CALIFORNIA HYDROGEN BUSINESS COUNCIL

Hydrogen Means Business in California!

Financing the 101st Station

Report for June 14-15, 2016 Workshop

Prepared by Emanuel Wagner & Jeff Serfass

Acknowledgements

This report on the Financing the 101st Station Workshop is a product of the California Hydrogen Business Council. The Workshop was created under the leadership of the Board of Directors with sponsorship from four leading companies in the hydrogen and fuel cell space. This workshop benefitted greatly from the leadership of Craig Scott and the lead sponsorship of Toyota Motor North America Inc.

The Business Council also gratefully acknowledges the support provided by sponsors Air Liquide, Linde Group and American Honda Motor Company Inc.

Steering Committee

We would also like to thank the members of the Steering Committee who created the plan for the Workshop, the invitation list and the agenda. Many of them personally connected with potential participants from the finance community, the target for this workshop. They are listed below:

- Dr. Andreas Truckenbrodt, Principal, Truckenbrodt Clean Energy Consulting
- Andrew Adams, Principal, Deloitte Consulting
- Dr. Robert Shaw, Managing Director, Arete Venture Management
- Brian Goldstein, Executive Director, Energy Independence Now (EIN)
- Cassandra Franceschini, Communications Manager, Air Liquide USA LLC
- Craig Scott, Director of Advanced Technologies Group, Toyota Motor North America Inc.
- Greg Fleming, ALIAD - Air Liquide Advanced Technologies U.S. LLC
- Dr. Katsuhiko Hirose, Professional Partner, R&D and Engineering Management Div, Toyota Motor Corporation
- Kohei Masaki, Senior Consultant, Deloitte Consulting
- Mike Beckman, VP/Head of H2 Fueling & Industrial Applications, Linde LLC
- Naoto Uzuka, Senior Manager, Deloitte Consulting
- Steve Cardona, CEO/Founder, Nzyme2HC
- Steve Ellis, Manager of Fuel Cell Marketing, American Honda Motor Co., Inc.

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101st Station Workshop

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Executive Summary

The Board of Directors of the California Hydrogen Business Council, with its automobile manufacturing and hydrogen production Directors, among others, decided to create a workshop to develop financeable business models for building hydrogen fueling stations, as California state funding would be expected to trend downward. With Toyota leading the sponsorship, Air Liquide, Linde and Honda also joined in as sponsors to support the staff work and venue expenses to conduct a high level meeting of finance experts. Essential to creating the design of the event, and creating the invitation list, was a dedicated Steering Committee listed on the previous page.

As CHBC staff and the Steering Committee proceeded, it became clear that attracting the finance community would be difficult. One prospective participant said rather clearly that if we showed him a model with cash flow able to support the debt and yield a return to investors, with several years of operating experience, then he would be interested. The development of the hydrogen infrastructure can't do that yet. In fact, at the careful, deliberately measured rate of sales of fuel cell vehicles, from a purely financial point of view, early stations purely servicing cars are not good investments, though they remain critical for getting the FCEV marketplace going and for addressing the environmental challenges of transportation.

The early presentations, designed to provide the context for the issues and discussions, provided depth to everyone's understanding, and one presentation in particular promoted discussion among the participants that the list of economic factors that have to fall in place is really rather simple. Based upon a 200 kg per day station:

- Vehicles/station ratio – must be 400 vehicles clustered around one station at a .5 kg/day/vehicle average consumption
- Margin on hydrogen sales – needs to be $3 per kg or better
- O&M cost – needs to be $100,000 per year or less
- Capital cost of station – must be $1,000,000 or less

These variables can vary as different station and networking models are considered.

Other contextual information focused on the fact that gasoline retail stations don't make their money selling gas, but on other convenience store and car washing revenues, as well as real estate appreciation. Maybe the gasoline station is not the right model to emulate. Fewer and fewer consumer purchases take place at physical locations these days. We need to think about hydrogen fueling differently, and there are many ideas expressed in this report that deserve consideration.

Perhaps we need to seek out sources of capital that have a strategic interest and willingness to share, with the automakers and the hydrogen providers, the business risks in some tri-party agreement. Different private financing models need to be identified.

However, we also need to realize that there is public value in the creation of the infrastructure that warrants government funding, as the California Air Resources Board (but no other ZEV state) has been demonstrating, and a "moon shot" or national highway system approach to funding and establishing a national fueling network should be considered.

A conclusion of this Workshop is that public funding will need to continue for some time, longer than currently envisioned in California, not ending at 100 stations. It is also believed that national policy needs to be supportive of the FCEV deployment and infrastructure problem if we are to see the benefits of the billions of dollars invested by private industry and government funding to date. We can't expect each state to provide the kind of funding applied in California, and there is no future for FCEVs in the U.S. if they are sold only in California.

Putting federal policies and infrastructure funding in place will require a politically active industry, and it will also require a succinct story that industry has not successfully articulated. The story needs to lay out the unique benefits of hydrogen in the energy space, particularly for transportation, that government and industry can't limit the damage of greenhouse gases without creating a zero emission light and heavy duty transportation and public transit future, and that fuel cell vehicles are an essential part of that zero emission future. The story also needs to dispel the misinformation about hydrogen that continues to propagate in some settings and put FCEVs into a positive light vis-à-vis BEVs.

In summary:

- Building out the H_2 fueling infrastructure is a very challenging task.
- In the early days when vehicle numbers are low, the financial economics of station installation and operation are not attractive.
- Eventually station economics will become sufficiently interesting to attract private capital, but that will take a number of years, even in California.
- But in the meantime, substantial government support will continue to be required, both in California and other ZEV states, as well as at the federal level.
- There are various ways that such support could be provided in addition to providing capital grants for station construction and operation, e.g.:
    - Tax incentives
    - Low cost loans
    - Loan guarantees
- There may need to be innovative thinking on the best model for sizing and locating stations:
    - Siting at existing gas stations may not be the best option.
    - Small stations located where vehicle traffic is high, like big box stores, could be attractive.
    - Mobile refuelers and even community and home refuelers are potential attractive options.
- Creative, compelling stories and messaging through various social media channels, on the importance of building a fleet of H_2 fueled vehicles and accompanying H_2 fueling infrastructure are a top priority, both for the H_2 industry and the nation.

There are a number of possible next steps presented in the Conclusion section. The California Hydrogen Business Council will work with other interested organizations and experts to convene a briefing on these results and to discuss next steps towards addressing the financing challenges of the hydrogen infrastructure. This workshop group concluded that it would like to get back together, possibly on a regular basis, to report on progress and developments and to engage with players missing at the Workshop, both locally and internationally.

Introduction

This report presents the results of the California Hydrogen Business Council's workshop on "Financing the 101st Station" held on June 14-15, 2016 at the Huntington Gardens in Pasadena California. Several presentations provided financing, fueling station model and automotive contexts for the workshop and then the participants led themselves through a facilitated development of the key topics important to the Workshop. A vigorous discussion took place throughout the two days.

The audiences for this report are varied: the hydrogen and fuel cell companies engaged in providing the hydrogen fueling infrastructure for fuel cell electric vehicles (FCEVs); government agencies and legislators committed to zero emission vehicles and the beginning of this infrastructure development; and financial actors in all their varied forms. Many of the companies in this industry are members of the California Hydrogen Business Council. It is the role of industry to turn the results of the workshop into actions, with the appropriate leadership and policy support from state and federal government legislatures and agencies.

This two-day "Financing the 101st Station" workshop was conceived in a Strategic Board Meeting of the California Hydrogen Business Council, September 2014 at South Coast Air Quality Management District in Diamond Bar, culminating in its inclusion in the CHBC 2015 Program Plan. The CHBC Board decided it was important to understand how AB 8 public funding support for the first 100 stations in California could transition to private financing of future stations. The State of California does not intend to be funding hydrogen stations indefinitely and industry needs the confidence of developing workable pathways to private funding.

AB 8

Assembly Bill No 8 was signed into law September 28, 2013 to stop implementation of the Clean Fuels Outlet regulation requiring suppliers to build hydrogen fueling stations, and instead provide $20,000,000 per year until there are 100 hydrogen fueling stations in California.

The Board commitment to the Workshop led to discussions between Craig Scott, CHBC Director and Toyota Director of the Advanced Technology Group and Jeff Serfass, CHBC Executive Director, to develop the Workshop approach. It was also influenced by discussions among Workshop Steering Committee members Bob Shaw, Andreas Truckenbrodt and Jeff Serfass, who had been meeting frequently to explore private investment approaches to building hydrogen fueling stations for the FCEV market. With sponsorship from Toyota, Air Liquide, Linde and Honda, the Workshop took shape.

Andrew Adams, Partner at Deloitte Consulting, facilitated the Workshop and Sophia Liang of the firm Graphic Footprints graphically recorded the discussion on the walls of the conference room. Some of those graphics are included in this report.

The CHBC was the logical organizer of the Workshop because of its California focus and the breadth of its 90+ membership which covers the span of the hydrogen and fuel cell industry and market sectors. A sizeable portion of the CHBC membership is engaged in hydrogen fueling, in vehicle manufacturing, goods movement fueling, hydrogen station building, and hydrogen production from renewable energy and natural gas. The CHBC and the Workshop have a California focus, but this was an event that reached beyond California. Some of the discussion considered the national perspective and the outcomes are likely to be relevant in other areas of the U.S. where public funding is largely absent. Finally, the focus was on private financing, but the Workshop needed to consider the future role of public policy in infrastructure development, a discussion assisted by the participation of Richard Corey, Executive Officer of the California Air Resources Board.

This was no ordinary CHBC event since it was by invitation only, designed to attract a group of individuals in the finance community, and many of the participants had not been part of a CHBC event before (see Appendix A for the list of participants). The attendees were pleased with the unusual and positive dynamics among important industry players and some that were new to the industry.

Context

The State of California has authorized $200,000,000 in cost-sharing to build 100 hydrogen fueling stations to meet the initial needs of the market for light duty hydrogen fuel cell electric vehicles. Twenty-two stations are now in full retail operation and additional stations are opening at a rate of nearly one per week. It is expected that the number of retail stations will total 40 by the end of 2016. Approximately 400-500 stations will be needed in California alone by 2030 assuming cars roll out as hoped. Without government funding, stations currently being completed or under development will not create enough revenue for investors, and even with government funding, many are likely to lose money for several years.

With appropriate acknowledgement of antitrust constraints at the outset, the Workshop convened 28 experts, bringing different perspectives and knowledge, to try to develop breakthrough insights that could enable the building of the hydrogen infrastructure primarily with private capital. This group was tasked to figure this investment challenge out, and to determine pathways towards viable financial plans. The broader vision for hydrogen energy extends to power generation, grid management of intermittent renewables, energy storage, and goods movement, including fuel cell lift trucks and heavy duty freight, all of which can benefit from the development of the infrastructure for fuel cell electric vehicles (FCEVs).

Initial presentations provided context at the Workshop for the fruitful discussions that happened in the midst of the presentations, in Q&A following them, and in the remainder of the Workshop:

- **The Challenge** – Craig Scott – Director, Advanced Technologies Group, Toyota Motor Sales
  The objective of this workshop was to obtain a shared vision of the future of hydrogen infrastructure, develop a financeable framework to get to that future, to identify specific actions and next steps. The workshop was intended to be highly interactive.
- **The Foundation: Reality of Hydrogen Station Economics** – Dr. Robert Shaw – Managing Director, Arete Venture Management
  The economic conditions that must be met to make hydrogen fueling station investments attractive to private investors were analyzed and presented for discussion. (See slides in Appendix B)
- **The Reality of the Fueling Station Business** – Brian Goldstein – Executive Director, Energy Independence Now
  Insights to the way existing gas station owner/operators view their business were presented to explore how hydrogen fueling might therefore be received by those players.
- **Wide-scale Station Roll-out Planning** – Dr. Joan Ogden – Professor, Institute of Transportation Studies, UC Davis
  Current thinking about development of the hydrogen fueling network in California, and what needs to happen to build a similar network in other states was presented, with several possible scenarios out to 2030. (See slides in Appendix C)
- **Innovative Ways to Fund Infrastructure** – Ole Hoefelmann – CEO, Air Liquide Advanced Technologies U.S.

Alternative ways to encourage financing of hydrogen fueling stations when traditional approaches may not be viable, including loan guaranties, REC transactions, and convertible debt were highlighted. (See slides in Appendix D)

- **Roles of Public Policy** – Richard Corey – Executive Officer, California Air Resources Board
  A number of comments on policy considerations were discussed.
- **How Automakers Think about Rollout Volumes and a Market Update** – Dr. Andreas Truckenbrodt – Principal, Truckenbrodt Clean Energy Consulting
  An automaker panel explained the challenges of introducing an entirely new vehicle type to the market, and how these challenges impact hydrogen station build-out. California Fuel Cell Partnership (CaFCP) data were provided on automaker deployment plans and current and planned fueling station operations in California. (Slides in Appendix E)
- **Hydrogen Society** – Dr. Katsuhiko Hirose – Presenting as World Premier International Research Center (WPI) Visiting Professor, International Institute for Carbon Neutral Energy Research, Kyushu University
  The Japanese view on a hydrogen society was presented.

Discussion Topics and Results

Facilitated discussion, which had already been vigorous throughout the contextual presentations, developed key topics that were further explored in smaller workgroups:

- Station finance – the current economic model and alternatives
- Fueling station models and alternative concepts
- New investor types – expanding the investment community
- Industry coordination and alignment
- The role of public policy
- The story – developing and communicating it

Station Finance – The Analytical Reality

The goal of the "Financing the 101st Station Workshop" was to increase the understanding of how to bridge from early government-supported funding to private investment supported financing of hydrogen fueling stations. To do that, we needed to first understand the current analytical reality of station profitability and their ability to support debt and/or equity financing.

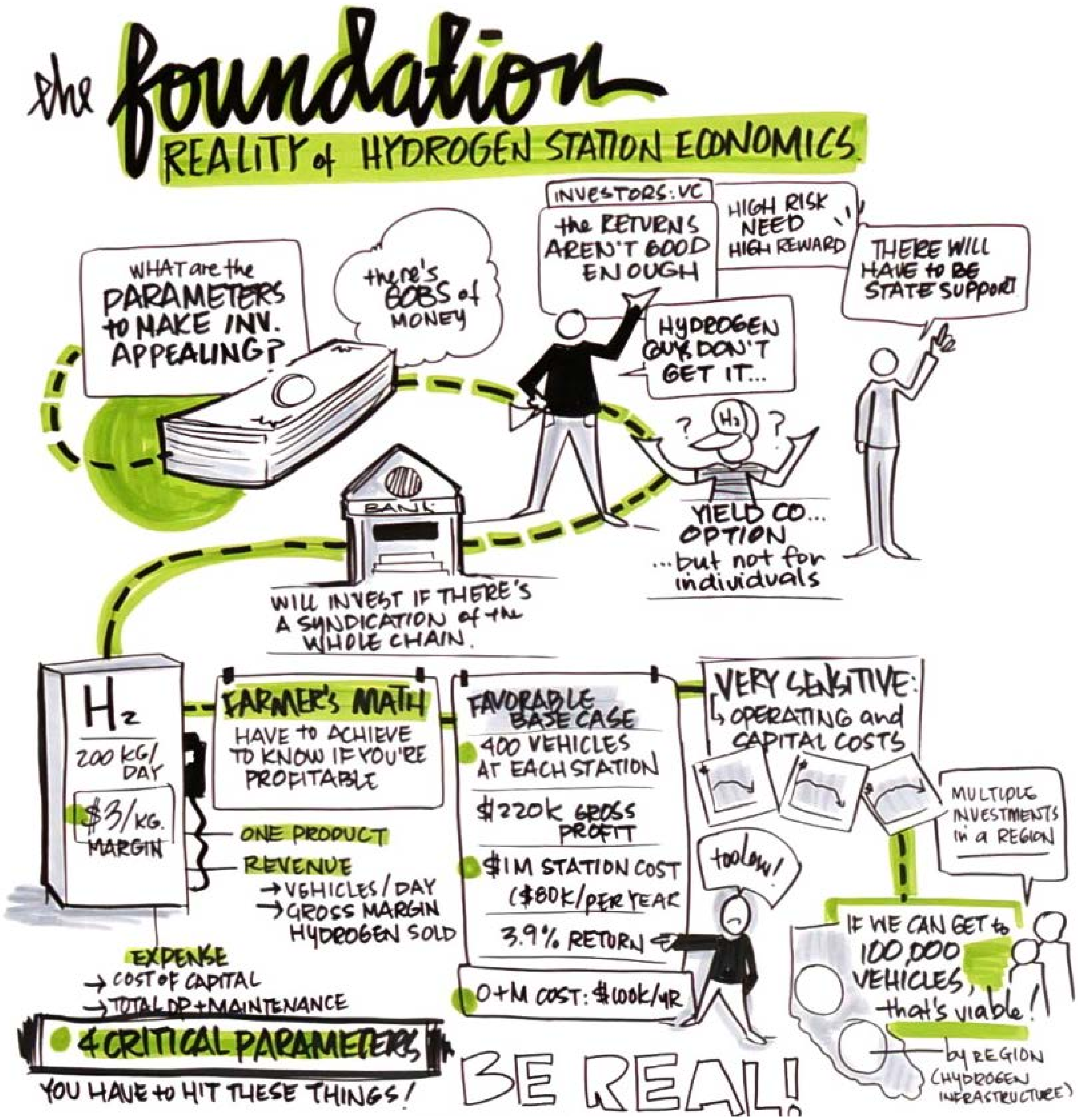
Key points from the presentation given by Dr. Shaw are summarized below. A full copy of his presentation is provided in Appendix B.

The graphic recordings, as shown in the graphic on the next page, were drawn at the Workshop and are illustrative of the discussions that took place. They should not be relied upon for conclusions as they were not subjected to critical discussion at the Workshop.

Speaking from his venture capital investing experience over two decades, Dr. Shaw said that investors look first for uncomplicated analysis for financing decisions, what Dr. Shaw called "Farmer's Math," in considering an investment proposal. In his analysis, for 200 kg/day stations, he found that four variables control station profitability. This simple model shows what the value of these four variables must be to achieve a return on investment:

- Vehicles/station – must be 400 vehicles clustered around the station at .5 kg/day
- Margin on hydrogen sales – needs to be $3/kg or better
- O&M cost – needs to be $100,000/year or less
- Capital cost of station – must be $1,000,000 or less

These four profitability factors can be varied, and the station model used will lead to use of different values. But if the stars are not properly aligned for these four critical factors, you can vary everything you want, like capacity factor or loan rates, and the "economics can range from not exciting to disastrous." Even the base case scenario with the values above would yield only a 3.9% return on investment. A 10% internal rate of return is needed, at a minimum, to attract investors. So financially, that poses a significant challenge.



Given the relatively slow roll-out of vehicles that automakers have announced, it will be challenging to achieve sufficient vehicle density to construct a business model that will make attracting private capital feasible unless:

- Governments are willing to continue supporting station build-out
- Key players (automakers, hydrogen suppliers and station owners/operators) are willing to engage in risk sharing agreements
- Investors are willing to accept significant losses in the early years to see out year returns, like by going public
- Data from automakers on projected rollout volumes that are publically reported will allow for better estimates.
- Workshop participants generally accepted Dr. Shaw's analysis and the metrics that are key to station profitability.
- There was also some discussion of the potential benefits of other station models, such as larger stations (400 kg/day or larger) to reduce the levelized cost of hydrogen via scale economies, assuming the hydrogen could be fully utilized.

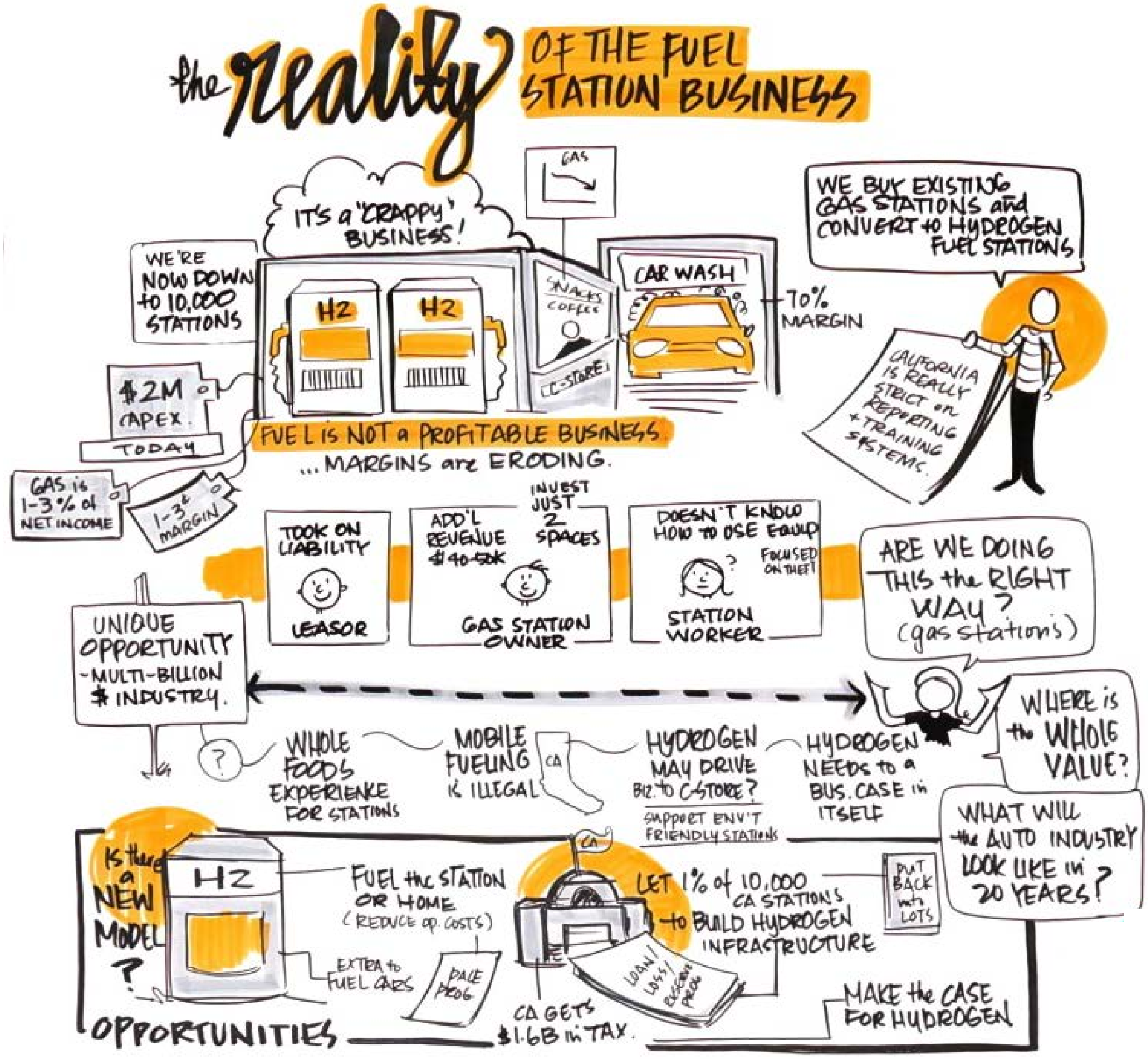
Station Model

Is the gasoline fueling station model the right approach for hydrogen?

The fueling business of regular gas stations today is not very profitable. Stations generate revenue from other revenue sources like convenience stores (c-stores) and real estate transactions. Most stations are owned by family businesses (not oil companies).

Brian Goldstein spoke about his work on financial models for gas stations, based on thousands of stations. His analysis shows that gasoline retailing is a "bad business" without other revenue streams. Numbers are falling from 13,000 stations a few years ago to 10,000 stations now in California. 800 stations closed solely because of the requirement to install advanced vapor recovery ($50,000 each).

With today's hydrogen station costs of $2,000,000 or more, it's very hard to justify investments. However, fueling attracts customers to their car wash and c-store businesses. For every gallon of gasoline sales, the station owner has on the high end a 15 cent margin, often only 8 cents, which excludes maintenance and delivery. Then, 90% of customers use credit cards, which is another 3 cents, which leaves at $3 a gallon only 5-12 cents for the station owner as net profit. Margins in the gas station business are rarely higher than 1-3%. A hydrogen station requires added capital of around $2,000,000, excluding maintenance. The real profit comes from car wash and quick serve, which have a 70% and 50% margin, respectively.



Comments made in discussions:

- Stations are a **landlord business** for many companies but a "land play" is not a reason to get into gasoline station business.
- Environmental integrity is very important in California for gas stations, which creates complexity and issues when hydrogen is added to existing gas stations. Furthermore, the mechanics of **gasoline stations are not ideal to adopt to hydrogen**. The purpose of gasoline stations is to attract more people to increase revenue from other sales. The owner of land leases to the business owner, who is usually an offsite manager, who oversees a number of station managers, who have several employees for the C-store. These employees are mostly focused on preventing theft and they do not do a lot of work on the lot, and don't usually check outside. Since hydrogen requires more attention, they are not usually able to fix issues outside. This poses the question of whether we can change the culture for employees to be able to address issues at the hydrogen pump, and do we want to? Developers sometimes don't want to have the employees be able to use the equipment and there may be liability issues.

- What about **auto maintenance** at the refueling stations? There are high profit margins for vehicle maintenance work, but OEMs may have issues with non-OEM technicians working on their technology, so this may not be a solution.

Are There Better Models for Hydrogen Fueling Stations?

Historically, oil companies have been the go-to group for fueling stations. Customers are used to this model. But what if this model is broken? Maybe the question is, where would you expect to buy quality fuel?

