July 2016

2016 Annual Evaluation of

Hydrogen Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development

California Environmental Protection Agency

Air Resources Board

2016 Annual Evaluation of

Hydrogen Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development

Pursuant to AB 8, Statutes of 2013

July 2016

List of Acronyms

AB 8	Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013)
AHJ	Authority Having Jurisdiction
ARB	California Air Resources Board
ARFVTP	Alternative and Renewable Fuel and Vehicle Technology Program
CaFCP	California Fuel Cell Partnership
CHAT	California Hydrogen Accounting Tool
CHIT	California Hydrogen Infrastructure Tool
CTEP	California's Type Evaluation Program
DMS	Division of Measurement Standards
DMV	Department of Motor Vehicles
DOE	U.S. Department of Energy
FCEV	Fuel Cell Electric Vehicle
GFO	Grant Funding Opportunity (California Energy Commission's formal communication of a current grant program)
GIS	Geographical Information System
GO-Biz	Governor's Office of Business and Economic Development
H2FIRST	Hydrogen Fueling Infrastructure Research and Station Technology
H35	Hydrogen at a pressure of 35 megapascal
H70	Hydrogen at a pressure of 70 megapascal
HFS	Hydrogen Field Standard
HGV	Hydrogen Gas Vehicle
HyStEP	Hydrogen Station Equipment Performance
HySUT	Research Association of Hydrogen Supply/Utilization Technology
IrDA	Infrared Data Association
ISO	International Organization for Standardization
LCFS	Low Carbon Fuel Standard
O&M	Operations and Maintenance
PON	Program Opportunity Notice (California Energy Commission's formal communication of a grant program in prior years)
POS	Point-of-Sale
NREL	National Renewable Energy Laboratory
RSA	Registered Service Agent
SB 1505	Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006)
SNL	Sandia National Laboratories
SOSS	Station Operation Status System developed by CaFCP
ZEV	Zero Emission Vehicle

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Executive Summary

With 20 retail hydrogen fueling stations operating as of June 17, 2016[1], California has successfully launched a nascent retail station network enabling market introduction of fuel cell electric vehicles (FCEVs). In fall 2015, Toyota began selling and leasing the Mirai in Southern California while Hyundai continues leasing the Tucson Fuel Cell. Mercedes and Honda customers also continue to enjoy driving their pre-commercial FCEVs. Others look forward to the expected release of a new Honda Clarity by the end of 2016. In late 2015 and early 2016, these customers gained access to a small but growing network of stations providing a retail fueling experience. The State of California remains committed to its strategy of establishing a base fueling network across the state leading vehicle launches. As the initial network is deployed and establishes fueling coverage for FCEV drivers, auto manufacturers can similarly expand their FCEV deployments.

> *Just as Prius changed the world nearly 20 years ago, the hydrogen-powered Mirai is ready to make history. With a range of over 300 miles per tank, a refueling time of under five minutes, and emissions that consist only of water vapor, Mirai is leading the world toward a more sustainable future.*
>
> Bill Fay
> Group Vice President
> General Manager
> Toyota Division

Even with the challenges inherent in launching a new fueling technology into the retail environment, customers have shown tremendous patience with the pace of station development. Feedback from outreach events shows these customers enjoy the performance of their FCEVs and are excited for the opportunity to be some of the world's pioneers in choosing to drive no-compromise zero-emission FCEVs.

Successful market launch and continued growth of both FCEVs and California's hydrogen fueling network are essential for the State to meet zero-emission vehicle goals set forth in Governor Brown's Executive Order B-16-2012 as well as greenhouse gas reduction, air quality improvement, and petroleum reduction goals set forth in state and federal laws and programs [1], [2], [3], [4], [5], [6], [7]. Staff from the Air Resources Board (ARB), California Energy Commission (Energy Commission), and Governor's Office of Business and Economic Development (GO-Biz), along with other state agencies, closely coordinate and work with other government and industry stakeholders to implement actions that support the development of a robust hydrogen and FCEV market. Auto manufacturers and station developers are working more closely than ever, recognizing that the success of one depends inextricably on the other. Stakeholders cooperatively set goals and expectations, identify challenges, and develop solutions. This collaborative setting helps keep California at the forefront of the developing worldwide FCEV market.

Because of the State's policy initiatives, California remains a focal point for development of hydrogen fueling technology and implementation. Many first-in-the-world successes have been achieved in California, and the state's retail fueling station network meets performance expectations and requirements more advanced than elsewhere. This presents great challenges especially in the early years of development, and California has dedicated significant resources to meeting the task.

1 These stations are referred to in this Annual Evaluation as Open- Retail. See the Station Status Definitions sidebar on page 20 and Appendix D for further information about the terminology used to describe station status.

Assembly Bill 8 (AB 8; Perea, Chapter 401, Statutes of 2013) establishes the framework for the Energy Commission to co-fund the base fueling network required to support the early FCEV market [8], [9]. This 2016 Annual Evaluation provides updated analysis in accordance with the requirements of AB 8, and is informed by ARB's interactions with various stakeholders over the past year. Analysis of coverage and capacity provided by the current and projected fueling network continue to be the basis of assessment in this Annual Evaluation. Additionally, ARB continues to update its understanding of the needs and expectations of retail hydrogen fuel customers to inform the assessment of technical capabilities that should become a part of the developing station network. ARB's assessments provide insight regarding the status of California's initiatives to advance hydrogen and FCEVs and to inform funding programs at the Energy Commission.

Hydrogen fuel cell vehicles are a zero emissions technology that Honda believes in, and has worked to advance for more than 20 years... Vehicles like the Clarity Fuel Cell are potential game changers because they offer an uncompromising, zero emissions customer experience, with utility, range and refueling times on par with today's gasoline-powered cars.

John Mendel
Vice President
American Honda Motor Co., Inc.

In the past year, there has been a great deal of activity both at the State and in the stakeholder community to advance the retail hydrogen fueling network. Since December of 2015, stations have been opening at a significantly accelerated pace, with two to three stations opened each month. Lessons learned over the past year are providing focus for efforts going forward, and some of these lessons are already being integrated through the Energy Commission's new Grant Funding Opportunity (GFO-15-605), the Hydrogen Station Equipment Performance device (HyStEP) program, the California Type Evaluation Program (CTEP), and other ongoing efforts. ARB has assessed the status of the network, FCEV deployment progress and plans, and State programs to make the following determinations:

- California's hydrogen fueling network has grown to 20 open stations providing a full retail experience[2] to FCEV drivers and an additional six legacy stations that continue supporting FCEVs. So far in 2016, the pace of development in the hydrogen fueling network has added two to three stations every month. By the end of 2016, ARB projects 38 stations will be open and all 50 currently funded stations, including upgrades for many non-retail stations, are projected to be complete by the end of 2017. This is in keeping with the strategy to ensure hydrogen fueling stations are in place and open in advance of broader FCEV rollout.
- While station development has progressed more slowly than projected in the 2015 Annual Evaluation, the recent acceleration in the pace of station openings is a positive indicator that many of the early challenges are successfully being overcome. The expected growth in FCEV deployment demonstrated through the 2016 auto manufacturer survey results similarly indicates confidence in the long-term viability of the network.

Hydrogen fuel cell technology has tremendous potential to meet diverse consumer demands for impressive range, rapid refueling speed and scalability to a variety of vehicle types and sizes. Hyundai is proud to join other leaders today as we educate, inspire and encourage people to see the many benefits of hydrogen as a zero-emissions vehicle fuel.

Mike O'Brien
Vice President
Corporate and Product Planning
Hyundai Motor America

2 The "full retail experience" is based on hydrogen stations providing performance at least on par with today's gasoline stations. This means that the hydrogen stations have open access to any FCEV driver, allowing them to drive up to the dispenser, purchase hydrogen with their preferred payment method, and receive a complete fill as quickly and reliably as today's gasoline vehicle drivers are able to.

> *The future is now. The industry has grown tremendously as fuel cell electric vehicles become available in the showroom, stationary applications continue to grow, and other markets, such as material handling, are taking off.*
>
> Morry Markowitz
> President
> Fuel Cell & Hydrogen
> Energy Association

- An important subnetwork has been established in the southern portion of the San Francisco Bay Area, enabling FCEV sales at northern California dealerships. Multiple stations opening in the Los Angeles area are beginning to provide the first measure of localized redundancy in the network. A new station in Coalinga enables travel between northern and southern California. New stations in Santa Barbara and Truckee enable travel to these popular tourist destinations.
- 331 FCEVs are currently registered with the Department of Motor Vehicles (DMV), representing a growth of 152 vehicles from the same time last year and confirming expectations reported in the December 2015 Joint Agency Staff Report [10].
- California's on-the-road FCEV population is now projected to grow to 13,500 vehicles in 2019 and 43,600 vehicles in 2022. Auto manufacturer survey responses indicate fewer vehicles will be launched prior to 2018 than previously projected. However, the survey results also show this delay will be matched by acceleration in later years and the difference will be recovered by 2020.
- The Energy Commission's new Grant Funding Opportunity (GFO) will bring additional coverage, capacity, and potential redundancy to the fueling network. GFO-15-605 encourages station proposals in priority locations ARB identified in the 2015 Annual Evaluation.
- Accounting for the expected growth in on-the-road FCEVs based on the auto manufacturer survey and business-as-usual growth in fueling capacity, there will be a statewide shortfall in hydrogen dispensing capacity as early as 2020.
- Continued annual allocations of $20 million are needed to build coverage and total fueling capacity. Considering the potential shortfall in total fueling capacity in 2020, there is additionally an urgent need to develop and implement station funding mechanisms that leverage increasing amounts of private investment beyond current business-as-usual.
- Maintaining a positive customer experience is an essential objective in the early retail station network. State agencies are supporting transparent communication to build stakeholder and customer confidence in individual station performance. State agencies will continue to play a vital role through programs such as meter certification and HyStEP station testing that can provide authoritative assurance of stations' technical capabilities.

These determinations are expressed through eight principal findings in this Annual Evaluation. Details of the analyses and observations that lead to these findings are presented throughout the body of this report. Each chapter addresses a particular reporting requirement outlined in AB 8 and presents summaries of data, discussions of analysis methods, and ARB's interpretation of results. ARB's analyses are performed with intent to establish a comprehensive appraisal of the current status of fueling network development and FCEV deployment, identify major challenges and opportunities among stakeholders, and provide suggested direction for further State initiatives.

Photos provided by FirstElement Fuel and the California Fuel Cell Partnership.

H2 and FCEVs in the News

Auto manufacturers continue to develop and bring to market their light duty fuel cell electric vehicle lineups, demonstrating ongoing confidence in and commitment to this important zero emission vehicle technology.

- In October of 2015, Toyota launched the retail sale and lease of its Mirai sedan to the general public, marking the occasion with a celebration and symbolic key delivery to its first customers in West Hollywood [11].
- In March of 2016, Honda began sales of its new Clarity Fuel Cell sedan in Japan, and reiterated an expected launch in the United States and Europe before the end of 2016 [12].
- In May of 2016, the Capitol Hyundai dealership in San Jose became the first Hyundai dealer in northern California to deliver an FCEV to a retail customer [13].
- At the 2016 Detroit Auto Show, Thomas Weber, a member of Daimler AG's Board of Management, indicated that a fuel cell powered version of its GLC SUV could be debuted in 2017 [14]. In June of 2016, Daimler previewed the SUV, revealing it will be the world's first plug-in hybrid FCEV [15].
- Lexus debuted their LF-FC luxury fuel cell vehicle concept at the 2015 Tokyo Motor Show [16]. Later interviews indicated that Lexus anticipates developing a production version by the end of the decade [17].
- General Motors (GM) and the United States Army announced a demonstration program that will convert a Chevrolet Colorado to fuel cell power and evaluate its potential in military operations [18].
- Audi showed its h-tron Quattro concept SUV at the 2016 North American International Auto Show. The concept features hybridization with a powerful battery pack capable of providing 100 kW of power to the wheels [19].

Continuing advances in fuel cell technologies help expand the potential vehicle applications and enhance the technology's value proposition.

- GM and Honda have continued to work cooperatively to advance fuel cell stack performance. In addition to reducing the size of the stack, the companies have reduced the size of accompanying balance of plant components and the platinum loading in the fuel cell, reducing costs. GM anticipates the next generation of fuel cell will further reduce platinum loading, size, and weight by about half [20].
- While developing the Clarity Fuel Cell sedan, Honda was able to reduce the size of the fuel cell system by a third and increase system voltage output. Honda reports these advancements allow the vehicle to accommodate five passengers (as opposed to four in the previous Clarity FCX) and increases torque output of the drivetrain [21].

Fuel cell electric vehicles continued to achieve noteworthy milestones and participate in major events.

- The Toyota Mirai was awarded Green Car of the Year at the New York International Auto Show on March 24, 2016 [22].
- In October of 2015, a group of five Mercedes Benz B-Class F-Cell owners drove from southern to northern California shortly after the Coalinga station first became open, demonstrating the potential for long-distance road trips in California enabled by the new connector station [23].
- On April 20 of 2016, ARB Chair Mary Nichols, Energy Commissioner Janea Scott, and GO-Biz Deputy Director of ZEV Infrastructure Tyson Eckerle also led a caravan

of stakeholders driving various FCEVs from Santa Monica to Sacramento. The event, dubbed Mary's Valley Rally, was similarly aimed at demonstrating the possibility of long-distance travel in an FCEV while also providing an early celebration of Earth Day [24].

- Toyota demonstrated long-term driving potential of the Mirai through a demonstration carried out in Hamburg. For 107 consecutive days, a Mirai was driven for 16 hours until it covered 100,000 km total. Toyota reported no mechanical breakdowns and 100% reliability of the fuel cell, even in challenging conditions down to -20°C [25].
- Hyundai has begun testing two Tucson Fuel Cell vehicles modified for autonomous driving on public roads in Nevada. This marks the first demonstration of autonomous FCEVs on public roads in the United States [26].
- Since 2014, Hyundai Tucson Fuel Cell drivers have travelled more than 1,000,000 miles on the roads and highways of southern California [27].

Fuel cell electric vehicles maintained a central role in energy and transportation planning for several nations around the globe and have been integrated into notable programs and events.

- The government of Japan has announced its goal to have 40,000 FCEVs on the road by 2020 and 800,000 FCEVs by 2030. To support this vehicle rollout, the country additionally plans to have 160 Hydrogen stations by 2021 and 320 stations by 2026 [28].
- The government of Japan has also announced its intent to develop the Fukushima prefecture into a central source of renewable hydrogen production, in time for the 2020 Olympic Games [29].
- In October of 2015, Toyota announced its Environmental Challenge 2050. The Challenge includes goals of achieving 30,000 annual global sales of FCEVs around 2020, achieving a global hybrid annual sales rate of 1.5 million vehicles by 2020, reducing new car average CO_2 emissions more than 22% by 2020, and various other energy and environmental goals addressing not only their products but also their manufacturing and business facilities [30].
- With nine fueling stations installed, Denmark has been recognized as the first nation in the world to achieve nationwide hydrogen fueling coverage for FCEVs (Denmark is approximately 1/10th the size of California in land area with approximately 1/7th the population) [31].
- In a first for Europe, the Aberdeen City Council introduced two Hyundai ix35 (Tucson Fuel Cells) to its public car sharing program to help encourage businesses and individuals to buy hydrogen vehicles, and to encourage the growth of hydrogen infrastructure in Scotland [32].
- The BeeZero car sharing service, a subsidiary company of Linde, will launch services in Munich in summer of 2016 and be the first in the world to exclusively use hydrogen powered fuel cell cars [33].

Local, state, and federal government efforts continue to pave the way for a successful FCEV market launch.

- In August of 2015, the Bay Area Air Quality Management District awarded $2.2 million to co-fund 12 hydrogen fueling stations under development in the region [34].
- In December of 2015, the Energy Commission and ARB published the first Joint Agency Staff Report on Assembly Bill 8, which assessed the expected cost and timing to reach the 100 hydrogen fueling station benchmark mentioned in AB 8 [10].
- In January of 2016, the United States Congress renewed the $8,000 tax credit available to customers who purchase an FCEV before January 1, 2017 [35].

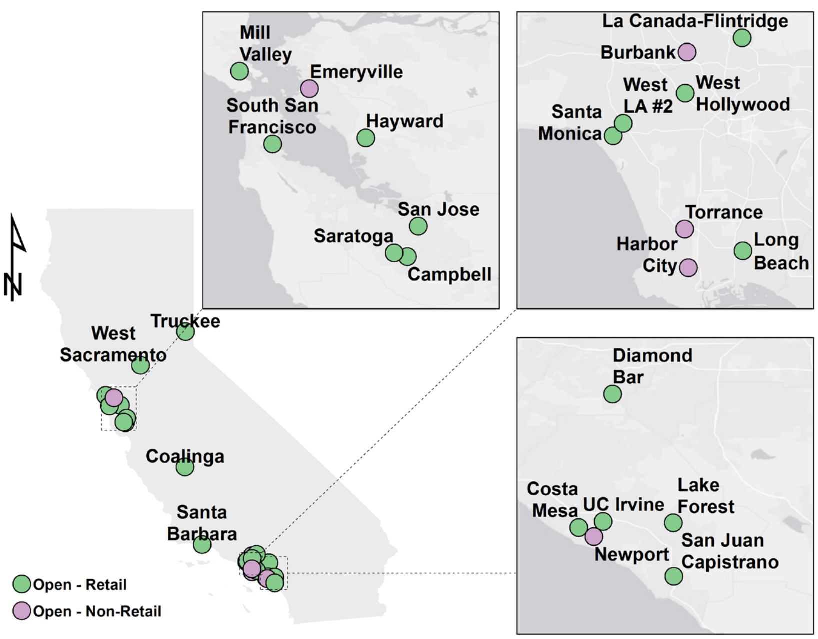
Findings

Finding 1: With 20 Open-Retail hydrogen fueling stations, California has launched a nascent retail station network.

