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Incentivizing Hydrogen Infrastructure Investment

Phase 1: An Analysis of Cash Flow Support To Incentivize Early Stage Hydrogen Station Investment

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Acknowledgement and Disclaimers

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.

In what follows, the hydrogen costs and retail margins are provided for analytical purposes only. Fuel providers and retailers are each independently responsible for determining the wholesale and retail price of hydrogen fuel.

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Introduction

This paper is a summary of an analysis conducted within the context of an industry and government collaborative effort launched in July 2011 to examine investment options for early commercial hydrogen infrastructure in California.

Objective:

The analysis had four objectives:

1) Determine likely cash flow scenarios of early commercial hydrogen stations, with a sensitivity analysis to identify key variables affecting rates of return.
2) Examine the impact of a cash flow support incentive payment on the attractiveness of investments in such stations.
3) Estimate the total size of the incentive fund required to provide such cash flow support to the first 68 stations in California.
4) Compare the cash flow support approach to the upfront capital cost buy-down approach currently used by the California Energy Commission.[1]

Context and Current Incentives

Compared to gasoline stations, hydrogen stations require relatively high up-front capital costs and maintenance expenses. These costs can ultimately be offset by potentially large margins on every kilogram (kg)[2] of hydrogen sold, but for the early hydrogen stations, when vehicles numbers are still low, fuel revenues are insufficient to offset the costs for many months. Some incentive funding is broadly acknowledged to be necessary to make a business case for investing in these early commercial stations.

Current State of California incentives for station deployment have focused on reducing equipment costs by providing cost-share grants to hydrogen station equipment providers. This model has been successful in making stations cheaper, but it does not address operations and maintenance costs that station owners incur, or leverage private investment from potential station developers who are not equipment providers.

Our analysis looks at a different form of incentive aimed at attracting this broader set of private investors to hydrogen station investment. The underlying premise of the analysis is that:

1. Companies that currently invest in gasoline stations (including energy companies, fuel marketing intermediaries, and others) may be interested in investing in hydrogen stations.

[1] The California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program currently provides hydrogen station developers with a grant to "cost-share" the up-front capital expense of a station.

[2] Hydrogen is expected to be sold by the kilogram (kg). One kg of hydrogen fuel has roughly the same energy content as one gallon of gasoline. On average, fuel cell vehicles can travel 2.5 times as far on one kg of hydrogen as an internal combustion engine vehicle can travel on one gallon of gasoline.

2. These companies are accustomed to seeing positive cash flows within a matter of months, and are highly averse to extended periods of negative cash flow, even if long-term profit potential and rates of return are high.

The core assumption of this analysis is that businesses will be motivated to invest in hydrogen if they can break even in the early months and make money in the later years.

A "Cash Flow Support" Incentive

To motivate this investment, we consider offering a cash flow support payment to investors during the early months to offset their losses until revenues and expenses reach a break-even point.[3]

This analysis assumes that hydrogen station developers will obtain financing (from a bank or other lender) to purchase and install hydrogen equipment. From the outset, they will need to make financing payments to their lender, as well as pay for operating and maintenance costs of the equipment and other operating expenses such as insurance and property tax.

Retailers' revenues will increase as hydrogen sales increase, due primarily to the number of fuel cell vehicles being sold and leased into the market. The cash flow support incentive described in this analysis is provided to retailers up until the point when they sell enough hydrogen to generate a positive cash flow.

Report Organization

In the following text, we start by examining the anticipated costs, revenues and resulting cash flow support needs from an individual station perspective. We then aggregate individual station information to estimate system-wide costs and compare the cash flow support approach to the capital cost buy-down approach. We include a summary table of assumptions as an appendix to the report.

[3] This cash flow support would be paid for with funds from any combination of public and private stakeholders.

Hydrogen Station Costs, Revenues & Cash Flows

A number of variables define the profitability of a hydrogen station. We define the expected costs and revenues in the following sections.

Costs

Expected costs include the following primary categories: 1) equipment and installation; 2) operations and maintenance (O&M); and 3) financing.

Equipment, Installation, and O&M: Table 1 presents the expected capital and O&M costs for a variety of stations, as collected from industry and presented by researchers from UC Davis. Capital costs include equipment purchase, permitting fees, and construction. Fixed O&M includes rent, maintenance, insurance, property tax, and permit fees.[4] Variable operations costs are directly tied to hydrogen sales; each kilogram of hydrogen sold requires incremental maintenance and electricity for compression.

The breakdown of costs includes baseline maintenance costs of $12,000 per year when there is no use, with an additional 6% for every increase in daily load of 25kg/day. In addition, electricity costs of $1,200 per year plus $0.30/kg are added. Other operating expenses include annual property tax (1% of capital cost), rent for the space on a convenience store-style station ($2,500/month), insurance ($1,600/month), and permit fees ($3,680). Based on our estimates, when a 500 kg/day station reaches 70 percent capacity utilization (i.e., 350 kg sold per day), total O&M costs level off just above $1 per kilogram of hydrogen sold.[5]

Table 1: Hydrogen Station Infrastructure Costs[6]

Station Timing and Size	Capital Cost	Annual Operating Expenses	
Station Built in 2014		No Load	Max load
100-170 kg/day	$0.9M	$75k	$100k
250 kg/day	$1.4M	$80k	$117k
Stations Built 2015-2017			
250 kg/day	$0.9M	$75k	$112k
400-500 kg/day	$1.5M-$2.0M	$81k	$167k

[4] Both construction and annual operations permit fees are included.

[5] Based on conversations with industry representatives, a $1/kg O&M cost target is aggressive but reasonable in the 2015 time-frame.

[6] Capital Costs pulled from UCD, 2011. University of California, Davis. Ogden, Joan et al. UCD Institute of Transportation Studies. "Analysis of a "Cluster" Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California." Sept. 16, 2011. Revised Oct. 5, 2011.

Financing: In our analysis, we assume that a hydrogen station developer will borrow 100 percent of the capital to buy and install hydrogen-fueling equipment. Typically, a gasoline station developer obtains a seven-year loan to construct a station and convenience store, and realizes a positive cash flow after one year (i.e., sales revenue pays for the loan and O&M costs).[7] A hydrogen station will take longer to reach positive cash flow in the early market and may require a longer-term loan to create a feasible business case. In the following analysis, we assume a 10-year loan at 5.5 percent, terms that members of the fuel financing industry indicate are feasible.[8] This financing would require the loan applicant to guarantee the loan on its balance sheet; a situation industry members have also indicated is possible.[9]

Revenue

Sales of hydrogen will ultimately drive the success of the commercial retail hydrogen market. These sales are wholly dependent on the deployment of fuel cell vehicles generating demand for hydrogen fuel. The benefit to the retail hydrogen seller can be quantified by multiplying fuel sales by an anticipated retail margin.

Revenue = (kilograms of hydrogen sold)(retail margin)*

Hydrogen Demand: To estimate the demand for hydrogen at an individual station, we used three potential deployment scenarios: Fast, Medium and Slow Growth (Figure 1). The Medium Growth curve represents the average utilization for the vehicle deployment projection curve provided by the California Fuel Cell Partnership (CaFCP) in their *Progress and 2011 Actions for Bringing Fuel Cell Vehicles to Market in California*.[10] The Slow Growth curve represents a prolonged vehicle ramp-up scenario while the Fast Growth curve represents growth that reaches full capacity after 4 years of sales, estimated for some of the higher use areas.