Comments made in discussions:

- To make financing work, **aggregate fueling sales** with fleets, car co-ops, local delivery fleets, etc. to get higher and more stable throughput. Also equipment that is not used regularly is more prone to failure – reliability is a big issue with current hydrogen stations.
- Stations can be more than just transportation fuel providers. Consider **other revenue streams**, e.g. selling electricity credits (solar, wind) with a guarantee to take some output
- Looking broadly at how people buy things today, gas stations, grocery shopping and dry cleaners, are the few remaining physical point-of-sale locations that haven't quite gone digital yet. The automobile fueling business is "**ready for industry disruption**" with a different shopping experience.
- What about **fuel deliveries to the customer**? In California, one can't legally deliver fuel (State law), but maybe this can be changed.
- Do **gas stations need hydrogen** to keep their business, either because the customer expects it or the state requires it?
- In the gas station business, we see a **high skepticism**, coming from ethanol and natural gas revolutions which stalled but left the station operators/owners with significant expenses and stranded investments.
- New models could be based on **collaborations**, e.g. with Whole Foods, who may be willing to invest in hydrogen stations to increase store sales by attracting new environmentally conscious customers, a combined marketing strategy to increase food customers who have similar environmental values. In addition, grocery stores and others with fleets could potentially use their own hydrogen – and provide a better throughput and green their image further.
- Retailers may have a **preference for allocating real estate to FCEVs** over BEVs because they may not want to have cars waiting at their site for 30+ minutes to recharge. Gasoline retailers and major oil companies know that there is a certain part of future transportation that will be zero emission, which can only be met by BEVs and FCEVs.
- Since high utilization stations are a key, maybe the **community station model** is key. In a new housing community, include hydrogen refueling with the cost buried as part of a larger investment: make it part of a bigger project. This creates a readymade demand for interested people. For new communities, require a spot for green fueling for each 1000 home development, building on the community aggregation concept, with community use of transportation fueling options.
    - Consider a **solar community**:
        - Solar inspires some small towns to go green and go solar, grid-independent of their utility
        - They could create a small hydrogen system to run off of their solar
        - The community can own the solar, and own the refueler
        - They are possibly less sensitive to cost since they are focused on the green aspects

- Companies like H2 Logic with **a drop-in fueling station** have an interesting model to reduce installation and permitting costs, although this approach wouldn't seem to scale to larger stations

- **Home refueling** was discussed but the high cost for low volume made the fuel cost high. It is a great option for certain circumstances but is not the solution that the Workshop was seeking. A home energy system which produces fuel, electricity and heat sounds interesting. Consider whole energy systems as part of home buying. Look at what is happening in Japan with fuel cells, CHP, solar, etc. Industry could talk to community solar people to explore interest in the combined community benefits of solar energy and hydrogen fueling. If net metering dies in the industry, it can be replaced with high-value hydrogen produced during excess periods.
- **Tri-gen systems** would allow for modular and flexible hydrogen production based on which output (electricity, hydrogen or heat) would be providing more revenue at any point in time.
- **Integrated multi-fueling stations** (e.g. NG, gasoline and hydrogen) have higher capital costs, but the ownership model might be more attractive for some investors.
- Although looking at the development of battery charging for BEVs is interesting, no lessons are learned from that due to the lack of maturity in that side of the ZEV business as well.
- Are transitions to **autonomous driving** and alternative vehicle ownership models going to create new models for fueling stations?

Except for some possibility of home refueling, which is not economical today, the workshop did not conclude with specific future scenarios suggesting new station models for today. But, the current point of sale gasoline retailing system is a mature technology, and it may not be the right approach for hydrogen.

Maybe the thinking needs to come from outside the gasoline fueling industry. Hydrogen could develop its own story, its own case, with a tabula rasa approach. Even traditional gasoline customers may prefer to go to alt-fuel stations to see and experience them, and be associated with the "green" business.

The results of this discussion are that there are alternative fueling station models that differ from today's gasoline model. Some of the interesting models are moving hydrogen fueling to locations in strategic partnership with other market sectors, like food stores, and aggregating customer demand across several sectors like fleets, buses and goods movement. The development of the hydrogen fueling infrastructure may well employ several strategies as the gasoline retailing business itself continues to evolve.

Station Network Development

OEMs require a network of stations in the regions in which they sell FCEVs so customers have redundancy, with several locations the customer can utilize for regular fueling. This is to account for varying driving patterns and also initially lower station reliability. To make the station investments economic given expectations about size and equipment costs, the concentration of customers around a single 200 kg/day station needs to be about 400 vehicles. Customers expect that they will be able to drive between regions which requires connecting stations which are likely to have low utilization (unless combined with fleet or goods movement markets). A network development strategy would need to employ these factors and more for a viable financeable plan to be developed.

Comments in discussions:

- It's **not a chicken and egg problem but more like a valley of death issue**, where stations simply need vehicles.

- California needs to build base coverage first, between 60 and 100 stations.
- A figure of the "**almond and chopsticks**" was drawn (see lower right portion of figure on Page 19) to graphically display that in the early years, in any region, the almond represents that the investments are larger than the number of vehicles would justify, and then the market for that region matures where future investments parallel the growing numbers of vehicles. This needs to be applied in a similar fashion in every single region of the state or country. The "almond" (upfront investment) issue is everywhere. However, over time, the customer understanding increases and vehicle sales increase, following a public learning period. Then the timeframe to station profitability is shorter.
- A few successful Phase 1 regions are needed that will then spill over to adjacent areas. We need **focused fueling infrastructure development**, not a shotgun approach. Develop clusters first, gain customer data and experience, and then reduce the cost and risk for other regions. This requires vehicles available in these same clusters – owned by private individuals and/or in some form of fleet. France is adopting a cluster-based approach, mainly with range-extender fuel cell/battery delivery vans.
- We should **develop data** on station success in California to help develop understanding. The ARB/CEC report from December 2015 is useful. Performance and financial data collected on the first stations would provide investors with key metrics for their decision making. This could be a request from industry.
- There is no chicken and egg problem. **OEMs decide vehicle volumes** based on seeing a real market, and infrastructure is a critical requirement since they can't sell vehicles ahead of station availability. Toyota is planning a 3,000 vehicles per year production in 2017 for their Mirai, with four years of back orders in Japan, and 3,000 preorders in California. 81 stations are in operation in Japan, without many cars yet. It takes a long time for OEMs to get production ramped up and then there is time required to build capability for larger production volumes, solve issues with the supply chain, and design the next generation vehicles including cost reduction and power train improvements.
- **Economies of scale** will play a role in station cost as stations are expanded, larger stations are built and equipment costs come down. Opportunities for onsite hydrogen production will offer competition to bulk delivery of hydrogen, all of which have the potential to drive the cost of hydrogen fuel downward in later years, assuring robust market growth and good utilization of the stations.
- An **underutilized network** causes the price of the dispensed fuel to be very expensive; higher utilization allows for possibly decent profit margins.
- Finally, we need to focus on station 101 to station 500, not the entire build-out to thousands of stations.

Many people have analyzed alternative strategies for building the hydrogen network that in the early years must satisfy both OEM and customer needs. They all point to higher utilization stations in clusters that can only occur with close alignment of OEM and station builder plans, and there will always be low utilization stations for which cross-market sector strategies are a solution to increase utilization.

New Financing Models

Are there other financing models that can be developed? We need to think not of replacing the dying model of gasoline, but instead to come up with entirely new models of funding the fueling infrastructure.

Comments in discussions:

- The value of a model based on **using hydrogen fueling to build customer traffic** in a retail setting is low in early years, though it may be useful in later years.
- Cooperation of local fleets and investors, and the availability of special municipal financing packages, could apply to **bus fueling stations**, and could also be applied to passenger cars. Bundling would improve the financial picture in early years but may be difficult to develop.
- A **co-op concept with car sharing** was proposed -- most car usage is very local and if car sharing takes on the refueling (with remote monitoring) it could consolidate fueling and the fueling infrastructure. Couple the unique automobile business model of car-sharing with a cooperative to provide fueling for the cars. It's being done right now in Munich with Linde and Hyundai
- Consider the model of investment trusts – **REITs** where there is lots of growth -- with investment in community associations.
- One approach to financing stations could be to utilize California and Federal gasoline excise taxes and/or local sales taxes on gasoline. The below table summarizes approximate annual average tax revenues at the individual station level in California. While average fuel volume across approximately 10,000 stations in California is about 1,250,000 gallons/year according to the California Energy Commission 2012 Retail Fuel Outlet Annual Report, most stations in the geographic areas targeted for early FCEV sales (Los Angeles & Bay Areas) have much higher volumes than the state average.

$.39/gal CA Excise	$487,500 – $493,750
$.30 - .42 Sales Tax (at $4/gal)	$375,000 – $525,000
$.10 Cap & Trade	$125,000
$.184 Fed Excise	$230,000

That amounts $1,221,750 - $1,371,250 in average taxes per station per year, and with 10,000 California stations, that is a lot of money. State, federal and or local policymakers could reinvest some of those taxes into a Loan Guarantee Program or Loan Loss Reserve Program, with four tax revenue sources from which to choose. 1% of taxes from California stations in one year alone can help build 100 new stations.

However, diverting even a portion of this tax revenue would be a big lift and may even be a State constitutional issue. It's a big lift because the California transportation infrastructure is currently seeing a $60 billion shortfall over the next 10 years while the mandate on reducing gasoline consumption in vehicles reduces the revenue the State receives from gasoline sales and tax revenue. So there's already a need to figure out how to raise revenue to replace the lost tax revenue.

- Tax reallocation could be a stepping stone to having stations paid for by other groups, and could also support renewable hydrogen production.
- Other ideas include financing programs like **PACE**, property assessed clean energy, a means of financing renewable energy upgrades. PACE can be used to finance loans with repayment guaranteed through property tax assessments, which are backed by state and local governments.

Consider the three phases of building stations:

- Phase 1: Unconditional buildup of base coverage
- Phase 2: Demand buildup for next stations
- Phase 3: Market successes – 100,000 cars, hydrogen is a business, traditional financing will work

Different support can be applied for different phases. For instance, ZEV credits could be channeled to infrastructure in Phase 1 and 2. Crowdfunding could be a solution for Phase 2. Private and conventional financing will work in Phase 3. Station building could be a dynamic model over time. The initial phases really need upfront take or pay contracts with OEMs (original equipment manufacturers, used as short hand for automobile manufacturers in this report) guaranteeing hydrogen payments to station owners, to bring assurance, clarity and liquidity to station developers. Maybe regional licenses can be provided to develop stations exclusively in some zip code areas which would protect early investors.

In hydrogen, there's no first mover advantage for the automotive industry, which needs to work together to build this market. Hydrogen is more efficient than gasoline, and provides operational advantages over battery electric vehicles, so hydrogen will have an important place in transportation over the longer term, but the issue remains as to who is to take on the financial risk in the early years.

There is no silver bullet for station financing, but there are creative public policy, market and finance bundling, and other strategies to be further developed by policy and financial entrepreneurs.

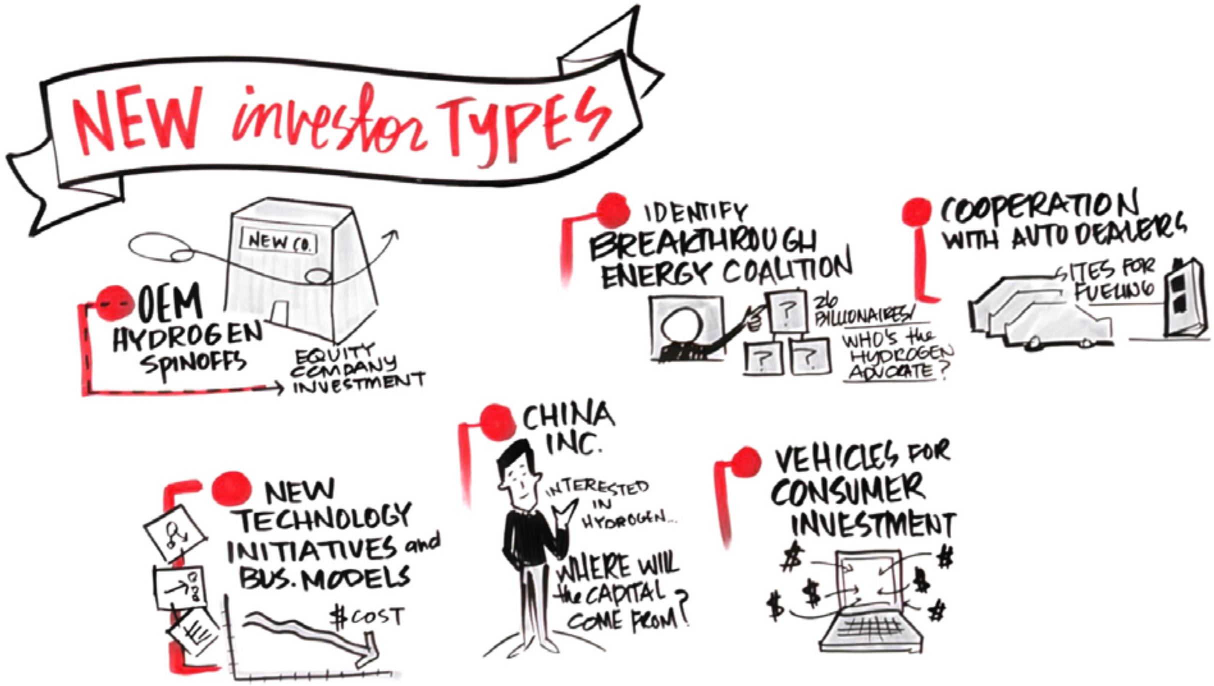
Investors

Maybe new investors are needed. Developing new funding approaches for this new technology initiative, as well as new business models that will attract a different pool of investors, will be key.

Comments in discussions:

- Interesting funders could include **China** and the sovereign wealth funds of **Saudi Arabia and other Middle East nations**. While they could have different investment strategies, all investors are accountable for their returns and when they bet on high risk, they expect a high return.
- Big automotive companies could consider **spinning off their FCEV businesses** to allow for new investment possibilities in new innovative companies. Investment would be bundled into the new companies which allows them to create investment strategies with an exit potential, like a venture capital fund. These companies would not use project funding but be "NewCo" equity-based.

- First Element Fuel is using a different approach with a **loan** structure.
- Substantial long term societal benefits can be gained by adoption of FCEVs, but the question is how to **apply these future benefits** to today's financing problem.



Where could capital come from for our industry?

Comments in discussions:

- Look at **China**. Consider cooperating with existing companies like a "China Inc". Consider what has been done in solar, where China alone took the technology to scale, providing massive production and this was government funded. The potential supply chain is in China with potential partnerships and demand.
- Industry needs to make connections with the **Breakthrough Energy Coalition** composed of people like Jeff Bezos, Richard Branson and Bill Gates. Start by finding a champion in that group and identify who knows the key people. This could be one of the best opportunities for the industry. They state that traditional methods of financing don't work, and they don't need traditional quick returns. To get to scale, we need to get one investor to build a great number of stations vs. 100 individual investors building 100 stations.
- **Berggrün** is another who has built an investment empire, started a think tank, and has created an operational fund in the LA area.
- **VC investment** can raise funding for a new product rather than an entire company and new technology that can be mass produced is attractive.
- **Crowd funding** is a creative innovation, maybe for customers
- Cooperation with **auto dealers having stations on site**
- **State loan guarantees** with strict criteria
- **Cap and trade funds** to be used in early years.

OEMs and other big companies have to satisfy their investors and have limitations that may be different from those that an Elon Musk, for example, faces.

There a number of interesting investor types with different strategic, environmental and public policy objectives. They are potentially part of the solution to station financing and need further analysis and development.

Industry Coordination and Alignment

One of the overarching challenges to station investments is that, early on, there's a need for more stations than are economically feasible in order to have sufficient coverage. Right now, EIA is expecting 35,800 FCEVs per year nationally by 2020. Hybrids took seven years to reach one million sales, three more years for the second million, and now they are selling at one million a year, and this is a vehicle that's interchangeable with current technology vehicles. This is going to take time.

OEM sustainability commitments, and high customer acceptance, can lead us to be optimistic that the market may grow more quickly than conservative business planners might expect. Toyota adds to their FCEV plans a commitment that by 2050 it is going to be a zero emission company in all of their operations. Sustainability is important to Toyota and they hope to their customers, but it is difficult to quantify and is also not sufficient by itself.

- The BMW i vehicles are very sustainable, but that fact doesn't necessarily **greatly influence customers' purchasing decisions.**
- What needs to be done, by OEMs and others, to **generate market pull**? Create purchase incentives, HOV lane access, reduction of cost of vehicle, long term incentives (Federal policy).
- There was concern that we don't see much **advertising** for FCEVs to build public awareness and investor interest. We don't see Toyota Mirai ads because vehicle numbers are limited and Toyota already has backlogs.

Are OEMs scared to move forward to invest more, after already having invested so much money? Should OEMs be funding the infrastructure? It's not the core business for the OEMs. OEMs are in the business of selling cars. If the vehicles are not making money in the early years, building infrastructure in addition to manufacturing the vehicles makes the OEM even less profitable.

The Role of Public Policy

While the Workshop was not specifically designed to explore public policy, except for invited speaker Air Resources Board Executive Officer Richard Corey, it was natural that discussion segued there. Dr. Hirose contributed to this public policy discussion by providing views as a visiting Kyushu professor on the Japanese hydrogen society.

- There's no individual incentive to switch to an alternative fuel car, so it becomes **a regulatory issue** for states and countries to reduce emissions.
- Maybe governments need to **write checks** to seed the transition process, just like DOE and ARPA-E pay for initial construction on new projects.
- Government needs to cradle this new industry if **the industry provides all of these societal environmental, energy security and jobs benefits.**
- Industry needs to **sell to the public** the idea that the public needs to make a larger investment in the sustainable energy economy.
- The financing calculations improve with **government support**, such as with a Low Carbon Fuel Standard (LCFS) and loan guarantee programs.
- Government **policy does stimulate demand**. 20-25% of new car sales would have to be electric drive to meet emission reduction goals, e.g. to meet the 80% CO_2 reduction by 2050 goal, so there's a government need for hydrogen vehicles.

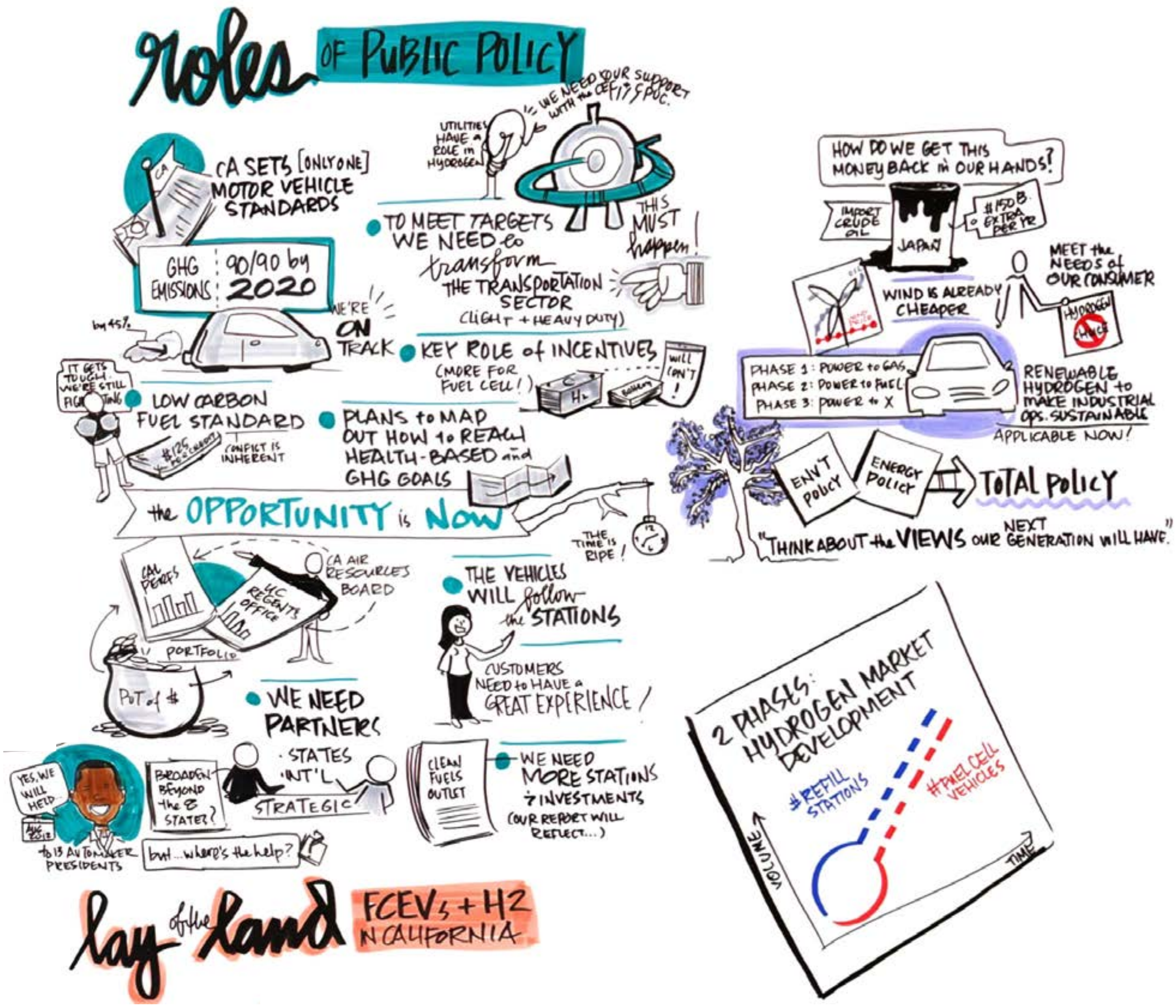
The Hydrogen Society from a Japanese Point of View

Dr. Katsuhiko Hirose of Toyota, "the father of the Prius", provided a high level view of the potential hydrogen society, representing the work he does at Kyushu University. The hydrogen society started 200 years ago when city gas (town gas) was used for lighting streets, with 70% hydrogen content, before electricity. Today, over $400 billion a year leaves the local economies of Europe and is distributed to foreign countries for oil (gasoline), all while wind power pricing is declining to the level of fossil fuel costs, and fossil fuel pricing is much more volatile over the long term. The variability of oil prices and the environmental impact of oil should be part of the economic calculus today.

While striving to meet environmental and energy security goals, car companies can't choose their customers, and they have to provide vehicle options which for some companies include battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs). Almost all car companies are preparing to launch FCEVs. Recent developments in Germany see diesel emissions declining by using renewable hydrogen from power to gas, and this hydrogen can also be used to produce, with CO_2, other fuels. Hydrogen's versatility allows for power-to-gas, power-to-fuel, and power-to-X. Hydrogen and the electric grid will be interconnected, combining fossil and renewable generation, a holistic view that combines the future of environmental and industry policy.

There needs to be a willingness for industry and government to collaborate to obtain the environmental benefit of hydrogen fuel, which will create jobs for our children in the process. Hydrogen solutions can create new jobs, and while initially costing more, they will create long term growth with societal and environmental stability.

The California Air Resources Board has been in existence for 50 years and was created under Governor Reagan. The State has considerable authority and ARB is a public health agency. It is the only agency in the U.S. to establish vehicle and fuel standards, with requirements for 40% reduction in GHGs from transportation, 80% reduction in NOx emissions, and 95% reduction in particulates. Beyond ARB, the air districts each have significant reduction goals.



2016 is a very significant year because the game plan for 2031 will be developed with the State Implementation Plan (Scoping Plan) under AB 32, and will define how to reach GHG reduction targets, including a Sustainable Freight Action Plan. The underlying analysis says California can't meet its targets without transforming the transportation sector, including light duty vehicles and heavy duty freight. Some targets will not be easy to meet, and to meet health-based and GHG-related targets, FCEVs need to be part of the solution.

AB 32

Assembly Bill 32, the California Global Warming Solutions Act of 2006, requires a sharp reduction of greenhouse gas emissions to 1990 levels by 2020.

Today, according to the U.S. Energy Information Administration, there are 200,000 electric vehicles on the road in California, but to grow the number with FCEVs, a more sustainable model for hydrogen stations needs to be developed. And this needs to be done in the context of very mature combustion engine technology that is hard to compete with. Everyone must be weaned off of combustion.

The Low Carbon Fuel Standard sets an important signal for the market since credits are currently valued at $120 per ton CO_2. Investors need to know if this will continue. So the standard needs to be pushed beyond 2020, and be embedded in scoping plan. LCFS authority far beyond 2020 is required. There is a new idea to combine credits to help infrastructure to be bought, which would bring the benefits of future technology to be applied today. The LCFS is on the top of the hit list from detractors, but it used to face an even worse situation. The longer the regulation has played out, the more facts are available, and there's a stronger case today than earlier that the LCFS is working. The volume of renewables in the transportation sector is five times what it used to be.

Comments made in discussions:

- **CALPERS** is a major investment fund in CA for California employees and has a mandate for environmentally preferred investments. But, in the meeting, one person reported that, in a meeting with CALPERS, they indicated that they had not heard of AB 8. It was not part of their calculus. ARB and CEC leadership should educate CALPERS to better understand fuel cell technology and investment needs. CALPERS and Toyota had conversations a few years ago in which Toyota asked for $150,000,000 to support infrastructure, CALPERS told them to come back when the industry needs ½ billion dollars; they don't invest in anything lower.
- The **California University system** has a fund which is directed to invest in environmentally beneficial technology as one component of the endowment for the University of California system.

The ARB Board will host a discussion in December 2016 on how regulations are playing out and what to do post 2025.

Comments made in discussions:

- Part of the issue is that the federal government is dragging its feet, and not helping with support as promised when President Obama and the OEMs came together a few years ago.
- What is the **patience** level at ARB? Will money run out too fast or can the government provide more money long term?
- Does **AB 8** need to be extended? What about **CFO**?

The key is that station rollout needs to accelerate, many more stations need to be constructed and completed, and the State government would love to see an effective business model be created to assure long term viability.

Comments made in discussions:

- **A state hydrogen refueling station mandate** might be considered as part of an extension of AB 8. This could parallel the regulations on vehicle numbers.
- What about the **Clean Vehicle Rebate Program in California**? It was out of money as of the Workshop.
- What relationship does ARB have with the **California Public Utilities Commission**? There's an ongoing "energy principals" coordination effort. The Self Generation Incentive Program has had the CPUC set an emissions threshold – 350 kg per MWH – standard for what is preferred or procured. At CPUC there is a resistance to hydrogen fuel cells and hydrogen energy storage, though there is

Clean Fuels Outlet

The Clean Fuels Outlet (CFO) legislation is a mechanism that would have required oil companies to build hydrogen stations, but then AB 8 was passed, removing the CFO requirement until 2024, and instead providing public funding for stations.

considerable momentum behind batteries. ARB help is needed. The SCAQMD as a big supporter is good, and the CEC is neutral. ARB needs to more clearly engage the CPUC on the requests and issues.