Over the course of the past year, California has made significant strides by opening retail hydrogen fueling stations. These new retail stations provide today's FCEV drivers with improved fueling options and will help grow the nascent FCEV market. As of June 17, 2016, there are 26 open stations across the state, with 20 of those providing full retail experiences akin to typical gasoline driver experiences and six non-retail stations[3] approved to fuel one or more models of FCEV though they may require upgrades to continue operating in future years. Figure ES1 displays the currently open network. Today's open network has achieved a number of critical milestones:

- FCEV customers in the Los Angeles and Orange County area may soon have multiple convenient fueling options
- The Coalinga station along Interstate-5 (I-5) in California's Central enables long-distance travel between northern and southern California
- The Santa Barbara and Truckee stations enable travel to these popular vacation and sightseeing destinations; local interest and a positive reception in Santa Barbara may be indications for a future market development opportunity
- With several new stations around the San Francisco Bay area in northern California, auto manufacturers are now able to offer FCEVs in this high-priority market region

Figure ES1: California's Currently Open Hydrogen Fueling Network



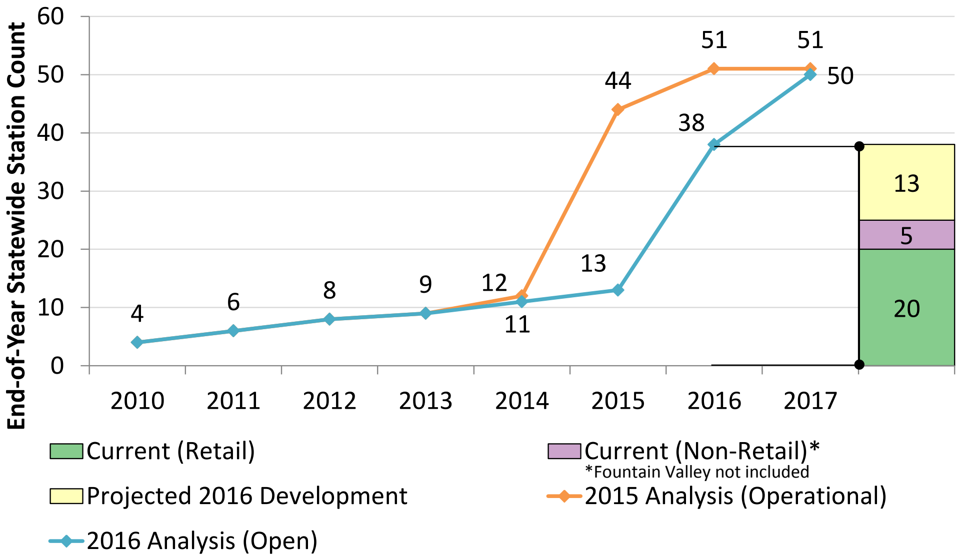
Rapid development of the remaining funded stations and future stations will be necessary to best capitalize upon these advancements. Ensuring a swift and sustained pace of station deployment will be critical to expand coverage, establish redundancy within the network, and ultimately enable more potential early adopters to choose to own and drive FCEVs.

3 The Fountain Valley station is projected to be decommissioned by the end of 2016 and not shown in Figure ES1.

Finding 2: Station development has progressed at a slower pace than projected in 2015.

The 2015 Annual Evaluation projected that 44 stations would achieve operational[4] status by the end of 2015. At the time, it had been assumed that the financial incentives available to stations funded under Program Opportunity Notice (PON)-13-607 would ensure they achieve operational status by the end of 2015. Ultimately, a range of factors determine the actual pace of development including timelines for business agreements between developers and site owners, negotiations between developers and city planners, coordination with local utilities, and schedules for permitting agencies among other factors. The experience gained over the past year has improved the quality of the information that the State relies on to project station development schedules. As a result of this real-world experience with specific station developers and projects, the State is now able to make more informed projections of station open dates. Open dates indicate when a station is able to provide customers with a full retail fueling experience, and are the dates by which auto manufacturers base their internal planning of vehicle deployments.

Figure ES2: Comparison of Statewide Station Projections between 2015 and 2016 Annual Evaluations



As shown in Figure ES2, the station network development is approximately one year slower than projected in the 2015 Annual Evaluation. Although differing baselines of operational (2015) and open (2016) are used in the comparison, this change alone explains only a small part of the extended development timelines. Loss of the original site host location, protracted contract negotiations, and long local permitting processes have significantly contributed to slowing the overall pace of development. For example, it took one project nine months to gain the owner's signature to submit permit applications. In another case, an ordinance had to be adopted by the city council to allow an unattended station. Other projects added months to their development timelines due to resident complaints about existing host gasoline stations. In none of these cases was the delay related to the hydrogen itself. In spite of these and many other hurdles, the first half of the year has seen encouraging growth in the number of open hydrogen fueling stations. Current average rates of station development indicate the projected 38 stations by the end of 2016 is an achievable outcome.

4 See the Station Status Definitions sidebar on page 20 and Appendix D for further information about the terminology used to describe station status.

Finding 3: Auto manufacturers' plans for 2020 and beyond continue to indicate robust FCEV deployment in California despite projecting fewer vehicles for the near term.

Figure ES3: Current and Projected On-Road FCEV Populations and Comparison to Previously Reported Projections

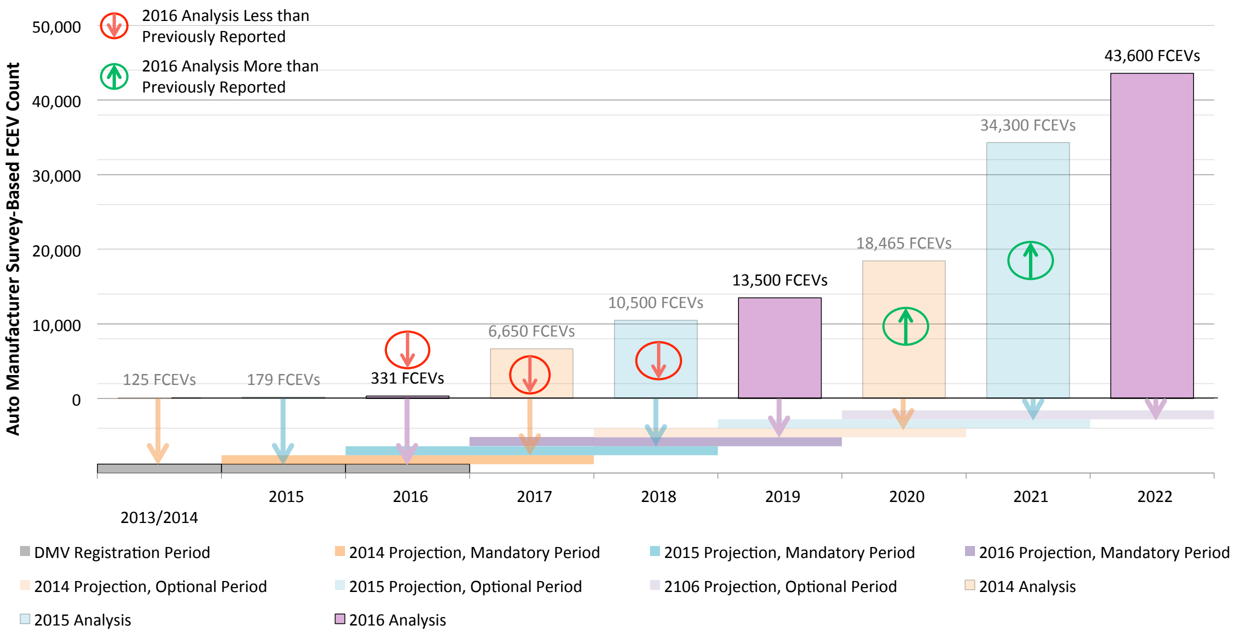


Figure ES3 shows the updated projection of FCEVs on the road, along with the previous Annual Evaluations' projections. New projections indicate that there may be as many as 43,600 FCEVs on the road in 2022, an increase of approximately 10,000 from the previously-reported projection of 34,300 in 2021.

Vehicle and station deployment rates in the early FCEV market are critically dependent on one another and must be synchronized well in order for success in both markets. Auto manufacturers can't sell or lease FCEVs until stations are in place, and stations won't succeed as businesses without a growing FCEV customer base. Comparing responses from the 2016 annual survey to prior years' responses shows that auto manufacturers have planned for approximately a one-year delay in FCEV deployments. Based on statements in the media and made in meetings with ARB and analysis of the auto manufacturer survey responses, this slower FCEV release rate in the early years correlates with slower station deployment.

The circled arrows in Figure ES3 denote the years in which the 2016 survey and DMV data indicate the on-the-road FCEV population is larger or smaller than previously reported. FCEV deployments in 2015 were less than previously projected (shown in Figure ES3 on the 2016 DMV record). On-the-road FCEV projections for 2017 and 2018 are also lower than previously projected, but the greatest discrepancy was seen in the comparison between current DMV records and prior projections for 2015. Projections based on the current survey show more FCEVs on the road than previously projected by 2020, thereby recovering completely from the short-term delay. Additionally, the 2016 survey shows strong continuous FCEV market growth from 2020 to 2022, similar to the projections previously reported in 2015.

These results demonstrate the current rate of progress in the station network development is having an immediate effect on auto manufacturer release plans, but there remains longer-term confidence in the potential of California's FCEV market and hydrogen fueling network. Although some station developers may be hesitant to make their stations operational until more FCEVs are on the road, both the station and vehicle provider industries' ultimate success requires continued resolve for swift deployment schedules.

Finding 4: San Francisco, Berkeley and surrounding cities, Greater Los Angeles, San Diego, and Torrance continue to be the highest priorities for further fueling network development.

Over the past year, a handful of stations awarded in previous AB 8 funding programs have required site relocation. These relocations are often the result of protracted or failed lease and/or contract negotiations, and in rare cases have experienced local opposition. A total of eight station grants have been amended to a new location in the past year. ARB's recommendations for additional station locations through the use of the California Hydrogen Infrastructure Tool (CHIT) are directly dependent on analysis of the coverage provided by open and funded stations. Even so, the net result of the eight station relocations has been to remove only a couple of Priority Areas whose coverage needs are now met with the new station sites, to elevate a couple of areas previously identified as Additional Priority into the First Priority category, and to slightly alter the borders of the Priority Areas. The Energy Commission incorporated this revised analysis into GFO-15-605 and additionally has decided to use CHIT analyses in general to help evaluate proposed stations' locations and nameplate capacities.

Finding 5: In order to meet the expected hydrogen demand in the developing FCEV market, the full $20 million in annual funds should continue to be utilized. With a continuing projection of capacity shortfall around 2020, there is increased urgency to identify opportunities to maximize the fueling capacity leveraged by State investments.

The 2015 Annual Evaluation first identified the potential for a widespread shortfall in hydrogen fueling capacity throughout the State if cost per kilogram of installed capacity does not decrease and the network continues to rely primarily on the $20 million of State money potentially available each year through AB 8. This Annual Evaluation provides revised and further-looking projections of FCEV and hydrogen station deployment. With no new station grant awards added to the planned network between the time of release of the 2014 and 2016 Annual Evaluations, ARB's current evaluation relies on nearly identical business-as-usual assumptions for station size and State cost share as in the 2015 Annual Evaluation. Figure ES4 demonstrates the anticipated shortfall in hydrogen fueling capacity if business-as-usual funding remains the sole mechanism of hydrogen fueling station development. As in the previous Annual Evaluation, the current pace of development forecasts that there likely will not be sufficient fueling capacity by 2020.

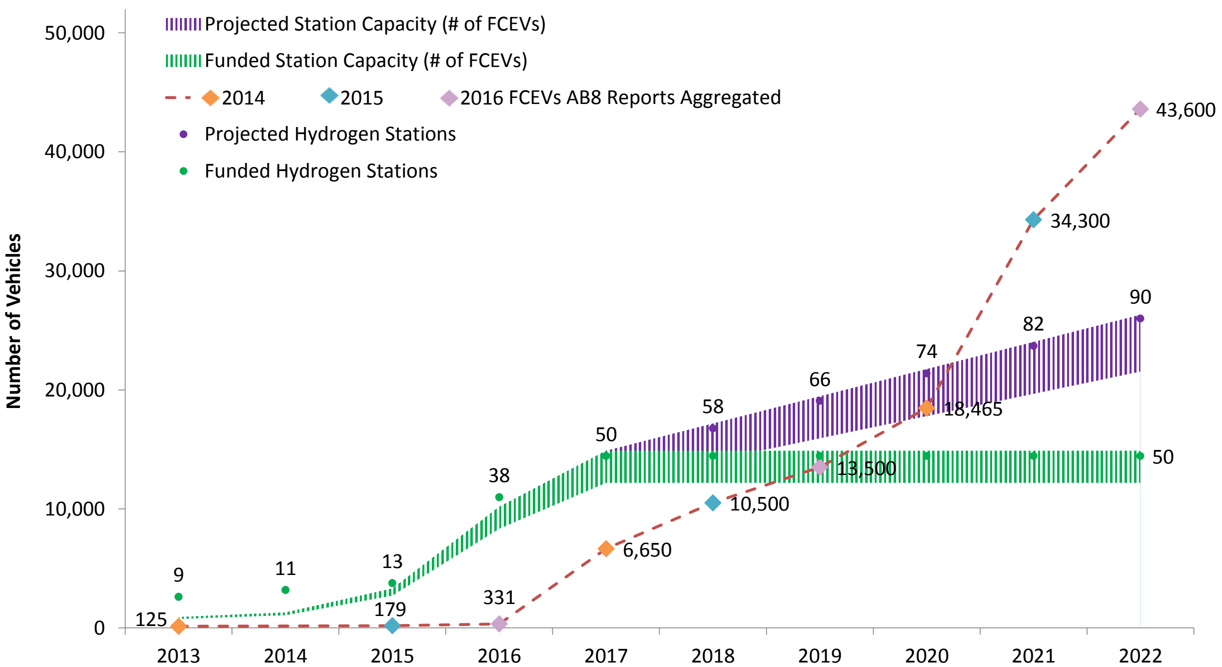
This finding was echoed in the December 2015 Joint Agency Staff Report, which identified the maximum potential capacity to be installed through AB 8 and the potential size of the hydrogen fueling station market needed to fill the capacity gap [10]. Accounting for potential cost reductions yet to be verified by ongoing and future station development, the Joint Report found the potential to install more fueling capacity than the business-as-usual assessment shown in Figures ES4. However, even this increased capacity needed to be met with an additional capacity of 28,000 kg/day funded by as-yet-undetermined sources, potentially including major private investment. The scale and imminence of the challenge underscore the urgency for action.

Considering the timing and scale of the projected capacity shortfall, ARB finds two actions are necessary and should be a near-term priority for stakeholders involved in developing the hydrogen fueling network:

1. State funding must be increasingly leveraged to yield more and larger hydrogen fueling stations; funding programs need to be designed to stimulate increased complementary private funding that brings additional capacity to the network
2. Substantial additional investment sources will need to be identified and applied to the challenge of hydrogen fueling network development to guarantee long-term success

Finding 6 of the 2015 Annual Evaluation identified four potential avenues to stimulate increased leveraging of private funds through state investments. The Energy Commission has begun to address these recommendations, particularly through greater minimum station capacity requirements in GFO-15-605. Further developments must occur in the next one to two years to allow sufficient time for action to meet the coming capacity challenge. The scope of this challenge is one that will require new thinking. New sources of capital investment, including growing participation from private capital, will be necessary. As the station network continues to grow, increasing participation of private funds may also afford the State an opportunity to investigate alternative funding mechanisms to maximize dispensing capacity and coverage achieved with public funds.

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



Finding 6: Learnings from the first retail stations highlight the need for a customer-centric focus in planning and implementing hydrogen stations.

The State's commitment to providing funds for hydrogen fueling infrastructure development through AB 8 is enabling the launch of the first fully retail hydrogen fueling network in the state. While these stations have been designed to provide FCEV drivers with an experience equivalent to gasoline drivers in ease and convenience, there have been a handful of recurring issues that have detracted from the overall quality of the fueling experience. Issues of station reliability and technical challenges for point-of-sale and customer interaction have shown that achieving open status alone is not necessarily a guarantee of consistency in meeting customer expectations. Auto manufacturers and station developers are working closely to resolve issues along with stakeholders from across the industry, such as dispenser manufacturers and point-of-sale system providers. Progress has been made to resolve technical issues more quickly and to avoid them altogether in future stations while customer outreach has been enhanced to ensure drivers are fully aware of station performance. The HyStEP device will help the State evaluate stations and ensure they meet minimum performance requirements before customers begin regular fueling. The Energy Commission has included requirements in GFO-15-605 to help ensure future stations are ready to provide consistent and reliable service from the first day they are open. New station grants will require that stations achieve Open-Retail status within 180 days of becoming operational. These have been important developments, and the lessons learned through the last year's experiences have made it clear that a continued focus on the customer experience is paramount in AB 8 analyses, planning, and funding program development.

Finding 7: California has successfully confirmed station performance through early testing and certification programs. These programs must be further developed and supported by State agency efforts.

As with any fuel, customers expect hydrogen fueling to be safe and convenient, and deliver high quality fuel. For hydrogen this requires verifying the fueling protocol that describes safety-based limits for acceptable rates of hydrogen transfer from the station to the vehicle. Other requirements are related to retail operations and must be met by any fuel offered for retail sale. These include verifying fuel quality compliance, proper signage and metering of the amount of fuel sold, reliable operation of the point-of-sale system, and clear communication of fueling steps to the customer at the dispenser.

Over the past year, several State-initiated programs for testing hydrogen fueling stations have continued development. The HyStEP device, developed in partnership with the US Department of Energy (DOE), H2FIRST, and Sandia National Laboratories (SNL), has been delivered to California and undergone validation testing so that it can begin to be used within the station confirmation process. The Division of Measurement Standards' (DMS) Hydrogen Field Standard (HFS) metrology device has certified the accuracy of many dispensers in use by the new retail stations. The certification program has also expanded in implementation, with at least one private company now included as a Registered Service Agent (RSA) who can coordinate with local weights and measures officials to certify new installations of dispensers that have been previously type certified by DMS. The success of these programs, and the rising awareness of operational and customer interaction challenges, underscore the need to develop similar programs to not only test, but also certify, that station performance meets expected standards and stated specifications. A certification program will help ensure that FCEV drivers have the best possible fueling experience.

Finding 8: California's Low Carbon Fuel Standard (LCFS) program offers important revenue potential to hydrogen stations.

During the past year, three entities have received provisional certification of their hydrogen fuel production pathways through the Low Carbon Fuel Standard program. All of these pathways have significantly smaller carbon intensity than reference gasoline, with four of the six certified pathways having a zero or negative carbon intensity. Additionally, one of these pathways is currently in use at the Emeryville station and signifies the first participation of a hydrogen fuel provider in the LCFS program. These in themselves have been landmark developments. However, it is the revenue generating potential of $2-$3 per kilogram of hydrogen that truly has the potential to be a game-changer in the hydrogen fueling industry. The December Joint

Agency Staff report already found that much lower LCFS revenue ($0.50 per kilogram) could be a deciding factor in stations' long-term viability [10]. With the potential revenues available via these new pathways, substantial operating cost reductions could be possible and may result in decreased customer-facing prices at the hydrogen dispenser. ARB staff encourages and supports hydrogen providers in developing new pathways and is currently seeking comment on proposed regulatory language that would integrate Senate Bill 1505 (SB 1505) requirements into the LCFS program, maximizing the potential for hydrogen providers to participate and access the value of LCFS credits. Revenue potentially available by participating in other similar programs, such as the federal Renewable Fuel Standard and ARB's Low Carbon Transportation funding program, may also prove in the future to be a similar-value revenue stream.

