary speakers included government and industry experts from several IPHE-member countries, who gave short presentations on their “2020 vision” for hydrogen infrastructure. The National Renewable Energy Laboratory then presented business case scenarios for five different hydrogen

station configurations and the CaFCP summarized the results from the Fuel Retailer Focus Group. In facilitated breakout discussion sessions, participants used the information from the plenary presentations and the focus group results to discuss and identify key challenges and opportunities for market implementation, and potential next steps for government and industry. At the end of the second day, representatives from each breakout group presented to all attendees on his or her group’s ideas and conclusions.



## Discussion Summary

### *Plenary Presentations*

This section summarizes the presentations made during the opening, plenary workshop session. The full presentations are available at <http://www.iphe.net/workshops.html>.

#### **United States**

John Garbak, of the US Department of Energy (DOE) Fuel Cell Technologies Program, presented on the progress the US has made regarding hydrogen and fuel cell research, development, and demonstration (RD&D). There are currently 55 hydrogen fueling stations across the US, but very few of those stations are retail-ready. In the next five to ten years, one of the most critical issues for commercial introduction of fuel cell vehicles will be infrastructure development. The current federal policies in place—hydrogen refueling facility tax credit (or grant) and an Investment Tax Credit for stationary fuel cells—have been helpful, but are unlikely to initiate a large-scale infrastructure build-out.

Catherine Dunwoody, Executive Director of the California Fuel Cell Partnership, gave an overview of the policies that affect fuel cell vehicle (FCV) deployment in California and the Partnership's strategy for FCV rollout. The state has adopted broad legislation to reduce greenhouse gases (GHG) to 80% below 1990 GHG levels by 2050. California has also passed targeted legislation to promote the use of clean vehicles—including fuel cell vehicles. The CaFCP FCV rollout plan is based on a survey of automakers, which found that the car companies could deploy thousands of FCVs in California by 2014. The CaFCP plan would develop 40 hydrogen fueling stations in areas where demand is concentrated, requiring a total investment of \$180 million over a four-year period. With eight stations in development, the hydrogen demand through 2012 is likely to be met, but more stations will

be needed to satisfy potential demand in 2014 and beyond.

#### **Germany**

Philippe Mulard, who leads TOTAL's hydrogen division, described the European Fuel Cells and Hydrogen Joint Technology Initiative (FCH JTI), a public-private partnership intended to accelerate the commercialization of hydrogen and fuel cell technologies in Europe. The group has developed a roadmap for a European FCV rollout, which anticipates between 400,000 and 1.8 million FCVs in Europe by 2020. Challenges to this development scenario remain, including a short development timeline, a lack of political consensus within the European Union, and disagreement within the FCH JTI regarding the economics of hydrogen stations. Mr. Mulard also described the German H<sub>2</sub> Mobility Initiative, which aims to establish Germany as a key early market for FCVs, through a comprehensive plan to develop infrastructure and deploy vehicles. Energy companies, hydrogen fuel providers, and automakers have signed on, indicating their commitment to the project.



TOTAL gaseous hydrogen station Holzmarktstrasse, Berlin, Germany

## Japan

Jinichi Tomoru, of the Engineering Advancement Association of Japan, spoke to workshop attendees about the current status of and future plans for the Japan Hydrogen & Fuel Cell Demonstration (JHFC) Project. The goal of JHFC is to develop initial demonstration projects for FCVs and hydrogen stations. JHFC currently operates 11 hydrogen stations in major urban centers in Japan, along with four cooperative stations. With the current phase of the project scheduled to end in 2010, the future of the next phase of JHFC is somewhat uncertain, though Mr. Tomoru expects a public announcement about the program's next phase to be released soon.

## South Korea

Byung Ki Ahn, Principle Engineer and General Manager of R&D for Hyundai-Kia, gave an overview of the South Korean government's hydrogen and fuel cell program, in addition to Hyundai's vision for FCV deployment. There are eight existing hydrogen stations in South Korea, with four additional stations expected to be operational by the end of 2011. With 97% of its energy imported, Korea stands to gain significant energy security with mass introduction of hydrogen and fuel cells. Hyundai is developing hybrid-electric vehicles (HEVs), but the company views HEVs and plug-in hybrid electric vehicles (PHEVs) as a transition strategy between internal combustion vehicles and the vehicles of the future—that is, fuel cell vehicles and all-electric vehicles. Hyundai plans to deploy 1,000 FCVs per year in the 2012-2014 timeframe, but the company's deployment strategy depends on the availability of at least 20 hydrogen fueling stations to refuel the vehicles.

## Business Case Scenarios and Summary of Focus Group Results

Marc Melaina, of the National Renewable Energy Laboratory (NREL), presented five

potential hydrogen fueling station business cases to the workshop attendees (see Appendix C). Each business case depicted a 700 kg/day hydrogen station, and included high-level information about cost, technologies, and station layout. The five station configurations included both distributed and central hydrogen production, gaseous and liquid delivery, and an offsite stationary fuel cell that uses natural gas to heat and power a commercial building and produce hydrogen for the station. The capital costs for each station varied between \$2 million and \$8.5 million, and the price of dispensed hydrogen varied from about \$5/kg to \$10/kg, depending on the station technology.

These five station configurations were shown to the fourteen participants in a Fuel Retailer Focus Group organized by CaFCP, NREL, and DOE. Chris White, of CaFCP, presented the results of that focus group at the workshop. Though the fuel retailers who participated were interested in hydrogen, cost remains the primary driver of new investment, which suggested that the long payback period and high upfront capital cost of hydrogen stations are important issues to tackle. The workshop attendees used the lessons gained from the focus group results to inform their discussions in the breakout groups.



Dual-pressure Air Products hydrogen dispenser at UC-Irvine offer public access to 350- and 750-bar fueling.

## **Breakout Discussion Sessions**

The following sections summarize high-priority ideas and common discussion themes of the breakout groups. Each breakout group addressed the same primary focus question: *What actions, strategies, business models, or approaches should be implemented to motivate and enable the construction and operation of hydrogen fueling stations for near term FCV rollouts (between now and 2018)?* Ideas were generated in six main topic areas, as shown below. The detailed results of the four parallel breakout groups are shown in Appendix D.

### **Starter Station Business Model**

The CaFCP focus group results suggest that many of the existing business models for hydrogen stations are not acceptable to fuel retailers. Particularly, retailers will not invest in 700 kg/day stations (which is enough capacity to fuel 200 passenger vehicles per day) if the demand for hydrogen is uncertain. Fuel retailers have a low appetite for risk, and though they recognize that alternative fuels have a future, they would prefer to invest in smaller stations with a much lower capital cost and footprint, representing a smaller investment risk. As a result, a number of the breakout groups favor the development of a relatively low-cost, single-dispenser starter station business model that can be sited and constructed at existing fueling stations in the early market years and expanded or moved to other locations as demand grows or shifts.

The starter stations should have a 100 kg/day capacity and low capital cost for installation. The advantages of a small station include:

- Easier and faster implementation with a more limited risk profile
- Minimization of impact on the retail business, such as construction time, equipment downtime, footprint, etc.
- Added flexibility and ease of upgrading stations

- More easily coordinated hydrogen infrastructure rollout
- Replicability of station installation and construction, and
- Enables the retailer to have a relatively low-impact way to “test the market” and gain operational experience.

The attendees recognized that smaller stations do not benefit from economies of scale, and thus must be coupled with government incentives and other benefits to the retailer if they are to be cost-competitive. Attendees agreed that a starter station model (or models) should be developed. Mechanisms to do this include competitive solicitations to hydrogen equipment suppliers, or analytical tasks to engineering firms or national labs. Attendees also suggested that CaFCP ask the focus group participants for feedback on starter station model designs.

### **Policies and Incentives**

Throughout the workshop, the attendees and speakers clearly acknowledged the importance of government policy—at all government levels—for hydrogen infrastructure development. Though government involvement should be limited, with a clear path for government to exit the market, some combination of incentives, regulations, subsidies, and public advocacy will be necessary for success.

The following policies and incentives were suggested as practical means for stimulating the development of hydrogen infrastructure:

- Tax incentives or grants for station development
- Industry-government cost sharing mechanisms
- Low-interest or zero-interest financing for stations
- A gas tax or carbon trust that would make low-carbon options more attractive

# IPHE INFRASTRUCTURE WORKSHOP

- The use of “green bonds” to fund hydrogen stations, and
- Regulations to enable streamlined permitting and siting processes.

Not only would government action provide tangible support for the industry, but policy also helps mitigate investor risk. Whether policymakers adopt a carbon trust, a set of tax incentives, or subsidies, the policy signal needs to be stable, consistent, and long-term.

## Information/Education Campaigns and Training

The workshop attendees agreed that one of the biggest barriers to widespread acceptance of hydrogen and fuel cells is a general lack of education and awareness of the benefits of hydrogen-fueled transportation. Just as the fuel retailers who participated in the CaFCP focus group did not immediately consider hydrogen an “alternative fuel,” and assumed that the problems encountered in retailing ethanol or biodiesel would be the same for hydrogen, many consumers do not realize how soon FCVs can be commercialized.

Additionally, many consumers do not fully understand how an FCV works, and how a transition to FCVs can reduce greenhouse emissions and improve energy security.

A broad-based public education program—featuring community engagement, mass media campaigns, and high-profile public advocacy—can help minimize the information gap. Education campaigns need to be simple and targeted, should communicate the wide range of benefits of hydrogen and fuel cells, and must address the safety concerns associated with hydrogen. Education of fuel retailers (and other potential hydrogen station owners) is needed, and an ongoing dialogue should be established. A consumer education campaign could include an unbiased comparison of all fuels using a variety of metrics, such as wells-to-wheels emissions and cost.



Though hydrogen advocates, like the CaFCP, National Hydrogen Association, and US Fuel Cell Council, should engage in public education campaigns, there is also a need for state, local, and federal governments to advocate for hydrogen. Additionally, innovative and non-traditional communications tools—such as social media outlets—should be utilized wherever possible. These education campaigns will help increase the understanding of hydrogen production, use and benefits, and could help eliminate many of the hydrogen “myths” that currently exist.

## Other Risk Reducing Strategies

In addition to developing starter station models and implementing effective policies to support hydrogen infrastructure build-out, attendees support the use of innovative mechanisms to reduce risk for hydrogen station owners. Fuel retailers’ low tolerance for risk, combined with the inherent uncertainty associated with the introduction of new fuel and vehicle technologies, makes high risk a primary barrier to hydrogen infrastructure rollout.

- **Establishing public-private partnerships** to fund stations would mitigate risk by diluting the need for private investment, and would also help demonstrate and prove the business case for hydrogen stations in early years. State organizations would work with a private entity—fuel retailers, hydrogen suppliers, or automakers—to jointly own and operate hydrogen stations. The conditions and

- terms of each partnership would vary by state and municipality.
- Funding early stations through a government cost-share** that decreases over time as stations grow and the industry reaches scale. Early stations that dispense only 100 kg/day might need a very high government cost-share, but as demand grows over time and the cost of hydrogen decreases, those stations could be upgraded and expanded to dispense up to 1000 kg/day. With high demand, the business case for hydrogen stations would improve, shortening the time for an adequate return on investment and lessening the need for government support. Similarly, a roadmap should be developed to show the path to profitability for hydrogen station owners over time. The roadmap should include clear targets for the industry to achieve profitability without government support, and should be developed in a coordinated effort between government and industry.
- Creating a risk-sharing consortium** would reduce costs for individual station owners—particularly insurance costs—and remove another investment barrier.
- Strong vehicle deployment signals from the automakers** will help assure station owners that there will be adequate hydrogen demand. Vehicle deployment announcements by the car companies should be backed up by financial commitments. Additionally, strong deployment signals may not be sufficient to convince individual station owners that customers will purchase fuel at their stations, so car dealerships could offer additional incentives for customers to purchase fuel at specific stations.

## Ways to Boost Hydrogen Demand

In the early market years, while hydrogen and fuel cell technologies continue to reach maturity, hydrogen demand will be relatively low, no matter what business cases and station configurations are chosen. Thus,

finding innovative ways to increase demand will effectively increase profit margins for station owners, making the investment environment more favorable and helping to speed the transition to profitability and market share for hydrogen. The workshop attendees developed a number of ideas to help station owners by increasing demand.

- Target fleet operators** to increase demand for hydrogen. Government agencies, private companies, local governments, and other organizations purchase vehicle fleets, which can be leveraged to boost hydrogen demand and drive down costs for private consumers. Additionally, highly visible vehicles fleets, like buses, help market the technology and persuade consumers of its viability. One option for stations could be to divide the station area in two, with public-access retail hydrogen dispensers in front and private fleet refueling “behind the fence.” Combining fleet and retail hydrogen demand in this way would increase the daily flow of hydrogen from the station, reducing idle capacity and improving the return on investment for the station owner. The automakers and energy companies should work with governments and other fleet owners to establish vehicle procurement commitments and build stations.
- Station owners can sell hydrogen to other fuel cell applications**, expanding the station’s customer base and increasing sales. Hydrogen dispensers for fuel cell forklifts and stationary fuel cell applications could be co-located with vehicle refueling stations, or hydrogen dispensers for vehicles could be added to sites where fuel cell forklifts are already being used. The grocers and large retail stores that have already invested in stationary fuel cell applications might be willing early adopters of the combined heat-hydrogen-power (CHHP) station model, in which a stationary fuel cell powers the commercial building, and also

produces a slipstream of hydrogen for vehicle fueling. Governments could establish incentives for these early market innovators, helping to reduce the cost burden.

- **Leverage the natural gas industry** to help create market pull for hydrogen. Currently, reforming natural gas is the most cost-effective way to produce hydrogen, and though it is not emissions-free, it produces less CO<sub>2</sub> on a wells-to-wheels basis than internal combustion engines, HEVs and PHEVs (depending on the grid mix). The natural gas industry has much to gain from the mass commercialization of fuel cell vehicles, but natural gas companies have yet to champion hydrogen. Gas providers and trade associations could engage natural gas providers and show a business case for their industry. If these companies see a future profit-making scenario, they may be willing to invest in early-market infrastructure.
- **Create an online marketplace for hydrogen** to increase competition and reduce price. The price of hydrogen would decrease with volume, would give stability and predictability to fuel providers, and would enable industry growth. Fuel providers would collaborate with a private company—like Google or E-Bay—to develop and market the site.

## Novel Business Models

Though government action is needed to make hydrogen attractive to both consumers and fuel retailers, there are a number of actions the private sector can take to improve the business case for hydrogen stations in the early years of commercialization. Non-traditional business models may be appropriate, and some conventions of the current fuel business should be abandoned if they become obsolete for hydrogen. More radical approaches will involve a higher level of risk taking, which traditional fuel retailers are not currently prepared for. Some ideas for novel business models include:

- **Approaching non-traditional financiers**, like private equity investors or foundations, for station funding. Finding a high-profile advocate would stimulate interest and increase visibility in the sector, while also attracting private capital. Approaching potential investors with a sound business case backed up with economic analysis could persuade them.
- **Leverage existing hydrogen infrastructure** wherever possible. Existing hydrogen production and pipelines used for industrial processes could be utilized and expanded at a lower capital cost than building entirely new infrastructure. Lower capital costs for production and delivery of hydrogen lead to lower costs of hydrogen for the consumer, and higher demand for the retailer. Another benefit would be faster permitting, because much of the infrastructure already exists. This strategy would only be beneficial in very early market penetration scenarios, however, because as demand grows, new infrastructure will be needed.

## Conclusion

Workshop participants agreed that actions taken in the next five years will be essential for the hydrogen and fuel cell industry, both in the United States and around the world. While a number of countries—namely, Germany, Japan, and South Korea—have begun preparing for a mass introduction of fuel cell vehicles, there is still very limited movement towards a coordinated strategy for station rollout in the United States, with most of the activity taking place in California.

If automakers are to deploy thousands of fuel cell vehicles by 2015, there needs to be adequate retail-ready refueling infrastructure, combined with widespread public confidence in the availability of that infrastructure. Achieving this goal will require targeted and sustained government support. It will also require the industry to think creatively about ways to circumvent the so-called “chicken and egg” problem. Old models for fuel retailing may need to be supplemented with more innovative approaches, like containerized, modular, or mobile starter stations ; fuel cooperatives; or combined heat, hydrogen and power stations.

Despite the barriers to introducing FCVs commercially in the United States, the workshop attendees were optimistic about the potential for thousands of vehicles to be deployed in California by 2017. Through a combination of creative policies and incentives, new business models for fuel sales, and novel approaches for designing stations, many of the challenges facing the industry can be mitigated or even eliminated. The following bullets summarize some of the most promising ideas generated at the workshop.

- **Build low-cost, easy to site starter stations** to satisfy early demand and provide fuel retailers with operational

experience. The starter station would include an upgrade path to a larger station.

- **Define a “line of sight” path to profitability** that businesses could use to justify investment and that government could use to show diminishing public funding.
- **Create co-ops or public-private partnerships** such as the German “H<sub>2</sub> Mobility” initiative to facilitate collaboration among vehicle and fuel producers and define public-private cost share models.
- **Enact policies and incentives** to make hydrogen more attractive for investors, including tax incentives or setting up a consortium for risk sharing or “eco-zones” to encourage the adoption of fuel cell vehicles.
- **Increase demand for hydrogen** by serving multiple applications (e.g., forklifts, stationary power generators, and vehicle fleets).
- **Provide unbiased alternative fuel education** to the public (to build consumer support and increase demand), to fuel retailers (to understand options) and to government (to clarify investments).
- **Leverage existing natural gas and hydrogen infrastructure** to reduce costs and enable faster implementation.

In closing, workshop participants were very encouraged by the international dialogue that has been started. Transitioning to commercial markets will require new perspectives and different approaches, and a continuing dialogue among the diverse (and widening) group of stakeholders will be pursued in local, state, national, and international forums. Actions must follow, however, to achieve the goal of making FCVs a viable clean-transportation choice for consumers.