- Utilities see value in BEV charging, but hydrogen can be produced from electricity, which could also present a big opportunity for utilities.
- California legislative efforts are impacted by some players to allow only for batteries. ARB could be a partner to send the right signals. Even within the CEC there's a division, and the solar movement in the state is very anti-hydrogen.

ARB could be a mediator to bridge the divide. Industry needs ARB to help balance what sometimes seems to be a winner and losers approach by the CPUC.

What could be the role of the California utilities? They know about the "duck curve" challenge which results from an ever increasing reliance on intermittent renewables. Hydrogen could be a big opportunity for **energy storage** and for blending of renewable hydrogen with natural gas, though the regulations regarding blending and eligibility for the LCFS may need to change.

Utilities are regulated – CPUC approval is required to get involved, and ARB could provide agency support to the CPUC.

Federal Government

What should industry ask of the Federal government? The discussion of batteries vs hydrogen is everywhere.

Comments made during discussions:

- The Federal level **bipolar BEC and FCEV thinking**, with a heavy BEV presence and negative thinking about fuel cells is unacceptable. Society wins if both systems win.
- With the exception of research and some market transition projects, the Federal government has not helped much at all to develop the FCEV industry. The light duty FCEV **tax credit** of $8,000 has had a short duration extension to the end of 2016 when it and medium and heavy duty tax credits expire.
- Though an earlier loan guarantee program did accept proposals from hydrogen infrastructure projects, the just announced **loan guarantee** program for ZEV infrastructure has no provision for hydrogen fueling.

It is in the state's interest to convince the federal government to expand support of the FCEV industry. California has laid the foundation and brought seven other ZEV states along, which could be used to influence the federal arena.

Comments made during discussions:

- Ask for **long term support** for vehicles and fuel infrastructure incentives to provide confidence to the states and to investors.
- Interest in FCEVs started with **standards and targets** in California. This has to happen at the national level with a likelihood of increasingly stringent requirements.

Industry needs to create a federal and state narrative to build momentum for hydrogen and fuel cells.

Comments made during discussions:

- Government should not create a negative view as happened in 2009 when a new Secretary of Energy came into office and supported mostly battery electric vehicles.
- The new administration needs to understand the value of supporting hydrogen-fueled electric vehicles to the same extent as the current administration supports battery electric vehicles, both viable ZEV options.
- The strategy today should be to approach and **educate senior presidential campaign officials** before ideas get cast by the campaign and early appointed officials.

Public Policy Engagement

Lobbyists need better technology understanding. There is an eight state ZEV alliance, but legislation on vehicles and fuels is not aligned well in those states. Industry needs to connect the infrastructure challenge with existing problems and the ZEV mandate in those eight states.

Comments made during discussions indicated that the message would be two-fold:

- Make the unique **case** for hydrogen while dispelling **myths** perpetrated by "hydrogen haters". A white paper needs to be developed, focused on a clean energy strategy.
- The other message is a **coordinated ask**. The strategy should be to have a big and broad request, and later develop the specifics. Ask for support on the order of $1B for 10 years. Very good talking points are needed.
- A July to February $200,000 work effort is necessary to get the desired policy foundations in place. A **strategy firm** in Washington is necessary for this work, with people from a former administration or former congressional operatives.
- American companies need to **seek support from taxpayer money**, to obtain votes and to create jobs. This industry will build American chains, local brands, local manufacturing, and local jobs. Industry will need to create economic impact and jobs data.

Though the workshop theme was oriented towards less reliance on government funding, alignment of government polices is critical for the industry to continue its investments, for California to continue its support, and for other ZEV states to apply their public resources to this critical energy and environmental opportunity. The need to engage with the presidential campaigns was also made clear.

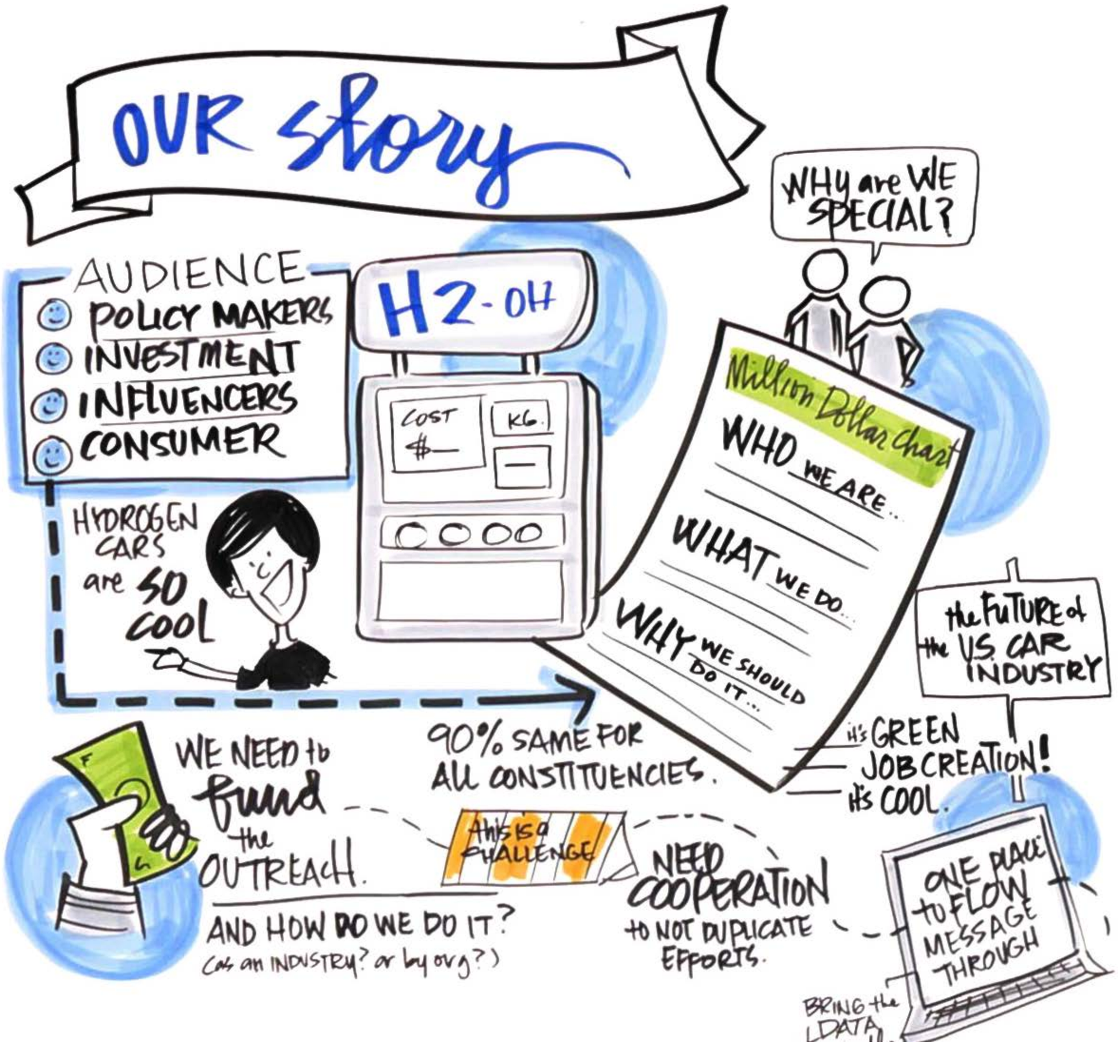
The Story for Hydrogen Fuel Cell Technology – Developing and Communicating It

Messaging is critical for investment successes. The industry needs one chart that everyone can use to lead discussions, which addresses the who, what and why – our elevator pitch. This can be used as an introduction for any White Paper to be used in any meetings with officials.

Comments made during discussions:

- **Consumers** want vehicle attributes that are environmental (green), have a cool factor, and allow for energy independence, long range, short fuel time, and reliability.
- The **policy makers** focus on the environment, energy independence and the effect on the economy.
- The industry has **no clear message**.

The core message needs to be clear and should allow for tweaking for different audiences, e.g. the investment community which focuses on ROI, market, and disruption and innovation (automotive, oil and gas, gas station). That message then needs to be carried by influencers like A-list celebrities and developed through a funded initiative with different components, including an outreach campaign, social outreach, influencers and events. Priorities include the financing of stations, education and outreach, infrastructure rollout and consumer experience.



Comments made during discussions:

- The **stakeholder groups**, which are OEMs, industrial gas and electrolyzer companies and others, need to put realistic money behind an education campaign.
- The **Fuel Cell and Hydrogen Energy Association** (FCHEA) is developing a new campaign, having raised $1,500,000 overall, and will apply about 80% of its effort to the Northeast and 20% to California. The California Fuel Cell Partnership (CaFCP) is also a home for information.

The 1st step would still be to create the message, and then work on the investment community.

Comment made during discussions:

- Air Liquide developed a **new platform for** sharing of energy information on the web and on mobile devices. The comment section allows for the collection of myths and issues which are then used to develop responses.

Hydrogen is not like oil and gasoline, but has a different appeal for customers, allowing for a positive consumer experience because it is clean. In the end, the story needs to engage consumers, investors and communities alike.

The results of this discussion were to highlight how important the hydrogen story is, that it needs to be developed, possibly from available corporate information, and then communicated in a carefully coordinated and aggressive way. It is unclear whether existing programs will do that as needed for the investment community, the target of this Workshop.

Conclusions

The California Hydrogen Business Council created this workshop to tackle the difficult problem of financing the hydrogen infrastructure, and others, with the CHBC, will continue to dive deeper into the possible solutions. This workshop has resulted in the following summary conclusions that may guide future activities to find the best solutions:

- Building out the H_2 fueling infrastructure is a very challenging task.
- In the early days when vehicle numbers are low, the financial economics of station installation and operation are not attractive.
- Eventually station economics will become sufficiently interesting to attract private capital, but that will take a number of years, even in California.
- But in the meantime, substantial government support will continue to be required, both in California and other ZEV states, as well as at the federal level.
- There are various ways that such support could be provided in addition to providing capital grants for station construction and operation, e.g.:
    - Tax incentives
    - Low cost loans
    - Loan guarantees
- There may need to be innovative thinking on the best model for sizing and locating stations:
    - Siting at existing gas stations may not be the best option.
    - Small stations located where vehicle traffic is high, like big box stores, could be attractive.
    - Mobile refuelers and even community and home refuelers are potentially attractive options.
- Creative, compelling stories, and messaging through various social media channels, on the importance of building a fleet of H_2 fueled vehicles and accompanying H_2 fueling infrastructure are a top priority, both for the H_2 industry and the nation.

In the end, it is not only about getting stations funded. The goal is to get hydrogen and fuel cells to be widely accepted energy options for all kinds of energy needs. Hydrogen producers, station developers and auto manufacturers all need to be successful in this.

This workshop started out with a vision and in its development, morphed into something different. It was a very important event, shaping the dialogue on station investment. The diverse group learned and grew a lot in the two short days, and big picture ideas have emerged. But there is no silver bullet yet identified.

Industry needs to:

- Complete the story to be developed, with smart policies and legislative activity defined
- Build an understanding of entrepreneurial investment models, rather than seeking the big idea, and evaluate the new fueling station models
- Build talking points with data to get investors excited

For any new technology, the user experience matters most. The technology (station fueling and cars) needs to be reliable and easy to understand. Fueling is most important and the little things really matter to make this experience positive.

FCEVs have to catch up, since federal public policy and ARRA funding have supported massive electric charging and BEV vehicle buildout, and the recently announced loan guarantee program for infrastructure development continues to target only battery charging stations. FCEVs are now four years behind and working against a big momentum on the BEV side. The next secretary of energy needs to be a fuel cell supporter. Right now, industry needs to look outward and forward, and win key decision makers. Coordination among industry folks is needed to create clear talking points. Without coordination and resources, industry will be unable to shape legislation and regulation. Public policy is key.

Are OEMs willing to share demand information with industry groups? CHBC could use experiential industry information and marketing to build messaging in California where the early markets are.

Venture Capitalists were invited to the workshop, but most were not at the table. The industry has a credibility gap and needs to show them working examples, and clear messages for a successful plan. More hydrogen startup companies are needed but it may be that other investors, not just VCs, are better positioned to lead.

Industry should request performance, environmental and financial data to be collected on the first stations and disseminated to provide investors with key metrics for their decision making.

China is strongly supporting FCEVs, mainly buses in the near term, and the fueling infrastructure. We need to pay attention to what's happening there. We also need to track the activities of oil companies which are more active in Europe and Japan than in the U.S.

A risk sharing chain needs to be developed with gas suppliers, station builders, and OEMs. Gas and auto companies need to help share risk with guys in the middle, the station builder/owner. Otherwise no one will invest.

Breakthrough Energy Coalition should be approached as traditional methods of financing are not working in this area.

Focus on low hanging fruit, ZEV credits, which will keep the technology and industry going until national funding comes down the road.

Try to find a way to get this group back together on a regular basis to report on progress and developments, and engage with the right players both locally and internationally. Schedule a series of meetings to focus on the next steps, messaging and progress in three or six months. At the same time, the group should develop score cards – set objectives, see what works and doesn't work, and keep everyone committed and accountable.

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The authors appreciate the substantial support from Dr. Robert Shaw in helping structure and edit this report.

Appendix A – Participants

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- Julius Basler-Meier, General Manager, BMW Group
- David Bow, Senior Vice President for Sales, Service and Marketing, Proton OnSite
- Steve Cardona, CEO/Founder, Nzyme2HC
- Richard Corey, Executive Officer, California Air Resources Board (CARB)
- Steve Ellis, Manager, Fuel Cell Marketing, American Honda Motor Co., Inc.
- Greg Fleming, ALIAD - Air Liquide Advanced Technologies U.S. LLC
- Ian Gardner, CEO, Clean Tech Institute and California Global Innovation Exchange (CAGIX)
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Appendix B – The Foundation: Reality of Hydrogen Station Economics – Dr. Robert Shaw – Managing Director, Arete Venture Management

The Reality of H2 Station Economics

Prepared
for
Financing the 101st Station Workshop -- June 2016

Dr. Robert W. Shaw, Jr.
Aretê Venture Management

Session Objective

- Create a common understanding of, and agreement on:
  - Important parameters governing H2 Station economics
  - Values those parameters must have to make the economics palatable to investors
- Arrive at a consensus view on whether it is likely that private capital will invest in stations
  - Immediately after the 100^{th} station is installed in California
  - As early vehicle introduction occurs in other states
  - And, if not, how much and for how long will continued government support be needed
- Questions and active discussion are welcome as we go along

Investor Perspective

- There is a lot of capital sloshing around in the economy but investors are pretty hardnosed about analyzing risk-adjusted return before investing.
- As my friend Mike Eckhart, a MD at Citicorp, said in a recent discussion on H2 station investment:
  - » "Equity gets invested when well-informed people see a good return for the risk."
  - » "Debt gets advanced when there is a five year track record of profitability, a net worth greater than the amount of the loan, and a believable story about repayment."

Investor Perspective…

- Different types of investors take different paths to return. For example:
  - Venture capitalists: Take high risk, can tolerate early losses, but must see the prospect for spectacular returns on at least a few deals in their portfolio.
  - Traditional equity market investors: Follow various investment theories (e.g. value, growth, market focus, geographic focus, etc.) but want returns better than average in their segment.
  - YieldCo investors: Will invest equity or debt in a security that aggregates a group of projects with established off-take agreements with credit-worthy customers (mortgages, solar/wind projects).
  - Commercial banks: Cannot tolerate default rates of more than 1% or so; they are risk intolerant and evaluate credit worthiness vigorously.
  - Investment banks: May syndicate high risk debt if their risk/return analysis suggests reasonable probability of attractive return.

H2 Station Economics

- So let's take a hard look at the realities of H2 station economics from an investor perspective.
- Focus first on 200 kg/day stations – similar to traditional gas stations – with delivered H2.
- In Appendix 1 we present a summary of similar analyses for
  - Mobile stations
  - Very small stations (2 kg/day – 10 kg/day) for home / community use

The “Farmer’s Math” Model

- The first step investors take in analyzing the financial viability of any business is usually to construct a simple economic model that captures the impact of a few critical parameters. We call this the “Farmer’s Math” model.
- We know that if the “Farmer’s Math” model doesn’t yield an acceptable economic return, adding more variables most likely will not – a conclusion we affirmed when we ran H2Fast models with similar inputs. (See Appendix 2)

The "Farmer's Math" Model…

- Think of an H2 station business in the simplest possible terms:
  - It's a one-product business – kg of H2
  - The revenue side of the business is driven by:
    - The number of vehicles buying H2 at the station
    - Gross margin/kg on H2 sold – what you can sell it for less what you pay for it
  - On the expense side all the possible costs can be condensed into:
    - Cost of the capital required to site and build the station
    - Total operating and maintenance cost

The “Farmer’s Math” Model…

- This simple model of the H2 station business ignores:
  - Capacity Factor: It assumes the station runs at 100% instead of the usual 70% or less
  - Time to permit and install the station and bring it up to capacity: 1 month installation time and zero time to ramp up is assumed
  - Various fees and taxes: In a venture fund situation (an LLC) the taxes on income would be paid by the various investors
  - Escalations of cost or revenue, and assumes flat dollars over 20 years
- It is designed to establish the boundary conditions, or “must haves”, that have to be met to have any chance of making money.

The "Farmer's Math" Model: Results

- **Base Case**: Suppose there are **100,000 FCEV's** in a reasonably compact geography. If we assume:
  - Clustering sufficient to have **400 vehicles** fueling at each station
  - Then there will need to be only **250 stations**
  - If each vehicle consumes **0.5 kg/day** of H2, then each station will dispense **200 kg/day**
  - Let's suppose the margin on H2 sales is **$3.00/kg**, then each station generates **$600/day of gross profit**, or **$219,000/year**
  - If **O&M costs** are **$100,000/year**, that leaves **$119,000/year** to cover the amortized cost of the station
  - If the station **capital cost** is **$1M**, and a zero down, heavily secured, note with 5% interest over 20 years is available, then payments of about **$80K/year** would be required. Obviously these loan parameters reflect a very optimistic case
  - In this favorable base case, the **operating profit** on each station would be **$39,000/year**, a 3.9% return on invested capital

“Farmer’s Math” Model: Impact of Key Variables

- **Variations on the Base Case**:
  - » If total vehicle numbers and clustering are such that there are only **250 vehicles/ station**, but all else remains the same, then each station dispenses **125 kg/day** for a gross margin of **$375/day** or **$136,875/year**. These stations **lose ($43,125/year)**. If consumption/vehicle is **0.7 kg/day**, the station makes **$11,625/year**
  - » Back to the base case of 400 vehicles/station, if O&M costs are **$125,000/year**, the operating **profit drops** to an unexciting **$14,000**
  - » If the station capital cost is **$1.5M**, and all else remains as in the base case, an annual payment of about **$120,000** leads to a **($1,000) loss**
  - » If all the base case parameters stay the same except for the margin on H2 sales, which drops from $3.00/kg to **$2.00/kg**, the station loses **($34,000/year**)
  - » If there are only **250 vehicles/station**, the gross **margin/kg** is only **$2.00/kg**, the **O&M** costs are **$125,000/year**, and the **capital cost** of the station is **$1.5M**, the result is a ***disaster***

    250 x 0.5 x 2.00 x 365 -125,000 -120,000 = 91,250 - 245,000 = **($153,750)/year**

NOT A VIABLE BUSINESS!

“Farmer’s Math” Model: Impact of Key Variables…

- On the other hand, if one were confident that the base case parameters could be hit and one had $250M available in a venture capital fund to build out those 250 stations all in one year, and did not have to finance them, then the investment would make $39,000 + $80,000 (add back of financing costs) = **$119,000/station/year** or **$29,750,000/year** on the investment in all 250 stations, or **11.9%/year** – a reasonable rate of return on invested capital.
- If one adds back salvage value of $500K/station at the end of 20 years, the IRR improves to 12.9% (assuming no inflation)
- So raising one or more large investment funds to build out the H2 infrastructure in a region might be interesting, if there were a reasonable prospect of getting to 100,000 vehicles quickly. That’s the catch!

The “Farmer’s Math” Model: Conclusions

- The point of this little “Farmer’s Math” exercise is to show that if the stars are properly aligned, H2 stations can make a modest profit, but <u>if any one of the four critical parameters</u>:
  - » Vehicles/station   (400 at 0.5 kg/day)
  - » Margin on H2/kg ($3.00/kg)
  - » O&M cost/year   ($100,000/year)
  - » Capital cost of the station ($1,000,000)

  is not at or better than the reasonably optimistic base case threshold shown, then the economics can range from not exciting to disastrous

Challenges and Recommendations

The major <u>challenges</u> flagged by our "Farmer's Math" model and confirmed by running H2Fast (see Appendix 2) are these:

- On the <u>cost side</u>:
  - » The total <u>**capital cost**</u> of installing a station must be reduced to at most $1M for a 200 kg/day station.
    - – As station capacities increase, if costs do not increase proportionally, that certainly helps a lot, assuming vehicle density increases with station capacity.
    - – Modular drop-in stations and mobile stations that could be mass produced are an attractive option – flexible siting, movable, little site work required.
    - – Very small (2-10 kg/day) residential/community stations will be challenging on the cost side unless mass production can quickly drive cost down, but have clear advantages in early markets.

Challenges and Recommendations…

- Challenges on the cost side…
  - Keeping **O&M costs** below $100K/year is necessary and probably achieveable if
    - The stations are highly automated (station to vehicle/customer communication, automated billing) and can be monitored remotely by a central operator (dispatchable maintenance, customer assistance)
    - Hardware reliability is very high (i.e. long MTBF for all components)

Challenges and Recommendations…

- Challenges on the revenue side:
  - The **margin on H2 sales** must be above \$3/kg, which may be quite challenging (Note: margins on gasoline at the pump are very small).
    - H2 prices at \$8-\$10/kg, perhaps a bit more, would be acceptable to customers seeking fuel price parity on a miles basis if gasoline prices go back to the \$3.50-\$4.50 range
    - Delivered or produced costs for H2 of \$5-\$7/kg are needed to achieve a \$3/kg margin.
    - CGH2 at 500 bar or more can very likely be delivered at this price range if the contracted quantities are substantial, the delivery distance is <50 miles and new high pressure tube trailers are permitted.

Challenges and Recommendations…

- But there will likely be constant pressure between suppliers wanting higher delivered prices and customers wanting lower retail prices.
- With gasoline in the \$2.00-\$3.00/gal range the economics are more challenging unless the FCEV customer is willing to pay a premium price/mile for fuel.
- Ability to produce H2 at the station could help relieve margin pressure if production costs are below delivered cost. Electrolytic production at 1MW scale is getting close, if ¢/kwh costs are reasonable. At, say, 45 kWh/kg the cost of electricity alone (at 10¢/kWh) is \$4.50/kg and the capital cost of the electrolyzer will significantly add to total station cost.

Challenges and Recommendations…

- The really big issue on the revenue side is **vehicle density**.
  - This will require quite a rapid increase in total vehicles sold and preferably clustering of stations around dealerships selling FCEV's in the early days.
  - The latest projections in California are 34,300 vehicles by 2021, and 86 stations (each around 200 kg/day capacity), so vehicle density will be close to the needed 400 vehicles/station, on average, at the end of this period.
  - In other states the ramp up of vehicle numbers to the level required to make the infrastructure economics palatable will likely be difficult without government support.
  - An option to mitigate vehicle density needed is to locate stations at sites where other applications for H2 are available (e.g. material handling, electricity generation).

Challenges and Recommendations…

- Recommendations to address these challenges:
  - » On the <u>cost side</u>:
    - – Support innovative R&D on station design and components aimed at cost reduction. Modular, mass-producible drop-in or mobile stations requiring little or no site work would be one potential approach. Venture funding could be available for initiatives in this area.
    - – Gather data on costs for operations, monitoring and maintenance in the early stations supported by government grants to identify problem areas and opportunities for improvement (see Appendix 3)
    - – Look at innovative ways to reduce site cost/fill – for example siting at big box stores or malls, combining retail stations with other applications for H2.

Challenges and Recommendations…

- On the revenue side:
  - Support intensive development efforts to reduce the cost of hardware (micro-SMR's and electrolyzers) so that H2 can be produced competitively on site in small quantities, giving station owner/operators more control over their gross margin/kg. Venture capital could well find investing in this effort attractive.
  - Look very hard at ways to reduce the cost of production systems that could be used at homes (a small 1-2 kg/day system able to provide 350 bar off the stack, providing a partial fill overnight, would be very attractive if priced in the $5000 range). This could also be a VC play.
  - Provide incentives that would encourage customers to purchase FCEV's in rapidly growing numbers (for example: no sales tax or registration fees on the vehicles; designated/low cost parking spaces; use of HOV lanes, and no tolls, on the highway).

Fundamental Conclusions

- The Good News: **If** the critical economic targets on
  - » Total capital cost of the H2 station: <$1M for a 200 kg/day capacity
  - » Total operating and maintenance costs: < $100K/year
  - » Gross margin on sale of H2 molecules: >$3/kg

  can all be met, which seems very possible over time, then H2 fueling infrastructure could be sufficiently attractive economically to attract private capital, **if** vehicle density per station is sufficient-- 300-400 vehicles/200 kg station capacity– which will clearly happen over time. When it does, capital will be available to grow the station fleet:
    - With eyes on taking integrated infrastructure companies public
    - Or, rolling up stations into "YieldCos"

Fundamental Conclusions…

- The Discouraging News: However, given the relatively slow roll out of vehicles that the OEM's seem to be projecting, it will be challenging to achieve sufficient vehicle density (absolute numbers ***and*** clustering) to construct a business model that will make attracting private capital feasible, ***unless***
  - Governments are willing to continue supporting station build-out.
  - Key players (OEM's, H2 suppliers, and station owners/operators) are willing to enter into binding risk sharing agreements that explicitly reduce investor uncertainty.
  - Investors are willing to accept significant losses in the early years because they see the out year return as very attractive (i.e. the potential to take a station builder/owner/operator public).