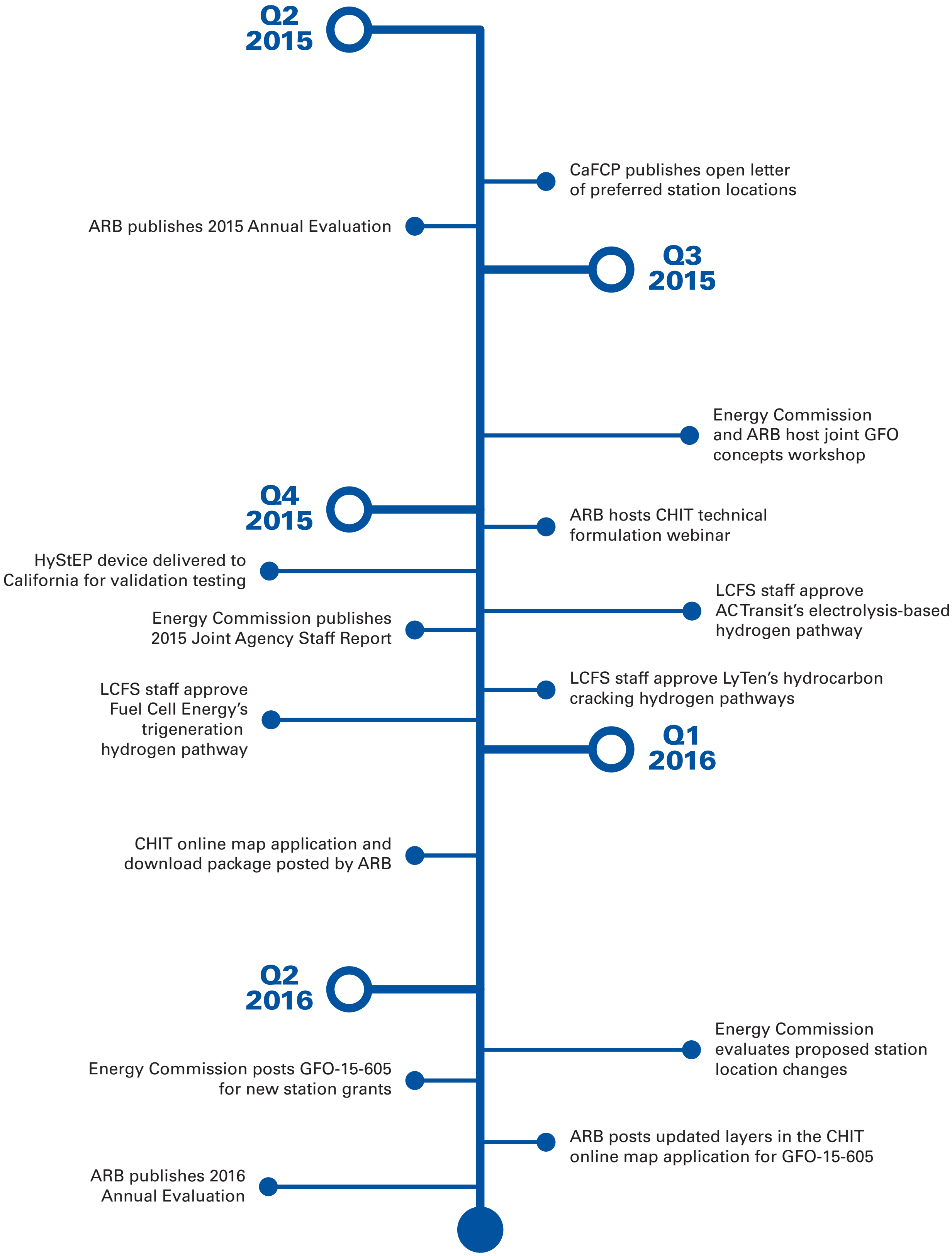
Conclusions

The State of California has made significant progress in laying the foundation for a hydrogen fueling network and should stay the course for funding additional stations. FCEVs are available for consumers to lease or purchase and 20 retail hydrogen stations are open, making it possible to drive in an FCEV from one end of California to the other. The past year has seen important progress in the development of the state's hydrogen fueling network. While it has been a harder-fought progress than previously expected, the State and the station developers have been proactive in identifying and resolving challenges and are continuously carrying forward lessons to improve the station development process. Stakeholders maintain confidence in the long-term viability of a consumer FCEV fleet and supporting hydrogen fueling network. The new challenges that have appeared in the last year emphasize that ongoing State actions need singular focus on the retail customer experience. Station testing and monitoring efforts already underway at the State and continued cooperation with station developers and operators help address these concerns. Capitalizing on this progress to develop new station confirmation and certification capabilities will continue building consumer and stakeholder confidence.

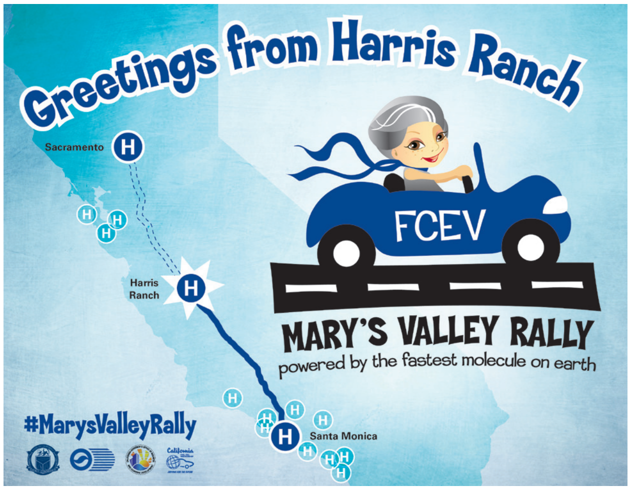
Other previously reported challenges remain as well. In order to meet the fueling demands of the expected fleet in 2020 and beyond, stakeholders and the State will soon need to identify additional sources of capital investment funds for the early hydrogen fueling network. The 2015 Annual Evaluation, the 2015 Joint Agency Staff Report, and now the 2016 Annual Evaluation all recognize that significant new sources of funding will be required in order to keep pace with expected demand. The 2015 and 2016 Annual Evaluations suggest this may present an occasion for the State to demonstrate financial opportunities to private investors and further leverage State spending with private capital. Other opportunities also exist to support station operations through State incentive programs like LCFS, but these opportunities alone do not appear to be sufficient for the projected funding need.

ARB expects that 2016-2017 will present many opportunities for further learnings and demonstration of the potential hydrogen transportation future. A new Energy Commission solicitation (GFO-15-605) is expected to allocate funds to a new set of stations by early 2017. Ongoing private-public collaboration continues to find solutions to unforeseen difficulties and the industry's larger known challenges. A new FCEV model is expected to be on the market by the end of the year and previously unseen volumes of FCEVs may be on California's roads within the next year. This will provide much more experience to all stakeholders than has been available in the past. Based on developments to date, this experience will only help reinforce the performance of the fueling station network and provide valuable learnings to the many stakeholders involved.

Timeline of major events since 2015 Annual Evaluation



Introduction



On April 20, 2016, ARB Chair Mary Nichols, Energy Commissioner Janea Scott, and Tyson Eckerle of the Governor's Office of Business and Economic Development, were joined by a small cohort of hydrogen infrastructure and FCEV stakeholders in a midday road trip from Santa Monica to Sacramento. The drive, "Mary's Valley Rally," was an opportunity made possible by important developments in the state's hydrogen fueling station network. In particular, the drive showcased the viability of Californians to have confidence in their ability to lease or purchase an FCEV and complete a drive between northern and southern California. Relying on new retail stations that have opened over the course of the past year, "Mary's Valley Rally" drivers, and any other future FCEV drivers, could travel between major centers of business, commerce, and even tourism across the state thanks to stations in Santa Monica, Coalinga, and West Sacramento. Though they were not visited as part of the Rally, other new stations in the Bay Area, Truckee, and Santa Barbara similarly enhance the utility of the state's hydrogen fueling network.

The Rally in April helped to underscore the major progress made over the course of the past year in the hydrogen fueling network. While fewer stations were opened in 2015 than projected in the 2015 Annual Evaluation, there have been major milestones achieved by the stations that are currently open and selling hydrogen to FCEV drivers. By the end of this year, the majority of the currently funded station network is expected to be open for business, providing retail fueling service coverage matching well to projected FCEV early adopter market areas.

Along with this progress, there have also been a number of challenges identified that will need to be overcome. Some of these challenges are persistent from previous years; stations continue to have difficulty securing lease agreements and contracts, station equipment reliability is too often below retail customer expectations, and there is a demonstrable need to begin planning now to maximize the available AB 8 funds and to identify funding sources beyond AB 8 to build out the necessary fueling infrastructure beyond 2020. Other challenges are only recently identified; technical difficulties at the point-of-sale have frustrated some drivers, while a few incidents regarding hydrogen fuel quality have brought forth a need for more focus on ensuring hydrogen purity at the dispenser. However, these challenges can be overcome. Stakeholders across the industry, including the State and private entities, have begun to address many of these concerns either with programs currently in place or planning for future solutions and programs.

The coming year promises to continue to provide information from lessons learned. As increasing numbers of new retail stations come online, especially those developed by new station developers, requirements of the station commissioning and confirmation process will continue to be refined. Customer experience and feedback with the new retail network will continue to provide information for improving the fueling experience and station-to-customer interactions. Continuing analysis of station status and availability will help add a new dimension to needs assessment for coverage and capacity in the fueling network. Applications to the Energy Commission's new solicitation, GFO-15-605, will help ARB and the Energy Commission gauge the status of hydrogen fueling station equipment technology development. Finally, new participation by the hydrogen fueling industry in the LCFS program will help reveal the value of the program for improving the business case of operational stations.

As in prior Annual Evaluations, ARB has relied upon updated FCEV registration data, station development status, and auto manufacturer FCEV deployment plans to inform its analyses of the projected needs for further developing the state's hydrogen fueling network. Major themes in this year's evaluation include:

- Refined projections of station development timelines based on improved information resources, real-world project development experience, and observations gained over the past year
- Assessment of the effect of station development timelines on auto manufacturer FCEV release plans
- Continuing development of ARB's analytical methods and greater incorporation within the overall AB 8 process, including the development of the Energy Commission's GFO-15-605
- Further exploration of the need for additional private investment in the hydrogen fueling network, as first presented in the 2015 Annual Evaluation and investigated in the December 2015 Joint Agency Staff Report
- A need to further emphasize the focus on the customer retail experience

Of these themes, updates in the station network development status and ARB's analytical methods have the greatest impact on the conclusions presented in this Annual Evaluation:

Station Development Progress

Over the past year, the hydrogen fueling network has grown and taken on a new, retail-oriented characteristic. As more FCEVs enter California's fleet, the customer perspective increasingly becomes the lens through which all stakeholders must evaluate progress. Hydrogen stations must be available in convenient locations, reliable, easy to use, and offer a positive retail fueling experience to meet customer expectations. In order for the hydrogen network and ultimately the FCEV market to be successful, FCEV driver expectations must be met for a retail experience and level of service similar to what gasoline drivers enjoy. Likewise, hydrogen fueling station developers must be experienced with station design, permitting, engineering, project management, and accounting so that publicly-reported estimates of development and deployment timelines can set realistic expectations for fueling availability. This Annual Evaluation details the impact of this focus on analysis of the hydrogen fueling network and State efforts to ensure these customer expectations can be fully met by the stations coming online today and into the future.

In accordance with this emphasis on retail stations, the 2016 Annual Evaluation assesses and discusses progress in the hydrogen fueling station network in the context of open retail stations. At the time of the 2015 Annual Evaluation, the vast majority of stations were not capable of this type of operation. Most stations operating at the time of the 2015 Annual Evaluation were intended primarily for demonstration or development of technology; while they could fuel multiple FCEVs per day, they were not expected to and could not provide a fully retail experience. Others were operational and in the process of transitioning to Open- Retail status. As of June 17, 2016, there are now 20 stations in the hydrogen fueling network that are open and able to provide this customer-centric retail fueling experience. An additional six demonstration-era stations also remain in operation.

Going forward, California anticipates that the retail hydrogen fueling station will be the new norm. Significant technological progress was made through experiences with the research and demonstration stations of past California programs. However, maintaining progress towards a fueling experience that meets all of a retail customer's expectations is critical for long-term success of the network.

In addition to the 20 Open-Retail stations, 25 funded stations and one mobile refueler remain in various stages of development, as shown in Figure 1. These stations will all provide a fully retail experience, as well. Most of the stations that have begun the permitting process are currently expected to be open by the end of the year, with the remaining few stations likely opening in 2017.

Energy Commission grants encourage accelerated station deployment through a funding structure that provides incentive for stations to quickly become operational. Although most station operators have strived to achieve the most ambitious schedules, the financial incentive alone cannot guarantee an early station operational date. Competing demands within the station developer company's own operations, coordinating schedules with permitting agencies, utility providers, and contractors, and scheduling station performance testing with multiple auto manufacturers can all have an effect on the actual station development timeline.

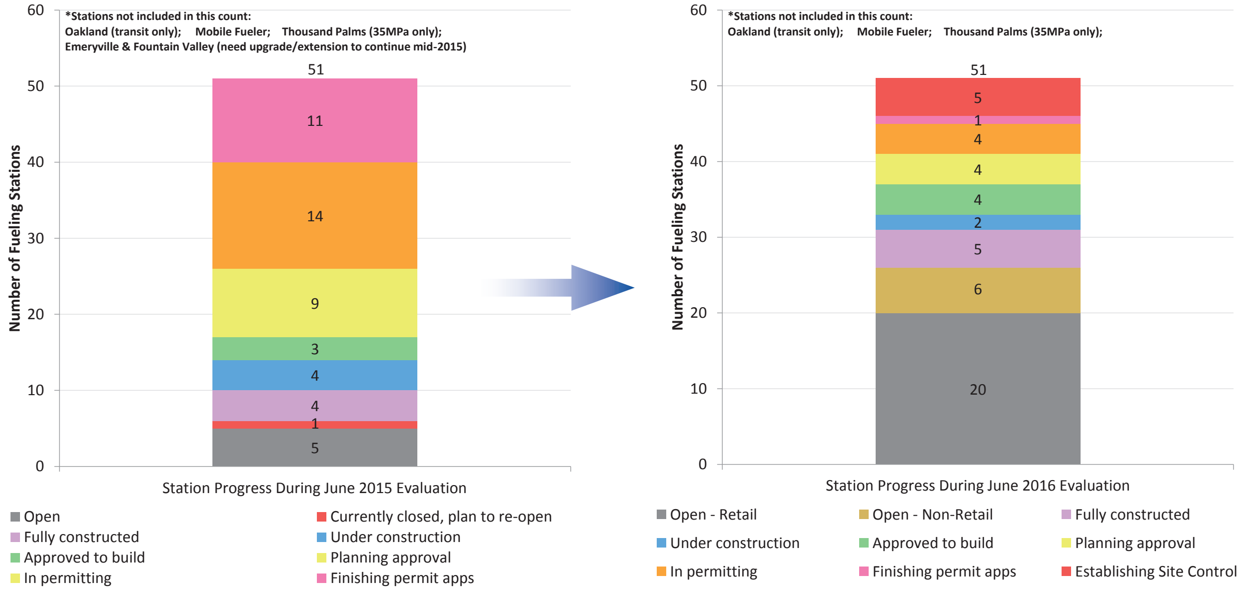
These and other considerations have resulted in a slower station deployment rate than the expected progress in the previous Annual Evaluation. This has temporarily reduced the fueling convenience and available redundancy in the earliest core markets, especially the greater Los Angeles area and the Bay Area. However, it is still expected that all 50[5] stations will be open by the end of 2017 and at that time, the network will provide robust coverage in areas with some of the highest market potential for FCEV adoption.

Projections for individual station development timelines in this Annual Evaluation are more informed than those made in the 2015 Annual Evaluation. In June 2015, because most stations were still in an early stage of development, it was too early to determine whether individual stations would meet the October 31, 2015 operational date to obtain the maximum incentive funding. Moreover, the stations under development were the first retail stations to be constructed in California. The experiences of these stations would ultimately form the first historical record of representative retail station development timelines. Because of the novel retail nature, stated project goals with associated financial incentive were the most reliable information available for projecting station operational dates. With the experiences gained in the past year, it is now possible to more accurately estimate the remaining time for stations still under development to reach deployment based on the observed development times for completed retail stations and assessment of individual stations' development challenges.

Looking forward, the Energy Commission has recently released a new funding program for hydrogen fueling stations, GFO-15-605. With $33 million available in grant funding for both capital expense and operation and maintenance expenses, it is anticipated that this GFO could fund the development of at least an additional sixteen hydrogen fueling stations. ARB anticipates that these new stations will continue to fill in coverage gaps, especially in the San Francisco and Berkeley areas. Additional learnings may also be gleaned from the stations currently remaining in development and the new stations funded by GFO-15-605. As information becomes available, ARB's estimates of timelines and network growth rates will continue to be refined.

5 The two previous Annual Evaluations reported a total of 51 stations. The Foster City station grant has recently been relocated to the existing Newport Beach location, as an upgrade. This consolidates the total number of funded and operating stations from 51 to 50.

Figure 1: Hydrogen Fueling Station Network Status, as of June 17, 2016 (the lightened figure on the left is reproduced from the 2015 Annual Evaluation; the full-saturation figure on the right is the current status)



New Features and Integration of CHIT/CHAT

In the 2015 Annual Evaluation, ARB first presented the key concepts and output products of its new evaluation and assessment tools, CHIT/CHAT. CHIT is a geospatial analysis tool that allows ARB to make detailed analyses of locations where potential FCEV market demand is not met with sufficient hydrogen fueling station coverage or capacity. CHAT (California Hydrogen Accounting Tool) is a database tool for tracking hydrogen fueling station status, DMV registration records for FCEVs, and annual automaker responses to FCEV deployment plan surveys.

Since the last Annual Evaluation, ARB has expanded on the functionality of CHIT by developing a method to calculate local capacity needs based on market assessment and installed hydrogen fueling station coverage. Additionally, ARB has made a few changes in the operation of CHIT and CHAT in order to more closely harmonize their inputs and outputs. County-level data provided in the annual auto manufacturer survey of FCEV deployment plans were compared to CHIT market evaluations similarly aggregated up to the county level. This comparison led to the development of a corrected county-based FCEV market share distribution. The corrected market share distribution is a product of both CHIT and CHAT, which led to more consistent use of information across the two tools. In particular, projections of future hydrogen demand now more accurately reflect ARB's assessment of the FCEV early adopter market, as determined through CHIT and the annual auto manufacturer survey. This directly affects ARB's capacity-based analyses; on the other hand, it does not affect the coverage-based determinations of need for new hydrogen fueling station locations.

In addition to new functionality and implementation in reporting, CHIT/CHAT has now been integrated into the funding program process by being included in the Energy Commission's GFO-15-605. Analyses of coverage gap and capacity need performed in CHIT are now factors in the evaluation of the Coverage, Capacity, and Market Viability Evaluation Criterion in the GFO. ARB is working closely with applicants and the Energy Commission to ensure that all stakeholders are aware of the evaluation process, its effect on application scores, and the CHIT evaluation of proposed station locations. Use of CHIT also enables consideration of the network effect of awarded stations in the GFO. As each successive station is identified as the highest-scoring application in the process, all remaining stations will be re-evaluated for their Coverage, Capacity, and Market Viability Evaluation Criterion via a revised analysis in CHIT that includes the higher-scoring (and thus proposed to be awarded) stations. By implementing this iterative evaluation process, the Energy Commission will be able to optimize the total coverage provided by the awarded stations.

