Hydrogen Fuel Cell Vehicle and Station Deployment Plan: A Strategy for Meeting the Challenge Ahead – Progress and Next Steps

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Hydrogen Fuel Cell Vehicle and Station Deployment Plan: A Strategy for Meeting the Challenge Ahead – Progress and Next Steps

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1 Introduction

In February 2009, CaFCP released the *Hydrogen Fuel Cell Vehicle and Station Deployment Plan: A Strategy for Meeting the Challenge Ahead.* The "action plan" is based on real-world learning and data, and details the major investments and actions needed to transition to a commercial market for fuel cell vehicles and hydrogen. The action plan has three primary areas of focus:

- Build retail hydrogen stations in the communities where passenger fuel cell vehicles will first be introduced.
- Support the expanding fuel cell bus program.
- Develop and implement the codes, standards, regulations and permitting processes that will enable the retail sale of hydrogen as fuel and adopt best-available fueling technology.

Commercializing fuel cell vehicles is a dynamic process. Actions and priorities will change as deployment proceeds, requiring refinements and adjustments as progress is made. The action plan identifies the need for ongoing review to adapt and refine strategies. This report presents the first such refinement by reporting progress and identifying immediate next steps required in 2010 and 2011.

2 Recent Progress

Most automakers have placed fuel cell vehicles with customers, and many plan to introduce fuel cell vehicles to the early commercial market around 2015. Transit agencies have been operating fuel cell buses in revenue service and are moving to next-generation technology. Customers have been fueling at private, fleet demonstration stations, and are awaiting a retail-ready network.

Since the release of the action plan in February 2009, CaFCP members have made progress toward commercialization, including the following examples:

Fuel Cell Vehicle Progress

- GM announced a fifth-generation fuel cell stack that is smaller, lighter and uses 50% less platinum. The new fuel cell stack is expected to have 120,000 miles durability[1].

- The Toyota FCHV-adv achieved an estimated range of 431 miles and an average fuel economy of 68.3 miles/kg during field evaluation testing with the federal government[2].
- The Honda FCX Clarity was named 2009 World Green Car at the New York Auto Show and Honda continues to lease vehicles to drivers in Southern California[3]
- Hyundai and Kia announced they will produce fuel cell vehicles within 2-3 years as part of their plan to develop more environmentally friendly vehicles[4]
- A Nissan fuel cell vehicle accumulated 100,000 actual road miles using the original fuel cell stack and components. Nissan also began its first North American customer demonstration program[5].
- Daimler is preparing for the global launch of 200 serial produced B-Class F-Cells in 2010 following 2.8 million miles of real-world driving with previous fuel cell vehicle demonstrations[6].
- UTC Power accumulated more than 5,000 operating hours on a fuel cell bus system[7].
- As fuel cell buses increased hours in operation and average monthly miles in several demonstration programs across the nation, they showed fuel economy improvement up to 141% when compared CNG and diesel buses[8].

Hydrogen Station Progress

- Five new retail-oriented stations were funded and began planning and design during 2009. (See Table 1)
- Several privately funded stations opened in the Los Angeles area. While providing fuel to limited fleet and retail customers, these stations supported technology development, expanded hands-on fueling experience and provided learnings about retail-like installations.
- The AC Transit hydrogen station in Emeryville received federal economic stimulus funds for solar panels to support production of renewable hydrogen[9].
- In March 2010, SAE International published TIR J2601, which establishes safety and performance requirements for gaseous hydrogen fuel dispensers[10].

CaFCP Bus Team participants and GTI developed the *Hydrogen Bus Fueling and Pressure Vessel Analysis* report to provide heavy-duty fueling input into the SAE J2601 fueling protocol standards development process.

- International standards organization ASTM published D7750-09[11], the first method specific to hydrogen fuel quality for fuel cell vehicles.
- California Department of Food and Agriculture, Division of Measurement Standards received $3.5 million from CEC AB118 funds to develop a type approval and field evaluation process for hydrogen dispensers, validate hydrogen quality analytical methods, and purchase and develop test equipment. These actions will enable retail sales of hydrogen as a transportation fuel.

Table 1: Public hydrogen stations funded in 2008 and 2009.