# IPHE INFRASTRUCTURE WORKSHOP

## Appendix A – Agenda

Hilton Sacramento Arden West  
2200 Harvard Street  
Sacramento, California 95815-3306  
February 25 - 26, 2010

## AGENDA

### THURSDAY, FEBRUARY 25

---

7:00 – 8:00 am	Registration and Continental Breakfast
8:00 – 9:00 am	<b>Pathways to 2020: Presentations from Selected IPHE Member Countries</b> <i>Number of vehicles and stations in each country in 2020; partners and funding; and progress, challenges, and showstoppers.</i> <ul style="list-style-type: none"><li>■ <b>United States:</b> <b>John Garbak and Fred Joseck</b>, U.S. Department of Energy and <b>Catherine Dunwoody</b>, Executive Director, California Fuel Cell Partnership</li><li>■ <b>Germany/EU (FCH Joint Undertaking and the German H<sub>2</sub> Mobility Initiative):</b> <b>Philippe Mular</b>, Hydrogen Programme Manager, TOTAL Refining &amp; Marketing</li><li>■ <b>Japan:</b> <b>Jinichi Tomoru</b>, Engineering Advancement Association of Japan (ENAA)</li><li>■ <b>South Korea:</b> <b>B. K. Ahn</b>, Principal Research Engineer, Fuel Cell Vehicle Team, Hyundai Motor Company</li></ul>
9:00 – 9:30 am	<b>Group Discussion</b>
9:30 – 11:00 am	<b>Hydrogen Fueling Station Business Cases</b> <i>Presentation and discussion of business cases for five different hydrogen station configurations (prepared by NREL) and results from a recent on-line focus group of leading retail fuel providers about the business cases.</i> <ul style="list-style-type: none"><li>■ <b>Marc Melaina</b>, National Renewable Energy Laboratory: Overview of Hydrogen Fueling Station Business Case Scenarios</li><li>■ <b>Chris White</b>, California Fuel Cell Partnership: Review of Fuel Dealer Focus Group Results</li></ul>
11:00 – 11:30 am	<b>Group Discussion</b>
11:30 – 11:45 am	<b>Remarks from Anthony Eggert, Commissioner, California Energy Commission</b>
11:45 – 1:00 pm	<b>Lunch</b>

# IPHE INFRASTRUCTURE WORKSHOP

1:00 – 4:30 pm	<b>Facilitated Breakout Group Discussion Sessions</b> <i>Groups will consider key obstacles to market implementation of hydrogen fueling stations, and develop ideas and action plans for overcoming the obstacles, particularly in the California market. Practical, solution-oriented thinking will be encouraged, as will creative thinking to generate challenging, innovative ideas that government and/or industry could pursue in the following topic areas:</i> <ul style="list-style-type: none"><li>■ Entry-Level Station Configurations and Strategies</li><li>■ Government Incentives and Policies</li><li>■ Reducing Risk to Station Owners</li><li>■ Information and Education for Retailers and their Customers</li></ul>
4:30 – 5:30 pm	<b>Plenary Session: Breakout Group Reports</b> <i>Each breakout session leader will report on their results for further consideration on Day 2.</i>

## FRIDAY, FEBRUARY 26

7:30 – 8:30 am	Continental Breakfast
8:30 – 10:30 am	<b>Breakout Groups: Exploring the Ideas</b> <i>Groups will complete and give final reports on the action plans for their top-priority ideas. For very challenging or innovative ideas, groups will consider what could be done to make these ideas attainable.</i>
10:30 – 10:50 am	Break
10:50 – 11:45 am	<b>Closing Session: Recap—Visions of 2020</b> <i>How do the ideas from the breakout sessions and industry focus group impact the 2020 visions described for the U.S., Germany, Japan, and South Korea? Are there action items that could be adapted for use in other countries or leveraged by international cooperation or collaboration?</i>
11:45 – 12:00 pm	<b>Closing Remarks and Next Steps</b>

<b>Optional</b>	<b>Public Tour of California Fuel Cell Partnership (CaFCP) Headquarters</b>
1:00 – 3:00 pm	CaFCP—3300 Industrial Blvd. Suite 1000, West Sacramento, CA 95691 <ul style="list-style-type: none"><li>■ Visit CaFCP's headquarters</li><li>■ Tour the world's busiest hydrogen station</li><li>■ Take a ride in the Sacramento-based fuel cell vehicles</li><li>■ Hear what people say and ask about FCVs and hydrogen</li></ul>

## Appendix B – List of Participating Organizations

- AC Transit
- Air Liquide
- Air Products & Chemicals, Inc.
- Argonne National Laboratory (ANL)
- Barnum and Celillo Electric, Inc.
- Bryte Energy Ltd
- California Air Resources Board (CARB)
- California Department of Food & Agriculture
- California Energy Commission (CEC)
- California Environmental Dialogue
- California Fuel Cell Partnership (CaFCP)
- Canadian Hydrogen and Fuel Cell Association
- Center for Energy Efficiency and Renewable Technologies
- Chevron
- Coalition for Clean Air
- Daimler
- Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE)
- DMC Green
- ENAA
- ENEA
- Energetics Incorporated
- Energy Independence Now
- FuelCell Energy
- Gas Technology Institute
- General Motors (GM)
- Honda
- Hydrogenics Corporation
- Hyundai-Kia
- Industry Canada
- Linde
- MightyComm
- National Hydrogen Association
- National Organisation Wasserstoff- und Brennstoffzellentechnologie
- National Renewable Energy Laboratory (NREL)
- Nissan
- Pacific Northwest National Laboratory (PNNL)
- Plug Power Inc.
- Proton Energy Systems
- Sentech
- Shell
- South Carolina Hydrogen and Fuel Cell Alliance
- South Coast Air Quality Management District
- Statoil Hydrogen Technologies
- SunHydro LLC
- Technova Inc.
- TOTAL
- Toyota Motor Engineering & Manufacturing
- Union of Concerned Scientists
- University of California—Davis
- University of California—Irvine
- US Fuel Cell Council
- US Navy
- Volkswagen
- ISE Corporation

# IPHE INFRASTRUCTURE WORKSHOP

## Appendix C – Online Focus Group with Large Fuel Retailers

### Objectives

- Determine general business practices and appeal of alternative fuels among fuel station owners.
- Expose fuel retailers to 4-6 ideas for a hydrogen station with high-level information about costs, ROI, incentives and space requirements.
- Understand the motivations and incentives for offering hydrogen fuel in an early commercial market, and understand the limiting and prohibiting factors.

### Methodology

- One online bulletin board discussion was conducted over a four-day period, from January 26-29, 2010.
- Features of the bulletin board discussion format:
  - Participants and moderator were sent access instructions to log into a secure web site
  - At the beginning of each day questions are launched with probes posted later in the day, as necessary.
  - Participants are asked to log into the web site each day at a convenient time. They spent up to 30 minutes per day responding to the questions and follow-up probes.
- A total of 14 respondents participated in the session. Participants are key decision makers from fuel retailers and are involved in the decision-making about which fuel services to offer at their stations.
- Verbatim comments appear throughout this report. In some cases, the comments have been edited to enhance clarity.
- Jennifer Caughlin, Ph.D., moderated the bulletin board sessions.

### Methodology – Statement of Limitations

- Bulletin board discussions seek to develop insight and direction rather than quantitatively precise measures. Because of the limited number of respondents and the restrictions and selectiveness of recruiting, this research must be considered in a qualitative frame of reference.
- The reader is reminded that this report is intended to clarify cloudy issues and point out the direction for future research. The data presented here cannot be projected to a universe of similar respondents.
- The value of bulletin board discussions is in their ability to provide unfiltered comments from a segment of the target population, for respondents to interact and build upon others' responses, and for decision-makers to gain insights into the beliefs, attitudes, and perceptions of their consumer base.

## Executive Summary

### Future of Retail Fuel Sales

- Fuel retailers must figure out new ways to maintain their slim profit margins as non-traditional fuel retailers continue to cause market erosion.
- Convenience stores will continue to own the convenience market and ‘hyper marketers’ (Kroger, Costco, etc.) will own the price market in fuel sales.
- Renewable fuels will likely increase in the marketplace as government mandates apply pressure. Biofuels, particularly in the form of ethanol blends and biodiesel, are likely to be a large portion of the alternative fuel progression.
- The transition to alternative fuels is expensive and will likely eliminate smaller retailers.
- Consumer demand may be a factor in alternative fuels, but only if gas prices continue to rise. Consumers tend to be “green” only when it is economical. Therefore, if oil prices decline, the demand for alternative fuels is also likely to fall.

### Advantages to Adding Alternative Fuels

- The primary benefit is fuel sales. Secondary benefits include meeting federal RFS standards, acquiring a new “green” customer segment, and competitive advantage.

### Disadvantages to Adding Alternative Fuels

- Fuel retailers have concerns about entering the alternative fuel market due to a variety of factors potentially influencing business and the fuel market. Concerns include:
  - Large financial investment
  - Government backing out of financial commitment, leaving blenders to carry the financial burden
  - Auto companies not producing sufficient number of alternative fuel cars
  - Consumers not buying sufficient number of alternative fuel cars
  - Consumers’ lack of understanding and negative perception around biofuel performance
  - Consumer interest in being “green” is based on economics
  - Inconsistent product availability and distribution.
- With the variety of alternative fuels available, retailers also worry a fragmented market may further hinder their success as they try to anticipate “the” alternative fuel of the future.

### Factors Influencing the Adoption of Alternative Fuels

- Most impact—profit from fuel sales and ancillary sales
- Second—subsidies and tax credits because they help make the economics more palatable.
- Least impact—government regulation compliance and marketing/brand position

### Affects of Global Warming Regulations on Future Retail Fuel Sales

- Federal and state mandated fuel changes will result in higher costs for retailers and consumers. These regulations will ultimately increase the cost of fossil fuels, forcing consumers to consider alternative fuels.

- Cap and trade proposals, the current revision of RFS-2, and future Stage II vapor recovery rules all have potential negative financial implications for fuel retailers.

## Initial Interest in Hydrogen

- Reactions are mixed, but most retailers are interested in the future development of hydrogen. With appropriate incentives and co-funding options to offset the initial costs, and a sufficient number of hydrogen vehicles produced by the auto industry, there may be growing interest in this fuel option.

## Evaluation of Five Station Configurations

- The high initial investment of all five models is likely to make them unaffordable without government grants or subsidies.
- While the storage cylinders are a unique and simple storage solution, the daily deliveries raise concerns about maintaining a consistent inventory.
- Underground storage minimizes the footprint required but suggests additional regulations and liabilities for station owners and operators.
- Using electricity to produce hydrogen on-site is risky due to the rising cost of electricity. Additionally, if electricity is pulled from the grid it is a polluting source of energy.
- Using a fuel cell to product electricity, heat and hydrogen is appealing, particularly when it is owned by the retailer.

# IPHE INFRASTRUCTURE WORKSHOP

## Key Findings

### Focus Group Respondents

ID	Years in Business	# of Locations	Types of Stations	Types of Fuel	Customer Base
5	80+	76	Retail w/fuel	Gasoline, ULSD, E85	Rural and interstate traffic
6	60+	600	Retail w/fuel	Gasoline, diesel, E10	Primarily retail (consumers), some wholesalers & dealers
7	34	20	Retail w/fuel	Gasoline, diesel, E85, CNG/LNG, propane, biodiesel,	Consumers – commuters and locals
9	35	298	Retail w/fuel	Gasoline, diesel	Consumers
10	39	299	Retail w/fuel	Gasoline, diesel, biodiesel	Consumers
12	14	320	Retail w/fuel		
13	120+	900	Retail, travel plazas, retail w/fuel	Gasoline, diesel, E85	Consumers, commercial and government fleets
14	80	68	Retail filling, card lock, travel plazas	Gasoline, diesel, E85, propane, biodiesel	Transient near highway & local customer base
15	<1	7	Retail, retail w/fuel	E85, biodiesel, electric charging station	Consumers, state and federal fleet vehicles
16	30	1	Card lock	Gasoline	Private fueling station for company employees only
17	63	32	Retail, card lock, retail w/fuel	Gasoline, diesel	Everyone
18	40	230	Card lock, retail w/fuel	Gasoline, diesel, E-10, occasionally biodiesel	1 convenience store, private fleets, retailers
19	30+	1000+	Retail	Gasoline, diesel, E85, propane, biodiesel, hydrogen	Private and transportation industry
20	35+	15+	Retail w/fuel	Gasoline, diesel, E85, biodiesel, kerosene	Consumers

## Future of Retail Fuel Sales

Fuel retailers will continue to look for new ways to make a profit despite the current price margin erosion occurring in this rapidly changing industry. *“Operational excellence is essential for survival.”*

- Traditional fuel retailers will continue to see price margin erosion with the increase of non-traditional fuel stations (Sam's Club, Costco, Kroger, Safeway) selling gas at cost. The big box stores are similar to convenience stores in that they make their profits on non-fuel sales, allowing them to price gas as their loss leader.
  - Rewards programs offered by grocery chains further impact fuel sale volume during rewards redemption periods.
  - With the struggling economy, consumers continue to be price-sensitive, particularly with fuel purchases, increasing the overall appeal of these big box retailers.
- Traditional fuel retailers may have to rely on non-fuel sales to make a profit and stay competitive in the industries.
- The number of small operators will decline as they struggle with the economic impact of government regulations, credit card fees, and equipment upgrades.

## Alternative Fuels

- The use of renewable fuels will increase as a result of government mandates and consumer demand. As automakers reintroduce diesel passenger vehicles, diesel demand will also increase.
- As a result of government mandates for renewable fuels, retailers will be forced to make changes, including upgrades in equipment and procedures, fuel handling, and maintaining tank integrity.
- Changes in the demand for alternative fuels will likely depend on the price of traditional fossil fuel. If gas prices remain low, price-conscious consumers have little incentive to change to an alternative fuel that may be more expensive.
- The retailers have an underlying concern that the retail fuel business may become so fragmented with fuel choices for consumers that retailers will not be able to provide all of the fuel types the public demands.
- The percentage of biofuel blended into gasoline and diesel will increase in the next 5-10 years as will the number of electric-powered vehicles. Overall, vehicles will be able to travel more miles before needing to refuel.
- They generally agree that biofuels, particularly in the form of ethanol blends, will be a large portion of the “alternative fuel progression.”

### ***Advantages of ethanol blends***

- E85 could be the fuel of the future if a cellulosic conversion is created that takes the ‘perceived’ pressure off the food chain.
- Ethanol blends are gaining acceptance in the corn belt.

### ***Disadvantages of (or barriers to) ethanol blends***

- Ethanol is produced from a product that is integral to the food supply.

# IPHE INFRASTRUCTURE WORKSHOP

- Sporadic distribution and inconsistent supply
- Price instability
- Difficulty in determining which blends to offer (E10, 14, 85) until entire fleets are turned over and all vehicles are compatible with E85.
- Negative consumer perceptions of performance issues with ethanol blends.
- Marine engines do not perform well on ethanol fuel blends.
- Current dispensing equipment is not UL certified for a blend greater than E10.

## Comments about Alternative Fuels

*"Retailers are going to be faced with the difficult decisions on what products we offer for sale."*

*"Over the next decade I expect we will see a tremendous increase in renewable fuels as well as the introduction of LNG and CNG. The first notable impact is that the transformation of this product is going to come with a hefty price tag. Today's dispensing equipment is not UL certified for a blend greater than E10. Additionally, the majority of vehicles on the road will not be compatible with blend rates higher than E15."*

*"Suppliers are providing blend at the pump modifications that allow customers to choose between E-5, E-10, E-15, and E-20. It is currently gaining acceptance in the corn belt and I'm sure we will see this technology spread as OEMs approve of the higher blends."*

***There are differing opinions about consumer acceptance of "green" practices.***

Some Believe Consumers will Embrace It	Others Suggest Interest is Purely Economical
<p><i>"Many of our customers have commented on our move to bring E-85 to the market. They are grateful we have made this choice and have supported the products at our locations. We are looking to improve our green footprint through the use of energy efficient lighting and supplemental solar electricity and geothermal heat sources. The public has responded favorably to these efforts."</i></p> <p><i>"Our biodiesel demographic is about the same as diesel. For ethanol, we get early adopters, environmentalists, and pro-U.S./anti-foreign oil and some super smart consumers that do the numbers. They know their mpg with gas and ethanol and make a decision based on finances. Ethanol is 15% less than regular unleaded but we have had spreads as high as 30%."</i></p>	<p><i>"In our markets the only benefits (of alternative fuels) are hitting required air quality standards and cost savings. The consuming public almost overwhelmingly resists the product, enough so that in one state we do not even offer them."</i></p> <p><i>"People talk green, but only when there is an economic benefit directly to them. Still, most people remain uneducated on FFVs and their ability to help save natural resources....It just shows the emotion attached to the public's input at the time, versus living with the reality of the issue day to day, and fill-up to fill-up."</i></p> <p><i>"The motoring public tends to let their wallets do the talking. They won't buy bio when it is more expensive than conventional."</i></p>

## Affects of Global Warming Regulations on Future Retail Fuel Business

Federal and state mandates will result in higher costs for retailers and consumers. Regulations will ultimately increase the cost of fossil fuels, forcing consumers to consider alternative fuels.

- Most retailers acknowledge mandates are inevitable and are already implementing some of the required changes.
- Cap and trade proposals create several negative reactions. Cap and trade proposals will:
  - Create an undue tax burden on refineries
  - Increase price of domestic production
  - Decrease domestic production which will ultimately increase U.S. dependence on (less expensive) foreign oil.
- The current revision of RFS-2 also elicits some negative reactions about the lack of necessary support ethanol needs in Congress.
- Smaller operations subject to future Stage II vapor recovery rules may be forced to close due to lack of return on the expense associated with the new rules.
- The use of electricity charging will increase but will require the increase of clean sources of electricity (wind, solar) to replace coal plant production.

## Advantages of Offering Alternative Fuels

While financial benefits are the key criteria when considering alternative fuels, retailers also recognize the potential marketing benefits of being an industry leader.

- Primary benefit is financial obtained through:
  - Increased business with a broader customer base
  - Competitive differentiation
  - Higher profit margins with blended fuels
  - Government rewards for meeting federal RFS requirements
- Secondary benefits:
  - Enhanced business image as an ‘earth friendly’ fuel provider
  - Capturing the emerging “green” consumer segment as interest and involvement increases
  - Improved “green” footprint
  - Environmental reward of helping preserve the planet

## Disadvantages/Obstacles of Offering Alternative Fuels

- Strong concerns about the financial costs and risks associated with entering the alternative fuel market. The investment required for the installation, storage and dispensing of alternative fuels is high and business owners are skeptical about the length of time required to see a return on the investment.
- Fear that the government may abandon support programs (tax breaks, subsidies, grants, etc.) of alternative fuels, leaving them to assume the full financial burden.
- Concerns that auto companies will not produce enough cars and/or consumers will not buy enough cars to support the alternative fuel infrastructure.