Station utilization will vary from location to location. Figure 1 expresses utilization as a percentage of a station's designed capacity. For example, at 70 percent utilization, a 500 kg/day station would sell 350 kilograms per day, or the equivalent of approximately 117 fuel cell vehicles fill-ups per day.[11]

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[7] Ken Gunn, personal conversation, Fall 2011.

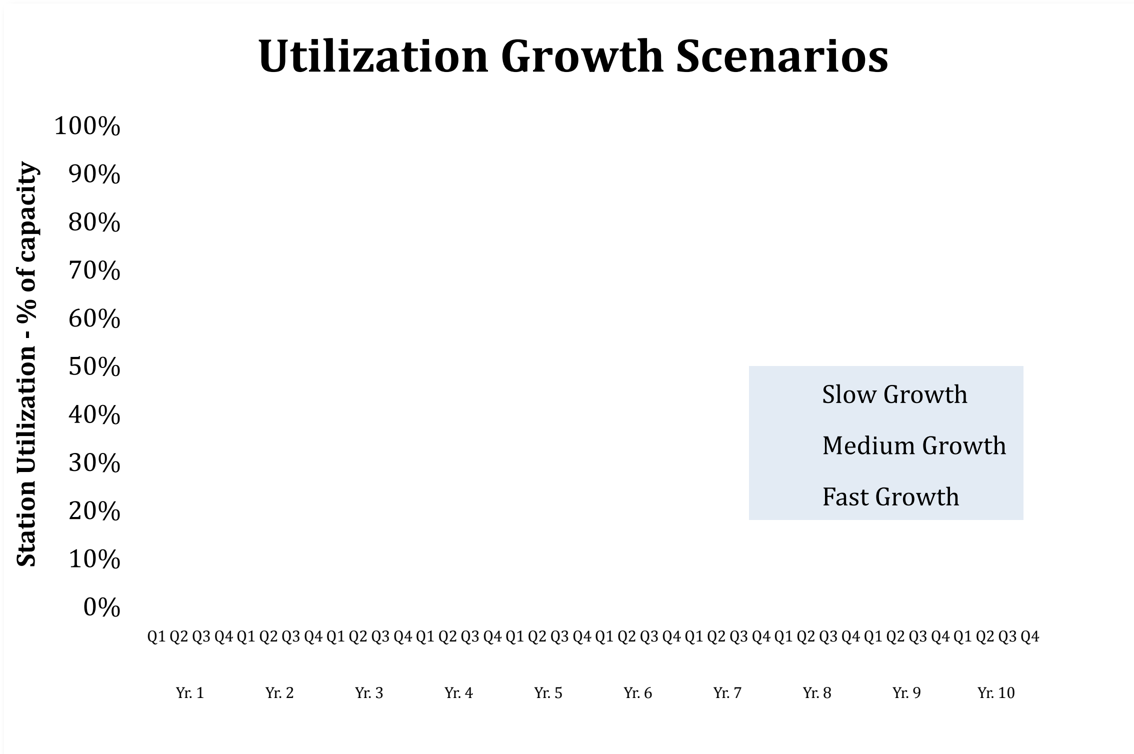
[8] Conversation with Patriot Capital Corporation, Fall 2011. http://www.patriotcapitalcorp.com/about-us.

[9] Ibid.

[10] Published February 2011: http://cafcp.org/sites/files/CaFCPProgressand2011Actions_0.pdf

[11] Two FCEVs are available to select consumers: 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. Assuming vehicles visit with the need for 3 kgs, 350 kg/day represents 117 individual fill events.

Figure 1: Utilization Scenarios



Construction Time Lag: The growth curves above begin with a full year during which there are no sales, to represent the conservative position that financing and other costs will be incurred from the outset to purchase equipment and construct the station. We include this "lag-time" effect in all estimates presented in this report.

Based on automaker and industrial gas company experience, stations take 7-12 months to construct once all parties (funders, lenders, owners, equipment providers) have reached agreement. Steps include:[12]

- Design: 2 to 3 months
- Permitting: 3 to 5 months
- Construction: 2 to 4 months

As businesses gain more experience, we expect these timelines to decrease. From a station owner perspective, lag time represents money spent without the potential for revenue generation. With the recognition that early stations could face some delays, we take a conservative approach and consider a one-year lag time, with full expenditure from day one. In reality, loan funds will likely be spent as costs are incurred, saving considerable money on loan payments on the front end of the project.

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[12] As presented by GM and confirmed by Air Products and Chemicals, Inc., both of which have extensive experience installing hydrogen infrastructure.

Table 2 summarizes the amount of time, in years, that it would take each station to reach full utilization under each growth scenario. These numbers include the one-year lag time.

Table 2: Utilization Growth Summary

Years to reach full utilization:

	Growth Curves		
Station Size	Slow	Medium	Fast
250 kg/day	**6.5**	**5**	**3.5**
500 kg/day	**7.5**	**6**	**5**

Price of Hydrogen: We cannot predict the retail price of hydrogen fuel. For the purposes of this analysis, we assume that hydrogen will be sold anywhere from $8-$11/kilogram, including sales tax. These costs include approximately $6/kg wholesale cost,[13] sales tax of 9% ($0.72 to $0.90/kg) and retail margins of $2-4/kg.[14, 15] Hydrogen is not currently subject to fuel excise taxes administered by the State of California Board of Equalization.[16] Once these taxes are determined, they will need to be included in the price of hydrogen.

Given that one kilogram of hydrogen holds approximately the same energy content as one gallon of gasoline, and that fuel cell electric vehicles (FCEVs) are about 2.5 times as efficient as conventional gasoline engine vehicles,[17] $8-11/kg hydrogen is comparable to gasoline priced between $3.20 and $4.40 per gallon. Consumers will be required to understand the efficiency of their vehicle as they compare $8-11/kg hydrogen to the current price of gasoline. As gasoline prices rise, educated FCEV drivers will view hydrogen priced at $8-11/kg as a competitive fuel.[18]

Cash Flow Projections

Figure 2 illustrates cash flow projections of a potential hydrogen fueling station that we use as the base case for this analysis:

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13 Based on industry estimates. Wholesale costs will vary by location. Cheaper wholesale hydrogen could enable an $8/kg retail price.

14 The retail margins are provided for analytical purposes only. Study participants and fuel retailers are each independently responsible for determining the retail margins to be assumed in any analysis and the prices they will charge.

15 To sell hydrogen for $8/kg, the retail margin would need to be less than $2/kg or the wholesale cost would need to be below $6/kg.

16 "Selling Hydrogen Fuel in a Pre-Commercial Environment within California". California Department of Food and Agriculture, Division of Measurement Standards. November 2011.