Station	Capacity (kg/day)	Pressure (MPa)	Expected opening date
Harbor City – Mebtahi	100	35/70	Q3 2010
Newport Beach – Shell	100	35/70	Q4 2010
San Francisco – SFO	120	35/70	Q2 2011
Torrance – Shell	50	35/70	Q3 2010
Westwood – UCLA	140	35/70	Q2 2011
Emeryville – AC Transit*	60 (passenger vehicles) 150 (transit)	35/70	Q4 2010
Fountain Valley – OCSD*	100	35/70	Q3 2010
Los Angeles – CSULA*	60	35/70	Q1 2011

* *– Station included in action plan*

Other Progress

- The National Renewable Energy Laboratory published updated composite data about the US Department of Energy National Hydrogen Learning Demonstration[12]. Hydrogen and fuel cell technologies have demonstrated excellent progress towards meeting DOE's goals[13].
- The International Partnership for Hydrogen and Fuel Cells in the Economy, with CaFCP, DOE and NREL, held a workshop focused on realistic, practical business issues faced by fuel retailers[14].
- UC Davis and UC Irvine published reports and released tools that provide analysis and planning guidance for hydrogen fuel cell vehicle commercialization, including station placement analysis, infrastructure network cost assessment and air quality and greenhouse gas emissions modeling[15] [16] [17] [18].
- The F-STEP program, California's emergency response training and education program for all alternative fuels, integrated CaFCP's hydrogen training materials for first responders, making it part of the state-wide training program for all fire departments.

3 Numbers of Vehicles

CaFCP conducts annual surveys of its automaker members to gain an accurate projection of planned vehicle deployments in the coming years. The surveys yield information that individual automakers would not normally make publicly available given the highly competitive environment of new vehicle development and commercialization. In December 2009 CaFCP conducted its second annual survey. The results show trends similar to the 2008 survey, confirming automaker plans for hundreds, thousands and then tens of thousands of fuel cell vehicles. Table 2 presents a summary of CaFCP's 2009 automaker survey results for passenger FCVs, which are consistent with CEC and CARB's recent automaker survey[19].

Table 2: 2009 CaFCP FCV Deployment Survey results: Passenger FCVs in operation.

	Hundreds	Thousands	Tens of thousands
	Through 2012	2013-2015	2016-2018
Total Passenger Vehicles*	450	4,200	54,300

** Total number projected on the road at the end of each timeframe*

In 2010, a collaboration of five San Francisco Bay Area transit agencies will begin operating a fleet of 13 fuel cell buses. SunLine Transit in Palm Springs and the City of Burbank will also operate fuel cell buses. To meet CARB's zero-emission bus (ZBus) regulation requirements, 10 California transit agencies are expected to start purchasing zero-emission buses as 15% of their fleet purchases in just a few years. Table 3 shows the number of fuel cell buses expected in each phase, based on the numbers required in regulation and transit agencies' reported plans.

Table 3: Number of fuel cell buses based on transit agency plans and ZBus regulation.

	Field Testing	Full-scale Demonstration	Commercialization
	2009-2011	2012-2014	2015-2017
Number of FCBs*	15 to 17	20 to 60	60 to 150

** Total number projected on the road at the end of each timeframe*

4 Next Steps: Position California for Success

CaFCP has identified specific steps that industry and government need to take in 2010 and 2011 to continue California's leadership in bringing fuel cell vehicles to the commercial market. Most prominent is the need to fund additional hydrogen stations so communities will be prepared and automakers can offer vehicles to more customers. It is important that government enable the retail sales of hydrogen as fuel, invest in early hydrogen infrastructure and better coordinate the regulations impacting fuels and vehicles. Steps are also needed to support the private sector as they develop viable business strategies for hydrogen fuel stations so future public funding can be reduced and ultimately eliminated. These and other actions are geared to support a launch of the commercial market in 2015. CaFCP plans to issue subsequent reports to detail additional needs and actions as commercialization proceeds.

4.1 Immediate station needs

The action plan identifies early market clusters in Los Angeles County, Orange County, Sacramento and the San Francisco Bay Area. CaFCP's 2009 vehicle survey confirmed that these communities will be the locations where automakers expect to engage their first fuel

cell vehicle customers. The eight new hydrogen stations opening in the next year will support the first customers, but will fall short after 2011.