# IPHE INFRASTRUCTURE WORKSHOP

- Skeptical about consumers' willingness to adopt new fuel technologies due to their price sensitivity at the pump, distrust of certain biofuels, and the general lack of understanding of biodiesels among consumers.
- Inconsistent product availability and distribution, and pricing concerns are other common obstacles to incorporating alternative fuels.
- With the potential variety of alternative fuels creating a fragmented market, retailers are unclear about how to identify which one(s) will succeed.

*"The biggest risk, in my estimation, is that we will dive into the renewable fuel and alternative energy business and then the demand will not materialize as projected... Installation of new UST's (underground storage tanks) will trigger implementation of newer, more strict EPA and state guidelines such as double wall piping - all resulting in additional capital dollars needed just to stay in business."*

*"Adding any alternative fuel to the business other than an E10 to E15 blend is going to be very capital intensive for retailers who have had to learn to live on razor thin margins already."*

*"Many customers expressed a lack of understanding of the product. They had heard that BioDiesel wasn't as good as regular diesel fuel. It would void warranties, it would freeze up in cold weather."*

*"E10 or any level of ethanol is not embraced within the majority of our southern markets. Historically, there have been problems caused by the heat creating vapor locks on systems, the cleaning effects of the fuel causing autos to miss or need fuel filters to be changed. Many people operate power saws, motor boats, motorcycles, weed eaters, lawnmowers and other small engine machinery that ethanol can create problems with. I also believe the media in many of the markets has flamed this disdain by running features on the problems and lower gas mileage."*

## Maximum Acceptable Time for ROI

**The maximum acceptable time to realize a return on investment is one to five years. Many agree any longer period of time would require some form of government co-funding.**

*"Capital is expensive and hard to get right now and there are plenty of places to invest it outside of alternative fuels to make it perform. We have a fiduciary responsibility to our shareholders."*

*"If you can't recoup your money in three (years), what's the point? In these changing times the next 'darling' of the media and the public will be entering the market and we will be expected (or required) to make it available. If we haven't recouped the money from the current venture, how will we afford the next?"*

*"It's hard to accept lengthy ROIs for income streams already working on tight margins for a new product that will almost certainly have low initial demand."*

*"I would want a quicker payback because of the rapid changes in the market place. In five years there could be new products on the market that are not sold through conventional liquid fuel*

*methods or need special lines, gaskets, etc. or legislative requirements that could change everything. I feel comfortable predicting within the next five years that the entire model will not convert."*

## Influential Factors in Adopting Alternative Fuels

- Generating profit through fuel sales and ancillary sales are the most influential factors affecting the decision to adopt alternative fuels.
- Regulatory compliance is also important to a few but not the main driver for most.
- Subsidies and tax credits are other influential factors because they help make the economics more palatable.
- Marketing/brand positioning is the least influential factor for most.

*"Fuel sales (at a profit if possible) and ancillary sales. We are a for-profit business and would like to stay that way!"*

*"We would like it to be about marketing and brand positioning, but without the current federal and state tax subsidies, it would really not make economic sense."*

*"Fuel sales, grants, and tax credits (are most influential)."*

*"Regulation compliance (is least influential). Right now there are no regulatory/compliance laws or rules in place or proposed that would have forced us to do this."*

*"Brand positioning (is least influential). Although it would be nice to be able to talk about all that we are doing for the environment, the consumer today is looking for the lowest cost of goods and that is not currently in the form of alternative fuels."*

*"Marketing and brand positioning would be the least influential. Within our (Southern) markets most consumers do not like the product (E10 or any level of ethanol) and have quickly realized they get less mileage and are fearful of the product especially in motorcycles, boats and small engines."*

## Alternative Fuels Likely to be Considered

- Many retailers are currently offering E85 and biodiesel and have little consideration for other alternative/renewable fuels.
  - Some, however, are less likely to consider biodiesel due to poor performance issues experienced during winter conditions.
- Others are willing to consider all types of fuel, assuming they can provide an ROI.
- Hydrogen and electric charging stations are not considered by many because test locations are primarily on the West coast or in large 'closed route' operations.

## Initial Reaction to Offering Hydrogen

**While reactions to offering hydrogen fuels are mixed, most fuel retailers express an interest in the future development of hydrogen.**

# IPHE INFRASTRUCTURE WORKSHOP

- Entering the hydrogen market must be affordable for fuel companies. Co-funding and government incentives will encourage these companies to consider adding hydrogen fuels at the retail level.
- Being a leading provider of hydrogen in the retail fuel market will enhance the overall visibility of those stations and increase the PR value for those locations.
- Fuel companies agree those first to enter the hydrogen fuel market have the best chance of becoming a dominant player in the market.
- With the increase in production of hydrogen-fueled vehicles by auto manufacturers, fuel retailers will become more interested in supporting hydrogen development.

Positive Comments about Hydrogen	Drawbacks of Hydrogen
<p><i>"We already offer hydrogen and we see this is one of the very best alternative solutions for the future."</i></p> <p><i>"(The most important reason to offer hydrogen) is to become a dominant player in the market."</i></p> <p><i>"We are not looking at hydrogen at this time, however it certainly is in our long range view. Of the approximately 65 hydrogen stations currently operating in the US, most are in California. ..Until a major auto manufacturer mass produces hydrogen fuel vehicles, it doesn't make economic sense in our market."</i></p> <p><i>"I am very intrigued with the possibility of hydrogen and it seems this alternative fuel does not get the attention of say, ethanol. From what I'm hearing it has many benefits and few drawbacks than ethanol, not to mention the food or fuel debate doesn't exist with hydrogen. I think we should all examine this option thoroughly."</i></p>	<p><i>"Hydrogen right now has no pros. There is such a high cost for the infrastructure \$3 million or more and really no hydrogen vehicles have been deployed at this time. With the big push for electric there may never be enough hydrogen vehicles for a station owner to build hydrogen infrastructure..."</i></p> <p><i>"I do not view hydrogen as a short term answer in our marketplace. With our present E85 locations, we do not see customers willingly driving extra miles to fill-up with that product, even when owning an FFV... Hydrogen may be an answer in highly-populated urban areas, but not in the rural communities that we supply."</i></p>

## Factors Affecting the Hydrogen Decision By 2015

**Factors with the biggest economic impact, such as tax credits, government subsidies, and co-funding/subsidies, are most influential when making the decision to enter the hydrogen market.**

Tax Credits	<p><i>"Tax credits are almost as good as profit! This would be highly motivating."</i></p> <p><i>"It would encourage us to move forward faster if it supported a case to improving profitability and supporting this product in the market."</i></p> <p><i>"It would help the cost of entry as well as sustaining the capital investment until demand grows."</i></p> <p><i>"It would have limited effect on our desire to implement."</i></p>
Gov't Subsidies	<p><i>"Government subsidies would help us to decide to invest, however, we all need to remember that the government subsidies came from our consumers and businesses like ours to begin with. I don't support additional subsidies if they are derived from a new tax or fee on the American people or businesses."</i></p> <p><i>"If government subsidies work to make the product price competitive with existing fuels then this would be a venture worth looking at. The buying public wants to be green. They just don't want to pay for it."</i></p> <p><i>"It would help the cost of entry as well as sustaining the capital investment until demand grows."</i></p>
Co-funding	<p><i>"Partnering with a provider that needs outlets to offer their product would be attractive to us."</i></p> <p><i>"If these types of programs create a competitive environment then there is potential."</i></p> <p><i>"(The influence is) slight on co-funding, high on subsidies."</i></p>
PR/Marketing	<p><i>"PR value is a moderate incentive but not a driving factor."</i></p> <p><i>"We market ourselves as a "green" company so PR would have value to us."</i></p> <p><i>"Becoming a dominant player and market leader would be secondary to our ability to be profitable."</i></p> <p><i>"Being first to a new product doesn't position you as the dominant player. It shows you have courage and faith. When things work you stand to profit. The downfall is you often have more expense in making it successful as you learn the pitfalls. Others coming in behind you get to learn from your mistakes."</i></p>
Carbon Credits	<p><i>"Carbon credits obviously have value...This would probably work best for an organization like ours if we could partner with a supplier."</i></p> <p><i>"The climate crisis can't be solved by buying offsets and claiming to be climate-neutral."</i></p> <p><i>"I do not see enough CC offset to warrant implementation."</i></p>

# IPHE INFRASTRUCTURE WORKSHOP

<b>Regulation Compliance</b>	<p><i>"As a retailer, we don't have the resources to have much impact on government regulation. If we could partner with a supplier that does, this would entice us to enter the market sooner."</i></p> <p><i>"We would comply with any mandate created through regulation. It may encourage us to close less profitable sites."</i></p> <p><i>"I see zero government regulation being passed to force us to offer hydrogen."</i></p>
<b>New Business Types</b>	<p><i>"Potential for new business types and incremental sales of convenience store products would be a high motivation to enter the hydrogen business early."</i></p> <p><i>"It would have medium (Influence). Transit fleets would require more expense for physical layout of construction and for greater storage space. "</i></p> <p><i>"Probably not (much influence). Transit fleets that are large enough to revamp their fleets are large enough to have their own fueling stations. Smaller fleets won't support the cost of installation."</i></p>
<b>Generate Electricity from the Fuel</b>	<p><i>"We are an end-user of electricity. To the extent that it would help us lower our cost of doing business we would be very supportive."</i></p> <p><i>"I would see this as more of a fit for our residential home heat and propane divisions. Making deliveries to homes equipped with hydrogen storage tanks."</i></p> <p><i>"(The influence) is very slight especially if now all of a sudden you become a regulated utility. Can we put it back on the grid and get paid for it?"</i></p>

## Reactions to Five Station Configurations

- The idea of selling alternative/renewable fuel in addition to conventional gasoline is appealing.
- The cost of entry, even on the least expensive option, is considered prohibitive by most participants. Without incentive, grants or subsidies, most of these options are not affordable. Features or incentives that help reduce the cost of entry, reduce O&M, and/or increase ROI enhance the overall appeal of all five configurations.
- While underground storage tanks (B) are preferred over the above ground storage cylinders (A) for their increased capacity, there are concerns regarding the regulations and liabilities of storing hydrogen underground. Some like the simplicity of storage the cylinders offer.
- On-site production (C & D) ensures consistent fuel supply but raises issues around the release of carbon dioxide as well as the regulatory hurdles for on-site production.
- Configuration E is most appealing when the off-site fuel cell is owned by the fuel company (alone or in a consortium) and the electricity can be sold back to the utility. This option ensure consistent inventory and helps reduce O&M expenses.
- Design suggestions for all stations
  - Smaller overall footprint
  - Larger footprint for retail. Inside sales necessary to support ROI.
  - Add E85 and remove one hydrogen pay point
  - Less obtrusive hydrogen infrastructure
  - Hydrogen dispensers on separate island

- “Green” hydrogen (made by “green” energy)
- Add canopy over dispensers

## Factors Influencing Interest

**When asked which features increase/decrease interest in these configurations, there is general agreement that any feature reducing the overall cost of entry and operational costs will positively impact perceptions.**

- Five years of subsidy for O&M costs have the most positive overall impact on the overall appeal of any station configuration for most participants.
- A regulation multiplier for early adopters (for example, 5x CO<sub>2</sub> credits) helps with the initial investment, but there are still concerns about ongoing operational expenses in this uncertain market.
- The ability to make heat/cooling and electricity for your business’s use or sell to the utility increases overall interest, particularly if the fuel cell is owned by the retailer, because it decreases operational costs and potentially increases ROI.
- From an economic perspective, serving more than 200 vehicles per day is essential for most models to be profitable, but most do not want to enter the market with a station this size. They are skeptical of initial 200 vehicle-a-day demand.
- Reducing the size of the footprint increases overall interest.
- The hydrogen production or delivery schedule and the ability to serve heavy duty vehicles or forklifts do not increase interest in this model.
- The ability to use waste products as fuel feedstock (e.g., wastewater, agricultural waste) does not greatly increase overall interest because it does not decrease costs or improve operations.

## Investment Co-op

**Respondents were shown the following table, representing the potential roll-out of hydrogen powered vehicles in the future and asked: If your needs for financing and co-funding were met, how many of your stations would offer hydrogen in your city by (year)?**

2010-2012	2013-2015	2016-2018	2019-2022
450	3,500	45,000	500,000

- Of the few respondents who answered this question, most agree they would enter the market slowly. Business and demand would be evaluated and stations added accordingly in subsequent years.

*“We would start with one station and evaluate its performance before additional stations would be built.”*

*“We would start with one location with limited dispensing.”*

# IPHE INFRASTRUCTURE WORKSHOP

- A consortium to help minimize the financial outlay and risk is appealing to respondents. Financial institutions, hydrogen producers, a local utility company, or energy supplier would be logical players in a consortium.

*"I would think there would be a lending institution or investment group, a hydrogen producer/and/or supplier, possibly a power company or local utility, an equipment supplier, possibly a large fleet owner or university that would be the 'buyer' once the station was constructed.*

## Appendix D – Business Case Scenarios

The hydrogen station business case scenarios presented here were prepared as materials for use in the online Fuel Retailer Focus Group. They were developed by NREL staff by modifying existing DOE H2A case studies to approximate near-term station costs and configurations. Costs were escalated from the H2A default costs with reference to near-term costs proposed in a recent industry stakeholder roadmap published by the Institute of Transportation Studies at the University of California Davis (*Roadmap for Hydrogen and Fuel Cell Vehicles in California: A Transition Strategy through 2017*, Ogden, Cunningham and Nicholas, UCD-ITS-RR-10-04, available online: <http://pubs.its.ucdavis.edu>). These estimates and proposed station configurations were developed specifically to stimulate discussion among participants in the Focus Group, and were not intended to inform actual business decisions or to be representative of future hydrogen stations in general. Additional information on the H2A models and downloadable H2A case studies are available online: [http://www.hydrogen.energy.gov/h2a\\_analysis.html](http://www.hydrogen.energy.gov/h2a_analysis.html).

# IPHE INFRASTRUCTURE WORKSHOP

## Station A: Hydrogen is delivered in tubes as a compressed gas

700 kg/day station serving 200 vehicles a day (85% equipment utilization)

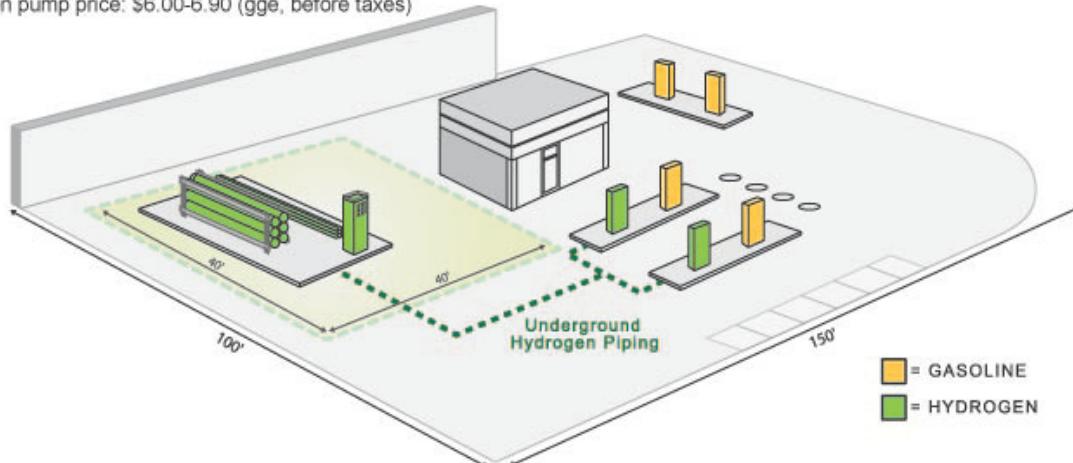
Filled tubes are delivered twice a day

Capital cost: \$3.7 million (equipment, site prep, installation)

Annual feedstock and O&M: \$940K

Annual anticipated revenue: \$1.45m

Hydrogen pump price: \$6.00-6.90 (gge, before taxes)



### About this station

Most of the hydrogen used today in refining, manufacturing and food processing is made from natural gas at a large steam methane reformer central production plant and delivered by truck or pipeline. In this station configuration, a truck delivers cylinders of compressed gaseous hydrogen twice a day. The cylinders would either stay on the back of the trailer or be mounted on a skid that the delivery driver would drop off. It does not involve unloading tubes one by one. Gaseous hydrogen can be made from high- or low-carbon energy sources, but we do not include carbon credits for this case. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	10% IRR	7% IRR	5% IRR
- Pump price of H <sub>2</sub> (with incentives*) (\$/gge)	6.70	6.30	6.00
- Pump price of H <sub>2</sub> (without incentives) (\$/gge)	6.90	6.40	6.1
- Payback period in years	7	9	11

Pump price is what the customer will pay, excluding taxes and including after-tax internal rate of return

\*Includes \$200,000 alternative fuel infrastructure tax credit

gge (gallon gas equivalent)—the energy in a kilogram of hydrogen is equivalent to the energy in a gallon of gasoline. Fuel cell vehicles are 2-3 times as efficient as a combustion engine, needing less fuel to travel the same number of miles.

### Cost Details

Capital cost:

Site preparation cost	\$ 934,000
Hydrogen storage & dispensing	\$ 2,279,000
NPV of replacement costs*	\$ 546,000

Total cost	\$ 3,759,000
------------	--------------

\*Replacement of compressors and dispensers after 10 years.

