Hydrogen
Network Investment Plan

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Tyson Eckerle
Remy Garderet

ENERGY INDEPENDENCE NOW

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Many individuals provided guidance and input on this work; however, Tyson Eckerle and Remy Garderet of Energy Independence Now (EIN) are the primary authors of this report and the underlying modeling work, and take full responsibility for the analysis and opinions contained in this report. Any errors or omissions are the sole responsibility of EIN.

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I. Executive Summary:

A broad commitment to fuel cell electric vehicles

The State of California has committed to transition the light duty vehicle fleet to electric drive, including both "plug-in" battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs), in order to meet long term greenhouse gas, air quality and energy diversity goals. While BEVs are now penetrating some markets successfully, FCEVs - which run on hydrogen gas - are widely accepted as a critical component of this transition. They alone provide the same performance, range and utility as gasoline vehicles, while reducing greenhouse emissions between 50-100 percent, depending on how the hydrogen is made.

Automakers are on board: the leading automakers have committed to fuel cell technology, overcome all significant technical hurdles, and announced plans to commercialize FCEVs in the 2015-2017 timeframe. The remaining barrier is fuel infrastructure: unlike plug-ins, FCEVs cannot be fueled at home. Early-market success of FCEVs depends on access to a baseline network of hydrogen fueling stations. These stations need to be built in advance of the cars, to enable automakers to sell the cars to consumers.

The current infrastructure strategy

State agencies such as the California Energy Commission (CEC) and Air Resources Board (ARB), as well as public-private partnerships such as the California Fuel Cell Partnership; have coordinated closely to develop plans for the minimum infrastructure network coverage needed to launch the FCEV market.

With commercial numbers of FCEVs on the road, the business of selling hydrogen fuel will ultimately be profitable. However, since stations are needed before FCEVs can be sold in commercial numbers, the initial station developers are likely to experience substantial financial losses during the early years.

The current infrastructure strategy centers on attracting the private sector to invest in and build this network by supporting the investments with government grants. Most recently, the CEC provided grants totaling 65% of capital costs (up to $1.5m per station), in the hope that this will be sufficient to attract these investors.

Challenges that need to be overcome

Private stakeholders have not responded to the CEC grant program at the scale or timeframe needed to provide sufficient coverage for the early market FCEV launch. The latest grant solicitation was undersubscribed, and previously awarded stations are taking a long time to open.

This paper, the Hydrogen Network Investment Plan, attempts to explain why. The findings are based on 18 months of detailed stakeholder interaction and lessons from a financial model built by Energy Independence Now (EIN) to understand the economic impacts of a variety of incentives under a range of plausible market scenarios, to see what is needed to stimulate investment in the hydrogen network.

I. Executive Summary

Providing stronger State leadership

The State Government is providing leadership of the hydrogen transition in many ways. In addition to the CEC's large cost-share grants, hydrogen sales will generate valuable credits under the Low Carbon Fuel Standard, the ARB's Zero Emission Vehicle (ZEV) regulation provides strong incentives for aggressive automaker sales, and the Governor's Office *ZEV Action Plan* provides the coordinating backdrop.

Despite these efforts, infrastructure deployment continues to stall. Discussion with potential investors show that uncertainty remains high and confidence low, and that ***funding alone cannot compensate for the current uncertainty about when a large scale FCEV market will emerge***.

To build marketplace confidence, the State needs to provide stronger leadership, with a plan that:

1. Demonstrates secure, long-term funding, to complete the network build-out,[1]
2. Details how the funding will be invested (how long, how much and with what partners),
3. Is backed by up-to-date, credible FCEV projections from automakers.

Without such a plan, even more generous grants may fail to attract the kinds of committed, large-scale fuel retailing investors needed to build this network.

Mitigating the initial market risks

Given the high operating costs of stations, early station investors face possible long, negative financial cash flows as they wait for cars to appear, capital costs-aside. At the same time, automakers fear these stations might close before they have time to get cars to market.

To neutralize both of these risks, we show how the government could modify its grant program to share in the financial risk of market delays. We propose adding market assurance grants (MAGs), regular payments that would support operations and maintenance expenses until they can be covered by revenues from hydrogen sales. MAGs can be a difference maker *if* investors see a credible pathway and plan to reach long-term FCEV success.

Motivating "First Mover" investors with a clear upside benefit

Even with significant capital cost-share *and* downside protection such as MAG grants, it remains unclear if the government can attract appropriate "first-movers" into this sector, namely entities that want to build and operate dozens of stations on a long-term basis. Some investors suggest that this market is one where a "fast-follower" will be more successful, gaining market share by building bigger and better stations with much greater market certainty once cars are on the road. To counter this problem, the State needs to explore what kind of upside it can create for early investors, in the form of non-monetary, strategic advantages that come from being a government-backed first mover. Unless the government can bring these investors off the sideline or increase investment of existing participants, early market investment may remain stalled.

[1] AB8 was signed into law in September 2013. This bill authorizes the State government to invest up to $20 million per year, through 2023, in hydrogen infrastructure.

II. Introduction

Why Hydrogen FCEVs?

Hydrogen fuel cell electric vehicles (FCEVs) are no-compromise, regular vehicles that can be fueled in five minutes, have ranges similar to today's gasoline powered vehicles, and emit only water from their tailpipes. Hydrogen can be made locally from a range of renewable feedstocks, which translates to the potential for zero well-to-wheel greenhouse gas emissions.[2] Given these benefits, many view hydrogen FCEVs as a key technology needed to earn energy independence from petroleum and meet California's long-term climate and air quality goals.

Automakers have invested billions into developing FCEV technology and are ready to introduce the vehicles at commercial scales in locations across the globe.[3] As the world's premier automotive market with clear air quality and climate change policy leadership, California is a critical bell-weather location. Success in California is highly likely to translate into success across the nation and world.

The requisite success in California depends on infrastructure. Unlike plug-in battery electric vehicles, FCEVs cannot be economically fueled at home today. Instead, to reach the necessary market penetration, a baseline network of hydrogen fueling stations must be established to support the use of FCEVs. This report lays out tools to establish this network, focusing on the economics of doing so.

The Hydrogen Infrastructure Challenge

With commercial numbers of FCEVs on the road, the business of selling hydrogen fuel is very attractive. However, stations are needed before FCEVs can be sold in commercial numbers, resulting in substantial financial losses for the early years of these first hydrogen stations. The challenge is leveraging public and private dollars to build an economic bridge to financial viability.

The State of California does not have a formal plan to open and maintain the early commercial hydrogen-fueling infrastructure needed to launch the fuel cell electric vehicle (FCEV) market. The California Fuel Cell Partnership (CaFCP) Roadmap clearly establishes the need for 68 hydrogen stations by the end of 2015 to reach California's early market potential for FCEVs and put the state on a pathway to long-term zero emission vehicle success.[4] It does not, however, define *how* to get there.

Currently, success of the Roadmap completely depends on the California Energy Commission's Alternative and Renewable Fuel and Vehicle Program (ARFVT), which aims to attract private sector developers and funds to complete the initial network. However, since beginning in 2009, although the

[2] Even when made from natural gas, hydrogen used in a FCEV results in a 50% reduction in greenhouse gas emissions, when compared to a similar sized gasoline vehicle (http://cafcp.org/w2w).
[3] Germany, Japan, Korea, U.K., Denmark, Norway, Sweden are other FCEV deployment leaders.
[4] The California Fuel Cell Partnership Roadmap is available here: http://cafcp.org/carsandbuses/caroadmap.

program has funded several stations, none have been opened to the public due to a variety of delays.[5] We will not reach the Roadmap target without a clear plan on how the additional stations will be funded, built and maintained through early market growth.

This Hydrogen Network Investment Plan (H2NIP) aims to complement the CaFCP Roadmap by giving the State of California the tools it needs to develop a clear plan to facilitate the development of the hydrogen fueling infrastructure network.

Key Finding: Dramatic Change is needed to Instill Marketplace Confidence
At this stage, the government needs to play *the* key role in creating an environment in which private investors have confidence that the hydrogen and FCEV market can and will develop and pay off. Using leadership and monetary tools, the government can be the confidence broker needed to overcome early market uncertainty. This requires the government (with the active support of all other stakeholders) to:

- Secure funding;
- Create a strategic vision and funding plan that earns stakeholder buy-in;
- Match investments to vehicle survey projections; and
- Empower strong leadership (either within or outside government) that can adjust to changing market realities and hold all relevant parties accountable.

Without confidence that FCEVs deployments will closely follow infrastructure investments, no amount of monetary incentive, short of full government procurement of stations, will motivate private investment. While a government program cannot provide full market certainty, with strong leadership, it can go a long way towards improving confidence.

This confidence hinges on a strong government plan, backed by credible FCEV deployment projections, with the implementing agencies fully empowered to lead and incentivized to deliver. Flexibility is fundamental to this empowerment. Without it, new opportunities and approaches based on prior learning are likely to be missed, to the detriment of the effort.

Report Approach and Structure

This paper is based on two fundamental sources:

1. Extensive stakeholder interviews and input collected by Energy Independence Now (EIN), between the Fall of 2011 and Summer of 2013.
2. EIN's Hydrogen Network Investment Plan Model (H2NIP Model), which was developed with stakeholder input.

Interviews and stakeholder discussions serve as the foundation of every recommendation that follows in the report. When appropriate, we analytically back recommendations using our H2NIP Model, which allows us to quantify and qualify the impact of multiple incentive scenarios and market assumptions on a) station economics and b) the overall incentive cost to the government.

[5] ARFVT funding has been designated for 17 stations, but as of September 2013, none had broken ground.

II. Introduction

Flexibility is inherent to the H2NIP. Many of the recommendations described by this document are conceptual in nature, and will require stakeholder effort to work out the specific mechanics for implementation. Our aim is to inform policy makers by matching challenges with solutions, and to arm all stakeholders with the tools needed to overcome market barriers to broad deployment of hydrogen fueling stations.

With stakeholder follow-through, the concepts presented in this document can vastly improve California's success at implementing hydrogen stations and launching the FCEV market.

III. The Context of the California Hydrogen Infrastructure Opportunity

Establishing a hydrogen-fueling network using public and private funds is a complex and challenging endeavor. In this chapter, we simplify and classify the fundamental challenges that need to be overcome to successfully launch the market.

Specifically, we discuss the following concepts:

1. **The California Opportunity**. With the right mix of coordination and incentives, California can help pave the way for worldwide hydrogen and FCEV adoption.
2. **Investment Phases**. The infrastructure deployment challenge varies by market phase. Station 15 faces a different reality than Station 101. The H2NIP considers incentives and solutions with specific market phases in mind.
3. **Hydrogen Network Investment Plan (H2NIP) Framework and Model**. The H2NIP model was developed to analyze various challenges and solutions, which are mapped on the H2NIP Framework.

The California Opportunity

With the right mix of coordination and incentives, California can help pave the way for worldwide hydrogen and FCEV adoption.

California is in a position to lead the nation and world into a new era of transportation based on sustainability, low to zero emissions, and locally sourced energy.[6] All of this can be done without sacrificing utility or affordability once hydrogen fuel and fuel cell electric vehicles (FCEVs) are accessible to the majority of the marketplace.[7]

To get to this sustainable transportation vision with hydrogen, the challenge is no longer technical; it is economic. This is a plan to get the infrastructure economics to work.

Existing Programs to deploy hydrogen stations

California has invested considerable effort at the state and local level to establish public hydrogen fuel stations. Programs funded and managed by the California Energy Commission, California Air Resources Board, South Coast AQMD and Bay Area AQMD have vastly improved our collective understanding of the challenges associated with launching a new fuel market to compete against a well-established fueling system. The existing hydrogen stations are enabling automakers to learn from early customer experience, but more needs to be done to facilitate a market build out and transition to a private lead market.[8]

Understanding the Challenges

The core challenges associated with starting a new market can be broken into two categories: 1) attracting the investment needed to get to a sustainable marketplace, and 2) overcoming execution challenges.

Attracting the Investment needed to get to a sustainable marketplace

To attract private investment into building the infrastructure network that automakers and FCEV customers need, three fundamental challenges need to be addressed:

1) Reduce the downside risk
2) Improve the upside potential of early investment
3) Establish a credible plan to build a sustainable market.

We cannot expect major resource mobilization without addressing all of these categories.

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[6] Mutually beneficial efforts exist in Germany, Japan, the U.K., Scandinavia, and South Korea.
[7] It is important to note that hydrogen FCEVs are not the only solution to get to a sustainable transportation system. Plug-in electric vehicles are a critical piece of the puzzle and should be aggressively pursued in tandem.
[8] For a comprehensive list of existing hydrogen fueling stations, refer to the California Fuel Cell Partnership stationmap: http://cafcp.org/stationmap

It should be noted that many companies are interested in provided hydrogen fueling infrastructure, and would benefit immensely from market success. The challenge is bridging the gap from today, when most of the overall market risk is well outside of an infrastructure provider control, to the future, when the station value proposition is clear.

Execution Challenges

Even if private investors can be attracted, building out the network is a complex, challenging endeavor. Success depends on:

1) Complex coordination between all stakeholders,
2) Streamlining the grant process, and
3) Overcoming today's slow station build out process.

Station delays undermine the confidence that is critical to this early market development.

These execution challenges are not unique to hydrogen; they are reflective of starting any market with public and private investment. The reality is that no one entity or group has all of the answers or expertise to accomplish the network build out, nor all of the influence needed for the program to be successful. This must be recognized in the government's approach to this sector: clearly defined leadership and management responsibilities are needed, as well as clear feedback loops and flexibility mechanisms to ensure that: a) station developers have the tools needed to succeed, b) feedback and learning can be applied to the program moving forward, and c) the strengths and influence of each party are leveraged.

The Global Context

California is not the only jurisdiction investing in hydrogen. Mutually beneficial efforts exist in Germany, Japan, the U.K., Scandinavia, and South Korea. H2USA launched in May 2013 to formalize efforts at the federal level.[9] However, many consider California the critical bellwether for zero emission vehicle technology. If FCEVs find success in California, there is a high probability that this success will translate into other markets.

This paper is based on extensive interviews and input collected by EIN over the last 18 months. We present challenges in greater depth within the upcoming solutions chapters.

[9] http://energy.gov/articles/energy-department-launches-public-private-partnership-deploy-hydrogen-infrastructure

Investment Phases & Tools

The infrastructure deployment challenge varies by market phase. Station 15 faces a different reality than Station 101. The H2NIP considers incentives and solutions with specific market phases in mind.

The challenge of bringing hydrogen and FCEVs to commercial success is dynamic in nature, and will evolve as the market develops. To prioritize our H2NIP recommendations, it is helpful to think of the various phases of investment, and the dominant challenges under each.

Phase 1: Coverage

Stations 1 - 68. Early market coverage is defined in the CaFCP Roadmap: 68 optimally placed stations should provide the coverage needed to enable the sale or leasing of early commercial levels of FCEVs. In other words, with 68 stations, most customers living in a cluster market should be able to drive their FCEVs to the same locations they would normally drive their gasoline car. For the purpose of this paper, this phase effectively ends when there is enough demand, or projected demand, to warrant the construction of station number 69.

Core Challenge = overcoming uncertainty. The fundamental challenges of Phase 1 are a) overcoming vehicle deployment and station availability uncertainty and b) coordinating station and vehicle rollout. Only the right mixes of incentives and execution will facilitate success and attract private investment at the required scale.

Lead Investors = Government + Private Investors (primarily strategic investors). Due to the high risk and uncertainty associated with the early market, government investment is critical to the launch of this market. Absent other policy drivers (such as a carbon tax or market forcing clean infrastructure regulations) we cannot expect the private market to be the lead investor in early hydrogen fueling stations. Government investment and programs can, however, be used to attract private cost share investment (currently coming from strategic investors, e.g. industrial gas companies).

Phase 2: Market Development

Stations 69 – 100. The second phase of market development will largely be capacity driven, compared to the coverage-driven Phase 1. As more FCEVs are added to the market, additional throughput capacity will be required. This capacity demand should be met by adding to existing stations, installing new stations in existing markets, and establishing fueling locations in new markets. This type of expansion is likely to drive market development well past station 100.

Core Challenge = maintaining investment interest. The 68 stations of Phase 1 are unlikely to have perfectly projected the sales patterns and fueling needs of FCEVs. We therefore recognize that stations 69 – 100, though they will be mainly capacity driven, still represent a nascent market in which key station locations will also need to be carefully selected to fill in gaps in coverage or build redundancy. The challenge here is to design and coordinate incentives so that stations can continue to be built ahead of projected demand, and that private developers remain motivated to build stations. If incentives are cut off after station 68, we could wait a long time for anyone to want to build station 69. Similarly, connector stations may continue to be unattractive to investors.

Lead Investors = Government + Private Investors (equity & strategic investors). By the time Phase 2 takes hold, some critical risk and uncertainty will have been removed. Investors (including the government) will have better information on FCEV adoption, station deployment timelines and capability, and what has or has not worked in other jurisdictions.[10] However, station costs may still be high relative to cost reduction potential, and uncertainties will remain as to whether or not FCEVs will be adopted by the mass market. It may be possible to reduce government support in some markets in Phase 2, coupled with increased private funding, to set up private market leadership. We expect traditional fuel retailers to begin investing during Phase 2 (and perhaps late Phase 1).[11]

Phase 3: Early Commercial

Stations 101-250. Once approximately 100 stations are established and succeeding in California, and station equipment costs continue to decrease, it becomes easier to make a business case for investing in hydrogen infrastructure. The need for central planning is likely to decrease through this phase (although station developers will be wise to continue to verify locations with automakers). Hands off incentives, such as preferential debt, and tax credits/rebates, will be effective to help the market continue to expand.

Core Challenge = transition to private market. The fundamental challenge in Phase 3 will be to ensure the market does not stall and lose momentum, and that expansion into new markets continues. Government must carefully consider incentives during this phase to ensure sufficient support remains while holding private investors accountable for risks proportional to their likely benefit.

Lead Investors = Private Investors (with some government support). Stations 101 and beyond should attract private investment with minimal government handholding, assuming preferential debt and tax incentives are in place.[12]

Phase 4: Commercial

Stations 250 plus. After approximately 250 stations, we expect traditional commercial financing to dominate the expansion of the hydrogen infrastructure market.

Table 1 summarizes these phases and the lead investors. It highlights the qualitative shift the nature of the challenge in the first phases, which we believe is one of the most important factors which government must recognize in understanding how to launch this market. The vehicle numbers within each phase are based on assumptions about the size of stations during each phase. Small stations during the coverage phase would be able to sustain fewer vehicles than the 20,000 indicated in the chart.

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[10] Germany, Japan, U.K., Scandinavia, Korea, Hawaii, North East States, etc.

[11] Fuel retailers are defined as market players who sell conventional and/or alternative fuels in California at any point in the supply chain.

[12] Station 101 is a number typically assumed by stakeholders as encompassing a more complete coverage phase. We note that we are not aware of a study that indicates how those 100 stations would be distributed.

Table 1: Summary of Market Phases, Challenges and Lead Investors

Phase	Coverage	Market Development	Early Commercialization	Commercialization
Stations	→68	→100	→250	>250
Challenges	Overcoming Uncertainty	Sustaining Initial Investment	Enabling Transition to Private Market	Ensuring Competitive Private Market
Lead "Investors"	Government + Strategic Stakeholders	Government + Strategic Stakeholders	Equity Investors + Strategic Holders + Limited Government Support	Equity Investors
Average Station Capacity (kg/day)	290	300	320	>350
# of Vehicles on the road	0-20,000	20,000 - 30,000	30,000 - 80,000	>80,000

The Hydrogen Network Investment Plan focuses on Phases 1 and 2, with a priority on Phase 1. We pursue intense focus on Phase 1 because without it, Phases 2, 3 and 4 are irrelevant. However, it should be noted that planning for Phases 2, 3, and 4 is important for all investors: the government needs a strategy to eventually exit the infrastructure funding business, station investors need to be able to plan long-term strategies if we expect them to mobilize at scale, and automakers need to know that all parties are committed to the commercial success of hydrogen fueling infrastructure and FCEVs. For these reasons, the H2NIP addresses strategies for transitioning to private lead investment.

Incentive Toolbox

The remainder of this paper focuses on addressing investment and execution challenges, by phase, with incentives and management strategies. Table 2 below shows the generic incentive tools that can be deployed to catalyze/support hydrogen infrastructure deployment.

Table 2: Incentive Toolbox

Incentive Type	Description
Grants	• Capital Expense Grants (linked to cost or capacity) • Operation Expense Grants (linked to cost, capacity, or throughput) • Market Assurance Grants (linked to utilization)
Risk Mitigation	• Market-development linked guarantees • Loan Guarantees
Debt Support	• Bond issuance, loan guarantees (-> low rates / long terms)
Tax Benefits	• Investment & Production Tax Credit • Accelerated & bonus depreciation • Property tax & other exemptions
Network Support	• Network Generated Funds → Linked to fuels, vehicles, other.
Non-Monetary	• Geographical buffers e.g., no grants to other stations in defined radius for X years

Each incentive has a role to play in creating a sustainable market. The key is to offer the right incentives to overcome the challenges that define each phase of market development.

The H2NIP Framework and Model

EIN developed the H2NIP Framework to analyze the interrelationship between the challenges and solutions associated with deploying early market hydrogen infrastructure, and developed an excel-based model to analyze these.

Framework

Table 3 below establishes the framework for the H2NIP analysis. The left side of the table groups the fundamental challenges that define the early hydrogen infrastructure market. The solutions listed across the top of the table have been specifically designed to address one or more core challenges. The remainder of this paper walks through each solution in order, from left to right. Each "X" denotes the overlap of a challenge and solution, which we hope can help the reader visualize how the components of this H2NIP work together.

Table 3: H2NIP Framework

			Recommendation to Address Immediate Market Issues							Recommendations for the Near Future			For Further Development				
			Sufficient Government Support	Conduct Annual Vehicle Surveys	Creat Govt. Plan & Strategic Vision	Market Assurance Grants	Infrastructure Monitoring	OEM based Location Vetting	Partners for Implementation	Tax Relief & Incentives	Unlocking Debt	A Scheduled Phasedown of Grants	Special treatment for key connector stations	Non-monetary incentives	Link Grants to Performance	Revenue for Ongoing Network Support	Transfer Value ofLCFS Credits
Investment Challenges	High Risks	Vehicle Uptake Uncertainty	x	x	x	x	x										
		Station Availability Uncertainty	x		x	x	x	x	x								
		Unclear Government Support & Exit Plan			x				x			x					
	Low Returns	Low Returns for early stations	x			x				x	x			x			x
		Getting retailers off the side-lines		x	x						x	x		x	x		
		Attracting investors to connector stations			x								x			x	x
Execution Challenges		A complex coordination challenge		x	x		x	x	x								
		Streamline grant process			x			x							x		
		Slow station buildout							x						x		

The H2NIP Model

EIN developed a Microsoft Excel based spreadsheet model to help quantify and analyze the financial challenges and opportunities associated with investing in hydrogen fueling infrastructure. The model allows the user to vary market scenarios (vehicle sales, infrastructure build out scenarios, station costs, fueling patterns and prices) and investment package scenarios (grants, debt, tax incentives and private contributions) to analyze the impact on both government and private investors.

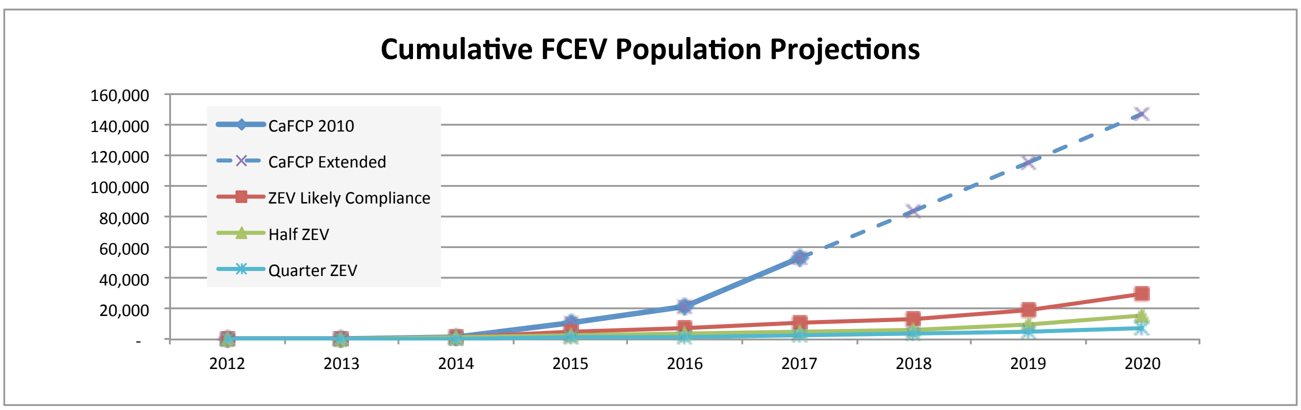
This report offers a summary of the H2NIP model and assumptions in Appendix A for the interested reader. In this section, we introduce four modeling concepts that are fundamental to describing and understanding H2NIP concepts and recommendations.

(1) Vehicle Sales Projections

Vehicle uptake rate is the most important driver that will determine the ultimate success or failure of hydrogen fueling stations. To illustrate the impact of this critical factor, we model four scenarios:

- **CaFCP 2010**. This data through 2017 comes from automaker surveys conducted in 2010 on the premise that infrastructure is not a limiting factor. For the years beyond 2017, the model repeats the growth projected between 2016 and 2017.
- **ZEV Likely Compliance**. The California Air Resources Board (CARB) developed likely compliance scenarios to inform revisions to the Zero Emission Vehicle (ZEV) Program (as adopted by the Board in January 2012).[13] CARB staff used these numbers to inform their "Lower Bound" estimate of FCEV sales projections for the proposed Clean Fuels Outlet Regulation. The H2NIP model uses these CFO projections for the ZEV Likely Compliance scenario.[14]
- **Half ZEV** is the 50% of ZEV Likely Compliance scenario.
- **Quarter ZEV** is 25% of ZEV Likely Compliance scenario. Both the Half ZEV and Quarter ZEV scenarios are modeled to show the risk to station developers if cars come more slowly or a station is not used as much as expected.

Figure 1: Cumulative FCEV Population Projections used in H2NIP Model



[13] Staff Report: Initial Statement of Reasons for 2012 proposed amendments to the California Zero Emission Vehicle Program regulations. Dec. 8, 2011. Section 3, Table 3.6.

[14] See CARB Staff Report: Initial Statement of Reasons, Advanced Clean Cars, 2012 Proposed Amendments to the Clean Fuels Outlet Regulation. Table IV-1. Number of FCEVs for Upper and Lower Bound FCV Scenarios, pg. 48. December 8, 2011.

(2) Market Segmentation

For the purposes of the analysis, we divide the market into three segments: Core, Emerging, and Connector:

- *Core Market (Cluster Station)*: A core market station has the greatest early market opportunity to make money. This is a station placed in one of the five cluster communities, as outlined in the CaFCP Roadmap.[15] These communities are the early markets with the highest expected consumer acceptance and adoption of FCEVs and consequently hydrogen sales, during the first phase of FCEV sales.

- *Emerging Market*: An emerging market station will initially be expected to support the travel and utility of core market based FCEVs, with limited FCEV placement anchored to the station.[16] Emerging markets are expected to development into core markets with time, but may see sales profiles similar to a connector station during early FCEV rollout.

  Connector: In the context of the CaFCP Roadmap for 68 stations, the I-5 station is the best, and perhaps only, example of a true connector station. The I-5 station is not expected to be the "home" station for any FCEVs in the early market, but is needed to solely fuel FCEV trips between northern and southern California.

(3) Network Build Out

Phase 1, Coverage: The baseline station coverage scenario that we use to explore the impact of various incentives is shown in Figure 2 below, described in greater detail in Appendix A. This is based on a similar station numbers as the "Realistic" scenario in Brown (2013), derived from spending an equal amount of capital on small and medium size stations, although the stations in this model are each slightly larger.[17]

Phase 2, Capacity: Beyond the coverage phase, the model builds stations to match capacity, with each new station assuming its proportional share of its market segment within a three year period. Given the near-term focus of this analysis, we do not consider stations larger than 500kg. New capacity needs are met equally by medium and small stations, meaning approximately twice as many small stations continue to be built as large ones. This assumption builds on work conducted by NREL.[18]

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[15] Cluster communities: Santa Monica and West LA, Coastal/Southern Orange County, Torrance and Nearby Coastal Cities, San Francisco South Bay Area, and Berkeley.

[16] Emerging market examples: San Diego, Anaheim, San Fernando Valley, Pasadena (see pg. 16 of CaFCP Roadmap for full list).

[17] Tim Brown, Lori Smith Schell, Shane Stephens-Romero, G.S. Samuelsen. Economic Analysis of Near-Term California Hydrogen Infrastructure. International Journal of Hydrogen Energy 2013.

[18] NREL's Melaina & Penev estimate station size build out based on a gamma distribution observed in the fueling industry, combined with the growth rate of fueling (i.e. station owners will build bigger stations if they see high growth). The distribution predicts stations of many sizes. When constrained to 250kg and 500kg stations, we observe a 51%:49% split in capacity, which we simplify to a 50:50.

Under our baseline "Realistic" coverage scenario, and likely ZEV compliance FCEV deployment, Phase 2 build out occurs in 2019, when there are approximately 20,000 vehicles on the road.[19] Figure 2 below shows this "Realistic" coverage scenario and subsequent capacity build out assuming vehicle populations match the ZEV compliance scenario.