Finally, being an analysis tool by and for the public, CHIT was involved in extensive public interaction over the past year. When the Energy Commission first proposed the use of CHIT as an evaluation tool for its GFO, ARB participated in a public workshop to share further details of the CHIT output products from the 2015 Annual Evaluation. Soon after, ARB provided a day-long public webinar covering the fundamentals, principles, and algorithms that guided and formed the CHIT tool. ARB also established a new public resource page for its hydrogen infrastructure analyses. The page hosts a recording of the CHIT webinar, a download package for the full CHIT tool, and a link to an online interactive map of CHIT results. ARB continues to respond to public inquiries about CHIT, provide further outreach when possible through stakeholder and public meetings, and meets with stakeholders on an ongoing basis to evaluate the results of CHIT and discuss opportunities for continued refinement.

STATION STATUS DEFINITIONS

OPERATIONAL: A station that satisfies the requirements of station operation as defined in Energy Commission grant programs, such as GFO-15-605. Operational stations have no access restrictions, demonstrated at least one successful fueling, passed an initial hydrogen quality test, dispense at 700 bar (350 bar optional)* , and have obtained all necessary permits. A station in operational status may not yet be tested and approved by any or all auto manufacturers for retail customer use. See Appendix D and the GFO-15-605 Application Manual for more details. Prior Annual Evaluations assessed station status based on the operational definition.

OPEN- NON-RETAIL: Typically a station from the research and demonstration phase of California's hydrogen fueling network development. Individual auto manufacturers may approve use by drivers of their vehicles, while others may not. These stations satisfy operational requirements, have usually undergone additional auto manufacturer testing, and may also include point-of-sale capability for metered sale of hydrogen. ARB anticipates at least some of the Open- Non-Retail stations will be upgraded to become Open- Retail.

OPEN- RETAIL: A station that has satisfied several retail performance requirements in addition to those in the operational category. These requirements include a certificate of occupancy from the local Authority Having Jurisdiction (AHJ), confirmation testing and approval by at least two auto manufacturers, certification by the appropriate authority that the dispensing meter meets requirements for retail sale by the kilogram, and connection to the Station Operational Status System (SOSS). Stations that are Open- Retail are available to drivers of any auto manufacturer's FCEV and allow hydrogen fuel purchases with common forms of payment. This Annual Evaluation assesses station status based on the Open- Retail definition.

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* 700 bar and 350 bar fueling are also referred to as H70 and H35, respectively

Location and Number of Hydrogen Fuel Cell Electric Vehicles

AB 8 Requirements: Estimates of FCEV fleet size and bases for evaluating hydrogen fueling network coverage

ARB Actions: Distribute and analyze auto manufacturer surveys of planned FCEV deployments. Analyze DMV records of FCEVs. Develop correlations between survey regional descriptors and widely accepted stakeholder frameworks for evaluating coverage.

Information Sources for FCEV Projections

To project the volume of FCEVs on California's roads, ARB utilized current DMV records of FCEV registrations and results of the annual auto manufacturer survey. The 2016 auto manufacturer survey included a mandatory reporting period and an optional reporting period. The mandatory reporting period for the 2016 survey spanned model years 2017-2019; the optional reporting period spanned model years 2020-2022. Auto manufacturers were provided with an updated map of expected hydrogen infrastructure fueling capacity by county, shown in Figure 2, and the updated list of actual and projected station open dates, provided in Appendix C: Auto Manufacturer Survey Material. In addition to updated information, there were several changes to the 2016 survey:

- The 2015 survey delineated between station operational and open dates. Today, auto manufacturers focus on open dates for developing internal vehicle launch plans. Thus, the 2016 survey only provided actual and projected station open dates. All data presentations in this 2016 Annual Evaluation similarly focus exclusively on station open dates. While additional factors also play a role, this shift to reporting based on open dates increases the apparent station development time compared to prior Annual Evaluations because of the inclusion of a station confirmation phase. Based on experience to date, the station confirmation phase has taken between 40 and 290 days, or 118 days on average.
- Prior surveys have requested both temporal and spatial distribution in the mandatory reporting period, and a single aggregated value for the entire state over the entire three-year optional period. The 2016 survey again requested statewide aggregate values in the optional period, with separate projections for each of the three individual years.

- The 2015 Annual Evaluation presented the development of CHIT, which allows ARB to spatially analyze the likely FCEV first adopter market based on census-based demographic indicators and vehicle registration data. Since that time, the tool has been shared and discussed with stakeholders in a number of venues[6]. For the 2016 survey's mandatory reporting period, ARB provided the auto manufacturers with default values for the county-based split of FCEV deployments. The default values were based on the relative sizes of the markets within each county, as determined by CHIT. Counties with less than 0.5% of the market share were not included in the default. Auto manufacturers could overwrite the default split in their responses, which also provided feedback to ARB in order to further refine its estimates of market share on the county level.
- Vehicle deployments not given a spatial allocation by auto manufacturers (such as in the optional period) were distributed according to market assessment, informed by CHIT and the mandatory period results. Prior Annual Evaluations distributed these vehicles according to the location of funded stations.

Some additional considerations were made based on auto manufacturer responses. The most direct consideration was for auto manufacturers who individually indicated a modification to the CHIT-determined vehicle spatial distribution during the mandatory reporting period. Based on survey responses, it was determined that some of the smaller markets included from the CHIT assessment were not yet a priority for individual auto manufacturers or the industry as a whole. Two modifications to the CHIT market assessment were then made for distributing the vehicles in the optional reporting period (and for any vehicles that were not distributed by the manufacturers in the mandatory period):

- The minimum county-based market share from the CHIT assessment was increased to 1%, as opposed to the 0.5% used as a cutoff in distribution of the survey.
- Any remaining county that was not independently confirmed to receive vehicles by multiple auto manufacturers' survey responses was additionally removed from the CHIT-based spatial distribution.

Table 1 shows the market shares provided to the auto manufacturers as a default value in the survey as well as the revised shares developed based on feedback from the mandatory period. In total, nine counties were removed based on manufacturer feedback, with their market shares redistributed among the remaining counties.

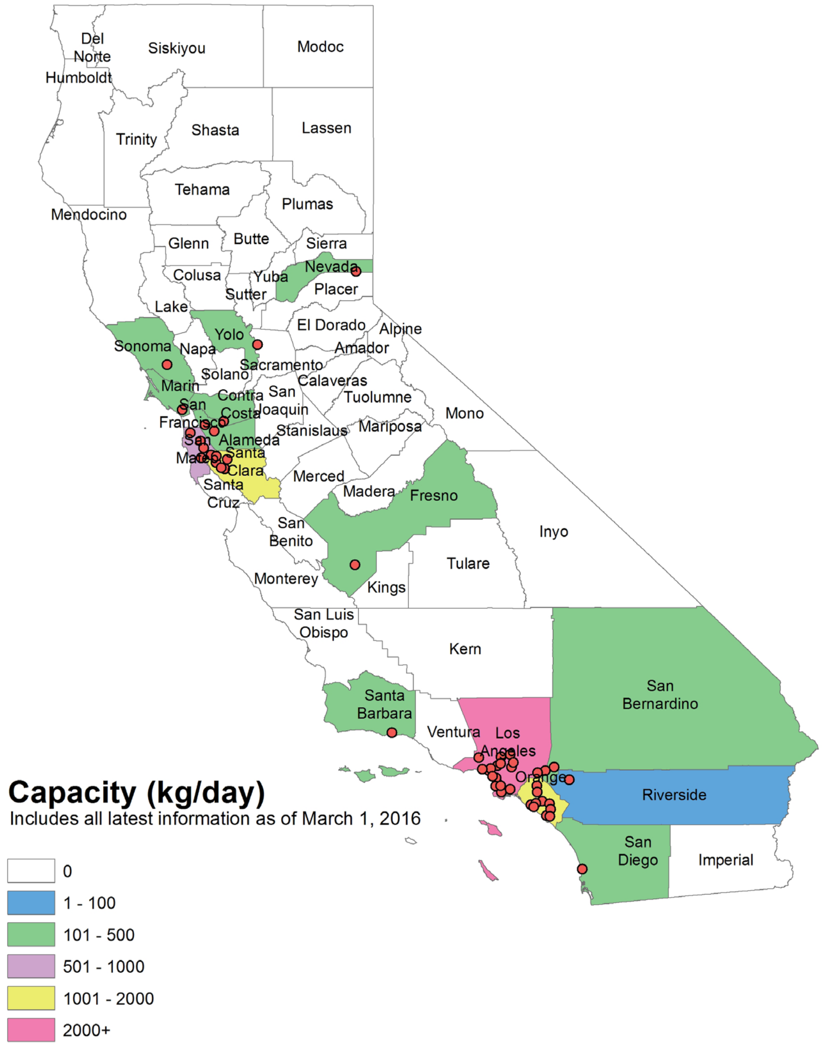
6 ARB provided overviews and detailed descriptions of the tool and outputs in various venues in 2015 and 2016:
- On July 13, 2015 ARB provided an overview of the 2015 Annual Assessment to members of the California Fuel Cell Partnership
- On August 13, 2015 ARB provided an overview of CHIT and its proposed use in a joint Energy Commission-ARB public workshop for concepts for what would become GFO-15-605
- On September 3, 2015 ARB provided an overview of the 2015 Annual Assessment to members of H2USA
- On October 9, 2015 ARB provided a full-day public workshop to present fundamentals of geospatial analysis and the technical formulation of CHIT
- On March 9, 2016 ARB made available two resources for stakeholders interested in CHIT:
    - An online mapping app that displays analysis results produced by CHIT that informed the 2015 Annual Evaluation
    - A download package with the full CHIT toolbox for ArcGIS, all input data used in the 2015 Annual Evaluation, and all outputs produced by each tool in the CHIT toolbox
- On April 1, 2016 ARB staff provided an overview of how geospatial information and analysis are used to inform infrastructure planning via CHIT at the American Association of Geographers Annual Meeting in San Francisco, California
- On April 26, 2016 ARB provided an overview of updated outputs from CHIT and their method of implementation in support of the Energy Commission's GFO-15-605

Table 1: Comparison of County-Level Market Shares Provided in Auto Manufacturer Survey and Adjusted Values Used in Analysis of Optional Survey Period Responses

	Market Share in Survey	Post-Survey Revised Market Share
Alameda	5.8%	6.0%
Contra Costa	2.7%	3.0%
Fresno	1.3%	1.0%
Kern	1.0%	
Los Angeles	32.7%	35.0%
Marin	0.8%	1.0%
Monterey	0.6%	
Orange	9.5%	10.0%
Placer	0.5%	
Riverside	3.0%	3.0%
Sacramento	2.4%	3.0%
San Bernardino	2.9%	3.0%
San Diego	8.5%	9.0%
San Francisco	9.4%	10.0%
San Joaquin	1.0%	
San Mateo	2.9%	3.0%
Santa Barbara	0.9%	
Santa Clara	9.0%	10.0%
Santa Cruz	0.6%	
Solano	0.7%	
Sonoma	0.9%	1.0%
Stanislaus	0.7%	
Tulare	0.5%	
Ventura	1.5%	2.0%
SUM	**99.5%**	**100%**

Although the information shown in Figure 2 was the most currently available information as of the date of the auto manufacturer survey's distribution, it is important to note that the Energy Commission has approved new locations for several stations. It is possible that some of the auto manufacturers' responses may have varied with the updated information. However, this most directly affects the vehicles reported in the mandatory period; as mentioned above, vehicles in the optional survey period were distributed among counties based on the adjusted CHIT-determined market assessment, which is independent of the locations of existing stations.

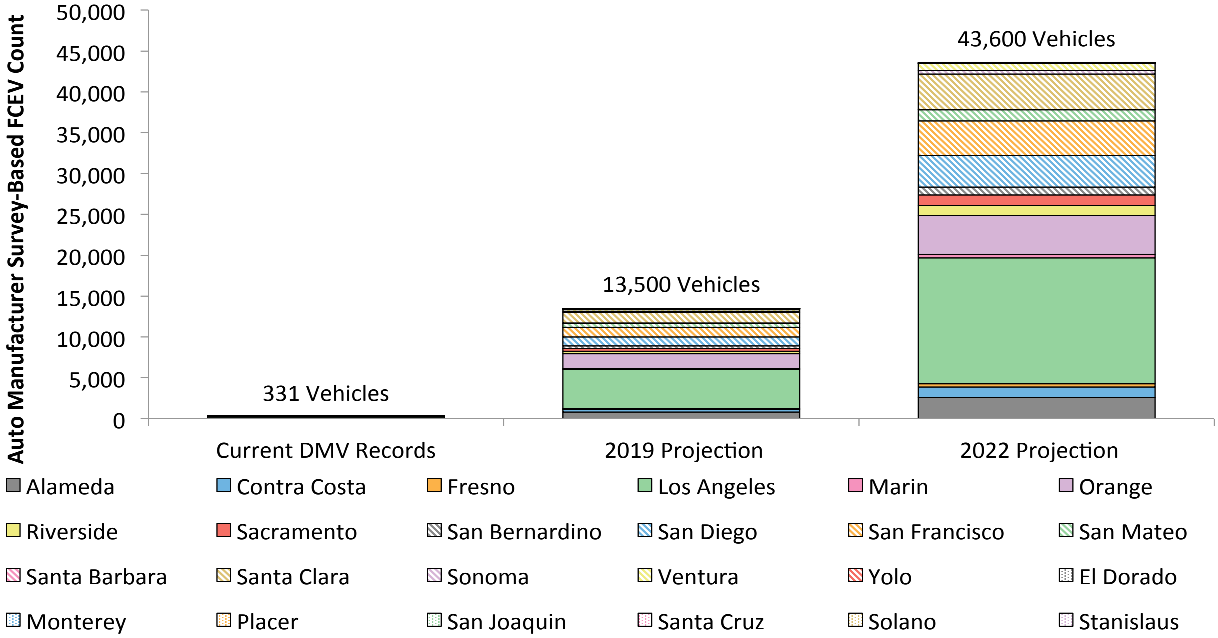
Figure 2: Map Provided with Auto Manufacturer Survey, Indicating Existing and Planned Hydrogen Dispensing Capacity by County



ARB Analysis of Auto Manufacturer Survey Reponses

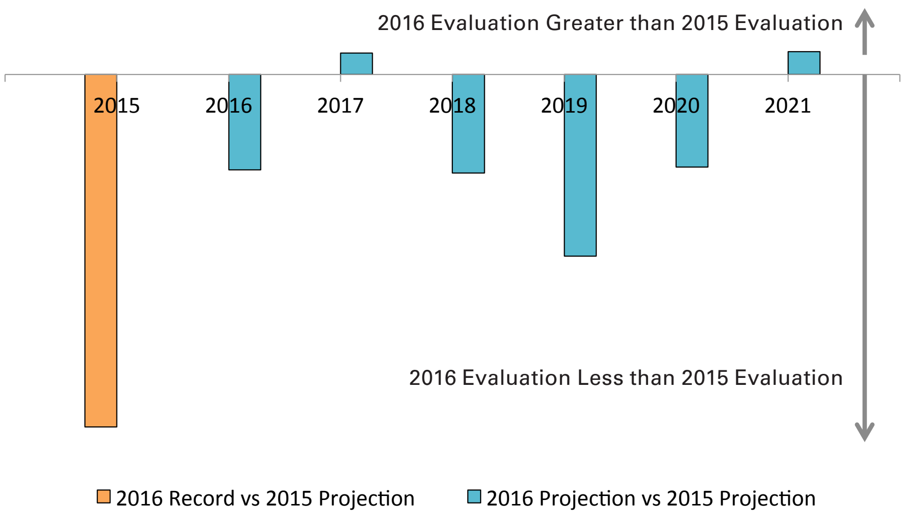
Following the same methodology as in the 2015 Annual Evaluation, DMV and auto manufacturer data were analyzed through CHAT. Updated DMV records were current as of April 16, 2016. One-third of all FCEV volumes for model years indicated on the auto manufacturer survey were assumed to be placed on the road in the prior calendar year; the remaining two-thirds were assumed to be placed on the road in the calendar year that matched the model year. Figure 3 shows the resulting count of FCEVs registered in the state and projections for vehicles on the road in 2019 and 2022. Current projections are 13,500 vehicles on the road in 2019 and 43,600 vehicles on the road in 2022.

Figure 3: Statewide Projected FCEV Population, Based on DMV Records and Auto Manufacturer Surveys



In December of 2015, ARB and the Energy Commission reported an estimated 300 vehicles could be on the road at the time, based on October 2015 DMV records and publicly announced release plans. As of April, there were 331 vehicles with an active registration in the DMV records. While that exceeds the 300 estimated in December, ARB is aware that the pace of delivery has been slower than previously expected; media reports indicate this is largely due to extended development schedules and uncertainties in establishing the early fueling station network [36], [37]. This was reflected in the survey results as shown in Figure 4, which shows the ratio of FCEV projections from the 2016 Annual Evaluation compared to the 2015 Annual Evaluation. Actual FCEV registrations at the end of 2015 were less than projected from the 2015 survey. Projections of FCEV counts in 2016-2020 were almost always higher based on the 2015 survey than the 2016 survey. With the greatest discrepancy in 2015 (by a wide margin) and an approach to equivalent projections in 2021, a one-year delay is apparent from the comparison of survey results. In spite of the delay, the 2016 survey showed that previous projections are recovered by 2021 and continued growth is expected out to 2022.

Figure 4: Ratio of 2016 to 2015 Projections of On-the-Road FCEVs[7]



7 The visualization provided is a ratio of the 2015 and 2016 Annual Evaluations' data, on a logarithmic scale with an undisclosed randomized base to protect individual auto manufacturers' confidential vehicle deployment plans. Values below the line indicate the 2015 projection was greater than the 2016 projection; values above the line indicate the opposite.