Annual cost:

Annual O&M	\$ 171,000
Electricity for storage and dispensing	\$ 30,000
Delivered hydrogen (@3.40/kg)	\$ 738,000
Annual total	\$ 939,000

### **Focus Group Responses to Station A**

**The above ground storage is polarizing – some like it as a simple storage solution while others dislike the above-ground aspect.**

Benefits	Drawbacks
<ul style="list-style-type: none"> <li>▪ Initial capital expense</li> <li>▪ Delivery of hydrogen as a compressed gas</li> <li>▪ Simple solution for hydrogen storage</li> <li>▪ Acceptable ROI</li> </ul> <p><i>"I see this as a good solution in big cities where space and power supply are limited."</i></p> <p><i>"It makes a healthy annual profit after expenses."</i></p> <p><i>"The only interest I would have would be in the drop-off nature of the replacement tubes."</i></p>	<ul style="list-style-type: none"> <li>▪ Initial capital expense</li> <li>▪ Daily truck load deliveries create potential for safety issues and possibility of running out of fuel</li> <li>▪ 40'x40' footprint too large</li> </ul> <p><i>"A cylinder exchange program is not the most appealing. There are multiple points of (potential) error that could result in the station not having product to sell. It is not very efficient because you have a human element involved and a potential safety issue with the cylinder delivery."</i></p>

### **Suggested Improvements**

- Permanent cylinders with refill option
- Lower total cost either through larger infrastructure tax credit or lower storage and dispensing cost
- Subsidies to help defray O&M costs

# I-PHE INFRASTRUCTURE WORKSHOP

Station B: Hydrogen is delivered and stored as a liquid, and dispensed as a gas

700 kg/day station serving 200 vehicles a day (85% equipment utilization)

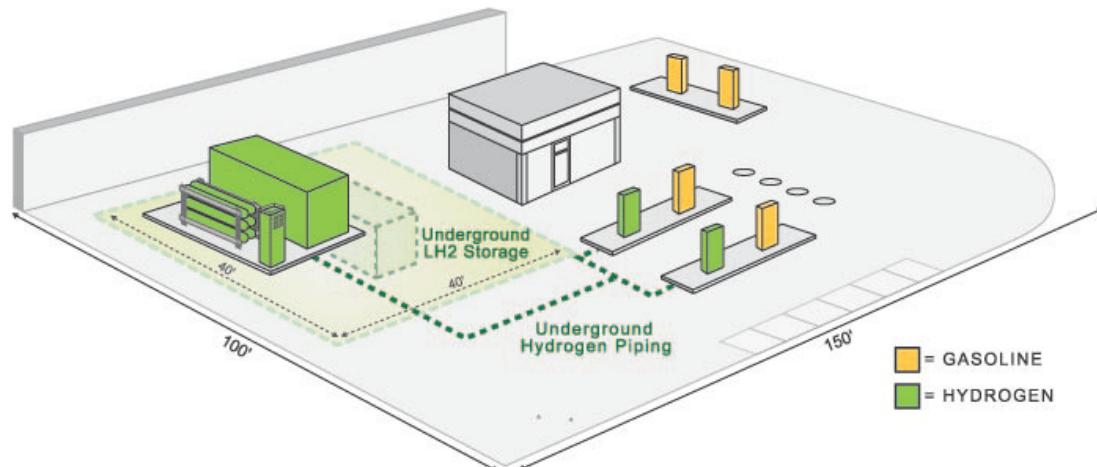
Hydrogen delivered once a week by tanker truck

Capital cost: \$2.0 million (equipment, site prep, installation)

Annual feedstock and O&M: \$1.0m

Annual anticipated revenue: \$1.1m

Hydrogen pump price: \$5.00-5.40 (gge, before taxes)



## About this station

Most of the hydrogen used today in refining, manufacturing and food processing is made from natural gas at a large steam methane reformer central production plant and delivered by tanker truck or pipeline. In this station configuration, a large underground tank holds liquid hydrogen in a vacuum—the tank does not need electricity to keep the hydrogen cold. Several times a day, the equipment automatically opens the tank to warm and compress the hydrogen, and then stores gaseous hydrogen in cylinders before it is dispensed into a vehicle. About once a week, a tanker truck refills the tank with liquid hydrogen. Liquid hydrogen can be made from high- or low-carbon energy sources, but we do not include carbon credits for this case. The codes and standards for underground liquid hydrogen at a retail station are currently being revised, and we have assumed here that setbacks will be similar to gaseous hydrogen. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	10% IRR	7% IRR	5% IRR
- Pump price of H <sub>2</sub> (with incentives*) (\$/gge)	5.20	5.10	5.00
- Pump price of H <sub>2</sub> (without incentives) (\$/gge)	5.40	5.20	5.10
- Payback period in years	8	10	12

*Pump price is what the customer will pay, excluding taxes and including after-tax internal rate of return*

*\*Includes \$200,000 alternative fuel infrastructure tax credit*

*gge (gallon gas equivalent)—the energy in a kilogram of hydrogen is equivalent to the energy in a gallon of gasoline. Fuel cell vehicles are 2-3 times as efficient as a combustion engine, needing less fuel to travel the same number of miles.*

# IPHE INFRASTRUCTURE WORKSHOP

## Cost Details

Capital cost:

Site preparation cost	\$ 934,000
Hydrogen storage & dispensing	\$ 713,000
NPV of replacement costs*	\$ 364,000
Total cost	\$ 2,011,000

\*Refurbishment of pump and replacement of dispensers after 10 years.

Annual cost:

Annual O&M	\$ 132,000
Electricity for storage and dispensing	\$ 30,000
Delivered hydrogen (@4.00/kg)	\$ 838,000
Annual total	\$ 1,090,000

## Focus Group Responses to Station B

**The larger underground hydrogen storage and lower start-up cost pique initial interest in this model.**

Benefits	Drawbacks
<ul style="list-style-type: none"> <li>▪ Lower initial cost</li> <li>▪ Underground storage</li> <li>▪ Larger storage capacity = higher daily volumes and fewer deliveries</li> </ul>	<ul style="list-style-type: none"> <li>▪ More expensive annual costs</li> <li>▪ Concerns about regulations surrounding underground storage of liquid hydrogen</li> <li>▪ Concerns regarding effects of storage container on different soil types and varying water tables</li> </ul>
<p><i>"The appeal of this configuration is the underground storage tank that requires fewer steps and less effort to maintain sufficient inventory versus station 'A'."</i></p> <p><i>"It seems logical that the most quickly adapted step would be 'B' where the hydrogen is stored as a liquid. We are already selling liquid fuels so maybe the conversion could be quick and cost effective."</i></p>	<p><i>"The lower capital expense is appealing but the high annual cost makes this scenario a non-starter."</i></p>

## Suggested Improvements

- Lower cost of entry/ lower annual costs/ improved IRR
- Higher pump price

# IPHE INFRASTRUCTURE WORKSHOP

## Station C: Hydrogen is produced onsite from natural gas or biogas

700 kg/day station serving 200 vehicles a day (85% equipment utilization)

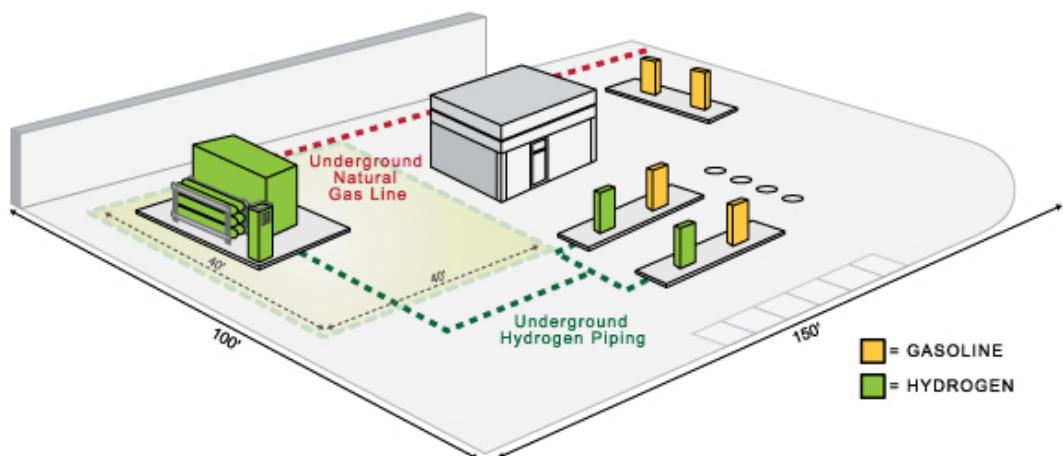
Capital cost: \$7.2 million (equipment, site prep, installation)

Annual feedstock and O&M: \$585k

Annual anticipated revenue: \$1.6m

Hydrogen price at pump: \$5.90-7.50 (gge, before taxes)

LCFS carbon credit: \$50/metric ton



### About this station

Hydrogen is produced onsite from natural gas or biogas that is supplied from a pipeline to an above-ground reformer. The gaseous hydrogen is compressed and stored in above-ground tubes until it is dispensed into a vehicle. This method of producing hydrogen, called steam methane reforming (SMR), is the most common way to make hydrogen today. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

#### Financial Performance

	10% IRR	7% IRR	5% IRR
- Pump price of H <sub>2</sub> (with incentives*) (\$/gge)	7.40	6.50	5.90
- Pump price of H <sub>2</sub> (without incentives) (\$/gge)	7.50	6.60	6.00
- Payback period in years	7	9	10

(all explanations as in earlier business cases)

#### Cost Details

Capital cost:

Site preparation cost	\$ 934,000
On-site production cost	\$ 1,370,000
NPV of replacement costs*	\$ 714,000
Hydrogen storage & dispensing	\$ 4,162,000
Total cost	\$ 7,180,000

\*Replacement of reformer catalyst, refurbishment of equipment, replacement of compressor and dispensers after 10 years.

# IPHE INFRASTRUCTURE WORKSHOP

Feedstock prices (for station owner):

Natural gas (\$/mmBtu)		\$ 7.00
Premium for renewable biogas (\$/mmBtu)		\$ 4.00
Grid electricity (\$/kWh)		\$ 0.082

Annual costs:

	1	2	3	4
<b>Fuel Pathway</b>	Natural gas, no carbon credit	Natural gas, carbon credit	33% biogas content in NG*, carbon credit	100% biogas content in NG*, carbon credit
Annual O&M	\$ 289,000	\$ 289,000	\$ 289,000	\$ 289,000
Natural gas and electricity for reformer	\$ 260,000	\$ 260,000	\$ 302,000	\$ 393,000
Electricity for storage and dispensing	\$ 36,000	\$ 36,000	\$ 36,000	\$ 36,000
Carbon credit (\$50/metric ton)	0	(\$ 85,000)	(\$ 126,000)	(\$ 192,000)
Annual total	\$ 585,000	\$ 500,000	\$ 501,000	\$ 526,000

\* Renewable percentages refer to the biogas content of natural gas used to produce hydrogen.

## Focus Group Responses to Station C

The most appealing feature of this model is the underground storage line that eliminates concerns of running out of hydrogen. However, the \$7mm cost of entry may put this option out of reach.

Benefits	Drawbacks
<ul style="list-style-type: none"> <li>▪ Lower initial cost</li> <li>▪ Underground storage</li> <li>▪ On-site hydrogen production for better inventory management</li> </ul>	<ul style="list-style-type: none"> <li>▪ More expensive annual costs</li> <li>▪ Perception that SMR releases high amounts of carbon dioxide.</li> <li>▪ Capital expense</li> <li>▪ Regulation and liabilities associated with onsite production</li> </ul>
<p><i>"The most appealing feature is the underground storage line that limits the amount of product stored by the retailer without causing concern for running out of stock."</i></p>	<p><i>"It is my understanding that this method releases a lot of carbon dioxide and that, for us, negates the value of a hydrogen vehicle. I am intrigued by the onsite product but would be concerned, especially in California, about regulatory hurdles and higher insurance for onsite production."</i></p> <p><i>"The \$7mm cost of entry makes this configuration un-doable for the standard c-store operator/owner."</i></p>

## Suggested Improvements

- Lower cost of entry/ lower annual costs/ improved IRR
- Produce less CO<sub>2</sub>

# I-PHE INFRASTRUCTURE WORKSHOP

## Station D: Hydrogen is produced onsite using electricity and water

700 kg/day station serving 200 vehicles a day (85% equipment utilization)

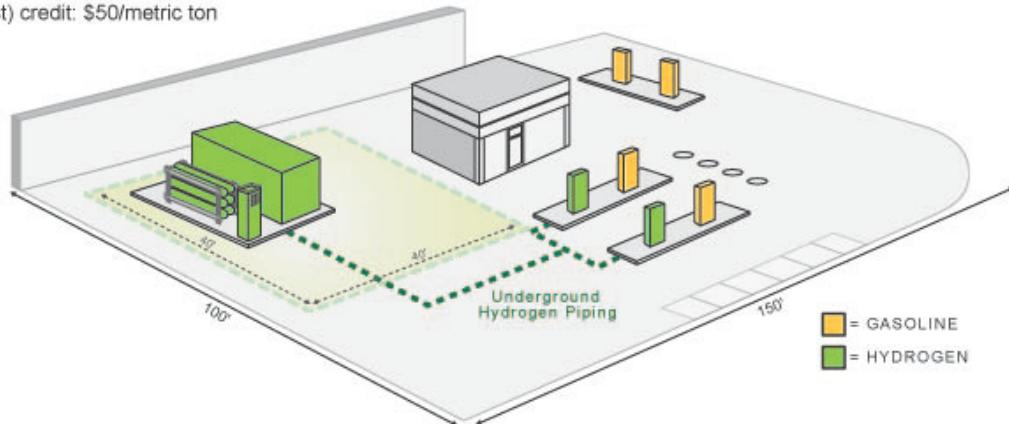
Capital cost: \$8.5 million (equipment, site prep, installation)

Annual feedstock and O&M: \$1.8m

Annual anticipated revenue: \$2.2m

Hydrogen pump price: \$8.50-10.40 (gge, before taxes)

LCFS carbon (cost) credit: \$50/metric ton



### About this station

Hydrogen is produced onsite using water and electricity. Deionized water and electricity from the grid or a renewable source are fed into an electrolyzer. The electricity splits water into hydrogen and oxygen. The oxygen is released into the atmosphere. The hydrogen is compressed and stored in cylinders until it is dispensed into a vehicle. Electrolysis using all or partially renewable electricity can earn carbon credits, but using average U.S. grid electricity can result in paying carbon costs. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

### Financial Performance

	10% IRR	7% IRR	5% IRR
- Pump price of H <sub>2</sub> (with incentives*) (\$/gge)	10.30	9.20	8.50
- Pump price of H <sub>2</sub> (without incentives) (\$/gge)	10.40	9.30	8.60
- Payback period in years	7	8	9

### Cost Details

Capital cost:

Site preparation cost	\$ 934,000
Cost of electrolyzing equipment	\$ 2,617,000
NPV of replacement costs*	\$ 800,000
Hydrogen storage & dispensing	\$ 4,162,000
Total cost	\$ 8,513,000

\*Refurbishment of electrolyzer and replacement of compressors and dispensers after 10 years.

Feedstock prices (for station owner):

Grid electricity (\$/kWh)	\$ 0.082
Premium for renewable electricity (\$/kWh)	\$ 0.02

# IPHE INFRASTRUCTURE WORKSHOP

Annual costs:

	<b>1</b>	<b>2</b>	<b>3</b>
<b>Feedstock Pathway</b>	Grid electricity, no carbon credit	Grid electricity*, carbon cost	Renewable electricity, carbon credit
Annual O&M	\$ 279,000	\$ 279,000	\$ 279,000
Electricity for electrolyzer	\$ 601,000	\$ 601,000	\$ 878,000
Electricity for storage and dispensing	\$ 22,000	\$ 22,000	\$ 22,000
Carbon credit or penalty (\$50/metric ton)	0	\$ 245,000	(\$ 217,000)
Annual total	\$ 902,000	\$ 1,147,000	\$ 962,000

\* Based upon the carbon intensity of the average U.S. grid. Regions with higher or lower carbon intensities would have higher or lower carbon cost penalties.

## **Focus Group Responses to Station D**

The \$8mm cost of entry makes this configuration unacceptable to participants.

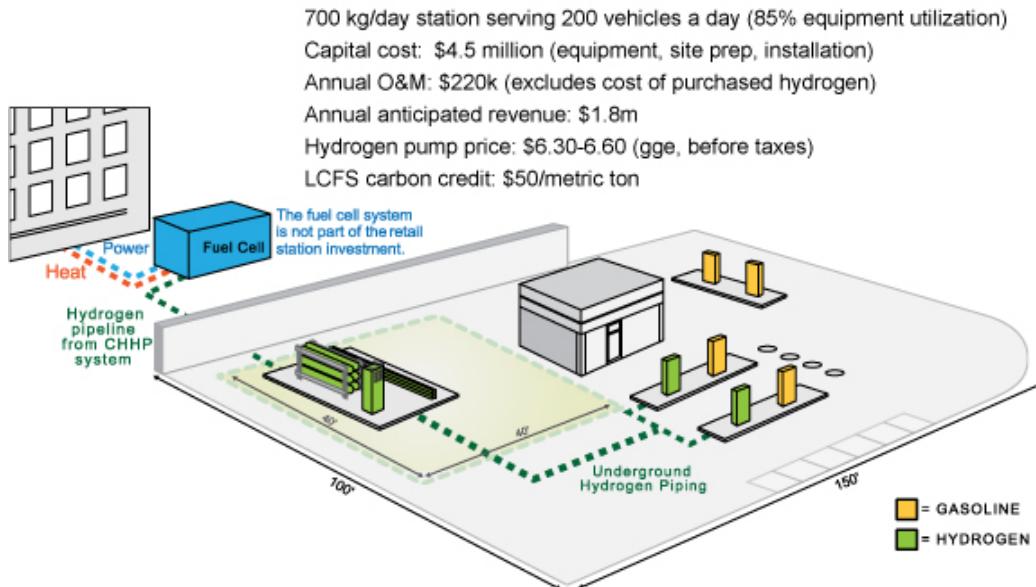
Benefits	Drawbacks
<ul style="list-style-type: none"> <li>▪ On site production of hydrogen to ensure consistent supply</li> <li>▪ Underground piping</li> </ul>	<ul style="list-style-type: none"> <li>▪ Capital expense</li> <li>▪ Operational expense</li> <li>▪ Polluting power supply (electricity pulled off the grid)</li> <li>▪ \$8 - \$10 per gge pump price</li> </ul> <p><i>"Why would anyone choose to spend \$8mm for the privilege of dispensing hydrogen at an average price of \$8- \$10 per gge?"</i>  <i>"For the \$8mm price tag, we could build 4-5 new large format c-stores on very high traffic corners and strengthen our market presence, therefore improving our chance of survival. There are better ways for us to invest the capital than in a single hydrogen facility with (initially) low demand."</i>  <i>"The cost of generated electricity is spiking in this market. It will be difficult to create a model where this is competitive."</i></p>

## **Suggested Improvements**

- Lower cost of entry or upfront grants
- Lower annual cost
- Wind and/or solar power supply

# IPHE INFRASTRUCTURE WORKSHOP

Station E: An offsite fuel cell uses natural gas to produce electricity, heat and hydrogen



## About this station

A CHHP system uses a stationary fuel cell to create electricity, heat and hydrogen from natural gas or biogas. The heat (or cooling) and power are used in the building and hydrogen is sent to the station via an underground pipeline. The gaseous hydrogen is compressed and stored in cylinders before it is dispensed into a vehicle. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

This configuration assumes that a nearby business, such as a hospital or office building, owns the CHHP system and sells the hydrogen to the station. A CHHP unit could be installed at a big box store or manufacturing facility to provide heat, power and fuel.