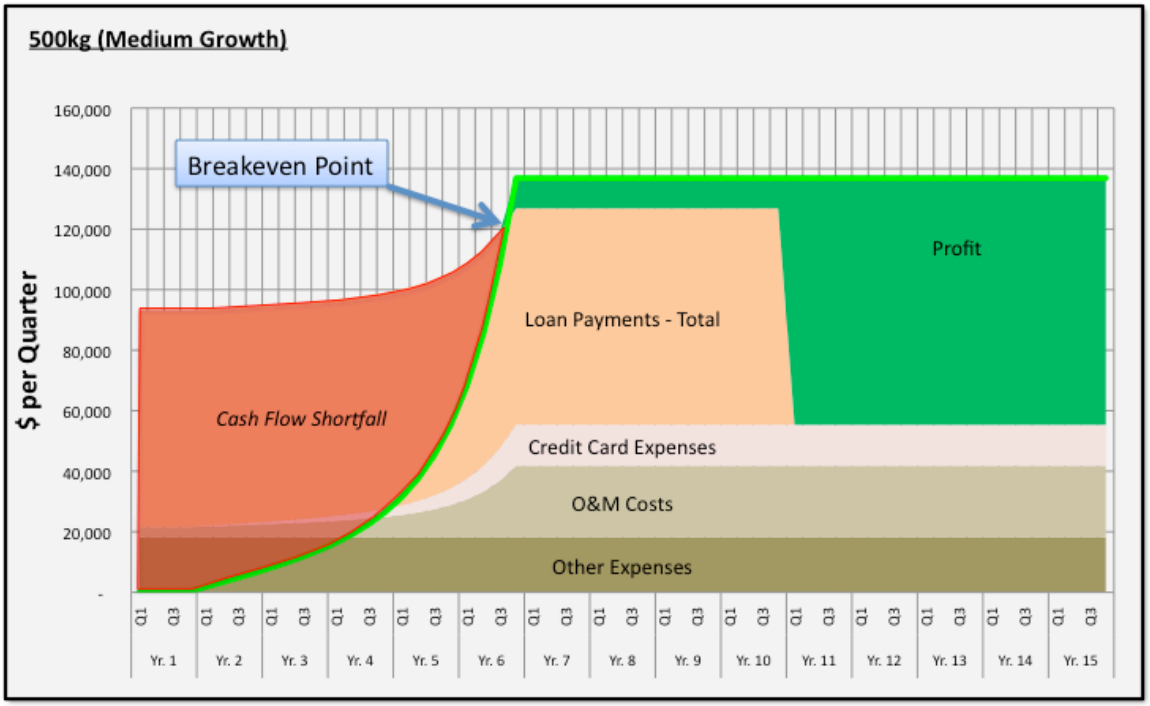
17 Proposed Amendments to the Low Carbon Fuel Standard. Staff Report: Initial Statement of Reasons for Proposed Rulemaking. California Air Resources Board. October 2011, adopted December 2011.

18 As a rule of thumb, we assume that auto companies will be able to market a fuel economy benefit if a kilogram of hydrogen costs twice as much as a gallon of gasoline.

- A maximum 500 kg/day capacity
- $2m capital costs +10% contingency, 100% financed
- 5.5%, 10-year loan
- O&M costs that rise from $81k/year to $167k/year at full utilization
- $3/kg retail margin, $6/kg hydrogen cost
- Capacity utilization capped at 100%, or 500 kg/day
- Medium growth curve, one construction time lag.

Costs are represented by the block colors, as labeled. After 10 years (i.e., at the end of the graph), principle and interest blocks would disappear.

Figure 2: Cash Flow Projections - Base Case



Given all of the parameters listed above, this station reaches a positive cash flow in 5 1/2 years and breaks even once it sells 440 kg/day (approximately 147 individual fills per day).[19] In this case, a station owner would have a cash flow shortfall of $1,687,000 over the first 5 1/2 years of station operation (represented by the red "cash flow shortfall" wedge on the left side of the Figure 2 graph).[20]

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[19] Assuming vehicles dispense 3 kgs at each fueling stop, 440 kg/day represents 147 individual fill events.

[20] Keeping all other parameters constant, if the retailer increases the margin, the cash flow shortfall decreases.

Incentive Funding Requirements for the Base Case

To spur investment, we consider using incentive funds to cover a station's cash flow shortfall until revenue exceeds costs. In the case of the station presented in Figure 2, the hydrogen station owner would receive $1.67 million in funding over the first five years to avoid losses. Once the owner reaches the breakeven point, the incentive would stop.

In the following section, we better define the expected cash flow shortfall on both a station and system basis. Our goal is to estimate the amount of incentive funding necessary to bridge the gap from government cost-shared hydrogen stations to commercially viable stations:

Incentive fund needed = (cost per station)(# of stations)*

Sensitivity analysis on cost variables

To determine the relative importance of each parameter on station cash flow, we conducted sensitivity analysis on the key cost variables of the base case described earlier, holding station utilization growth curves constant. Figure 3 shows the effect of altering these variables down to 40% of the original assumption, and up by almost 180% (assuming 100% as the base case). The steeper sloped lines indicate variables that have a greater impact on the overall cash flow. In this case, gross retail margin, capital costs, and the loan term have the strongest effect on cash flow projections.

Figure 3: Parameter Sensitivity Plot

To illustrate the impact of the three primary variables, we compare the impact of varying retail margin, capital cost, and loan term.

As shown in Table 3, if capital costs increase by 50 percent (from $2 to $3 million), and retail margin decreases by 25 percent (from $3.00 to $2.00), then cash flow support needs more than double to $4 million. If, however, capital costs decrease by 50% (from $2 to $1 million) and retail margin increases by 33 percent (from $3.00 to $4.00), cash flow support can be cut by more than 55 percent, to $750,000.

Table 3: Impact of Retail Margin and Capital Costs on Base Case Cash Flow Shortfall

		Capital Costs		
		$1m	$2m	$3m
Retail Margin	$2.00	-999k	-2,462k	-3,991k
	$3.00	-853k	-1,687k*	-3,056k
	$4.00	-752k	-1,517k	-2,376k

*Base Case

In Table 4, we look at the effect of a shorter-term loan compared to our base case of 10 years. If a station owner procures a seven-year loan, the retail margin must be greater than $4 to keep the cash flow shortfall within $1,687,000 in the base case. In this case, years 8 through 10 would generate substantial profits for the station owner.

Table 4: Impact of Retail Margin and Loan Term on Base Case Cash Flow Shortfall

		Loan Term		
		15yrs	10yrs	7yrs
Retail Margin	$2.00	-2,073k	-2,462k	-2,706k
	$3.00	-1,262k	-1,687k*	-2,300k
	$4.00	-1,161k	-1,517k	-2,018k

*Base Case

Estimating the Range of Total Incentive Needs

The base case presented in Figure 2 represents a foundation designed to gain understanding of the cash prospects of a generic hydrogen station. From this foundation, we consider variations that impact cash flow support needs:

- Potential for lower station capital costs in later years
- Various utilization growth rates
- Starting with smaller, expandable stations

Station Size

As shown in Figure 4, we have obtained capital cost projections for four station types.[21, 22] In the expansion case, the $500,000 capital cost represents the incremental cost required to expand a 250 kg/day station to 500 kg/day.[23]

Figure 4: Per Station Capital Cost by Size

Station Size	Built In	Capital Cost	Notes
170 kg/day	2014	$900K	•Very difficult to make money. Without expansion, would need to subsidize station through life of the loan or have a Retail Margin > $4/kg.
250 kg/day:	2014	$1.4m	•Need a Retail Margin > $3.80/kg to break even (w/o expansion).*
	2015+	$0.9m	•Need a Retail Margin > $3.00/kg to break even.*
Expansion (250->500)	2014+	$500K	•$500K = incremental cost •High profit potential
500kg/day	2015+	$1.5m - $2m	•Attractive profit potential can emerge at high volumes.