Figure 5: County Level Vehicle Projections Based on DMV Records, Auto Manufacturer Surveys and CHIT Early Adopter Market Assessment

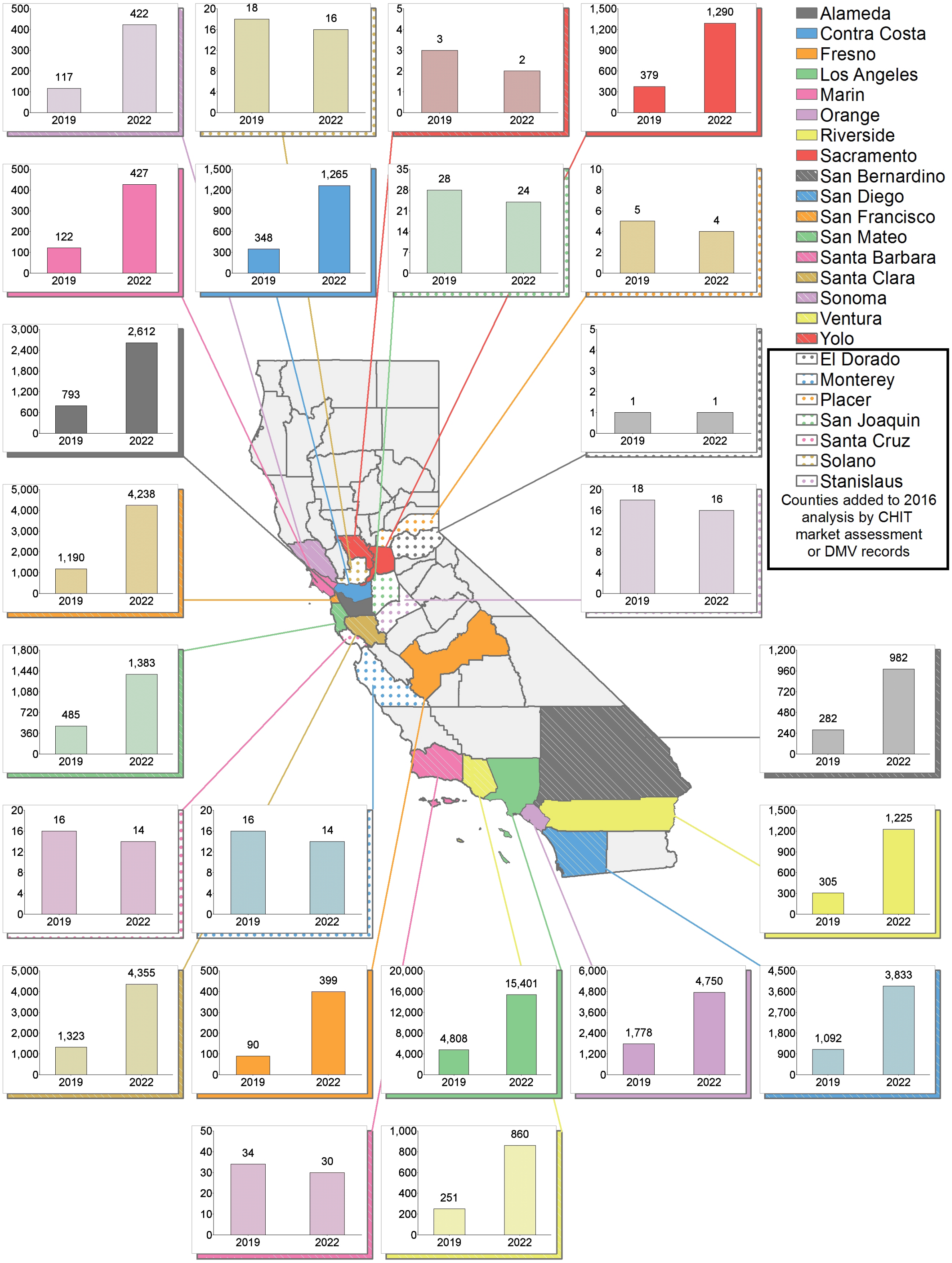


Figure 5 provides additional detail for the county-level distribution of vehicles expected in 2019 and 2022 based on CHIT and auto manufacturer feedback. A couple of counties (Yolo and El Dorado) show low volumes with no growth; these counties currently have registered FCEVs, but the market assessment did not project local growth for future years. Thus, out to 2022, these counties were not assumed to receive any additional FCEVs. It is likely these drivers depend on fueling stations in nearby counties. Other counties (like San Joaquin, Solano, and Santa Cruz) show a slightly larger but still decreasing volume from 2019 to 2022. These counties were indicated by an individual auto manufacturer as a target market in the mandatory reporting period. Without corroborating data from a second manufacturer, these counties were not included in the projection of vehicle placement for the optional reporting period. After 2019, these counties' FCEV populations decrease due to assumed vehicle attrition rates (caused by a number of factors, including vehicle loss, accidents, and trade-ins). While it is unlikely that an individual auto manufacturer would stop sales in any particular county, the projected volumes in these counties are small. Limited auto manufacturer participation implies difficulty in developing a large enough market for a self-sustaining local fueling network. In total, these counties account for 118 FCEVs, or 0.3% of the projected 2022 market. Future Annual Evaluations will continue to monitor auto manufacturer feedback regarding these counties and adjust projections as necessary.

Trends Across 2014-2016 FCEV Projections

Figure 6 shows the developing trend of future on-the-road FCEV projections from the 2014 through 2016 Annual Evaluations. As in the 2015 Annual Evaluation, the developing plans for vehicle placement appear to follow closely to a power function, which is again supported by the dependence of FCEV sales growth rate on the cumulative projected volume of on-the-road FCEVs, as shown in Figure 7. The close match between the compiled data (blue line and diamonds) and the ideal power law fit (dashed purple line) indicate reasonable confidence that the projected growth of on-the-road FCEVs follows a mathematical power function. Likewise, the R^2 value of 0.94 for the fit indicates a strong correlation between growth rate in on-the-road FCEVs and count of on-the-road FCEVs, as would be expected when modeling the trend according to a mathematical power function.

Compared to the 2015 analysis, the distribution of vehicles is expected to occur in more counties than previously identified, as delineated by the counties inside the box shown in the legend of Figure 5. Additionally, the market share of some major counties has shifted substantially. For example, in the 2015 Assessment, San Francisco County was not given a large market share because the vehicle placement method in that Annual Evaluation depended on the location of built or funded stations. With no station yet built in the county, the only vehicles placed there were those reported by auto manufacturers during the mandatory survey period. Now, San Francisco County is projected to have 10% of the state's FCEV market share. Similarly, Ventura and Sacramento counties are now projected to have a substantial market share for the same reasons.

Alameda, Contra Costa, and San Diego counties have all also increased their market shares compared to the previous Annual Evaluation. A few counties, like Fresno, now receive fewer vehicles in this Annual Evaluation's market-based assessment. In the case of Fresno in particular, this is likely closer to reality as the Coalinga station (which was the reason it previously received a larger proportion of vehicles) is envisioned to serve as a long-distance connecter station and is not expected to serve a large local market. Likewise, Yolo County now has fewer projected vehicles. While the West Sacramento station is physically located in Yolo County, it is very close to the border of Sacramento County, where market analysis determines most of the local first adopter drivers likely reside.

Although these observations show meaningful shifts in vehicle projections among the counties, ARB believes the current market-based method provides a more accurate means of projecting future vehicle placement. It is still expected that as the hydrogen fueling network progresses, auto manufacturers will target vehicle placement in markets near the fueling stations, in the order that they establish sufficiently reliable and redundant coverage to the local market. Using market assessments to project FCEV placement lends accuracy to ARB's assessment of future hydrogen station needs and ensures that stations are built in areas with a greater chance for success. Stations placed in high-market areas will likely enable faster releases of FCEVs in larger volumes than stations placed without consideration of market potential. Finally, these market share shifts have the greatest effect on projected hydrogen demand within each county; ARB's determination of areas in need of new station coverage is not affected by this adjustment to the analysis method.

Figure 6: Comparison of FCEV On-The-Road Vehicle Counts in 2014-2016 Annual Evaluations

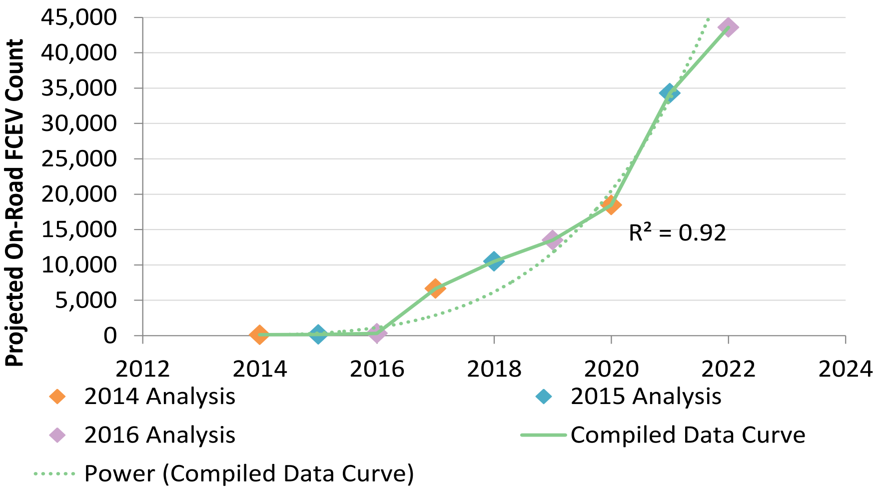
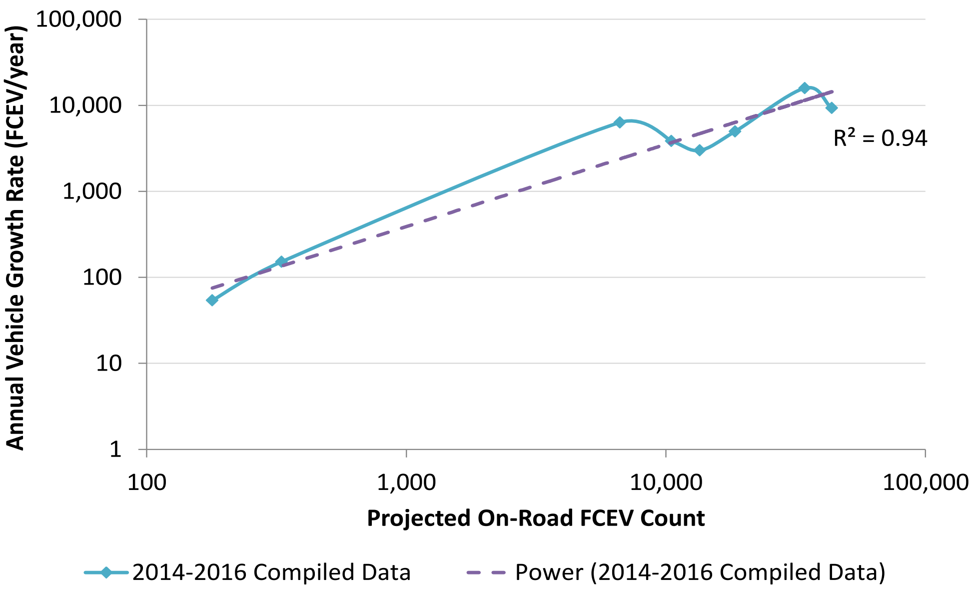


Figure 7: Projected Growth Rate of On-The-Road FCEVs



Location and Number of Hydrogen Fueling Stations

AB 8 Requirements: Evaluation of hydrogen fueling station network coverage

ARB Actions: Determine the regional distribution of hydrogen fueling stations in early target markets. Assess how well this matches projections of regional distribution of FCEVs in these markets. Develop recommendations for locations of future stations to ensure hydrogen fueling network coverage continues to match vehicle deployment.

Overview of Coverage Concept

For the 2015 Annual Evaluation, ARB developed the California Hydrogen Infrastructure Tool (CHIT). CHIT is ARB's primary tool for spatially assessing need for hydrogen station coverage and capacity and continues to be utilized in the 2016 Annual Evaluation. Coverage in CHIT is defined as an evaluation of the spatial extent and redundancy of fueling service provided by one or more stations in the open and funded hydrogen fueling network. For example, consider the neighborhoods in Orange County shown in Figure 8 and Figure 9. All of the indicated neighborhoods are covered by at least one station within a nine minute drive, though the degree of coverage varies by location. The Turtle Rock, Corona Del Mar, and South Costa Mesa communities all have the least nine-minute coverage shown because they each are only within reach of a single station. The North Costa Mesa and Newport Beach communities have a bit more coverage because they can reach two stations within nine minutes. Meanwhile, the Newport Back Bay community has the highest nine-minute station coverage shown, lying within a nine minute drive of all three stations.

On the other hand, evaluation of the six-minute coverage reveals more restricted fueling options. None of the indicated neighborhoods have the opportunity to fuel at multiple stations, and the Turtle Rock community has no coverage at all within a six-minute drive. Overlapping coverage from multiple stations and shorter drive times to those stations indicate increasing degrees of coverage. Comparing the degree of coverage provided to these communities by the three stations shown, the order in this example (from least to most) would be:

- Turtle Rock
- Corona Del Mar and South Costa Mesa
- North Costa Mesa and Newport Beach
- Newport Back Bay

CHIT performs assessments similar to this example across the entire state and for a wider set of drive times. These assessments are synthesized into an overall evaluation of coverage provided by the open and funded station network. This statewide assessment is shown in Figure 10; in all coverage figures, areas of gray have no coverage. Areas with a larger market potential should have a higher degree of coverage, implying greater numbers of stations and redundancy. CHIT performs this assessment and provides recommendations for new station locations by evaluating the degree to which local coverage matches aggregated indicators for the FCEV first adopter market. The larger the discrepancy between the market and the coverage, the greater the priority placed on that area for a new station.

Figure 8: Coverage Provided to Neighborhoods within a 9 Minute Drive of Southern California Beach City Stations

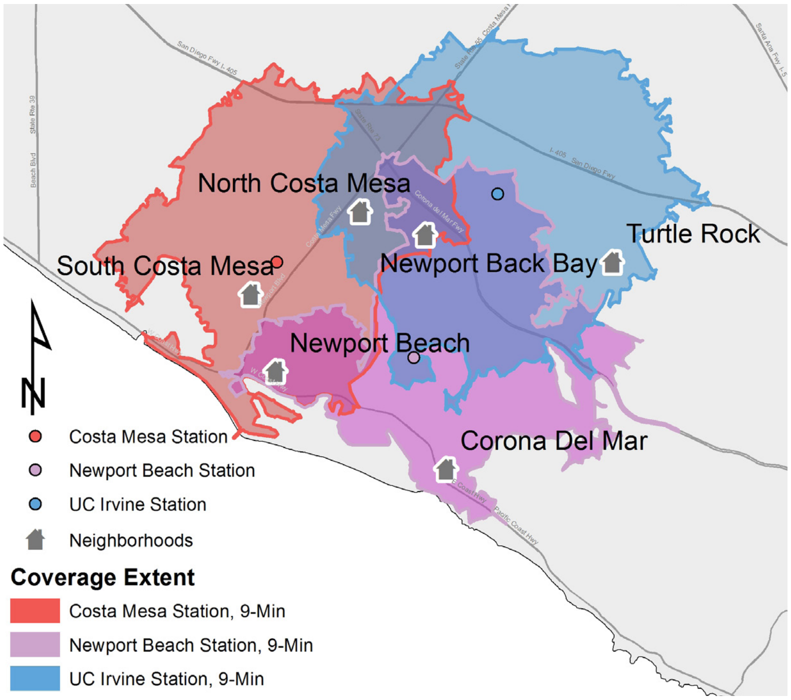


Figure 9: Coverage Provided to Neighborhoods within a 6 Minute Drive of Southern California Beach City Stations

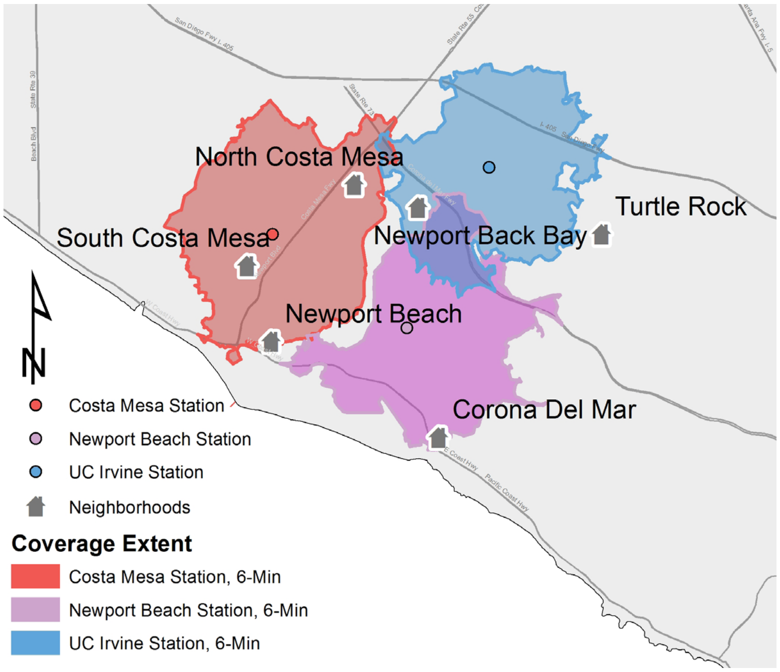
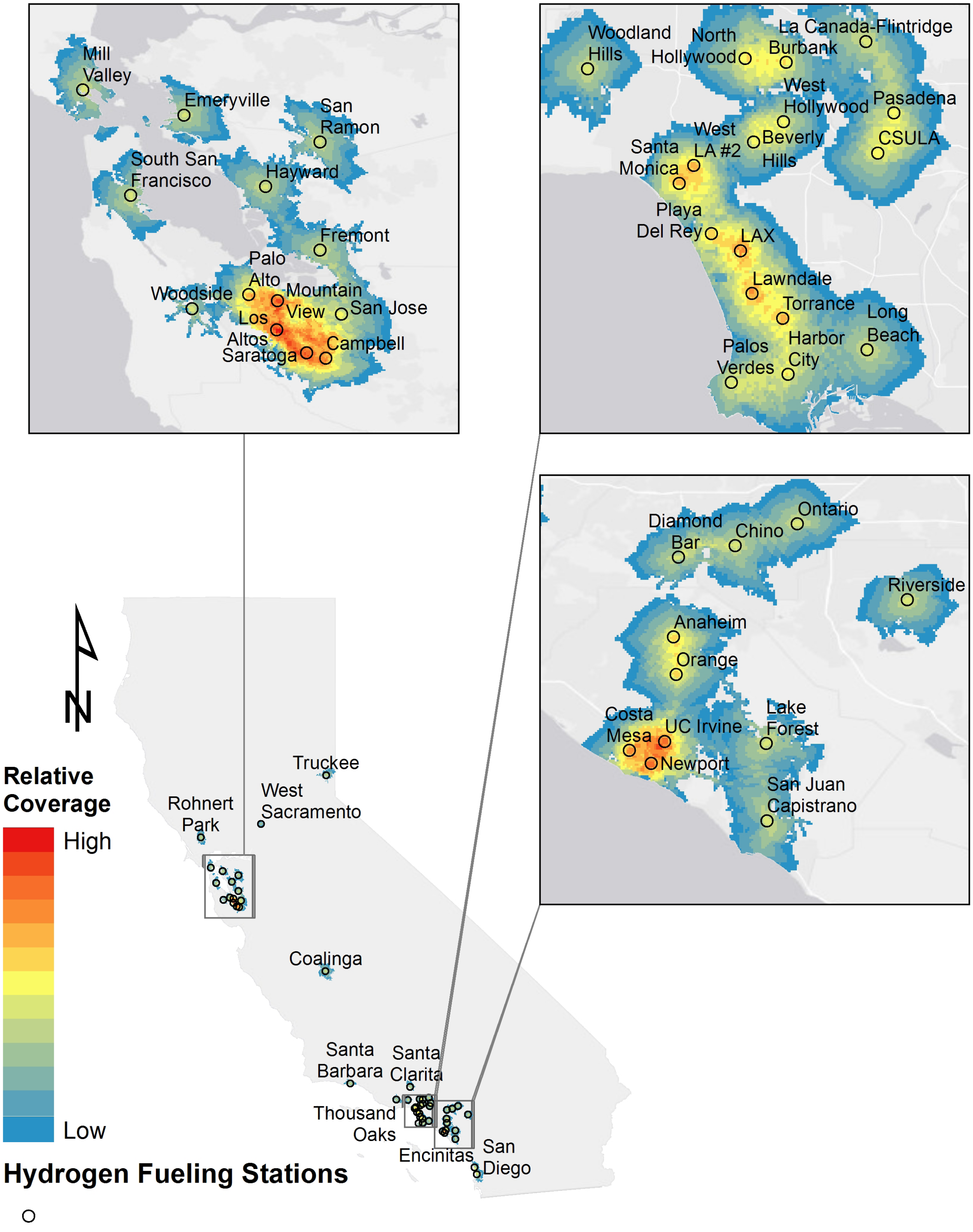


Figure 10: Assessment of Coverage Provided by Existing and Funded Stations



Current Open and Funded Stations

Beginning with the 2016 auto manufacturer survey, ARB began tracking and performing analyses of the station network status in the context of stations that have achieved fully open status. Open status differs from the operational status used in past Annual Evaluations in that it additionally includes the station confirmation process. While an operational station has the technical capability to fuel a vehicle, it has not yet completed a series of tests that confirm the repeatability of the station's fueling performance and retail functions. Historically, the station confirmation process has been carried out through careful coordination among the station developer, the individual auto manufacturers, and the State. This coordination can be complex, which has meant that the length of time for station confirmation has been long and highly variable. As will be discussed in Chapter V, station confirmation is now being aided by the newly arrived HyStEP device and may in the future be accomplished completely through a State certification program.