Closing Perspective

- Ignoring the challenges that must be faced to achieve economically attractive H2 fueling infrastructure would be a very bad idea.
- If private capital is not willing to invest, then the FCEV option may not have a future, and that would be a tragedy.
- Aggressive cooperative efforts involving governments, auto OEM’s, H2 suppliers, and fueling equipment manufacturers are urgently needed to insure that H2 stations can be built and operated economically.

Appendices

- Appendix 1: "Farmer's Math" analyses for
  - A fleet of 6 Air Products HP-150 mobile refuelers
  - Small (2 Kg/day & 10 Kg/day) home/community H2 refuelers
- Appendix 2: Comparison with H2Fast Model Results
  - Exhibit 1: H2Fast Basic Model run, showing base case results with margin on H2 sales at $4.50/kg
  - Exhibit 2: H2Fast Advanced Model run, showing base case results with margin on H2 sales at $3.00/kg
  - Exhibit 3: Same parameters as Exhibit 2 except margin on H2 sales is $4.50/kg
- Appendix 3: Suggested financial data to be gathered from government supported H2 stations

Appendix 1
"Farmer's Math" Analyses for Mobile and Home Fuelers

In this Appendix we look at "Farmer's Math" calculations for:

» A fleet of 6 Air Products HP-150 mobile H2 fuelers

» Small (2 Kg/day and 10 Kg/day) home/community H2 fuelers

Analysis of Fleet Economics for
Six HP-150's Refilled Once/Day
and Dispensing up to 90 Kg of H2/Day

Number of Vehicles using X kg/day	Kg of H2 used per month	Revenues/month with margins on fuel sales of		Fueler Rental costs/month (6 units)		Range of Profit or (Loss) per month	
		$3/kg	$5/kg	Low	High	Worst	Best
100							
X = 0.50	1,500	$4,500	$7,500	$30,000	$90,000	($85,500)	($22,500)
X = 0.75	2,250	$6,750	$11,250	$30,000	$90,000	($83,250)	($18,750)
250							
X = 0.50	3,750	$11,250	$18,750	$30,000	$90,000	($78,750)	($11,250)
X = 0.75	5,625	$16,875	$28,125	$30,000	$90,000	($73,125)	($1,875)
400							
X = 0.50	6,000	$18,000	$30,000	$30,000	$90,000	($72,000)	$0
X = 0.75	9,000	$27,000	$45,000	$30,000	$90,000	($63,000)	**$15,000**
1,000							
X = 0.50	15,000	$45,000	$75,000	$30,000	$90,000	($45,000)	**$45,000**
X = 0.75	16,200*	$48,600	$81,000	$30,000	$90,000	($41,400)	**$51,000**

* The HP-150's can only dispense 16,200 kg/month (90x6x30) unless
the units can be re-supplied more frequently than once/day.

Analysis of Home / Community
H2 Fueling Units

Unit Size		2 Kg/Day		10 Kg/Day
Vehicles Fueling (@ 0.5 kg/day)		4		20
Cost to produce fuel electrolytically 45 kW/kg @$0.10/kWh =$4.50/kg		$3,285/year		$16,425/year
Maintenance Contract & Insurance		$2,000/year		$6,000/year
Total Operating Cost		**$5,285/year**		**$22,425/year**
Savings on purchased H2 (@$10/kg)		$7,300/year		$36,500/year
Operational Savings (Total operating cost minus savings on purchased H2)		$2,115/year		$14,075/year
Return if pay $X cash for unit				
	X = $10,000	21.20%	X = $50,000	28.20%
	X = $25,000	8.50%	X = $125,000	11.30%
	X = $50,000	4.20%	X = $250,000	5.60%
Breakeven Price if owner has to take out a 5% 20-year loan		~$27,000		~$178,000

Appendix 2
Comparison with H2Fast

In this Appendix we look at how the “Farmer’s Math” assumptions play in the H2Fast model:

- First the Basic Version in which a lot of assumptions are hidden
  - The base case assumptions led to a negative IRR
  - Increasing the H2 gross margin from \$3.00/kg to \$4.50/kg brings the IRR up to 11.3% (Exhibit 1)

Exhibit 1

Spreadsheet Version | </> Share/Embed

H2FAST

About

Station Inputs

Installation time [months]	1
Demand ramp-up [years]	0
Station type:	Delivered Gaseous H2
Long-term station utilization [%]:	100
Vehicle refills [refills/day]:	50
Hydrogen per refill [kg]:	4
Total capacity [kg/day]:	200
Hydrogen price [$/kg]:	10
Equipment capital cost [$]:	1000000
Total installation cost [$]:	0
Planned and unplanned O&M costs [$/yr]:	100000

Scenario Inputs

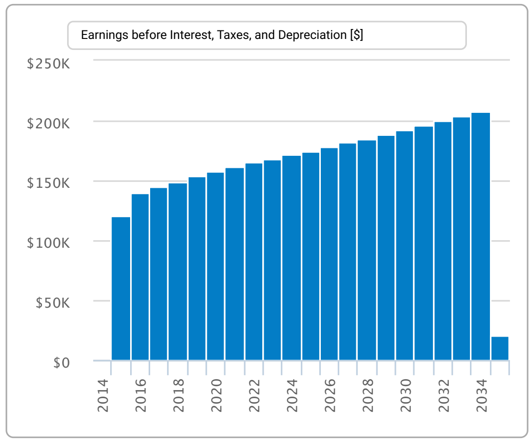
Capital incentive [$/station]:	0
Initial production incentive [$/station]:	0
Annual decrement of production incentive [$/station]:	0
Incidental revenue [$/year]	0
Cost of delivered hydrogen [$/kg]	5.5
Cost of electricity [$/kWh]	0.12
Cost of natural gas [$/mmBTU]	8

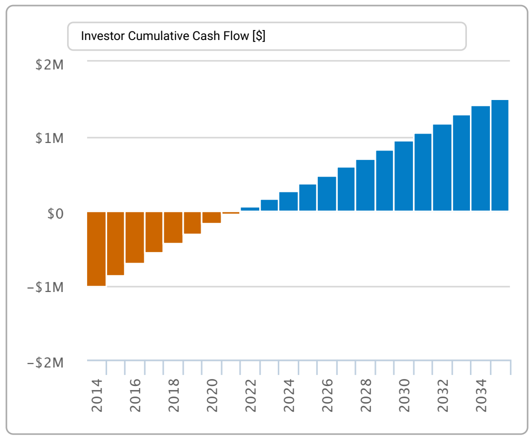
Financing Inputs

Debt interest rate [%]:	0
Minimum debt to equity ratio:	0

Reset Inputs

Internal Rate of Return [% / year]:	11.3
Break-Even Hydrogen Price [$ / kg H_2]:	$9.79
First Year Positive EBITD:	2015
Investor Payback Period [years]:	8
NPV:	$87115





Download Results CSV

Comparison with H2Fast…

- Next let's look at the <u>Advanced Version</u> of H2Fast, in which essentially all of the assumptions can be adjusted
  - With all of the other cost parameters (credit card fees, sales tax, etc.) left in the base case IRR was only 2.7%, considerably less than the 11.9% IRR result from the "Farmer's Math" model; but with H2 gross margin raised to $4.50/kg the IRR is 12.91% (See Exhibits 2&3)
  - When all the extraneous expenses except income tax were set to zero, the IRR jumped to 7.72% with base case inputs. If income tax is eliminated at the fund level, then IRR is 9.53%, still less than "Farmer's Math" result of 11.9% IRR with similar inputs

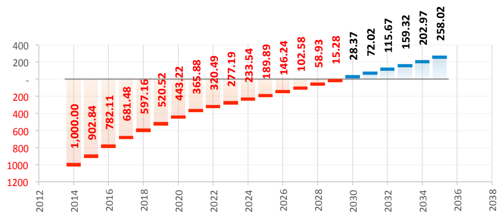
Exhibit 2

H2FAST: Hydrogen Financial Analysis Scenario Tool

Overall Financial Performance Metrics	Restore defaults
Leveraged, after-tax, nominal IRR	2.70%
Investor payback period	16 years
First year of positive EBITD	analysis year 1
After-tax, nominal NPV @ 10% discount	$ (380,575)
Estimated break-even leveraged price ($/kg)	$ 10.56

Chart Selector & Description	Toggle chart labels
Cumulative investor cash flow	
Investor contribution + previous year investor contribution	

Station 2: Cumulative investor cash flow, (Thousands)



Station(s) Information	
Select interface type	Basic / Advanced
Enter number of stations to model	6
Total dispensing capacity (kg/day)	200
Equipment capital cost	1,000,000
Installation cost	-
Planned & unplanned maintenance ($/year)	100,000
Maintenance escalation (% annually)	0.0%

Multi-Station Inputs			
Select station(s) to analyze	2		
Station being analyzed (yellow background)	1	2	3
Station type	Delivered gas	Delivered gas	Delivered gas
Total dispensing capacity (kg/day)	100	200	300
Equipment capital cost	$ 930,156	$ 1,000,000	$ 1,000,000
Installation cost	$ 213,936	$ -	
Planned & unplanned maintenance ($/year)	$ 82,852	$ 100,000	$ 100,000
One time capital incentives (grant or ITC)	$ -	$ -	$ -
Annual operating incentives (grant or PTC)	$ -	$ -	$ -
Annual incidental revenue	$ -	$ -	$ -

Incentives Information	
One time capital incentives (grant or ITC)	$ -
Annual operating incentives (grant or PTC)	$ -
Operating incentives decay rate (%/year)	10%
Operating incentives sunset (years)	10
Incidental revenue	$ -
Incidental revenue escalation rate (%/year)	0.0%

Demand Projection	$ 4.06
Price of hydrogen at project onset ($/kg)	9.50
Project start year	2015
Price escalation rate (% annually)	0.00%
Installation time (months)	1
Demand ramp-up (years)	0.0
Long-term nominal utilization (%)	100%

Feedstock Information	
Cost of delivered hydrogen ($/kg)	$ 6.50
Escalation rate of hydrogen cost (% annually)	0.0%
Price of electricity ($/kWh)	$ 0.120
Escalation rate of electricity cost (% annually)	0.0%
Price of natural gas ($/mmBTU)	$ 8.00
Escalation rate of natural gas cost (% annually)	1.9%

Other operating expenses	
Credit card fees (% of sales)	2.50%
Sales tax (% of sales)	2.25%
Road tax ($/kg)	$ -
Road tax escalation rate (%/year)	1.90%
Staffing labor hours (h/year-station)	-
Labor rate ($/h)	$ 40
Labor escalation rate (% annually)	1.9%
Licensing & permitting ($/year-station)	$ -
Licensing & permitting escalation rate (%/year)	1.9%
Rent of land ($/station-year)	$ -
Rent escalation (% annually)	1.9%
Property insurance (% of dep capital)	0.0%
Selling & administrative expense (% of sales)	0.0%

Financing Information	
Project operational life (years)	20
Total tax rate (state, federal, local)	38.50%
Is installation cost depreciable?	No
Are operating incentives taxable?	No
Is capital incentive depreciable?	Yes
Are tax losses monetized (tax equity application)	Yes
Allowable tax loss carry-forward	7 year
General inflation rate	0.00%
Depreciation (MACRS)	7 year
Leveraged after-tax nominal discount rate	10.0%
Debt/equity financing	0
Debt type	Revolving debt
If loan, period of loan (years)	20
Debt interest rate (compounded monthly)	6.00%
Cash on hand (% of monthly expenses)	100%

Real levelized values ($/kg H_2)

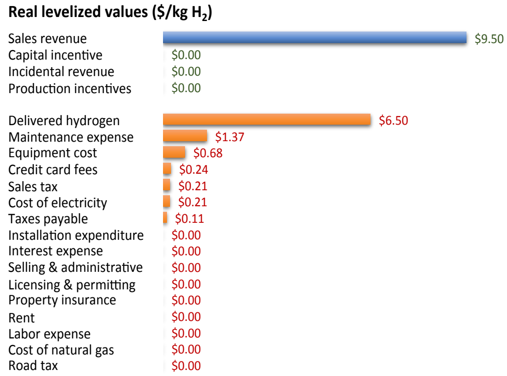


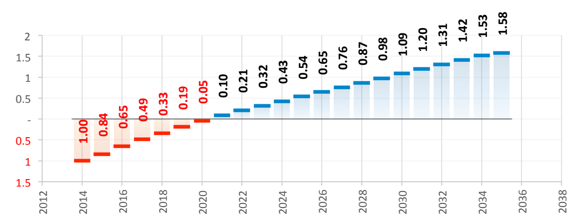
Exhibit 3

H2FAST: Hydrogen Financial Analysis Scenario Tool

Overall Financial Performance Metrics	Restore defaults
Leveraged, after-tax, nominal IRR	12.91%
Investor payback period	7 years
First year of positive EBITD	analysis year 1
After-tax, nominal NPV @ 10% discount	$ 181,412
Estimated break-even leveraged price ($/kg)	$ 9.50

Chart Selector & Description	Toggle chart labels
Cumulative investor cash flow	
Investor contribution + previous year investor contribution	

Station 2: Cumulative investor cash flow, (Millions)



Station(s) Information	
Select interface type	Basic / Advanced
Enter number of stations to model	6
Total dispensing capacity (kg/day)	200
Equipment capital cost	1,000,000
Installation cost	-
Planned & unplanned maintenance ($/year)	100,000
Maintenance escalation (% annually)	0.0%

Incentives Information	
One time capital incentives (grant or ITC)	$ -
Annual operating incentives (grant or PTC)	$ -
Operating incentives decay rate (%/year)	10%
Operating incentives sunset (years)	10
Incidental revenue	$ -
Incidental revenue escalation rate (%/year)	0.0%

Demand Projection	$ 4.06
Price of hydrogen at project onset ($/kg)	10.00
Project start year	2015
Price escalation rate (% annually)	0.00%
Installation time (months)	1
Demand ramp-up (years)	0.0
Long-term nominal utilization (%)	100%

Feedstock Information	
Cost of delivered hydrogen ($/kg)	$ 5.50
Escalation rate of hydrogen cost (% annually)	0.0%
Price of electricity ($/kWh)	$ 0.120
Escalation rate of electricity cost (% annually)	0.0%
Price of natural gas ($/mmBTU)	$ 8.00
Escalation rate of natural gas cost (% annually)	1.9%

Other operating expenses	
Credit card fees (% of sales)	2.50%
Sales tax (% of sales)	2.25%
Road tax ($/kg)	$ -
Road tax escalation rate (%/year)	1.90%
Staffing labor hours (h/year-station)	-
Labor rate ($/h)	$ 40
Labor escalation rate (% annually)	1.9%
Licensing & permitting ($/year-station)	$ -
Licensing & permitting escalation rate (%/year)	1.9%
Rent of land ($/station-year)	$ -
Rent escalation (% annually)	1.9%
Property insurance (% of dep capital)	0.0%
Selling & administrative expense (% of sales)	0.0%

Financing Information	
Project operational life (years)	20
Total tax rate (state, federal, local)	38.50%
Is installation cost depreciable?	No
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Debt/equity financing	0
Debt type	Revolving debt
If loan, period of loan (years)	20
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i

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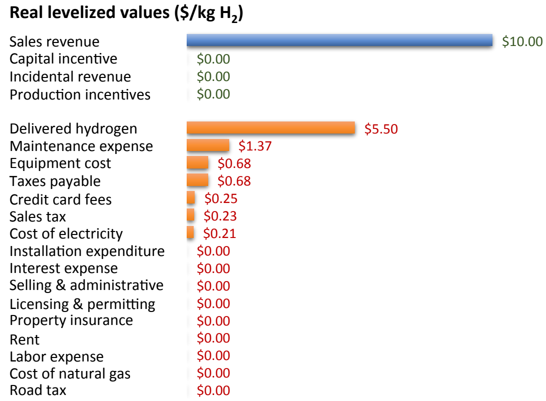
One time capital incentives (grant or ITC)	$ -	$ -	$ -
Annual operating incentives (grant or PTC)	$ -	$ -	$ -
Annual incidental revenue	$ -	$ -	$ -

Real levelized values ($/kg H_2)



Comparison with H2Fast…

- The important point here is that the investment return results from a more complete model like H2Fast are uniformly less attractive than those from the very simple “Farmer’s Math” model. So the base case parameters set the boundary conditions for any reasonable hope to achieve an acceptable return

Appendix 3

Suggested financial data to be gathered from government supported H2 stations

Appendix 3

Suggested Requirements for Reporting
Financial/Performance Data for Each H2 Fueling Station

1. Capital Costs: Both for initial construction and later additions (i.e. more storage, increased capacity, equipment upgrades)
   - Component level costs for all station equipment, e.g.
     - » Compressor(s)
     - » Chiller
     - » Dispenser
     - » Storage tanks: CGH2/LH2
     - » Monitoring and control equipment
     - » On site H2 production equipment if appropriate
     - » Containment/building(s)/trailers as appropriate; other
   - Site work, broken out in detail
   - One time costs of energy supply (e.g. electric connection)
   - Permitting and approval costs; other

2. Hydrogen Costs and Pricing: by calendar quarter
   - Delivered cost/kg if appropriate, specifying
     - » Mode of delivery: tube trailer, liquid carrier, pipeline, other
     - » Typical kg/delivery if appropriate
   - Cost of production if H2 is produced on site: by electrolysis or with small SMR
   - Price charged to customer/kg
   - From which gross margin/kg on H2 sales can be determined

3. Operating Costs (other than H2): At a detailed quarterly income statement level, including as appropriate
   - Labor: salaries and benefits
   - Rents/lease costs: e.g. land, equipment, etc.
   - Energy (electricity, natural gas, propane)
   - Insurance
   - Taxes, if any
   - Maintenance of capital equipment
   - Services (e.g. site cleaning, snow removal, etc.)
   - Other (e.g. incentive awards, bad credits, theft, damage)

4. Cost of Capital
   - By financing source (debt: senior, junior; equity: common, preferred; grant, gift, internal corporate capital)
   - How measured if appropriate: interest, shares (price/share)

5. Operations Data:
   - Total unique vehicles filled or served/day: recorded daily, reported quarterly
   - High, low, and average amount/fill
   - Total kg of H2 sold/day, reported quarterly
   - Daily sales: average, maximum, minimum, per quarter
   - Station capacity factor: each quarter
   - Annual return (or loss) on total invested capital (including grants)

Appendix C – Wide-scale Station Roll-out Planning – Dr. Joan Ogden – Professor, Institute of Transportation Studies, UC Davis

H2 Fuel Cell Vehicle Transition: Infrastructure Build-Out Scenarios for the US

Prof. Joan Ogden,
Institute of Transportation Studies
University of California, Davis
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Presented at the Financing 101st Station Workshop
California Hydrogen Business Council
Pasadena, California
June 14, 2016

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H2 FCV TRANSITION IN THE US 2015-2035

- What are required investments in vehicles and infrastructure
  - To provide initial infrastructure
  - to bring vehicles and fuel to breakeven “competitiveness” with incumbents
  - to fully build out fuel infrastructure
- What are subsidies might be needed to support this transition and possible policies?

This is a partial analysis. We also do not address a transition to low carbon primary sources for hydrogen

ANALYZE US NATIONAL H2 FCV ROLLOUT SCENARIO AS A SERIES OF REGIONAL ROLLOUTS

- Introduce H2 in Series of 60 Lighthouse Cities by 2035

  5 cities 2016-2020

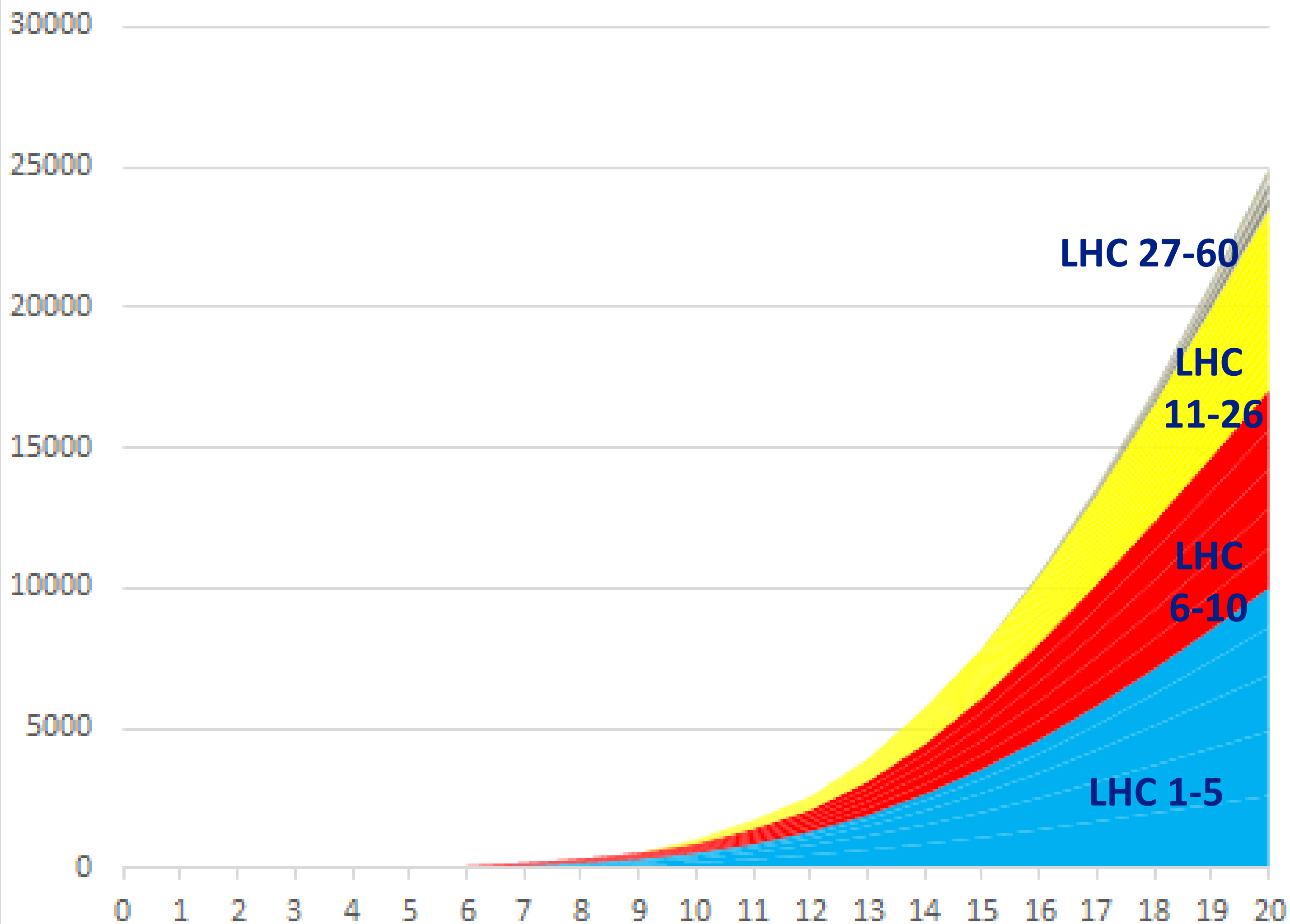
  +5 cities 2021-2025

  +16 cities 2026-2030

  +34 cities 2031-2035
- Scenario for number of FCVs in each city => H2 Demand
- Design H2 Network in Each City Based on Cluster strategy: Stations with Truck Delivery, Onsite Production
- Find station investment ($), H2 cost ($/kg) vs. time
- Aggregate to Get National Numbers

Introduce H2 FCVS in Series Of 60 "Lighthouse Cities"

Station Costs and Infrastructure Design Based On Regional Rollouts (H2 FCVs = 7% of on-road US LDVs in 2035)