Figure 2: H2NIP Station build-out baseline coverage scenario, by market and type

Market	Station Types	2012	2013	2014	2015	2016	2017	2018	2019	2020
Core Market	180-DH2	2	6	13	13	13	13	13	13	13
	250-DH2	-	-	1	6	11	15	15	15	37
	500-DH2	-	-	3	7	11	17	17	17	28
	Total	2	6	17	26	35	45	45	45	78
Emerging Market	180-DH2	2	4	6	8	10	10	10	10	10
	250-DH2	-	-	2	5	8	12	12	12	12
	500-DH2	-	-	-	-	0	0	0	0	0
	Total	2	4	8	13	18	22	22	22	22
Connectors	180-DH2	-	-	-	-	0	0	0	0	0
	250-DH2	-	-	-	-	0	1	1	1	1
	500-DH2	-	-	-	-	0	0	0	0	0
	Total	-	-	-	-	0	1	1	1	1
	Stations in Place	**4**	**10**	**25**	**39**	**53**	**68**	68	68	101
	Incremental	*4*	*6*	*15*	*14*	*14*	*15*	*0*	0	33

(4) Market Timing Impact

When considering the impact of incentives on various station investors, it is important to consider these impacts in terms of time and location. A 500kg/day station deployed in a core market in 2016 has a much greater opportunity to return a profit than a 250kg/day station deployed in an emerging market in 2015. This difference is due to a number of factors: more FCEVs are likely to be on the road in 2016, a core market will have a larger share of fueling demand, and larger stations can sell more fuel.

The incentives considered and proposed in this plan take into account the range of market conditions in these three markets.

[19] This assumes 68 stations sell 14,000 kg per day (0.7kg/day*20,000). 0.7kg/day represents expected per vehicle consumption.

IV. Recommendations to Address Immediate Market Issues

Without sufficient early infrastructure coverage, the FCEV market would never have the opportunity to develop. In many ways, the early market offers the most difficult challenges, as the proverbial investment "valley of death" must be crossed before attractive returns are in sight.

The following elements are essential to achieve early market coverage:

1. **Secure Sufficient Government Support**. Sufficient, committed government support is crucial to the success of the early market. Without clear commitment of sufficient incentive funds to achieve the stations needed for early market coverage, private investors are unlikely to have the confidence to participate at the scale required to facilitate success.

2. **Conduct Annual Vehicle Surveys**. Accurate vehicle sales projections are the foundation of the hydrogen and fuel cell vehicle coordinated rollout. Without them, it is difficult to justify public or private investment.

3. **A Government Investment Plan and Strategic Vision.** If government accepts its role as lead investor and network planner, it needs to communicate its vision and establish a plan to turn that vision into reality.

4. **Offer Market Assurance Grants (MAGs).** Uncertainty in the pace of FCEV market uptake and uncertainty in future station availability can paralyze the market launch. Without a tool to address these uncertainties, California will fall well short of the coverage needed to launch the FCEV market.

5. **Infrastructure Monitoring**. A monitoring program is essential for market assurance grants to work, and for OEMs and the government to know how the initial network is performing and being used. Real world data and interpretation will enable all parties to adapt plans accordingly.

6. **Incorporate OEM-based Location Vetting.** A formal OEM role is essential in the decision making on station locations. A body, recognized by the government as representing OEM input, needs to be in place to take responsibility for location choices in the coverage phase.

7. **Use Partners for Implementation**. Deploying early market infrastructure is complex, challenging, and a bigger challenge than any single entity can both lead and manage. Leveraging partners can alleviate some of significant burden currently being carried by the CEC and help improve opportunities for learning and program improvement.

Secure Sufficient Government Support

Sufficient, committed government support is crucial to the success of the early market. Without clear commitment of sufficient incentive funds to achieve the stations needed for early market coverage, private investors are unlikely to have the confidence to participate at the scale required to facilitate success.

Government support is essential in the coverage phase of the hydrogen infrastructure build-out. Having a secure source of funding, together with a plan for how to use it, is critical to attracting private investors into this space.

The State of California achieved this first step with the adoption of AB8 (Perea) on September 29, 2013. AB8 extends the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVT) through 2023, and designates up to $200 million to help establish a 100-station fueling network.[20] Funding for this program is generated by a combination of vehicle related fees.[21]

There is a clear rationale for using fees, as in AB8, or *general* tax-derived revenues to transform the transportation fuels market. Multiple studies have demonstrated the significant gains to consumers from vehicle electrification, even without counting the benefits of helping mitigate climate change. Future generations using zero emission vehicles have a consumer benefit that vastly offsets the transitional investment costs, making it a prime example of rational, inter-generational taxation.[22]

This analysis, which officially began in December 2012, was conducted under the premise that a) sufficient, long-term government funding would be available to facilitate the transition to a private lead hydrogen infrastructure market, and b) the CEC would manage the funds under its ARFVT Program.[23] AB8 has turned this premise into reality.

While securing sufficient funding is the critical first step, this funding needs to be coupled with:

1. Ensuring the CEC has sufficient capacity and flexibility to incentivize developers appropriately, as outlined in upcoming sections of this report.

[20] Up to $20m per year through 2023, in addition to funds already allocated under the existing ARFVT program.
[21] Fees to help fund ARFVT: $3 annual vehicle registration, $8 smog abatement fee, $5 for special identification plates, $10 or $20 vessel registration fee.
[22] Transitions to Alternative Vehicles and Fuels. National Research Council of the Nation Academies, 2013; as well as David Greene presentation to the California Energy Commission at the Integrated Energy Policy Report meeting, July 31, 2013.
[23] The ARFVT program has been central to the hydrogen investment program to date since 2009.

2. Ensuring the CEC role and leadership is complemented by the other necessary mechanisms of implementation, such as vehicle information, network planning, location vetting and monitoring.

Funding and Leadership

In the context of ensuring the initial coverage of hydrogen infrastructure, the most important current factor is ensuring that government support is secure and sufficient. California has taken this first step. Outside of the California context, if funding cannot be secured (or if funding security is compromised in California), a different approach to building this infrastructure would be needed in the early market, as introduced in the section on non-monetary incentives. Though this is beyond the scope of this paper, launching a hydrogen fueling market without significant government financing might require structures such as regulated monopolies, with territory concessions, much like the electric and gas utilities function in many regions.

Together with public funding comes a significant level of responsibility and accountability for deploying the infrastructure. Regardless of the source of funds, the agency in charge of disbursing those funds will become the *defacto* lead investor of this build-out. As lead investor of a new market, it must take a greater level of responsibility than typically assumed in a cost-sharing, grant program for an existing market. This issue is discussed in greater depth in the upcoming "Government Investment Plan and Strategic Vision" chapter.

Conduct Annual Vehicle Surveys

Accurate vehicle sales projections are the foundation of the hydrogen and fuel cell vehicle coordinated rollout. Without them, it is difficult to justify public or private investment.

A survey of automakers was conducted annually by the CaFCP, and later by the CEC in 2011, to gather information on when fuel cell vehicles were anticipated. The survey results formed the basis of the Fuel Cell Partnership 2012 Roadmap, and were instrumental in getting station developer interest in the initial ARB and CEC solicitations, as well as galvanizing state-agency support.

Since that time, many individual OEM announcements have modified the expected timeline of vehicle introduction in the California market, in part due to the state of station deployment, yet there are no official, up to date vehicle projections to use.

This lack of aggregated vehicle projections is a core contributor to the uncertainty faced by station investors, and must be resolved for any of the incentives described in this paper to have an effect.

Goal of the survey: regular, aggregate projections
A single, annual survey that generates aggregate vehicle sales projections is needed to serve as the basis around which a government investment plan is developed and adapted.

Government as the target audience
As the lead investor, the government – in this case represented by CEC – is the entity most in need of good vehicle projections. Private investors will look closely at these numbers also, but are likely to do their own, in-depth supply chain analysis before committing resources.

Survey Conducted either by the Government or a 3rd Party
Government Survey: Under AB8, the California Air Resources Board (ARB) is required to conduct annual surveys that project FCEV three years out. ARB already collects sensitive information from automakers for its ZEV and LEV regulatory programs; information which it will be able to compare to projections and use to inform state investment decisions. In the California context, one advantage of a close collaboration between OEMs, ARB, and the CEC in conducting such a survey is to strengthen the State's understanding of the dynamic and inter-related timing of station deployment and vehicle production projections. This survey will form the basis of the CEC's hydrogen investments, be built on a platform of OEM input, and should feed directly into the State's Hydrogen Network Investment Plan (as described in the next chapter). In other words – if the government is going to be the lead investor, let it also lead the effort to have timely market projections.

3rd Party Survey: A survey conducted by a 3rd party that is not vested in the outcome of the numbers, yet trusted by industry and the government to collect and aggregate such numbers, could increase collective confidence in survey results and be instrumental in expanding FCEV deployments in other states. Such an approach would allow automakers to make predictions without concern that their individual projections be used in other, regulatory proceedings or seen by competitors. The experience of Germany, in which a clean data room has been set up – run by an independent consulting firm – to inform the H2 Mobility process has gathered and validated OEM and infrastructure information, is instructive. This information has helped form a strong, trustworthy platform for collaboration between industry and government.

The National Renewable Energy Lab (NREL) could play the 3rd Party role. Historically the OEMs have provided a variety of sensitive information to NREL, which aggregated this information in a clean room to provide public overviews that did not convey any individual information. As a trusted source that already has nondisclosure agreements in place with OEMs and the CEC, they may be well suited for this activity, especially as FCEV deployment efforts extend beyond California.

The incentive for good information
It is important to emphasize that OEMs recognize that it is in their interest to provide as accurate as possible a set of numbers. If they under-project their production timelines and volumes, government investment may be withdrawn, and they will face a lack of infrastructure and an inability to sell vehicles. On the other hand, over-projecting will result in disappointment in relation to overly high expectations among shareholders, consumers, the press and regulators. Overall, the forces counter-act.

A well-designed survey can overcome any biases and elicit accurate, valuable data. Furthermore, having the survey conducted on a regular, annual cycle will provide positive feedback mechanism that supports accuracy. A company that repeatedly provides data that conflict with reality will quickly be discredited within the survey process itself.

Designing the Annual Survey:
For the projections to be accurate, the survey design must take into account the constraints facing OEMs in making such projections. As such, the survey needs to be designed with major input from the automakers themselves, regarding what they can and cannot predict, and the conditions that affect these predictions. Three key parameters will need to be included, along with an aggregated communication strategy.

- **Infrastructure conditions at time of prediction**. The survey will need to include conditionality. Questions may need to be phrased in the form: “If, in 2015, there are 16 operational stations throughout the state, and 25 under contract to be completed by 2016, what production figures could your company predict (in 2015) as being likely target in 2017, for availability to California buyers? What about targets for 2018, and 2019, again as seen from 2015 under 2015 conditions?” These types of question include the condition, the time delay between those conditions and the vehicle projection, and the projected number itself.
- **Probability of the prediction**. Each prediction should also be assigned a probability number, to indicate the level of confidence within the matrix of timing and infrastructure availability. The above condition could allow the respondent to reply: 2017: 500 (90% probability), 5,000 (with 30% probability), 10,000 (10%).

- **Aggregated Communication**. On an aggregate level, these numbers can be combined for public release, to give a probability distribution over a set of numbers, for a given infrastructure state, without releasing individual OEM data on the probabilities of each individual projection. To allow aggregation, the survey design may need to establish pre-determined threshold levels of vehicles, and ask for probabilities around those numbers.

The aspects listed above are key, but we urge those designing the survey not to be tempted to use the survey to also make granular predictions of sales within regions, as a proxy for station planning priorities. Such regional predictions are unlikely to be robust – if cars are available for the California market, dealer will be more likely to sell them in areas where stations are operational. The placement of these stations must be assured through a separate process for OEM input into the network planning priorities, not through this survey.

Create a Government Investment Plan & Strategic Vision

If government accepts its role as lead investor and network planner, it needs to communicate its vision and establish a plan to turn that vision into reality.

To invest at the scale needed to launch commercial sales of FCEVs, private investors need to have confidence in the government's staying power and commitment. An investor is more likely to invest in Station 20 (and more) if there is a clear, credible plan to get to Stations 68 and 100. If only 20 stations can be counted on, the probability of long-term market success, and subsequently investor motivation, is low. From a utility perspective, the value proposition of a FCEV (e.g., "can I go to X and Y with my FCEV?") reaches a reasonably marketable level once 68 or more optimally placed stations are established in California.[24] Without a plan to get there, the probability of an investment in hydrogen infrastructure paying off, even with large subsidy, is low.

To earn the confidence that the market will reach the starting line and beyond, as the lead investor and planner, the government needs to communicate both a strategic vision and plan to reach that vision in a manner private investors can buy into. This vision and plan should:

1. Set the strategic vision and targets for hydrogen deployment
2. Clearly define roles and responsibilities for reaching that vision
3. Establish adaptable planning and implementation systems
4. Develop a long-term funding and incentive plan

Without assurance that these components have been taken care of, investing in hydrogen at scale is too risky for most private capital.

1. Setting the Strategic Vision

The strategic vision should be adopted and propagated at the highest level of government possible (e.g., the Governor's level). It should describe the rationale for investment, establish investment targets for number of stations within a given timeframe, and specifically align the agency efforts around the common purpose. It should empower agency staff, both current and future, to make decisions aimed at fulfilling the vision, and clearly communicate California's commitment to success.

The Zero Emission Vehicle (ZEV) Action Plan, adopted in February 2013, is an excellent example of a very public, adaptable plan aimed at holding government accountable and building all-around stakeholder confidence in the State's commitment ZEV deployment.[25] It is organized around a clear ZEV deployment target and outlines the steps the state government will take to reach this target. Thus far, the plan has

[24] 68 stations represents the consensus minimum "market coverage" needed to launch FCEVs. This consensus position is detailed in the CaFCP Roadmap (http://cafcp.org/sites/files/20120814_Roadmapv(Overview).pdf).
[25] This document was developed under Executive Order B-16-2012, which established a clear target for ZEV deployment in California

successfully aligned agency efforts, solidified intra-agency cooperation, and held agencies accountable for specific actions.

EIN strongly believes that a similar approach to hydrogen would have a profound effect on market confidence. Clarifying the government's role, expectations, and rationale accomplishes at least four primary objectives:

- It reduces uncertainty, both inside and outside of government
- Helps mobilize and coordinate agency action
- Aligns all stakeholders around common targets
- Communicates California's efforts to a broad audience.

The last point is critical. While it is certainly possible to get the FCEV and hydrogen market started with the current market players, the probability of success will greatly improve if additional investors can be attracted. Currently, the California Fuel Cell Partnerships' "A California Road Map" is the most comprehensive plan for hydrogen FCEV deployment.[26] While visionary and instrumental in communicating broad support for an infrastructure deployment strategy, the document does not carry the weight of the State of California behind it or communicate a plan to fund the infrastructure. Both are needed to gain the sustained attention of potential investors who currently are fully or partially on the sideline.

2. Defining Roles and Responsibilities

Early market success requires clearly defined responsibilities between the public and private sectors. These responsibilities, and accountability, should be established and delineated by the strategic vision document. Such delineation must address the following questions:

- **Who takes the leadership role in planning the initial hydrogen network?** The CaFCP Roadmap lays out the early market network needs and locations by community, but implementation of the plan needs to be dynamic and reflect feedback from previous location decisions. At one extreme this dynamic planning could be a responsibility of the government, and at the other extreme, a private entity could be empowered to do so. Any variation between these extremes which includes shared leadership will need a well-constructed process of roles and feedback systems to ensure success, as this process involves considerable OEM information as well as interfacing with infrastructure realities on the ground.

- **Who manages the actual deployment and monitoring of stations?** The same entity or group of entities that are leading the planning may manage station deployments and monitoring, but other options exist in which entities closer to the region implement the network, and monitor its performance. To be successful, individual station developers need to be accountable to the

[26]Please refer to the CaFCP Roadmap: http://cafcp.org/carsandbuses/caroadmap

overall success of the network. Again, clear role and feedback loops are needed to manage the system if implementation is to be separate from network planning.

3. Establishing Planning and Implementation Systems.

In many ways, planning and implementation systems are inherent in defining roles and responsibilities. However, clearly defined information and decision-making pathways can vastly improve the speed of capital deployment and program adaptability. The following functions should be addressed and delegated by the strategic vision document:

- **Network planning**. Government needs a formal, adopted plan it uses to allocate money and give concessions. The entity or collaborative conducting network planning must determine priorities for the type, size, number and location of stations throughout the deployment process. They must incorporate vehicle deployment status and projections from OEMs. They must incorporate learning from on-the-ground experience into the network plan. It will be essential to update and communicate the plan to stakeholders on a regular basis.
- **Location vetting**. At a more granular level, potential stations need to be vetted to ensure they meet broader planning criteria. If plans need to be changed, easy to navigate, flexible modification process needs to be in place.
- **Vehicle deployment projections**. Annual, verified surveys are critical to the government investment plan. If vehicles are projected to come faster than expected, the government and private investors need to be able to prepare to scale up the station deployment program. Conversely, if expected FCEV penetration decreases, slowing delaying station deployment can save public money.
- **Station performance monitoring**. A wide range of data can and should be collected from existing stations so that subsequent stations and solicitations can be improved. While some data or information must remain confidential, much can and should be shared with the network (perhaps in a scrubbed or "clean room" fashion) to ensure system improvements.

4. Developing the Long-Term Funding and Incentive Plan

While the strategic vision should be set at the Governor's level, this report asserts the incentive/investment plan should be developed by the agency or agencies responsible for spending the money.[27] This establishes accountability for the program and empowers the implementing agency to make decisions in the best interest of the effort.

The government investment plan should demonstrate a long-term funding/incentive plan that industry can plan around. Please refer to the "Link Capital Grants to Performance, Rather than Costs" (pg. 77) section for a suggested framework for a long-term capital grant incentive plan that would communicate

[27] Under the current CEC run hydrogen investment structure, the hydrogen investment plan could be developed as part of the annual Alternative Fuel and Renewable Vehicle Technology Program Investment Plan.

long-term incentive levels for stations.[28] These suggestions mirror the approach taken by the California Solar Initiative, which established a long-term incentive schedule, designed to compensate the early adopters who help lower costs for later installations. The plan communicated certainty, a critical factor in investing.[29]

The state-adopted hydrogen investment plan will need to balance providing incentive certainty with the ability to adapt to updated knowledge and feedback. Although challenging, a balance can be struck, and that the most important factor is communicating the government's commitment to long-term success as long as pre-defined, agreed upon targets are met. If the program is not working, the government's exit should be predictable well in advance, to all parties. This Hydrogen Network Investment Plan (e.g., the one you are reading) together with information from the CEC and ARB station funding programs and the CaFCP Roadmap can serve as a conceptual foundation for a government adopted hydrogen investment plan. It will be critical to develop the plan transparently with broad stakeholder and public input. It should be updated regularly.

Identifying and Empowering a Hydrogen Champion within Government

In an ideal world, the government adopted investment plan would facilitate efficient coordination of government and private resources. In reality, the actions and targets laid out in the plan are likely to become another component of busy staff-person duties, opening up the potential for key components to be delayed or fall through the cracks.

To counteract this reality, the state needs a point person with a near singular focus on ensuring successful public investment into hydrogen infrastructure. This person should be empowered to speak and act on behalf of the state, and to work across agencies to facilitate, support, and do the work and coordination necessary for success. They should be able to hold parties accountable to deliverables, and have or develop strong relationships with industry.

Having a strong, empowered "hydrogen champion" within the State government could be the difference between successful station deployment and a stalled system.

[28] A comprehensive government investment plan will incorporate plans for capital grants, market assurance/O&M support, connector stations, debt and tax tools, as well as non-monetary incentives.
[29] Nearly all of the California Solar Initiative incentives have been used. The program has been very successful and can take a considerable share of the credit for California leading the nation in solar installation.

Offer Market Assurance Grants

Uncertainty in the pace of FCEV market uptake and uncertainty in future station availability can paralyze the market launch. Market assurance grants can address these uncertainties by assuring stations will be open and provide positive cash flow.

Market Assurance Grants are one type of priority mechanism to implement to address the high level of risk inherent in the early market, coverage phase. Before describing how one version of this type of grant could be designed, we elaborate on the scale of the problem and the two goals of these grants:

- Goal 1: Reduce the risk related to uncertain vehicle sales
- Goal 2: Reduce the risk related to uncertain station availability.

Goal 1: Reducing the risk related to uncertain vehicle sales (faced by station developers)

Stakeholders widely accept that a core network of stations needs to be in place before a credible case for selling FCEVs to consumers can be made. In California, approximately 68 optimally placed stations can establish the requisite early network.[30]

However, it is uncertain how quickly or in which areas the market for FCEVs will develop, despite OEM's best intentions to make vehicle sales projections.[31] A private station developer therefore faces significant risk that the station he builds will see little utilization for a number of years. Even with considerable incentives to reduce the initial cost of capital, a developer may face the prospect of many years of negative cash flows, losses that may force the station to close.

Figures 3, 4 & 5 illustrate this challenge from a network level perspective, with the underlying assumption that 68 stations will be built by the end of 2015.[32] For this analysis, we assume that the 68 stations are comprised of a mix small (250kg) and medium size (500kg) stations in core markets, and only small stations in emerging markets and connectors.

If the FCEV market uptake follows the aggressive CaFCP projections from 2010,[33] demand for hydrogen would quickly exceed the capacity of 68 fueling stations (Figure 1). In contrast, if the rollout follows the

[30] See the CaFCP Roadmap. 68 stations represent a negotiated compromise between OEMs, funding agencies, and station developers: Substantially fewer stations would limit the FCEV marketability (but still enable FCEV sales); considerably more stations would increase the public support needs for the network build out.
[31] As evidenced by previous sales of hybrid and plug-in vehicles.
[32] The CaFCP Roadmap sets a target of 68 stations to be open and operating by the end of 2015.
[33] The CaFCP scenario is based on the OEM survey conducted in 2010, and is underlying basis for CaFCP roadmap. These are real projections of what automakers are prepared to do if stations are available to support FCEVs (i.e., stations are not a limiting factor). In our modeling, we use it as a high scenario of an aggressive roll-out in a context in which stations are available in time for OEM mass production.

California Air Resource Boards likely compliance scenario for the ZEV regulation,[34] 3 to 4 years would pass until new stations are needed to satisfy demand for hydrogen (Figure 4).

These scenarios show the considerable uncertainty facing a station developer. In the aggressive FCEV market uptake scenario, a cluster station (i.e., a station in a core vehicle sales market) constructed in 2014 is likely to have substantial throughput in the 2015-16 timeframe. That same station could wait 3 or more years before generating any profits if car sales are slower. Figure 5 shows that long wait if the cars are sold at 25% of the ZEV compliance scenario.[35]

Figure 3: CaFCP Survey Projections

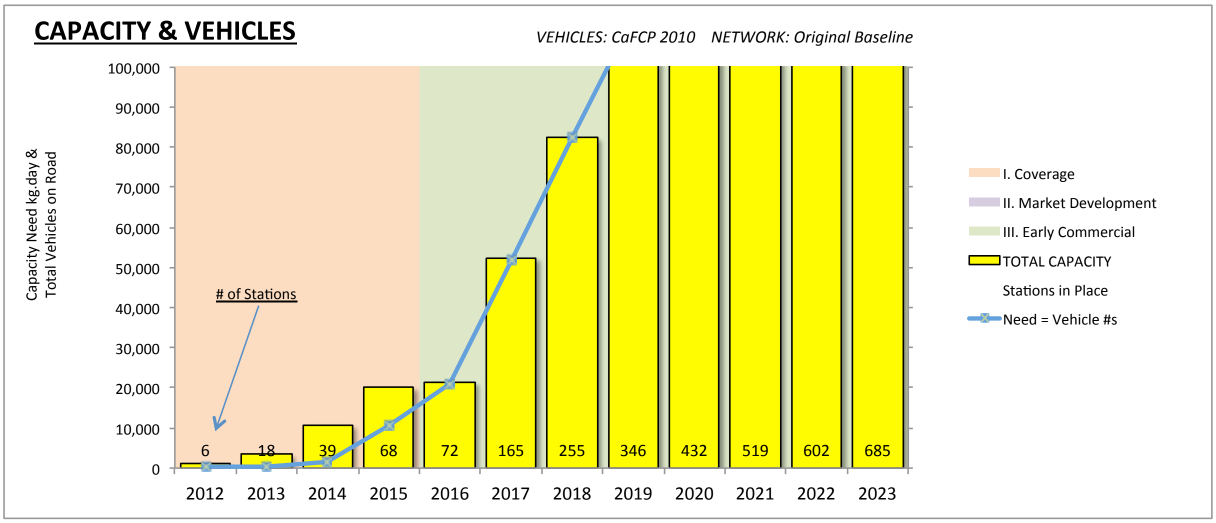
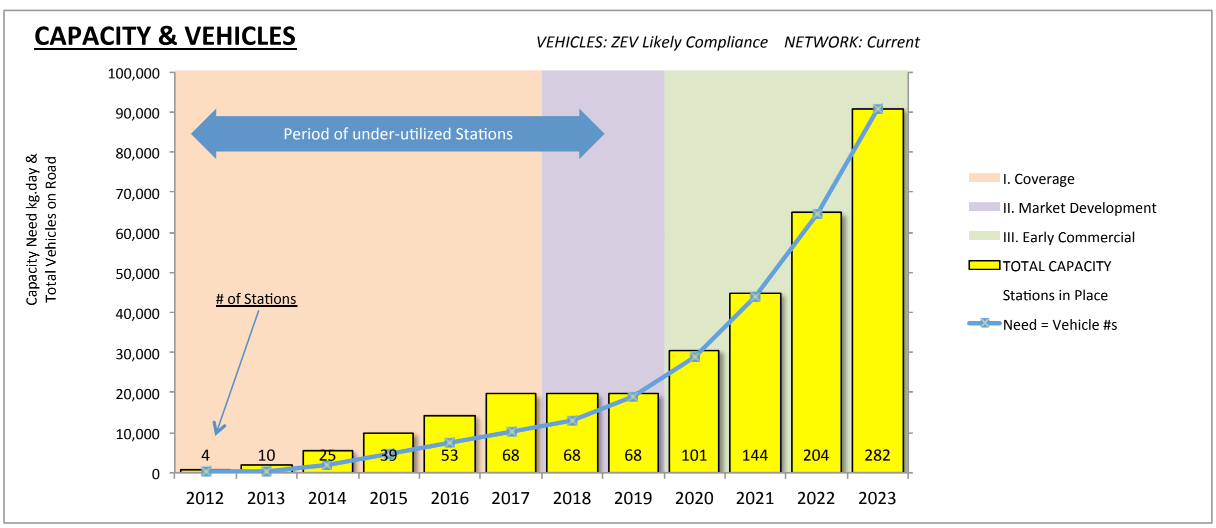
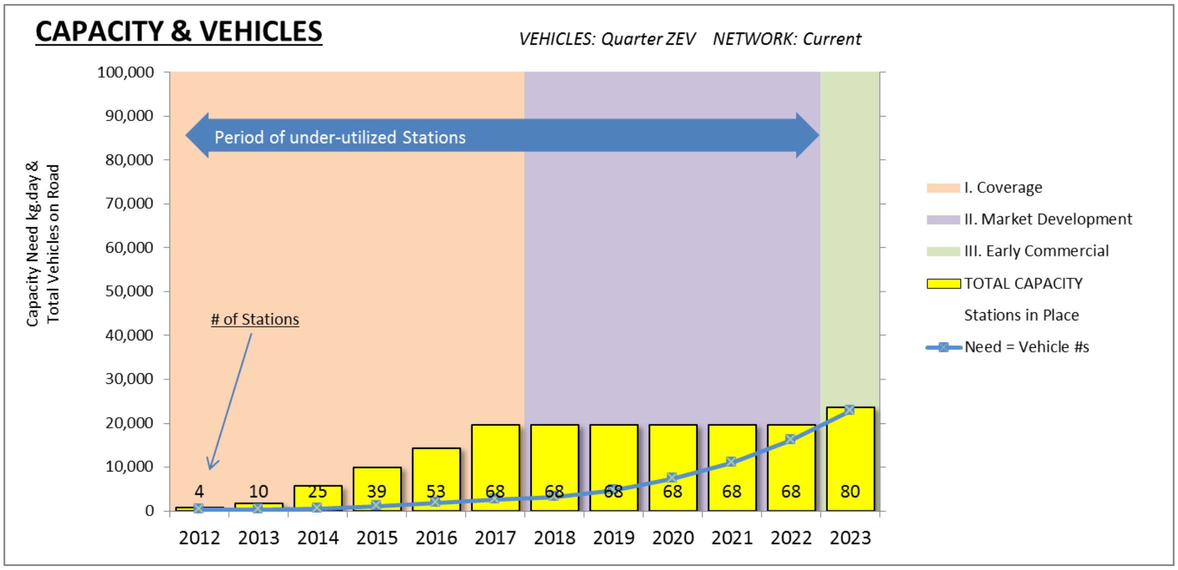


Figure 4: Likely Compliance Scenario, CARB ZEV Regulation



[34] Staff Report: Initial Statement of Reasons, Advanced Clean Cars, 2012 Proposed Amendments to the Clean Fuels Outlet Regulation, December 3, 2011.
[35] The Half ZEV and Quarter ZEV scenarios are modeled to show the risk of a slow FCEV rollout to station providers.

Figure 5: Quarter ZEV Likely Compliance Projections



Quantifying the Risk to Station Investors

For the FCEV market to have a reasonable opportunity to develop and succeed, we assume that a well-placed hydrogen fueling station needs to:

a) Be open and operating for a minimum of 10 years.[36]
b) Sell hydrogen at a competitive price.[37]

Fixed costs associated with keeping a station open can range anywhere from $55,000-$120,000 per year, depending on current estimates of rent, insurance, permits, taxes, and maintenance.[38] For simplicity and illustration, we use a figure of $100,000 per year of fixed operating expenses for a station receiving compressed or liquid hydrogen deliveries, which implies a total costs $1 million to keep a station open for 10 years.[39] For this illustration, we ignore the time value of money, and so do not discount future costs.

