



Financial Innovations Lab Report

Financing the Hydrogen Highway

Background

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The prospects of a hydrogen economy through public-private partnerships emerged in the business world as early as 2001 with several traditional energy corporations—Shell, British Petroleum and the newly created ChevronTexaco—optimistically targeting hydrogen as a dominant fuel carrier by the end of the decade. Shortly thereafter, the European Union began to speak of the hydrogen economy as a policy goal, but it took President Bush’s State of the Union address in January 2003 to accelerate activity on hydrogen with a pledge of \$1.7 billion in federal research and development spending.

This objective would create a network of hydrogen stations throughout California

In California, Governor Arnold Schwarzenegger campaigned in part on bringing the “hydrogen economy” to that state. Once elected, he issued an Executive Order empowering state resources to work on implementing a hydrogen highway. This objective would

create a network of hydrogen stations throughout California to facilitate and accelerate the introduction of hydrogen transportation. Hydrogen refueling stations and the creation of a hydrogen highway are essential to creating a cost-competitive hydrogen infrastructure. Hydrogen stations could be modeled after current retail fueling stations. Linking Los Angeles and San Francisco via a hydrogen highway was identified as an important symbol for the growing vitality of a hydrogen economy in California.

One key component under discussion for implementing a California Hydrogen Highway is that stationary hydrogen power as an energy supply



should precede that of hydrogen for vehicle refueling stations (Isherwood et al., 2000; Lipman, Edwards and Kammen, 2002; Ogden, 2003; Clark et al. 2005; Lamont et al. 2005). Two basic reasons for this approach are that 1) there are not enough vehicles on the road today in need of hydrogen and will not be until 2010; and 2) stations supplying hydrogen for local power needs can be cost effective and market drivers for reduced costs. The costs of stationary hydrogen power supply are among the fundamental components to commercialization under discussion and in need of innovative finance mechanisms today (Clark et al, 2004).

In November 2004, the Milken Institute convened a Hydrogen Highway Financial Innovations Laboratory (Lab) to sort out issues associated with the financing of the hydrogen highway. The structure of the Lab was comprised of five day-long breakout panels comprised of financial, legal and policy professionals focusing on public financing mechanisms, private financing mechanisms, societal issues, technological issues, and cross-cutting solutions. The ultimate objective was to provide input to the Governor’s Hydrogen Blueprint Team for consideration.

Lab members represented public, private and nonprofit sectors. Some had been involved in the earlier Governor’s Hydrogen Highway Network, while others brought a fresh and new perspective to the financing discussions. Participants and their affiliation are identified in Appendix A.

Prospects for a Hydrogen Economy

The premise currently driving interest in a hydrogen economy is that hydrogen will be used as an energy carrier for vehicle fuel or for stationary power that will promote energy independence and a transition away from the fossil fuel and coal energy economy (FOET, 2004, and Hexerberg, 2004). Technically, hydrogen is becoming increasingly cost competitive and available from the reforming of natural gas and other fossil fuels. The amount of energy produced today by hydrogen per unit weight of fuel is about three times the amount of energy contained in an equal weight of gasoline and almost seven times that of coal (FOET, 2004).

The motivation for a hydrogen energy public policy is the precedent that the cost of innovations and advance technologies emerge historically when government paves the way for mass markets (e.g., electrical distribution, diesel fuel, internet, motorization, etc.) through research, development and deployment.

There needs to be creative new government initiatives that leverage resources and link state with local and regional resources

As its point of departure, the Lab took the Governor’s Economic Team Report conclusion (December 2004) that focus should be on how to fund the first critical stages of fueling infrastructure expansion. This would catalyze further research and development, vehicle production and sales, and ultimately, the arrival of a commercial market for hydrogen-based energy and transportation services. Both private and public benefits from capital invested in the hydrogen highway would accelerate further commercialization of hydrogen-based transportation services beyond the target set by Governor Schwarzenegger of 200+ stations by 2010. However, the pace of market development for hydrogen vehicles and associated hydrogen fuel revenue streams at fueling stations was found to be below that

needed to attract private investment alone to accomplish these goals (CAH₂Net Economic Team, 2004: 8.) Lab participants concluded that there needs to be creative new government initiatives that leverage resources and link state with local and regional resources through public-private partnerships without negatively affecting the state budget.