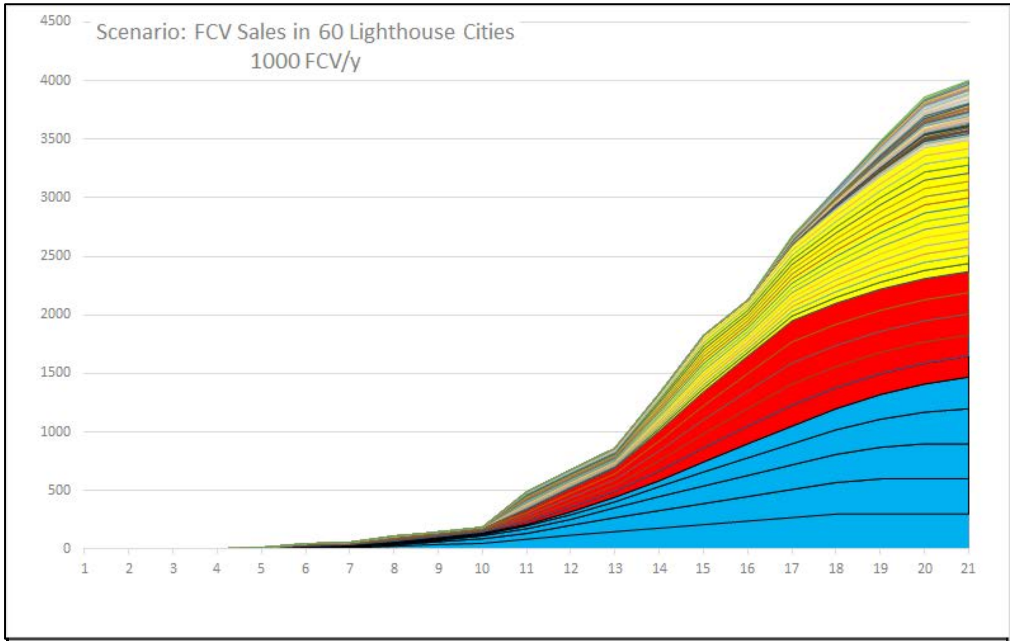


Year of Introduction

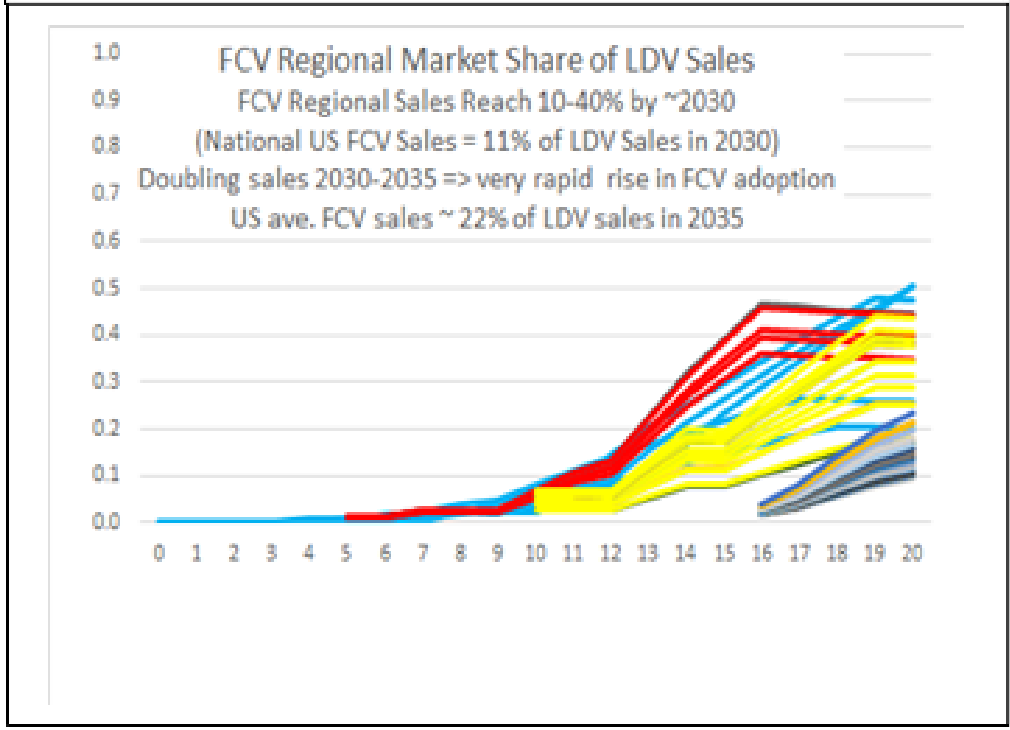
UCDAVIS SUSTAINABLE TRAN

SALES IN LIGHTHOUSE CITIES

#FCV Sales/Year



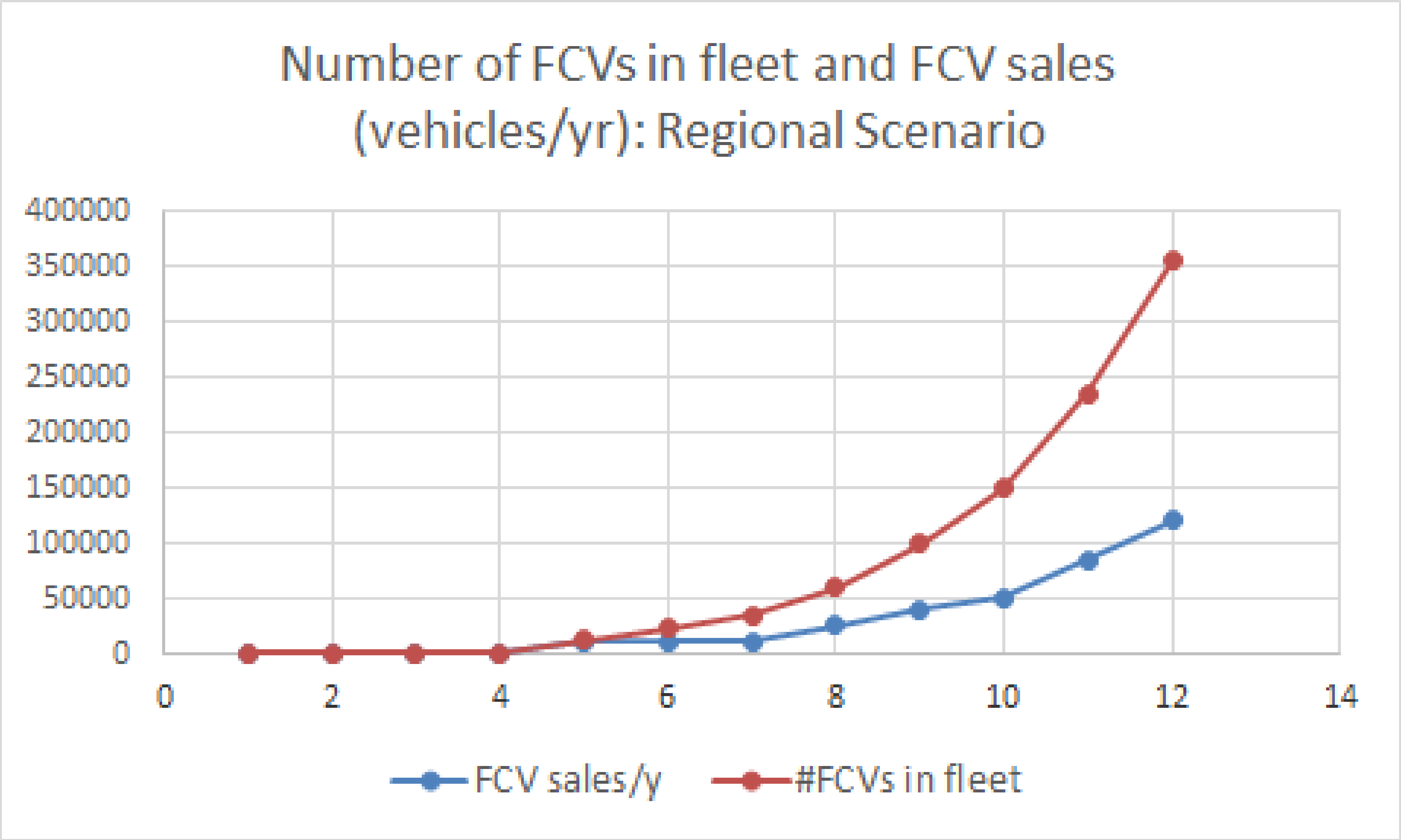
FCV Sales Fraction in Each Regional Market



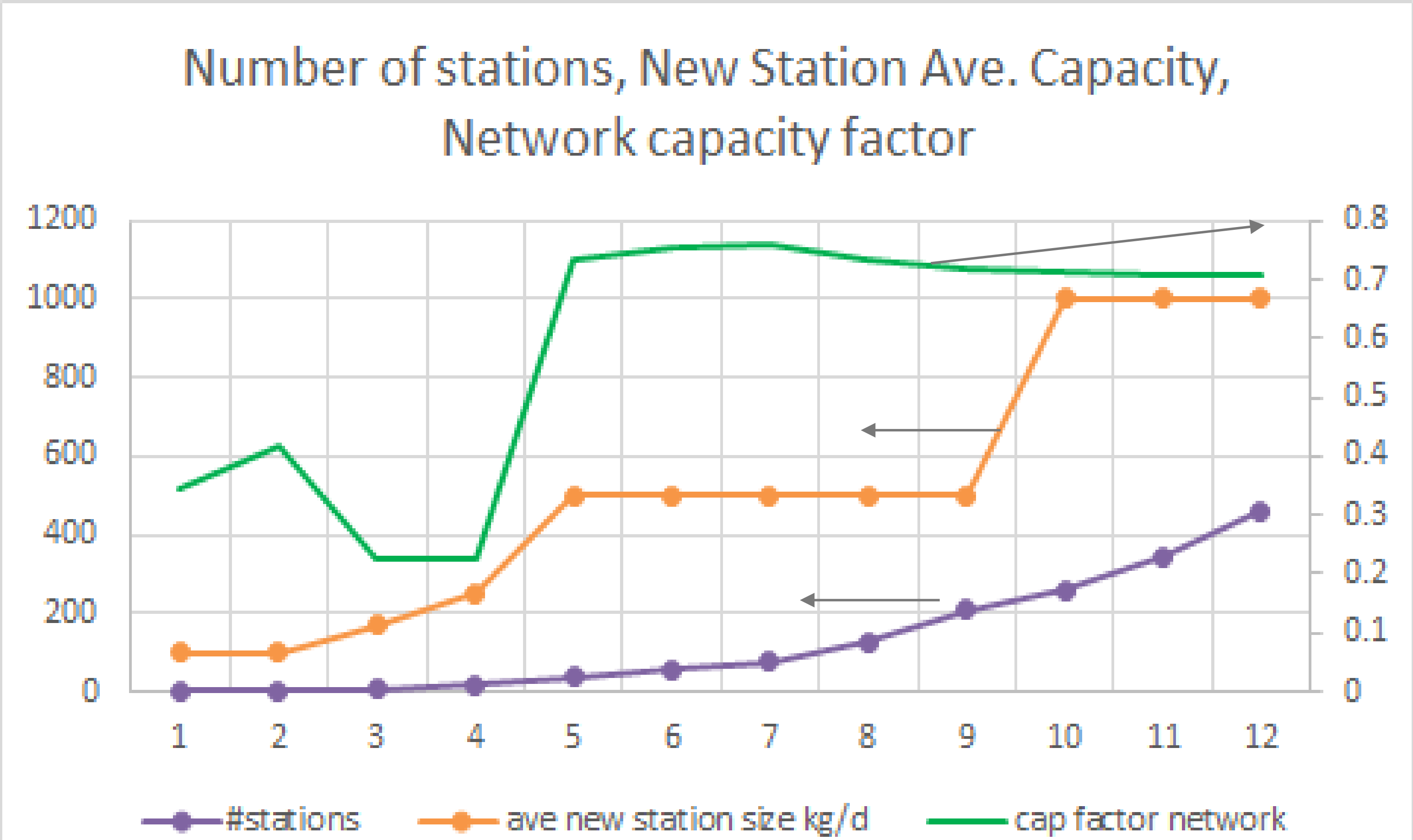
2035 FCV LDV Market Shares
US 22%; Regional 10-40%

UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

How Much Investment is Needed to Launch Infrastructure? Regional Scenario for I H2 FCV Rollout Years 1-12



Regional Scenario for station rollout to year 12

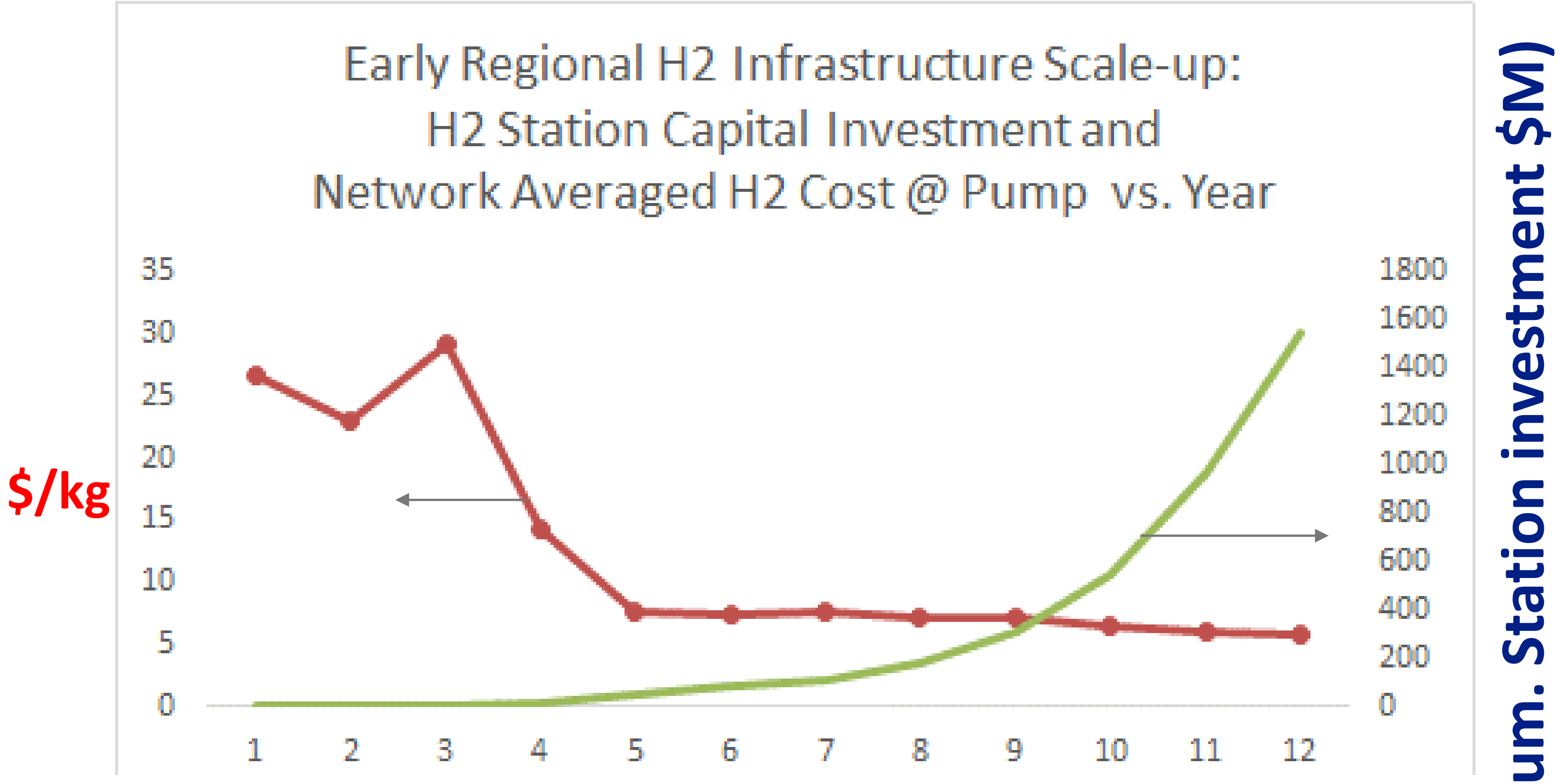


At first, network capacity factor low, as stations are built ahead of vehicle deployment. In first few years stations small, located to provide coverage for early adopters

H2 Station Cost Assumptions.

	Capital Cost	Annual O&M cost $/yr
Compressed gas truck delivery		
<u>Phase I (year 1-2)</u> 100 kg/d -> 170 kg/d 250 kg/d	 $1 million $1.5 million	$100 K (fixed O&M) + 1 kWh/kgH2 x kg H2/yr x $/kWh (compression elec cost) + H2 price $/kg x kg H2/y (H2 cost delivered by truck)
<u>Phase 2 (year 3-5)</u> 100 -> 170 kg/d 250 kg/d	 $0.9 million $1.4 million	Same as above
<u>Phase 3 (year 5+)</u> 100 -> 170 kg/d 250 kg/d 400 -> 500 kg/d	 $0.5 million $0.9 million $1.5-2 million	Same as above
Onsite SMR(phase3) 1000 kg/d	$4.4 million	$524,000 (fixed O&M)+ 0.154 MBTU NG/kgH2 x NG price ($/MBTU) + 3.08 kWh/kg x elec price ($/kWh)

Investment to launch regional H2 fuel supply



$100-300 million capital investment for ~100-200 stations (serving 50,000-100,000 FCVs) to reach H2 <$7/kg, Assumes FCV market grows rapidly.

This Regional Analysis roughly consistent w/2015 CA Joint Report but differences too.

Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California

California Energy Commission

California Air Resources Board

Edmund G. Brown Jr., Governor

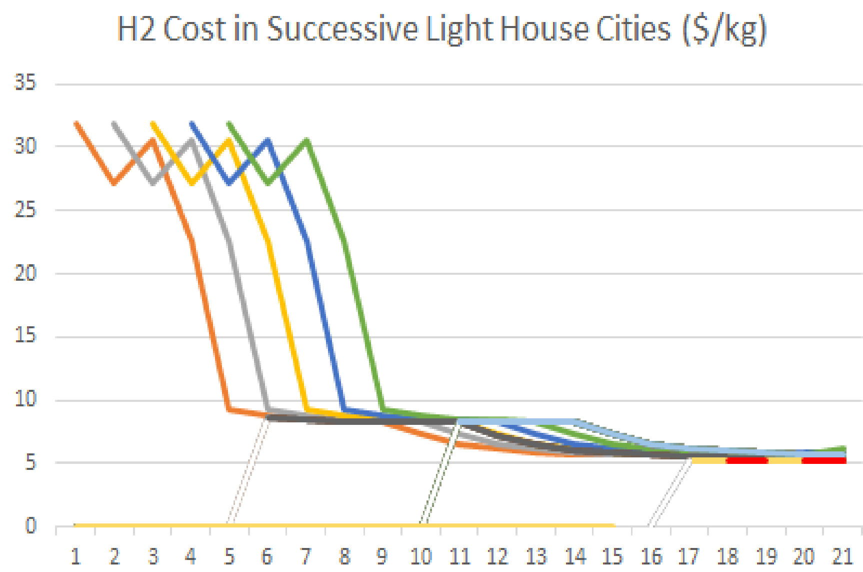
December 2015 | CEC-600-2015-016

Table 4: Summary of 49 Hydrogen Fueling Stations and Technologies Funded with Energy Commission ARFVTP Funding

Station Developer	No. of Stations Funded	Station Technology	Technology Provider	Average Daily Capacity (kg/day)	Total Station Cost ($ million)	Levelized Costs ($/kg)
FirstElement	19	Delivered Gaseous H2	Air Products and Chemicals	180	2.05	$13.00
Air Products and Chemicals	10	Delivered Gaseous H2	Air Products and Chemicals	180	1.93	$12.40
Linde	7	Delivered Liquid H2	Linde	350	2.78	$9.90
HyGen	3	On-Site Electrolysis	Giner	130	3.25	$24.00
Air Liquide	2	Delivered Gaseous H2	Air Liquide	180	3.26	$13.80
ITM Power	1	On-Site Electrolysis and Delivered H2	ITM Power	100	2.73	$22.70
H2 Frontier	1	On-Site Electrolysis	ITM Power	100	4.61[2]	$33.30
HTEC	1	On-Site Electrolysis and Delivered H2	McPhy	140	3.25	$17.90
Ontario CNG	1	On-Site Electrolysis	Hydrogenics	100	2.51	$18.30
Upgrade Stations						
H2 Frontier (Burbank)	1	On-Site SMR[1]	H2GEN	100	0.93 [4]	NA[3]
Air Liquide (L.A. - Aviation Blvd)	1	On-Site SMR and Delivered H2	Air Liquide	180	2.12 [4]	NA
TBD	1					NA
Shell Equilon (Torrance)	1	Pipeline Delivery	Air Products and Chemicals	200	2.47[4]	NA
Totals	49			9,260		

McKinney, Jim, et al. 2015. *Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California.* California Energy Commission. Publication Number: CEC-600-2015-016.

H2 cost in successive cities and US ave. H2 cost



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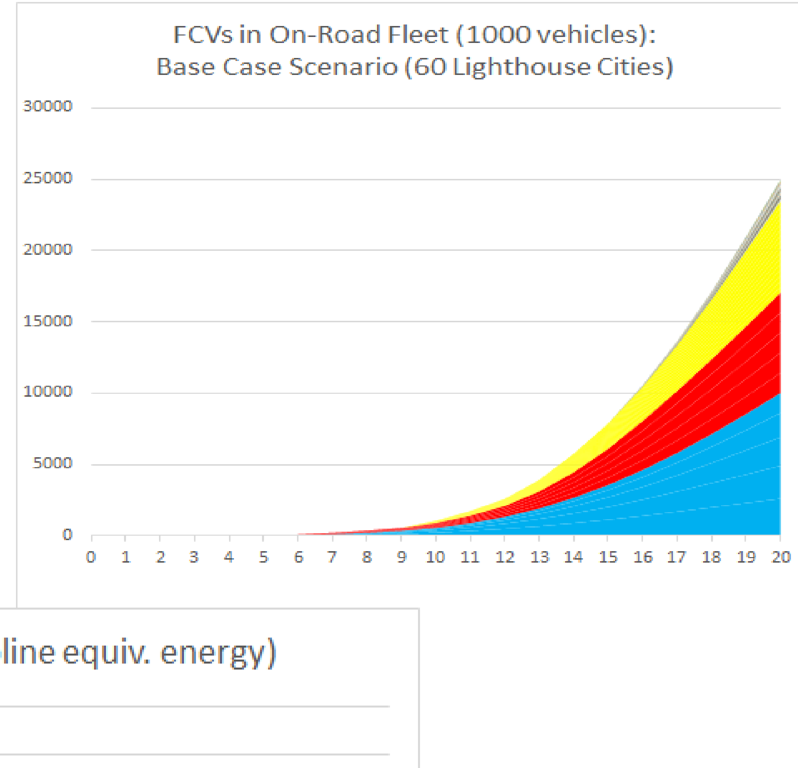

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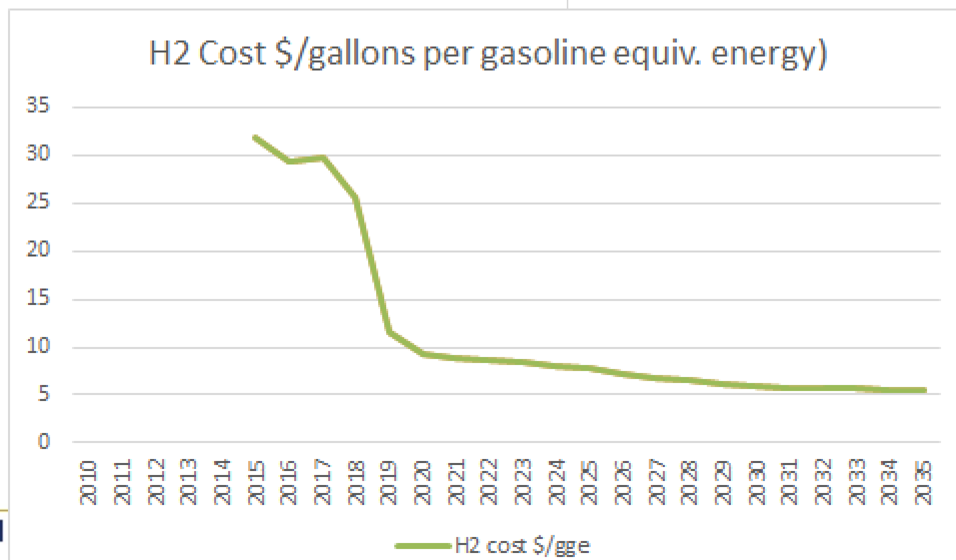
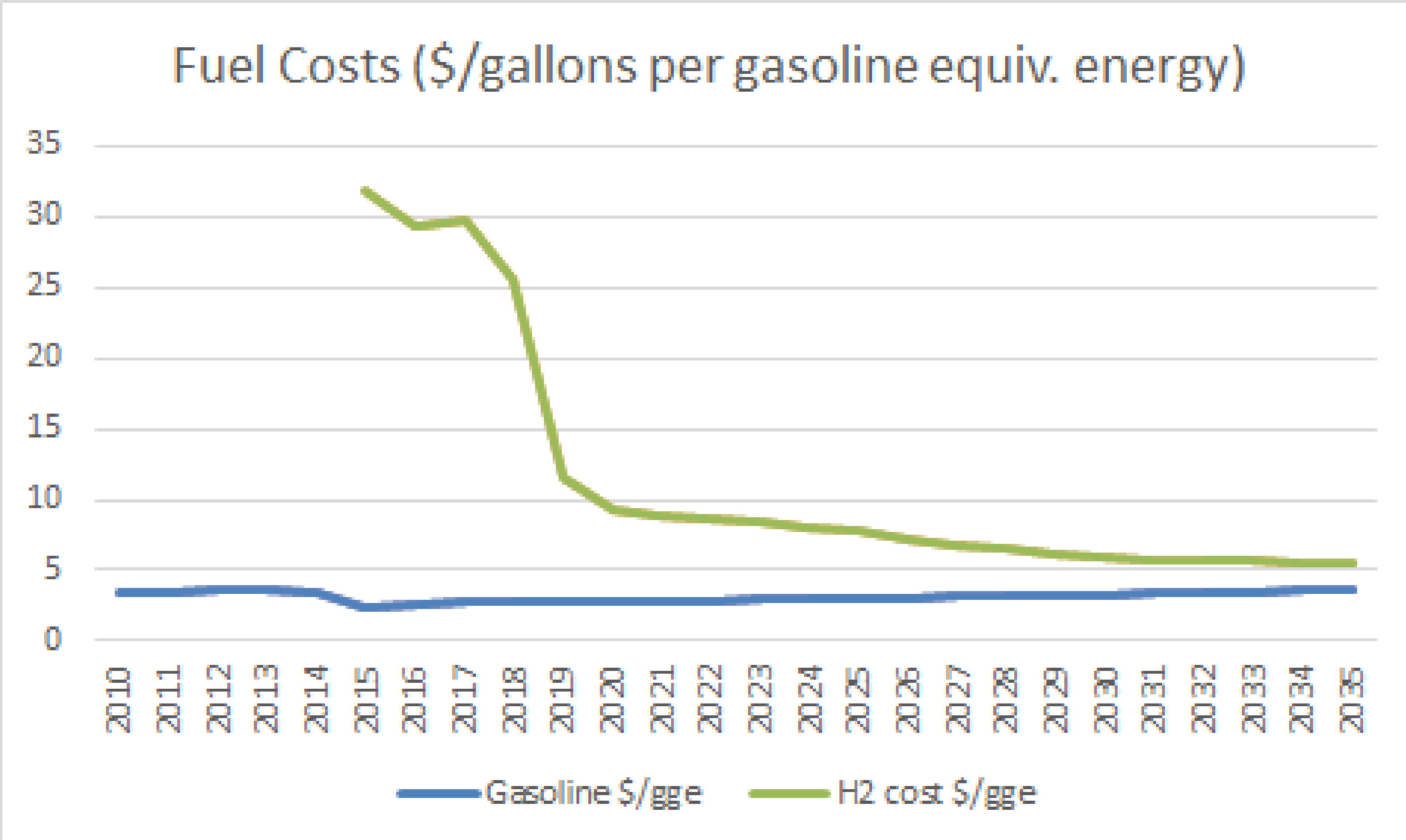