As FCEV sales ramp up, revenue from fuel sales will offset these costs. However, at the extreme, a station developer faces the possibility of a having negative cash flows of up to $1 million over the initial

[36] Further analysis will be needed to determine the appropriate length of time. 10 years is a presumed maximum, based on the expected life of the early equipment.
[37] A competitive price for H2 is important, yet hard to control. In this analysis, we assume a comparable price on a $/mile basis as a ceiling. With fuel cell drivetrains providing 2-2.5x the efficiency of gasoline engines, and California gasoline at about $3.90 (May 2013), this currently corresponds to a range of $7.80-9.75 per kg. This analysis therefore uses $9/kg as the baseline.
[38] Please refer to Appendix A for a detailed explanation of underlying assumptions.
[39] $100K represents anticipated fixed O&M costs for delivered hydrogen with 700 bar dispensing: Ogden, Joan et al. UC Davis Institute of Transportation Studies. “Analysis of a ‘Cluster’ Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California.” Presentation, Sept. 16, 2011. Revised Feb 22, 2012.

10 year period if FCEV sales do not materialize. The public or private station investor therefore risks both the upfront capital and operating expense, as shown below for a generic 500kg/day delivered hydrogen station:

$1.5m Capital Investment + $1m 10-year fixed Operation Expense = $2.5m Risk

Even if a grant covered 100% of the capital cost of installing a station, a station owner would assume nearly $1 million in operational risk if he or she were expected to keep the station open for 10 years. This cost clearly represents a significant financial risk to first movers in this market that is in the same order of magnitude as the capital investment, even if discounted over time.

The CEC Grant – a partial reduction of this risk

The most recent CEC grant (PON 12-606, released November 19, 2012) starts to address the risk that FCEVs may not penetrate the market quickly enough to cover O&M costs. This PON authorizes up to $200,000 in operations and maintenance support over the first 3 years of a project, with a total project cap of $1.5 million (including capital costs). This matches the CEC requirement to keep the station operating for a minimum of 3 years.

Using the same logic as above, under PON 12-606, a station developer faces the following risk for a 3 and 10-year commitment respectively:

*3-year commitment: ($1.5m * 35%) + ($0.3m operations - $0.2m grant) = $0.63m risk*[40]

*10-year commitment: ($1.5m * 35%) + ($1m operations - $0.2m grant) = $1.33m risk*[41]

In reality, businesses will have varying levels of tolerance for risk and willingness to stay in the market. Under the current program rules, it would be unlikely for a business to maintain a station for 10 years without continually improving throughput.

[40] The $1.5m cap translates into a $2m station (65% CEC share = $1.3m) plus $200K in O&M support.

[41] On a NPV basis, discounted at a 10%, these numbers are $560k and $926k respectively, still a difference of $366k over the period.

Goal #2: Reducing the risk related to Uncertain Station Availability (faced by OEMs)

Individual OEMs also face considerable financial risk relating to the location of stations and the growth pattern of the early market.

Given the current requirement to maintain and operate a station for 3 years, the only way an OEM can guarantee a station stays open year 4 and beyond is by selling enough vehicles in the area to generate sufficient hydrogen sales. In reality, hydrogen sales at most stations will depend on the efforts of multiple OEMs, making it difficult for an individual OEM to be in control of their network wide fueling destiny.

To complicate matters, automakers make deployment volume and target location decisions based on station status up to three or more years prior to launch.[42] With poor timing, an OEM could be scaling up production just as stations are closing. If an OEM makes plans to deliver FCEVs to certain market, and a core or supporting station closes, one or more vehicles will not be able to be sold or leased. This is one of the fundamental risks an OEM bears.

Quantifying Risks to Automakers

Automakers have already invested billions of dollars in FCEV technology development and demonstration.[43] For the purposes of this analysis, we will not attempt to estimate the cost of bringing FCEVs to commercial production levels. We can, however, quantify the impact of the *inability* to place FCEVs in California in the context of the California Air Resources Board's (ARB) Zero Emissions Vehicle (ZEV) regulation.

Under ZEV, a large volume automaker is required to place a percentage of pure ZEV vehicles in California (i.e., hydrogen FCEVs or plug-in battery-electric vehicles). If an OEM plans to depend on FCEVs in its strategy, and cannot place enough FCEVs, the company will need to purchase ZEV credits or pay a penalty. This risk can be quantified using the ZEV credit scale and penalty costs.

Under the ZEV credit system approved in January 2012, a Model Year 2018 FCEV with a range of 350-miles or greater qualifies for 4 ZEV credits. FCEVs delivered prior to 2017 qualify for 7 to 9 ZEV credits.[44] The ARB can assess a fine of $5,000 for every credit an OEM is short of its requirement.[45] Thus, one FCEV is worth $20,000 to $45,000 in avoided penalties (4 to 9 ZEV credits * $5,000/credit = $20,000 to $45,000).

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[42] Aggregated automaker feedback.

[43] OEMs have invested over $9 billion developing FCEVs worldwide, according to the Alliance of Automobile Manufacturers and Global Automakers (as communicated in support of California's SB11 and AB8 bills heard in the 2013 Legislative session).

[44] CARB, ZEV Regulation: 2009 through 2017 Model Years. 2018 and Subsequent Model Years. Title 13, California Code of Regulations. Note that FCEVs can generate even more credits under the ZEV travel provision, which allows a placed FCEV to be counted in each ZEV states without hydrogen infrastructure. If California is the only ZEV state with infrastructure, one FCEV essentially generates 12 ZEV credits.

[45] Health & Safety Code, Section 43211 – From ZEV Reg: "the number of vehicles not meeting the ARB's standards shall be equal to the manufacturer's credit deficit".

If one 500kg/day station enables the support of 500 FCEVs, its closure or failure to open has the potential to cost OEMs $10 - $22.5 million:

500 FCEVs * $20K to $45K per FCEV = $10 to $22.5 million risk

This core risk facing OEMs could be eliminated if the investment plan could ensure that stations stay open during FCEV early market penetration.

Recommendation: Address Uncertainty with "Market Assurance Grants"

The following section details how a well-designed "Market Assurance Grant" (MAG) could be used to address both of the above problems.

Without hydrogen demand, or with a very slow ramp up in demand, a hydrogen station investment cannot provide a reasonable rate of return to investors, regardless of the upfront financing/grant structure used to construct a station.[46] As currently structured under the CEC program, if the vehicles do not materialize, station owners must face all the losses.

A MAG is a grant or investment that would pay a qualifying station investor a predetermined sum per year until hydrogen demand from fuel cell vehicles eliminates the need for support. The grant would:

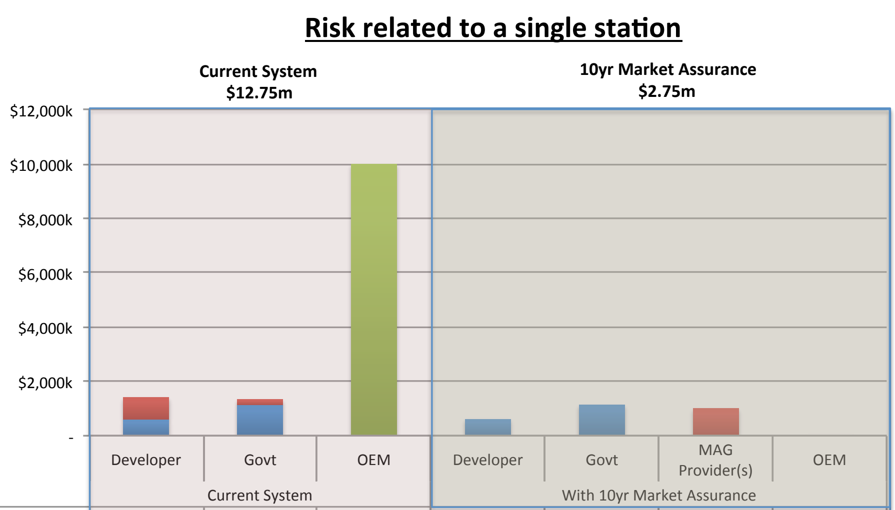
a) Eliminate the downside risk which early station investors face from uncertain vehicle sales, by transferring that to the MAG provider[47]
b) Eliminate the significant downside risk OEMs face from premature station closure, by keeping them open with assurance of operational support.
c) Provide an additional, ongoing mechanism to ensure stations provide high quality fueling service for the customers.

Figure 6 illustrates the risks related to a single station, and how a "Market Assurance Grant" can reduce these risks.

[46] It costs $55,000-$120,000 per year to keep a hydrogen station up and operating. Our assumptions in this analysis assume $100,000 per station, following Ogden, Brown. Please refer to Appendix A for a detailed list of assumptions.

[47] A MAG could be provided by government, auto companies, or other private investors with a stake in the long-term health of the hydrogen FCEV market.

Figure 6: Market Assurance Grant transfers developer risk, and reduces total risk.



	Current System: Developer	Current System: Govt	Current System: OEM	With 10yr Market Assurance: Developer	With 10yr Market Assurance: Govt	With 10yr Market Assurance: MAG Provider(s)	With 10yr Market Assurance: OEM
Station availability Risk (min)			$10.0 m				0
Vehicle Deployment Risk (max)	$800k	$200k				$1,000k	
Station Capital	$613k	$1,138k		$613k	$1,138k		

[48]

Market Assurance Grants – Station & Grant Maker Perspective

Table 5 shows the impact of a Market Assurance Grant on a 500kg/day, $1.75 million, delivered hydrogen Core Station that opens in 2015. This assumes hydrogen delivered at $5.50/kg, and sold for $9/kg. After variable costs, taxes and credit cards, this provides a $2.18 net margin per kg.

The table shows that the internal rate of return (IRR) to the investor is not large under all incentive scenarios. Without a grant, they would get a negative 3.1%, which is raised to 10.2% with a 65% cost share, assuming cars are bought at the ZEV likely compliance scenario rate. A Market Assurance Grant would increase that slightly to 14.4% - a rate that may or may not overcome a typical infrastructure investor's hurdle rate, or minimum market entry point.

The Slower Grow scenario exposes the core challenge of early market hydrogen infrastructure: even with a 65% cost-share, the investor loses money. The MAG grant brings returns back into the positive, with 5.9%. To provide this downside protection, the MAG grant paid by the government rises from $164k (ZEV compliance scenario) to $457k (Quarter ZEV).

[48] The graph highlights that the station developer faces a risk worth up to $1m to have to keep the station open for 10 years, but since he has they option to close, it creates the OEM risk related to station availability.

Table 4: Impact of MAG Grants on IRR of Developer and Grant $ Required

Station	Incentives	IRR for Developer		Grant $ Required	
		Baseline Growth (ZEV Compliance)	Slower Growth (Quarter ZEV)	Baseline Growth (ZEV Compliance)	Slower Growth (Quarter ZEV)
500kg (2015) *$1.75m Capital, 107k/yr O&M*	No Grant	**-3.1%**	**-8.3%**	-	-
	65% Cost Share	**10.2%**	**-0.7%**	$1,138K	$1,138K
	65%+Market Assurance Grant	**14.4%**	**5.9%**	$1,302k Mag = $164k	$1,689k MAG = $457k

As with all the analysis, the actual return depends largely on the upfront capital expenditures. The cost of MAGs to the grant-maker depends entirely on FCEV rollout and station deployment timing. A core station deployed in 2015 may only need 6 months of support; a connector station deployed the same year may require 10 years plus of support.[49]

This Investment Plan discusses strategies to lower costs in other ways (see section on "Performance-based Grants" and their downward pressure on costs throughout the supply chain), but the effect of the Market Assurance Grants highlight the need to minimize the downside risk of the station developers' investment.

Design of Market Assurance Grants

The success of a MAG program will depend on a good design, as well as efficient and predictable administration of the funds.

Set the MAG funds apart from annual government or corporate budgets

To accomplish the goal of providing full stakeholder assurance, the MAG funds need to be divorced from political processes, ideally with all of the potential need set aside up front.[50] For example, if offering a 10-year MAG to a station with a $100K/year O&M budget, the equivalent of a sum of $1 million should be earmarked for that station and held in a separate fund until the defined throughput threshold is reached. That full $1m would only be used if the station never reached the throughput threshold.

We recognize that if the government supplies some or all of the MAG grant, spending requirements and timelines will require that such funds be limited to the initial market.

[49] Please refer to the "MAG Sensitivity Considerations" on page 43 for a discussion on how capital costs and retail margin impact a station's payback and the efficacy of MAGs.

[50] MAGs could be administered by a number of organizations: CEC, ARB, AQMDs, or a third party (e.g., a Hydrogen Infrastructure Trust, HyTrust, iGate).

Make the MAGs available to approved, coverage stations only

A MAG should only be offered to stations that meet the following criteria:

- **Only for the Initial Coverage Stations (the first 68).** This is a targeted mechanism to address the uncertain coordination of stations and vehicles in the early market, not a start-up grant for future stations.
- **Locations must be approved by an OEM group/consensus**. It is not prudent to support stations in areas where OEMs have not committed to market the first vehicles.
- **Location cannot be too close to another station**. To avoid undermining each other, and forcing multiple stations to receive MAG payment indefinitely, a defined radius could be set for each area (i.e. core markets, emerging markets, and connectors). A future developer would not be eligible for a MAG if within that radius.

Pay the MAG incentive based on previous quarter actual sales.

Setting the metric against which a station receives a payment is difficult. In an ideal world, stakeholders believe that a combination of both actual station throughput, and the number of vehicle that are located nearby would be the most fair way compensate a station owner. This would cover the possibility that a station has poor sales through no fault of its own, as well as the other possibility - that it is not being marketed or maintained well enough. The MAG should not disincentivize good performance.

However in reality, a system linked to vehicle placement is probably too complex to implement, given the wide variety of station locations and roles they play in this initial coverage. Therefore we recommend that the system just be linked to actual throughput for a station, and that the incentive to grow sales be ensured in two, different ways.

- First, the payment structure needs to be such that it is always more preferable to sell hydrogen than it is to receive the incentive. For every kg sold, the loss in incentive must therefore be lower than the net margin made (this is described describe this in more detail below).

- Second, high performance can be ensured through minimum performance requirements. Though these would not directly reward a higher performance station, they would set a minimum threshold below which that station would not receive it's MAG payment, even if it had low throughput.

Require minimum performance and information thresholds:

As described above, Market Assurance Grants can be used to ensure a minimum level of performance from the stations. Payments should only be received if the station meets the following conditions:

- **Performance requirements**. A station should meet minimum requirements, specified in a contract. These should be based on the specifications developed by SAE International and those submitted by the OEM workgroup and CaFCP and submitted to the CEC for PON 11-609.[51]

[51] Docket No. 12-HYD-1 "Hydrogen and Transportation"; http://www.energy.ca.gov/contracts/notices/2012-07-10_workshop/comments/ July 10, 2012 CEC Staff Workshop.

- **Insurance requirements**. Other requirements that could be linked to MAG payments would include the station having active liability insurance, to avoid the need for any contracts with users or OEMs.
- **Information requirements**. MAG payments would also be subject to a requirement that the station meets informational needs of the system. This could go beyond throughput information. It could be aggregated in a "Clean Room," and serve as the basis for the amount of the payment as well as analysis of the overall network.[52]

Limit Availability of MAG payments to 10 years

Stakeholder input suggests that a long duration of the Market Assurance grant is key to sending the signal that a station will be supported until vehicles come. However, the life of the equipment in this early market is unlikely to extend much beyond 10 years, so we recommend these grants be structured as 10-year agreements.

It is important to note two key points regarding the length of MAGs:

1. Stations in different markets (i.e. core vs. emerging and connector) will clearly experience different growth rates. The proposed 10 year coverage for them all is a critical signal to investors that all parts of the network are covered during this initial build-out.
2. In core markets, it is highly unlikely that MAG payments would be needed for 10 years. Assuming reasonable market growth (i.e., the ZEV Compliance Scenario), many stations would no longer need MAG support after 1 to 3 years.

Structure MAGs to leverage the system

We have assumed State government funding would be the prime source of MAGs in our analysis. However, the MAG system could also be used to bring in additional funding streams and partners to the system, complementing the capital focus of the CEC. These could come from regional air quality districts, federal funding, or other financing vehicles, such as revenues linked to Low Carbon Fuel Standard (LCFS) credits, or from auto companies, possibly in the form of pre-paid fuel. We discuss the idea of leveraging LCFS credits in greater detail in a Chapter 7 (page 90).

One other advantage of having a new party involved in providing MAG grants is that it could serve as a powerful signal to stakeholders that other entities, beside the State of California, are vested in a successful outcome of the build-out. This investment signal sent by having commitment from multiple stakeholders would be extremely valuable, allowing all of these MAG partners to demonstrate the "skin-in-the-game" that is so critical to private investors.

Set a steadily declining payment:

A simple option often proposed is to compensate stations for their actual losses in a type of reimbursement scheme. However, this provides little incentive to the station owner to drive costs down or to improve sales.

[52] A "clean room" is a secure data center which can safely collect and aggregate sensitive information without compromising the mission or market position of the data provider.

Instead, we suggest a steadily declining payment that is set up to ensure the station is compensated for losses, but not disincentivized to perform. The true breakeven point for a station depends on its net revenue per kg sold, as well as its O&M expenses and capital payments. Unfortunately, a payment scheme that tries to link to these becomes overly complex.

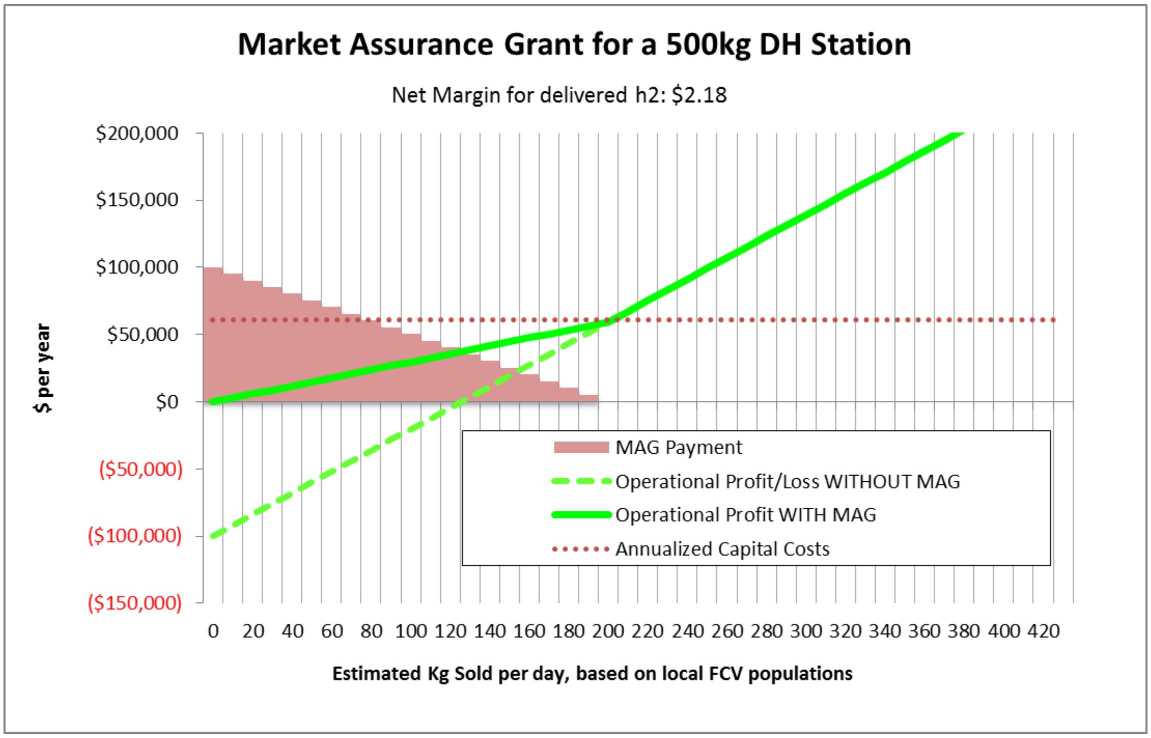
Instead, we propose the following strawman structure, which prioritizes simplicity and uniformity.

1) **Set a single system for all stations, regardless of size**. Our data on stations suggest that although the O&M costs do vary by station configuration, there is a not a significant enough range among the likely coverage stations to warrant a design-specific MAG grant. We use $100,000 per year, to include O&M, property rent, permitting, and property taxes as our starting point.
2) **Ignore capital costs, but assure operational profits**. The aim of this system is to cover O&M costs, not ensure operational profits can pay for capital. We therefore ignore the capital cost of the system, assuming that the investor will make their calculation in conjunction with capital oriented grants.
3) **Assume a net margin between $2-$3 per kg sold**. It is impossible to predict, but given current delivered hydrogen costs, and the upper ceiling of a gas-equivalent hydrogen pricing, a $2-$3 range for net revenue per margin (after variable costs, taxes and credit card fees) should be reasonably attainable.

These parameters allow the design illustrated in the graph below (see Figure 7). The red shading illustrates a MAG payment that starts out paying $100,000 to a station that has no throughput. Without this MAG payment, the station would have an operating loss of $100,000 (e.g., where the dotted-green line intersects the y-axis). The MAG payment brings the operations balance sheet up to the solid green line – i.e. breaking even, operationally. Note that this does not constitute profitability – the red dotted line reflects a simplified annualized capital cost, after a 65% grant, for this 500kg station over a 10-year lifespan.

As throughput increases, the payment decreases steadily. For every increase in 1 kg/day, the MAG payment decreases. A station with a throughput of 100kg/day would receive an annual payment of $50,000. When it reaches 200kg/day, the MAG payments cease.

Figure 7: The impact of MAGs on operational Profit.



With this system, a station owner is always incentivized to increase sales. He will gain an additional $2-$3 for every kg, but lose a $1.37/kg MAG payment, for a steady net gain as shown by the solid green line.

Whether this seems overly generous or not depends on the margin one assumes. If one wanted to phase out payments at 100 kg/day of sales, this would mean that for every kg sold up until that point, the owner would be forfeiting $2.79/kg MAG payment with every kg sold ($100,000/365/100). This is clearly either a dangerous disincentive, or requires an assumption of high prices to consumers.

We use the above scheme in considering MAG payments in the analysis for this paper.

Off-ramps and other design elements

It is essential that flexibility be incorporated into a MAG contract, to allow some adaptation to on-the-ground reality once vehicle sales begin. The following flexibility elements should not undermine the risk-reduction of the MAG payment.

- **Off-ramps**: The MAG contract will need to allow for several off-ramps. The government may need to buy-out a station owner if the evolving network suggests that the capital and it's associated MAG commitments are best re-deployed elsewhere. Likewise, the station owner may want to act on contractual off-ramps under pre-set circumstances or milestones. Stakeholder input suggests that a long contract, with off-ramp clauses, is far preferable to a series of contracts. This long-term approach is clearly essential to provide the overall assurance intended by these grants.

- **Station declines**. It is possible that a station could pass the 200 kg/day in one quarter (ending the need for MAG payments) and fall below 200 kgs/day in the next quarter. This could be the case if a new station opens up to help provide sufficient capacity. If this occurs, it must be clear whether or not the station remains eligible to receive MAGs when throughput declines below 200kg/day. EIN believes stations should remain eligible for MAG funding through the life of the station's MAG contract. However, this concept should be carefully considered before contractual commitments are made to ensure stations are incentivized to sell increasing volumes of hydrogen.

Cost of the Network

Figure 8 and Figure 9 below show the incentive cost associated with Capex and Market Assurance Grants with the following assumptions:

- FCEV rollout follows the ZEV likely compliance scenario
- 68 stations are constructed before the end of 2017, resulting in approximately 20,000 kg/day capacity
- 100 stations are constructed before the end of 2020, resulting in approximately 30,000 kg/day capacity
- FCEV sales are concentrated around core markets
- Grants pay for 65% of Capital Costs up to 68 stations, and 50% up to 100 stations[53]
- The cost of Stations 26-68 correspond to EIN's "Baseline" costs; 69-100 assume EIN's "Low" cost for delivered gas stations, as shown in Appendix A (Table 9: Station Cost Assumptions).
- A station is eligible for up to $100,000/year to cover O&M costs in the form of a MAG, based on a linear declining payment reaching zero at 200 kg/day
- MAGs are available for a maximum of 10 years, and are made available to stations 1 – 68.
- Stations 1 – 25 have already funded through ARB's Hydrogen Highway Program, CEC's AB118 Program, and by Shell. These investments are not included in the CapEx estimate below.[54]

The red line represents cumulative expenditures, while the red bars (with the black border) in the graph represent annual grant expenditures (pink bars represent annual station industry investment).

[53] CEC's March 2013 Program Opportunity Notice (PON 12-606) offered up to 65% capital cost share.
[54] The CapEx estimate includes CEC's AB118 investments

Figure 8: Total Capital Expenditure and Capex Grants for the 100 Station network

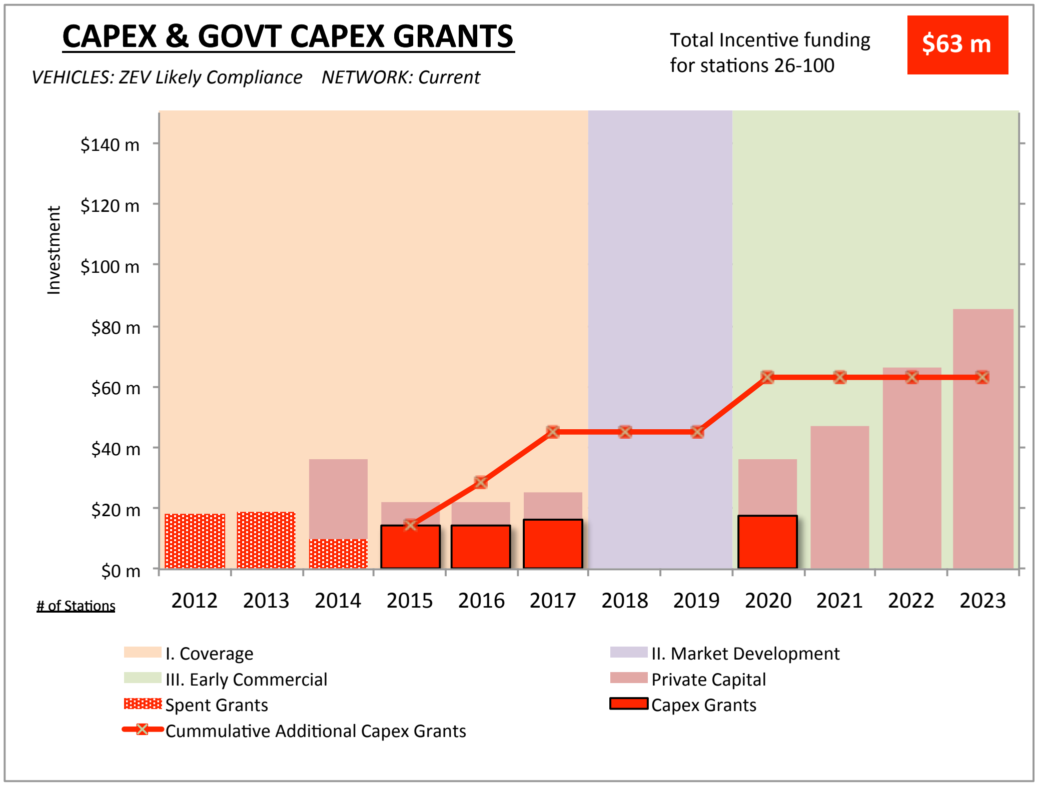
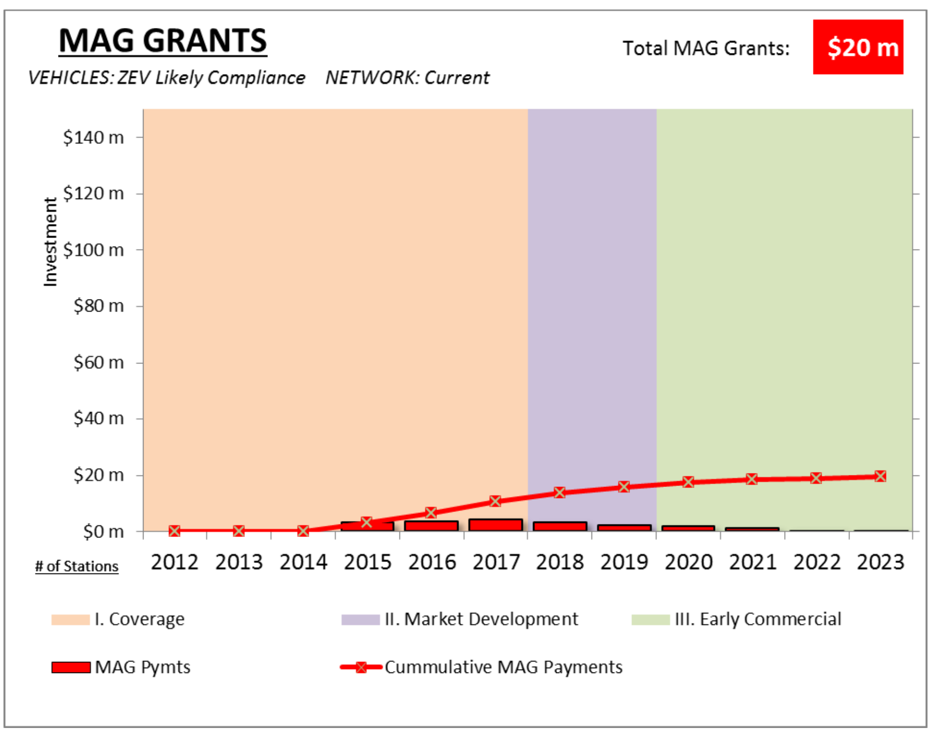


Figure 9: Total cost of Market Assurance Grants under the ZEV Likely Compliance Scenario



Given the above assumptions, the total cost of the incentives needed to get to a 100-station network from the existing 25 would be approximately $81 million ($63m Capex + $18m MAG).

If the FCEV rollout followed the lower, 25% of ZEV compliance path projections, the capital grants payments would remain the same, but the MAG payments would rise to $38m, for a total of $98m.

We assert that despite the many uncertainties inherent in projections of this kind, the result is clear. A Market Assurance Grant approach has the potential to significantly change the investment calculation for private investors who currently have been wary to invest, and send a powerful signal of the State's commitment. In addition, the cost, in relation to the overall investment, does not appear to be insurmountable.