*Assuming full capacity utilization

Larger stations have the greatest profit potential, while smaller stations may have to generate a greater retail margin to break even. Owners may find the expansion model attractive because they can minimize upfront costs (and therefore risk) and expand the station when hydrogen sales increase. Assuming demand continues to grow, payback can be relatively quick.

[21] Non-expansion capital costs from UCD, 2011. University of California, Davis. Ogden, Joan et al. UCD Institute of Transportation Studies. "Analysis of a "Cluster" Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California." Sept. 16, 2011. Revised Oct. 5, 2011.

[22] Capital costs include equipment purchase, permitting fees, construction, and labor.

[23] Conversations with Air Products and Chemicals Inc., Fall 2011.

Utilization

To examine the impact of station utilization on cash flow needs we hold the following variables constant:

> *Retail Margin: $3/kg*. Each hydrogen station owner will determine this number. Based on our cost inputs, $3/kg creates a workable balance between cost to the consumer and loan payback and profits. $2/kg may be too little to pay back a loan in a reasonable timeframe, and $4/kg may make hydrogen too expensive to effectively market.
>
> *Loan: 10 years, 5.5% interest rate*. As discussed above, a typical fueling equipment loan is issued for a seven-year loan term, but can be extended with justification. However, a seven-year loan places considerable additional financial pressure on a project (see Table 4). For the purposes of this exercise, we assume that a strong package can be put together to attract longer financing. If not, each project would require additional funding, a lower interest rate, a back-loaded payback structure, or a greater retail margin to make up the difference.[24]
>
> *Construction Time Lag: 1-year*. Justification described above.
>
> *Capacity Utilization*. A 250 or 500 kg/day rating represents the maximum capacity that a single station is designed to deliver in one day. However, based on conversations with fuel providers, it is unlikely that a station will consistently deliver 100 percent of its nameplate capacity on a daily basis. Given that most fueling takes place during peak hours, a typical fueling station is expected to deliver 70 percent of its capacity on average. For the purpose of the cost analysis moving forward, we limit daily hydrogen sales to 70 percent of a station's nameplate capacity (i.e., at full utilization, a 500 kg/day station would sell 350 kg/day). In reality, a station should be able to sell more than 70 percent of its capacity, but this limitation ensures cash flow shortfall estimates remain conservative.

Table 5 shows how the utilization growth curves (as shown in Figure 1) impact the cash flow support required in each station configuration. In short, the slower the utilization growth, the longer a station returns a loss to the station owner.

[24] If a hydrogen station were completely funded by private investment, we expect the interest rate to be greater than 5.5% because hydrogen infrastructure payback potential has not yet been demonstrated. This analysis assumes that the employment of a designated cash flow support fund greatly increases the probability of successful loan payback, thereby decreasing risk to the lender and the requisite interest rate.

Table 5: The Impact of Utilization on Cash Flow Support Needs

	Year Built (Capital Cost)	CASH FLOW SUPPORT NEEDED IF (in millions of $'s): *Slow Growth*	*Medium Growth*	*Fast Growth*
250 kg/d Stations	2014 ($1.4m)	$1.90	$1.83	$1.58
	2015+ ($0.9m)	$1.14	$1.06	$0.957
500 kg/d stations	2014 ($2m)	$2.31	$2.05	$1.31
	2015+ ($1.5m)	$1.54	$1.28	$0.70

At 70 percent maximum station utilization, a $2 million, 500 kg/day station would not breakeven until the ten-year loan is paid off (after which the station would be positioned to make large profits). Cash flow support for the base case station (500 kg/day, $2 million capital cost, medium growth curve, as presented in Figure 2) increases from $1.69 million to $2.05 million when daily hydrogen sales are limited to 350 kg/day (approximately 117 fill-ups).[25] Cash flow support needs substantially decline as capital costs decrease and utilization increases.[26]

Support for Existing Stations

In addition to the cost of installing and operating new stations, some existing stations operate at a loss and will continue to do so until enough FCEVs are in the market to purchase fuel. To estimate cash flow support needs for existing stations, we consider a station funded under the current AB 118 Alternative and Renewable Fuel and Vehicle Technology Program.[27] This program buys down the capital costs of a station by providing a station developer 50 to 70 percent of a capital and installation cost. Industry covers the remaining costs.

Figure 5 shows the financial profile of a 250 kg/day station for which capital costs have been cost-shared by government and industry. On a daily basis, each station faces fixed and variable O&M, as well as credit card fees on hydrogen sold. Such a station needs to sell approximately 93 kilograms per day to break even.[28] Assuming a slow growth curve, due to the fact that these stations are being placed in 2012 – 2014, such a station has a total cash flow support need of approximately $223,000. A similar station facing a medium growth curve would require $203,000 in cash flow support.

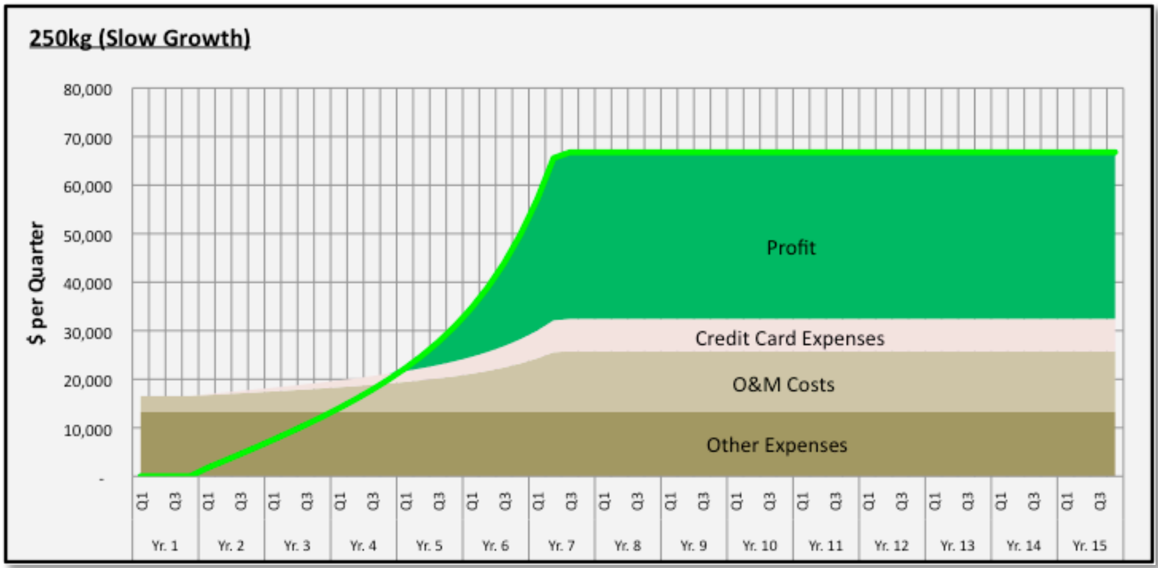
[25] Assuming vehicles dispense 3 kgs at each fueling stop, 350 kg/day represents 117 individual fill events.