Automakers and transit agencies identified seven new stations needed in specific communities before 2012, and four existing stations that need upgrades, expansions or extended operations. Table 4 lists the locations of new and upgraded stations needed by the end of 2011.

Table 4: Additional hydrogen stations or upgrades/expansion immediately needed*.

County	Cluster area	Community	Operator	Capacity (kg/day)	Note
Los Angeles	Network connector	Burbank	City of Burbank	116	Provide O&M support
	Santa Monica	West LA	Shell	30	Expand capacity and pressure
		Santa Monica	*TBD*	*100*	*New station*
		Beverly Hills	*TBD*	*100*	*New station*
	Torrance	*Beach area (Redondo, Hermosa, Manhattan)*	*TBD*	*100*	*New station*
	Network connector	Diamond Bar	SCAQMD	12	Expand capacity and pressure
Orange	Irvine	Irvine	UCI	25	Expand capacity
		Irvine	*TBD*	*100*	*New station*
		Laguna Niguel/Hills	*TBD*	*100*	*New station*
Sacramento & Yolo	Sacramento	*Sacramento/West Sacramento*	*TBD*	*100*	*New station*
Alameda	Bay area	*Oakland (transit station)*	*TBD*	*180*	*New transit station*

Automakers identified these locations as best suited to provide “home” stations to their first customers, including existing stations that can be upgraded or expanded to meet customer needs. The goal is to maximize station utilization, make the best use of limited funding, and provide adequate fuel and convenience for customers. The current transit-only station in Oakland will close at the end of 2010 and a new station needs to take its place. If one or more of the recommended existing stations cannot be upgraded or expanded, a new station in close proximity will need to take its place in the network to successfully deploy vehicles.

These stations, along with existing stations and those in development, will provide sufficient fueling opportunities and convenience for the first customers. Stations within each cluster form a network that will enable customers to use a fuel cell vehicle as their primary vehicle. Specific locations are important in a small station network, as moving any one piece can impact the whole network. Figure 1 shows the locations of the California network in Northern and Southern California.

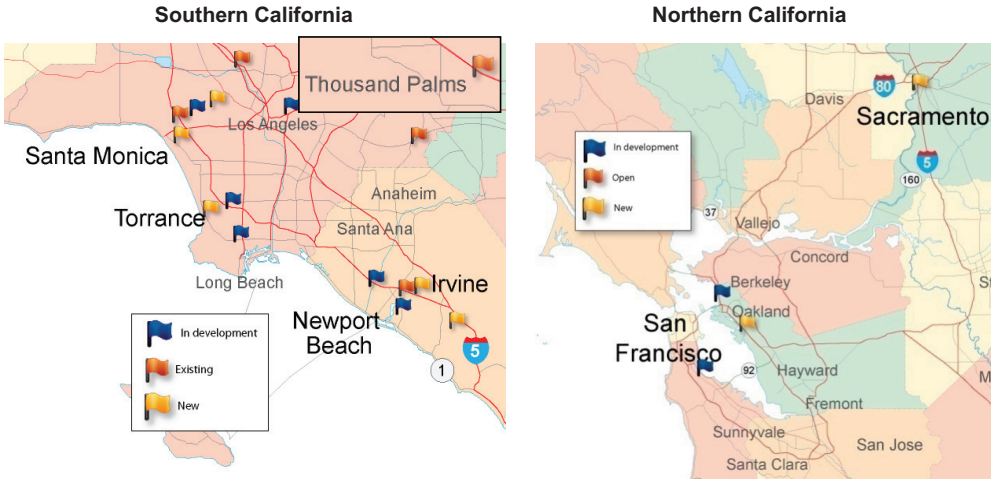

Figure 1: 2011 hydrogen station network.

Currently, hydrogen stations open 12-24 months from the funding date, meaning these 11 stations must be initiated immediately so they are open by the end of 2011. Infrastructure development funding, including the $22 million for hydrogen stations described in the *2009-2010 Investment Plan For The Alternative And Renewable Fuel And Vehicle Technology Program*, should focus on the locations listed in Table 4.