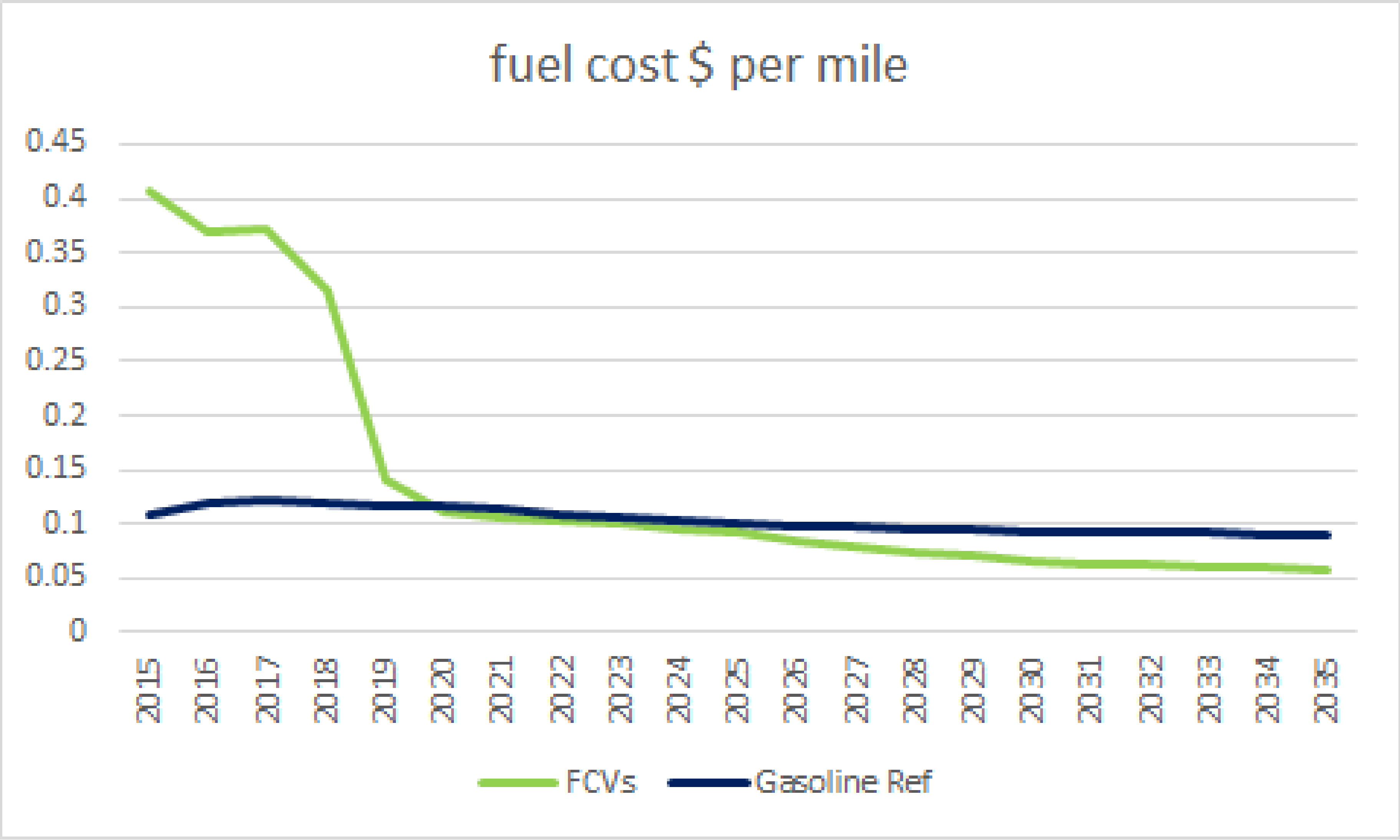
US Average Estimated Fuel Cost ($/gallon gasoline eq.)

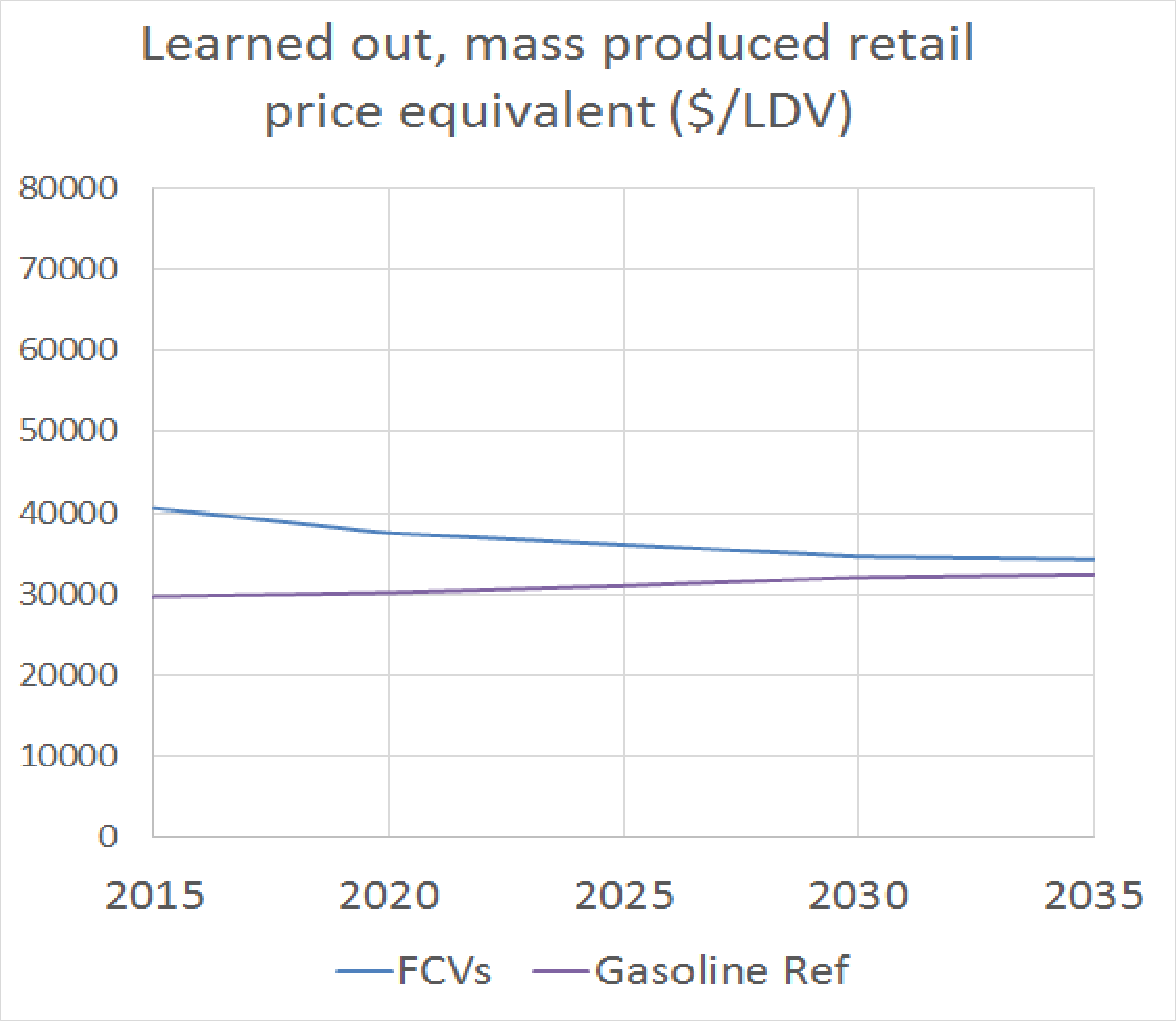


UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

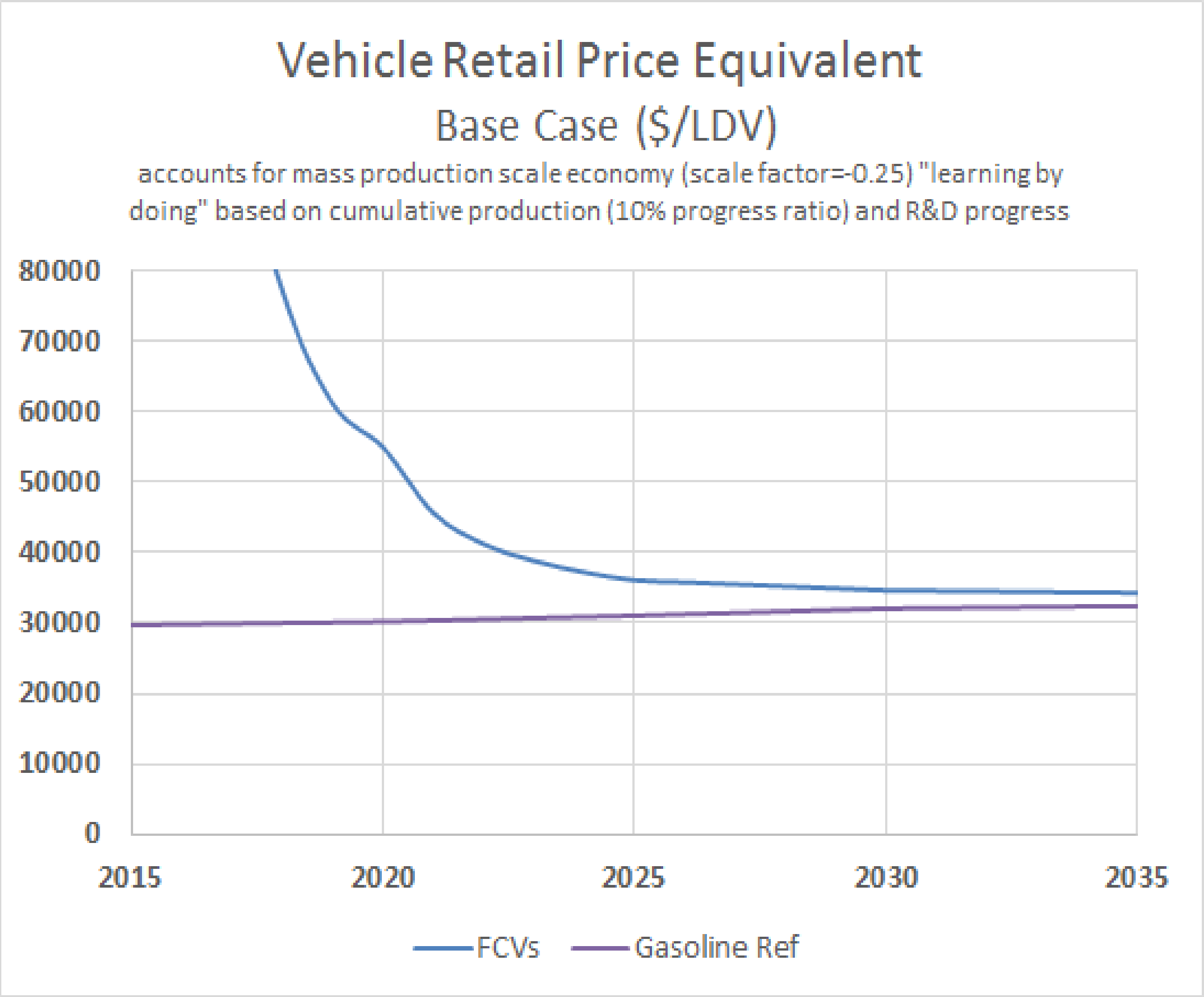
Estimated "Fuel Cost Breakeven" ($/mile)

FCV (H2 US ave.) < gasoline ICEV after ~2024



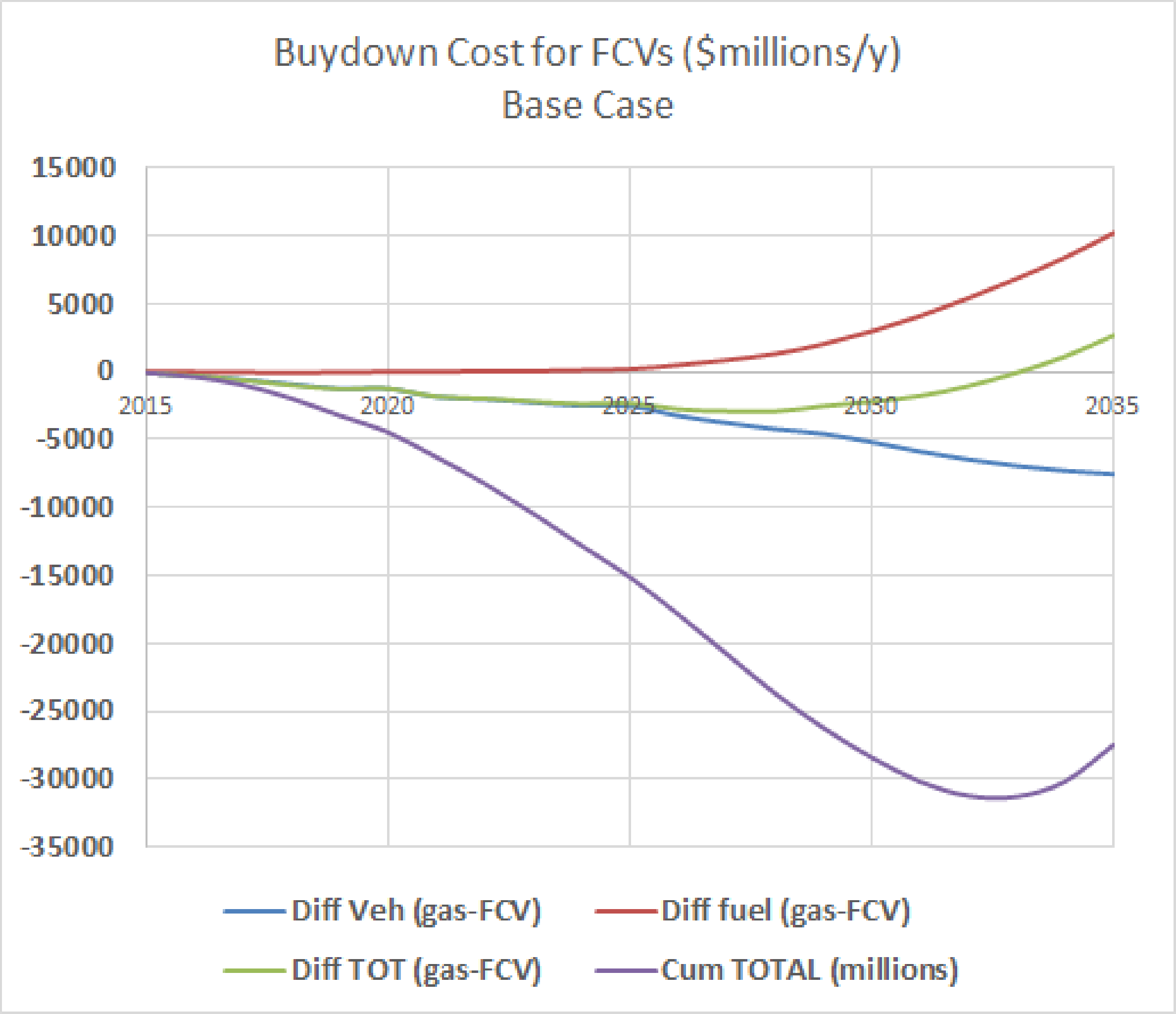


Based on NRC 2013 vehicle costs



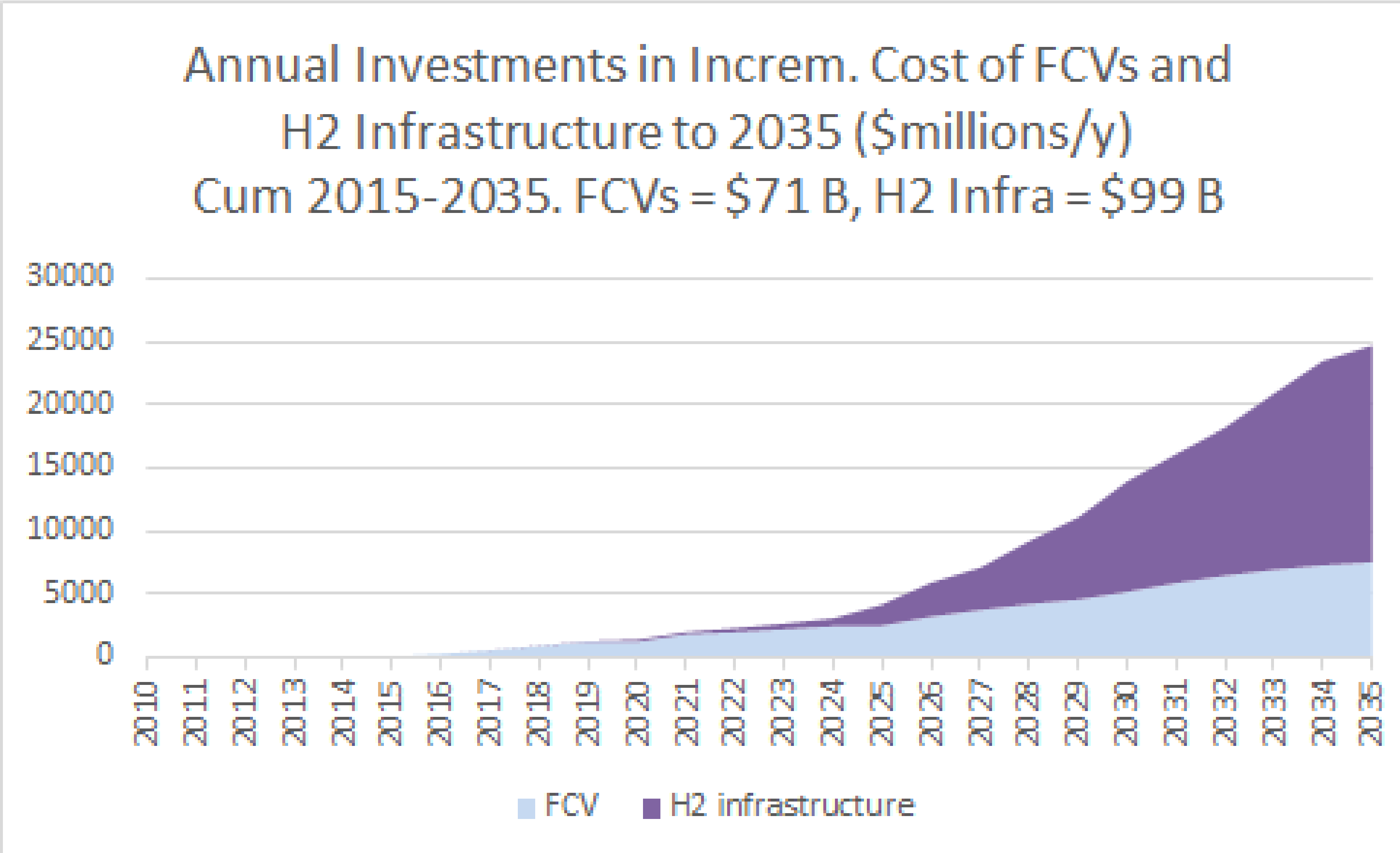
Based on NRC 2013 vehicle costs, accounting for dis-economies of small-scale, early vehicle production (scale elasticity = -0.25)

Define "Vehicle Breakeven" when fuel savings > extra cost of FCVs compared to gasoline ref. vehicle H2 FCV breakeven in 2032, ~15 million FCVs

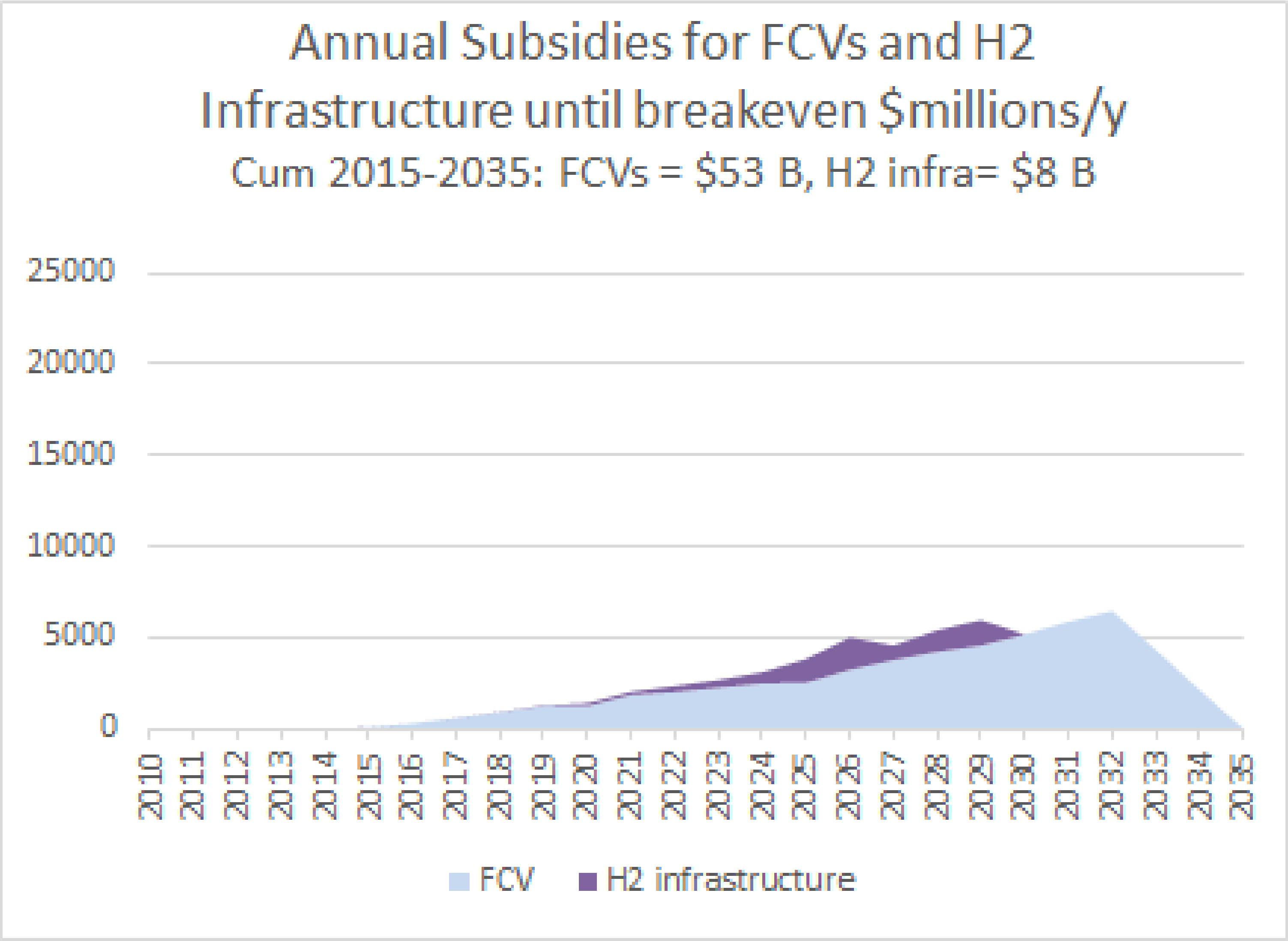


UCDAVIS
SUSTAINABLE TRANSPORTATION ENERGY PATHWAYS

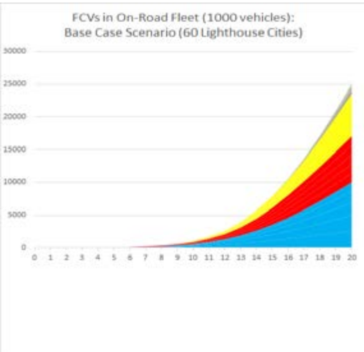
Incremental INVESTMENTS for H2 FCVs and H2 Infrastructure to 2035 ($M/y)

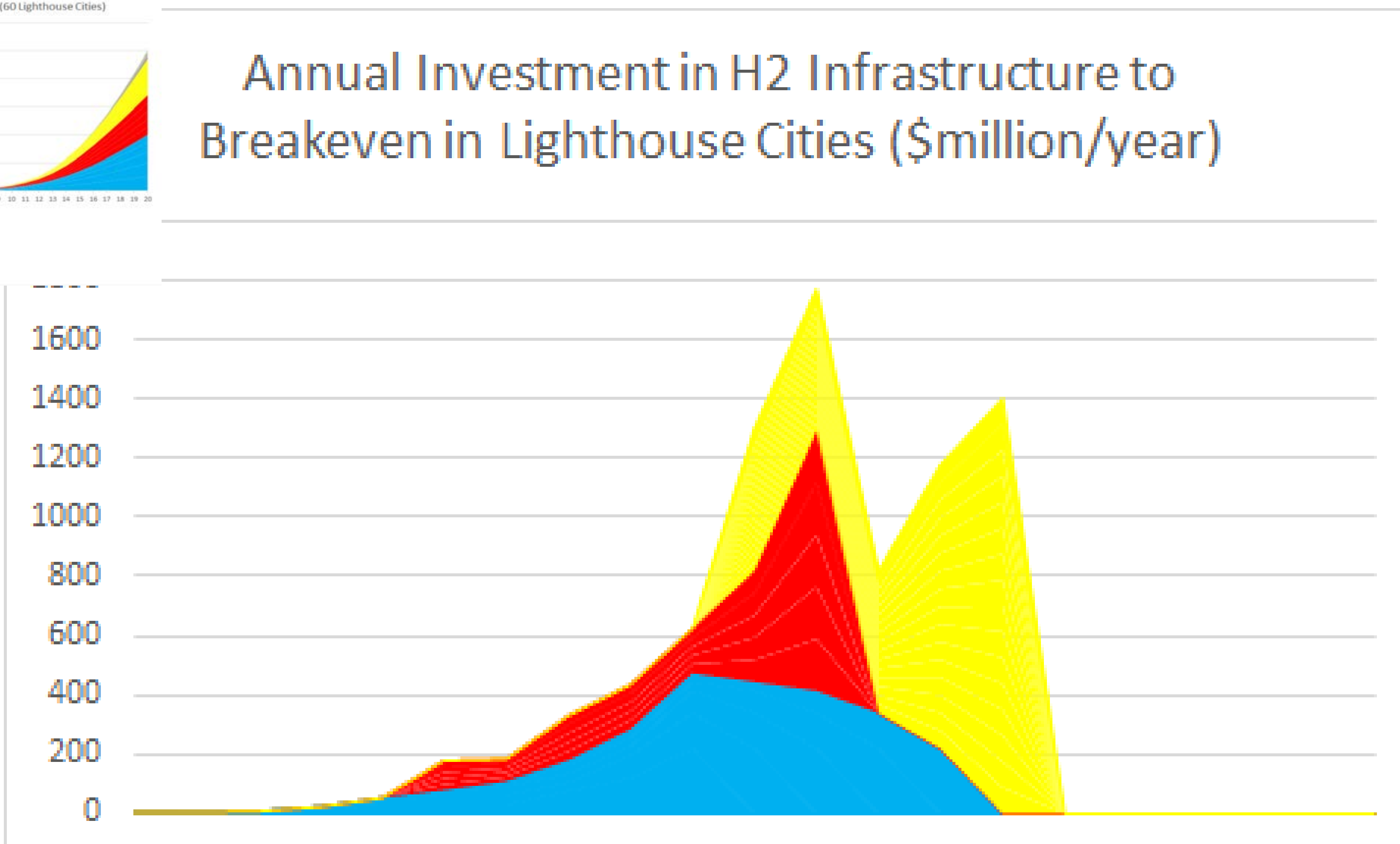


SUBSIDIES for Fuel Cell Vehicles and Infrastructure til Breakeven, w/ 3-yr phase out after Breakeven ($M/y)