Financial Performance	10% IRR	7% IRR	5% IRR
- Cost of H <sub>2</sub> purchased by station owner (\$/gge)	4.60	3.90	3.40
- Pump price of H <sub>2</sub> to customers (with incentives*) (\$/gge)	8.40	7.10	6.30
- Pump price of H <sub>2</sub> to customers (without incentives) (\$/gge)	8.60	7.20	6.40
- Payback period in years	8	10	12

## Cost Details

Capital cost:

Site preparation cost	\$ 934,000
Onsite production cost	N/A
NPV of replacement costs*	\$ 545,000
Hydrogen storage & dispensing	\$ 2,985,000
Total cost	\$ 4,464,000

\*Replacement of compressor and dispensers after 10 years.

# IPHE INFRASTRUCTURE WORKSHOP

Feedstock prices (for station and/or fuel cell owner):

Natural gas (\$/mmBtu)		\$ 7.00
Premium for renewable biogas (\$/mmBtu)		\$ 4.00
Grid electricity (\$/kWh)		\$ 0.082

Annual costs:

	1	2	3	4
Fuel Pathway	Natural gas, no carbon credit	Natural gas, carbon credit	33% biogas content in NG*, carbon credit	100% biogas content in NG*, carbon credit
Annual O&M	\$ 184,000	\$ 184,000	\$ 184,000	\$ 184,000
Natural gas and electricity onsite production	N/A	N/A	N/A	N/A
Hydrogen purchased from fuel cell owner	\$ 1,001,000	\$ 1,001,000	\$ 1,116,000	\$ 1,351,000
Electricity for storage and dispensing	\$ 36,000	\$ 36,000	\$ 36,000	\$ 36,000
Carbon credit (\$50/metric ton)	0	(\$ 26,000)	(\$ 79,000)	(\$ 186,000)
Annual total	\$ 1,221,000	\$ 1,195,000	\$ 1,257,000	\$ 1,385,000

\* Renewable percentages refer to the biogas content of natural gas used to produce hydrogen.

## Focus Group Responses to Station E

This configuration is more appealing when the retail operation assumes ownership of the fuel cell, decreasing risks associated with production and supply and increasing potential financial benefits.

Benefits	Drawbacks
<ul style="list-style-type: none"> <li>▪ Lower cost of entry</li> <li>▪ Generating hydrogen</li> </ul> <p><i>"Generating hydrogen through the use of a fuel cell is both interesting and appealing to our business."</i></p> <p><i>"What are the costs of the fuel cell? If we could own that and make electricity and hydrogen on demand, that would be very appealing."</i></p> <p><i>"It could be more appealing if there were an underground pipeline capable of distributing hydrogen to the retail station or some other back-up system, in the event that something goes awry with the co-op program. Retail business cannot afford to be out of their primary products."</i></p>	<ul style="list-style-type: none"> <li>▪ Reliance on another entity to provide fuel</li> </ul> <p><i>"The prospect of being reliant on another entity to provide the fuel for sale at retail at an adjoining station seems to be a risk."</i></p>

## Suggested Improvements

- Owning the fuel cell with ability to sell additional electricity back to utility
- Reducing cost of entry/lower O&M cost/improved IRR

# IPHE INFRASTRUCTURE WORKSHOP

## Appendix E – Detailed Outputs from Breakout Groups

### Breakout Group 1

#### DISCUSSION SESSION 1: Actions, Strategies, Business Models, or Approaches that Will Motivate or Enable Near-Term Hydrogen Fueling Station Construction

##### Government Incentives and Policies

- Offset hydrogen price with subsidies until it becomes cost competitive.
- Establish a carbon trust fund to provide a stable funding for portfolio, with those who succeed paying back to the fund.
- Expand military and other federal programs, e.g. mail, Post Exchange fuel.
- Determine what percentage of station cost is needed as an incentive.
- Tie funding levels to performance, cost, location quality, and accessibility.
- Establish consistent incentives and messaging from governments on energy and transportation policies to send signals to industry and consumers
- Develop whole pathway policies that include both vehicles and infrastructure.

##### Information, Education, and Training for Retailers and Customers

- Educate legislators and consumers on the environmental aspects of all fuels (wells-to-wheels impact) and the true cost of fuels.
- Develop a clear roadmap of "station first, vehicles later," which is the model used in Japan.

##### Other Risk Sharing or Reducing Strategies

- Establish a "line of sight" to a commercial hydrogen station with a timeline and roadmap (commercial = profitable and practical).
- Bring OEMs to consensus on a common dispensing option—350 bar, 500 bar, 700 bar or CcH<sub>2</sub>—so station owners can develop a common station configuration.

##### Novel Business Concepts

- Share risk by having Google coordinate or broker hydrogen availability for customers in the form of a co-op or some new business model they create.
- Serve multiple applications—including vehicles, forklifts, fleet vehicles, and stationary fuel cells—to build station volume.
- Partner with a credit card company to remove fees for hydrogen sales, saving the retailer money.
- Establish a "library mobile" model for hydrogen fueling from mobile refueler.

##### Build End User Demand

- Give parking permissions in restricted areas and access in city centers.

# IPHE INFRASTRUCTURE WORKSHOP

## Early Market Strategies

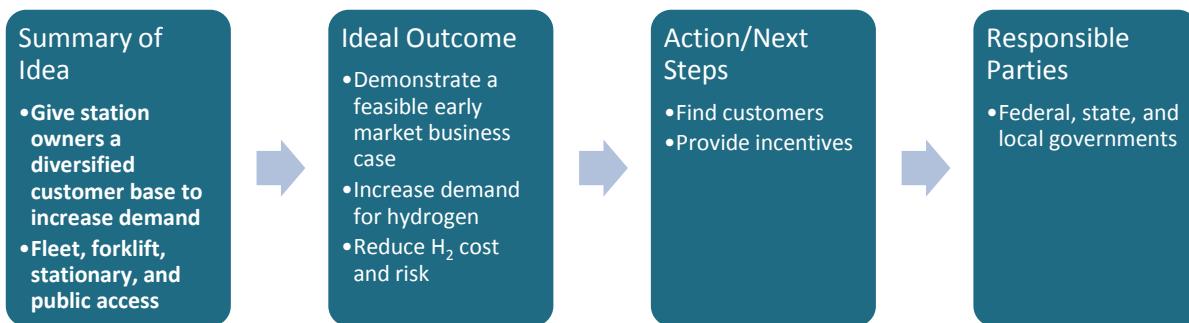
- Offer an attainment zone—airport, seaport, or resource board incentive.
- Look for businesses that want to attract "greenies" as first movers.
- Identify early adopters among retailers of gasoline (or other) via outreach bid-box.

## Entry Level Station Configurations

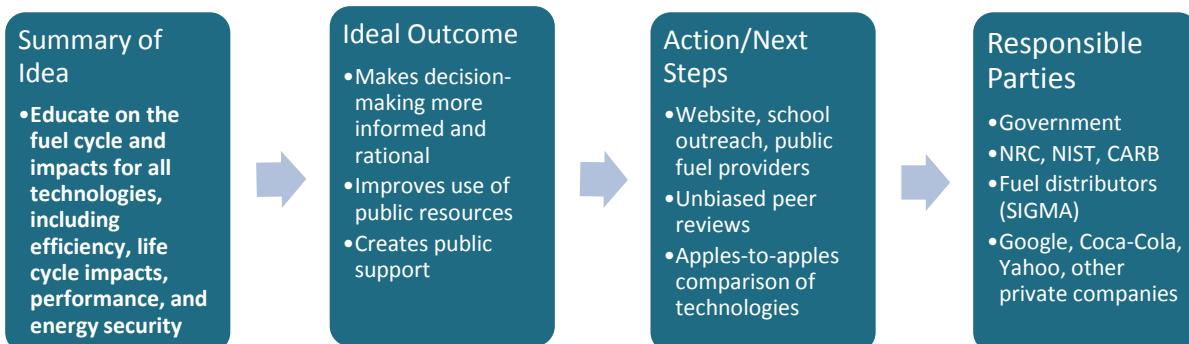
- Attract low-cost, small (100 kg/day) stations that can be sited in initial years and moved as demand grows.
- Develop and build "starter stations" that have low capital costs.
- Build an anchor store that fuels fleet vehicles and is also open to the public.
- Start by adding one hydrogen pump at retail stations, then convert gas pumps to hydrogen over time as demand grows.
- Develop several design and hydrogen delivery models for stations with small usage, low footprint, and low capital cost, and share technical know-how about what works.
- Use liquid hydrogen delivery in both the short-term and long-term.

## SESSION 2: Analysis of Top Priority Activities – Breakout Group 1

**Idea #1: Serve multiple applications to build station volume. Provide configuration that fuel both stationary applications and vehicles.**

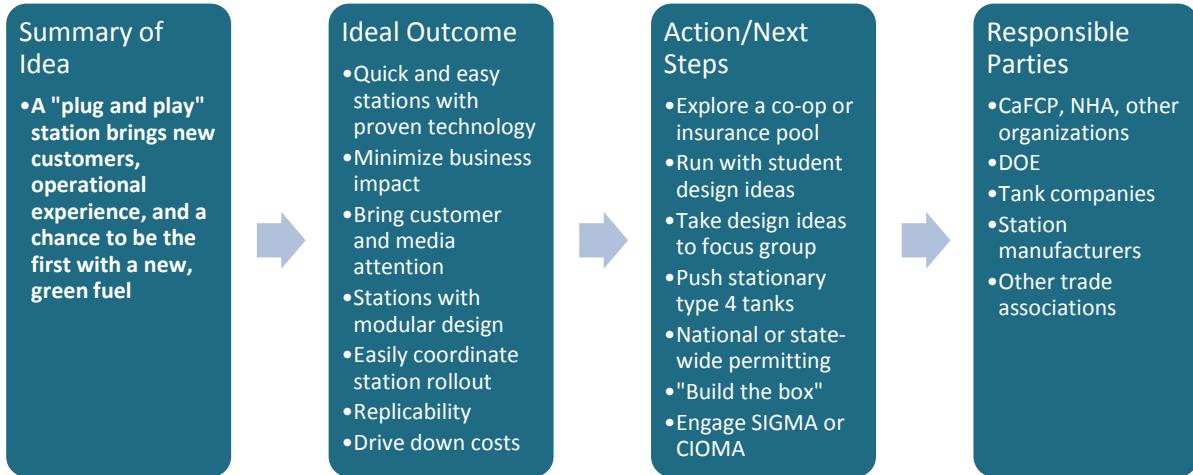


**Idea #2: Educate legislators and consumers on the environmental aspects of all fuels, including wells-to-wheels impacts and the true cost of fuels.**

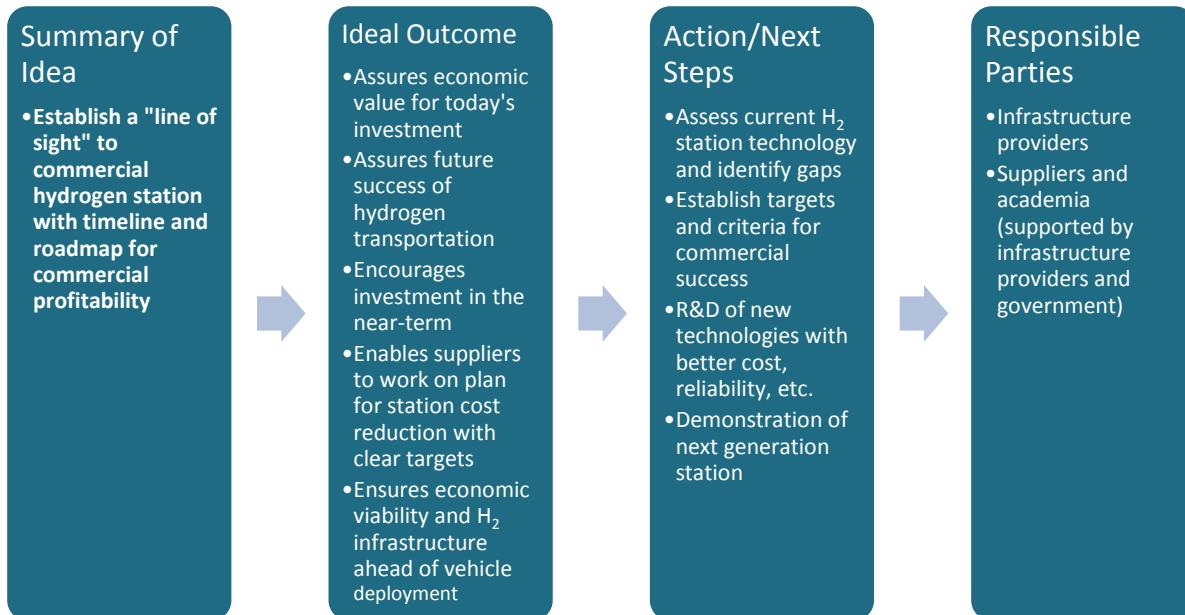


# IPHE INFRASTRUCTURE WORKSHOP

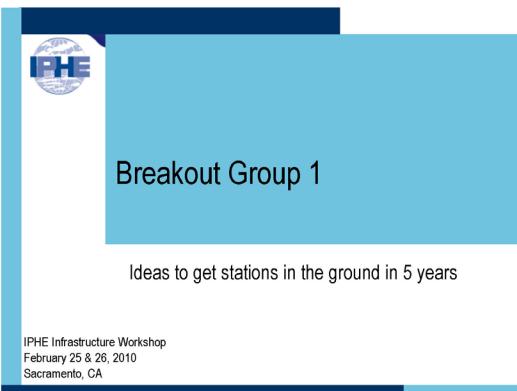
**Idea #3: Attract low-cost, small (100 kg/day) starter stations that can be sited in initial years and moved as demand grows. Stations should have low capital cost for installation support R&D of suppliers and equipment providers, and allow savvy business folk to execute.**



**Idea #4: Establish a "line of sight" to commercial hydrogen station with a timeline and a roadmap for commercial profitability.**



## Summary Presentation – Breakout Group 1



### Most important points

- Retailers need to see a path to profitability
- Education is key
- Limit the gamble
- Increase the customer base
- Mutual commitment and coordination
- Greenies may drive the investment

### Ideas that are easy

- Website comparing all alt fuels
  - AAA Project Greenlight (CARB to get ball rolling)
- Building a starter station
  - Station manufacturers (with input and feedback)
- Establish a line of sight to profitability for station owners
  - Infrastructure providers with govt & academia input

### Ideas that are not so easy

- Diversify the customer base around a fueling site (transit, forklift, stationary)
  - Government, USFCC
- Form an investment pool (Co-op, Carbon Trust, credit trading)
  - Industry and government
- Identify early adopter businesses to host stations
  - Associations, govt, OEMs, station builders

### Ideas that need exploring

- Waive credit card fees at stations that sell H2
  - Reduces retailer's overall cost to offset capital expense
- Large business as a "broker" (e.g. Google)
  - Business co-op as an alternative to fleet
- Car dealership endorses station to all vehicle buyers (gas card, advertising)
  - Increases new customers (including gas and diesel) to help offset capital costs of H2
- Identify the stations—GPS, highway signs, iPhone app

### Next steps

- Starter station model—the box, the handbook, the line of sight
  - Station manufacturers this year
  - Funding to do this
  - OEMs
- Get the website ball rolling
  - CARB
- Identify early adopter green businesses
  - Everyone's marketing and sales people

## Breakout Group 2

### DISCUSSION SESSION 1: Actions, Strategies, Business Models, or Approaches that Will Motivate or Enable Near-Term Hydrogen Fueling Station Construction

#### Government Incentives and Policies

- Provide 80% government cost share (including operational cost) for the first station roll out.
- Use government mandates to force the development of hydrogen stations.
- Court big-box stores and award a large grant for multiple stations to the winner of a competitive bid.
- Create and fund a state revolving low-interest loan fund for hydrogen station deployment.
- Develop "green bonds" to enable the private sector.
- Establish a gas tax to raise the price of gasoline and make hydrogen more competitive.
- Establish government fuel cell vehicle fleets and refueling networks.
- Simplify the permitting process to reduce cost.
- Create a goal to reduce greenhouse gas emissions by 80% in 2050.

#### Information, Education, and Training for Retailers and Customers

- Provide a rationale for moving aggressively to hydrogen through a public information campaign.
- Educate fuel retailers by demonstrating a prototype portable station to targeted retailers.
- Increase consumer familiarity with hydrogen and fuel cells, utilizing demonstrations, deployments, and school programs.

#### Other Risk Sharing or Reducing Strategies

- Deploy stations that service multiple end uses, including forklifts, cell towers, CHHP, and a growing vehicle fleet.
- Quantify the number of vehicles to be deployed by 2014.
- Fund refueling technology R&D for innovative systems to achieve economic and scalable solutions.

#### Novel Business Concepts

- Identify an attractive "hook" to pair with hydrogen fueling to bring customers to the station.
- Fund refueling at car dealerships.
- Begin home or office refueling.
- Establish a co-op that owns a station's hydrogen, and when a customer purchases a fuel cell vehicle, they also pay to be a co-op member.
- Establish a fund to write off loan repayment after a certain number of years, provided the retailer has met all the requirements.
- Create the opportunity to sell and buy hydrogen over the Internet, enabling retailers to purchase based on price.
- Give first-time buyers of fuel cell vehicles a voucher for hydrogen fuel for a specified amount of time.
- Provide fueling service to customers via a hydrogen delivery truck that runs all day and can service multiple applications.