MAG Sensitivity Considerations

The MAG concept is not designed to generate profits for every station, just reduce the risk associated with opening an early coverage station. The actual returns are highly sensitive to the capital cost and retail margin of hydrogen.

Figures 10 and 11 illustrate this concept. In these figures, potential capital costs for a 500kg/day core market station are shown on the left column. The long-term retail price of hydrogen is listed along the top. The most profitable stations are found in the top right corner (i.e., a $1m station selling hydrogen for $12/kg). The outputs are based on the same assumptions made to estimate the cost of the network, which include MAGs (see page 41).

Green shading indicates an IRR greater than 15%, when considering a 10-year project life.[55] For illustration purposes, the yellow box highlights the intersection of a $2 million station selling hydrogen at a competitive $9/kg price.[56]

Figure 10 shows that the IRR of the baseline core market station, under the ZEV compliance growth scenario, and with 65% cost share but no MAG-type payments, is 9.5%.

[55] We chose 15% for illustrative purposes. 15% is the typical investment hurdle rate for natural gas production. In other words, a typical natural gas development firm will invest if the IRR is expected to be 15% or greater (Bentek presentation to the CaFCP, Spring 2013).
[56] Stakeholders expect a 500 kg/day station built in 2015 to cost approximately $2 million: Ogden, Joan et al. UC Davis Institute of Transportation Studies. "Analysis of a "Cluster" Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California." Sept. 16, 2011. Revised Feb 22, 2012.

Figure 10: IRR Sensitivity under ZEV Compliance Scenario (65% cost-share, no MAGs)

	IRR of a 2015 Core Market: 500-DH2 Station				*Vehicle Sale: / Likely Compliance*				
	If long term Hydrogen Retail Price								
Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-2.7%	11.4%	21.0%	28.8%	36.0%	43.0%	49.9%	56.7%	63.4%
$1,100k	-3.8%	10.1%	19.5%	26.9%	33.7%	40.2%	46.6%	53.0%	59.1%
$1,200k	-4.9%	9.0%	18.0%	25.2%	31.7%	37.8%	43.7%	49.7%	55.5%
$1,300k	-5.8%	7.7%	16.7%	23.7%	29.9%	35.6%	41.3%	46.8%	52.4%
$1,400k	-6.7%	6.5%	15.5%	22.3%	28.2%	33.8%	39.1%	44.4%	49.6%
$1,500k	-7.6%	5.4%	14.3%	21.1%	26.8%	32.1%	37.1%	42.1%	47.1%
$1,600k	-8.3%	4.4%	13.3%	19.9%	25.4%	30.6%	35.4%	40.2%	44.9%
$1,700k	-9.1%	3.4%	12.3%	18.8%	24.2%	29.2%	33.8%	38.4%	42.8%
$1,800k	-9.7%	2.5%	11.4%	17.8%	23.1%	27.9%	32.4%	36.7%	41.0%
$1,900k	-10.4%	1.7%	10.4%	16.9%	22.1%	26.7%	31.1%	35.2%	39.3%
$2,000k	-11.0%	0.9%	9.5%	15.9%	21.1%	25.6%	29.9%	33.9%	37.8%
$2,100k	-11.5%	0.1%	8.6%	15.1%	20.2%	24.6%	28.7%	32.6%	36.4%
$2,200k	-12.1%	-0.6%	7.7%	14.3%	19.3%	23.6%	27.6%	31.5%	35.1%
$2,300k	-12.6%	-1.3%	6.9%	13.5%	18.5%	22.7%	26.6%	30.4%	33.9%
$2,400k	-13.1%	-1.9%	6.2%	12.7%	17.7%	21.9%	25.7%	29.3%	32.8%

As described earlier, this IRR drops significantly when vehicle sales growth is lower. Figure 11 shows the expected returns if a 65% cost share were the only monetary incentive. Without a MAG, a station owner would need to price hydrogen well above a $4/gallon gasoline equivalent and have access to a cheap station to earn a motivating return ($4/gallon of gasoline is roughly equivalent to $8 - $10/kg of hydrogen).

Figure 11: IRR Sensitivity Quarter ZEV Scenario (65% cost-share, No MAGs)

	IRR of a 2015 Core Market: 500-DH2 Station				*Vehicle Sale: Quarter ZEV*				
	If long term Hydrogen Retail Price								
Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-21.1%	-9.6%	-3.1%	1.6%	5.4%	8.8%	11.9%	14.8%	17.5%
$1,100k	-21.4%	-10.0%	-3.5%	1.1%	4.8%	8.1%	11.1%	13.9%	16.5%
$1,200k	-21.8%	-10.4%	-4.0%	0.6%	4.2%	7.4%	10.4%	13.0%	15.5%
$1,300k	-22.1%	-10.9%	-4.4%	0.1%	3.7%	6.8%	9.7%	12.3%	14.7%
$1,400k	-22.5%	-11.4%	-4.8%	-0.3%	3.2%	6.3%	9.0%	11.5%	13.9%
$1,500k	-22.8%	-11.8%	-5.2%	-0.7%	2.8%	5.7%	8.4%	10.9%	13.2%
$1,600k	-23.1%	-12.2%	-5.6%	-1.1%	2.3%	5.2%	7.9%	10.3%	12.5%
$1,700k	-23.4%	-12.7%	-6.0%	-1.5%	1.9%	4.8%	7.3%	9.7%	11.9%
$1,800k	-23.7%	-13.1%	-6.4%	-1.9%	1.5%	4.3%	6.8%	9.1%	11.3%
$1,900k	-23.9%	-13.4%	-6.8%	-2.2%	1.1%	3.9%	6.4%	8.6%	10.7%
$2,000k	-24.2%	-13.8%	-7.2%	-2.6%	0.8%	3.5%	5.9%	8.1%	10.2%
$2,100k	-24.4%	-14.2%	-7.7%	-3.0%	0.4%	3.1%	5.5%	7.7%	9.7%
$2,200k	-24.7%	-14.5%	-8.1%	-3.4%	0.1%	2.7%	5.1%	7.2%	9.2%
$2,300k	-24.9%	-14.8%	-8.5%	-3.7%	-0.3%	2.4%	4.7%	6.8%	8.8%
$2,400k	-25.1%	-15.1%	-8.8%	-4.1%	-0.6%	2.1%	4.3%	6.4%	8.4%

Figure 12 shows how the addition of MAG grants helps protect against downside risk by bringing the baseline station to a revenue neutral position, As Figure 12 shows, under the Quarter ZEV Scenario, a developer with a $2 million dollar station would need to charge over $11/kg to earn an attractive return on the station, even with MAG support.

Figure 12: IRR sensitivity. Quarter ZEV scenario, with 65% cost share AND MAG grants.

	IRR of a 2015 Core Market: 500-DH2 Station				*Vehicle Sale:*	*Quarter ZEV*			
	If long term Hydrogen Retail Price								
Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-9.6%	2.7%	10.0%	15.4%	19.9%	24.0%	27.7%	31.2%	34.6%
$1,100k	-10.7%	1.5%	8.5%	13.8%	18.1%	22.0%	25.5%	28.8%	31.9%
$1,200k	-11.6%	0.3%	7.3%	12.3%	16.5%	20.2%	23.6%	26.7%	29.6%
$1,300k	-12.5%	-0.8%	6.1%	11.1%	15.1%	18.6%	21.9%	24.9%	27.7%
$1,400k	-13.3%	-1.8%	5.1%	10.0%	13.9%	17.2%	20.4%	23.2%	25.9%
$1,500k	-14.0%	-2.8%	4.1%	8.9%	12.7%	16.0%	19.0%	21.8%	24.4%
$1,600k	-14.7%	-3.6%	3.2%	8.0%	11.7%	14.9%	17.8%	20.5%	23.0%
$1,700k	-15.3%	-4.4%	2.4%	7.1%	10.8%	13.9%	16.7%	19.3%	21.7%
$1,800k	-15.9%	-5.2%	1.6%	6.3%	9.9%	13.0%	15.7%	18.2%	20.6%
$1,900k	-16.4%	-5.9%	0.8%	5.6%	9.1%	12.1%	14.8%	17.2%	19.5%
$2,000k	-16.9%	-6.5%	0.1%	4.8%	8.4%	11.3%	13.9%	16.3%	18.5%
$2,100k	-17.4%	-7.2%	-0.6%	4.2%	7.7%	10.6%	13.1%	15.5%	17.6%
$2,200k	-17.9%	-7.7%	-1.3%	3.5%	7.0%	9.9%	12.4%	14.7%	16.8%
$2,300k	-18.3%	-8.3%	-1.9%	2.9%	6.4%	9.2%	11.7%	13.9%	16.0%
$2,400k	-18.7%	-8.8%	-2.5%	2.3%	5.8%	8.6%	11.0%	13.3%	15.3%

It should be noted that for some companies, there are legitimate commercial or competitive reasons to invest in the early market even if returns are likely to be below 15%.[57] However, it is dangerous to assume that sufficient capital can be attracted that is both patient enough, AND willing to absorb large, multi-year losses.

MAG-type operational support grants are likely a necessary, though maybe not sufficient, mechanism to attract and enable investment capital participation in this early phase.

[57] A company might want to grow the market for hydrogen, develop proprietary systems and equipment, create a company that can be sold later, etc.

Set up Infrastructure Monitoring

A monitoring program is essential for market assurance grants to work, and for OEMs and the government to know how the initial network is performing and being used. Real world data and interpretation will enable all parties to adapt plans accordingly.

A successful Market Assurance Grant program will hinge on reliable data collection and interpretation. It is critical to simultaneously establish MAGs and a robust infrastructure monitoring program.

We do not know how the hydrogen market will develop, how customers will use stations, or which stations will be the most successful. We can make assumptions, but assumptions remain theoretical until they can be verified by real world experience at market scale. What we do know, however, is that we have an opportunity to continually learn from each station that gets funded. To ensure that stakeholders capture this learning, and can apply it, it is absolutely critical to establish a formalized data collection and interpretation process. It is practical and sensible for government supported stations to share non-proprietary information that can help achieve the goals of the program.

Data collection can and should be a requirement for the life of each funded station. This data could be collected and aggregated by a range of public or private entities. We believe that the National Renewable Energy Laboratory (NREL) is best positioned to collect and interpret data, as they have existing relationships with most hydrogen/FCEV stakeholders, a data "clean room" already established, and successful programs dedicated to interpreting and presenting data in a trusted and digestible manner. Assuming NREL ultimately becomes responsible for data collection, this data would be used for three fundamental purposes:

1. Program Learning & Adaptation. Lessons from existing stations should be used to inform the solicitation process to ensure that public dollars help develop a successful initial network and provide individual stations with the highest probability of success.
2. Determining Market Assurance Grant Payments. MAG payment can only be optimized if the funding is tied to real, on the ground experience. In this context, formal, predefined data collection and use would be established so that MAG funding is transparent and predictable.
3. Verifying Projected Performance. Government or potential third party investors need assurance that their investments are performing according to specification so that future strategies, expectations and incentives can be adjusted as necessary. In particular, if capital grants are changed to a performance basis (as opposed to cost basis) the program will need to be able to verify that stations perform as projected so that program compensation can be adjusted.[58]

[58] Please refer to the "Link Capital Grants to Performance, Rather Than Costs" (pg. 77) chapter for an explanation on moving to performance-based grants.

Incorporate OEM-based Location Vetting

A formal OEM role is essential in the decision making on station locations. A body, recognized by the government as representing OEM input, needs to be in place to take responsibility for location choices in the coverage phase.

Market-Based Location Vetting: formalize OEM input

PON 12-606 designated the specific areas for hydrogen fueling stations. The polygons included in the PON were developed using the National Fuel Cell Research Center's (NFCRC) STREET model, a sophisticated GIS based model that incorporates demographics, driving times, and OEM input. Based on the scoring criteria, it would be very difficult for a developer to receive funding outside the designated polygons. This upfront network planning helped to communicate optimal site locations to the developer community. This upfront planning, while important, cannot account for unexpected events such as site changes or subjective decision making factors.

Unexpected changes. Even with substantial planning, current station development efforts have been met with location challenges. In many cases, delays in project awards and contracts have opened up site owners to change: some decide to make other plans and/or site conditions change. In others, permits could not be obtained, or site location issues have surfaced leaving developers scrambling to find new locations. These issues have caused considerable delays and left the CEC with the responsibility to determine the suitability of new locations, without direct OEM input. The current system does not account for the dynamic nature of early market deployment.

Subjective decision making factors. The National Fuel Cell Research Center's (NFCRC) STREET model can generate optimal site locations based upon drive times and a given number of stations in a defined area. The original model does not, however, have the ability to prioritize site options among multiple areas or take into account subjective factors such as the personality or resources of any given station owner. For example, if Station A is in a great location, but has a reluctant owner, and Station B is in a good location with an owner with the desire to spread hydrogen across his holdings, Station B may be a better choice for the long-term success of the market. Station B is unlikely to be selected under the current system.

Both unexpected changes and subjective decision making factors point to the need for a clearly defined, multi-faceted and dynamic location decision making process. To capture the impact on the end user, it is critical that the location decision process explicitly includes OEM input.

Why formalize OEM input?

At the end of the day, it is in all stakeholders' best interest to put stations where FCEV customers need them. OEMs have the best understanding of their customers and company marketing/rollout strategy, as well as the subtleties that translate into attractiveness of stations from consumer perspectives, something no algorithm can generate. All else being equal, with limited vehicles in the early marketplace, an OEM vetted station has a much higher probability of being successful – meaning that both public and private dollars are put to best use.

Based on our conversations, many participants see challenges with the current system.

- The CEC does not want to have to micro-manage the location issue (they do not with the other fuels they fund).
- Developers believe the polygons limit their negotiating power and the station owners they can deal with.
- OEMs are discouraged that some priority locations have not been funded even as lower priority locations received awards.

A formalized input process can help free developers to propose stations that may make better subjective sense, increase OEM confidence in the state's effort to build stations (allowing them to plan more aggressively for market introduction), and decrease the burden currently being carried by the CEC.

What would the location vetting process look like?
OEM input should be collected at three formal decision making points:

1) Prior to solicitation development,
2) After the CEC approval process and
3) For any location changes of previously approved projects.[59]

Before the solicitation is developed, OEMs could provide an aggregated station location priority list to help bidders identify greatest needs areas. During the review process, to protect the program from biasing one developer over another, OEMs could be kept blind to station specifications and developer providing input only to the location of the project, and its priority. Furthermore, this aggregation process group should be separate from the CaFCP and CEC to avoid ties with station developers. For reasons discussed in the following section, we believe that NREL could be a logical host of the location vetting process.

To build on the current process, we recommend that OEMs feed their insights into a formalized location vetting process. This process would incorporate the inputs of optimization models, such as the NFCRC STREET model currently employed by the CEC, as well as other network optimization inputs such as those of UC Davis. It also needs to include other factors such as location availability, and long-term goals of station owners. It would be up to NREL to interpret market data, modeling outputs, and OEM input and prioritization, and feed this information into the CEC decision-making process. Regardless of the arrangement, final location decisions must follow OEM input as closely as possible, as described in #2 above. Without this close input and final review, important market subtleties will be lost, as well as the ultimate prioritization of alternatives.

[59] OEMs would only see station locations for stations that meet minimum CEC screening requirements.

While the CEC would retain ultimate authority for funding decisions, a strong case would need to be made to go against OEM location recommendations. The process would be orchestrated with the understanding that no stations outside the current network plan (i.e., the Roadmap) would be funded without OEM approval.[60]

When should the system be established?

The location vetting should be established as soon as possible (for the next PON at the very latest). Ideally, the process should inform any station location changes for projects that have already been approved.

The group should be able to be approached informally during the project application process so that station developers ensure their time is well spent applying for station support.

[60] The CEC would be the only party with all of the information in this arrangement. They may have justifiable reasons to go against OEM prioritization (such as a compelling economic case, market diversity, or renewable capacity).

Use Partners for Implementation

Deploying early market infrastructure is complex & challenging, and a bigger task than any single entity should undertake. Leveraging partners can alleviate some of the burden being carried by the CEC and help improve opportunities for learning and program improvement.

Need for Complex Coordination: the inherent challenges of launching a fuel network

Building a fueling network is an inherently more challenging task than funding a single entity or facility. The successful execution of the CaFCP Roadmap plan depends on close co-ordination and dynamic feedback between infrastructure investors (both government and private), and the automakers that understand and represent their customers' needs – the same consumers that investors will depend on for return on their investment.

Part of the coordination challenge can be defined by the need to pool resources and expertise to make difficult investment choices. The specifications of stations, sizes, and locations all require a combination of commercial, technical and strategic input from different groups of people other than the private investor, to ensure public funds are being spent in a way that will result in a successful launch the private market.

Leveraging the AQMDs to Accelerate Station Deployment

Under the current AB118 framework, we believe the CEC and its hydrogen program would benefit from leveraging its regional government partners to help with execution of the hydrogen infrastructure build-out. These partners can offer additional resources, may have greater flexibility to trial innovative incentives, and relevant local knowledge and connections that can facilitate an aggressive build out.

These partners could take on much of the project management that currently falls on CEC staff. Of the 11 stations granted funding in 2010, none are open as of July 2013. Blame for this delay cannot be placed on any one party, as the issue is systemic and multi-faceted. At the level of individual stations, opening early increases the chance that a station will lose money because fewer cars are on the road. Given an uncertain FCEV uptake rate, from a purely economic, station developer perspective it is best to wait as long as possible to open, once funding has been secured.

If an applicant underperforms, the CEC has limited options for repercussion. In many cases, if the CEC were to take back funding from an applicant, a station (or stations) and associated funding would simply be lost. Furthermore, the CEC does not have the resources to actively project manage each station, leaving the majority of that responsibility to the applicants. If it makes economic sense to delay station deployment, an inherent conflict exists between the program goals and project management.

Formal participation by the local AQMD could help tilt this equation in favor of timely development. Their local access would help them to actively manage funded projects by tracking progress, helping to facilitate permitting, and motivate site owner participation. They also have direct relationships with Municipal Planning Organizations (MPOs), further improving the local station deployment process. Applicants could be motivated by non-hydrogen related relationships with the AQMD, and the AQMD may be able to couple their project management with local incentives for performance.

The table below illustrates how responsibilities might be shared between various agencies and offices, to relive some of the burden on the CEC. We offer this as a starting point, recognizing that significant stakeholder input and analysis is needed to develop this further.

Table 5: Roles and responsibilities among government agencies and the CaFCP.

Governor's Office	• Establish and coordinate agency roles and responsibilities (similar to ZEV action plan)
CEC	• Develop Government Investment Plan ○ Formalize implementation partners, suggestions below • Make Funding Decisions
CARB	• Survey OEMs about expected FCEV placement, feed information to CEC • Provide input into CEC funding decisions • Project management – track projects, ensure deadlines are met
AQMDs	• Local grant-making and incentive experimentation • Project management – track projects, ensure deadlines are met • Permitting – help project developers interface with permitting agencies.

NREL/DOE	• Run station performance monitoring program
	• Collect station performance & utilization data. Interpret, share station specific findings/data with CEC
	  ○ Publish findings for public use (Scrub as appropriate)
	  ○ MAG funding could rely on this data

State Fire Marshall	• Provide a permitting ombudsman to serve as a resource for local permitting agencies
Universities	• Modeling and analysis to inform government plan development and site selection ○ Example: NFCRC STREET Model and interpretation
CaFCP	• Information coordination - ensure the CEC has all relevant data & subjective input to make funding decisions • Station mapping and real-time availability monitoring • Network level demand management (I-5 fill reservation system)?

V. Recommendations for the Near Future

In this chapter, we address issues and tools that will become increasingly important as the market develops. While these second tier items are not game changers in the near term, it is critical to plan for and implement these systems as soon as possible.

1. **Secure Tax Relief and Incentives**. Taxes can have a substantial impact on a project's bottom line. Investment credits are needed now, while other favorable tax incentives will be helpful once the market begins to mature.

2. **Unlock Debt for Smaller Investors and Large Scale Projects**. The established fueling industry relies on debt for many station installations. Government programs can improve debt access and affordability, and help transition the market to mature, long-term finance structures.

3. **Establish a Scheduled Phasedown of Capital Grants**. Investors in the hydrogen market need to know what the government's overall commitment is, and how it will end. By laying out a plan that includes a steady phase down of support, CEC would establish confidence in the government's long-term plan for the sector, improve the relative incentive for first-movers, and enable industry to plan for a smooth transition to a private market.

Secure Tax Relief and Incentives

Taxes can have a substantial impact on a project's bottom line. Investment credits are needed now, while other favorable tax incentives will be helpful once the market begins to mature.

Tax incentives have played a key role in infrastructure development for other alternative energy sectors, from biodiesel and ethanol to the residential solar market and utility-tied wind.

It is important to emphasize that tax incentives alone cannot overcome the uncertainty and leadership and coordination challenges facing the hydrogen market in the current phase. However, they can provide support in important ways. One is through simply improving the financial outcomes of hydrogen investment, through tax relief, tax credits and preferential depreciation of a developer. The other is in possibly attracting tax equity investors, a class of 3rd party private investor who seek these tax benefits and might otherwise not be interested in this sector.

Tax Relief:

Sales Tax relief – highly valuable when sales are being made

The relatively high costs of early hydrogen stations, and low volumes, puts great pressure on having a sufficiently high margins on every kg sold. If one receives hydrogen at a delivered cost of $5.50/kg and sells it at $9/kg, after the 29 cents of power to compress it, the margin is $3.21 per kg. A 9% average sales tax taxes takes 81 cents off this margin, or 25% of the profit margin. For a 500kg station running at 70% average utilization, this amounts to over $100,000 per year. Even for a station running at only 50 kg/day, taxes cost about $15,000 per year. Sales tax relief (or reduction) would make a tremendous difference on a station's bottom line.

Since sales tax relief only matters when there are sales, it will only become valuable as the market picks up. We believe it could be a highly valuable incentive in the early commercial market, when stations are still costly but the volume for each has begun to pick up. The relief could be pegged to a vehicle threshold, such as 50,000 FCEVs on the road, after which it would phase out. In reality, the value would most likely be split between consumers and producers. Most importantly, it would provide a little more comfort to producers (and automakers) that hydrogen could beat the price of gasoline, even if gasoline price drops in the near future.

Property Tax Relief – valuable in the coverage phase

Given the high capital cost of the equipment, property taxes also constitute an area where relief could be applied. If assessed at the standard 1%, property taxes on a $1.75m, 500kg station would add $17,500 to the annual operation cost.

Unlike sales tax, property tax is assessed even when there is no little or no usage of the station in the early years. Relief would therefore be especially useful during the coverage phase.

Fuel Tax Exemptions – clarification required.

Hydrogen has not been sold at a retail level on a per kilogram basis in California, as the certification of measurement devices has yet to be completed. Stakeholders widely assume no fuel taxes will apply to hydrogen, however it is unclear whether current law federal law calls out such sales as being exempt. IRS rules appear to indicate that this exemption is limited to farm use and use by non-profits and the government, not the general public.[61]

Tax Credit & Depreciation

Investment Tax Credits – greatest potential if the cap is raised

An investment tax credit of 30% exists for hydrogen station developers. However it is capped at $30,000, which on an investment of $1.75 million has a negligible affect on a station's balance sheet.

Following the 2008 financial crisis, this cap was raised to $200k, a far more significant credit. We urge stakeholders to focus on reinstituting this higher cap. Since it is not linked to any sales, it provides the equivalent of a $200k grant with minimal paperwork, and represents a good way for the federal government to contribute towards moving the industry down the technology cost/learning curve.

Production Credit – an opportunity to clarify.

Most federal alternative fuel credits were discontinued in December 2011, but a hydrogen provision still exists.[62] However, the current credit is only applicable to liquid hydrogen sales for aviation, or fuel blends of liquid hydrogen with gasoline, diesel or kerosene. There may be an opportunity to extend this credit to all hydrogen fuels, for all transportation purposes.

Like the sales tax relief, the production tax credit is only valuable as sales pick up, and therefore in our assessment most important in the early commercial market phase.

Accelerated & Bonus Depreciation – a sweetener for investors who can use it

Accelerated depreciation rules allow investors in alternative energy to depreciate an asset over the first 5 years instead of the lifetime. Bonus depreciation rules have also been available since the financial crisis, which allow an even greater front-weighted depreciation of assets.

If that project is generating profit, or the depreciation can be offset against other profits in the business, this front weighting can be of some value to investors. We have not been able to determine if IRS rules explicitly cover hydrogen-fueling stations for this treatment, thought the inclusion of a wide range of alternative fuels indicates they should.

More importantly, the front weighting allows tax benefits to be concentrated, rather than spread out, which – together with investment and production tax credits can attract tax equity investors.

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[61] http://www.afdc.energy.gov/laws/laws/US/tech/3255. Also see http://www.irs.gov/pub/irs-pdf/i720.pdf

[62] http://www.irs.gov/publications/p510/ch02.html#en_US_201207_publink1000116975; http://www.afdc.energy.gov/laws/law/US/8320

Tax Equity Investors.

Favorable tax credits and depreciation rules can result in significant value that a project owner may not be able to capture, if the project is not generating profits during that initial period. However, there are many investors who specifically seek investments that will provide these tax credits to offset against profits in other area.

Tax equity investment has been a core driver of renewable energy investment. It promises:

1. A large source of investment capital with good terms, in exchange for tax credits.
2. Discounted purchase prices to long-term operators, after tax equity investors extract tax value over the initial few years.

Both of these elements sound very attractive, and may indeed be replicated in the hydrogen sector in the early commercial period. For example, tax equity investors might play an important role as a bridge between the initial developers and future station-owner investors. The possibility of tax equity investors owning the stations and then transferring them at a discount to the operators – having captured the tax value in the projects first 5 years – sounds attractive.

There are two key things to keep in mind, however, in tempering optimism about tax equity investment. The first is that the current state of hydrogen risks and returns is vastly different than those in the renewable energy space, where immediate 'production' occurs, and power purchase agreements with utilities assure revenues based on this production. The second concern is that tax equity investors would need significant guarantees that the capital itself is not at risk, which would compromise the tax value. We therefore do not believe it is a very relevant source of investment capital for the current coverage phase, and that this risk may be a problem even at later phases.

If risk issues can be overcome, attracting tax-oriented investors may be feasible, but the structure and scale of projects will need to be adapted – the stations would need to be grouped significantly to be of interest to a tax equity fund. Further discussions with such investors would be valuable at this later stage.

The value of taxes

On balance, we believe that tax relief, credits and depreciation incentives are not game changers for attracting private investment in the current phase of hydrogen development. As we have highlighted in the previous section, the immediate challenge is establishing greater certainty and better coordination processes.

Instead, these taxes will be useful additions to either improve a given risk/reward calculation for a strategic private investor in the space, or – on the other side of the equation – help the government ease out of grant-based programs more quickly, once the market for fuel cell vehicles has begun to take off.

Unlock Debt for Smaller Investors and Large Scale Projects

The established fueling industry relies on debt for many station installations. Government programs can improve debt access and affordability, and help transition the market to mature, long-term finance structures.

Debt financing does not appear to be an important investment enabler in Phase 1, the coverage phase, for at least two reasons:

1. First, without significant numbers of vehicles on the road, there is no reasonable expectation of revenues for several years. There are no fixed revenue contracts upon which to assure debt repayments, as would typically be required on a project-finance arrangement, nor a history of revenue to base reasonable projection on.
2. Second, none of the stakeholders and potential investors interviewed as part of this research have mentioned access to debt financing as a potential solution or even alleviation to the current reluctance to invest.[63]

Phase 2 and beyond, however, may find this approach useful. State backed project financing programs could be essential to the growth of hydrogen infrastructure once clear vehicle growth is seen in the early market. These types of programs can enable smaller station developers to finance, own and expand their hydrogen fueling capability.

Comparing Hydrogen to Retail Gasoline Stations

Most of today's traditional gasoline/diesel fueling stations are installed using borrowed money. This debt allows station development companies to expand their investment capability without depleting their scarce capital. Generally speaking, in the well-established gasoline fueling industry, risks are well known by both the developer and lender. A strong company can access favorable debt terms in the private market for a justified station installation or upgrade.

In contrast to gasoline and diesel stations, hydrogen station projects are not currently in a market that is suitable for debt, or in a position to access favorable financing without public support. Risks are too high for the lender to offer low rates, and the collateral that would be needed to improve lending terms is too high for the developers.

General Programs to Unlock Private Sector Investment

To address analogous problems with nascent industry, the State and Federal government have a wide range of programs aimed at enabling private sector investment. These creative (and successful) bond and financing programs could be adapted to hydrogen. They focus on deploying economically and environmentally beneficial projects that would otherwise be difficult to execute using traditional

[63] If the market leading industrial gas companies wanted to, they could take out a loan against their balance sheet, without any expectation of default.

commercial financing.[64] The programs lower the cost of borrowing by either a) reducing the interest rate or b) lengthening the loan term when compared with commercial lending. Typically, credit enhancement (such as a loan guarantee or loan loss reserve account) and/or tax benefits (i.e., tax exempt bonds) are used to generate these term and/or rate improvements.[65]

This state-backed financing has been used successfully for wastewater and recycling facilities, and in aggregating small investments like energy efficiency, truck rehabilitation, site remediation, and other capital projects (i.e., recycling plants). Other State programs like the Property Assessed Clean Energy program (PACE) tackle the credit problem from a different angle, allowing debt to be tied to the property on which the assets are placed to overcome credit history, collateral, or long-term return issues.

The following section explores how these programs could be adapted to facilitate the transition from pre-commercial public lead investment (Phase 1) to commercial private lead investment (Phase 2 and beyond).

Loan Guarantees

Loan guarantees are perhaps the most straightforward approach to unlocking private lending. In the case of government loan guarantees, the government assumes all or partial debt obligation if a borrower defaults. Depending on the structure of the guarantee, this removes some or all of the risk to the lender, enabling better lending terms for the borrower. These programs typically help small businesses access credit they otherwise would not have the collateral needed to access. California's Small Business Loan Guarantee Program, which backs up to 80% of a small business loan, is a good example of this type of program.[66]

On a larger scale, the Department of Energy has a robust loan guarantee program aimed at financing large clean energy projects ($25 million is the minimum project size supported without additional conditions). Both the DOE and California Small Business Programs are defined by a key benefit: if projects are successful, no public money is lost, and funds can continue to be put forward as guarantees as long as there is a need. This contrasts with grants, which expend money upfront.