With each new round of stations funded and opened, and with more customers driving fuel cell vehicles, the network must grow and evolve. CaFCP will monitor progress and conduct annual surveys to identify gaps and opportunities in the station network. This dynamic process will help ensure that future funding, such as the $14 million proposed in the draft 2010-2011 Investment Plan[20], will be targeted toward the most important next investments and actions needed to move commercialization forward.

4.2 Retail station criteria

New and upgraded stations must be retail-ready, providing best-available commercial technology and a customer experience similar to (or better than) fueling at retail gasoline stations. CaFCP has defined these new stations as “showcase stations;” using practical retail criteria even as standards development organizations work to finalize commercial standards. Showcase stations offer:

- Retail customer experience—similar to existing gasoline/diesel/E85 stations, including reasonably priced hydrogen, no fueling agreements and locations near home or work.
- Right sized and ready for growth—capable of supplying at least 100 kilograms of hydrogen a day to provide sufficient fuel for the first customers and maximize throughput for the retailer. Growing vehicle deployments will strain supply, so new station capacities should increase over time and all stations should be expandable.

- Retail-oriented technology—the latest technology for dispensing hydrogen fuel, meeting current codes, standards and guidelines, including those published by SAE, ASTM, NFPA, DMS and others.

5 Additional Needs and Activities

Commercial launch in 2015 will require more than building stations. CaFCP members have identified other actions that need to be started or concluded in 2010 and 2011 to ensure successful rollout.

Synchronize and augment regulations and policies

As government increases focus on reducing greenhouse gas emissions, improving air quality and reducing dependence on petroleum, federal, state and local agencies are harmonizing regulations and policies and considering new ways to reach goals.

- The California Air Resources Board staff will propose renewable hydrogen regulations to the Board in October 2010; propose updates of the regulations for Zero-Emission Vehicles in late 2010 and Zero-Emission Buses in 2011; and evaluate how the Clean Fuels Outlet and other programs can be optimized to help ensure hydrogen and other alternative fuels are available to customers as vehicles enter the market.
- In 2010, through the Annual Merit Review and working with the International Partnership for Hydrogen and Fuel Cells in the Economy, the U.S. Department of Energy plans to continue coordinating information and learnings from fuel cell and hydrogen programs worldwide, including Germany, Japan and Korea, to promote early market commercialization of fuel cells for material handling, stationary power and vehicles
- The U.S. Department of Transportation, Federal Transit Administration, will finish the research and analysis phase of its Electric Drive Strategic Plan in 2010. The plan defines a five-year electric drive research plan in the context of a 20-year strategic outlook to provide guidance toward public transit electrification, including fuel cell buses.
- The California Energy Commission will issue their first solicitation for funding hydrogen stations by mid-2010 and will finalize their 2010-2011 Investment Plan supporting multiple fuel pathways, including hydrogen, to achieve the State's energy and climate goals.

Complete codes and standards for retail sales of hydrogen

Codes and standards for all fuels and fueling technologies continue to be developed and refined. For hydrogen, it is important to finish the first codes and standards for fuel metering and quality so that hydrogen can be a retail fuel. CaFCP and its members will continue to participate in the standards development process with specific goals that include:

- The National Institute of Standards and Technology will propose changes to Handbook 130[21] and 44[22] in June 2010, enabling the National Conference of

Weights and Measures to approve these changes in 2011 and allow the retail sale of hydrogen.

- California Division of Measurement Standards, with support from NIST and the U.S. National Working, expects to finalize hydrogen metrology standards by 2011.
- ISO and SAE expect to publish draft hydrogen quality standards by late 2010.
- ASTM will publish supporting hydrogen quality analytical standards, in addition to those already published, and initiate round-robin testing with DOE by the end of 2010.

Support business models developed by the private sector

To be successful, all new technologies require a path to profitability that is self-sustaining and does not require support from government or ratepayers. CaFCP will continue to collect and share real-world information so stakeholders and entrepreneurs can begin developing business models for retail hydrogen infrastructure. In 2010 and 2011, CaFCP and its members will:

- Collect and distribute vehicle and station deployment data so current and future station owners can accurately project growing fuel demand.
- Conduct land surveys in early market communities to identify new station opportunities.
- Align hydrogen station technical information and real-world data with fuel retailers' needs so industry can develop business models for hydrogen as a transportation fuel.
- Identify synergies among fuel cells for material handling, stationary power and transportation that businesses can use in developing new models.
- Investigate long-term financing models that move away from government support toward private industry financing, including methods that other countries are using to build hydrogen infrastructure (e.g. infrastructure challenge grants, trust funds, tax exemptions, revenue bonds and/or public and private land donations).