# IPHE INFRASTRUCTURE WORKSHOP

## Global Partnerships across Groups

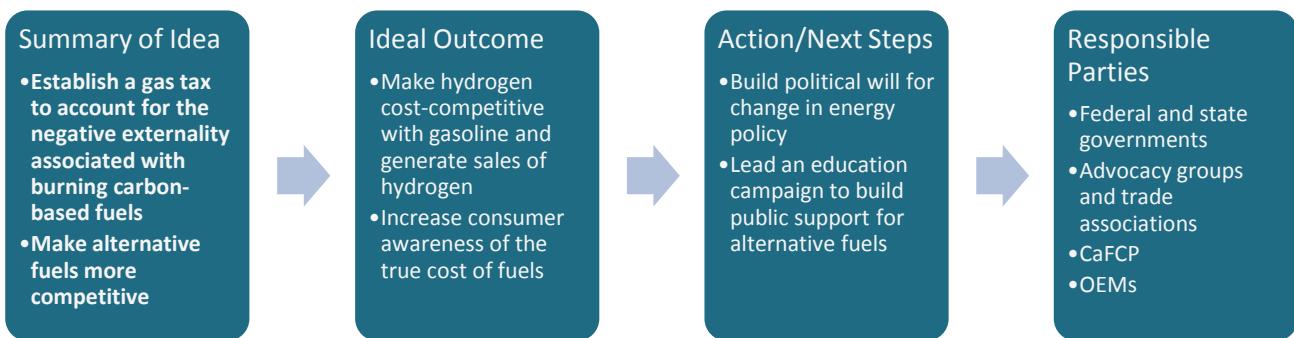
- Form a global alliance or expand the H2 Mobility Initiative to the United States, and involve interested parties, like Google.
- Partner with electric vehicle stakeholders and CHP advocates.

## Entry Level Station Configurations

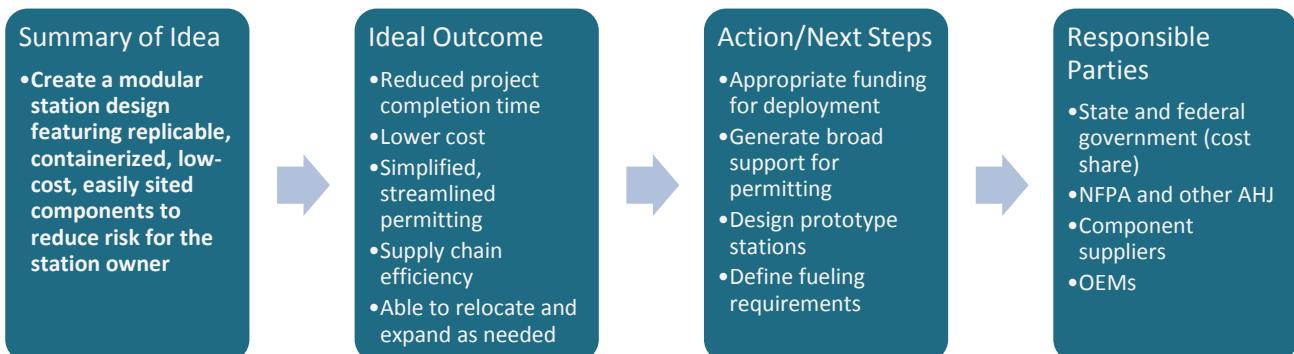
- Create a modular station design that looks permanent, can be expanded, has a small footprint, and is attractive to the station owner.
- Create a mobile tank with a dispenser that can be connected to a building.
- Adapt existing stations with minimal impact (e.g. on rooftops).
- Utilize as much existing hydrogen infrastructure as possible, by placing hydrogen stations close to existing refineries where hydrogen is ready.

## SESSION 2: Analysis of Top Priority Activities – Breakout Group 2

### Idea #1: Generate demand for hydrogen and other alternative fuels by establishing a tax on gasoline, incorporating the negative externality imposed by burning fossil fuels.

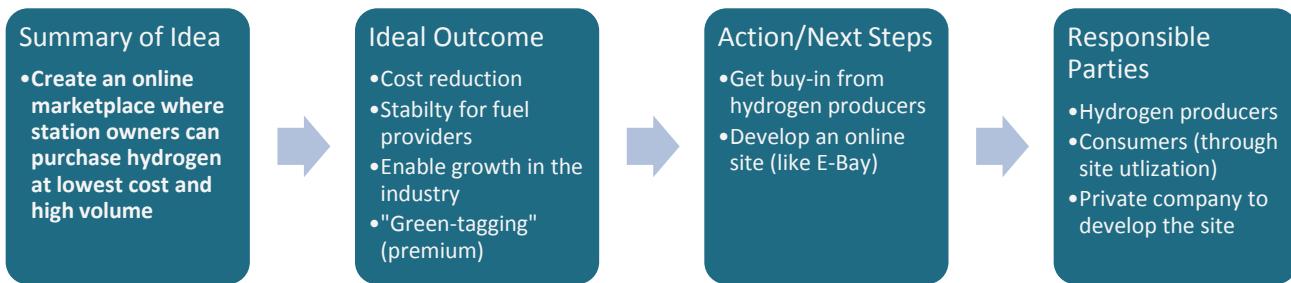


### Idea #2: Design modular, low-cost stations to reduce capital cost and mitigate risk for the station owner.

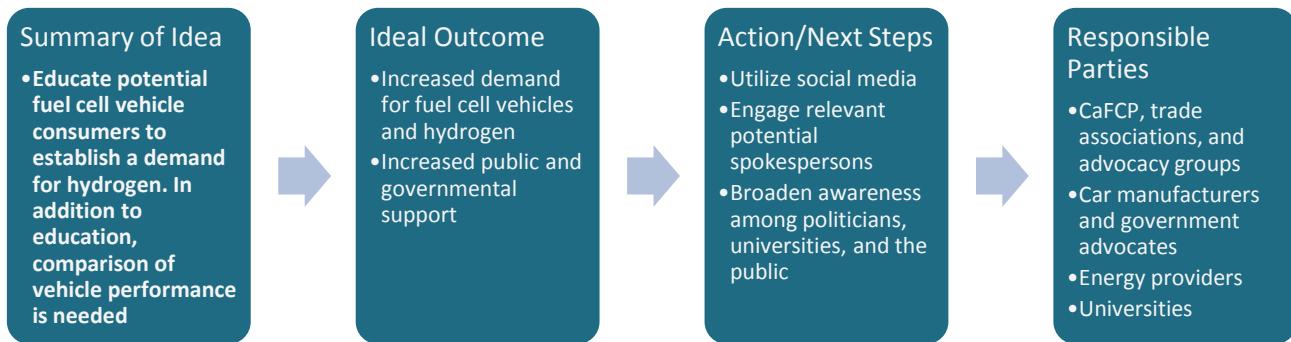


# IPHE INFRASTRUCTURE WORKSHOP

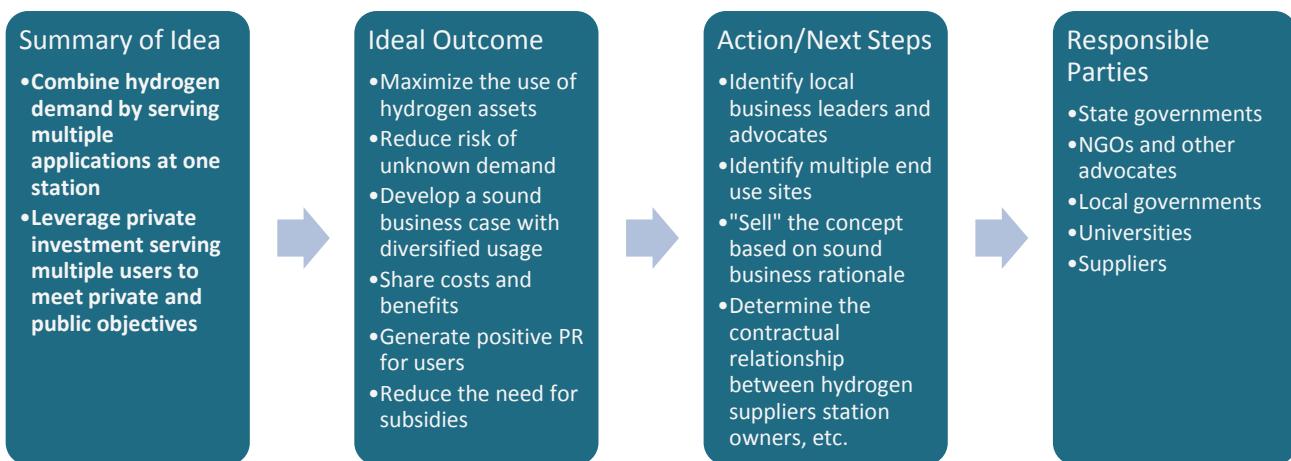
## Idea #3: Create an online marketplace for selling hydrogen to increase competition and reduce cost.



## Idea #4: Educate potential fuel cell vehicle consumers to create demand for hydrogen.

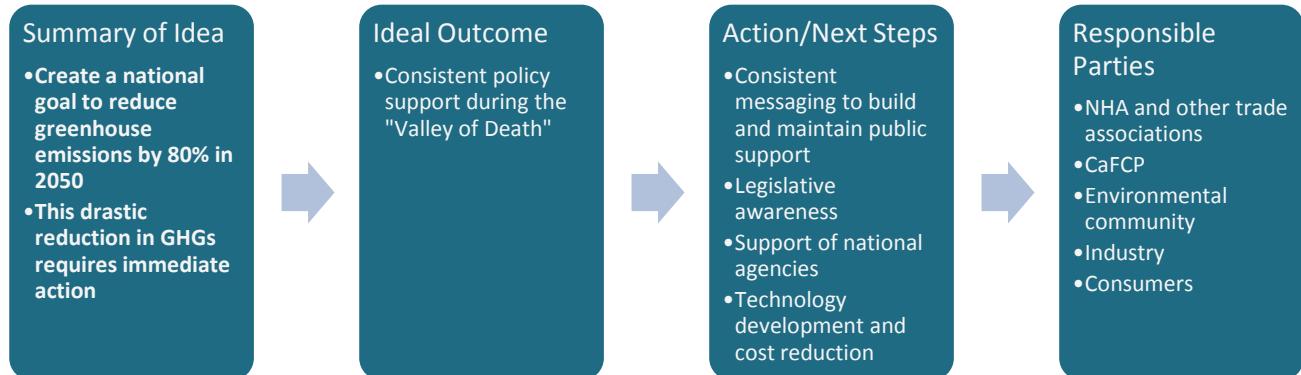


## Idea #5: Increase hydrogen demand by combining multiple fuel cell applications, creating a viable business case for hydrogen stations.

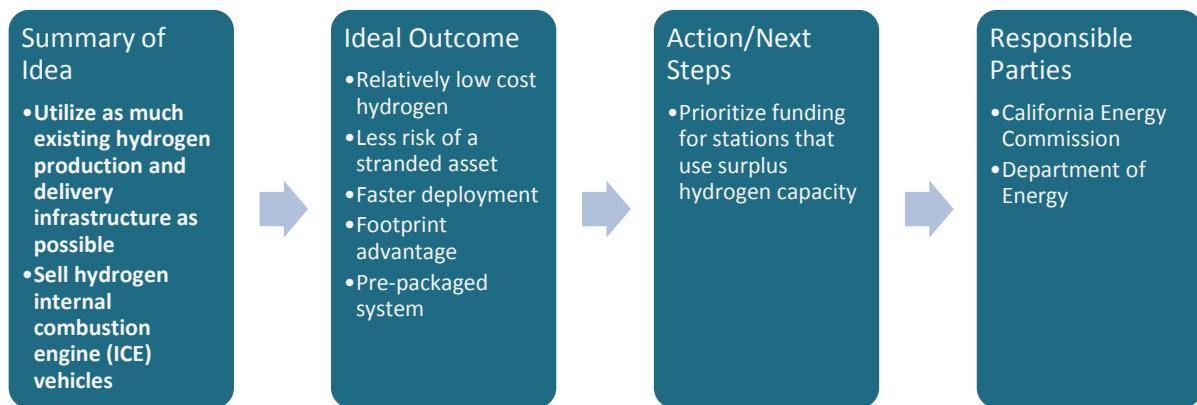


# IPHE INFRASTRUCTURE WORKSHOP

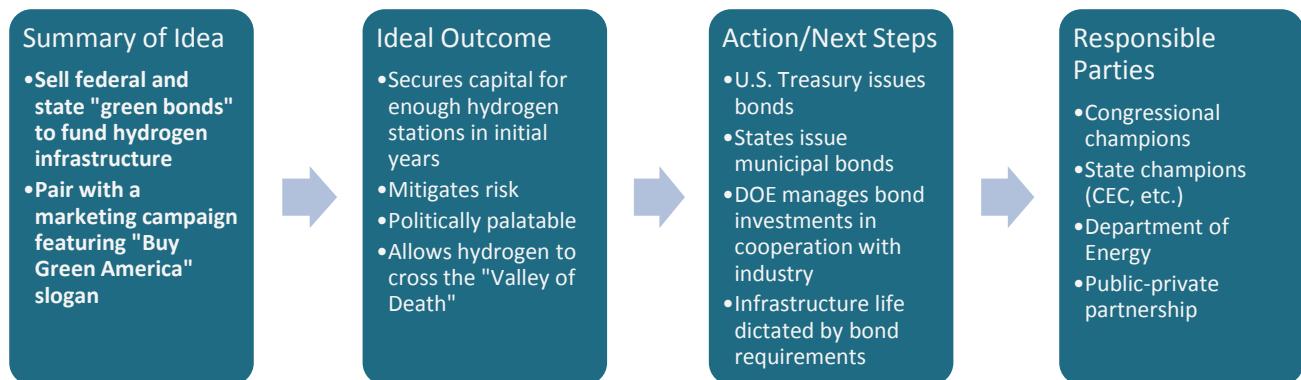
## Idea #6: Create a national goal to reduce greenhouse gas emissions by 80% in 2050—“80 by 50”



## Idea #7: Utilize as much existing hydrogen infrastructure as possible to lessen the need for new capital.



## Idea #8: Sell “green bonds” to secure capital for stations and mitigate the need for additional subsidies.



## Summary Presentation – Breakout Group 2



The slide features the IPHE logo at the top left. The title "Breakout Group 2" is centered in a large blue box. Below the title, the speaker's name "Mark Ruth, NREL" is listed. At the bottom, there is a small text block: "IPHE Infrastructure Workshop February 25 & 26, 2010 Sacramento, CA".

### Ideas that are relatively easy

- Combine H2 demand by multiple-sector users to create a viable business case for a H2 fueling station (e.g., CHHP, cell towers, fork lifts)
  - Market driven solution leverages private investment
- Next Steps:
  - Identify local champions; multiple end use sites; convince them to "sell the concept" based on sound business rationale
  - Determine contractual relationship
  - Universities, states, NGOs, state/local governments, OEMs, etc.

### Most important points

- Winning business models must be developed – all stakeholders must work together to create them!
- Simplicity and ease of siting – standardization and repeatability
- Political will is required – sustained support for the technology (H2) is/are needed
- Clear and concise – factual – information is needed
  - "Why Hydrogen?"

### Ideas that are relatively easy

- Modular station design with retail feel
  - Containerized, either produced on-site or delivered
  - All inclusive & turn key
  - Easily sited/permited
- Next Steps:
  - Appropriate funding for deployment (State & federal government)
  - Broad-based support for permitting (NFPA, AHJ, Federal oversight, etc.)
  - Design (suppliers)
  - Definition of fueling requirements (OEMs)

### Ideas that are relatively easy

- Educate potential FCV customers to create market pull
  - Beyond education, performance needs to be compared
  - Utilize social media
- Next Steps:
  - Engage relevant spokespersons
  - Broaden awareness among politicians, universities, general public
  - CaFCP, NHA, CHBC, car manufacturers, energy providers, universities

# IPHE INFRASTRUCTURE WORKSHOP

## Ideas that are relatively easy (or hard)

- Develop Green Bonds – “Buy Green America”
  - U.S. Treasury, State, and/or municipality issues bonds
- Next Steps:
  - Identify Congressional champions
  - DOE manages G-bond investments in cooperation with industry/stakeholders
  - Infrastructure must be permanent, not demonstration

## Ideas that are hard to do

- “80 in 50” – 80% GHG Reduction by 2050
  - A mandate – not just a goal
  - Requires immediate action to meet long-term goals
  - Consistent messaging to build and maintain public support
  - Legislative awareness
  - National agency support
  - NHA and all other trade associations
  - Consumers, industry, and “enviro-community”

## Ideas that are hard to do

- Sell H2 on the Internet
  - Wholesale, retail markets
  - Buy-in from H2 producers
  - Develop on-line site (“H2-Bay”)
  - Privately-funded initiative for consumers who purchase on-line
  - Various pricing schemes needed

## Next steps

- Immediate next step (0-12 months):
  - Identify funding for business cases and construction support
  - Find the funding for consistent, long-term PR and education – build on DOE, CEC and CARB funding
  - Broaden awareness, create a sense of urgency through major PR and education effort
  - Develop strong, national political alliances (White House/DOE)
  - Use existing alliances to plan and carry out a statewide education effort
  - Identify and highlight existing/planned green H2 projects

## Next steps

- Mid-term step (2011-2014):
  - Standardize design and production process
  - Work more closely with retailers, station owners
  - Diversify outlets – line up at least one “big box” store for a strong alliance and other options such as home delivery
  - Address permitting requirements across the State
  - Create a sense of urgency through major PR and education effort
  - Maintain political alliances



Questions?