In addition to the financial benefit of improving access to cheap financing, a loan guarantee represents a critical endorsement. By guaranteeing a project or company, the government becomes vested in that project/company's success, a tremendous, qualitative benefit.

Loan guarantees for hydrogen stations

In the hydrogen context, loan guarantees could be offered to achieve one of two goals:

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[64] Please refer to the California Alternative Energy and Advanced Transportation Financing Authority (CAETFA) and California Pollution Control Finance Authority (CPCFA), run through the State Treasurer's Office, for examples.
[65] http://www.treasurer.ca.gov/cdiac/debtpubs/handbook.pdf
[66] http://www.bth.ca.gov/res/docs/pdfs/SBLGP_Brochure.pdf

1. Enable small businesses, which otherwise would not have access to affordable debt, to participate in the market.
2. Help large businesses scale their build-out.

Small Business Debt. We do not know whom, or which companies, will be the hydrogen infrastructure market leaders of the future. A pivotal private partner could be easily be missed without tools to enable small business participation: a small business with a plan to make hydrogen infrastructure its core focus may in fact be a better (i.e., more motivated) partner than a large company making investments to simply stay in the game if the market takes off.

As introduced above, loan guarantees can help small businesses overcome an inherent disadvantage when trying to compete in a new, capital-intensive marketplace by granting access to capital. We believe loan guarantees targeted at small businesses can play a critical role in spurring market development and completion in Phase 2 and beyond.

Securing Debt for Large Scale Build out. While debt is not expected to be a game changer for large companies in the early Phase 1 context, it can be transformative if a company wants to finance a massive build out of stations. For example, if the market is starting to take hold in California, and develop elsewhere in the U.S. or abroad, a developer may choose to deploy 20, 50, or 100 stations at once (or in sequence). This would help the developer capture benefits of station standardization, earning economies of scale that can decrease the cost of each individual station.

Such a multi-station undertaking could fit in a DOE-scale loan guarantee program. Table 6 illustrates the potential impact of preferential debt on a single, $1.5m – 500 kg/day delivered hydrogen station constructed in a core market in 2016 (assuming $9/kg → $2.18 margin). These findings can be scaled up to multiple stations.

Table 6: The Impact of Preferential Debt on a Single Station

	Capital Grant Amount (%)	Debt			Total Govt set-aside (& spend if OK)	IRR for Station	
		Amount (debt % of priv. capital)	Rate & Term	Guarantee (% of debt)		Baseline Growth (ZEV Compliance)	CaFCP 2010 Growth
Case 1: Market-rate Loan	$750k (50%)	$525k (70%)	5.5% 7yr	0	**$1,275k**	6.9%	14.7%
Case 2: Govt-backed loan	$750k (50%)	$525k (70%)	2% 10yr	$420k (80%)	$1,660k **($1,257k)**	8.8%	19%

Assuming the market develops, the ending government contribution would be the same in both cases. However, in Case 2, the loan guarantee increases the upside for the private investor.[67]

In summary, a multi-station loan guarantee may provide the leverage a large company needs to facilitate a large-scale station deployment after FCEVs begin to gain traction in the marketplace, but before the declaration of commercial success. Similarly, on a smaller scale, loan guarantees can enable small businesses to participate in the market.

The Role of Bonds

In the hydrogen infrastructure context, bonds can serve two functions. They can a) reduce the cost of borrowing money or b) bring future revenue streams forward. We will talk about each of these functions in turn.

When considering bond backed financing (to reduce the cost of borrowing money), it is important to point out a fundamental difference between early market hydrogen infrastructure (Phase 1) and typical bond programs: absent government intervention, early hydrogen stations do not have a predictable, secure funding stream, while typical bond financed projects do (i.e., hospitals, schools, pollution control facilities, clean energy projects, toll-roads, etc.).[68] In the following text, we discuss how government intervention can help deploy the power of bonds to reduce the cost of borrowing money and bring revenue stream forward.

Phase 1 Tool: Bringing Revenue Streams Forward

Bonds can play a crucial roll in obtaining upfront capital for capital-intensive projects. For example, voter-approved bonds serve as the foundation for the development of the California High Speed Rail. In the High Speed Rail example, bond funds will be paid back using general obligation funds. For hydrogen infrastructure, bonds could be secured (paid back) using general obligation funds or hydrogen related revenue streams:

- *AB 8 funds*. This would have the effect of creating a large, guaranteed up-front sum of money to be paid back with future funds designated for hydrogen development. It would allow the state to focus on reaching the CaFCP Roadmap target for early market coverage, bringing the FCEV option to a wide range of customers.[69]
- *Revenue from future hydrogen related sales*. With a large enough program that focuses on buying down the costs of both FCEVs and infrastructure, a case could be made for securing bonds against future FCEV and hydrogen fuel sales.

If the state were to leverage future revenues made available by new legislation to reach 68 stations, it could become easier to attract private cost share contributions. Such a move would signal the seriousness of the government and greatly increase the probability of market success. It would enable

[67] It should be noted that if the cars come slowly (i.e., the Quarter ZEV scenario), preferential debt has little impact, as the station would loose money (unless the hydrogen price were raised).
[68] For reference, hydrogen market uncertainty is quantified in the Market Assurance Grant section.
[69] Such a strategy would likely need legislative approval, as each year the state budget must be appropriated.

automakers to invest in pushing FCEVs to the California market and give customers confidence that if the purchase or lease a FCEV, they will have sufficient utility.

Phase 2+ Tools: Using Bonds or Credit Enhancement to Improve Debt Terms

Tax-Exempt Bond Financing. The California Pollution Control Financing Authority's (CPCFA) Tax Exempt Bond Financing Program is a prime example of leveraging tax benefits for investors to generate project support money. For this program, qualified borrowers can apply for tax-exempt bond project financing (to construct a recycling facility, for example). Once a project is approved, the CPCFA issues tax exempt bonds that high asset investors can take advantage of to lower their tax burden. The returns to the investor, and rates to the bondholder (i.e., project developer), are based the project risk profile: higher risk projects will have a higher interest rate. These rates are typically less than what the project developer would receive through commercial lending channels.

Aside from the benefits to the project investor, from the public sector perspective tax-exempt bond financing programs can be implemented without seed money (only administration money is needed to get started). This avoids the need to direct public money towards the program, making it fiscally and politically easier to implement.

Tax-exempt bond financing has the potential to be incredibly useful to hydrogen station developers once the FCEV market begins to take hold and expand (thus reducing the risk of default), perhaps in Phase 2. We believe that the risk of default is too high in Phase 1 to effectively employ this type of financing without some collateral support or credit enhancement.

Credit Enhancement. The Market Assurance Grant section details the risk to the station developer. In short, a bond is only effective if it all parties involved believe it will be paid back. High interest rates can compensate for some uncertainty, but only to a point. For high-risk projects, such as an early market hydrogen station, some form of credit enhancement is likely to be necessary to unlock bond-backed project financing.

Two good examples of credit enhancement rely on outside funds to collateralize (guarantee) otherwise risky loans. CPCFA's California Recycle Underutilized Sites Program (CALReUSE) uses voter-approved funds (Proposition 1C, 2006) to backstop project loans for up to 60% of the program projects. The California Capital Access Program (CalCAP), also under the CPCFA, uses funds from the U.S. Treasury State Small Business Credit Initiative to create loan-loss reserve accounts for lenders. In both cases, if a loan goes into default, the private lender can tap into designated public money to make up for their losses. This reduces the risk, and in-turn the interest rate, of each loan in the respective programs.

The above examples required voter and legislative approval, respectively, making analogous implementation for hydrogen potentially difficult. However, the recently adopted AB8 legislation, which extends the AFVRT Program, enables the CEC to use a wide variety of methods to achieve program goals. It is possible that AFVRT funds could be used as loan guarantee against a bond, if the CEC deemed the approach appropriate.

Revolving loans

Revolving loan funds can turn a fixed incentive amount into a long-term asset by lending and re-lending money once original loans are paid back. Perhaps the cleverest example of this type of program is the Recycling Market Development Zones Revolving Loan Program implemented by CalRecycle, which provides access to attractive loans, technical assistance, and free product marketing of recycled materials (repaid loan funds are recycled into new loans). As stated in the Loan Guarantee section, a revolving loan project signifies a partnership and vested interest from the government. This type of arrangement could be a useful tool in Phases 2 and 3.

Establish a Scheduled Phasedown of Capital Grants

Investors in the hydrogen market need to know the government's overall commitment, and how it will end. By laying out a plan that includes a steady phase down of support, CEC would establish confidence in the government's long-term plan for the sector, improve the relative incentive for first-movers, and enable industry to plan for a smooth transition to a private market.

The Existing Capital Grant Program

Currently, the main source of incentives to infrastructure developers are the cost-share grants disbursed by the California Energy Commission, as part of the AB118 Investment program

These grants are linked to the capital cost of building stations. To award the grants, CEC has established a comprehensive scoring system to evaluate proposals it receives for its solicitations, including attributes of the developer, location, and station design. In the most recent solicitation, winning proposals were eligible to receive up to 65% of capital costs, as well as up to 3 years of operating costs, with a total per project cap of $1.5 million (see PON 12-606).

The capital grants given by the CEC and by CARB (through the Hydrogen Highway Initiative), have successfully:

1. Incentivized pioneer industrial gas companies to develop new station designs, with a focus on cost effectiveness.
2. Built expertise within CEC and CARB staffs on evaluating station design and cost effectiveness.
3. Built expertise and consensus around network planning.
4. Begun the transition from research and development projects towards a commercial deployment focus.

To build on this progress, we suggest modifications to the grant structure to help future iterations of the program meet two fundamental goals:

1. Facilitate a smooth transition to private lead investment, and
2. Improve station deployment timelines.

The Need for a Scheduled Phasedown of Grants

While it may seem premature to talk about phasing down grants while we are in the middle of the initial build out, we strongly believe this discussion is needed. The current system does not communicate a clear long-term plan. It sets grants at 65% of costs without an indication of how this might change for future solicitations. The annual AB118 Investment Plan process leaves the total amount of funding available to hydrogen from year to year uncertain. Station proponents therefore view the program as politically precarious and lacking a plan to complete the network and establish a successful market. This clearly undermines their desire to invest.

A planned phase-out to the capital grant program could attract investment by signaling the long-term grant strategy. Please note that the recommendations that follow are made with the assumption that the grants given for capital are first separated from those given for O&M, the latter being linked to market development as described in the Market Assurance Grants section.

Rationale for a phasedown schedule

A steady phasedown schedule makes sense when one looks at the underlying rationale for subsidies in the first place. There are two key reasons that justify grants to support capital expenditures in hydrogen infrastructure. The first is that as with all new technologies, industry learning and scale economies will occur during the early hydrogen infrastructure rollout, reducing the initially high capital costs over time, through a range of supply chain innovations and improvements. The second reason is more specific to this industry - small stations are inherently less cost-effective than large stations (from a per-kg delivered perspective), but they are appropriate in the early days while vehicle populations are low. For these two reasons, initial stations cost more to build, through no fault of the developer.

Researchers at NREL and UC Davis have conducted extensive analysis and projections on how the cost of capital is expected to come down over time based on the two cost-reduction factors.[70,71] NREL has extrapolated a formula that indicates how the cost (measured in kg-per-day capacity) can be estimated at any time during the period the industry comes down this cost curve. These projections follow a well-established pattern experienced by other technologies, and are thought to be fairly conservative.

A key finding is that the in the long term, hydrogen station costs level off somewhere between $2,000 and $3,200 per installed kg per day, for large stations. These figures are derived mainly from onsite SMR and electrolysis pathways, given NREL's focus on more mature markets, though findings from gas delivery pathways indicate a similar approximate range.[72]

We believe that an optimum system would compensate an early investor for the difference between current capital costs and the expected long run level. For example, if the long run expected cost per kg/day installed is $2,000, and current cost is $6,000 per kg/day installed, an early investor would receive the difference: a $4,000 subsidy for every kg/day installed. As capacity grows, bringing with it savings from learning, scale of activities and being able to build larger stations, the incentive would be reduced. We demonstrate an example of this later in this chapter.

Benefits of a phasedown schedule

This steady phasedown would ensure a steady, even playing field over time. It would:

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[70] Hydrogen Infrastructure Market Readiness: Opportunities and Potential for Near-term Cost Reductions. M.W. Melaina, D. Steward, M. Penev (NREL); S. McQueen (Energetics); S. Jaffe, C. Talon (IDC Insights). NREL Technical Report NREL/BK-5600-55961, August 2012 (pg. 26).

[71] Ogden/Nicholas 2011.

[72] In recent studies by Ogden and Nicholas at UC Davis, they found mature tech. gas truck delivered station specific capital costs of $3000-4000 per dispensed kg per day ($1.5-2.0 million for a 400-500 kg/d station c. 2015+). "Analysis of a 'Cluster' Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California." Presentation, Sept. 16, 2011. Revised Feb 22, 2012.

VI. Recommendations for the Near Future

1. **Minimize the current disincentive to be first.** Currently, an investor can expect a similar level of subsidy in 2-3 years, and is better off waiting for someone else to go first. He can then capture industry learning, as well as build a larger, more cost-effective station, and capture either greater margins or greater market share by doing so. If instead there were a predetermined phasedown that offset the declining cost curve, the investor would benefit less by waiting. He would still get some network benefits by waiting until a larger network is in place, more consumer confidence and more confidence by investors in the market taking off for FCEVs, but from a pure cost perspective, the disadvantage would be neutralized.
2. **Ensure a smooth transition to a free market**. Without a phasedown linked to actual long-run costs, the market will experience a sudden shock. If, for example, station 68 receives a significant subsidy, which then suddenly falls to zero for the next one, it will be difficult for any investor in station 69 to compete, thereby freezing investment in further stations. Like other subsidies that suddenly stop (as has occurred in the market for wind power), this can create major disruptions in investment, and seriously disrupt an emerging supply chain. OEM planning large-scale deployment plans cannot tolerate the uncertainty that infrastructure investment may suddenly freeze.
3. **Clarify the Government's exit strategy**. With a predetermined schedule, government provides a clear signal of how, and when, it will exit the infrastructure business. This is important for the government itself, allowing it to clearly estimate its total investment, and manage funds and political support accordingly. It also important in how the industry prepares itself – without a phasedown plan, there is an implicit message that funding will remain in place until the government determines it is no longer needed, encouraging industry to develop a perpetual "infant industry" argument, with the associated endless lobbying.
4. **Send a signal of deployment, rather than R&D**. A predetermined, declining subsidy sends a clear message to investors that the sector is in deployment mode, rather than research and development. Current government funding, which is set at 65% with a hint that the preference is 50%, fails to communicate that there is an industry ready for market-led deployment, or when the takeoff point is expected.

The combination of the above implies that if the State of California wishes to help launch a hydrogen infrastructure market that can quickly and smoothly transitions to a free market, it needs to establish a clear schedule for a steady, rational decrease in the subsidy it will provide until a market takeoff point is reached.

Important elements

There are a few important points to note about such a schedule:

1. **This should only be done in conjunction with Market Assurance Grants (MAGs).** It is critical to note that it would be counterproductive to talk of reducing incentive levels without first offsetting the market uncertainty risks through the MAGs discussed in earlier. As shown in that section, these market uncertainty risks are of the same magnitude as the current subsidy itself, and we believe are distorting the current attractiveness of investments.

2. **This declining capital subsidy only neutralizes the disincentive to go first – not more**. Having a large subsidy now which ramps down over time only serves to level the playing field between early movers and later market entrants, with respect to capital costs. It does not provide a net incentive to go first. If first-mover strategic *advantages* are not apparent or significant enough, other incentives beyond neutralizing initial high capital costs may be needed.
3. **The actual costs are linked to both U.S. and overseas activities**. In reality, the cost of infrastructure will come down based not only on what occurs in California, but also in the rest of the United States and other countries such as Germany, Japan, South Korea and the U.K., given that the dominant companies involved are global players experiencing learning and scale across all their investments. Currently, California, Japan and Germany are on comparable deployment schedules, with each jurisdiction's investment helping to bring down deployment costs and contributing to the strength of the system. In discussing the details of a phasedown schedule, a decision will have to be made on whether to integrate these national and global investments into a formula for the California-specific subsidies, or to peg it to the California-specific numbers only. Regardless of the approach, active coordination will help facilitate mutual progress.
4. **Capital support is likely required until 100 stations or more are deployed**. The 68 stations outlined in the CaFCP Roadmap reflect the need for coverage, and it is dangerous to assume that capital cost share can vanish after 68 stations and that the market will magically drive expansion from there. The amount of subsidy needed, and how long it will take, will require further analysis, building off the work NREL and others have done in analyzing the cost curve, and incorporating the benefits of leveraging global investment in the technology. The market adoption rate of FCEVs should play a strong role in the ramp down schedule.

A steady, planned decline in subsidy values is clearly valuable regardless of what the metric that subsidy is attached to. In the Section titled "Link Capital Grants to Performance, rather than Costs" page 77, we highlight the most logical performance metric to associate the subsidy with.

VI. For Further Stakeholder Development

The following elements deserve special attention moving forward, and all have the potential to play pivotal roles in successful market development. Further development and stakeholder engagement will be needed to formulate definitive recommendations.

1. **Special Treatment for Key Connector Stations**. Connector stations (i.e., I-5) present a unique economic and deployment challenge. They are likely to have low average throughput, but high peak requirements, making it difficult to entice private stakeholders to build them. They will require specialized treatment to attract interest.

2. **Create Non-Monetary Incentives for Investors**. While MAGs can minimize investors' downside risk by protecting against losses, to truly motivate investment in a risky market, investors also need to see a large upside potential to make a profit.

3. **Link Capital Grants to Performance, Rather Than Costs**. Linking grant levels directly and transparently to the projected performance level of a station, rather than the cost of the station would provide a range of benefits, including driving down costs and increasing flexibility. In such a system, a developer would receive a capital grant subsidy directly linked to the useful capacity a station provides to the system. The station's cost would not be a criterion for awarding grants, nor the basis for the amount of the awards.

4. **Capture Revenues for Ongoing Network Support**. There may be a need for ongoing support of connector stations, beyond the government's initial investment, to facilitate the continued build-out of the network.

5. **Transfer Value of Low Carbon Fuel Standard Credits**. LCFS credits potentially hold considerable value that could benefit multiple parties. Private party arrangements could trade future value for upfront investment, helping to create the hydrogen fueling market.

Special Treatment for Key Connector Stations

Connector stations (i.e., I-5) present a unique economic and deployment challenge. These stations are likely to have low average throughput, but high peak requirements, making it difficult to entice private stakeholders to build them. They will require specialized treatment to attract interest.

In the "Understanding the Challenges" chapter, we introduced the challenge of attracting investors to connector stations. The I-5, or possible CA-99, station suggested in the CaFCP Roadmap is the prime example of a connector station, as it will likely only serve transient populations for many years to come. However, this station (or stations) is very important to early FCEV consumers as it helps establish the network and enables driving between northern and southern California. Even with substantial support from the government, such a station will be challenged to make money under the current CEC hydrogen solicitation parameters (PON 12-606).

The connector challenge relates not only to throughput, but also to timing. If, on average, one-quarter of FCEV drivers make one trip a year from north to south and back (or vice versa), but the majority of those trips happen during the 4th of July and Thanksgiving, the station could find itself severely over-used during these holidays, and under-used the rest of the year. If the goal is to make the FCEV experience seamless when compared to gasoline, the I-5 connector likely needs to be a large, high performing station to handle holiday traffic (or a series of smaller stations able to handle to same use).

Figure 13 illustrates the connector challenge. Lets assume a station is built anticipating the need to support 5,000 FCEVs, and 25 percent of those vehicles travel round trip on I-5 once per year, resulting in 2,500 annual fuelings. If each fueling draws 3 kilograms of hydrogen, the station should push out 7,500 kilograms per year.[73] If trips were evenly distributed throughout the year, a very small station (25kg/day) could handle the demand. If, on the other hand, 10 percent of the total trips occurred on the 4th of July weekend (5 percent of the trips on Friday, July 3rd) the station would need to be able to dispense 375 kilograms in one day to satisfy customer demand. These are two very different stations.

[73] Two FCEVs are currently available to select consumers for lease: the Honda FCX Clarity and Mercedes F-CELL. The FCX Clarity's tank holds 3.92 kgs, and the F-CELL holds 3.7 kgs. We assume that most vehicles will leave their starting point with a full tank.

Figure 13: Illustrating the Connector Challenge

Evenly Distributed Demand

5,000	# of FCEVs
25%	FCEVs traveling I-5
1	trips per year per FCEV
2	fuelings per trip
3	kgs per fueling
2,500	total annual fuelings
7,500	total annual fuelings (kg)
21	daily fueling (kg), evenly distributed

Peak Demand

5,000	# of FCEVs
25%	FCEVs traveling I-5
1	trips per year per FCEV
2	fuelings per trip
3	kgs per fueling
2,500	total annual fuelings
7,500	total annual fuelings (kg)
375	daily fueling (kg) on July 3rd (5% of trips on one day)

Estimating FCEV trips on I-5: For reference, approximately 5,000 passenger vehicles travel between San Francisco and Los Angeles on I-5 each day, for a total of 1.8 million trips per year.[74] This compares to approximately 23 million passenger vehicles in California, or trips by about 0.8% of passenger vehicles.[75] One can assume that relatively new vehicles make most of these long-distance trips; a class FCEVs fall into. One can also assume that part of the appeal of FCEVs is their ability to make long distance trips. With these assumptions in mind, we assert that more than 0.8% of FCEVs will make the I-5 trip in a given year (Figure 13 assumes 25%).

If a developer built for the evenly distributed scenario, they could save some upfront capital expense, but would likely disappoint customers with a lack of peak availability, potentially discouraging FCEV owners from using their FCEV to traverse the state (depressing the economics of the station and future FCEV sales). On the other hand, building for the peak demand scenario could leave a substantial amount of capital stranded for the majority of the year.

In short, the I-5 connector station is an exceptionally risky proposition for a private investor. We believe that a special request for proposal (RFP) is likely necessary to ensure a station (or multiple stations) is installed and maintained.

Strategies for Attracting Interest in Connectors

A 65% cost share (plus $200,000 for O&M) is not enough to attract interest in connector stations. As introduced earlier, Market Assurance Grants can be employed to protect against downside risk. Again, from the station owner perspective, all MAGs can do is reduce the risk of the investment if FCEVs do not show up. To motivate somebody to install a connector station, they will need to see a bigger potential upside.

[74] This estimate is the result of University of California, Irvine researcher efforts to scale up data from the California Household Travel Survey.

[75] Please refer to http://dmv.ca.gov/about/profile/official.pdf for vehicle numbers in California.

Offer Block Grants
One way to encourage the installation of a connector is to make it a requirement of a block grant. For example, a grant could be made to one entity for multiple stations, helping an applicant reduce costs by ordering components in bulk, lining up continuous construction contracts, etc. The winning bidder could be required to install one or more connectors (with the expectation that some of the grant money would be used for this purpose). If such a concept were combined with MAGs, the overall outlook could be favorable.

Create more generous incentives
It may take a full, or nearly full, cost share to get applications to install the I-5 station, especially if more predictable core market locations remain available. Regardless of the incentive levels, a single, uniform solicitation is unlikely to drive interest in connector stations. Special provisions should be called out to specifically address connectors.

Leverage other hydrogen applications
If the business model behind a connector station remains challenging on its own, another approach may be to leverage other hydrogen applications to spread out the risk, such as a hydrogen forklift, fuel cell bus, or stationary power application. In this approach, the non-FCEV use would serve as the primary application, which would be augmented to provide FCEV fueling. In this scenario, the retail experience may not be on par with a cluster location, in terms of setting or performance, but could be a valuable network addition without having to fully rely on FCEV use to justify investment in baseline hydrogen infrastructure.

Government Commissioning of a Station
If neither the block grant nor individual targeted RFP attract interest, the government may need to commission a party to build and operate the station, with the government assuming ownership responsibility. In this case, the government would pay the full cost of equipment as well as pay for all of the operation and maintenance of the station to ensure it remained open. Given that the I-5 station is unlikely to be within an existing maintenance service area, it could be more expensive to maintain, when compared to other stations. On the positive side, rent costs are likely to be less than in core market areas.

Because other stations, such as Sonoma and Lake Tahoe, are destinations and have the potential to be a home station for some FCEVs, the I-5 station is unique and may be the only station where government commissioning approach should be considered. However, if no private partners step up to these other non-cluster stations, they may need to be commissioned as well.

To determine which stations need a special RFP, we recommend that the CEC (or analogous funding agency) build on its existing knowledge by collecting input from stakeholders to assess interest and capabilities in developing each location designated in the CaFCP Roadmap. This could come in the form of a survey, request for information, or pre-application designed to inform an upcoming program opportunity notice (PON). Stations with little or no interest should be given special consideration.

Managing Connector Station Demand

Figure 13 above presents a real challenge. To match supply with demand, both consumers and fuel providers will likely need to think outside of traditional fueling/transportation models. In the early years, it might not be possible (or wise) to take a spur of the moment road trip from Los Angeles to San Francisco without first reserving fuel at the I-5 station. A fuel provider may need to include mobile fuelers in their operation plan to meet heavy holiday weekend demand.

Some combination of real-time demand management and station supply could go a long way towards helping make the I-5 station economically viable.

Create Non-Monetary Incentives for Investors

While MAGs can minimize investors' downside risk by protecting against losses, to truly motivate investment in a risky market, investors also need to see a large upside potential to make a profit.

The monetary incentives discussed up to this point have focused on reducing the downside risks and costs associated with being the leader in hydrogen infrastructure development. However, downside risk protection is only one half of the equation. Investors need to see a compelling upside benefit to moving first before jumping in to lead the market.

From a strict financial investment perspective (i.e., the perspective of a player who wants to purchase equipment and sell fuel but does not have a strategic equipment or fuel advantage), there is an inherent disadvantage to going first. In short, when compared to late movers, the first investor can expect to pay more for a lower performing station with fewer cars on the road. Assuming someone else will go first, it pays to wait.

In contrast, investors that are also vendors of equipment or gas face a different calculation. There is a benefit to establishing an industrial gas company's (IGC) equipment and technology early in the marketplace, as it increases the probability of selling equipment and hydrogen over the long-term. For this very reason, the players currently leading the market are the industrial gas companies. While each company is different, the current market leaders do not appear interested in leading station development indefinitely; their preference is to sell gas and equipment.

In this section, we examine approaches that can be taken to overcome the prospect of low returns for smaller, early market stations. These ideas are aimed at attracting traditional fuel retailers/marketers, or outside investors, to the hydrogen market to lead station development efforts and help facilitate growth.[76]

Defining Vendors vs. Retailers

In discussing the first mover benefits, we distinguish between benefits that attract companies that want to play a role as future vendors to the hydrogen fueling industry, versus those that want to invest in owning retail fueling infrastructure (retailers).

For the purpose of this discussion, retailers are defined as investors that profit only from retail margins on fuel sales. This contrasts with equipment or gas vendor companies that profit from the sale of equipment, gas, and service contracts. A variety of parties can play this retail function, generally fitting into one of two backgrounds (with a wide variety in between):

[76] It is important to note that industrial gas companies can also play the station development leadership role over the long-term if they decide to add this to their core business strategy.

1. *Station owners*. The owner of one or more stations commits his/her company's capital to buying fueling equipment and arranging for gas supply contracts.
2. *3rd Party investors*. The investor rents a portion of a station owner's lot, buys and owns equipment to place on that lot, and collect the profits from fuel sales.

These retail-oriented investors are key to the success of hydrogen infrastructure, as their participation can help drive down costs, ease the construction process, and help align vendors in their preferred role. To set the market up for long-term success, we believe that incentives need to be aligned to attract those that want to take on the station development investment needed beyond the early coverage phase.

The distinction between retailer and vendors may ultimately go away. It is entirely possible that the segments merge into one – i.e. that a vertically integrated market develops, with companies that are producers, distributors and retailers of hydrogen gas.[77] The gasoline business was like this for many years, and it has many advantages in terms of managing risks and driving investment. However, we believe it is highly risky to assume this will occur, and that incentives need to be aligned with the possibility that it does not.

The following options – beyond market assurance grants and capital expense grants – might be necessary to make hydrogen station investment more attractive to both types of players.

Existing investment & early mover advantages

The investment to date in California has been led primarily by companies that are industrial suppliers of hydrogen gas, such as Air Products, Linde, and Air Liquide. Only a handful of investments have been made by what we might consider a 3rd party developer (e.g., Hydrogen Frontiers) who does not also serve as a vendor of equipment.[78, 79]

It is logical that the industrial gas companies are investing in this market, despite the risks and costs, to assure at least some of the following goals:

1. Growing the overall market for a product they specialize in: hydrogen gas.
2. Ensuring this market develops in a way that they can continue to participate as suppliers.
3. Developing proprietary station equipment, with the help of government grants that can interface with their preferred form of gas supply.
4. Drive equipment costs down through learning and scale before others do, to establish a market lead.
5. Picking locations that work well with their current gas production or distribution.

[77] An on site hydrogen generator could become a source for other local stations, for example.
[78] Hydrogen Frontiers operates an onsite SMR station in Burbank and is developing on on-site electrolysis station in Chino Hills. Both stations could potentially sell excess fuel to other stations/industrial uses, likely using equipment purchased from the larger IGCs.
[79] Shell invested in and maintains three stations in California, but has not responded to any of the CEC PONs, the first of which was offered in 2010.

6. Establishing a brand presence within the infrastructure industry before it gets crowded.
7. Establishing patents and royalties that give them strategic advantage in the out years.

These are technology and market first mover advantages that companies get as vendors in the supply chain.

From the perspective of gains as retailers, these early movers also gain some advantages, but far fewer.