[26] A slight increase in the retail margin can substantially improve the bottom line and decrease cash flow support needs.

[27] California Energy Commission: http://www.energy.ca.gov/2010-ALT-1/index.html

[28] For the purpose of this analysis, any station with a nameplate capacity greater than 93kg/day would start to break even once 93kgs are sold per day.

Figure 5: O&M Support for a Capital Cost Buy Down Station



Estimating System Wide Costs

Efficient development of hydrogen infrastructure relies on two primary factors: coverage and capacity. In the early years, coverage is the critical component, as FCEVs can only be successfully marketed if fueling stations are available in locations that fit potential owner driving patterns. Once the key areas are covered, or stations become heavily used, capacity becomes the primary factor. Fuel needs to be available for anyone who comes to a station.[29]

In this section, we estimate the total cost of using the cash flow support to establish maintain sufficient market coverage to support the deployment of commercial numbers of FCEVs.

Determining the Number of Stations Needed

Automakers in the California Fuel Cell Partnership worked closely with UC Irvine's National Fuel Cell Research Center (NFCRC) to project the minimum number of hydrogen stations needed in to launch the early commercial hydrogen FCEV market in California. This effort was funneled into the NFCRC's Spatially &Temporally Resolved Energy Environment Tool (STREET) model, which uses historic traffic flows and demographic data to determine station accessibility and potential utilization.

According to this effort, 68 optimally placed stations can provide sufficient fueling accessibility in California's key markets.[30] This represents a driving time of less than six minutes to access fuel in key markets, an initial expansion into additional markets, and connector and destination stations. In other words, 68 stations can provide the *coverage* necessary to launch a commercial market.[31]

Assuming funds are allocated as planned, California will be more than halfway to the 68-station marker by 2015. By then, approximately 37 small (i.e., 60-240 kg/day) stations are expected to be operational (Table 6).

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[29] California Fuel Cell Partnership Roadmap, June 2012.

[30] The UC Davis Sustainable Transportation Energy Pathways (STEPS) Program Fuel Cell Vehicle Roadmap Project independently arrived at a similar conclusion. While the UC Davis model does not point to 68 stations specifically, it validates that 68 stations is solid target.

[31] This station approximation is contingent on having a complete network of public, optimally located and standardized (i.e., SAE J2601) stations with sufficient capacity.

Table 6: Stations expected by 2015

8	Existing (or soon to be existing) public stations
11	California Energy Commission (CEC) cost-shared stations awaiting contract
11	CEC AB 118 cost-shared stations expected with funds allocated in the 2011-2012 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program
7	CEC AB 118 cost-shared stations expected with funds allocated in the 2012-2013 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program
37	Total stations expected

This analysis targets an additional 31 stations that currently do not have the incentive money needed to reach 68 stations by the end of 2015. We refer to these as "gap stations."

Station Development Scenario

As noted above, 68 stations will provide sufficient coverage to offer FCEV customers a fueling experience similar to gasoline in key markets. To ensure these stations can meet growing demand, sufficient capacity needs to be built into the system. Perhaps the most useful capacity target comes in the form of the Clean Fuels Outlet Regulation (CFO), which the California Air Resources Board adopted in January 2012. According to the regulation, once automakers project 10,000 FCEVs in an air basin, or 20,000 FCEVs across the state, companies that import oil to or refine oil in California will be required to ensure sufficient hydrogen fueling capacity is available. Achieving 68 stations in California enables automakers to market 20,000 FCEVs in California, at which point the CFO regulation is expected to assure that hydrogen infrastructure is available to match demand.

For planning purposes, it is widely accepted that each FCEV adds the need for additional capacity of one kilogram of hydrogen per day.[32] Therefore, to support 20,000 FCEVs and trigger CFO, the hydrogen station network needs approximately 20,000 kg/day available. Table 7 shows a scenario that would create 68 stations with the capacity to serve at least 20,000 FCEVs. Such a scenario would cover both the initial coverage and capacity needed to launch the early commercial FCEV market.

[32] This measure builds sufficient overhead into the system to allow for fueling during peak traffic times. It reflects the same calculation as an estimate of 0.7kg/day usage by an FCEV, and a 70 percent average utilization of a station.

Table 7: System Capacity

Station Type	Station #'s	Per Station Capacity (kg/day)	Total Capacity (kg/day)
Planned Stations	37	216*	7,995
Gap Stations: - Larger station	22	500	11,000
Gap Stations: - Smaller station	9	250	2,250
Totals	**68**		**21,245**

* Average size of existing and planned stations[33]

Each of the stations in Table 7 will face unique utilization growth curves depending on timing, placement, and vehicle deployments. In general, we assume that larger stations are placed in the areas with the greatest expected utilization. To estimate the cash flow support needs of the entire network (planned stations and gap stations), we explore a several utilization and capital cost scenarios.

Capital Costs
Just as FCEV deployments are expected to increase over time, station costs are expected to decrease. The costs in Table 8 are from the previously presented UC Davis data (see Table 1).

Table 8: Expected Capital Costs per Station

	2014	2015
500 kg/d		$1.5 - 2M
250 kg/d	$1.4M	$0.9M

To estimate the total incentive needed to construct, operate and maintain 68 stations, we consider two cost cases to reflect the range presented in the UC Davis data. For stations built in 2015, a high capital cost case assumes that 250 kg/day stations cost $0.9 million and 500 kg/day stations cost $2 million to build. The low cost case assumes $0.9 million and $1.5 million, respectively. In both cases, we include a 10 percent contingency to account for unexpected cost increases.

[33] At time of publication, station capacities were available for 17 existing and planned stations (from 60 kg/day to 240 kg/day, refer to the CaFCP Roadmap [2012]). The remaining 20 planned stations (i.e., non-gap stations) are estimated to provide between 200 and 500 kg/day.

Cash Flow Support Scenarios for a 68 Station Network

The following scenarios consider high and low capital costs, coupled with slow and medium growth projections (from the utilization scenarios in Figure 1), for all of the stations presented in Table 7. To estimate total needs, we multiply the number of stations by the estimated cash flow shortfall. For example, a $0.9 million, 250-kg/day station facing a slow growth curve would cost $1.14 million to support on a cash flow basis. Nine of these stations would require just over $10 million in support. Each scenario adds the expected cash flow support needs for 31 "gap stations" (highlighted blue and green) to the O&M support estimate for the 37 stations planned to be on the ground by the end of 2014 (highlighted orange).[34]

Table 9: High Capital Cost, Low Utilization

Support for Gap Stations:	**Cash Flow Shortfall per Station** (in $m)	**2014** (# stations added)*	**2015** (# stations added)	**Total Cash Flow Shortfall** (in $m)
500kg (slow growth)	$2.31		22	$50.8
250kg (slow growth)	$1.14		9	$10.3
O&M Support for Planned Stations				
Slow Growth Station - (Over 115 kg/day)	$0.223	37		$8.3
Medium Growth- (Over 115 kg/day)				
# of Stations by Year		37	31	68 Total Stations
*The 2014 Stations include all operating stations by EOY 2014			**Total Cost**	**$69.3**

[34] These 37 existing stations are expected to have been initially cost shared between the government and industry, leaving only O&M costs potentially in need of support.