Support early market communities

Hydrogen and fuel cell projects can help communities reduce environmental impacts, improve resource efficiency, use local renewable energy sources and develop green jobs. Increasing awareness and support at the local level will enable communities to develop these projects sooner. To support communities, CaFCP will:

- Refine and implement the Community Hydrogen Action Plan in the six early market communities identified in the action plan
- Work with other community-based groups and environmental organizations to provide information and coordinate activities
- Continue outreach and education of local leaders and the general public

6 Conclusion

CaFCP members have made significant progress toward the commercial launch of hydrogen fuel cell vehicles. FCVs have achieved range and performance comparable to conventional vehicles, developers have reduced size and cost, and some automakers have started serial production. The first retail-oriented hydrogen stations have been funded and are in development, with additional infrastructure funding expected by mid-2010. Standards development organizations have begun publishing codes and standards, public agencies began harmonizing regulations and policies, and universities have developed new reports and tools to further analyze and assess rollout strategies.

Progress must continue if California is to retain leadership in fuel cell vehicle commercialization, bringing environmental and economic benefits, including a potential 25,000 new jobs the DOE estimates the industry could create [23]. This report identifies actions needed in 2010 and 2011:

- Fund the identified seven new and four existing retail-ready “showcase” stations
- Synchronize and augment regulations and policies
- Complete codes and standards for retail sales of hydrogen
- Support business models developed by the private sector
- Support early market communities

Commercialization is a dynamic process that requires current information and effective communication among all stakeholders. CaFCP and its members are collaborating to inform, assess and refine future activities needed to stay on track towards the launch of a commercial fuel cell vehicle market in 2015.

7 Appendix A: Scenario for Hydrogen Station Rollout in California 2010-2011

The following table provides the retail station scenario for existing, upgraded, in development and newly proposed hydrogen stations outlined in this document. Details include expected supply in kg/day and the expected status of each station by the end of each year. Stations that are not open to all automaker vehicles or are expected to close in 2010 are not listed.

County	Cluster Area	Community	Operator	2010	2011	Pressure (MPa)	Capacity (kg/day)	Note
Los Angeles	Santa Monica	West LA	Shell	Open	Open	35	30	Expand capacity/ pressure
		Westwood	UCLA	Development	Open	35/70	140	
		Santa Monica		New	Open	35/70	100	
		Beverly Hills		New	Open	35/70	100	
	Torrance	Harbor City	Mebtahi	Development	Open	35/70	100	
		Torrance	Shell	Development	Open	35/70	50	
		Beach area		New	Open	35/70	100	
	Connector	Diamond Bar	SCAQMD	Open	Open	35*	12	Expand capacity/ pressure
		Los Angeles	CSULA	Development	Open	35/70	60	
		Burbank	Burbank	Open	Open	35/70	116	Provide O&M support
Orange	Irvine	Irvine	UCI	Open	Open	35/70	25	Expand capacity
		Irvine		New	Open	35/70	100	
		Laguna Niguel/Hills		New	Open	35/70	100	
		Newport Beach	Shell	Development	Open	35/70	100	
	Connector	Fountain Valley	OCSD	Development	Open	35/70	100	
Sacramento/ Yolo	Sacramento	Sacramento/West Sacramento		New	Open	35/70	100	
SF/Alameda	SF Bay Area	South San Francisco	SFO	Development	Open	35/70	120	
		Emeryville	AC Transit	Development	Open	35/70	60/ 200*	FCV and transit
		Oakland		New	Open	35	0/ 150*	Transit only
Other	Destination	Thousand Palms	SunLine	Open	Open	35	60/ 100*	
Total operational stations *(anticipated)*				**12**	**20**			

** FCV/transit supply*

Open – operational Development – previously funded and in development as of April 2010 New – proposed locations for 2010 funding

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