A Financial Tool Box for the Hydrogen Highway

Hybrid finance mechanisms must be identified and operationalized to meet the policy goals of the hydrogen highway. Chip Schroeder of Proton Corporation and co-chair of the Hydrogen Highway Economic Team offered a matrix of financial categories from which specific financial instruments or tools could be crafted (Schroeder, Chip. 2004. “Overview of the Economics for the Hydrogen Highway,” Presentation to Hydrogen Highway Advisory Group, South Coast Air Quality Management District, Diamond Bar, California, September 9.)

Economy Team	Tool Box	
	Private Resources	Public Resources
Market Based Concepts	●	
Mandates	●	●
Cross Subsidies		●
Direct/New Subsidies		●
Non-Profit	●	
Reinforcing Mechanisms	●	

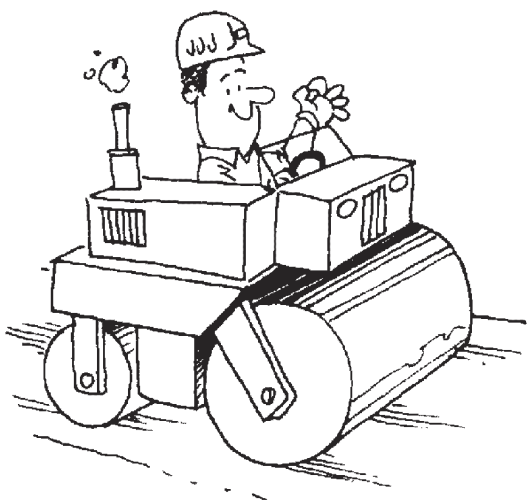
The matrix of “tools” is divided into two basic columns representing (a) private financing sources—i.e. resources from nongovernmental sectors of the economy—and (b) public financing sources—i.e. fees, taxes or other revenue mechanisms derived by government from the general public. If responsibility for financing the hydrogen-fueling infrastructure is placed on all citizens, a general revenue mechanism is appropriate. But if the decision is to place financing responsibility primarily on specific economic sectors closer to the supply end of the economic stream, then it may be appropriate to implement specific mechanisms targeted at private sectors of the economy.

The six rows in Exhibit A correspond to various mechanisms (or tools) for influencing the flow of capital from private or public sources into the California Hydrogen Highway Network (CA H₂Net).

- A. **market-based mechanisms** aimed at influencing the financial attractiveness of investment in the H₂Net;
- B. **mandates** that actively affect behaviors of various private or public actors;
- C. **cross subsidies** that transfer some of the benefit of current subsidy programs from existing recipients to new recipients—namely, the participating service providers in the CA H₂Net (for example, transfer of a portion of existing gasoline tax receipts to the program);
- D. **new subsidies** that involve new taxes or other new revenue sources to enable the program);
- E. **nonprofit organizations** with public-service or philanthropic missions that embrace environmental/energy sustainability or economic development goals; and
- F. **reinforcing mechanisms**, such as awards and incentives that, while not sufficient to fund the fueling infrastructure, may contribute to the broader goal of accelerating development of the hydrogen economy.

Each of the toolbox areas yielded both pro and con analyses and detailed data.