Infrastructure investment to breakeven in successive cities



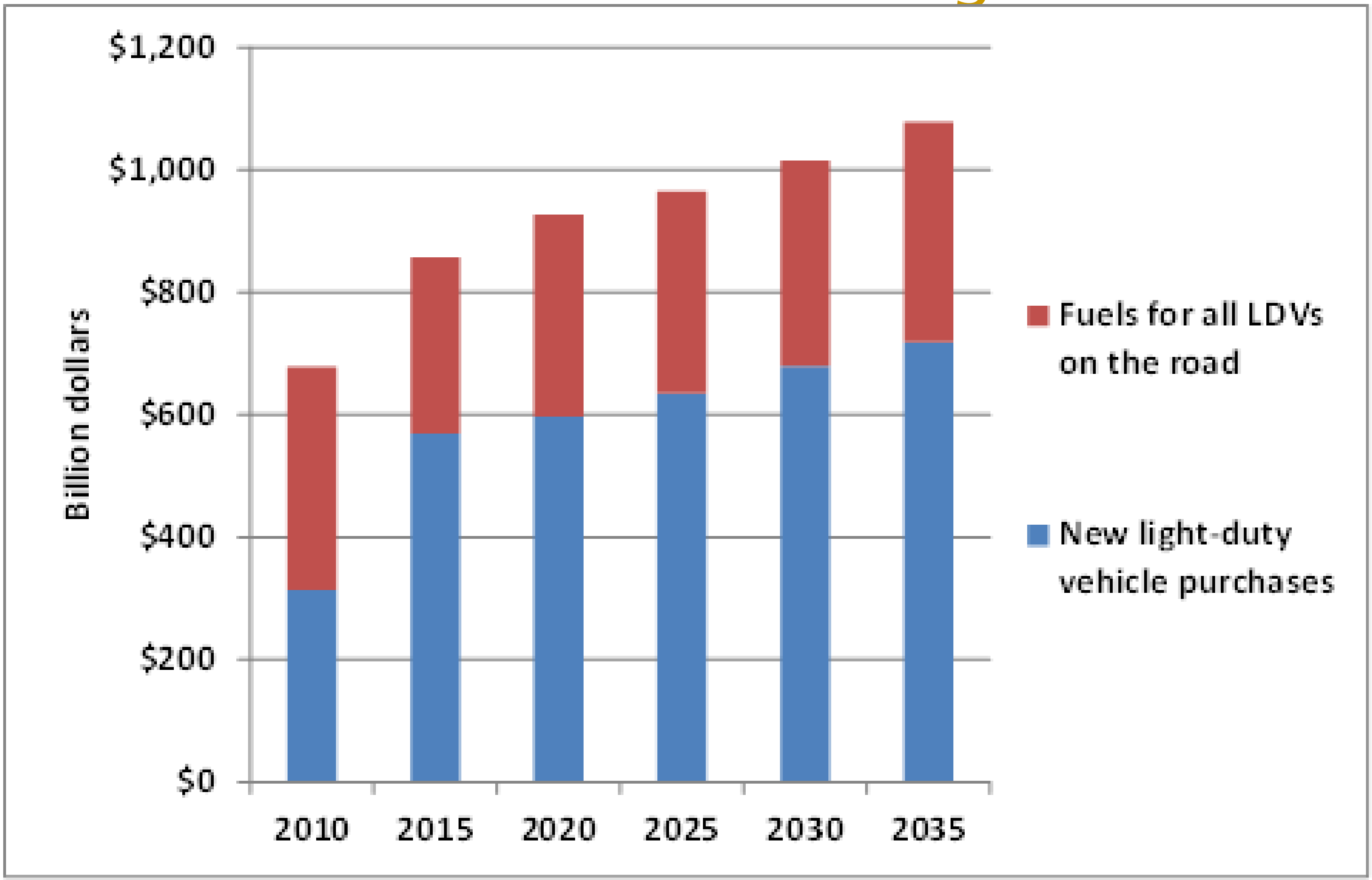


US Transition costs

- Base case US H2/FCV scenario breaks even ~2032. Beyond this, fuel savings outweigh incremental costs for vehicles.
- Regional station networks in lighthouse regions can break even in 5-10 years depending on many factors
- **Cumulative INVESTMENTS** to 2035 for fuel stations serving 22 million FCVs are about $100 B
- **Cumulative infrastructure SUBSIDIES** are only about $8 B (assuming we subsidize station cost until delivered H2 cost reaches $7/kg in successive lighthouse cities)
- The results are sensitive to a lot of assumptions

IS THIS A LOT OF MONEY?

In the US we will spend around $19 trillion on new cars and fuels through 2035



NRC 2013 LDV transition in US: Subsidies ~ $40B, 2015-2030, but long term societal benefits far greater

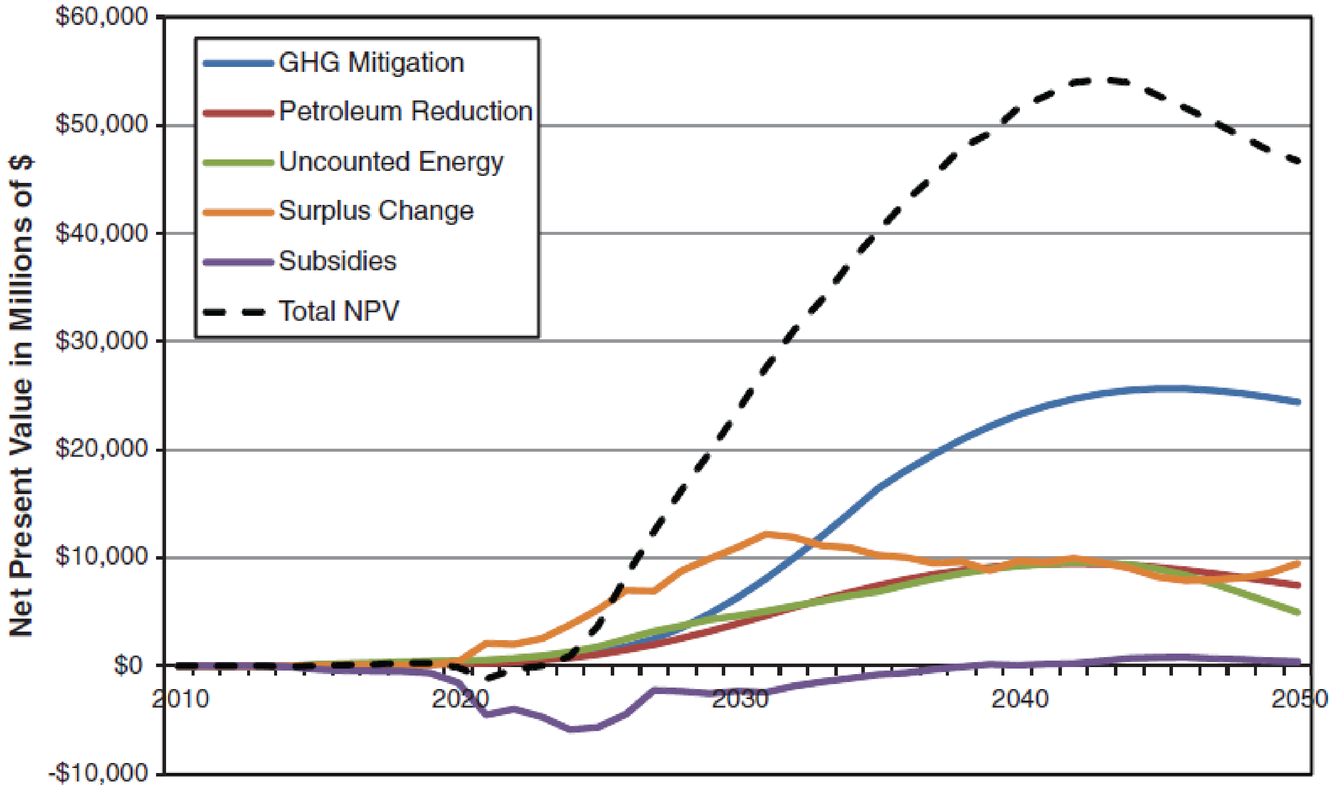


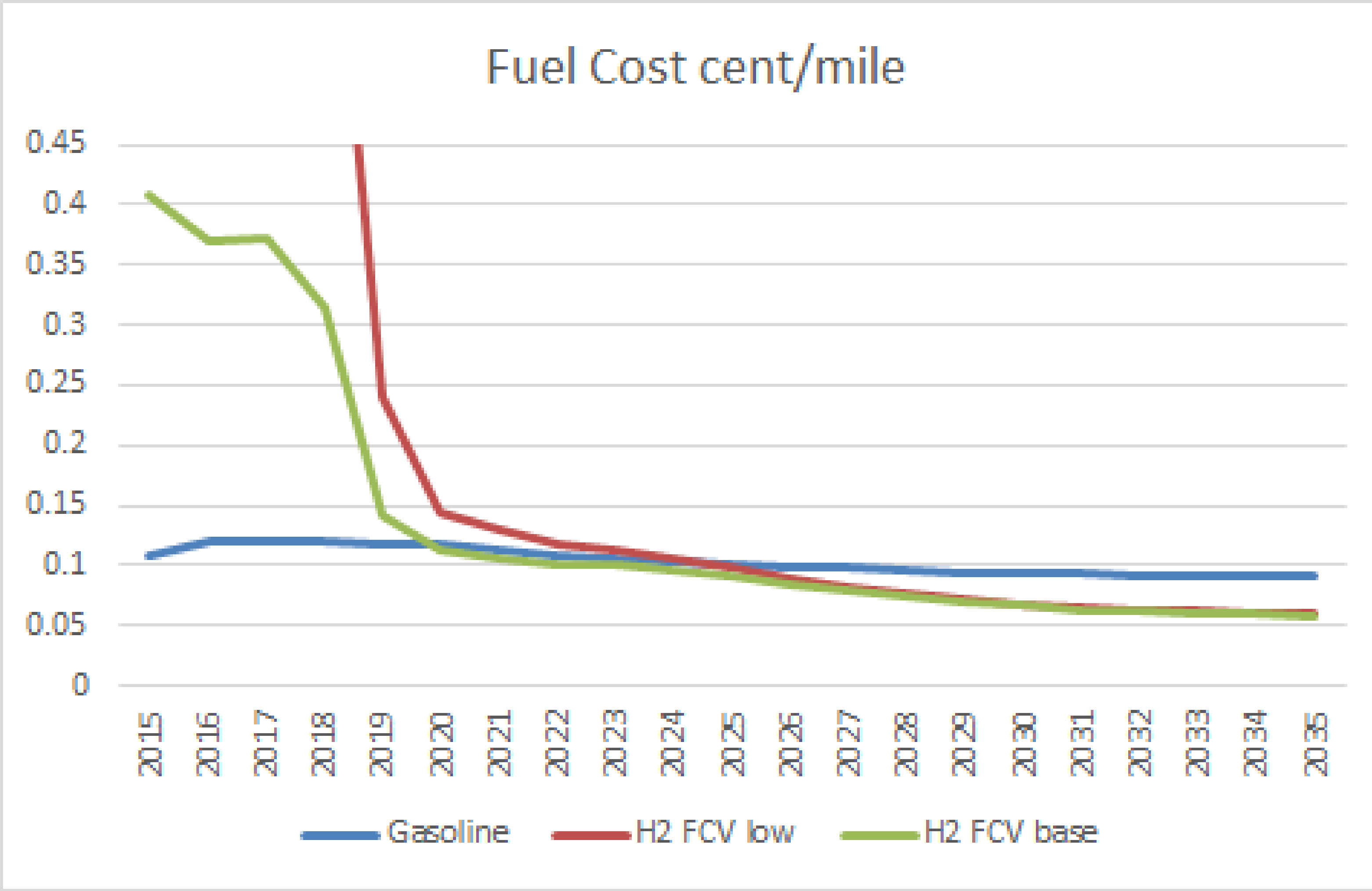
FIGURE 5.24 Present value cost and benefits of a transition to hydrogen fuel cell vehicles using midrange technology assumptions, fuel cell vehicle subsidies and additional incentives, and a low-GHG infrastructure for the production of hydrogen.

National Research Council. *Transitions to Alternative Vehicles and Fuels* . Washington, DC: The National Academies Press, 2013. http://www.nap.edu/catalog.php?record_id=18264

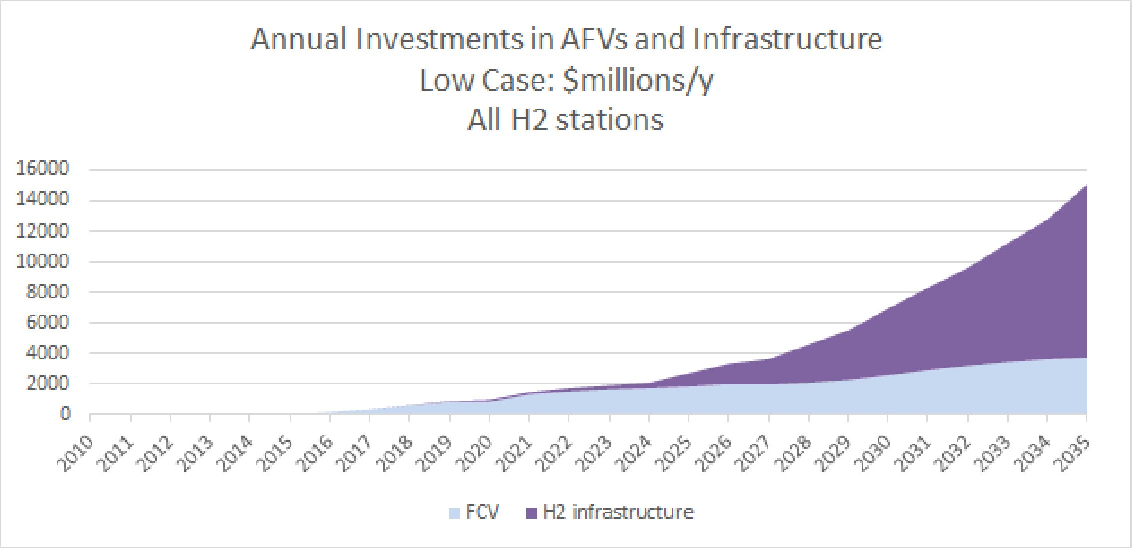
extras

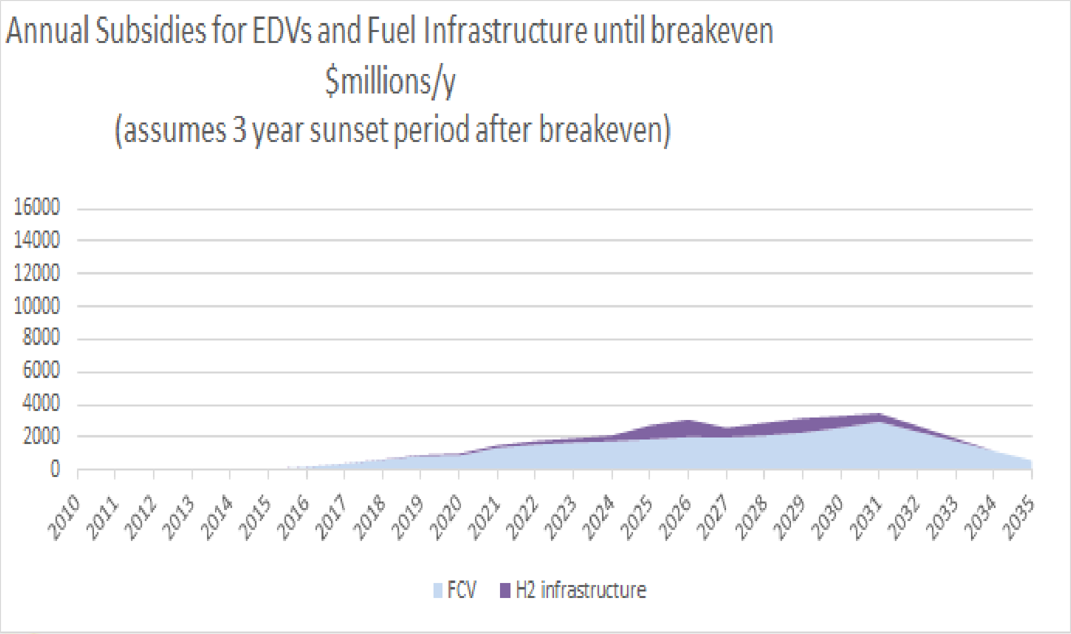
Estimated "Fuel Cost Breakeven" ($/mile)

Happens later with slower station rollout



Investment and subsidy for Slow Ramp Case

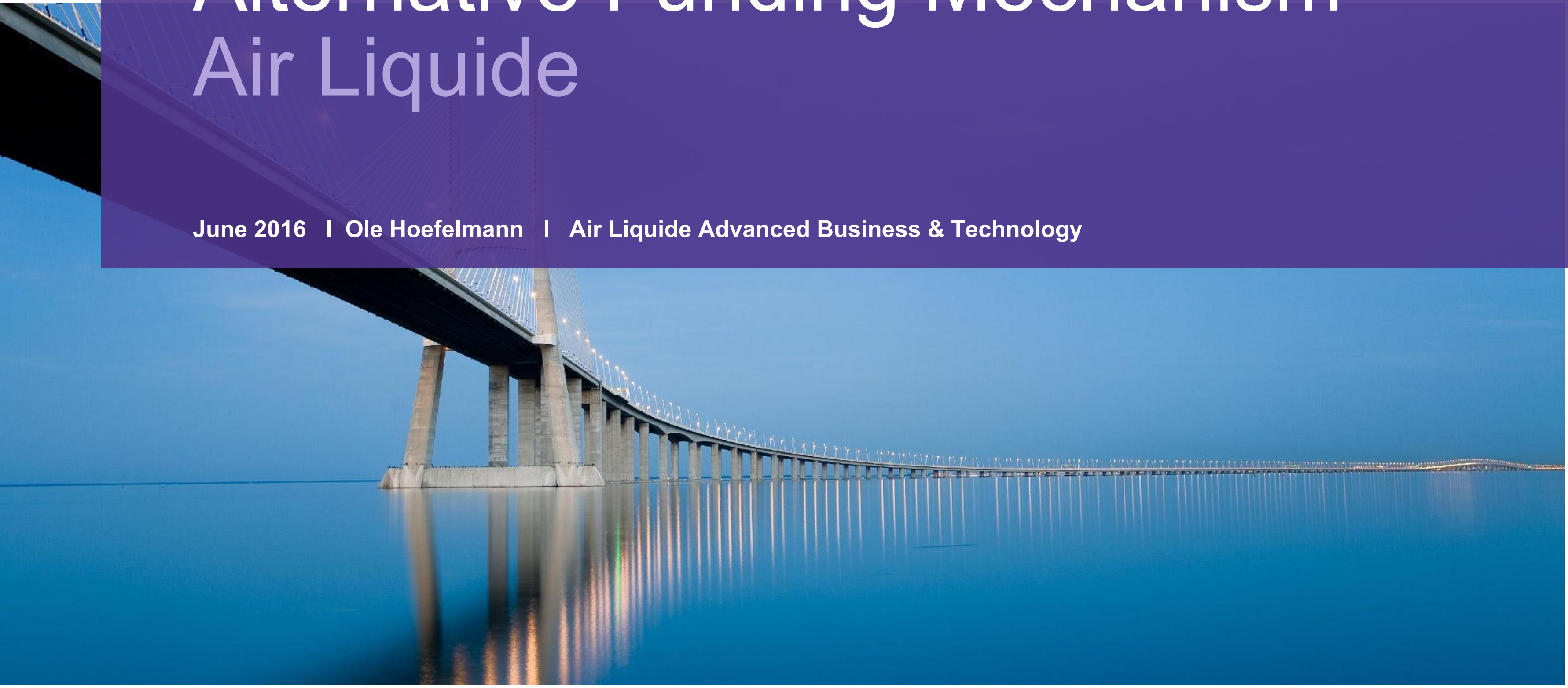




Appendix D – Innovative Ways to Fund Infrastructure – Ole Hoefelmann – CEO, Air Liquide Advanced Technologies U.S.

Alternative Funding Mechanism
Air Liquide

June 2016 I Ole Hoefelmann I Air Liquide Advanced Business & Technology

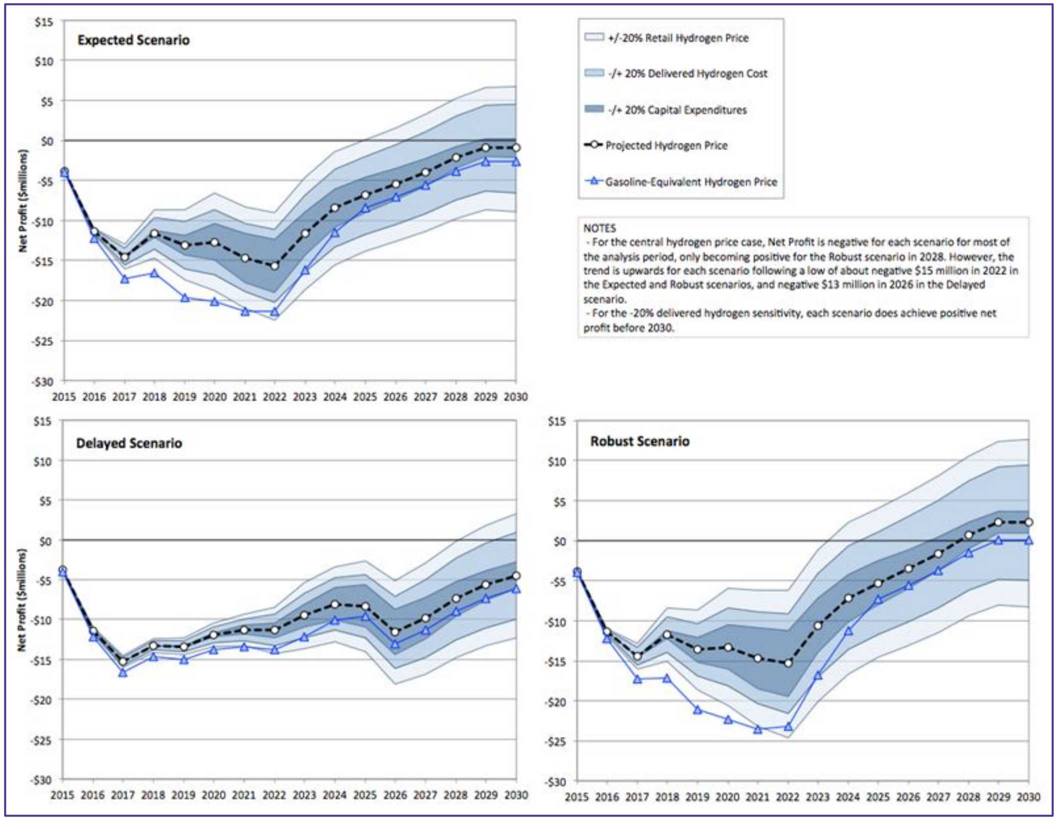


Observations and obstacles of current situation

- **Today it appears the public does not make a “simple” connection between H_2 and clean air**

- **Rolling out the infrastructure has been complex for many reasons, including getting through the “valley of death.”**

- **Some funding mechanisms exist today**



Source: California Energy Commission

Ole Hoefelmann

AIR LIQUIDE

Observations and obstacles of current situation

- **First mover advantage in this space is proving to be difficult**

- **Investments today are primarily governments, OEMs, and industrial companies**
  - **NO third party participation**

AIR LIQUIDE
Creative Oxygen

THE LINDE GROUP

TOTAL

TOYOTA

- Mirai commercialized since 2015
- Production capacity = 3,000 / yr
- 30,000 / yr from 2020

- Tucson commercialized since 2014
- Production capacity = 1 000 / yr
- 6,000 / yr from 2018

HYUNDAI

HONDA

- Clarity commercialized since 2015
- Production capacity = 1,000 / yr

- New model to be released in 2017

DAIMLER

Mercedes-Benz

BMW

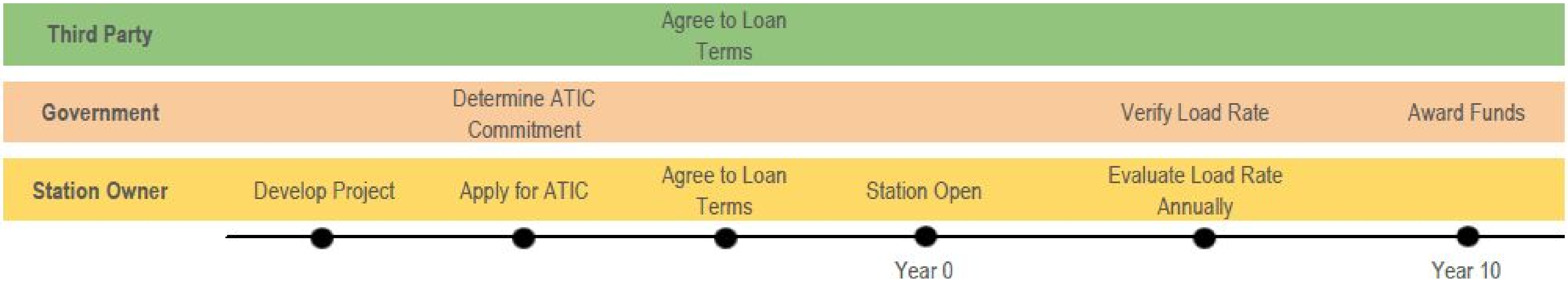
- **<u>Can we do something different to attract more players, including third party, and leverage mechanisms that already exist?</u>**

Ole Hoefelmann

Advanced Transportation Infrastructure Certificate (ATIC) Mechanism

The ATIC is a government-backed note to award funds at a future date if hydrogen demand is not established.