Open status has been chosen as the basis for tracking and evaluation in 2016 as it has become clear that operational status may be too far removed from the capability for a station to provide service to retail customers. Fully retail operation is the ultimate goal of the stations co-funded by the State's AB 8 program, and is explicitly referenced in the Energy Commission's latest GFO-15-605. Because of the additional time taken by the confirmation process between operational and open status, the historical trends presented in this Annual Evaluation are not directly comparable to those in previous years. Additionally, since end-of-year counts are typically presented in the Annual Evaluations, some stations that were (or were planned to be) operational towards the end of a given year may now be counted as open in the following year.

Figure 11 shows the updated assessment of individual stations achieving open status while Figure 12 provides the county-level aggregates of numbers of open stations. Note that in both figures, the data for 2009-2013 have not been adjusted, as these years largely refer to pre-retail stations and their operational capability was not expected to meet the requirements of today's open retail stations. Several changes to station location in the funded hydrogen fueling network have occurred since the June 2015 Annual Evaluation was published. These changes are highlighted in Figure 11 for the affected station projects. The changes that have been made are:

- The grant agreement for the Oakland Airport station is in process for an amendment for an upgrade of the existing Emeryville station. Currently, the Board of AC Transit (the site owner of the Emeryville station) has provisionally agreed to pursue the development of a station upgrade to bring its existing equipment to full retail capability. The Emeryville station was described in the 2015 Annual Evaluation as a station with an uncertain future and could not be counted for projections beyond 2016. This station relocation brings greater confidence to the Emeryville station's continued service. A capacity upgrade will be expected, but has not yet been specified.
- The grant agreement for the Foster City station is in process for an amendment for an upgrade of the existing Newport Beach station. A capacity upgrade to 350 kg/day has been specified and included in all analyses.
- The grant agreement for the Pacific Palisades station is in process for an amendment for a new location in North Hollywood.
- The grant agreement for the Redondo Beach station is in process for an amendment for a new location in Rancho Palos Verdes.
- The grant agreement for the Irvine North station is in process for an amendment for a new location in Santa Clarita.
- The grant agreement for the Laguna Niguel station is in process for an amendment for a new location in Thousand Oaks.
- The grant agreement for the Mission Viejo station is in process for an amendment for a new location in Encinitas.
- The grant agreement for the Redwood City station is in process for an amendment for a new location in Fremont.

Individual station open date projections in Figure 11 may not match entirely with the information provided in Appendix C: Auto Manufacturer Survey Material. Projected open status for the survey was based on then-current station status, number of days in the current phase of development, and the average days elapsed for all current and remaining development phases as discussed in the December 2015 Joint Agency Staff Report on AB 8 [10]. The projections in this Annual Evaluation include adjustments at the individual station level based on discussions with the Energy Commission and the Governor's Office of Business and Economic Development regarding the most recent progress.

Based on the most current information, 38 stations are projected to be open in the state by the end of 2016, with all 50 currently funded stations open by the end of 2017. The total number of stations in this Annual Evaluation (50) is one fewer than previously reported because the Foster City station was moved to a station that had also been previously counted in the network. This consolidated their combined count from two to one. Additionally, it is important to note that projections for open dates in the 2016 Annual Evaluation are based on a much more informed assessment than was possible in prior years. In the 2015 Annual Evaluation, many stations were not far along enough in their development process to determine accurate operational date projections. Only stations that showed considerable difficulty with the very earliest development stages were considered unlikely to be completed by year's end. Determination of the remaining stations' likely schedule of progress was driven by the financial incentive for an October 31, 2015 operational date. Additionally, there was not yet a robust historical record on which to base generalized schedules. With the additional year of experience and records, it is now possible to provide better-informed evaluations of individual stations' likely rate of future progress.

Figure 11: Individual Station Open Year History and Projections

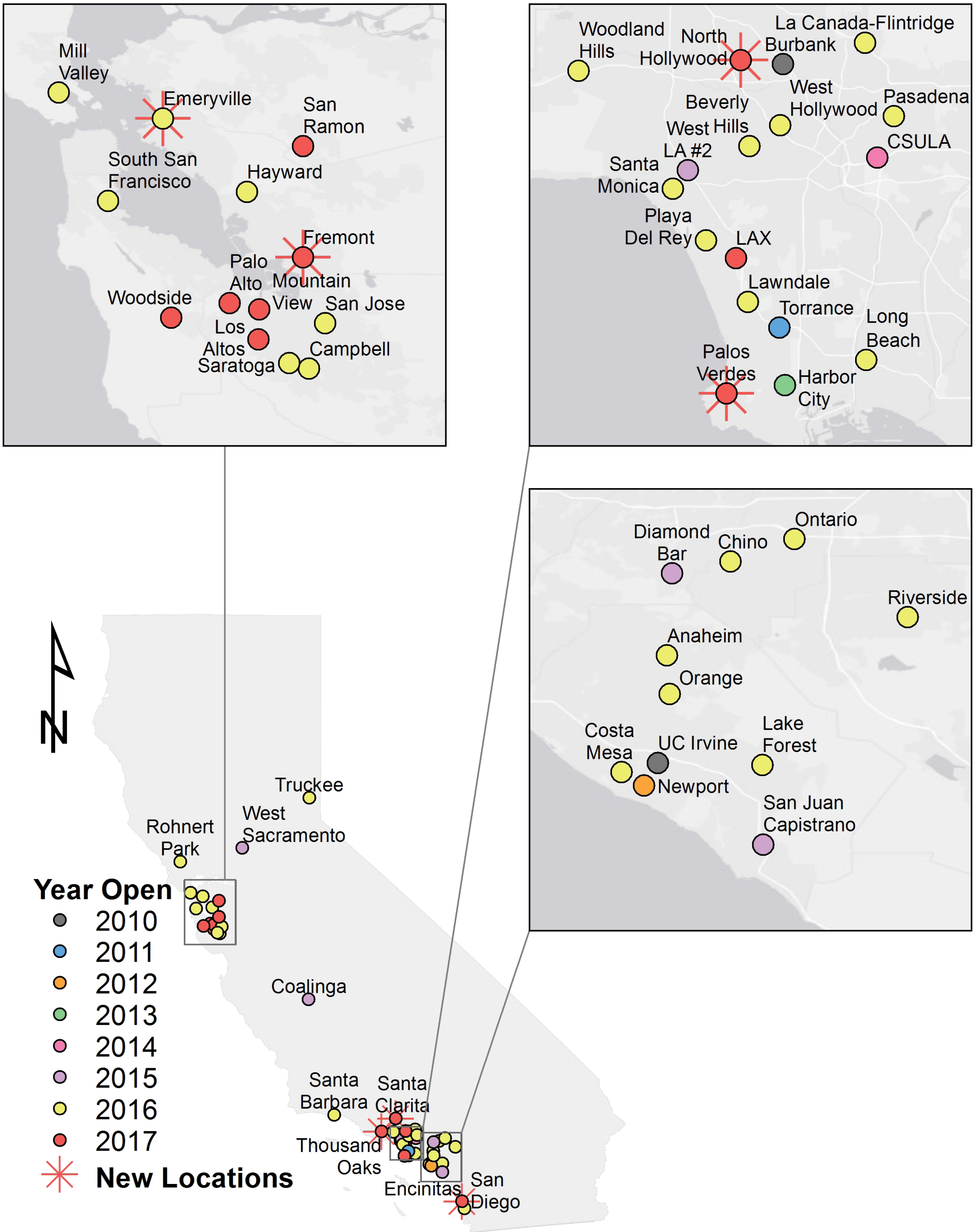


Figure 12: End of Year Station Projections by County and Statewide (as of June 17, 2016)

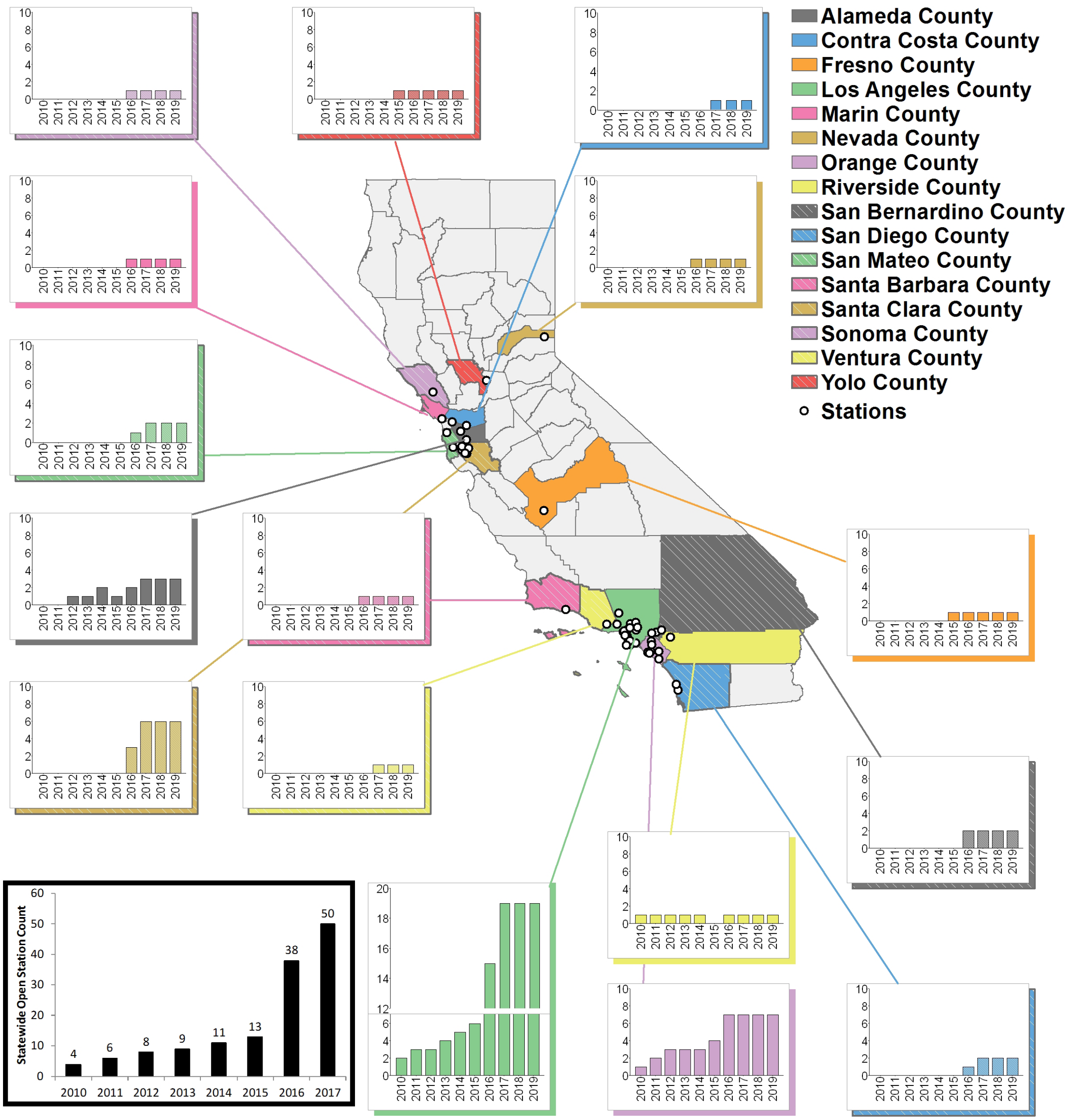
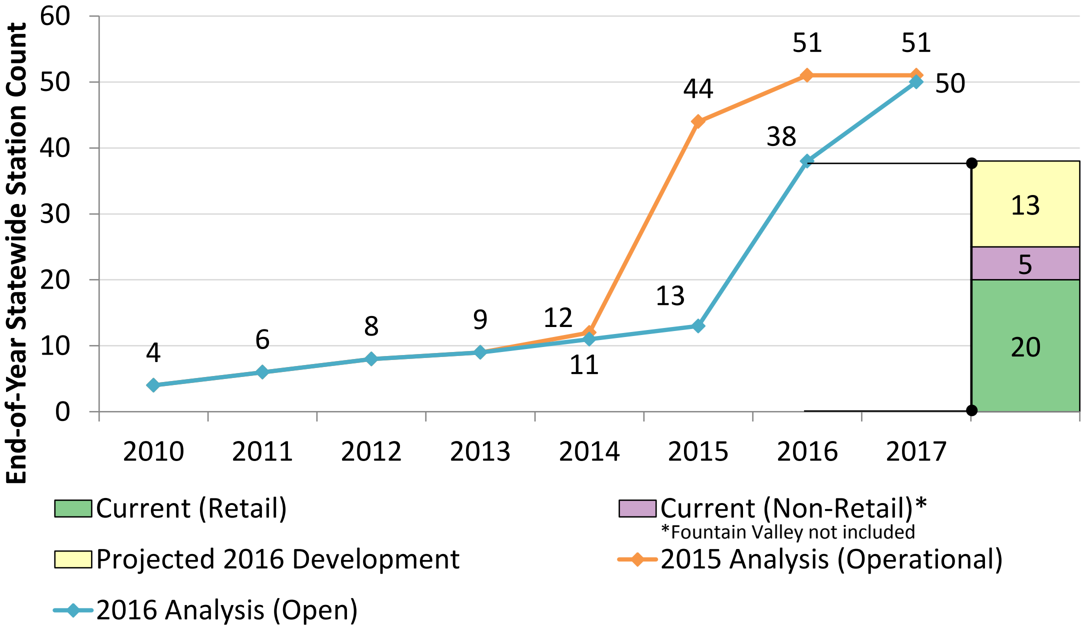


Figure 13 provides a comparison between the current end-of-year projections for station open dates and the previous Annual Evaluation's projections of operational dates. As previously discussed, the additional step between these milestones contributes an apparent reduction in this year's station projections compared to the 2015 Annual Evaluation. However, this alone does not explain the full magnitude of the difference between projections shown in Figure 13. For reference, instead of the 44 stations previously projected to achieve operational status by the end of 2015, 20 stations had done so. Significantly extended project timelines have clearly had an effect on the timing of the overall station network development, which was likely reflected in the auto manufacturer survey responses. The December 2015 Joint Agency Staff Report identifies developer difficulties in securing a station location, longer than expected permitting reviews, prolonged contract negotiations with suppliers and landlords, and in a few cases neighborhood resistance as some of the reasons why station development has taken longer than initially anticipated [10]. As previously stated, these considerations and the developer's own corporate priorities and schedules determine whether or not stations become operational in time to receive the maximum incentive funding.

Figure 13: Comparison of Statewide Station Projections between 2015 and 2016 Annual Evaluations



Additionally, once stations are open, they have typically had a "shake-out" period during which certain systems like the point-of-sale require debugging to provide the optimal retail customer experience or to ensure sufficient reliability. Until resolved, these issues can ultimately affect a customer's perspective of the station's functionality. As a response and to keep FCEV drivers fully informed, GO-Biz and the California Fuel Cell Partnership's (CaFCP) SOSS have adopted a strategy of first reporting stations as "Soft Open" prior to a full-fledged open status. This status remains until the station has, for a sufficient length of time, exhibited the capability for reliable and consistent operation. Customers who choose to visit a Soft Open station are advised that they may need to make multiple attempts to receive a 100% full fill, experience unexpected downtime while visiting the station, or may not receive an accurate receipt on their first attempt. Stations may typically be expected to solve all issues during the Soft Open phase within 60 days. GO-Biz is currently working with stakeholders in industry and the State to establish a definite process for stations to transition from Soft Open to Open- Retail. Currently, 26 stations (including retail and non-retail) are available for FCEV drivers to fuel.

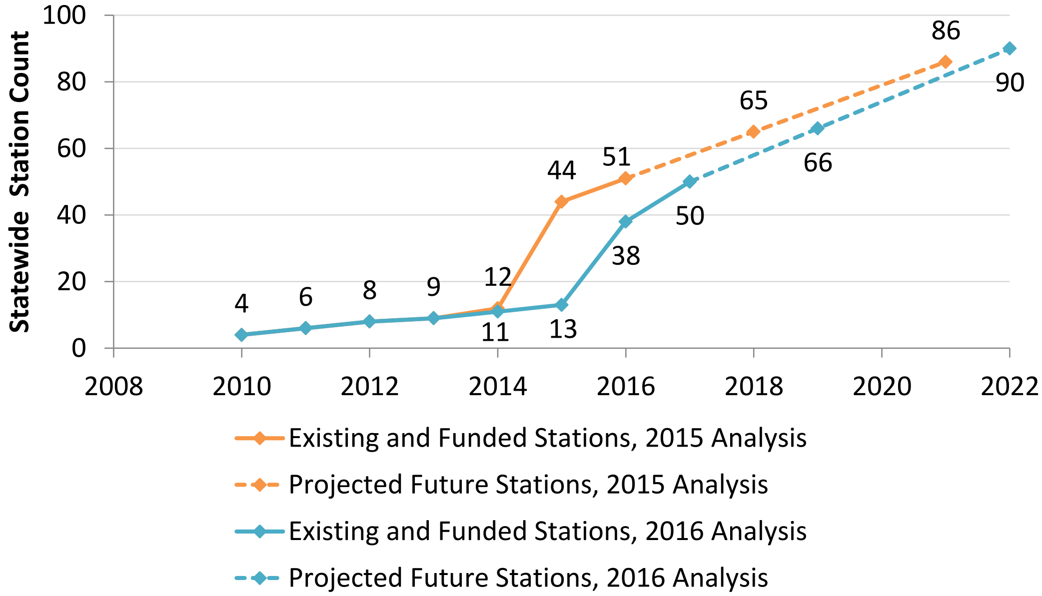
Finally, multiple stations that offer key functionality to the network have opened in the past year; in fact, since December the number of open stations has doubled, as two to three stations have consistently been opened each month. Several stations in the Bay area have established the fueling network in this important market and enabled Hyundai to begin local releases of its Tucson Fuel Cell. The Coalinga station opened in December of 2015 and established the first long-distance connector station, enabling travel between Northern and Southern California. This was demonstrated publicly through the ARB-organized "Mary's Valley Rally" in April of 2016, when ARB Chair Mary Nichols, Energy Commissioner Janea Scott, and GO-Biz Deputy Director of ZEV Infrastructure Tyson Eckerle drove a caravan of FCEVs from Santa Monica to Sacramento, relying on the Coalinga station for midway fueling. The Santa Barbara station has opened and initial resident feedback through CaFCP has been positive and excited; what was originally viewed as a travel destination station may prove able to serve a strong local market sooner than expected.