Getting the Hydrogen Highway Rolling

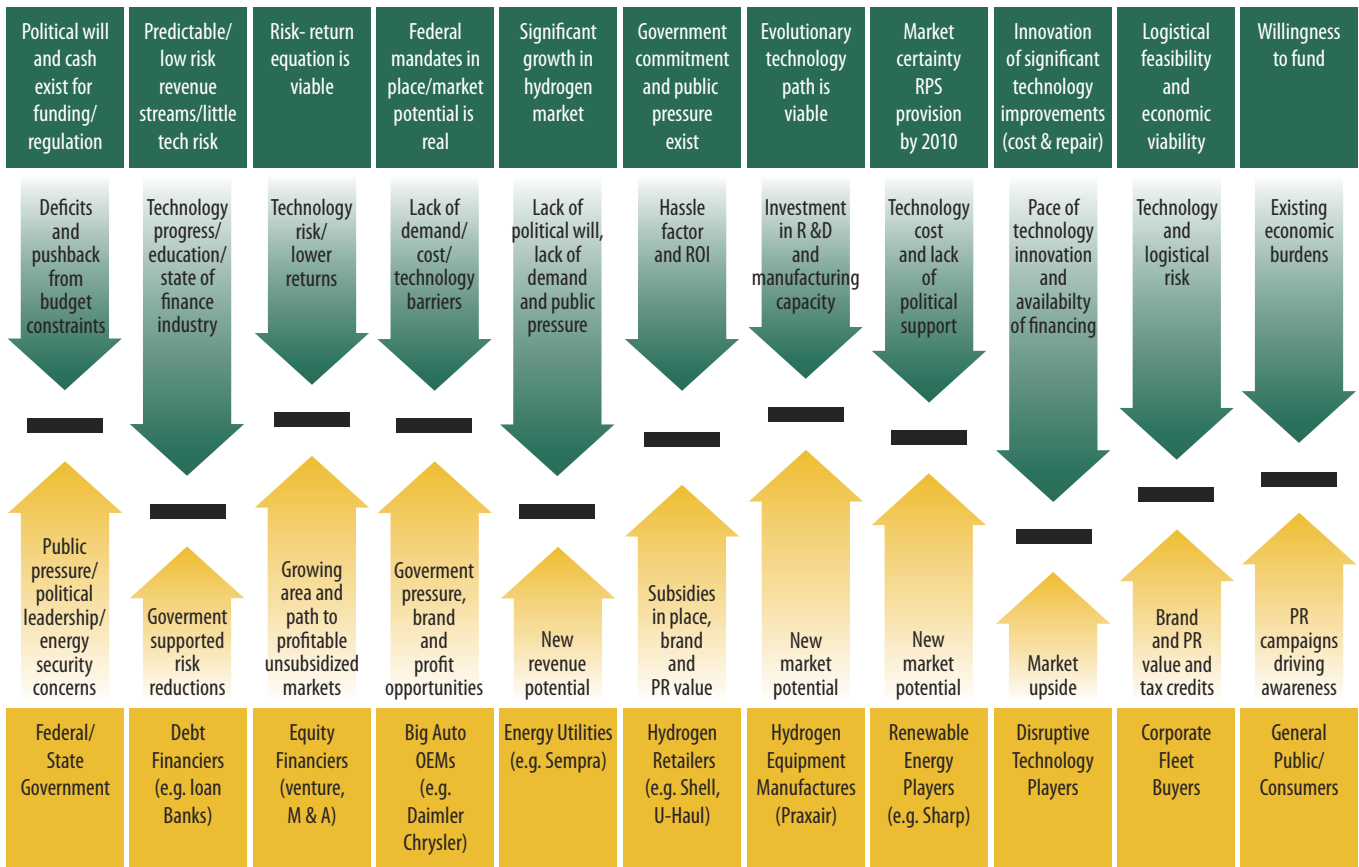


At the Lab, the Monitor Group summarized part of the discussion in a schematic (Graph 2, Endgame) which describes the links, barriers, and leverage points for various financial options. This schematic provides a continuum of financing mechanisms that provide viable, near-term solutions to the financing issues. The key assumption is the agreement on the “endgame” or government policy direction and leadership set by the state.