1. Early retailers get to pick the preferred locations with limited or no competition among the planned network, from the perspective of likely fuel sales.
2. Early retailers build expertise in interfacing with regulatory permitting, fire and safety bodies, allowing faster, smoother development.

Options for improving first mover benefits for all parties

To make early investment more attractive, the following mechanisms could be added to the current system.

1. ***A geographical buffer for early investors***
   In awarding grants, the government could also provide a contractual assurance that it would not provide grants, for a predetermined period, to stations within a given geographical radius. Although this is currently implicit in the way the solicitations are set up, with limited spots for specified locations, making it explicit would create a clear signal for a true advantage of going first in this area. Some potential parameters include:

   - The buffer would not exclude private investors without subsidies. It would just prevent grants going to someone who wanted to build a bigger, cheaper station next door to the early investor as soon as the market looked healthy.
   - The geographical buffer could be different for each station. For example, a connector station might get a larger buffer than a core station, and the station on I-5 may get the largest buffer.
   - The buffer could be reduced over time. For example, after the coverage phase is complete, it could fall linearly to zero within 3 years.
   - Some exceptions could be written in: Non-performance could void the buffer or, the same station owner could be allowed to seek funding for a second station within the buffer, in lieu of expansion. If a station is not performing to specification, the buffer could be reduced to reflect a diminished ability to serve customers.

2. ***A priority status for early investors***
   In awarding grants, the government could award priority status points to early investors. In later funding rounds, this status could play a role, assuming these investors met baseline criteria.[80] More

[80] E.g. projects were developed on time, stations remained operational and good standing, etc.

points would be received for the early stations than later ones. This status could be used to provide the following advantages:

- General advantage – priority status would add to the overall score of subsequent grant applications, giving them the edge over a competitor.
- Geographical advantage – priority status could be used to provide an advantage, for the geography the company is already vested in. This might attract players with an interest in establishing themselves in an area, removing the risk of being crowded out if they don't move fast.

3. ***Multi-station block grants***
   Grants could be organized to enable one company to install and operate a block of stations in a given region for a defined time period, assuming minimum performance targets are met. This would ensure a given investor would capture all of the demand in the defined region, enabling cross-subsidization of stations to limit the risk of underperformance (i.e., high demand stations could help support lower demand stations).

Balancing investor benefits with consumer benefits.

From the perspective of a retail-oriented developer (a buyer of equipment and gas, not seller of it), the attractiveness of the market depends on the ability to get a foothold in some of the most attractive locations, and ensure good retail margins for as long as possible. Clearly, this goal competes with the needs of consumers. In the extreme, a system that provides monopoly-type conditions for a company (locked in customers, and high margins) is the opposite of what is good for fuel consumer (competing stations and low prices).

The core question in attracting investment is therefore:

1. Are deeper incentives necessary to attract retail-oriented investors?
2. If so, how strong should these be, and for how long should they be in place, without sacrificing the needs of early consumers of this market too much?
3. Do the incentives still reward the best stations, from the consumer perspective.

Options to ensure consumer benefits: If strong, long-lasting market incentives are indeed necessary to attract investment, yet the cost to consumers is seen as too great, then two other options should be considered: 1) the government must accept its role as lead investor and owner, as it has done for many public infrastructure needs, or 2) a system of regulated monopolies like that of utilities is needed, with geographical franchises in exchange for consumer-oriented protection.

Assessing the need prior to implementing non-monetary incentives

The current lack of retail-oriented hydrogen fuel developers is of significant concern. If the current investment leaders (vendors) are motivated just by seeding the market, and do not intend a significant infrastructure build-out, there is a risk of being left with a gap to fill between their investments and the long-term mature market. It is also of fundamental importance that experienced retailers participate in the market, as these are the entities that truly understand and know how to serve the retail consumer fueling market.

For this reason, we believe it is imperative that further inquiries are made into whom might this second wave of investors be, and how we intend to attract them. The addition of the non-monetary incentives mentioned above might help, but they come at a cost to consumers – they purposefully limit competition in the early days in the hope of attracting investors during that more challenging period. Before progressing with such incentives, we recommend that a systematic survey be conducted among potential retail investors and private equity investors, to gauge whether these incentives would be game changers at this stage. Market Assurance Grants, in combination with a defined government investment plan, might be enough to motivate retail investors.

Backup plans if incentives are not enough

The incentives mentioned so far, including reducing the downside risk with MAG grants, special treatment of key connector stations, and adding non-monetary incentives are all aimed at improving the risk/reward profile of this sector at this stage, in the hope that private investors will see an opportunity and bring the capital that is needed.

However, if such stimulus is insufficient to attract that investment, or the costs to consumers of providing the non-monetary (anti-competitive) incentives are too high, then a backup plan is needed, and needs to be thought through now.

Link Capital Grants to Performance, rather than Costs

Linking grant levels directly and transparently to the projected performance level of a station, rather than the cost of the station would provide a range of benefits, including driving down costs and increasing flexibility. In such a system, a developer would receive a capital grant subsidy directly linked to the useful capacity a station provides to the system. The station's cost would not be a criterion for awarding grants, nor the basis for the amount of the awards.[81]

Performance-based incentive systems have been successfully implemented to incentivize and commercialize solar rooftops in California, through the California Solar Initiative. In short, incentives are doled out based on installed capacity on a set ramp-down schedule. Consumers who installed solar on their houses at the start of the program received more money per watt ($2.50 for residential) than those who waited ($0.20/watt for the last recipients).[82] Since the start of the program in 2007, the average cost per watt of installed solar has decreased from just over $8 to $6 (as of April 2013).[83]

We wish to emphasize that a performance-based system would not replace all the other criteria used in the government's solicitations of station. A mechanism to select appropriate locations, and to score each applicant on the merits of their project, the site, development experience and other factors would still be appropriate.

The main change would be that the State would no longer need to gather, evaluate or score each applicant's "Project Budget" (currently scoring criteria number 5 in PON 12-606). Instead, the stations that scored highest on all the other criteria would be offered a grant of a pre-determined amount, based not on its costs but on a simple metric such as the kilograms of hydrogen that a station can deliver per day.[84] We discuss this metric in more detail below.

Benefits of a change to performance-based grants

Changing the way grant values are set would bring several important benefits:

1. **Put real downward pressure on costs by encouraging profit.** High capital costs remain one of the key barriers to allowing attractive returns on hydrogen infrastructure investment. If a recipient of the grant program were encouraged to make aggressive cost-cutting reductions by allowing them to pocket the savings, cost reductions would ripple throughout the industry and its supply chain.

[81] For this system to work, a strong verification system would need to be in place. We discuss this concept in Chapter VII, under "Set up Infrastructure Monitoring".
[82] http://www.gosolarcalifornia.ca.gov/documents/CSI_HANDBOOK.PDF
[83] http://www.californiasolarstatistics.ca.gov/reports/quarterly_cost_per_watt/
[84] Verification and monitoring are clearly important, as discussed in the "" section.

2. **Streamline grant processing for the government.** The CEC has had to allocate many internal resources to vetting and assessing station proposals. In the near future it will need to fund many more stations, in a much shorter timeframe to meet CaFCP Roadmap goals. Removing the need to collect private cost information on the project, assess and compare the full cost effectiveness of each project would significantly reduce this burden.[85] Furthermore, much of the follow-on administrative burden relating to any changes in grant agreements would be removed.
3. **Reduce the burden on applicants, attracting more of them.** The current application for funding is daunting for applicants in many respects, including the financial projections, grant reporting and modifications processes. Removing the financial projection burden would help make it easier for new companies to be able to apply, as well as encourage the current companies to find innovative, cost-saving improvements during project development.[86]
4. **Remove competitive concerns relating to financial information.** Companies must currently divulge sensitive financial information to apply for funding. Removing this requirement would increase the comfort level of industry players. It could also allow a company such as an industrial gas supplier to be both an applicant for a grant and a vendor to a 3rd party developer. Currently, the financial arrangements are likely to be too sensitive to allow this.
5. **Encourage a diversity of technologies.** Linking the incentive to the value it provides consumers would encourage projects other than pure fueling facilities to apply. For example, a developer considering a combined heat and power system that makes financial sense could consider an add-on hydrogen production capability, knowing the incentive level it would receive. Currently, the financial analysis of such a system would be very difficult to assess by the CEC, and the relative burden of applying for a hydrogen-dispensing grant could dissuade potential applicants.
6. **Allow technology comparison**. The single metric also helps encourage diversity in that it allows policymakers and business investors to compare multiple technologies on an apples-to-apples basis. There is currently widespread misinformation about the actual, versus nameplate value of a station, given that delivered hydrogen stations and onsite production stations differ considerably in what constraints they face. The existence of an agreed upon, technology-neutral metric that accurately represents the value of a station to consumers would tremendously benefit industry and policymakers, and likely lead to more flexibility in considering a diverse pool of hydrogen fueling technologies.[87]

[85] Instead of analyzing the cost effectiveness of each project, the CEC would have a pre-established cost-effectiveness measure: the State would be pre-authorized to invest X dollars in a station depending on the station'

[86] EIN staff spoke with one potential project applicant who estimated spending 100+ hours to come up to speed with the PON 12-606 application. Another project developer expressed frustration about the paperwork and process required to shift funding around after approval, despite having no impact on the final outcome.

[87] See Table 8: for an example of how a performance based metric can enable technology neutral comparison.

Choosing an appropriate performance metric

We recognize that the daily dispensing capacity is a simplified metric to approximate performance. Stakeholders have emphasized that the value of a station includes:

- Daily capacity – the maximum that can be delivered within 24 hours.
- Maximum throughput – the maximum number of cars it can fuel, during peak periods. This includes constraints of equipment as well as physical arrangements of islands and dispensers.

There is an important balance to make on these two elements. If the metric over-rewards daily capacity, it will encourage systems that are oversized in capacity in relation to the service they provide during peak times. Customer lines can be expected. In contrast, over-rewarding peaking capacity may mean that total daily capacity needs fall short, and the station is "empty" on some days by the evening.

Although both of these values are critical, and must not be lost in a revised system, we believe it is important to seek a single metric in the interest of simplicity and transparency. We also believe that such a metric, that encompasses both storage and peak capacity, is possible and can effectively ensure that an incentive built on it will encourages developers to build stations that meet the range of consumer needs.

To help develop this metric, we propose a system that we will call Average Feasible Daily Capacity. This recognizes that a station must be able to handle peak traffic, and that the real life average daily use, when spread out over a week, is much smaller than that made possible by peak performance. According to a study based on Chevron data in gasoline stations, a peak-to-average ratio of approximately 2.78 can be observed in gasoline stations. [88]

In an early hydrogen market in which we are trying to reduce station development costs, we assume a less stringent peak-to-average ratio of 2x would be sufficient, with users shifting some fueling to off-peak to avoid lines where necessary.

The calculation for the Average Feasible Daily Capacity would be set by the minimum of two numbers: either the total daily storage, or an amount limited by the maximum throughput in a rush hour situation. Table 7 below shows how this would work for four illustrative stations. In each case, the highlighted cell shows which aspect of the design is the bottleneck, and therefore used for the metric, in Column D.

[88] Hydrogen Delivery Infrastructure Options Analysis, Final Report. Project Director, Tan-Ping with the following partners: Air Liquide, Chevron Technology Venture, Gas Technology Institute, NREL, Tiax, ANL. DOE Award Number: DE-FG36-05G015032. See pages 2-41.

Table 7: Illustrative Performance Metric

	A	B	C	D
Station	Max Daily Storage (kg/day)	Max sustained vehicle fueling in a 2 hour period (kg/hr)	Max rate divided by peak-to-average ratio, multiplied by 24. (B / 2 * 24)	Average Feasible Daily Capacity (= Min of C or A)
250/10	250	10	125	125
250/20	250	30	360	250
400/20	400	20	240	240
400/40	400	40	480	400

Further input is necessary to work out the optimum formula. For example, if the State is inclined to prioritize expandability of stations, a higher peak-to-average factor than 2 could be used, to ensure that developers are encouraged to build higher peaking capability, with the assumption that storage can easily be added later.

We suggest that all other performance characteristics aside from daily and peak capacity (such as location, experience, sustainability, etc.) be incorporated into screening metrics for the grants, to ensure the station is well suited for the market and its customers.

Other goals of the state, such as encouraging new technology or compensating for extra costs of developing renewable hydrogen facilities, should be addressed through a separate or augmented grant, to avoid complicating this deployment-optimized system.

Strawman Design: Restructuring grants to be performance-based with a phasedown schedule

To illustrate how a performance-oriented grant program with a phasedown schedule could be constructed, we propose the following strawman structure:

1. **Set up a two-tier capacity payment structure.** This is to be able to fairly compensate both small and large stations.
   - Tier 1: Pay an initial $7,000 per kg-day capacity, up to the first 100kg-day[89]
   - Tier 2: Pay 1/5 of the tier 1 rate ($1,400/kg-day) for capacity beyond 100kg-day[90]

   This two tier structure would mean that the first 250 kg station would receive a grant of $910,000 (100 x $7,000 + 150 x $1,400), and a 500 kg station would get $1.26m (100 x $7,000 + 400 x $1,400).

[89] Keeping Tier 1 low sends the signal that early market "coverage" is more important than "capacity". This priority will eventually change as FCEVs deploy in greater numbers.

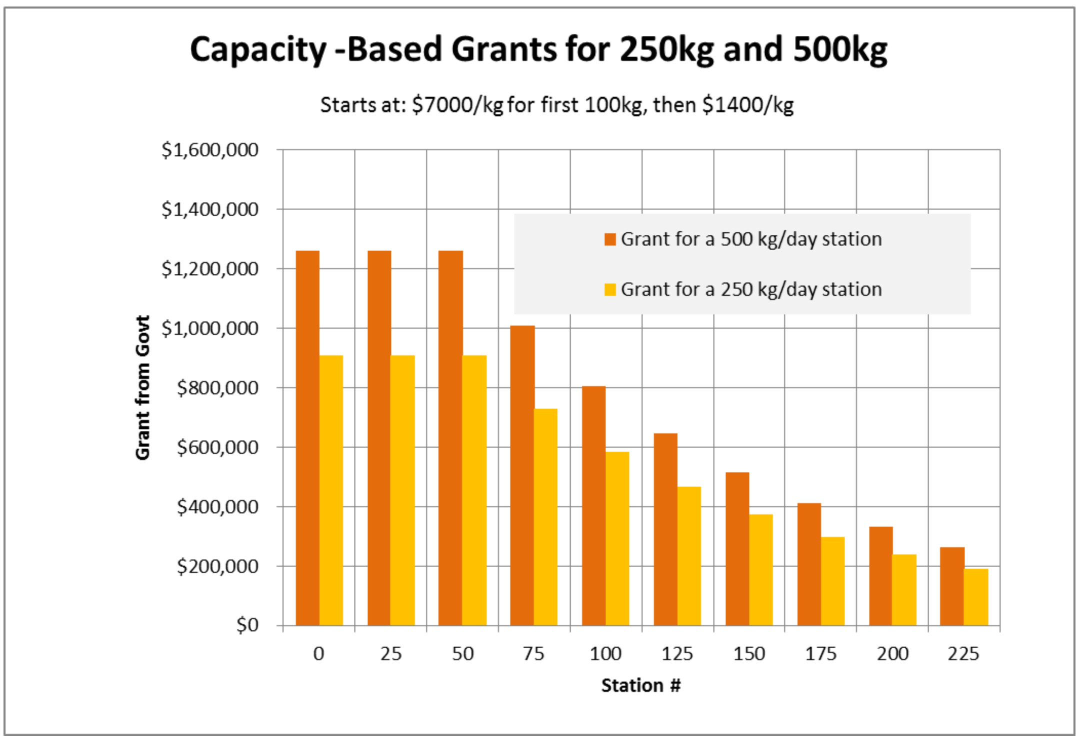
[90] Note: these numbers are reverse engineered to fit reasonable cost profiles. Further analysis on the component costs of systems is needed to set the tiers levels.

2. **<u>Establish a phasedown schedule of these tiers</u>,** using a steady factor linked to the number of stations installed. This will reduce the tier levels as stations are developed. Though analysis is necessary to determine the precise metric and phasedown rate, for discussion purposes, we propose a schedule in which the tier structure is reduced by 20% for every 25 stations after station 75, up until 250 stations. (*Please note that these numbers will need further vetting. This strawman is built on an assumption that the bulk of industry learning will occur by about 250 stations. If further inquiry reveals that number to be too large or too small, the related figures must all be adjusted.)* If there are approximately equal numbers of each size of station, resulting in an average of around 375kg/day, we would reach the 250th station when there are about 134,000 vehicles on the market, assuming each consumed 0.7kg/day.[91]

- The Tiers for stations 75-100 would therefore be $5,600 for Tier 1 (0.8 x $7,000), and $1,120 for Tier 2, and so on.[92]

Combining these two, the total capital grant given to two illustrative stations of 250kg and 500kg would be as shown in Figure 14

Figure 14: An illustrative Capacity-Based Grant



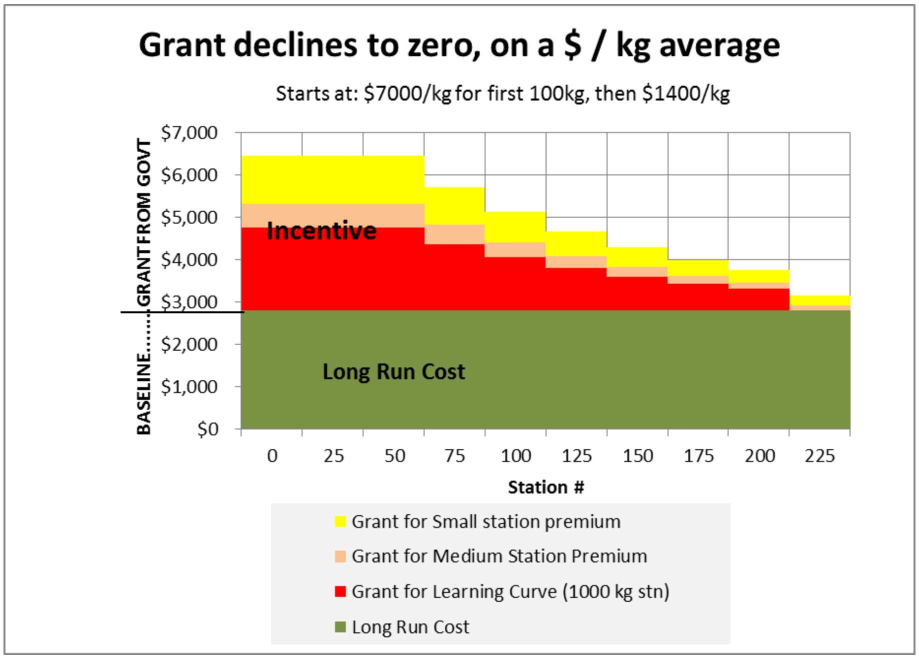
[91] Final numbers still need review using EIN model. The 50/50 split is indicated using NREL distributional analysis of stations, but needs more analysis.

[92] To illustrate the concept, we start from station 1 and move forward through station 250. In reality, the initial Tier rates would start later in the development. As of July 2013, California has 25 public station either open or in the funding/construction pipeline.

The incentive in relation to long run costs

To put these grants in perspective with the long run cost of unsubsidized hydrogen infrastructure, we show these grants on a $/kg basis. In Figure 15 below, the green area shows the long run cost baseline as $2,800 kg/day, which the private investor is expected to pay both now and in the long term.[93] The government subsidy is the red/orange/yellow area above, broken into the components it reflects. The red reflects the general cost of learning (as exemplified by the grant received for a large, 1000 kg/day station). The orange reflects the premium for needing to build medium size stations, and the yellow the additional cost of having to build smaller, less profitable stations in the early days.

Figure 15: Hydrogen Station Grant Payment, on an average $/kg basis

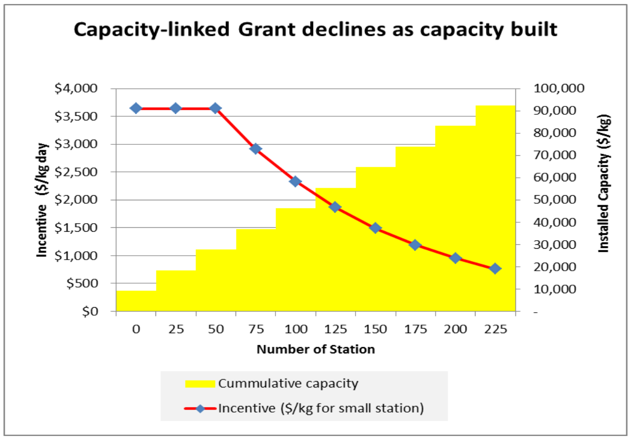


As can be seen in Figure 16 below, the result of proposed incentive closely mirrors the structure of solar rebates offered through the California Solar Incentive (CSI). In the hydrogen case, the highest subsidy provided (for a 250kg/day station – assuming those are the smallest), starts out at about $3,600 per kg-day, dropping to just below $400 per kg-day. This compares to the per-megawatt "Performance Based Incentive (PBI)" and "Expected Performance Based Incentive (EPBB)" offered through the CSI.

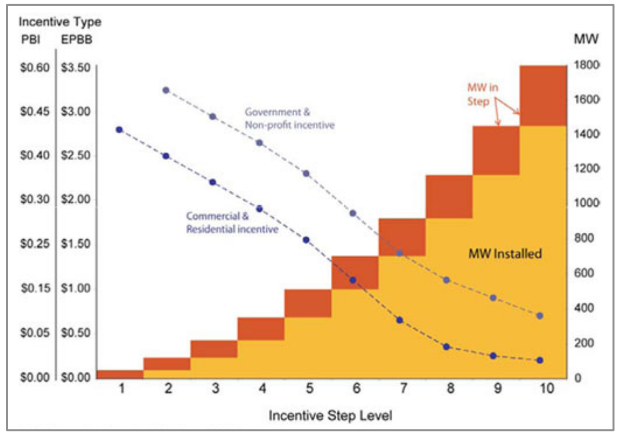
[93] Melaina, M. and M. Penev. Hydrogen Station Cost Estimates: Comparing Hydrogen Station Cost Calculator Results with other Recent Estimates through a National Simulation of Station Rollout Dynamics. National Renewable Energy Laboratory, Golden, Colorado. August 2012. Pending publication.

Figure 16: Comparison of Proposed Hydrogen Incentive and CA Solar Initiative

Proposed Hydrogen Incentive



California Solar Initiative Incentive



Additional elements of such a structure.

In revising the grant program, other ways to streamline the program should also be considered:

1. **Set the grant payment tier only when the station is operational.** Although a portion of the grant payment can be made to support the development of the station, the final payment tier should be set only when the station is open for business.[94] In other words, if the 25th station to be approved becomes the 26th station to open, it would receive less funding than if it were the 25th station to open. This would ensure no entity tries to lock in advantages and then delay development.
2. **Increased payment tier for renewable hydrogen projects**. Renewable hydrogen projects will become increasingly critical for the state to meet long-term climate goals. The benefits brought by renewable hydrogen projects are likely to come with increased costs, costs that can and should be met by increasing support tiers for renewable projects.

[94] Setting the appropriate up-front funding level will depend on close coordination with station developers, the California Energy Commission, NREL and other academics.

Additional Stakeholder Benefits of Performance-Based Grants

Promoting Diversity of Fuel Pathways

Stakeholders in California typically assume that the initial hydrogen build-out will be based on stations that depend on delivered hydrogen, produced centrally and brought in by truck in either gas or liquid form. This is in part because these stations are cheaper to build than onsite hydrogen production, a key factor if early capital investments will be under-utilized while there is little initial demand.

However, the upfront capital cost is only part of the equation. At a slightly larger scale than the current stations, an onsite SMR station costs roughly twice as much to build as a delivered gas station. Yet it can then produce hydrogen for far less than the current market price of delivered hydrogen. When it is being well utilized, and natural gas feedstock remains cheap, an onsite SMR stations gains a significant production cost advantage over the delivered model, which can compensate for the upfront capital cost.

Table 8 compares the impact of grants on two such stations. Since both stations have a nameplate 500kg/day capacity, they both receive the same size grant. As can be seen, although the onsite SMR costs twice as much, their internal rates of return under three different growth scenarios are similar, given the production cost advantage of the SMR.

Table 8: IRR of delivered H2 and Onsite SMR, with a Performance-based, equal grant.[95]

		Delivered Gas 500 kg	Onsite SMR 500kg
Capital Cost of Station		$1,750,000	$3,555,000
Performance-Based Grant (Based on $7000/$1250 tiered pricing discussed above)		**$1,260,000** (72% of capex)	**$1,260,000** (35% of capex)
Financials at 70% average utilization	Production & Delivery Cost / kg	$5.79 / kg	$3.16 / kg
	EBITDA[96]	$171k / yr	$615k / yr
IRR (2014 core market station)	Slow growth (25% ZEV)	7%	8%
	Med growth (50% ZEV)	13%	12%
	Fast growth (ZEV scenario)	21%	17%

We do not wish to suggest that the focus on delivered hydrogen is flawed. The onsite SMR station only makes sense under a high utilization rate that may be too risky to bet on in the initial market coverage period. The same is true for electrolysis stations, which have similarly high upfront capital costs, offset by lower production costs, when able to use low value electric power (for example at night or in areas of excess renewable production).

[95] The 3 growth scenarios reflect proportions of ZEV Compliance projections (25%, 50%, 100%), for a station built in a core market in 2014. Other assumptions are EIN's H2NIP model baselines, presented in Appendix A.

[96] EBITDA = Earnings Before Interest Tax Depreciation and Amortization

It is critical to avoid becoming overly focused on the upfront capital cost, which could inadvertently prejudge and reject pathways that may make business sense when lower production costs are included. This problem can be alleviated in switching from the current, cost-based system to the recommended performance-linked one. It will ensure that the grant giver is not overly influenced by the capital cost of the station, making for a more technology neutral grant-giving program, which is likely to enable greater diversification in the marketplace.

Supporting complimentary, add-on projects

One further advantage of a performance-based grant program over a cost-based one is that it may allow for add-on investments, and not just transport-dedicated investments at existing stations. This could include applications that combine vehicle fueling with other hydrogen uses, such as forklifts, tri-generation projects, integration with renewable electricity storage solutions, and co-location with CNG infrastructure.

For example, a materials handling facility that uses hydrogen for its forklift trucks might be able to offer fuel for light duty vehicles. The added expense, whether done upfront or after the fact, could provide fuel capacity for an incrementally low price. Under the current system, the CEC and such an applicant would have an incredibly difficult analytical job trying to separate the business as usual investment from one including public fueling capacity. In contrast, a performance-based system would have a transparent grant. For 50kg/day of capacity, perhaps very useful in a remote area of the network, the grant would be $350,000 ($7,000 x 50), under the tiered pricing proposed above. It would be up to the business to decide whether this made sense, but no complicated negotiations would be needed.

Similarly, one can imagine many future opportunities for tri-generation, where a business invests in a fuel cell to provide heat and power, and may consider adding hydrogen production capacity to sell to FCEVs with this incremental incentive. Recent research suggests that there may be applications for supermarket-scale systems that could provide a nominal level of fuel capacity.[97]

We do not know how viable these projects are, and are not suggesting they form a core part of the strategy of the initial build-out. One thing is clear: their complexity and small scale means we are unlikely to see them under the current, cost-based grant program. However, a performance-based system that easily supported such incremental investment, without in-depth financial inquiry, might generate some worthwhile technological innovation while providing low cost additions to the fueling network. The supermarket or other business could build their business case on the reliable savings from the heat and power production (supported with self-generation incentives). The hydrogen fueling capacity grant would be an add-on, contributing transparently to the incremental expense of such an activity.

[97] Li, Xuping and Joan M. Ogden (2012) Understanding the Design and Economics of Distributed Tri-Generation Systems for Home and Neighborhood Refueling—Part II: Neighborhood System Case Studies. Journal of Power Sources 197, 186 - 195

A summary of benefits for different stakeholders

As described in this section, a performance-based grant structure with a phasedown schedule provides many advantages. Overall the approach aims to:

1. Facilitate a smooth transition to a private market, though a transparent, planned phase out of subsidies.
2. Improve station deployment timelines, by making the grants more transparent and easier to implement.

For the industry applicant, the system would:

1. Remove the current disincentive to be first, in relation to high capital costs.
3. Encourage station developer to cut development costs, in order to pocket savings.
4. Provide transparency to all participants, on the amount to expect, without needing to try to understand the government's cost-effectiveness preferences.
5. Allow applicants to keep confidential financial information private. There would be no need to provide any cost information.
6. Allow industry participants that are not equipment providers to make solicitations, without the risk of divulging discrepancies in cost estimates from equipment vendors.
7. Allow seamless proposals for hydrogen capacity that is one component of a stationary system, such as combined heat and power or a CNG/hydrogen project.
8. Give applicants the flexibility to manage financial decisions and costs, without the onerous requirement of having to report and approve variances from the original bid.

For the government, performance based grants and scheduled phasedown would:

1. Signal and communicate a long term plan and budget, and avoid having to defend it on an annual basis.
2. Reduce the administrative & analytical burden of evaluation proposals, as the budget and cost-effectiveness of proposals would no longer be part of the evaluation.
3. Reduce the administrative burden of tracking grantee spending.
4. Avoid having to make increasingly difficult technology choices as the market grows, by having a single metric that compares projects transparently.

Capture Revenues for Ongoing Network Support

In the medium term, there may be a need for ongoing support of connector stations, beyond the government's initial investment, to facilitate the continued build-out of the network.

In the initial market coverage phase, and the market development phase that follows it, funding will clearly need to come from outside the infrastructure network to help launch this market. We believe there is widespread acceptance of this.

However, once fuel cell vehicle are on the road in large numbers, it will be important for the market to transition away from public support as quickly as possible, to take advantage of the efficiencies and market signals that are necessary for a robust infrastructure market.