## Breakout Group 3

### Discussion Session 1: Actions, Strategies, Business Models, or Approaches that Will Motivate or Enable Near-Term Hydrogen Fueling Station Construction

#### Government Incentives and Policies

- Establish long-term government subsidies and incentives until a viable business plan can be established
- Implement a 75% cost-share on stations that can grow from 100 kg/day to 1,000 kg/day over six years
- Regulate energy companies on clean fuels and establish restrictions on driving gasoline-fueled vehicles
- Standardize the permitting process to facilitate installation
- Create special awards for early investment innovation
- Give a “Made in the USA” premium to fund hydrogen refueling stations
- Consider vehicle and infrastructure government policies through 2025 on an international basis
- Create large government investment in one focused showcase market
- Require a certain percentage of all new development to use CHHP and allow them to connect to the grid
- Give a peak power incentive for hydrogen as energy storage
- Establish a gasoline tax or a price floor for gasoline, or a carbon policy
- Rapidly accelerate the Zero-Emission Vehicle Mandate
- Establish a government-run risk pool to reduce liability
- Create a self-generation incentive for transportation fuel
- Reduce trade barriers to enable foreign investment

#### Information, Education, and Training for Retailers and Customers

- Market fuel cell vehicles as “EV Unplugged”
- Engage in general consumer education of hydrogen benefits
- Train and educate first responders
- Educate public officials and the press

#### Other Risk Sharing or Reducing Strategies

- Evaluate feasibility of setting up a risk-sharing consortium to supply hydrogen
- Produce and market hydrogen internal combustion engine vehicles to accelerate demand
- Allow retailers to be the dominant provider in a given area to ensure a faster return on investment
- Use a vehicle-to-grid option

#### Marketing Approaches

- Get the natural gas industry involved.
- Target existing fleet operators to adopt fuel cell vehicles to build critical mass of users.
- Develop a non-traditional channel to market, including big-box and grocery stores already using fuel cell technology for CHHP and forklifts.
- Engage the OEMs to send strong deployment signals.
- Highlight the smaller carbon footprint and environmental benefits of fuel cell vehicles.
- Show positive infrastructure cost compared to other options, such as electric vehicle charging.
- Demonstrate fuel cells and vehicles at high visibility sites.
- Lead by example: let politicians driving fuel cell vehicles.
- Work with groups that will gain from FCVs, including OEMs, fuel providers, and equipment vendors
- Have TOTAL initiate hydrogen activity in the US.

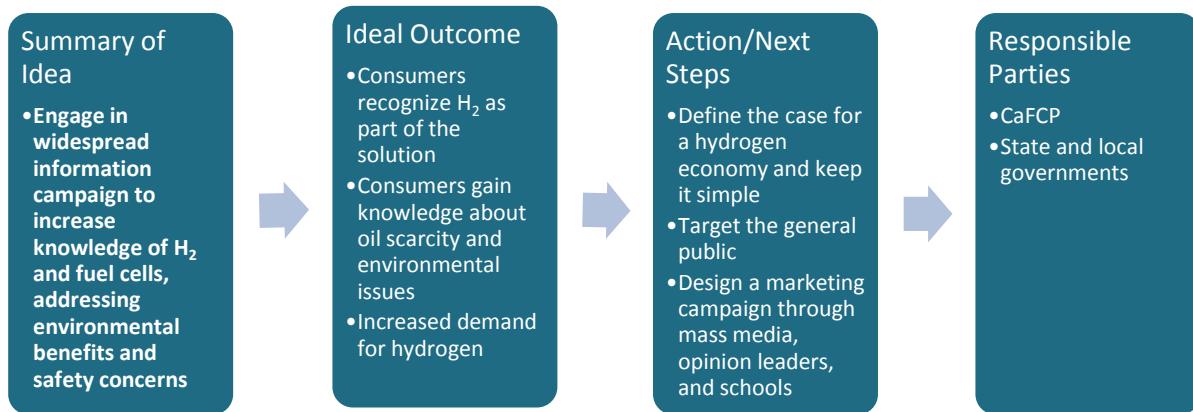
# IPHE INFRASTRUCTURE WORKSHOP

## Entry Level Station Configurations

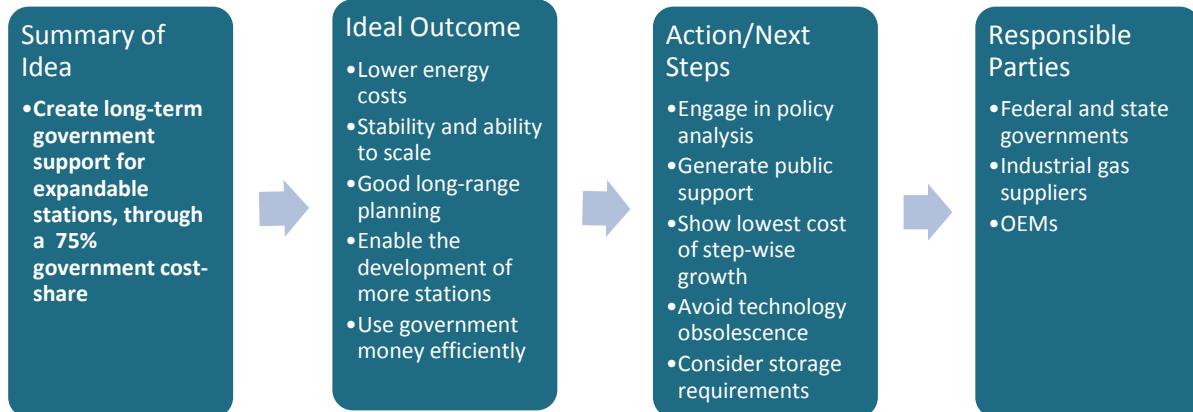
- Optimize HRS components supply chain
- Take hydrogen to the customer with mobile refueling
- Co-locate electrolyzers and fuel cells for electric vehicle charging and hydrogen dispensing
- Create a multi-purpose solution for fueling multiple applications
- Leverage CHHP at big box stores, grocery stores, and shopping malls
- Build large electrolytic hydrogen plants combined with a demand response program, resulting in lower cost hydrogen and more intermittent renewable energy penetration on the grid
- Establish a rental model for initial stations to eliminate the financing issue at individual stations
- Build two or three centralized (existing) production plants with pipelines to 40 locations
- Pursue low-cost liquid hydrogen distribution stations through distribution liquefaction tied to guaranteed renewable energy consumption at ports

## Session 2: Analysis of Top Priority Activities – Breakout Group 3

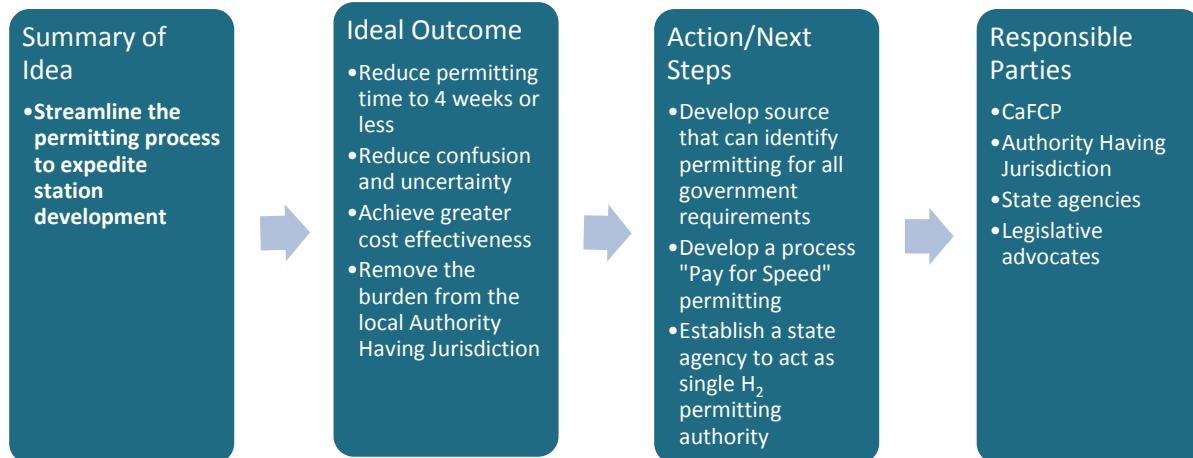
### Idea #1: General Consumer Education of the Benefits of Hydrogen



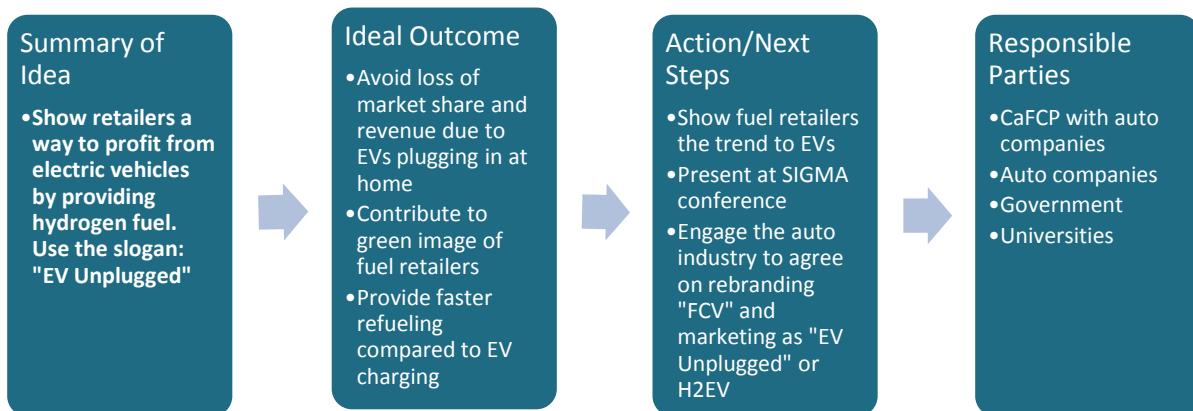
### Idea #2: Establish a 75% government cost-share on stations that can grow from 100 kg/day to 1,000 kg/day over 6 years.



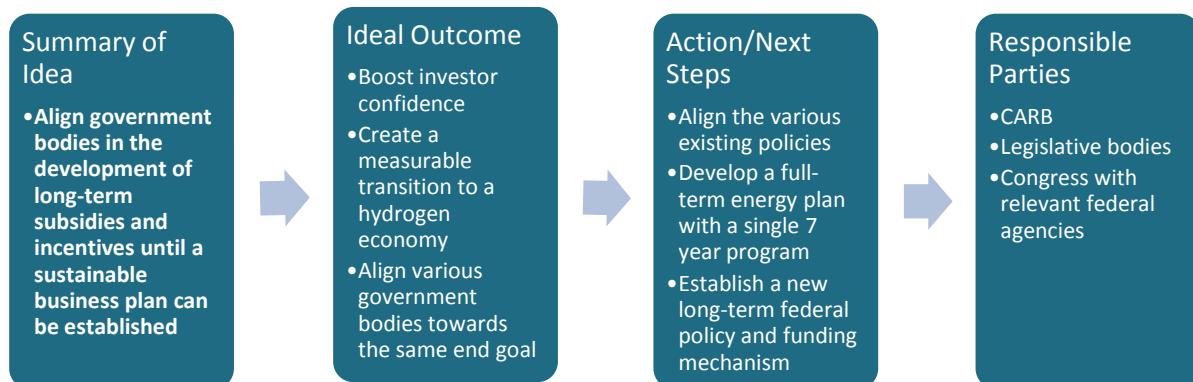
## Idea #3: Generate government support for standard permitting processes to facilitate installation.



## Idea #4: Use the slogan, “EV Unplugged” to convey that fuel cell vehicles are electric drive vehicles.

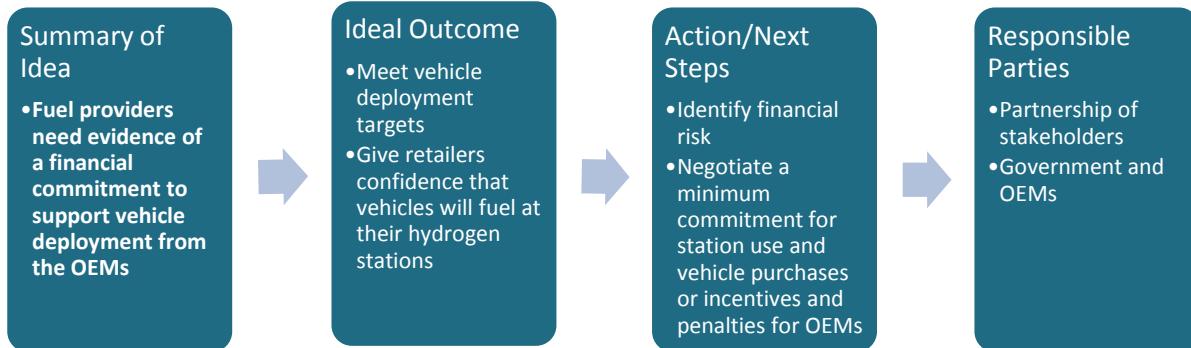


## Idea #5: Provide longer-term (6+ years) government subsidies and incentives until a viable business plan can be established.

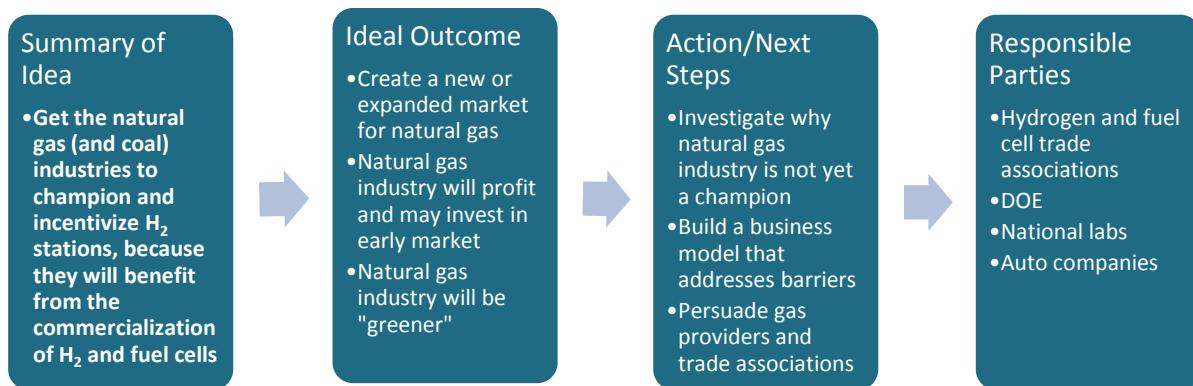


# IPHE INFRASTRUCTURE WORKSHOP

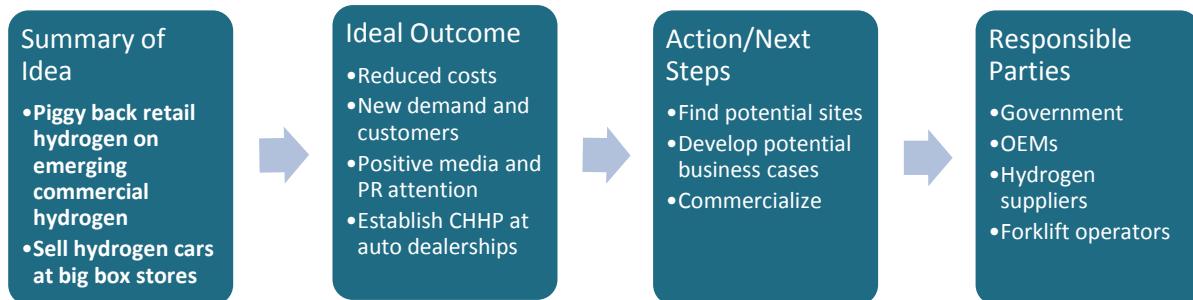
## Idea #6: Elicit strong deployment signals from the OEMs.



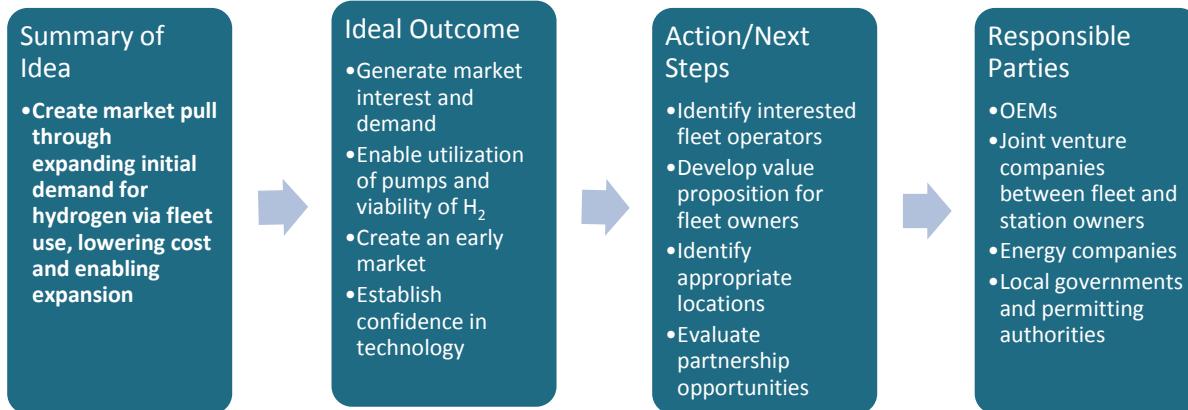
## Idea #7: Get the natural gas industry involved in the initial rollout of hydrogen infrastructure.



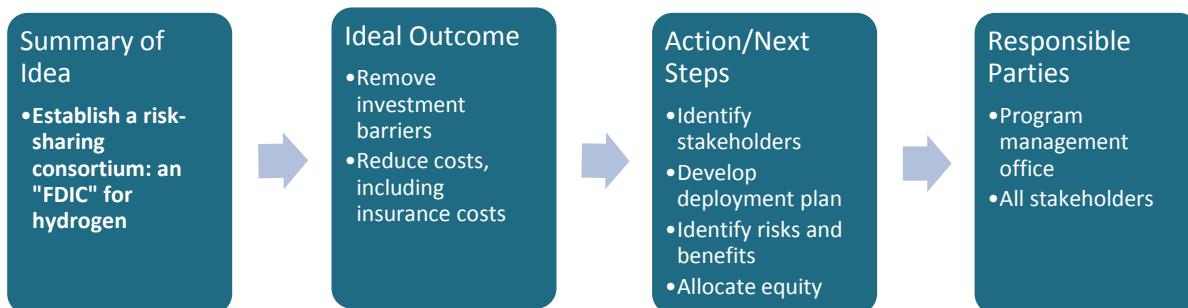
## Idea #8: Develop a non-traditional channel to market, including big-box and grocery stores already using fuel cell technology for CHHP and forklifts.