Table 10: Low Capital Cost, Low Utilization

Support for Gap Stations:	Cash Flow Shortfall per Station (in $m)	2014 (# stations added)*	2015 (# stations added)	Total Cash Flow Shortfall (in $m)
500kg (slow growth)	$1.54		22	$33.9
250kg (slow growth)	$1.14		9	$10.3
O&M Support for Planned Stations				
Slow Growth Station - Over 115 kg/day	$0.223	37		$8.3
Medium Growth- Over 115 kg/day				
# of Stations by Year		37	31	68 Total Stations
*The 2014 Stations include all operating stations by EOY 2014			**Total Cost**	**$52.4**

Table 11: High Capital Cost, High Utilization

Support for Gap Stations:	Cash Flow Shortfall per Station (in $m)	2014 (# stations added)*	2015 (# stations added)	Total Cash Flow Shortfall (in $m)
500kg (medium growth)	$2.05		22	$45.1
250kg (medium growth)	$1.06		9	$9.5
O&M Support for Planned Stations				
Slow Growth Station - Over 115 kg/day				
Medium Growth- Over 115 kg/day	$0.208	37		$7.70
# of Stations by Year		37	31	68 Total Stations
*The 2014 Stations include all operating stations by EOY 2014			**Total Cost**	**$62.3**

Table 12: Low Capital Cost, High Utilization

O&M Support for Planned Stations	**Cash Flow Shortfall per Station** (in $m)	**<u>2014</u>** (# stations added)*	**<u>2015</u>** (# stations added)	**Total Cash Flow Shortfall** (in $m)
500kg (medium growth)	$1.28		22	$28.2
250kg (medium growth)	$1.06		9	$9.5
O&M Support for Planned Stations				
Slow Growth Station - Over 115 kg/day				
Medium Growth- Over 115 kg/day	$0.208	37		$7.70
# of Stations by Year		37	31	68 Total Stations
*The 2014 Stations include all operating stations by EOY 2014			**Total Cost**	**$45.4**

The preceding scenarios bound the potential incentive fund needs. Table 13 summarizes the costs (in millions of dollars) if all stations utilize a maximum of 70 percent of their nameplate capacity:

Table 13: Incentive Funding Needs Matrix

	Low Cost	High Cost
Slow Growth	$52.4m	$69.3m
Medium Growth	$45.4m	$62.3m

Given all of the assumptions in the model, the total cash flow shortfall to build, maintain, and operate a 68-station network, until vehicle volume reaches approximately 20,000 FCEVs, should fall between about $45 and $70 million.[35] This estimate does *not* include public and private money invested in (or planned to be invested in) the 37 existing and planned public stations.

To arrive at a single cost estimate, we take a conservative, grounded approach. In terms of cost, we consider the higher capital cost case, given that a number of factors could drive the business cost of a station up (i.e., higher interest rates, shorter loan term, decreased capacity utilization, retail margin). In terms of utilization, we assume that the early stations (the 37 planned stations) will face a slow growth curve because they will be installed prior to the planned 2015-2017 commercial launch of FCEVs. For the new 31 stations, we assume that the nine

[35] As a reminder, these cash flow shortfall estimates are based on the assumption that retailers will be able to recoup a $3/kg margin on hydrogen, secure 10-year, 5.5% loans, and face a one-year lag time (except for the 37 first stations, which would already be in operation). Changes to these values will impact the amount of incentive funding needed.

smaller, 250 kg/day stations will be in areas with lower early growth expectations, and that the 22, 500 kg/day stations will be in areas with higher growth projections. This scenario is presented below in Table 14.

Table 14: High Capital Cost, Likely Utilization

Support for Gap Stations:	**Cash Flow Shortfall per Station** (in $m)	**2014** (# stations added)*	**2015** (# stations added)	**Total Cash Flow Shortfall** (in $m)
500kg (medium growth)	$2.05		22	$45.1
250kg (slow growth)	$1.14		9	$10.3
O&M Support for Planned Stations				
Slow Growth Station - Over 115 kg/day	$0.223	37		$8.3
Medium Growth- Over 115 kg/day				
# of Stations by Year		37	31	68 Total Stations
*The 2014 Stations include all operating stations by EOY 2014			**Total Cost**	**$63.6**

Given the scenario presented by Table 14, a total cash flow support incentive fund of $63.6 million is required to build, operate and maintain a 68-station network. To better reflect the uncertainties captured in this number, we round this estimate up to $65 million.

Capital Cost Buy-Down Scenarios for a 68 Station Network

To gain comfort around the cash flow support cost estimate, we consider a scenario in which station owners may prefer an upfront capital cost buy-down approach for high capital cost stations. This approach would rely on paying for a percentage of capital and installation costs upfront, as well as support operations and maintenance of all stations to ensure they remain open during the FCEV commercial launch.

The most recent California Energy Commission (CEC) Grant Solicitation for Hydrogen Fuel Infrastructure offers a 40 to 85% cost share of capital expenses, depending on the project.[36] Table 15 explores various capital cost buy-down scenarios.

[36] February 2012 PON-11-609. According to the solicitation, a normal project would be eligible for 40 to 70% cost share. Applicants can quality for up to an additional 10% cost share if more than 33.3% of the hydrogen is renewable, and an additional 5% if the project is completed in 18 months or less.

Table 15: Capital Cost Buy-down Scenario

Gap Stations:	2014 (# of Stns)	2015 (# of Stns)	Capital Cost Buydown 50% Buydown (in $m)	60% Buydown (in $m)	70% Buydown (in $m)	100% Buydown (in $m)
500kg (medium growth, $2M Station)		22	$22.0	$26.4	$30.8	$44.0
250kg (slow growth, $0.9M Station)		9	$4.1	$4.9	$5.7	$8.1
O&M Support						
Slow Growth Stations – Between 60-240 kg/day	37	9	$10.3	$10.3	$10.3	$10.3
Medium Growth Stations - 500 kg/day		22	$4.6	$4.6	$4.6	$4.6
# of Stations by Year	37	31				
Total Incentive			$40.9	$46.1	$51.3	$66.9
Required Industry Capital Contribution			*$26.1*	*$20.8*	*$15.6*	*$0*
Total Cost			**$66.9**	**$66.9**	**$66.9**	**$66.9**