In this later, market-driven phase, there are several reasons why some form of ongoing network support funds may be necessary, including:

1. Extra connector stations. We recommend the MAG support be limited to the first 68 stations, which will cover the station on I-5. However, one can easily imagine that FCEV consumers will want connectors stations that extend their range into Oregon, Nevada and Arizona as well. These are clearly valuable to the network as a whole, but unlikely to be built without special support.
2. Expansion beyond the initial market. A sustained expansion of the hydrogen network into new regions may need some form of initial assistance similar to the Market Assurance Grants provided to the first 68. An example might be a station in emerging markets such as Las Vegas, Eureka, Portland, or Fresno.

For such cases, it is helpful to consider how much funding could be generated from within the hydrogen network to support activities that provide value to the overall network. In whatever manner such funds are collected, they are ultimately fees that consumers pay to support the broader network, which gives them and their vehicle greater value.

Options to link revenue to

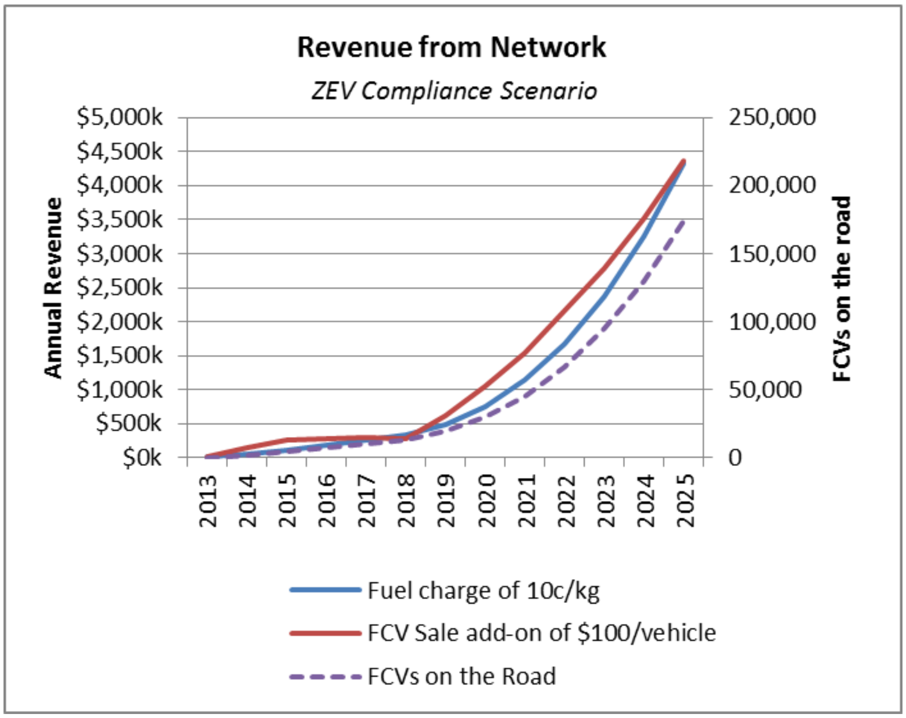
To indicate the amount of money that self-funding could generate for an infrastructure fund, we consider three possible linkages. In each case, we are not specifying WHO pays, but rather what the payment is linked to.

1. **Revenues linked to fuel sales**. A payment contributed for every kilogram sold. As mentioned above, this could be paid by the infrastructure owner, by the auto company (through some kind of pre-payment or membership arrangement), or any number of matching grant arrangements.

2. **<u>Revenue linked to vehicles sales.</u>** Again, the payment could be contributed by a variety of sources, including the OEM on behalf of the owner, as a portion of the rebate provided by the state, etc.
3. **<u>Revenues linked to annual vehicle registrations.</u>** An annual registration payment could build a more sustained source of revenue, similar to today's AB 118 program.

To illustrate the potential scale of these fees, Figure 17 shows two that would generate similar revenue levels, though collected in different ways. A fuel charge of 10c/kg, or $100 per vehicle sold can quickly become a significant source of revenue when vehicle sales take off. For reference, $1 million could keep approximately 10 stations open and operating for a year.[98]

Figure 17: Illustrative Revenue from two different revenue mechanisms



We strongly encourage stakeholders, including both the government and OEMs, to discuss ways in which consumers will support the network once the initial government-led coverage is built. The above simple calculations show that a minimal fee may generate valuable funds that could go towards supporting connector or expansion stations.

Rewarding Early Consumers

It is possible to reward early consumers who contribute to the market build out of connector stations. A consumer owned co-op (similar to REI's model) could be established with clear membership benefits, such a fuel discounts at supported stations, and/or dividends once stations become profitable or sold.

[98] Assuming $100K/year O&M, and no fuel sales.

We have not explored this approach with stakeholders in great detail, but suggest that there are ways this could be a complementary mechanism.

For example, the infrastructure fund that collects fees from consumers in any of the above ways could be owned in part by these early consumers. If it were a consumer-owned co-op, in which the first 10,000 willing vehicle buyers were entered as members, fuel and dividend benefits could easily be extended to these members. Further discussion is needed, but the concept of early consumers being rewarded by later consumers could complement or be linked to the vehicle rebates and other incentives.[99]

[99] Conversations with two current customers indicate a strong willingness to pay for increased utility, especially in a co-op scenario. Obviously, more customers would need to be surveyed to learn the true potential of this approach, but a voluntary opt-in approach might be a feasible early strategy.

Transfer Value of Low Carbon Fuel Standard (LCFS) credits

LCFS credits potentially hold considerable value that could benefit multiple parties. Private party arrangements could trade future value for upfront investment, helping to create the hydrogen fueling market.

The LCFS represents another source of potential revenue linked to the hydrogen network itself. Currently, a LCFS credit is generated when hydrogen is sold, given that it has a lower carbon intensity than gasoline. The owner of the hydrogen at the time of fueling (i.e., the developer), can register with the ARB as part of the LCFS program, and will be given LCFS credits that he can then sell to oil companies who need them for LCFS compliance.

The value of this credit is uncertain. However, if one assumes a delivered gas pathway, and a value for the credit equivalent to $30/ton of CO_2,[100] this translates into approximately 50c per kg of hydrogen, a significant number for the station owner.[101] The quantity of credits declines slowly over time as the gasoline standard comes down, but the value of each credit may be much higher than $30/ton, if LCFS parties struggle to meet the standard in later years. If LCFS credits were trading at $100 in 2018, this would be equivalent to $1.50 per kg of hydrogen sold.

If the hydrogen network were up and running, these credits could be extremely valuable to station developers, and would be factored into their revenue stream. However, since the current volumes are insignificant, the LCFS mechanism is currently not able to play much of a role. Furthermore, at low volumes, a hydrogen producer may conclude the administrative burden of reporting to the LCFS and attempting to find buyers for the credits is simply not worth the effort.

Supporting the initial rollout.

Creative financial tools could be used to bring the LCFS stream of revenue forward in support of hydrogen station development. To do this, one or more parties would need to provide funds to a station developer in exchange for the right to these future credits, taking on the risk that the credits are actually created (which depends on vehicle sales), and that they can be sold for a reasonable price (which depends on demand and supply balance in the LCFS program).

This transaction can be done privately, in a contract between a financing entity and an individual station. To give a sense of the value, if credits were sold at $30/ton equivalent, a 500kg core market station built in 2014 would generate credits worth a cumulative value between $134k and $307k through 2020 (the

[100] Trading values reported by CARB averaged $29/ton in the first quarter of 2013, with second quarter monthly averages moving from $35/ton in April to $57/ton in early July. http://www.arb.ca.gov/fuels/lcfs/20130731_q1datasummary.pdf

[101] Estimate based on a 98.8 gCO_2e/MJ value for hydrogen, a 2.5 Energy Efficiency Ratio for the engine, and the LCFS gasoline standard baseline of 94.89 gCO_2e/MJ for 2013.

range is based on whether sales come at 25% or 100% of the ZEV likely compliance scenario). Currently, this value is likely to be lost.

Alternatively, one can see the value of an individual vehicle. If a vehicle uses 0.7kg/day, it will generate credits based on 256 kgs a year. Based on the LCFS tables, $30/ton translates to approximately $0.50/kg for hydrogen derived from natural gas. Over 10 years, if LCFS credit prices average $30/ton, one FCEV would generate an LCFS value worth $1,280, (this assumes the LCFS program is extended beyond 2020). Again, this value is currently likely to be lost.

Some automakers have proposed changes to the LCFS to allow this cumulative value of either stations or vehicles to be brought forward and credited to station developers. While there may be merits to this, we believe it is highly unlikely that the LCFS program would be modified in this way, given that it is strongly tied to actual CO_2 reductions, not potential ones.

Instead, we see an opportunity for a purely financial transaction between two players: 1) a station investor who gives up LCFS credits in exchange for an up-front payment and 2) an entity willing to bet that FCEVs will be sold in specific numbers, and that the credits generated can be sold for a given value. That entity could make huge profits if cars came faster than their agreement with stations specified, or the LCFS credits rose in value. They could of course lose it all if vehicle sales fell short.

We recognize that that it may be too difficult for government entities to enter into this type of financial contract. However a private entity, working either alone or with OEMs, could conceivably take on that risk. Setting this up in an aggregated way for all the stations would lessen the risk to the financial entity in terms of exactly where the vehicles are sold.

Later Support & Renewable Hydrogen

If station owners keep the credits for themselves, this significant value will help their bottom line. One other aspect is that producers who use renewable feedstock (biogas), or renewable-based electrolysis will see a greater credit value. The LCFS value for onsite reforming using 1/3 biogas is already 76.1gCO_2/MJ, resulting in 16% premium above all the numbers given above.

VII. Conclusion

Of all the recommendations listed above, the first priority is to instill confidence in the market. Actions such as increasing capital cost-share levels, offering Market Assurance Grants, and offering preferential debt are pointless without a concerted effort to improve confidence that the market will develop and hydrogen stations will pay off.

With good reason, infrastructure providers will remain hesitant to jump into the market without confidence that the vehicles are in fact coming. Again, with good reason, automakers will not invest in vehicle deployments without confidence FCEVs will have reasonable access to fuel.

The government sits in the key position, with the ability to broker confidence on both sides of the equation. As stated in the Introduction, this requires the government (with the active support of all other stakeholders) to:

- Secure funding;
- Create a strategic vision and funding plan that earns stakeholder buy-in;
- Match investments to vehicle survey projections; and
- Empower strong leadership (either within or outside government) that can adjust to changing market realities and hold all relevant parties accountable.

Through this H2NIP effort, it has become increasingly clear that the government needs to set the tone and provide the leadership in the early market. To get the market off of the ground, industry is needed to support the government's effort, not the other way around.

Assuming the points above are met and investors can move forward with more confidence, powerful monetary tools such as Market Assurance Grants in the early market, and preferential debt later on, can be difference makers. People who provide fuel for a living are eager to find new ways to make money. If the state can provide a pathway to do it with hydrogen, the rest will very likely take care of itself.

VIII. Appendices

Appendix A - H2NIP Model Assumptions

The H2NIP Model relies on a variety of input assumptions, captured in the tables below. The numbers qualified as “low, baseline, and high” represent EIN’s best judgment given our literature review, review of AB118 Hydrogen applications, and conversations with hydrogen stakeholders.[102]

Table 9: Station Cost Assumptions

Parameter	Value			Source	Rationale
Capital Cost (Delivered H2)	*Low*	*Baseline*	*High*		
100-180 kg/day Station	$0.9m	$1m	$2.2m	Ogden 2012, IGCs, AB118, Ogden&Nicholas, Brown 2013	Includes design, construction, training & labor costs (***true for all Capital Cost Estimates below***)
250 kg/day Station	$0.9m	$1.5m	$2.5m	UC Davis, IGCs, AB118	
500 kg/day Station	$1.5m	$2m	$2.8m	UC Davis, IGCs, NREL, Brown 2013	
Expansion, 250 to 500 kg/day		$0.5m		IGCs	Represents the incremental cost of expansion.
Expansion, 500 to 1,000 kg/day		$0.5m	$0.6m	IGCs	Represents the incremental cost of expansion.
Delivered H2 Cost		$5.50/kg	$6.00/kg	Plug Power, IGCs, Brown 2012 & 2013	Plug Power estimates $5.50/kg as the cost of hydrogen molecules, delivered (based on real world pricing). IGCs recommend $6/kg estimate. Brown calculates costs ranging from $2.50 to $12/kg. Plug Power wants low prices, IGCs better of with high prices.
Forecourt Compression Energy (kWh/kg)	0.81	2.91	5	Ogden&Nicholas, Brown 2013	Compression varies by system. Liquid H2 requires less forecourt compression than Gaseous H2
Capital Cost (Onsite SMR)	*Low*	*Baseline*	*High*		
250 kg/day Station	$1.8m	$2.9m	$4m	Melaina 2012, Ogden&Nicholas	
500 kg/day Station	$2.3m	$3.6m	$4.8m	Melaina 2012, Ogden&Nicholas, NREL, IGCs	
1000 kg/day Station	$4.9m	$6.3m	$7.8m	Melaina 2012, Ogden&Nicholas, NREL, H2A Model	
Forecourt Compression Energy (kWh/kg)		3.08	4.49	Ogden&Nicholas, H2A Model	
Natural Gas Feedstock Consumption (MMBTu/kg)		1.56		Ogden&Nicholas	
Natural Gas Cost ($/MMBTu)	$7		$12	Brown 2013, Ogden&Nicholas	
Capital Cost (Onsite Electrolysis)	*Low*	*Baseline*	*High*		
130 kg/day Station	$1.9m	$2.5m	$3.2m	Ogden&Nicholas, IGCs, Melaina 2013	
260 kg/day Station	$2.6m	$3.4m	$4.2m	Ogden&Nicholas, IGCs, Melaina 2013	
1000 kg/day Station	$4.4m	$6.8m	$9.3m	Ogden&Nicholas, IGCs, Melaina 2012, NREL, H2A Model	
Forecourt Compression Energy (kWh/kg)		55.2		Ogden&Nicholas	
Electricity Cost ($/kWh)	$0.06	$0.10		Ogden&Nicholas, Brown 2013, IGC	Electrolyis systems make economic sense at low electricity cost ($0.06/kWh) - ideally curtailed renewable electricity

[102] The references listed under “Source” correspond to the “References” provided at the end of this Appendix.

Table 10: Fixed Costs of a Station

Fixed Business and Operations & Maintenance					
General Proxy/Groundtruth		$100K/yr		UC Davis, Industry	Used for all station types in UC Davis numbers. Represents sum of all fixed O&M.
Rent ($/month)	$1,000	$3,000	$4,000	IGCs, Industry Consultant, NREL	$500/month could be enough to rent space that will bring in customers (from Industry Consultant). $3000 based on IGC experience & AB 118 Applications.
Insurance ($/month)		$1,600	$1,667	Federated Insurance, Brown 2013	Same as CNG = Twice normal gasoline station.
Maintenance ($/month)		$2,800	$3,083	NREL	
Property Tax ($/year)	$5,000	$15,000	$25,000	CaFCP	1% of assessed value. The model calculates 1% * Capital Cost of station.
Permit Fees ($/year)	$1,000		$3,680	CaFCP Station	$3,678 for West Sac Station
Total Fixed Business and O&M (Baseline, $/year)	$99,000	$104,000	$107,500	EIN Model	Model Calculation using baseline costs

Table 11: General Assumptions and Parameters

Parameter	Value	Source	Rationale
Average Utilization of a Station	70%	EIN Cash Flow Project	This figure is used to estimate network-wide capacity planning - i.e. stations are built such that 70% of installed capacity is available to meet fuel demands
Max sustained utilization	70%	EIN Cash Flow Project	This number is used to cap a station's useage for annual financial calculation. We assume a station owner would consider expanding at this utilization rate.
Equipment Life (yrs)	10	Industry	Upgrades may keep the equipment operating longer. Based on industry input, 10 years is a reasonable target for current equipment
Daily Vehicle Fuel Use (kg/d)	0.7	Brown 2012	
Market Rate for loans for comparison (%)	5.5%	Patriot Capital	Used as a baseline to compare the value of low interest, long-term loans
Market Terms for loans for comparison (yrs)	7	Patriot Capital	This is the longest loan typically offered for fueling equipment.
Taxes & Fees			
Sales Tax	9%	Cal. State Board of Equal.	Sales tax varies by City. While some locations have rates of 10%, 9% is the more typical highest tax rate.
Credit Card Fees	3%	Industry	
CreditCardUsage	80%		We assume the majority of transactions will be done using a credit card
Corporate Marginal Tax - Federal	35%	IRS	Highest rate for 2012
Corporate Marginal Tax - California	8.84%	Calif. Franchise Tax Board	Corporation rate
Terms for Internal Rate of Return	10 years		The useful life of the current stations is not expected to be longer than 10 yrs given the rapid rate of innovation at this early stage. Financial returns are calculated accordingly.

Market Development Scenarios

Vehicle Deployment and Home Base

Fuel cell electric vehicle (FCEV) deployment and market uptake will play the primary role in station economics. The H2NIP model considers four potential FCEV deployment scenarios, as shown in Table 12. For reference, the ZEV Likely Compliance Scenario comes from the staff analysis behind ARB's 2012 Zero Emission Regulation Modification. The CaFCP 2010 Survey was the baseline of the CaFCP Roadmap.

Table 12: FCEV Deployment Scenarios, Cumulative # of FCEVs, by year

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
ZEV Likely Compliance	312	430	1,900	4,600	7,500	10,500	13,400	19,600	30,200	45,600	67,200	95,000	130,200	173,800
Half ZEV	312	312	950	2,300	3,750	5,250	6,700	9,800	15,100	22,800	33,600	47,500	65,100	86,900
Quarter ZEV	312	312	475	1,150	1,875	2,625	3,350	4,900	7,550	11,400	16,800	23,750	32,550	43,450
CaFCP 2010	312	430	1,389	10,518	21,036	52,590	84,144	115,698	147,252	178,806	210,360	241,914	273,468	305,022

In addition to the cumulative number of FCEVs in the California market, from a station owner's perspective, it really matters *where* these vehicles fuel. To estimate fueling patterns, the H2NIP model employs assumptions on market share and fueling habits.

As described in the main paper, the H2NIP model divides the market into three segments: Core, Emerging, and Connector. Table 13 shows our percentage market share assumptions assuming that FCEV deployment focuses around Core stations. This "concentrated" scenario is the basis of all of the outputs we have captured in the H2NIP paper. The percentage corresponds to the total percentage of FCEVs in a given market, in a given year (for example, in 2017, Core Markets would be the home base of 93% of the entire FCEV population).

Table 13: Market Share, Concentrated around Core Markets

Concentrated:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Core Market	100%	100%	99%	97%	95%	93%	91%	89%	87%	85%	83%	81%	79%	77%
Emerging Market	0%	0%	1%	3%	5%	7%	9%	11%	13%	15%	17%	19%	21%	23%
Connectors	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 14 shows a "dispersed" pattern, reflecting the uncertainty around where FCEV interest will focus.

Table 14: Market Share, reasonably Dispersed FCEV uptake

Dispersed:

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Core Market	100%	100%	99%	94%	89%	83%	78%	73%	68%	62%	57%	52%	47%	42%
Emerging Market	0%	0%	1%	6%	11%	16%	21%	26%	31%	36%	41%	46%	51%	56%
Connectors	0%	0%	0%	0%	0%	1%	1%	1%	1%	2%	2%	2%	2%	2%

Station Utilization

Determining where FCEVs "live" is the first step to determining fuel demand in a given market. The second step is determining where FCEV owners tend to refuel. The scenarios shown in Table 15 are loosely based on work done by Kitamura and Sperling (1987).

Table 15: Fueling Habits of FCEV Owners

	Resident of ↓.....Fuels car in →	Core Market	Emerging Mkt	Connectors
Home-based	*Core Market*	95%	4%	1%
	Emerging Market	14%	85%	1%
	Connectors	8%	2%	90%
Widespread	*Core Market*	90%	8%	2%
	Emerging Market	18%	80%	2%
	Connectors	7%	6%	87%

On top of the above fueling habits, for a given fuel demand in a market, we either assume each station gets the same share, or in proportion to their size. The numbers and illustrations in the H2NIP paper assume a "proportional" share of market demand.

As stations come online, we assume the customer base takes time to grow, as show by the capacity utilization parameters shown in Table 16. Seventy percent reflects the "max sustained utilization" assumption shown in Table 11. Once a station reaches 70% utilization, the model assumes that station is "full," prompting the need for a new station in the capacity phase (stations 69 and beyond).

Table 16: Station Utilization Ramp-up Rate

Capacity	yr1	yr2	yr3	yr4	.....
180 kg/day	33%	66%	70%	70%	.....
250 kg/day	33%	66%	70%	70%	.....
500 kg/day	33%	66%	70%	70%	.....

Station Roll-Out

Finally, stations impact stations. As new stations are opened, existing stations can be subject to temporally reduced demand. For coverage stations (i.e., Stations 1-68) we manually input the desired/likely build out. These stations are driven by a need to cover the market. See Table 17Table 18 for two of the many the scenarios we considered. Ultimately, Table 17 served as our baseline scenario used to illustrate concepts in the H2NIP paper.

Table 17: Baseline Coverage (Stations 1-69) Buildout Scenario for Modeling Runs

H2NIP Baseline

	Station Size	2012	2013	2014	2015	2016	2017
Core Market	180kg/day	2	6	13	13	13	13
	250kg/day			1	6	11	15
	500kg/day			3	7	11	17
	Total	2	6	17	26	35	45
Emerging Market	180kg/day	2	4	6	8	10	10
	250kg/day			2	5	8	12
	500kg/day				0	0	0
	Total	2	4	8	13	18	22
Connectors	180kg/day	-	-				
	250kg/day				-		1
	500kg/day						
	Total						1
TOTAL		4	10	25	39	53	68

Table 18: CaFCP Roadmap Coverage Buildout Target

CaFCP Roadmap Target

	Station Size	2012	2013	2014	2015
Core Market	180kg/day	6	16	16	16
	250kg/day		2	12	27
	500kg/day			8	17
	Total	6	18	36	60
Emerging Market	180kg/day	0	0	0	0
	250kg/day		0	2	5
	500kg/day				0
	Total	0	0	2	5
Connectors	180kg/day	-	-		
	250kg/day			1	3
	500kg/day				
	Total	0	0	1	3
TOTAL		6	18	39	68

The H2NIP model assumes the 69th station will be capacity driven, as opposed to coverage driven. In other words, station 69 and beyond will be built when there is a projected un-met demand for hydrogen. Table 19 shows the scenarios we employ in our model. The "Baseline" is based on work done by Mike Penev and Marc Melaina at the National Renewable Energy Laboratory (NREL). [103]

[103] NREL's Melaina & Penev estimate station size build out based on a gamma distribution observed in the fueling industry, combined with the growth rate of fueling (i.e. station owners will build bigger stations if they see high growth). The distribution predicts stations of many sizes. When constrained to 250kg and 500kg stations, we observe a 51%:49% split in capacity, which we simplify to a 50:50.

Table 19: Capacity Buildout Scenarios (Stations 69 and beyond)

		Small Bias	Baseline	Large Bias
Core Market	180kg/day	0%	0%	0%
	250kg/day	70%	50%	10%
	500kg/day	30%	50%	90%
	Total	100%	100%	100%
Emerging Ma	180kg/day	0%	0%	0%
	250kg/day	70%	50%	10%
	500kg/day	30%	50%	90%
	Total	100%	100%	100%
Connectors	180kg/day	0%	0%	0%
	250kg/day	70%	50%	10%
	500kg/day	30%	50%	90%
	Total	100%	100%	100%

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Appendix B - Determining the Appropriate Cost Share Level

Through both the ARB's Hydrogen Highway and the CEC's AB118 programs, the agencies have offered to share hydrogen station capital costs, on a percentage basis, with private applicants. These funds are designed to offset the cost of installing a hydrogen station. Under AB118, the CEC has offered public contribution ranging from 65% per station (most recently under PON 12-606) to 75% (under PON 09-608, offered in 2010) for a station meeting the minimum renewable requirement.

In the main H2NIP document, we argue that moving to a performance based grant system would help streamline and simplify the grant program, driving down infrastructure costs while ensuring the state captures the desired benefits. However, given the history of funding fueling infrastructure, maintaining percentage based capital cost share might be the most administratively viable option in the short term.

Setting the appropriate cost share level is a delicate task. Set the percentage too high, and the public spends more money than it has to. Set it too low, and not enough private interest is generated. As a rule of thumb, EIN believes *it is far better to overpay than underpay*, for two primary reasons:

1. With a successful market build-out, the benefits (climate, air quality, energy independence, etc.) are expected to significantly outweigh the costs.[104]
2. Underpayment, and the resultant build-out delay, can lead to the market stalling on both sides of the equation (vehicles and stations). In the early stages, one market stall-out can kill the program by reducing consumer confidence and weakening political support. This would essentially strand all investment.

To generate the desired outcome, the State needs to fully commit to success. The following sections demonstrate the impact of various cost-share percentages and the Market Assurance Grants (MAG) on a station's bottom line, given a variety of market scenarios.

The reader will see that hydrogen demand (i.e., consumption) plays the key role in determining how agency decisions play out on the ground. Similarly, when taken as stand-alone projects, stations in emerging and connector locations will need *higher* cost share to become attractive. Some connectors will only be attractive as a network support function that can help increase FCEV market share, subsequently increasing hydrogen demand at other stations.

Scenarios to Explore Probable Returns

The following figures are sensitivity outputs from the EIN Hydrogen Network Investment Plan (H2NIP) Model. We use the table to demonstrate the impact of capital cost (y-axis) and the retail price of hydrogen (across the top) on the Internal Rate of Return (IRR), or profitability of a station, given a market scenario. This internal rate of return (IRR) shows what an investor would make from their private contribution to the station, over a fifteen-year station life.

[104] Transitions to Alternative Vehicles and Fuels. National Research Council of the National Academies, 2013

For the sake of demonstration, we chose a 15% hurdle rate for the IRR.[105] In other words, if an investor expects the project will generate a 15% IRR, they would decide to go forward with the project.

In what follows, we use two scenarios of vehicles sales to illustrate the impact of capital cost share and market assurance grants (MAG) on a station's bottom line. "ZEV Likely Compliance" is a scenario developed by CARB staff during the development of the 2012 Zero Emission Vehicle Regulation Revision.[106] "Quarter ZEV" represents 1/4th of the ZEV Likely Compliance scenario. The Quarter ZEV Scenario is used to understand the downside risk station developers face if FCEVs permeate the market very-slowly. It is a proxy for the calculation a station developer is likely to make to determine the risk of a potential investment in an early market fueling station.

Figure 18: Illustrative Market Scenarios, Total Number of FCEVs on the Road

	2012	2013	2014	2015	2016	2017	2018
ZEV Likely Compliance	*312*	*430*	*1,900*	*4,600*	*7,500*	*10,500*	*13,400*
Quarter ZEV	*312*	*312*	*475*	*1,150*	*1,875*	*2,625*	*3,350*

	2019	2020	2021	2022	2023	2024	2025
ZEV Likely Compliance	*19,600*	*30,200*	*45,600*	*67,200*	*95,000*	*130,200*	*173,800*
Quarter ZEV	*4,900*	*7,550*	*11,400*	*16,800*	*23,750*	*32,550*	*43,450*

Core Market Station Scenarios

Baseline demand (ZEV Compliance scenario) and no Market Assurance Grants

Figure 19, Figure 20, and Figure 21 below show the 10-year internal rate of return for a delivered hydrogen 500kg station, built in 2015 in a core market, assuming the ZEV Compliance Scenario. The cell in yellow shows the IRR under our baseline assumption of a $2 million station and $9/kg retail price, which translates into a $2.18/kg margin for delivered gas in our model.

As the diagrams show, and the reader can intuit, lower capital costs, higher hydrogen sale prices, and higher cost share percentages benefit the station developer/operator. The benefits of lower capital cost and higher cost share can also be transferred to the consumer in the form of lower hydrogen fuel prices.[107]

Under a ZEV Likely compliance scenario the baseline assumption IRR (in yellow) goes from 3% to 20.7% with higher cost-share, though a higher retail price (moving to the right), or lower capex affects that IRR considerably.

[105] 15% IRR is a typical hurdle rate for natural gas field development (Bentek presentation to the CaFCP Steering Team, February 12, 2013). Each company will make its own judgment to determine an appropriate hurdle rate. Generally speaking, as long-term market confidence increases, a company can justify lower hurdle rates.

[106] Staff Report: Initial Statement of Reasons for 2012 proposed amendments to the California Zero Emission Vehicle Program regulations. Dec. 8, 2011. Section 3, Table 3.6.

[107] $9/kg hydrogen is roughly equivalent to $3.91/gallon of gasoline. This assumes a 2.3 energy efficiency ratio for FCEVs.