## Idea #9: Target existing fleet operators to adopt fuel cell vehicles to build consumer demand.



## Idea #10: Evaluate the feasibility of a risk-sharing consortium to supply hydrogen.



## Summary Presentation – Breakout Group 3

 **Breakout Group 3**

H2 Infrastructure – Actions, Strategies, and Business Models,

IPHE Infrastructure Workshop  
February 25 & 26, 2010  
Sacramento, CA

### Most important points

- Assurance of government funding and policy support for the long term
- Funding and outreach through public-private partnerships
- Coordination of deployment of multiple applications
- Lower cost of building, equipping, and maintaining stations
- More certainty with vehicles and demand

# IPHE INFRASTRUCTURE WORKSHOP

## Ideas that are relatively easy

- Piggy Back Retail H2 on emerging commercial H2
  - Government, OEM's, H2 suppliers, forklift operators
- Get natural gas Industry to champion and incentivize H2 stations
  - NHA, DOE, national labs, USFCC
- Target high profile fleet operators for critical mass of users
  - Post office, Hi\_tech, Entertainment, Taxi, Fed Ex, UPS, governmental fleet, car rental
- Messaging – FCV equals EV unplugged
  - CAFCP, OEM's

## Ideas that are relatively easy

- Align government bodies in development of long term subsidies, incentives, policies until a sustainable business plan can be established
  - ARB, Congress, DOE, DOT, EPA,
  - Provide 75 percent cost share for H2 stations, decreasing as progress made (Government, energy providers, OEM's, industrial gas suppliers)
- Government support for standard permitting processes
  - CAFCP, state agencies, state legislators
- OEM's continue to send strong deployment signals
  - OEM's, government
- Conduct general consumer education
  - CAFCP, state governments

## Ideas that are hard to do

- Large government investment in one large focused showcased market
  - Program management office and all key stakeholders
- Set up a consortium for sharing financial risk and liability – “FDIC for Hydrogen”
- Gasoline tax / price floor
- Rapidly accelerate ZEV mandate

## Ideas that need exploring

- Car cost to include portion of infrastructure cost and consumer gets the fuel benefit
- Metering for H2 retail – critical to do
- Allow power generation (CHHP) to sell electricity back to the grid
- Regulate energy companies on green fuel
- Time-of-use hydrogen fueling – demand management to maximize infrastructure utilization

## Next steps

- Establish ongoing dialogue with fuel retailers
- Coordinate messaging and education of legislatures (Federal and State)
- Obtain assurance from OEMs that vehicles will be available
- Identify private partners (e.g. natural gas industry) to offset station costs

Questions?



IPHE Infrastructure Workshop  
February 25 & 26, 2010  
Sacramento, CA

## Breakout Group 4

### Discussion Session 1: Actions, Strategies, Business Models, or Approaches that Will Motivate or Enable Near-Term Hydrogen Fueling Station Construction

#### Government Incentives and Policies

- Establish a public-private partnership to help fund early stations by 2015, with plans to privatize by 2020.
- Establish a “green tax” to monetize environmental benefits.
- Issue competitive grants for station development.
- Issue loan guarantees for stations and infrastructure, and give benefits to station owners.
- Find a larger public vision, similar to the “man on the moon” vision shared in the 1960s.
- Establish clear and sustained regulatory policies.
- Set standard nationwide site offset limits for HP tanks.
- Engage in an economic comparison for hydrogen versus other technologies.

#### Information, Education, and Training for Retailers and Customers

- Find advocates at the government level.
- Advocate the importance and benefits of hydrogen.
- Re-establish initiative credibility, education for the investor, and convince venture capitalists to buy stations and invest in early infrastructure.
- Emphasize the link between renewables and hydrogen as energy storage.
- Identify the revenue generation opportunity associated with grid balancing.
- Find a communication strategy that connects with the community, including first responders and schools.
- Design and build competitions in schools.

#### Other Risk Sharing or Reducing Strategies

- Implement tax incentives for private buyers to ensure sufficient vehicle demand and government fleet purchases.
- Build hydrogen internal combustion engine vehicles in early years.
- Establish uniform guidelines and regulations.
- Attract new stakeholder groups interested in sustainability of transportation.
- Deploy CHHP at retailer sites.

#### Entry Level Station Configurations

- Develop a standard, modular station concept using containerized packaging during initial rollout.
- Leverage public transit opportunities.
- Initiate a multi-staged strategy to upgrade stations according to demand, allowing redeployment of low-capacity modules.
- Establish mobile refueling trucks that can fuel large fleets or individual vehicles when parked.

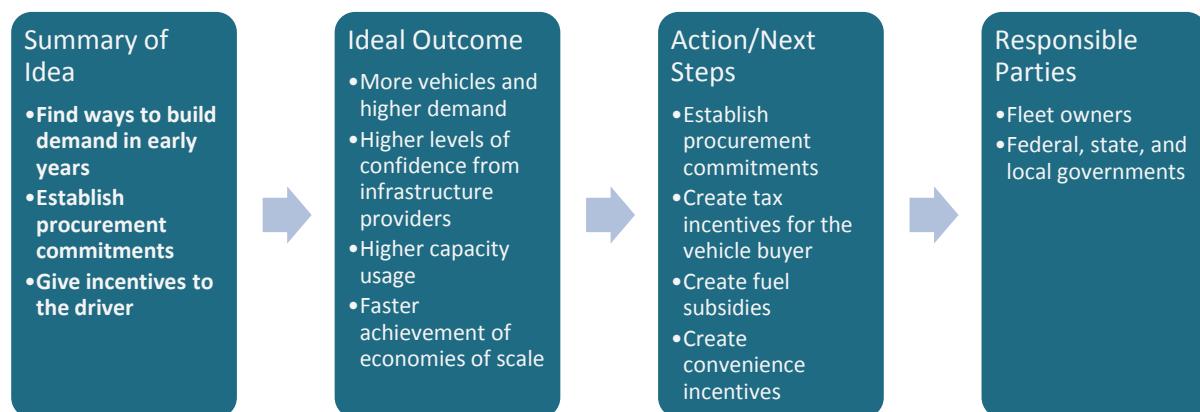
# IPHE INFRASTRUCTURE WORKSHOP

## Novel Business Concepts

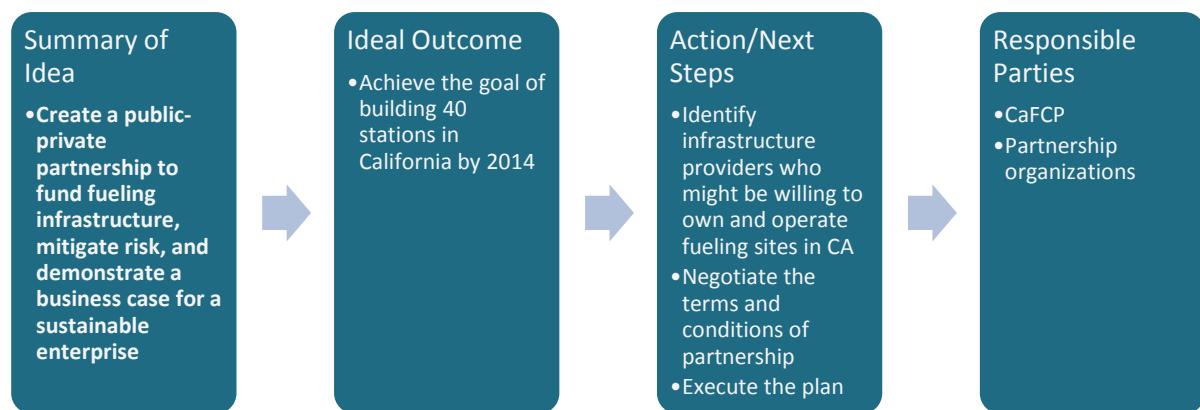
- Build an eco-friendly town, where only fuel cell vehicles, electric vehicles, and plug-in vehicles are allowed.
- Build government-owned and operated hydrogen stations.
- Sell home refuelers or neighborhood refuelers.
- Establish a fuel co-op.
- Lease vehicle concepts including the fuel package solution.
- Create special tariffs for controllable loads and establish a gas company tariff structure to fund early hydrogen infrastructure at low cost, ensuring the ability to amortize costs.
- Utilize stationary applications and other early market applications.
- Develop non-traditional fuel infrastructure providers and locations
- Include hydrogen in the decision-making process when determining electricity production options.

## Session 2: Analysis of Top Priority Activities – Breakout Group 4

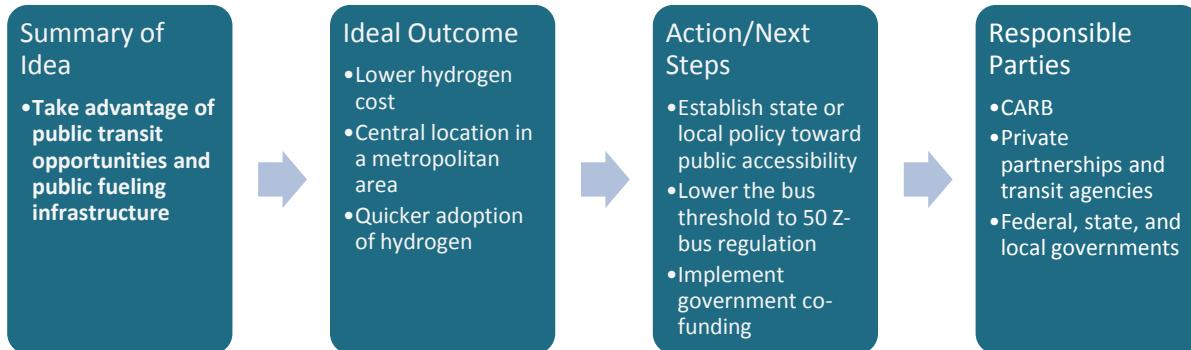
### Idea #1: Ensure sufficient vehicle demand by securing procurement commitments and giving incentives to drivers.



### Idea #2: Create public-private partnerships to mitigate risk and demonstrate the business case.



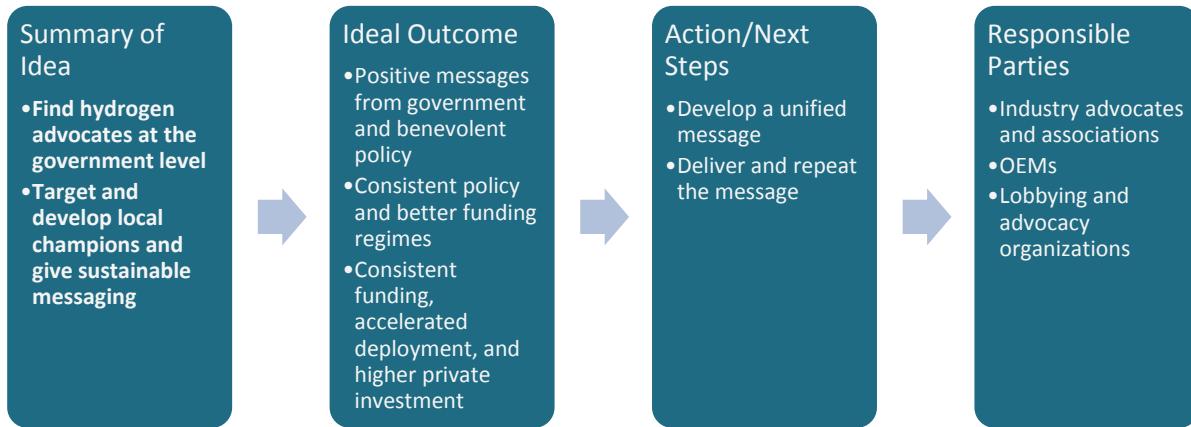
## Idea #3: Utilize public transit opportunities and public fueling infrastructure to build demand.



## Idea #4: Offer benefits to hydrogen station owners.



## Idea #5: Find a high-level government official to advocate for hydrogen.

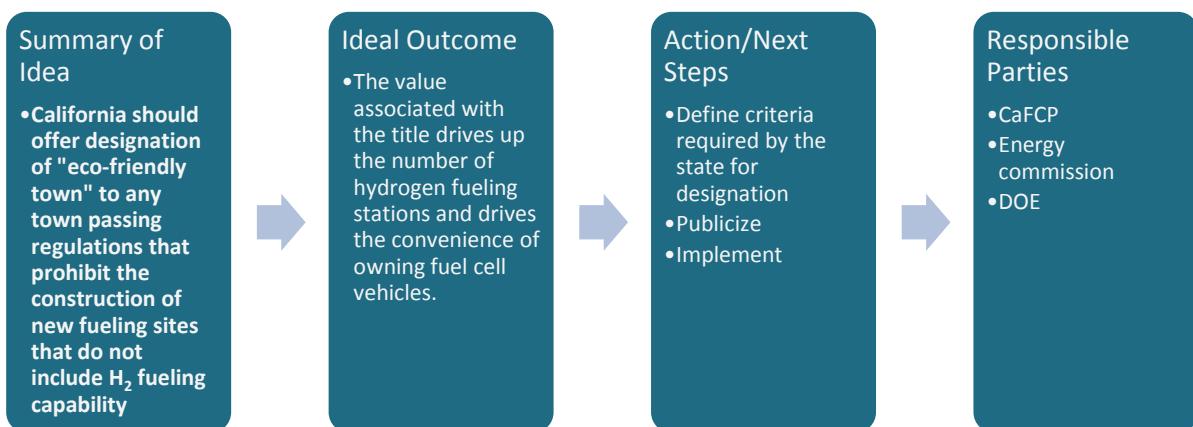


# IPHE INFRASTRUCTURE WORKSHOP

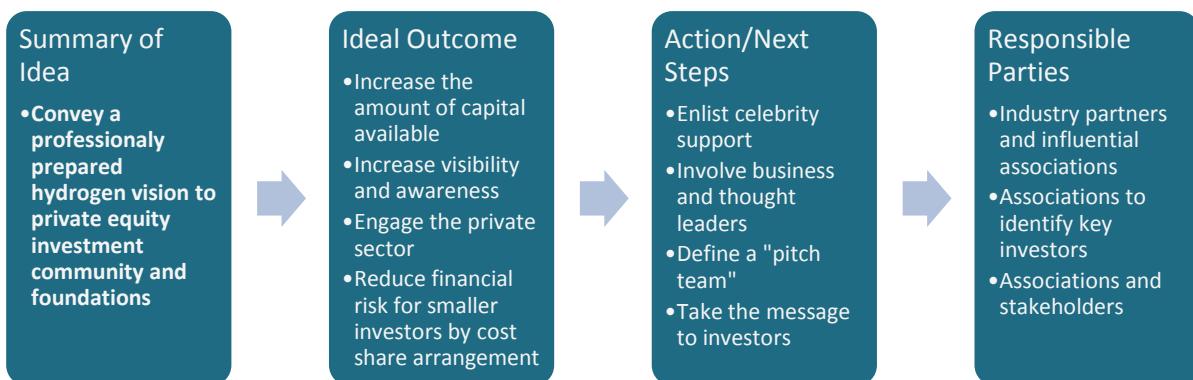
## Idea #6: Establish a clear vision that can be communicated to the public and promote the benefits of hydrogen and fuel cells.



## Idea #7: Designate "eco-friendly towns" to any town passing hydrogen-friendly regulations and policies.



## Idea #8: Convey the hydrogen vision to non-traditional financiers, like private equity groups and foundations.



## Summary Presentation



### Breakout Group 4

IPHE Infrastructure Workshop  
February 25 & 26, 2010  
Sacramento, CA

#### Ideas that are relatively easy

- Ensure sufficient vehicle demand
  - Companies at workshop: Commit to acquiring vehicles “walk the talk”
  - Gov’ts and fleet owners: procurement commitments
  - Gov’t: tax incentives/rebates for vehicles, fuel subsidy, convenience incentives (HOV, parking, etc)
- Offer benefits to hydrogen station owners (land, education, permitting, monetary, liability insurance, codes & standards)
  - CaFCP: locate available land (brownfields/sites that might otherwise close)
  - Consultant: locate financing opportunities

#### Ideas that are hard to do

- Establish and communicate a clear vision to the public and key stakeholders re: benefits of hydrogen and fuel cells (answers the question “Why hydrogen?” to the layperson)
  - Groups like NHA, CaFCP, USFCC, DOE hire a marketing firm to create communication package & roll-out plan
- Convey this message to private equity investors and foundations.
  - Industry partners: enlist celebrity support
  - Associations & stakeholders: involve business and thought leaders, take message to investors, define a “pitch team”
- Create an eco-friendly geography that offers advantages to hydrogen stations and vehicles
  - CaFCP, DOE, CEC: define criteria required by the state for designation, publicize, implement

#### Most important points

- Positive communication is critical at every step.
- Many novel and visionary ideas can have mid- to long-term impact; to achieve immediate impact, a structured, direct, practical and dynamic approach will be needed.
- Need to learn from past experiences.
- Need create a sense of urgency.
- Cost and station siting are big issues.
  - One opportunity to prevent stranded capital risks might be to identify alternative uses for hydrogen infrastructure assets.
- Typical business cases may not apply – need to interest socially conscious investors with deep pockets – OR – look at new business concepts.
- There is a large role for governments to play, at multiple levels, if they are willing to do so.
- What does “relatively easy” mean?
  - People at this workshop have control over it, or can set it in motion.
- Public private partnerships are key.

#### Ideas that are relatively easy

- Create a public private partnership based on the H2 Mobility model
  - CaFCP: identify infrastructure providers willing to own/operate fueling sites in CA
  - Partnership participants: negotiate terms and conditions of participation, execute plan
- Leverage public transit opportunities – high impact for modest incremental cost (garbage trucks, fleets)
  - CARB: policy towards public accessibility, lower bus threshold to 50 Z-bus regulation
  - Partnerships & associations: education of transit companies
  - Gov’ts: government co-funding
- Advocacy at government level – permanently embedding the case for hydrogen
  - Associations: develop a unified message
  - Lobbyists: deliver the message

Questions?

IPHE Infrastructure Workshop  
February 25 & 26, 2010  
Sacramento, CA

# IPHE INFRASTRUCTURE WORKSHOP