Continued Station Deployment Rates

ARB has revised its estimate of the number of stations that can be developed with annual commitments of $20 million to eight stations a year. ARB adjusted this projection based on the results of the Energy Commission's awards in PON-13-607 and the structure of GFO-15-605. Considering the total capital expense grants of $45,625,814 awarded under PON-13-607 for the 28 stations (without accounting for the mobile refueler also funded by PON-13-607) together with $300,000 per station for Operations and Maintenance Support grants, a total of approximately $54 million in award money were committed by the State in PON-13-607. Each station was eligible for up to $2.425 million in State grant funding but on average requested $1.93 million; each station therefore requested 80% of the potential amount available. Assuming this same average per-station grant proportion applied to the funding levels available in GFO-15-605 ($2.64 million and $2.43 million for stations above 300 kg/day and 180 kg/day - 299 kg/day, respectively), ARB estimates that sixteen stations can be built with the $33 million available in GFO-15-605. For each $20 million annual allocation provided by AB 8, ARB therefore estimates that eight stations can be built. GFO-15-605 combines the current and next funding years' funds into a single solicitation. Thus, an average of eight stations per year has been assumed as a new baseline rate for all years going forward.

Figure 14 shows the current projection of future cumulative station counts, compared to the same projection from the 2015 Annual Evaluation. This pace of development is slower than the annual rates assumed in the December 2015 Joint Agency Staff Report. However, the evaluation in that report was based on decreasing costs per station and infusion of private capital to ensure that the pace of station development was always exactly matched to the fueling demand from the growing FCEV fleet. The constant rate shown in Figure 14 is based on an evaluation limited only to the funds available through AB 8, which is only a subset of the funds assumed in the Joint Agency Staff Report. Moreover, eight stations per year is a rate within the range of values assumed for some years across the multiple scenarios evaluated in that report. Comparison between ARB's funding-limited analysis and the Joint Agency Staff Report's exploration of potential buildout scenarios is further discussed in Chapter IV.

Figure 14: Cumulative Existing, Funded, and Projected Publicly Funded Station Counts, with Averaged New Station Funding Rate of Eight per Year



CHIT Updates and Further AB 8 Program Integration

The 2015 Annual Evaluation introduced ARB's FCEV first adopter market and hydrogen fueling station coverage evaluation tool, CHIT. CHIT is a method and automated toolbox in the ArcGIS environment for performing statewide geospatial analysis of the localized match between fueling station coverage and the strength of the first adopter market. CHIT performs this evaluation through the following steps:

- Assess the relative strength of the FCEV first adopter market across the state
- Assess the relative degree of hydrogen fueling station coverage across the state
- Compare market and coverage assessments to determine coverage gap
- Analyze patterns in the spatial distribution of coverage gap to identify areas with a prominent coverage gap
- Distribute projected vehicle population and hydrogen demand according to the market assessment

This process leads to ARB's suggested areas for further infrastructure investment in future Energy Commission programs. Figure 15 illustrates the conceptual framework for combining the coverage evaluations demonstrated in Figure 8 through Figure 10 with a market evaluation to determine coverage gap. Figure 16 shows the full statewide evaluation and the locations of Priority Areas as determined in 2016 based on the station locations shown in Figure 11. In addition to updating the station location input for CHIT evaluation, several new updates and activities involving CHIT have occurred in the past year.

Figure 15: CHIT Evaluation Process Comparing Market and Coverage Assessments to Determine Coverage Gaps

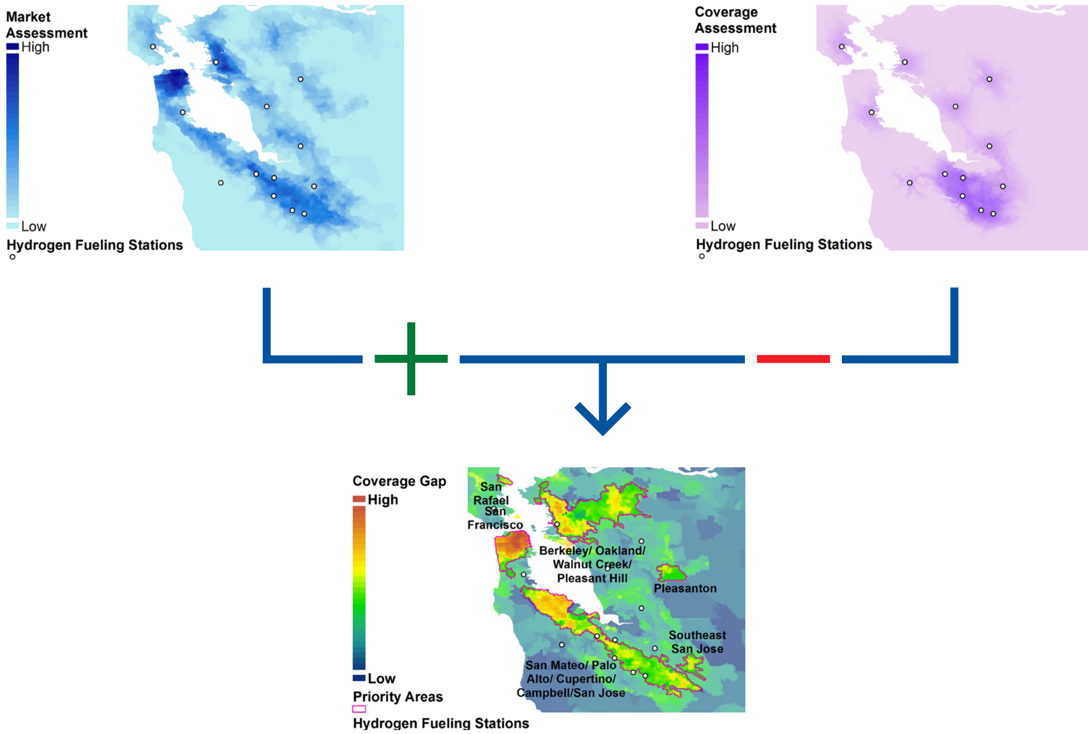
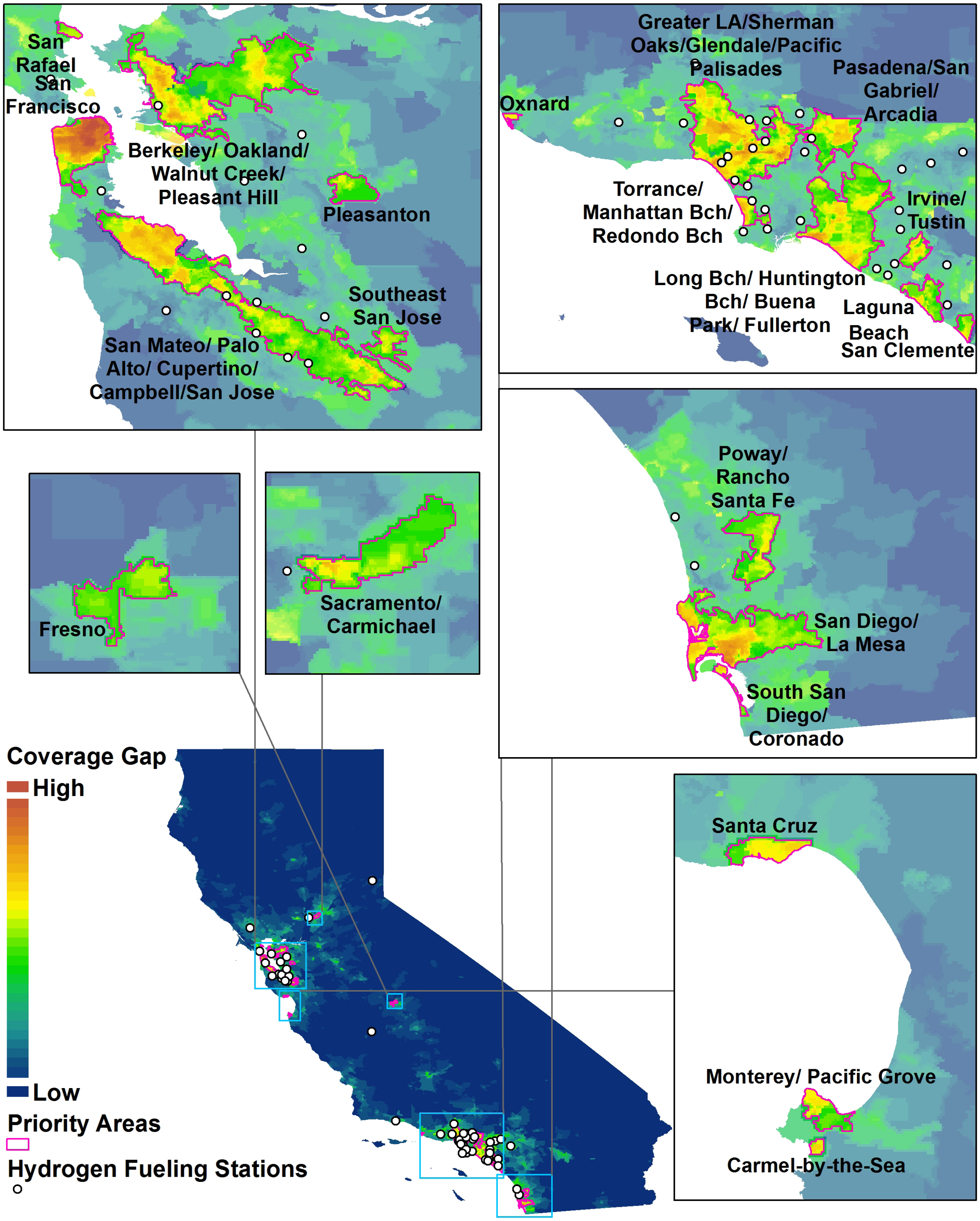


Figure 16: Revised Evaluation of Coverage Gap and Identification of Priority Areas Conducted for GFO-15-605



CHIT/CHAT Harmonization

As discussed in Chapter II, the 2016 Annual Evaluation marks the first use of a market assessment to guide the projection of FCEV placement in the auto manufacturer survey. In prior evaluations, projected vehicle placements for the optional period were spatially distributed according to the location of hydrogen fueling stations. This method was guided by prevailing paradigms of near-term vehicle placement, but did not consider potential for new and future market growth. By using CHIT's market assessment adjusted for auto manufacturer feedback, the 2016 Annual Evaluation is able to provide a more consistent and representative evaluation of local market growth. As will be discussed in Chapter IV, elements of CHIT's coverage assessment were also used in this year's assessment of county-wide hydrogen budget to account for FCEV markets that may be serviced by fueling stations in adjacent counties. The end result of this effort is to ensure that the county-based calculations of projected hydrogen demand more closely reflect the CHIT FCEV early adopter market analysis.

Inclusion of CHIT in GFO Evaluations

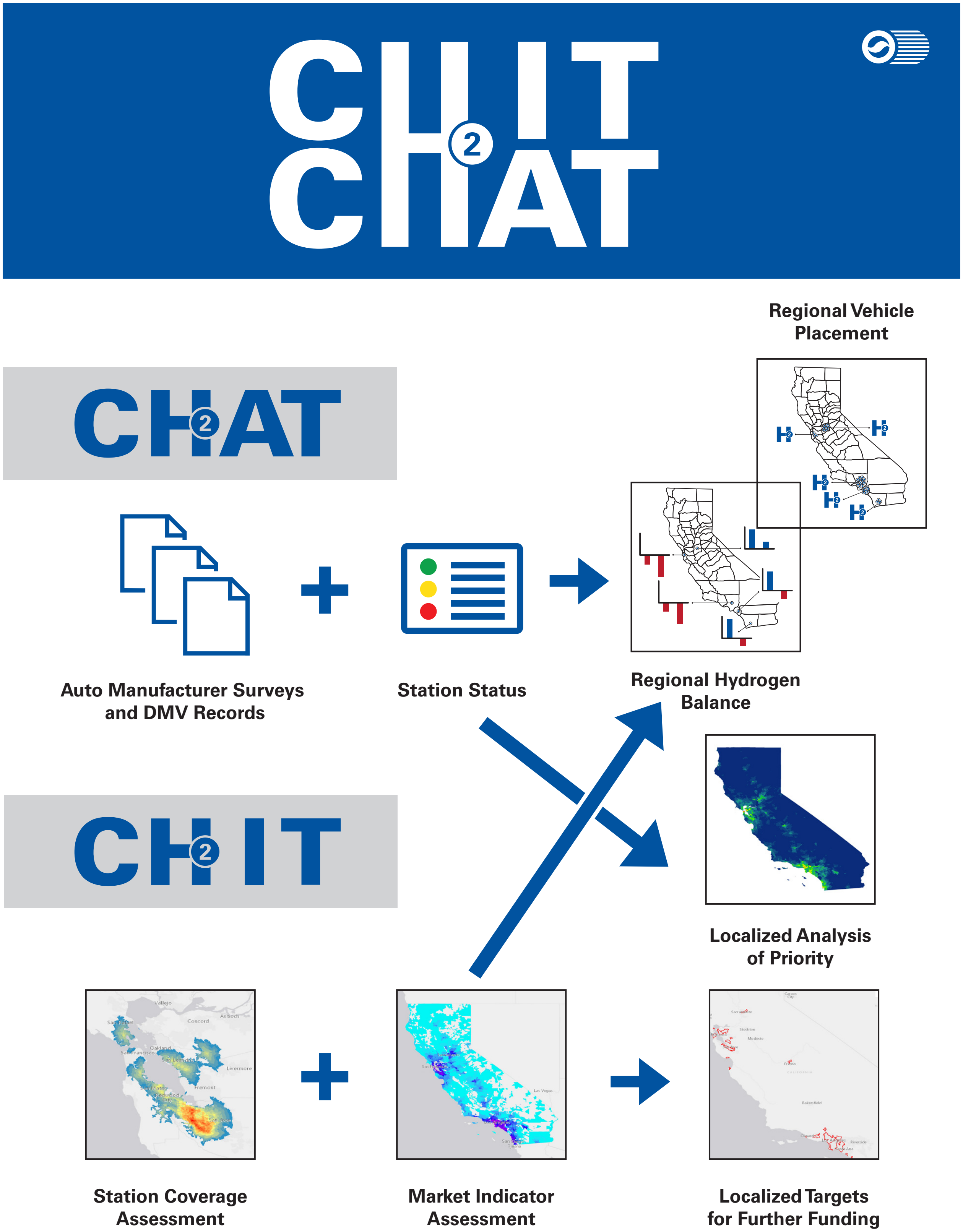
CHIT was developed to help ARB determine its location-based recommendations to the Energy Commission for use in hydrogen infrastructure funding programs. As development of the tool progressed and the Energy Commission developed GFO-15-605, CHIT was also adopted into the GFO development and evaluation process. As published in the Solicitation Manual for GFO-15-605, the Energy Commission will incorporate evaluations in CHIT into its scoring of proposed locations and station capacities [38]. Locations are scored according to the coverage gap that they address. Capacities are scored according to the appropriateness of the proposed station size for the 2021 market (34,300 FCEVs statewide). Applicants are also given the opportunity to provide informational narratives addressing factors that may not have been captured by the CHIT evaluation. Inclusion of CHIT in the Energy Commission's funding process helps ensure consistent analyses and goal setting throughout the entire AB 8 process.

CHIT Online Results Viewer App

In order to more effectively communicate with stakeholders and the general public, ARB developed an interactive online CHIT results viewing app. The app can be accessed from ARB's Hydrogen Fueling Infrastructure Assessments page[8]. When visiting the app, users are able to view layers from the 2015 Annual Evaluation including station locations, Priority Areas, Coverage Gap, and Capacity Need. In addition, ARB posted revised layers for the GFO that display evaluations based on the updated station network. These maps are lower-resolution versions of the output created by the desktop CHIT tool, but it is ARB's intent that they provide enough information for the public to draw general conclusions and for GFO applicants to make basic comparisons between potential station locations.

8 *http://www.arb.ca.gov/msprog/zevprog/hydrogen/h2fueling.htm*

Figure 17: Thematic Overview of CHIT/CHAT Tools, Input Data, and Output Goals



Full CHIT Download Package

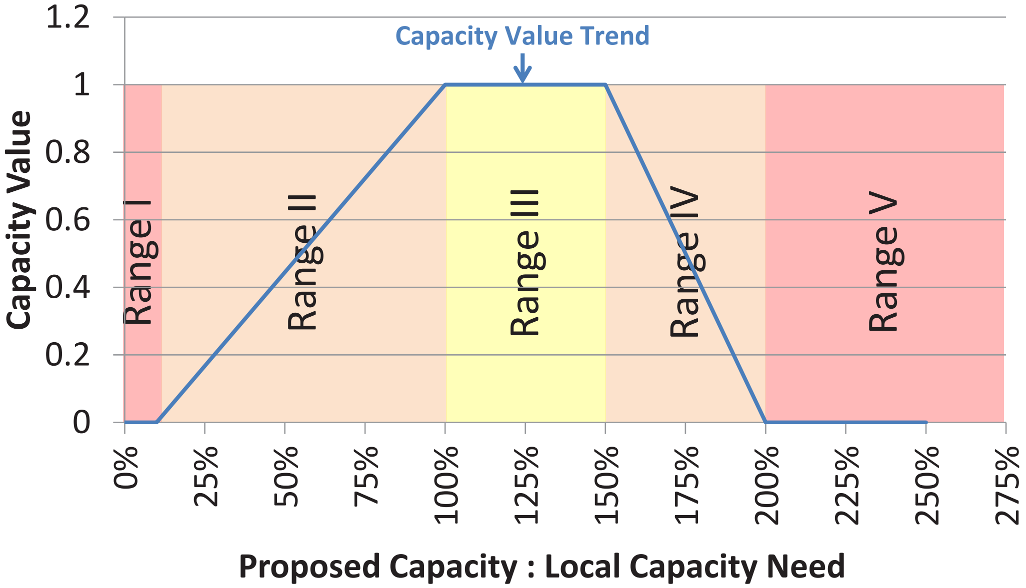
In addition to the public online map viewing app, ARB posted a full CHIT download package on its Infrastructure Assessments page. This download package includes the full CHIT toolbox for use in the ArcMap desktop application, all the input data utilized in the 2015 Annual Evaluation, output layers from each step of the CHIT process, and a Users' Guide. For those with access to the appropriate ArcMap software licenses, they can recreate the analysis that informed the 2015 Annual Evaluation's recommendations, investigate alternative analyses using different inputs, or modify steps in the CHIT algorithms. Open source (and free) GIS software may also enable viewing of the input and output files.