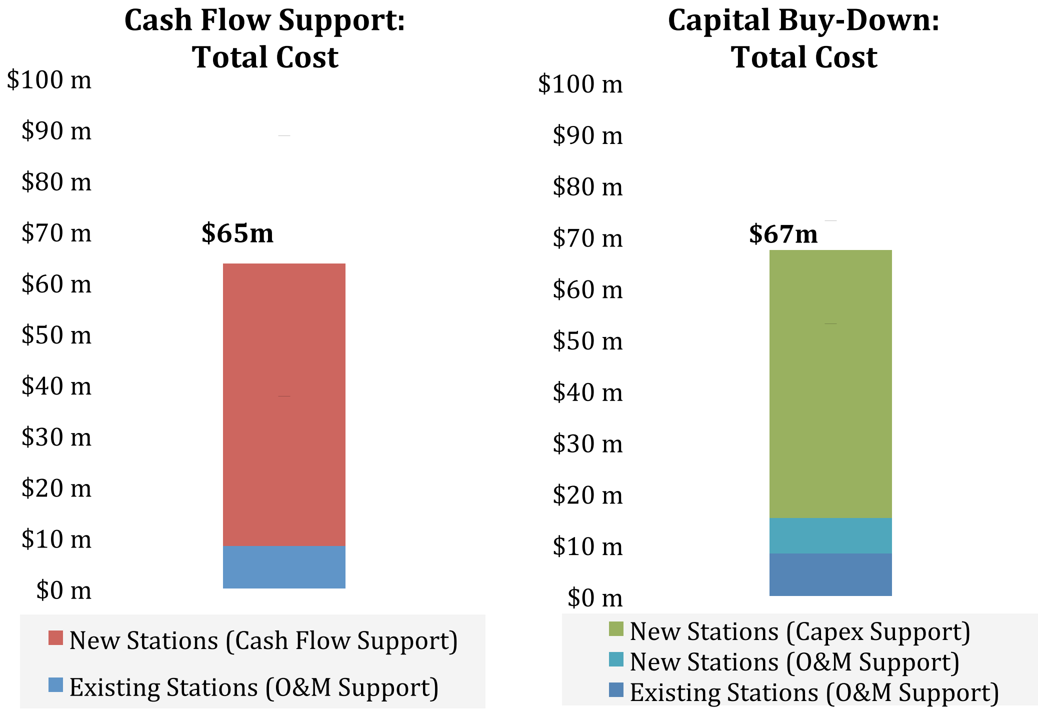
Should the current CEC capital cost buy-down approach continue, industry players would be required to invest 15-60% of the capital cost. Regardless of the industry contribution level, we estimate the total cost of the 68-station network to be $66.9 million using the capital cost buy-down approach.[37]

Comparing the Cash Flow and Capital Cost Buy-down Approaches

Based on our above estimates and assumptions, the total investment needed to build, operate, and maintain a 68-station hydrogen station is between $65 million (in the cash flow example) and $67 million (for the capital buy-down approach). These numbers represent a best estimate, and will undoubtedly need to be revised as more is learned. Figure 6 demonstrates how changes in the upfront capital cost, retail margin, and utilization can impact total incentive required to support the network.

[37] This estimate does not include financing costs associated with industry contribution. It also does not include the 10% contingency that was added to the up-front cost in the cash flow model. We assume that with known cost target, a grant-making entity would not increase funds up front to account for contingencies.

Figure 6: Comparing Two Hydrogen Station Incentive Approaches



In both cases, the most expensive outcomes illustrated by the error bars pair high capital costs (i.e., a $2 million, 500 kg/day station) with a $2 retail margin and "Slow Growth" FCEV deployment. Conversely, the least cost outcomes benefit from low capital costs (a $1.5 million, 500 kg/day station), a $4 retail margin, and "Medium Growth" FCEV deployment, allowing a station to become profitable sooner.

The cash flow support approach demonstrates greater variability primarily because the stations are 100 percent debt financed, which allows hydrogen fuel sale revenues to be used to pay off station debt. If cars are rapidly adopted, the amount of incentive needed to support cash flow shortfalls decreases. Conversely, if the car deployments were delayed, cash flow support payments (i.e., money not coming from hydrogen sales) would be prolonged.

Industry Risk

Industry would assume risk in both funding approaches. In the cash-flow support case, a station-developer would carry 100 percent of the project's debt.[38] Should FCEV deployments stall or fail, the developer would be on the hook to pay off any project debt without the help of revenue from hydrogen sales. As a network, if the incentive pool was capped at $65 million, but support needs reached close to $90 million (as shown in Figure 6) industry would be on the hook for approximately $25 million.

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[38] A station developer could put equity into a project or projects depending on risk tolerance, economics, lending relationships, etc.

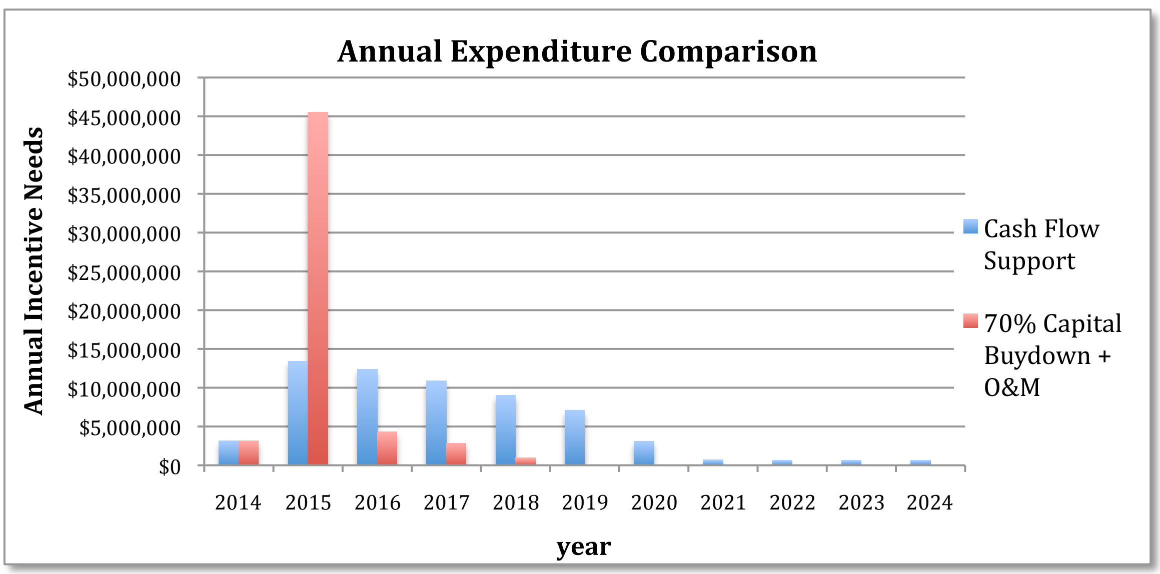
Under the capital buy-down approach, the incentive distribution entity would set industry contribution requirements. Assuming a 50 to 70% cost share, industry would need to provide between $15 and $26 million to help fund the construction of the network.

Incentive Fund Timing for Cash Flow & Capital Buy-down

One of the advantages of the cash flow support approach is that less money is needed on an annual basis. Figure 7 compares a 70 percent capital cost buy down approach to the cash flow support approach on annual basis.

In terms of cash flow support, two factors dictate the amount of incentive money needed each year: number of stations and hydrogen fuel sales. The early years require increasing cash flow support as more stations come on line. As hydrogen sales increase, the need for cash flow support decreases as stations begin to pay for themselves. In contrast, the capital cost buy-down requires substantial upfront investment.

Figure 7: Annual Expenditure Comparison



In practice, the 68-station build out may require a combination of the cash flow support and capital cost buy down approaches. High utilization growth areas will be prime candidates for a cash flow support approach, as station operators will have greater confidence they can achieve positive cash flow sooner. Expansion markets and connector stations are likely to experience slower utilization growth, and station operators may be unwilling to finance 100% of the capital costs due to greater uncertainty as to when they can achieve positive cash flow.

Recommendation

We recommend budgeting **$65 million for an incentive fund to support businesses that build and operate** a 68-station hydrogen network through the early commercial launch of FCEVs in California.