Graph 2, Endgame

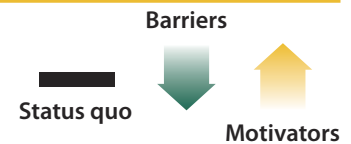
Endgame: Hydrogen Highway is Rolling

Endgame Conditions



Value Delivery Components

Graph courtesy of Cross Cutting Panel, © 2004 Monitor Group



The Lab recommends the following:

1. Create the Hydrogen Highway Finance Authority (HHFA): Public finance through public-private partnerships is a key way to finance this policy objective. In an era of limited budgets, the people's money should be used to leverage private finance, rather than become a sole source for hydrogen financing as the latter is neither politically feasible, nor economically sustainable. Creating a special purpose authority could utilize public finance for both technology development and implementation of the hydrogen highway. An array of financial instruments could leverage state appropriations, federal grants, private funding, credit enhancement, and bond issues. One such instrument could be a revolving loan fund for bond issuance for hydrogen sites (based on the EPA model). A development fund managed through the Authority could coordinate loans, guarantees, grants and credit enhancements to further advance this technology.

The range of products could be defined as anything that uses hydrogen for power in buildings of any size, use of hydrogen forklifts, golf carts, buses, or other vehicles.

2. Initiate the Hydrogen Market through the Hydrogen Highway Initiative: State, regional and local governments should coordinate set up facility and vehicle specifications to issue competitive procurement bids for hydrogen stations and vehicles. The range of products could be defined as anything that uses hydrogen for power in buildings of any size, use of hydrogen forklifts, golf carts, buses or other vehicles. The technology panel felt that hydrogen may be used first through internal combustion engine vehicles as the transition to hydrogen fuel cell vehicles matures and become increasingly competitive. The critical issue is when the fuel cell vehicle will come into the marketplace. Public sector sponsorship of higher risk research and development through its higher education budget and science and technology competitions would mobilize and target other state expenditures toward this important policy objective of energy independence.

3. State Standards and Codes: Clearly defined government standards coordinated with hydrogen highway goals are important in order to align existing state tax and energy credit programs. Tax breaks, tax shifts, grants, rebates (e.g., solar/PV buy-down and rebate programs) could be used more effectively with objectives consistent with financing the hydrogen highway. State funds could be offered on a matching basis for new technologies that show commercial potential. Government incentives must be predictable for industry to plan and invest in terms of time length, scope, upgrades and liability. For example, tax credits are used to help support new technologies, but are often subject to legislative renewal every two years. This puts a severe limit on equity investors who are looking for longer term investment horizons.

4. Leverage Federal and State Facilities¹

The first viable network for the hydrogen highway would be to utilize and leverage existing government-owned real estate for fleet fueling and power generation. Several existing state property types provide a physical platform for the hydrogen network:

- ◆ The 2006 Base Closures (BRAC) would be useful for implementing hydrogen stations on-site.
- ◆ CalTrans facilities could be used as hydrogen power stations now (next 3-5 years) and thereafter converted to hydrogen refueling stations in the near future (5-10 years). Lab participants considered this important.
- ◆ State and local government procurement policies could be directed toward standards for hydrogen fuel cell vehicles and stations.
- ◆ State natural gas and EV refueling stations through CPUC low emission refueling funding programs are other resources that could be swiftly mobilized.

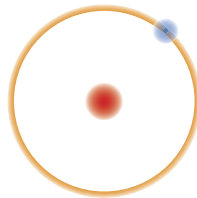
5. Transition from Clean to Green (Renewable) Energy Sources for Hydrogen: Currently, natural gas is the prime source for clean hydrogen production. Ultimately, renewable conversion to hydrogen will be important. Natural gas reforming should be seen as a near-term solution for 3-5 years until electrolyzing costs from renewable sources such as wind, sun and water will be comparable to natural gas prices today. Transition to renewables is vital since future fossil fuel costs will remain difficult to control, and international pressures and national security needs call for energy independence.

6. Quantify Societal and Health Benefits: Social and health cost reductions are much needed (Wallerstein, 2004) and possible to monitor as an outcome of the hydrogen highway. Measuring and monitoring these benefits will facilitate further financing in the future.