ATIC Lifecycle for a Project

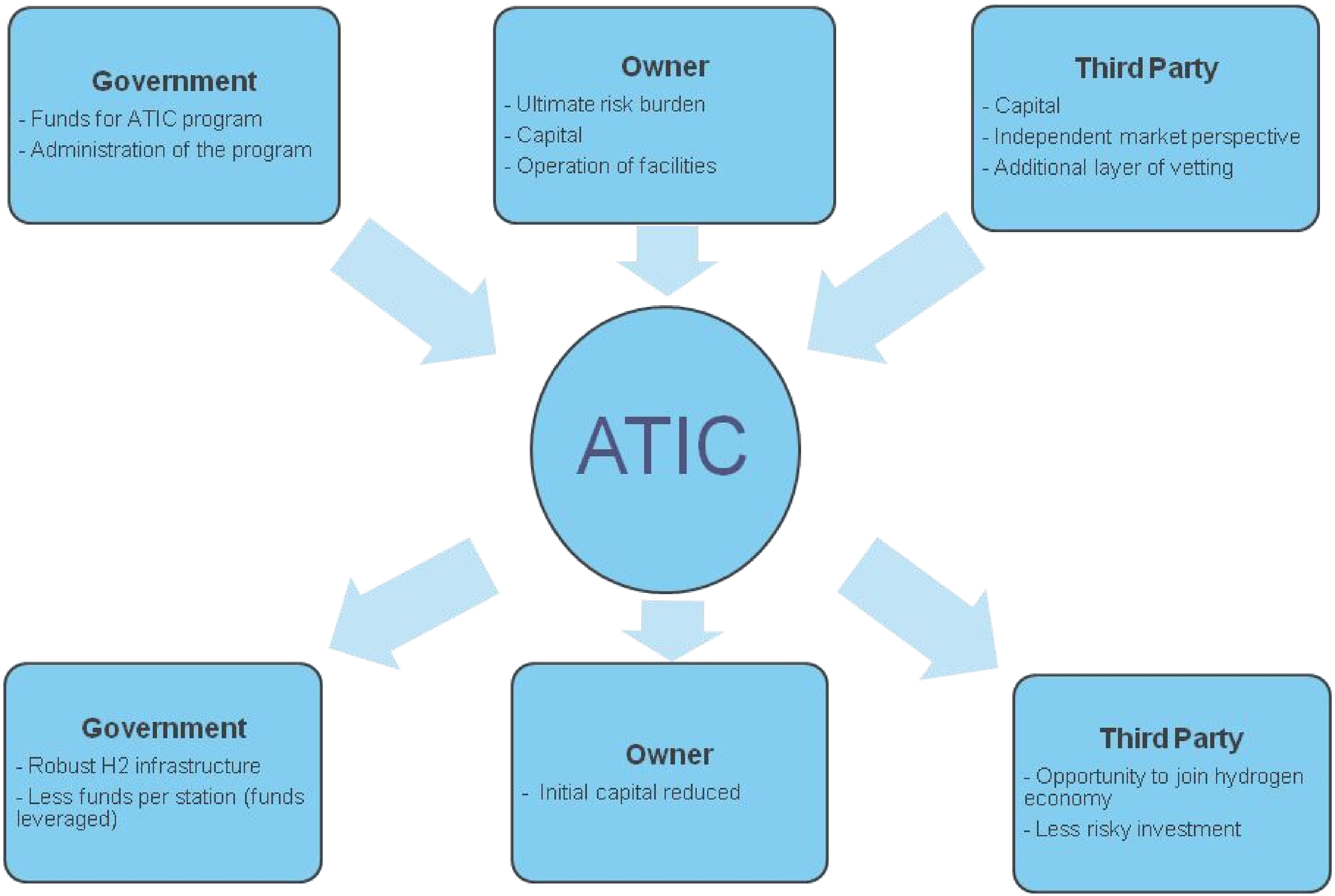


Award amount = ATIC Commitment × (100% - Load Rate)

ATIC vs. Grants

The ATIC is not exclusive of capital grants or O&M grants, and is used in conjunction with existing grant programs. Similar to the grant programs, the ATIC is competitive and is awarded to projects that are most likely to succeed.

Contributions and Benefits



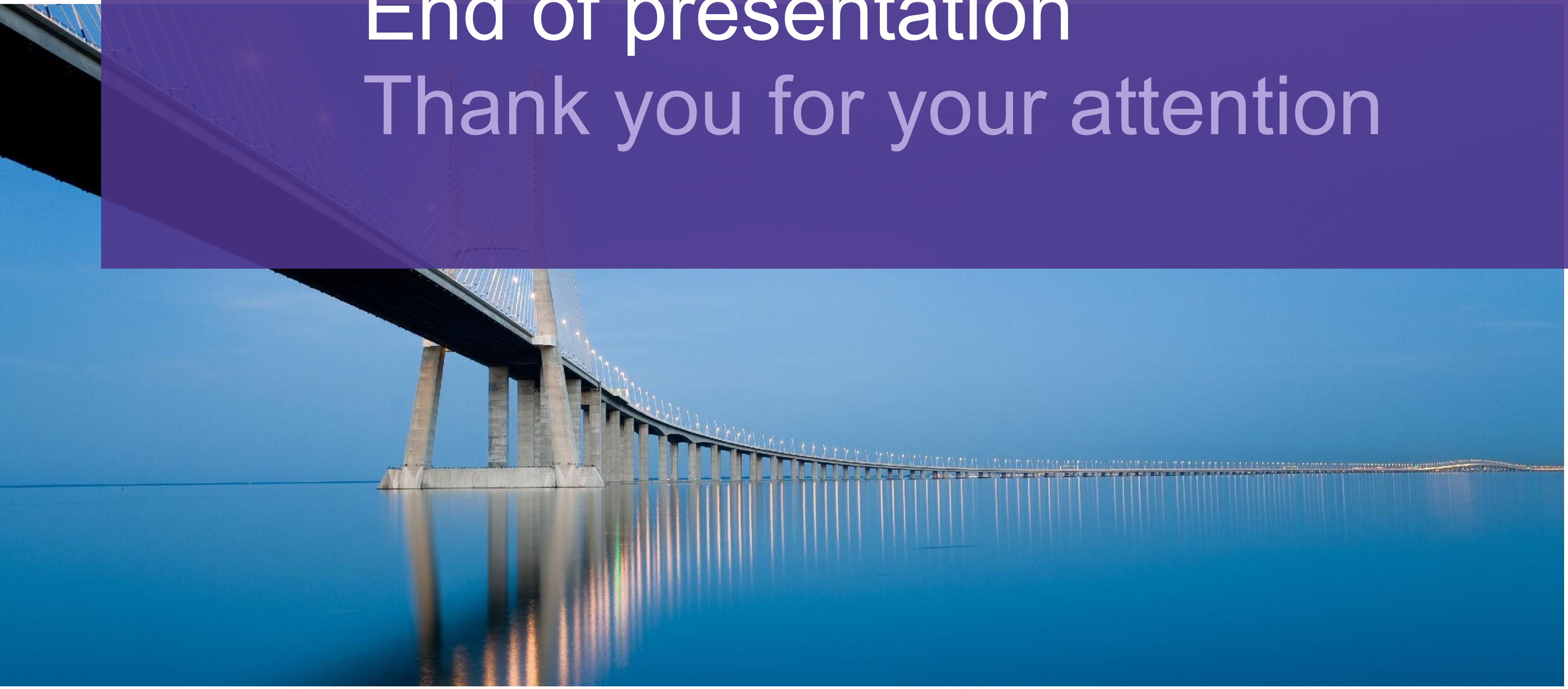
Ole Hoefelmann

Questions / Thoughts

- **How do you assign a value to the ATIC?**
  - **Is it project by project?**
- **Where does the funding guarantee sit?**
  - **How do governments account for it?**
- **How do you project the load of the station?**
  - **How is an owner/operator incentivised to ensure reliability, availability and attractiveness of the station?**
- **What current programs can be used to fund this?**
- **When does the third party get paid out, and at what rate?**
  - **Does it vary for each project? Competitive bid…**
- **...**

End of presentation

Thank you for your attention



Appendix E – How Automakers Think about Rollout Volumes and a Market Update – Dr. Andreas Truckenbrodt – Principal, Truckenbrodt Clean Energy Consulting

FCEVs and H_2 in California
The Lay of the Land

Financing the 101st station workshop
June 14, 2016

Andreas Truckenbrodt, TCEC
Bill Elrick, Keith Malone, CAFCP

2012 Roadmap

100 stations statewide

- Establish initial network coverage
- Clusters in big cities
- “Connectors” and “destination” stations across the state
- Vision for commercial rollout

The vehicles are coming …

300+- FCEVs on the road

- Hyundai leases the Tucson; Mercedes-Benz, the F-CELL
- Toyota introduced the Mirai in 2015
- Honda intros the next-gen Clarity in late 2016/2017
- Many automakers will come to market:
  - Audi, BMW, Ford, GM, Lexus, Mercedes, Nissan, Volkswagen
- 4 transit agencies operate 20 buses
  - East Bay
  - Coachella Valley
  - UC Irvine
  - OCTA

Retail station progress

DRIVING FOR THE FUTURE

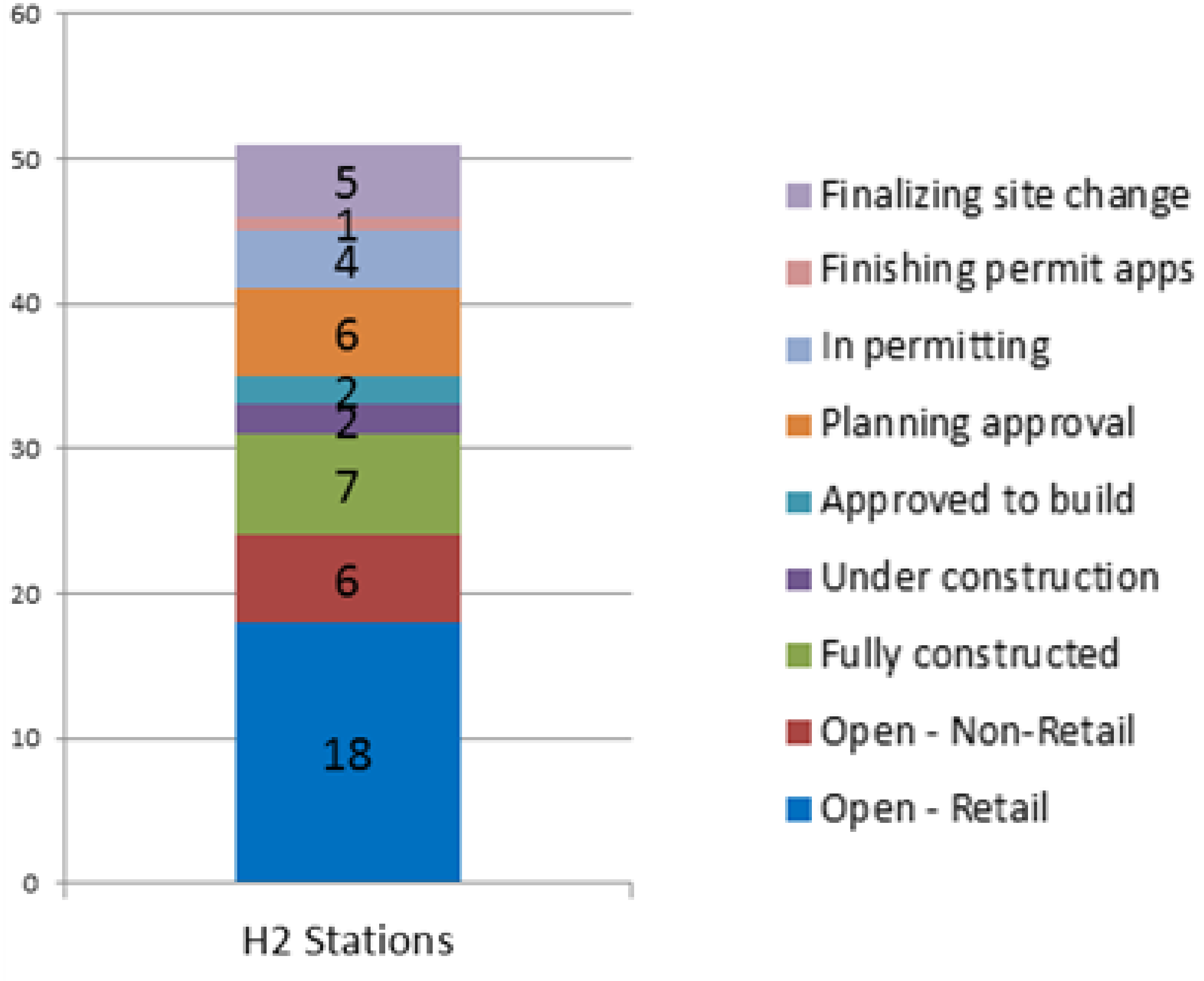
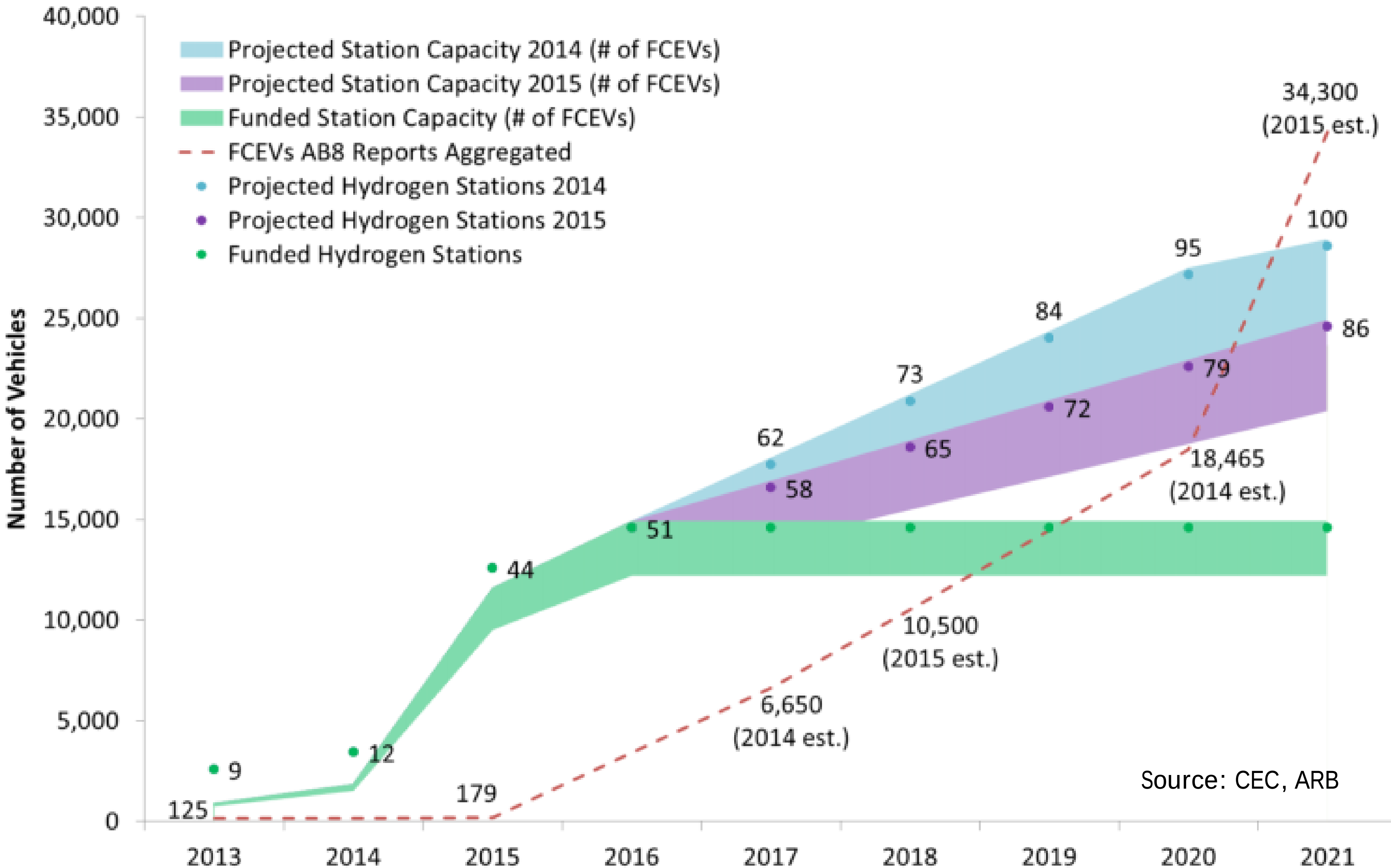


Figure ES4: Need for Continued Station Investments and Increased Average Capacity to Support Future FCEV Fleet, Given Business as Usual Assumptions in State Incentive Programs



Medium and Heavy Duty Action Plan

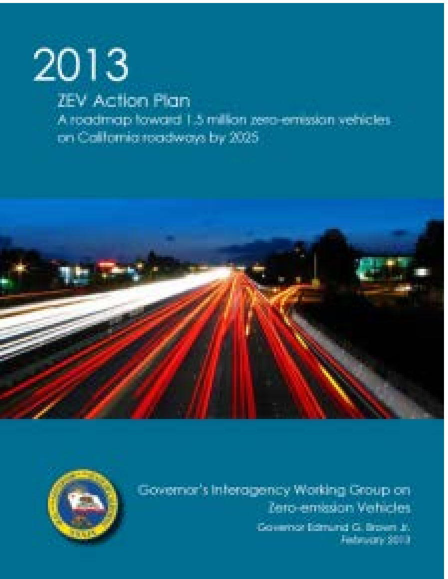
Publication: Soon

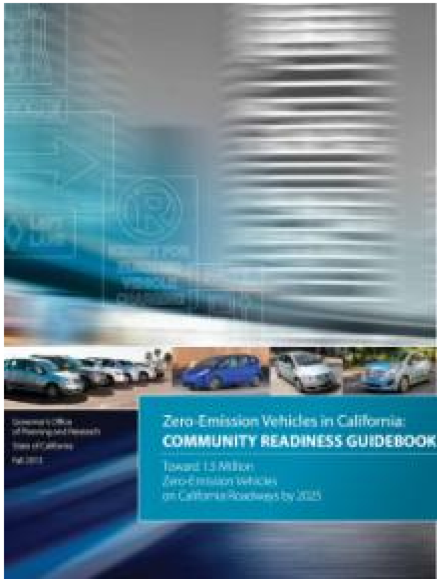
- Developed by CaFCP members
  - Input from industry
- Specific vehicle platforms
  - 1 MD FCEV platform: Class 4-6 package delivery
  - 1 HD FCEV platform: Class 8 short haul/drayage trucks
- Address MD/HD fueling infrastructure
  - Distinguish what H2 stations could facilitate MD FCEVs and/or HD FCEVs
  - Need for fueling infrastructure for MD/HD FCEVs
- Focus on industry consensus to where technology is most viable and first steps should be taken
- Recognize commonalities between different HD FCEV platforms

Backup

California ZEV Action Plan

- By 2015: California major metropolitan areas "ZEV-ready" with infrastructure and streamlined permitting
- By 2020: California ZEV infrastructure can support up to 1 million vehicles
  - Including widespread use of ZEVs for freight and public transit
- By 2025: Over 1.5 million ZEVs in California





California is taking the lead

Funding	For at least 100 H_2 stations through California Energy Commission
ZEV Action Plan	Agency actions to enable FCEVs and BEVs
ZEV Manager	Governor appointee to help with planning and permitting for H_2 and charging stations
State Fire Marshal	Including hydrogen and FCEVs in state training guidelines
Weights & Measures	Setting standards for certifying dispensers
Evaluation	Survey of OEM deployment plans

May 2016

Northern CA Hydrogen Stations

Retail: Open

Hayward
San Jose
Saratoga
South San Francisco
West Sacramento

Other: Open

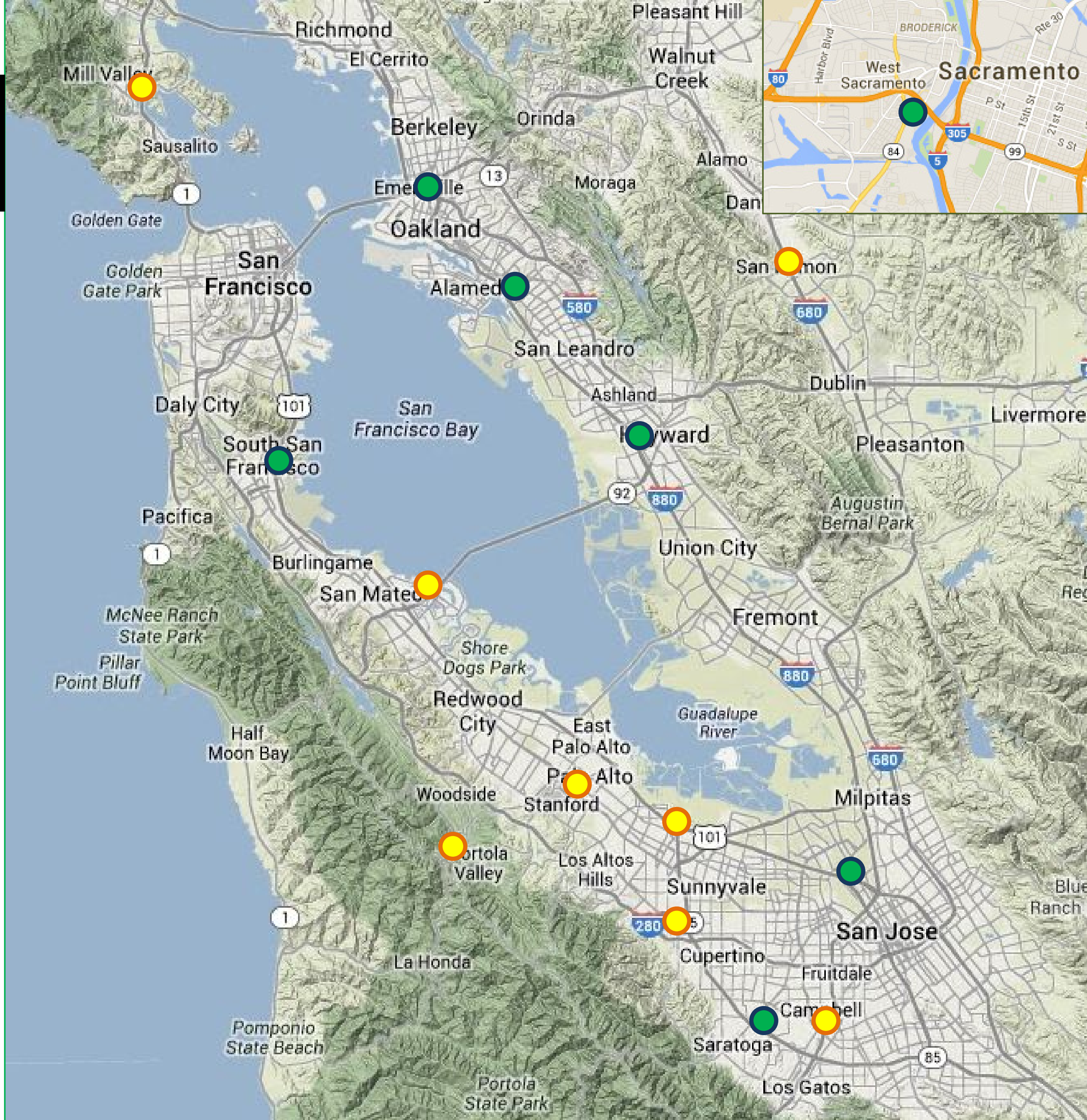
Emeryville – AC Transit
Oakland – AC Transit

Retail: In Development

Campbell open
Foster City
Los Altos
Mill Valley
Mountain View
Palo Alto
*Rohnert Park
San Ramon
*Truckee
Woodside

Not shown on map

California Fuel Cell Partnership
www.cafcp.org/stationmap



May 2016

Southern CA Hydrogen Stations

Retail: Open

Costa Mesa
Diamond Bar
Fairfax-LA
*Harris Ranch
La Cañada Flintridge
Lake Forest
Long Beach
San Juan Capistrano
*Santa Barbara
Santa Monica
UC Irvine
West LA

Other: Open

Burbank
Fountain Valley
Harbor City
Newport Beach
*Thousand Palms – SunLine Transit
Torrance

Retail: In Development

Anaheim
Cal State LA
Chino (upgrade)
*Del Mar
Lawndale
Hollywood
LAX (upgrade)
North Hollywood
Ontario
Orange
Playa Del Rey
*Riverside
South Pasadena
Woodland Hills

Not shown on map