Figure 19: 50% Cost Share, ZEV Likely Compliance Scenario

Capital Expense of Station	***IRR of a 2015 Core Market: 500-DH2 Station***					*Vehicle Sale: / Likely Compliance*			
	If long term Hydrogen Retail Price								
	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-7.0%	5.5%	13.6%	19.9%	25.6%	30.9%	36.1%	41.2%	46.1%
$1,100k	-8.1%	4.3%	12.2%	18.2%	23.6%	28.6%	33.5%	38.3%	42.8%
$1,200k	-9.2%	3.1%	10.9%	16.7%	21.9%	26.6%	31.2%	35.6%	40.0%
$1,300k	-10.1%	1.9%	9.7%	15.4%	20.3%	24.8%	29.2%	33.4%	37.5%
$1,400k	-11.0%	0.8%	8.5%	14.2%	18.9%	23.3%	27.4%	31.4%	35.3%
$1,500k	-11.8%	-0.2%	7.5%	13.1%	17.7%	21.9%	25.8%	29.6%	33.3%
$1,600k	-12.5%	-1.2%	6.6%	12.1%	16.5%	20.6%	24.3%	28.0%	31.5%
$1,700k	-13.2%	-2.1%	5.7%	11.1%	15.5%	19.4%	23.0%	26.5%	29.9%
$1,800k	-13.9%	-2.9%	4.8%	10.3%	14.5%	18.3%	21.9%	25.2%	28.5%
$1,900k	-14.5%	-3.7%	3.9%	9.4%	13.7%	17.3%	20.8%	24.0%	27.1%
$2,000k	-15.1%	-4.5%	3.0%	8.6%	12.8%	16.4%	19.8%	22.9%	25.9%
$2,100k	-15.7%	-5.2%	2.3%	7.8%	12.1%	15.5%	18.8%	21.9%	24.8%
$2,200k	-16.2%	-5.8%	1.5%	7.1%	11.3%	14.7%	17.9%	20.9%	23.7%
$2,300k	-16.7%	-6.5%	0.7%	6.4%	10.6%	14.0%	17.1%	20.0%	22.8%
$2,400k	-17.2%	-7.1%	0.0%	5.7%	9.9%	13.3%	16.3%	19.2%	21.9%

Figure 20: 65% Cost Share, ZEV Likely Compliance Scenario

Capital Expense of Station	***IRR of a 2015 Core Market: 500-DH2 Station***					*Vehicle Sale: / Likely Compliance*			
	If long term Hydrogen Retail Price								
	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-2.7%	11.4%	21.0%	28.8%	36.0%	43.0%	49.9%	56.7%	63.4%
$1,100k	-3.8%	10.1%	19.5%	26.9%	33.7%	40.2%	46.6%	53.0%	59.1%
$1,200k	-4.9%	9.0%	18.0%	25.2%	31.7%	37.8%	43.7%	49.7%	55.5%
$1,300k	-5.8%	7.7%	16.7%	23.7%	29.9%	35.6%	41.3%	46.8%	52.4%
$1,400k	-6.7%	6.5%	15.5%	22.3%	28.2%	33.8%	39.1%	44.4%	49.6%
$1,500k	-7.6%	5.4%	14.3%	21.1%	26.8%	32.1%	37.1%	42.1%	47.1%
$1,600k	-8.3%	4.4%	13.3%	19.9%	25.4%	30.6%	35.4%	40.2%	44.9%
$1,700k	-9.1%	3.4%	12.3%	18.8%	24.2%	29.2%	33.8%	38.4%	42.8%
$1,800k	-9.7%	2.5%	11.4%	17.8%	23.1%	27.9%	32.4%	36.7%	41.0%
$1,900k	-10.4%	1.7%	10.4%	16.9%	22.1%	26.7%	31.1%	35.2%	39.3%
$2,000k	-11.0%	0.9%	9.5%	15.9%	21.1%	25.6%	29.9%	33.9%	37.8%
$2,100k	-11.5%	0.1%	8.6%	15.1%	20.2%	24.6%	28.7%	32.6%	36.4%
$2,200k	-12.1%	-0.6%	7.7%	14.3%	19.3%	23.6%	27.6%	31.5%	35.1%
$2,300k	-12.6%	-1.3%	6.9%	13.5%	18.5%	22.7%	26.6%	30.4%	33.9%
$2,400k	-13.1%	-1.9%	6.2%	12.7%	17.7%	21.9%	25.7%	29.3%	32.8%

Figure 21: 80% Cost Share, ZEV Likely Compliance Scenario

IRR of a 2015 Core Market: 500-DH2 Station — Vehicle Sale: / Likely Compliance

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	4.0%	21.2%	33.9%	45.1%	56.0%	67.0%	78.6%	90.5%	102.8%
$1,100k	2.9%	19.8%	32.1%	42.7%	53.0%	63.2%	73.9%	85.0%	96.0%
$1,200k	1.8%	18.6%	30.5%	40.6%	50.5%	59.9%	69.8%	80.0%	90.3%
$1,300k	0.9%	17.3%	29.0%	38.8%	48.1%	57.1%	66.2%	75.6%	85.5%
$1,400k	0.0%	16.1%	27.6%	37.1%	45.9%	54.5%	63.1%	71.9%	81.0%
$1,500k	-0.8%	14.9%	26.3%	35.6%	44.0%	52.3%	60.3%	68.6%	77.1%
$1,600k	-1.6%	13.8%	25.1%	34.2%	42.2%	50.2%	57.8%	65.6%	73.6%
$1,700k	-2.3%	12.7%	24.0%	32.9%	40.7%	48.3%	55.6%	63.0%	70.5%
$1,800k	-3.0%	11.8%	22.9%	31.6%	39.2%	46.5%	53.6%	60.6%	67.8%
$1,900k	-3.7%	10.8%	21.8%	30.5%	37.9%	44.9%	51.8%	58.4%	65.2%
$2,000k	-4.3%	10.0%	20.7%	29.3%	36.7%	43.4%	50.0%	56.4%	62.9%
$2,100k	-4.9%	9.1%	19.8%	28.3%	35.5%	42.0%	48.4%	54.6%	60.8%
$2,200k	-5.4%	8.4%	18.8%	27.3%	34.4%	40.7%	46.9%	53.0%	58.9%
$2,300k	-6.0%	7.6%	17.8%	26.4%	33.3%	39.5%	45.5%	51.4%	57.1%
$2,400k	-6.5%	6.9%	17.0%	25.4%	32.3%	38.4%	44.2%	49.9%	55.5%

Under Very Low Demand (1/4 of ZEV Compliance scenario)

The very low demand scenario shows how even the higher cost-share of 80% cannot compensate for the potential downside if vehicle growth is slow. In this case, with 80% cost share the IRR is negative for the baseline station.

Figure 22: 50% Cost Share, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station — Vehicle Sale: Quarter ZEV

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-22.6%	-11.9%	-5.8%	-1.6%	1.9%	5.0%	7.7%	10.3%	12.7%
$1,100k	-23.0%	-12.3%	-6.3%	-2.1%	1.2%	4.2%	6.9%	9.3%	11.7%
$1,200k	-23.4%	-12.7%	-6.8%	-2.7%	0.6%	3.5%	6.1%	8.5%	10.7%
$1,300k	-23.8%	-13.3%	-7.3%	-3.2%	0.0%	2.9%	5.4%	7.7%	9.8%
$1,400k	-24.2%	-13.8%	-7.7%	-3.6%	-0.5%	2.2%	4.7%	7.0%	9.1%
$1,500k	-24.5%	-14.3%	-8.2%	-4.1%	-1.0%	1.7%	4.1%	6.3%	8.3%
$1,600k	-24.9%	-14.8%	-8.6%	-4.5%	-1.4%	1.2%	3.5%	5.7%	7.7%
$1,700k	-25.2%	-15.2%	-9.0%	-4.9%	-1.9%	0.7%	3.0%	5.1%	7.0%
$1,800k	-25.5%	-15.6%	-9.4%	-5.3%	-2.3%	0.3%	2.5%	4.5%	6.4%
$1,900k	-25.8%	-16.0%	-9.9%	-5.7%	-2.7%	-0.2%	2.0%	4.0%	5.9%
$2,000k	-26.1%	-16.4%	-10.4%	-6.1%	-3.0%	-0.6%	1.6%	3.5%	5.3%
$2,100k	-26.3%	-16.8%	-10.8%	-6.5%	-3.4%	-1.0%	1.2%	3.1%	4.9%
$2,200k	-26.6%	-17.2%	-11.2%	-6.9%	-3.8%	-1.4%	0.8%	2.6%	4.4%
$2,300k	-26.9%	-17.5%	-11.6%	-7.2%	-4.1%	-1.7%	0.4%	2.2%	4.0%
$2,400k	-27.1%	-17.8%	-12.0%	-7.6%	-4.5%	-2.0%	0.0%	1.8%	3.5%

Figure 23: 65% Cost Share, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station *Vehicle Sale: Quarter ZEV*

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-21.1%	-9.6%	-3.1%	1.6%	5.4%	8.8%	11.9%	11.9%	17.5%
$1,100k	-21.4%	-10.0%	-3.5%	1.1%	4.8%	8.1%	11.1%	13.9%	16.5%
$1,200k	-21.8%	-10.4%	-4.0%	0.6%	4.2%	7.4%	10.4%	13.0%	15.5%
$1,300k	-22.1%	-10.9%	-4.4%	0.1%	3.7%	6.8%	9.7%	12.3%	14.7%
$1,400k	-22.5%	-11.4%	-4.8%	-0.3%	3.2%	6.3%	9.0%	11.5%	13.9%
$1,500k	-22.8%	-11.8%	-5.2%	-0.7%	2.8%	5.7%	8.4%	10.9%	13.2%
$1,600k	-23.1%	-12.2%	-5.6%	-1.1%	2.3%	5.2%	7.9%	10.3%	12.5%
$1,700k	-23.4%	-12.7%	-6.0%	-1.5%	1.9%	4.8%	7.3%	9.7%	11.9%
$1,800k	-23.7%	-13.1%	-6.4%	-1.9%	1.5%	4.3%	6.8%	9.1%	11.3%
$1,900k	-23.9%	-13.4%	-6.8%	-2.2%	1.1%	3.9%	6.4%	8.6%	10.7%
$2,000k	-24.2%	-13.8%	-7.2%	-2.6%	0.8%	3.5%	5.9%	8.1%	10.2%
$2,100k	-24.4%	-14.2%	-7.7%	-3.0%	0.4%	3.1%	5.5%	7.7%	9.7%
$2,200k	-24.7%	-14.5%	-8.1%	-3.4%	0.1%	2.7%	5.1%	7.2%	9.2%
$2,300k	-24.9%	-14.8%	-8.5%	-3.7%	-0.3%	2.4%	4.7%	6.8%	8.8%
$2,400k	-25.1%	-15.1%	-8.8%	-4.1%	-0.6%	2.1%	4.3%	6.4%	8.4%

Figure 24: 80% Cost Share, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station *Vehicle Sale: Quarter ZEV*

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-19.2%	-6.7%	0.6%	5.9%	10.4%	14.4%	18.1%	21.5%	24.8%
$1,100k	-19.5%	-6.9%	0.3%	5.6%	9.9%	13.8%	17.4%	20.7%	23.9%
$1,200k	-19.7%	-7.2%	0.0%	5.2%	9.5%	13.3%	16.8%	20.0%	23.0%
$1,300k	-20.0%	-7.6%	-0.3%	4.9%	9.1%	12.8%	16.1%	19.3%	22.2%
$1,400k	-20.2%	-8.0%	-0.6%	4.6%	8.7%	12.3%	15.6%	18.6%	21.5%
$1,500k	-20.5%	-8.4%	-0.9%	4.2%	8.3%	11.8%	15.0%	18.0%	20.8%
$1,600k	-20.7%	-8.7%	-1.2%	3.9%	7.9%	11.4%	14.5%	17.4%	20.2%
$1,700k	-21.0%	-9.1%	-1.6%	3.6%	7.6%	11.0%	14.0%	16.9%	19.6%
$1,800k	-21.2%	-9.4%	-1.9%	3.3%	7.2%	10.6%	13.6%	16.4%	19.0%
$1,900k	-21.4%	-9.7%	-2.3%	2.9%	6.9%	10.2%	13.1%	15.9%	18.4%
$2,000k	-21.6%	-10.1%	-2.7%	2.6%	6.6%	9.8%	12.7%	15.4%	17.9%
$2,100k	-21.8%	-10.4%	-3.1%	2.3%	6.2%	9.5%	12.3%	15.0%	17.4%
$2,200k	-22.0%	-10.7%	-3.4%	1.9%	5.9%	9.1%	12.0%	14.5%	17.0%
$2,300k	-22.2%	-10.9%	-3.8%	1.6%	5.6%	8.8%	11.6%	14.1%	16.5%
$2,400k	-22.4%	-11.2%	-4.1%	1.3%	5.3%	8.5%	11.2%	13.7%	16.1%

Lower Demand but with Market Assurance Grants

Market Assurance Grants (MAGs) can help buffer station investors against slow vehicle roll out with higher cost share percentages. Under a Quarter ZEV scenario, when a MAG is used, the baseline station IRR (in yellow) starts to look tenable in terms of protecting against downside risk at 65% or greater cost share.

Figure 25: 50% Cost Share plus MAG, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station *Vehicle Sale: Quarter ZEV*

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-13.5%	-2.4%	4.0%	8.6%	12.4%	15.9%	18.9%	21.8%	24.5%
$1,100k	-14.5%	-3.6%	2.7%	7.2%	10.9%	14.1%	17.1%	19.8%	22.4%
$1,200k	-15.4%	-4.6%	1.6%	6.0%	9.5%	12.7%	15.5%	18.1%	20.5%
$1,300k	-16.2%	-5.6%	0.6%	4.9%	8.3%	11.3%	14.1%	16.6%	18.9%
$1,400k	-16.9%	-6.5%	-0.4%	3.9%	7.3%	10.2%	12.8%	15.2%	17.5%
$1,500k	-17.6%	-7.4%	-1.2%	3.0%	6.3%	9.1%	11.7%	14.0%	16.2%
$1,600k	-18.3%	-8.2%	-2.0%	2.2%	5.4%	8.2%	10.6%	12.9%	15.0%
$1,700k	-18.8%	-9.0%	-2.8%	1.4%	4.6%	7.3%	9.7%	11.9%	14.0%
$1,800k	-19.4%	-9.7%	-3.5%	0.7%	3.9%	6.5%	8.8%	11.0%	13.0%
$1,900k	-19.9%	-10.3%	-4.2%	0.0%	3.2%	5.7%	8.0%	10.1%	12.1%
$2,000k	-20.4%	-10.9%	-4.9%	-0.6%	2.5%	5.1%	7.3%	9.4%	11.2%
$2,100k	-20.9%	-11.5%	-5.5%	-1.2%	1.9%	4.4%	6.6%	8.6%	10.5%
$2,200k	-21.3%	-12.0%	-6.2%	-1.8%	1.3%	3.8%	6.0%	7.9%	9.8%
$2,300k	-21.7%	-12.6%	-6.7%	-2.4%	0.8%	3.2%	5.4%	7.3%	9.1%
$2,400k	-22.1%	-13.0%	-7.3%	-2.9%	0.2%	2.7%	4.8%	6.7%	8.5%

Figure 26: 65% Cost Share plus MAG, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station *Vehicle Sale: Quarter ZEV*

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-9.6%	2.7%	10.0%	15.4%	19.9%	24.0%	27.7%	31.2%	34.6%
$1,100k	-10.7%	1.5%	8.5%	13.8%	18.1%	22.0%	25.5%	28.8%	31.9%
$1,200k	-11.6%	0.3%	7.3%	12.3%	16.5%	20.2%	23.6%	26.7%	29.6%
$1,300k	-12.5%	-0.8%	6.1%	11.1%	15.1%	18.6%	21.9%	24.9%	27.7%
$1,400k	-13.3%	-1.8%	5.1%	10.0%	13.9%	17.2%	20.4%	23.2%	25.9%
$1,500k	-14.0%	-2.8%	4.1%	8.9%	12.7%	16.0%	19.0%	21.8%	24.4%
$1,600k	-14.7%	-3.6%	3.2%	8.0%	11.7%	14.9%	17.8%	20.5%	23.0%
$1,700k	-15.3%	-4.4%	2.4%	7.1%	10.8%	13.9%	16.7%	19.3%	21.7%
$1,800k	-15.9%	-5.2%	1.6%	6.3%	9.9%	13.0%	15.7%	18.2%	20.6%
$1,900k	-16.4%	-5.9%	0.8%	5.6%	9.1%	12.1%	14.8%	17.2%	19.5%
$2,000k	-16.9%	-6.5%	0.1%	4.8%	8.4%	11.3%	13.9%	16.3%	18.5%
$2,100k	-17.4%	-7.2%	-0.6%	4.2%	7.7%	10.6%	13.1%	15.5%	17.6%
$2,200k	-17.9%	-7.7%	-1.3%	3.5%	7.0%	9.9%	12.4%	14.7%	16.8%
$2,300k	-18.3%	-8.3%	-1.9%	2.9%	6.4%	9.2%	11.7%	13.9%	16.0%
$2,400k	-18.7%	-8.8%	-2.5%	2.3%	5.8%	8.6%	11.0%	13.3%	15.3%

Figure 27: 80% Cost Share plus MAG, Quarter ZEV Scenario

IRR of a 2015 Core Market: 500-DH2 Station *Vehicle Sale: Quarter ZEV*

If long term Hydrogen Retail Price

Capital Expense of Station	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00
$1,000k	-3.1%	12.0%	21.3%	28.5%	34.8%	40.7%	46.1%	51.4%	56.6%
$1,100k	-4.2%	10.4%	19.4%	26.3%	32.2%	37.6%	42.8%	47.6%	52.3%
$1,200k	-5.3%	9.0%	17.7%	24.4%	29.9%	35.1%	39.9%	44.4%	48.8%
$1,300k	-6.2%	7.7%	16.3%	22.7%	28.0%	32.9%	37.4%	41.7%	45.7%
$1,400k	-7.1%	6.5%	15.0%	21.2%	26.3%	30.9%	35.2%	39.3%	43.1%
$1,500k	-7.9%	5.4%	13.8%	19.9%	24.8%	29.2%	33.3%	37.2%	40.9%
$1,600k	-8.6%	4.4%	12.7%	18.7%	23.5%	27.7%	31.7%	35.3%	38.9%
$1,700k	-9.3%	3.5%	11.7%	17.5%	22.3%	26.4%	30.1%	33.7%	37.1%
$1,800k	-9.9%	2.6%	10.7%	16.5%	21.1%	25.2%	28.8%	32.2%	35.4%
$1,900k	-10.5%	1.8%	9.8%	15.6%	20.1%	24.0%	27.5%	30.8%	34.0%
$2,000k	-11.1%	1.1%	8.9%	14.7%	19.2%	23.0%	26.4%	29.6%	32.6%
$2,100k	-11.6%	0.4%	8.1%	13.8%	18.3%	22.0%	25.4%	28.4%	31.4%
$2,200k	-12.1%	-0.3%	7.3%	13.0%	17.4%	21.1%	24.4%	27.4%	30.2%
$2,300k	-12.6%	-0.9%	6.6%	12.3%	16.7%	20.3%	23.5%	26.4%	29.2%
$2,400k	-13.1%	-1.5%	5.9%	11.6%	15.9%	19.5%	22.6%	25.5%	28.2%

The previous three sections (Figures 19 through 27) indicate that to target a return of about 15% or more, a combination of an 80% cost-share PLUS a MAG would be needed to protect against the potential for a slow vehicle rollout in a core market.

As described in detail in the MAG section, an incentive package of 65% plus MAG grant appears to strike a reasonable balance in a core market, providing IRRs in the range summarized below. As a reminder, actual MAG support is a function of hydrogen demand. If FCEVs enter the market quickly, less MAG support will be needed.

Table 20: 65% Cost Share plus MAG, Core Market, $2m 500kg/day Station.

	Internal Rate of Return (IRR)		
	$8.50/kg	$9.00/kg	$9.50/kg
ZEV Compliance Demand	3.7%	12.8%	19.7%
Quarter ZEV Demand	-6.5%	0.1%	4.8%

Connector Stations

The H2NIP paper describes the fact that connector stations face a unique financial challenge and will likely need tailored financing packages. Although the demand is difficult to predict at a connector location, the average demand will be low for many years. Our demand projections highlight the reality that it will be difficult to make money at a connector location in the early years.

Table 21 below shows that a higher proportion of cost-share, PLUS a MAG grant, is the only way to make such a station attractive. This table assumes that - based on stakeholder input - a connector station (i.e., the I-5 station) will cost about the same as a core station ($2m), given the need for high reliability and peaking ability. For comparison purposes, the IRR's assume a $9/kg sale price. Higher sale prices, which are likely tenable in a connector scenario, would improve the picture slightly.

In reality, there is low likelihood that a developer will propose an I-5 station under a generic solicitation. An I-5 station, as well as other emerging and connector markets, will likely either require a specific solicitation, with unique ownership, procurement and risk-sharing mechanisms, or a requirement that such a station be proposed as part of a bigger award for multiple core stations.

Table 21: IRR's for a 2017 Connector Station, assuming ZEV Likely Compliance

	Cost-share only			Cost-share plus MAG		
	65%	**80%**	**95%**	**65%**	**80%**	**95%**
Baseline Demand	-24.1%	-18.2%	-4.3%	-12.8%	-2.1%	51.5%
Low Demand	-33.0%	-30.3%	-26.1%	-16.0%	-7.7%	23.8%

Appendix C - Government Grants in the Current Context

In this appendix we address California's current incremental investment needs. The following analysis represents the funding and station situation as of September 2013.

Funding Sources

Three funding sources are relevant to current station situation: CARB's Hydrogen Highway Program, CEC's AB 118 Program, and the AB8 bill signed by Governor Brown in September 2013. In total, money already allocated to public hydrogen stations through September 2013 (via the Hydrogen Highway and AB118 Programs) is expected to result in **25 Stations** open to the public **in 2014**. This leaves a need to fund 43 additional stations to get to the 68 targeted in the CaFCP Roadmap, or 75 stations to get to the 100-station target presented in AB8.

Figure 28 below includes available funding under AB118 and AB8. The CEC has allocated $30 million for hydrogen stations under the remaining AB118 program. AB8 adds the potential for the state to invest up to $20 million per year until at least 100 publically accessible stations are established (the revenue sources for AB8 end January 1, 2024). In total, $210 million is available to fund hydrogen stations moving forward. This funding will be administered by the CEC.[108]

Figure 28: Potentially available hydrogen funding

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
AB118 - 2010-2013 Investment Plans	$10.0 m										
AB118 2013/14 Investment Plan		$20.0 m									
AB8 Potential			$20.0 m	$20.0 m	$20.0 m	$20.0 m	$20.0 m	$20.0 m	$20.0 m	$20.0 m	$20.0 m
Cummulative Available (AB118)*	$10.0 m	$30.0 m									
Cummulative Potential (AB118+AB8)			$50.0 m	$70.0 m	$90.0 m	$110.0 m	$130.0 m	$150.0 m	$170.0 m	$190.0 m	$210.0 m

**Available funds do not include the $27.7m awarded for stations under PONs 09-608 and 12-606*

How much funding will it take to get to 100 Stations?

The utility of AB8 funds depends on how the CEC decides to put the money to work. Table 22 summarizes the **incremental** funding need to reach 68 and 100 fueling stations. These estimates assume the following, with reference to the assumptions laid out in Appendix A:

Station Costs, Based on Delivered Gas

- Stations 1 – 25: *High Costs*
- Stations 26 – 68: *Baseline Costs*
- Stations 69 and beyond: *Low Costs*

[108] The legislation authorizes spending on stations if CARB justifies the need for investment based on automaker projection surveys.

Cost Share Percentage

- Stations 1 – 25: *65%*
- Stations 26 – 68: *65%*
- Stations 69 and beyond: *50%*

Market Assurance Grants

- Offered in full for stations 26-68.
- Offered years 4 through 10 for stations 1-25.[109]

Market Build-out Scenario

- H2NIP Baseline Scenario, as shown in Table 17: Baseline Coverage (Stations 1-69) Buildout Scenario for Modeling Runs (Appendix A).

Table 22: Incremental Funding Need Estimate

	FUNDS NEEDED TO REACH 100 Stations		
	Stations 26-68	Station 69-100	TOTAL
# of Stations	**43**	**32**	**71**
Small (180 kg/d)	4	0	4
Medium (250kg)	25	21	46
Large (500kg)	14	11	25
Cost of Stations	**$70 m**	**$35 m**	**$101 m**
Small (180 kg/d)	$1.0 m	$0.9 m	$4 m
Medium (250kg)	$1.5 m	$0.9 m	$56 m
Large (500kg)	$2.0 m	$1.5 m	$45 m
Govt Cost Share	65%	50%	
Total Govt Capex Support	**$45 m**	**$18 m**	**$63 m**
MAG support for stations 1-68 (Range of sales scenarios)			$18m - $35m
TOTAL CAPEX & MAG			**$81m - $98m**

Table 23 estimates the total spend by Government by including the $47.5 million cost share funds already spent for Stations 1 – 25.[110] Given all of the assumptions made above, the total government support needed to launch a 100 station network ranges from $128m to $145m.

[109] CEC funded stations have a requirement to remain open for 3 years. For these stations, MAGs would kick in once the contractual obligation to remain open expires, if necessary.

[110] This $47.5m estimate includes $41.8m from the CEC (PONs 09-608 [$15.7m] and 12-606 [$12m], as well as interagency agreements with the SCAQMD [$6.7m] and of $15.2m for 7 stations funded under the Hydrogen Highway Initiative.

Table 23: Total Estimated Network Cost to the Government

		Estimated of Total Network Cost			
		Existing (1-25)	Needed (26-68)	Needed (69-100)	Total
# of Stations		**25**	**43**	**32**	**100**
of which	Small (180 kg/d)	19	4	0	23
	Medium (250kg)	3	25	21	49
	Large (500kg)	3	14	11	28
Cost of Stations		**$58 m**	**$70 m**	**$35 m**	$163 m
	Small (180 kg/d)	$2.2 m	$1.0 m	$0.9 m	
	Medium (250kg)	$2.5 m	$1.5 m	$0.9 m	
	Large (500kg)	$2.8 m	$2.0 m	$1.5 m	
Govt Cost Share		var	65%	50%	
Total Govt Capex Support		**$48 m**	**$45 m**	**$18 m**	**$110 m**
MAG, under ZEV Compliance Scenario		$6 m	$12 m	NA	$18 m
under 1/4 ZEV Compliance Scenario		$12 m	$23 m	NA	$35 m
Total Govt Support including MAGs					**$128m - $145m**

Table 24 and Table 25 show the annual funding amounts associated with the investments captured in Table 22: Incremental Funding Need Estimate (and the assumptions captured therein). Both of these scenarios assume that coverage stations (26 – 68) are built at a pace of 14 to 15 stations per year to establish the market. Stations 69 and beyond are built in response to expected demand, based on automaker projections. These estimates do not include funding for stations 101 and beyond.

Table 24: Government Payments assuming the ZEV Likely Compliance Scenario

	2014	2015	2016	2017	2018	2019	2020	2021-24	TOTAL
Vehicles on the road (end yr)	*1,900*	*4,600*	*7,500*	*10,500*	*13,400*	*19,600*	*30,200*	*130,200*	
New Stations built	15	14	14	15	-	-	33	282	
In Place (by end of yr)	25	39	53	68	68	68	101	383	
Capex Grant encumbered (beg of yr, for next yr)	$14 m	$14 m	$17 m	-	-	$18 m	-	$0 m	**$63 m**
MAG Payments		$1.6 m	$2.8 m	$4.3 m	$3.2 m	$2. m	$1.6 m	$2.4 m	**$18 m**
TOTAL	**$14 m**	**$15.9 m**	**$19.4 m**	**$4.3 m**	**$3.2 m**	**$19.6 m**	**$1.6 m**	**$2.4 m**	**$80.6 m**

Table 25: Government Payments assuming the Quarter ZEV Scenario

	2014	2015	2016	2017	2018	2019	2020	2021-24	TOTAL
Vehicles on the road (end yr)	*475*	*1,150*	*1,875*	*2,625*	*3,350*	*4,900*	*7,550*	*32,550*	
New Stations built	15	14	14	15	-	-	-	37	
In Place (by end of yr)	25	39	53	68	68	68	68	105	
Capex Grant encumbered (beg of yr, for next yr)	$14 m	$14 m	$17 m	-	-	-	-	$18 m	**$63 m**
MAG Payments		$1.8 m	$3.7 m	$6.4 m	$6. m	$5.4 m	$4.4 m	$7.2 m	**$35 m**
TOTAL	**$14 m**	**$16.1 m**	**$20.2 m**	**$6.4 m**	**$6.0 m**	**$5.4 m**	**$4.4 m**	**$25.0 m**	**$97.7 m**

In any scenario, the government needs to be able to commit to the full MAG cost potential. For new stations, this would be $1m per station (up to $100K in support for 10 years). For already funded stations, which are generally committed to being open for 3 years, this would be up to $700K per station (up to $100K for 7 years).[111] With the Capex and MAG support shown in the tables above, the government would need to commit $123.5m, but only likely to spend $81m- $98m:

Set Aside + Capex:

$63m for CapEX
$43m for MAG for Stations 26-68
+$17.5m for MAG for Stations 1-25
$123.5m Set Aside

Bottom line: AB8 funding is sufficient, but only with strong leadership & flexibility

The hydrogen money offered by AB8 (up to $230m when paired with AB118 money) is sufficient to facilitate the build-out of a 100-station network, *if private developers believe the market will embrace FCEVs*. This includes offering capital cost share and market assurance grants to the first 68 coverage stations, and capital cost share for stations 69 – 100 (as shown in Table 23).

While the cumulative funding designated in AB8 is sufficient to bring the station total to 100, five issues should be highlighted:

1. Marketplace Certainty. As highlighted above, the estimate framework only works if private developers have reasonable certainty that FCEVs are coming. To achieve the scale outlined in the Roadmap, the state may be required to spend significantly more on early stations to develop the necessary confidence in the marketplace. The above estimate leaves considerable room for this potential reality.
2. Flexibility. Almost by definition, new markets are dynamic in nature. The government must have the flexibility to adapt to changing realities (for example, to get market off the ground, cost share levels may need to be much higher than those used for other fuels).
3. Timing. AB8 would authorize hydrogen investments up to $20 million per year. As shown in Table 24 and Table 25 above, $20 million/year is a solid ballpark number to reach 68 stations by 2017. However, depending on how the market develops, and the actual capital costs of stations, outside contributions may be required to support MAGs, or the CEC may need to borrow money from future years. To be successful, CEC must have flexibility to match investments with on the ground market development needs.
4. Renewable Hydrogen and On-site Production. The cost estimates made above rely on delivered gas stations, believed by most stakeholders to be the lowest cost early market option. Both renewable and on-site production could add to the total cost.
5. Getting beyond Station 100. Outside of the established core market areas, it is highly likely that some government support will be needed to continue building out the network beyond station 100. EIN highly recommends planning for the need for continued support beyond station 100. A declining support structure, like the one illustrated in the "Strawman Design: Restructuring grants to be performance-based with a phasedown schedule," section (pg. 80) will help ease the transition to a fully funded private market, and help avoid a market stall out at Station 101.

[111] A shorter MAG time period could be appropriate, we use 10 years to line up with expected equipment life.

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