Conclusion

Building “hydrogen highways” across California would supply fuel for stationary power for homes, businesses and public buildings now, and provide the hydrogen vehicles currently in use and those coming into the market in the near future the infrastructure in place for refueling. New hydrogen stations as power for local communities are infrastructures that are not far away in the future. California already has a natural gas infrastructure, albeit limited, thus in a short period of time (3-5 years) hydrogen could be reformed from natural gas sources. More significantly, the state has an abundance of renewable energy sources like sunshine, wind and geothermal that can be electrolyzed into hydrogen at the same time. It is this immediate conversion of renewable energy sources at slightly higher prices today that will be cost effective in the near future (3-5 years) for hydrogen production.

After a transition period, renewable energy sources to be used for on-site and grid connected power could be the primary policy goal in California.



1 Matching goals and appropriate collaborations from central government departments such as Energy, Defense, Education, Labor and EPA for R&D focusing on systematic analysis, demonstration projects, and prototypes to determine where the greatest impact can be achieved for near-term medium to high-risk research are in order. New technologies must have more demonstration and prototype system models that can be turned into commercial and retail operations. Examples of near-term commercial applications are fuel cells, forklifts, buses as in the EU program, or fleet vehicles and hydrogen stations as in Japan.

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Appendix A

The Hydrogen Highway Financial Innovations Laboratory

The Hydrogen Finance Laboratory (Milken Institute, November 18, 2004) was designed to bring together public and private technologists, and finance and policy decision makers to bring new and objective ideas to the discussion of a hydrogen highway. The Laboratory sought to generate a series of documents with specialized input, background information and guidance from resources that were not involved in the 10-month process and would otherwise be unavailable to California's Hydrogen Blueprint Teams. The most immediate results are the Executive Summary delivered in December 2004 to the Governor's Hydrogen Highway Team and this policy paper.

Participation was limited to a small number of people in order to make the panels interactive. The chair, Woodrow Clark, and co-chairs, Mr. Elias Azrak and Jerry Cole of Hydrogen Ventures, a California company, gathered names and nominations. Only one participant per organization was allowed to attend. Of the 32 who attended, there was a mix of academics, public policy makers, private companies, bankers, venture capitalists, technologists, associations and legal experts. Two graduate students from UCLA assisted along with another from U.C. Davis who had designed the economic model for the Hydrogen Economic Team of the Governor's Highway Network.

Welcome	Richard Bloom	Mayor, City of Santa Monica	
Opening	Mike Klowden	President, Milken Institute	
Chair	Dr. Woodrow W. Clark	Senior Fellow, Milken Institute	
Panels	Members	Affiliation	Facilitator
Public	Dan Emmett Glenn Yago Devinder Garewal Ellen Batzel Steven Walder	EnergyNow Milken Institute California Air Resources Board Batzel LLC NADBank	Facilitator
Private	Kevin R. McSpadden Tod O'Connor Kay Siegel Randy Brown Gadi Meir Kevin Harris Darius Sankey	Milbank, Tweed Hydrogen Science Advisory Team H2 Safe LLC Semptra Wells Fargo Hydrogenics Zone Ventures	Facilitator
Societal	Elias Azrak Jonathan Weinert Betsy Parker Ben Meyer Marc Stuart	H2 Ventures UC Davis Monitor Group UCLA Public Policy EcoSecurities	Facilitator
Technical	Jerry Cole Naoki Yoshimi Travis Ritchie Vasilios Manousiothakis Brian Goggin Mike Eaves Neel Sirosh	H2 Ventures Sharp UCLA Public Policy UCLA H2 Safe LLC California Natural Gas Vehicle Coalition Quantum	Facilitator
Cross Cutting	Woody Clark Matthew Long Marty Murphy David Sandrich Chris O'Brien	Milken Institute UCLA Public Policy National Renewable Energy Lab Monitor Group Sharp	Facilitator