Sixty five million dollars is sufficient to deploy 31 additional hydrogen stations and support the entire network of 68 stations using either the capital cost buy-down or the cash flow support incentive approaches for new stations. If conditions are more positive than projected in this analysis, the network will require less support and remaining funds could be used to build redundancy, expand into new markets, or increase renewable hydrogen production capacity. If conditions are worse than projected in this analysis, funding will fall short and the deployment strategy will need to be adjusted.

This $65 million funding estimate assumes the Clean Fuels Outlet (CFO) will assure continued build-out of the network beyond 68 stations. Without the CFO, more incentive funding may be needed to expand into new market communities and expand station capacities. However, if FCEVs are accepted into early market communities and grow as planned, a strong hydrogen station business case should rapidly emerge.

Conclusion and Next Steps

This analysis provides a realistic, fact-based estimate for the incentive funding necessary to establish and operate a 68-station hydrogen network as FCEVs enter the early commercial market. To further evaluate how and whether cash flow support can incentivize investment, it is necessary to further engage with the fueling business community. Business owner input will help determine station locations that can benefit from a cash flow support approach, a capital cost buy-down approach, or a hybrid of the two.

The cash flow support approach described in this paper has a number of benefits. It decreases the amount of incentive funds needed in any given year, can be used to attract new players into the hydrogen infrastructure market, and can offer a cost-effective incentive option as FCEV market growth begins to accelerate. The entire program, however, must be funded up front and placed in trust to provide assurance to business owners that they will receive cash flow support payments through the market growth phase. This model will prove successful if the promise of cash flow support motivates capable parties to utilize their resources to deploy hydrogen stations.

To help businesses decide whether or not to engage in hydrogen infrastructure development, Phase 2 of this effort will add key financial measurements for potential station developers to consider, including the significant tax implications for any investment made toward a station, and a more detailed study of the utilization curves in specific cluster and connector markets. Through this effort, we will look for ways to increase the probability that $65 million sufficiently ensures that a 68-station network is fully operational by the end of 2015. This network is expected to support the early commercial FCEV push projected by the California Fuel Cell Partnership.

Appendix A - Assumptions

Parameter	Value	Source	Rationale
Retail Margin	$3/kg		Provides reasonable, cost competitive H2 compared to gasoline (*$6 wholesale H2+$3 retail margin+ CA sales tax < $10/kg at pump*). $2/kg and $4/kg also considered, but not analyzed in depth.
Capital Cost			
100-170 kg/day Station	$0.5M-$1M	UC Davis, Industry	Includes upfront permitting fees, and training & labor costs. Costs come down over time; before 2013=$1M; 2014=$0.9M; 2015=$0.5M
250 kg/day Station	$0.9M - $1.5M	UC Davis, Industry	Includes upfront permitting fees, and training & labor costs. Before 2013=$1.5M; 2014=$1.4M; 2015=$0.9M.
500 kg/day Station	$1.5M - $2.0M	UC Davis, Industry	Includes upfront permitting fees, and training & labor costs. 2015+ Range of projected costs.
Expansion, 250 to 500 kg/day	$500,000	Industry	Represents the incremental cost of expansion.
Expansion, 500 to 1,000 kg/day	$500,000 to $600,000	Industry	Represents the incremental cost of expansion. Included for future consideration.
Utilization			
Fast Growth	Straight growth; a 500kg station reaches full capacity after 4 years of sales		Commercial phase. Cluster station. This growth rate reflects estimates for growth in cluster markets in 2016 and beyond.
Medium Growth	Exponential; about 5 years to reach full capacity	CaFCP Projections	This curve approximately tracks CaFCP average projections. Early commercial (i.e., 2015).
Slow Growth	Exponential; about 6 years to reach full capacity		Very early commercial (i.e., installed 2014 or before or outside cluster region later).
Capacity Utilization	70%	Various	Conservative estimate. Given expected fueling patterns, stations may not be in the position to deliver 100% of nameplate capacity daily.

Parameter	Value	Source	Rationale
Loan Term	10 years	Patriot Capital, Ken Gunn	7 years is normal for station development business; 10 years allows a more reasonable payback and is considered doable with solid financial backing.
Loan Rate	5.5%	Patriot Capital, Industry	Conservative, inclusive loan rate based on what is currently available as of Winter 2011, assuming full balance sheet backing.
Operations & Maintenance			
General Proxy/Ground truth	$100K/yr	UC Davis, Industry	Used for all station types in UC Davis analysis.[39] Represents sum of all fixed O&M.
Fixed:			
Rent	$2,500/month	Industry - $2,500; Ken Gunn - $500	$500/month could be enough to rent space that will bring in customers. $2500 based on IGC experience & AB 118 Applications
Insurance	$1,600/yr	Federated Insurance	Same as CNG = Twice normal gasoline station.
Property Tax	$5,000-$20,000/yr	CaFCP	1% of capital expenditure used as estimate.
Permit Fees	$3,680/yr	CaFCP Station	$3,678 for West Sacramento Station.
Variable:			
Variable Maintenance	$1000/month + 6% per 25kg increase		This figure of 6% per 25kg increase is used to arrive at the O&M cost profile that ranges from $85k to $165k for the 500kg station. It is not based on a specific source, but has been verified as reasonable by industy.
Incremental Electricity	$100/month + $0.30/kg	Brown, Tim, Shane Stevens Romero and G.S. Samuelsen. Quantitative Analysis of a Successful Public Hydrogen Station. Pending publication, 2012.	This figure derived in two ways. Together with the variable electricity figure, it results in an average O&M profile that matches industry ranges of $85-$165k for a 500kg station. The figure of $0.30/kg also aligns with Brown, T., which refers to a range of 0.7-5 kWh/kg from literature, and reports the UC Irvine station using 2.5-2.7 kWh of electricity for compression. At a cost of $0.12/kWh, this is $0.30-$0.32/kg. Note that the UC Irvine station overall figure is 5 kWh/kg, but this high rate includes fixed electricity costs, such as a cooling, spread over a very low volume.

[39] UCD, 2011. University of California, Davis. Ogden, Joan et al. UCD Institute of Transportation Studies. "Analysis of a "Cluster" Strategy for Introducing Hydrogen Fuel Cell Vehicles and Infrastructure in Southern California." Sept. 16, 2011. Revised Oct. 5, 2011.

Parameter	Value	Source	Rationale
Fuel Use	0.6 to 0.7 kg/vehicle/day	UC Irvine Station	1 kg/day used to plan capacity needs; 0.6 to 0.7 kg/day based on data - represents conservative estimate from individual station perspective.
Credit Card Fee	3%	Industry	Fees can be more or less, based on card used.
Sales Tax	9%		CA sales tax. Credit card fees applied after sales tax. Note: assumption is that sales tax does not reduce $3/kg margin in the model.
Cost of Goods	$6/kg	Industry	Based on industry input, this is a reasonable proxy. Plug Power, currently the largest purchaser of retail hydrogen, averages less than $6/kg to purchase hydrogen from various IGCs to supply to fuel cell forklifts.
Contingency	10%	Common industry practice	Protects against unexpected cost increases.
Construction Time Lag	1 year		Target = 6 month construction time lag (i.e., time from lending to opening). Conservative 1-year time lag accounts for learning in new market.