New Localized Capacity Calculation

As part of the effort to integrate CHIT with GFO-15-605, ARB added a function that calculates total localized capacity need based on the market assessment. This capability helps the Energy Commission evaluate whether proposed hydrogen fueling station capacities are appropriate for their locations. Capacity needs are determined assuming local hydrogen fueling markets are defined by all places that can be reached within 15 minutes of any home location. Total market potential within each 15-minute market determines the proportion of FCEVs assigned to that market. Hydrogen demand from those vehicles and fueling capacity of existing stations with coverage in those markets are then compared. This comparison determines the additional fueling capacity needed within each market. For GFO-15-605, the evaluation was completed for the projected 2021 fleet of 34,300 FCEVs statewide.

The ratio of capacity need and nameplate station capacity determines the suitability of a proposed project. Evaluation of suitability is designed so that only severe over- and under-build are discouraged. The evaluation of suitability also avoids penalizing proposals in challenging markets that have a need much larger than modern station designs. Figure 18 shows the variation in capacity value at a given location for various proposed capacities and demonstrates the preference for appropriately-sized stations at specific locations. Figure 19 demonstrates how stations proposed in higher-need areas have the potential for a more favorable evaluation of suitability while maintaining preference for appropriately sized stations in all locations according to the calculated need.

Figure 18: Variation in Capacity Value for the Ratio of Proposed Station Capacity to Local Need



Range I: Avoid severe under-building

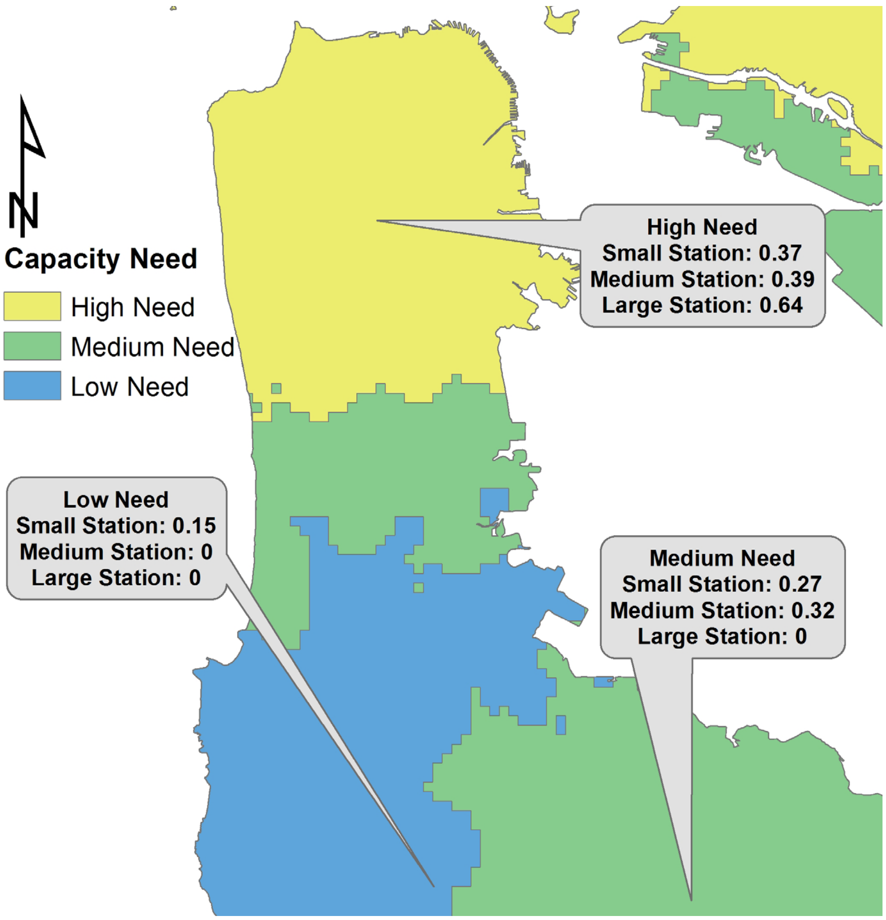
Range II: Growth to maximum score at station capacity meeting exact need

Range III: Buffer to allow reasonable overbuild

Range IV: Decrease in score as overbuild approaches excess

Range V: Avoid severe overbuild

Figure 19: Demonstration of Capacity Value Preference for Appropriately-Sized Station Proposals[9]



New Traffic Intensity Factor in Development

In October of 2015, ARB held an in-person and webcast seminar covering the fundamentals of geospatial analysis and development of the CHIT tool. This day-long event was attended by interested parties from government, academia, the auto manufacturer industry, hydrogen station technology providers, and hydrogen station developers. As part of the webinar, ARB sought feedback from participants regarding data sets or factors not considered in the current version of CHIT that could be utilized in further development of the tool.

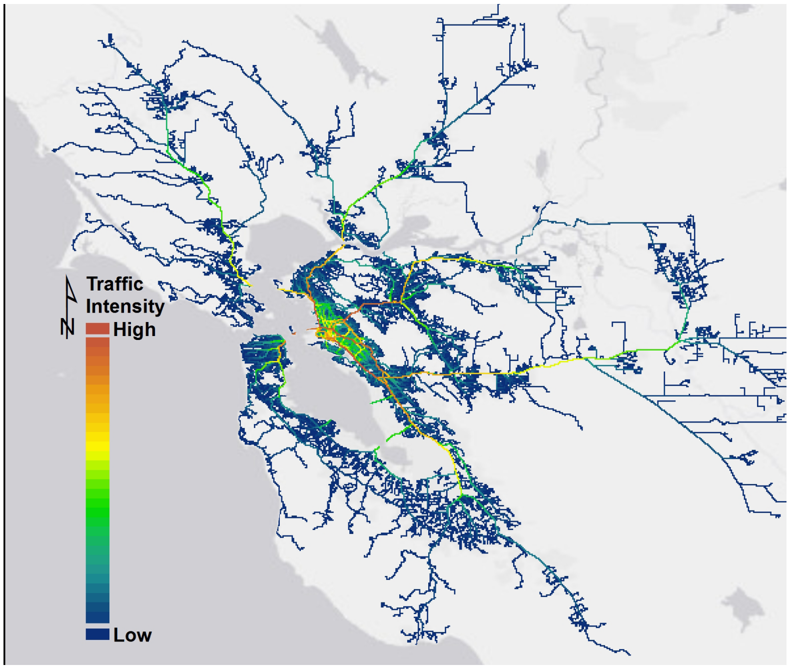
At the webinar and several meetings since, multiple stakeholders have expressed interest in utilizing a data set in CHIT that could consider traffic flow patterns. This represents an input that is fundamentally different from CHIT's analysis methods, which suggest new station locations in or near communities where FCEV early adopters live. Evaluation based on traffic flow patterns would instead seek to prioritize siting of stations along commonly-used routes.

As discussed during the webinar, ARB was not and still is not aware of a public traffic data set that can be implemented in CHIT. ARB had previously investigated the use of traffic volume information contained in the same Integrated Transportation Network data set that CHIT relies upon for on-the-road speeds. However, the volume data did not exhibit the necessary data quality.

9 This map is for conceptual demonstration purposes only. It does not reflect actual values as determined for GFO-15-605. Note that stations of all sizes have the potential for a higher score in a higher need area, but the most appropriately-sized station receives the highest score available in its location.

Thus, ARB has begun an effort to develop a simulated statewide traffic intensity factor. The US Census Bureau publishes the Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics data set. These data provide the number of people traveling from home at any given block in the state to work at any other given block. ARB is using these location pairs and its TIGER-ITN roadway dataset to simulate the likely afternoon commute path for all work-home pairs in the California data. With more than 7 million routes to simulate and synthesize into an aggregate assessment of traffic intensity, ARB anticipates this simulated data set will be complete by the end of 2016. At that point, ARB will assess the utility of integrating this feature into CHIT's evaluations. Figure 20 provides a partial analysis of the evaluation based on some of the calculations completed to date.

Figure 20: Sample Simulated Traffic Intensity Evaluation for 100,000 Commute Routes in the Bay Area with Less Than a 2-Hour Drive Time



Suggested Station Counts and Locations for Next Funding Program

Since the publication of the 2015 Annual Evaluation, the Energy Commission has announced its latest hydrogen infrastructure grant funding opportunity, GFO-15-605. This new GFO was released on April 6, 2016. CHIT was utilized to provide a revised evaluation of the current hydrogen fueling network, accounting for all the changes that have been made in individual station locations. Changes in the station locations had various effects on the identified Priority Areas as compared to the 2015 Annual Evaluation. Of particular note, the Priority Area previously identified as "Palo Alto/Mountain View/Cupertino/Campbell" expanded to include San Mateo. The Encinitas, Fremont, and Thousand Oaks areas were no longer identified as priorities since stations moved into these areas. The two Sacramento Priority Areas combined into a single area. All Priority Areas that persisted in the revised evaluation had slightly different outlines due to changes in localized coverage. Finally, the order of Priority Areas shifted, given the revised coverage provided in some areas. The top two areas of San Francisco and Berkeley maintain their position in the revised evaluation and though in a different order, the top nine areas remain.

Table 2: Priority Area Recommendations for GFO-15-605

	Area Name	Stations
First Priority	San Francisco	2
	Berkeley/Oakland/Walnut Creek/Pleasant Hill	2
	Greater LA/Sherman Oaks/Glendale/Pacific Palisades	1
	San Diego/La Mesa	1
	Torrance/Manhattan Bch/Redondo Bch	1
	South San Diego/Coronado	1
	Pasadena/San Gabriel/Arcadia	1
	Long Bch/Huntington Bch/Buena Park/Fullerton	1
	Santa Cruz	1
	Irvine/Tustin	1
	San Mateo/Palo Alto/Cupertino/Campbell/San Jose	1
	Sacramento/Carmichael	1
	San Clemente	1
	Laguna Beach	1

The Energy Commission utilized the revised assessment as a guide for applicants regarding how many stations could potentially score high in each Priority Area under the Coverage, Capacity, and Market Evaluation Criterion. Adjustments were made for the GFO given the planned budget of $33 million for both capital expense and operation and maintenance grants. The revised set of Priority Areas utilized in the GFO is shown in Table 2. Only stations in the "First Priority" category shown are identified in the GFO as Core Market Areas, though the grant program is open to proposals at any location throughout the entire state.

The recommendations provided in Table 2 represent an incremental update from last year's Annual Evaluation, based on a handful of station location changes. It is anticipated that the Energy Commission's GFO-15-605 will result in an estimated sixteen newly funded hydrogen fueling stations. Future evaluations of the network, likely to be published in the 2017 Annual Evaluation, may differ more substantially from this and the prior assessment.

Evaluation of Current and Projected Hydrogen Fueling Capacity

AB 8 Requirements: Evaluation of quantity of hydrogen supplied by planned hydrogen fueling network. Determination of additional quantity of hydrogen needed for future vehicles

ARB Actions: Determine statewide and regional capacity of hydrogen supply. Translate statewide and regional vehicle counts of Chapter II to hydrogen demand. Determine balance between capacity and demand as guideline for additional amount of capacity required.

Taking into account the several hydrogen fueling station location changes, the revised estimates of station open dates, and the revised projection of eight new stations per annual allocation of $20 million, installed hydrogen fueling capacity in each county and across the state is expected to grow as shown in Figure 21. Total funded statewide capacity has changed slightly as a few developing projects have had adjustments in nameplate capacity. It is expected that by the close of 2017, the current network of 50 stations will provide fueling capability of 9,380 kg/day. With a business-as-usual assumption of 180 kg/day for new stations, ARB projects a statewide capacity of 16,580 kg/day in 2022.This is a lower bound projection, as GFO-15-605 specifies that the minimum required daily fueling capacity is 180 kg/day. Based on the responses and awards in GFO-15-605 (and future funding programs), ARB anticipates refining its estimate of future station capacity for upcoming Annual Evaluations.

Figure 22 provides a comparison of the business-as-usual assumption to the projections provided in the "Expected" scenario of the December Joint Agency Staff Report. The Expected scenario is an analysis of capacity needed to meet demand, with station development explicitly leading vehicle deployment as projected in the 2015 Annual Evaluation. The first 100 stations in the Expected scenario had a similar capacity, in the range of 175-200 kg/day. Additionally, the Expected scenario assumed decreases in station cost, growth in station capacity, and private investment not assumed in the business-as-usual case. In Figure 22, stations in the Expected scenario are divided into two groups: those that receive State co-funding to reach the AB 8 goal of 100 stations (shown in blue), and additional stations that may be funded entirely by private investment or co-funded with a new State program or extension of AB 8 (shown in green). Stations in this second group are particularly large, growing to an average of 275 kg/day.

As Figure 22 shows, business-as-usual development of future hydrogen stations will not be sufficient to meet the demand forecasted in the 2015 Annual Evaluation. Comparison of the business-as-usual and Expected scenarios reveals two critical changes need to be made for successful development of the hydrogen fueling network beyond 2020:

1. State funding must be increasingly leveraged to yield more and larger hydrogen fueling stations; funding programs need to be designed to stimulate increased complementary private funding that brings additional capacity to the network
2. Substantial additional investment sources will need to be identified and applied to the challenge of hydrogen fueling network development to guarantee long-term success

Item 1 above should address the gap (approximately 2,000 kg/day) between the capacity provided by the Expected Scenario's 100 State co-funded stations and the business-as-usual capacity. Assumptions in the Expected Scenario (reduced cost per station, reduced State share of cost, etc.), may be necessary developments in order for AB 8 dollars to be used as effectively as appears necessary. Item 2 will be necessary to address the even larger gap (approximately 28,000 kg/day) between what the Expected Scenario assumed AB 8 funds could achieve and what the projected demand might require. Although the projections for future capacity differ between this Annual Evaluation and the Joint Agency Staff Report, both lead to the same conclusion: sources for significant increases in hydrogen fueling investment and effectiveness of existing programs must be prioritized in the near-term in order to ensure long-term success of the hydrogen fueling network and the FCEV market.

Figure 21: Statewide and By County Hydrogen Fueling Capacity, with Averaged New Station Funding Rate of Eight per Year

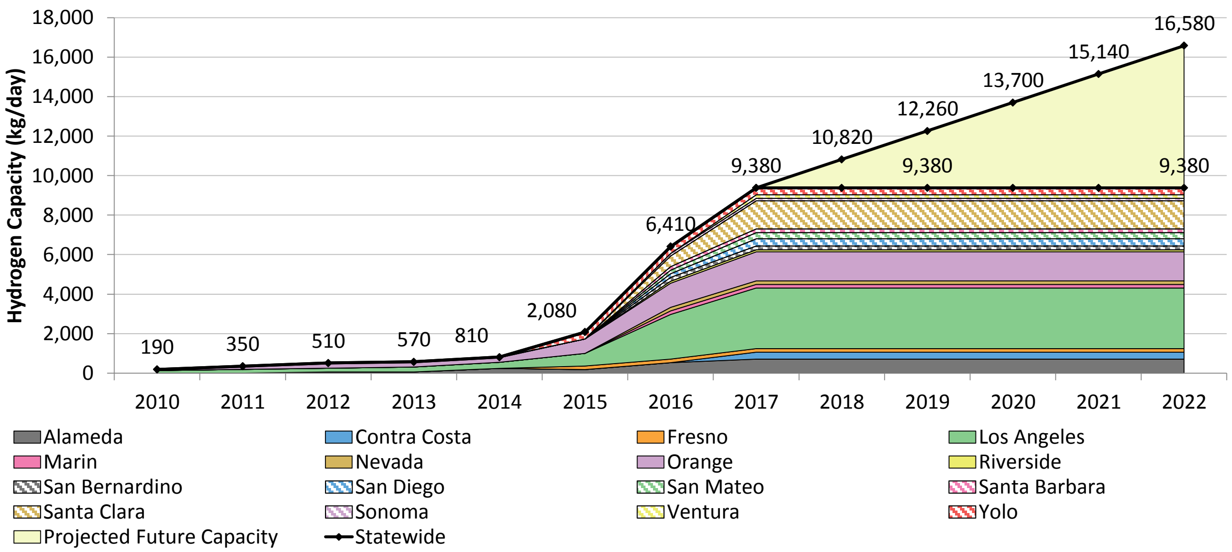
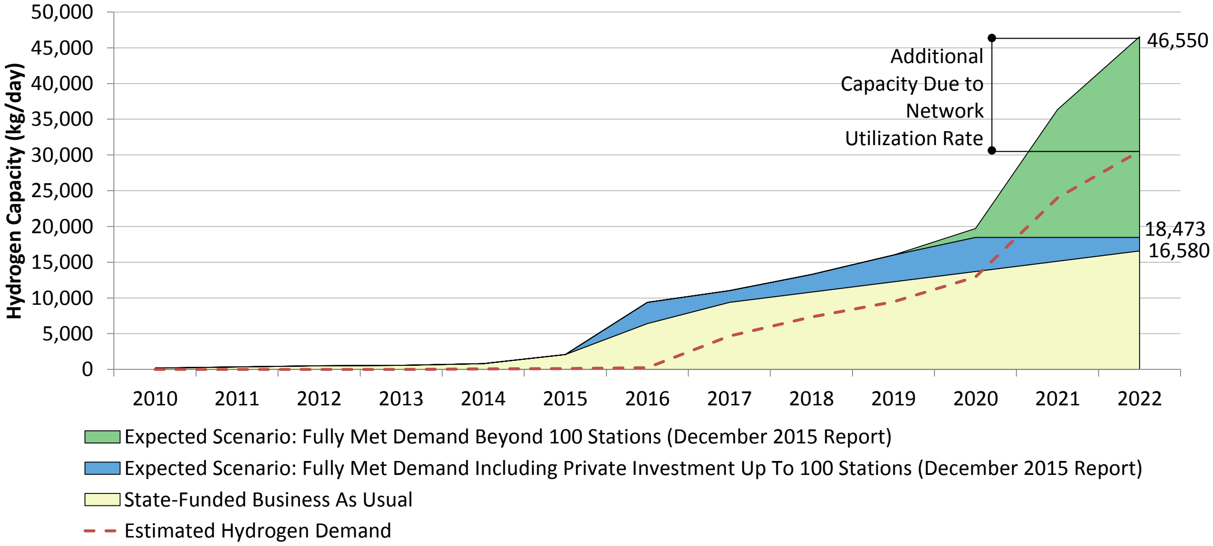


Figure 22: Comparison of Capacity in Future Scenarios with and without Additional Private Investment



For county-based assessments, ARB has made a market-based adjustment to its calculation of hydrogen fueling capacity balance. In the 2015 Annual Evaluation, hydrogen fueling stations were assumed to service FCEV markets only within the borders of the same county where the fueling station is located. For stations well within the interior of the host county, this is a sound assumption. However, there are several stations located near the edges of the host county and expected to provide service to FCEVs in neighboring counties. In some cases, the host county is not projected to have an FCEV market by 2022 and the neighboring counties would likely supply the entirety of the station's regular demand (not including long-distance driver demand). An example is the West Sacramento station, located in Yolo County just inside the border with Sacramento County. Although a few vehicles have been indicated for placement in Yolo County, the projected market in Sacramento County is much larger and is expected to be the main source of demand on the West Sacramento station.

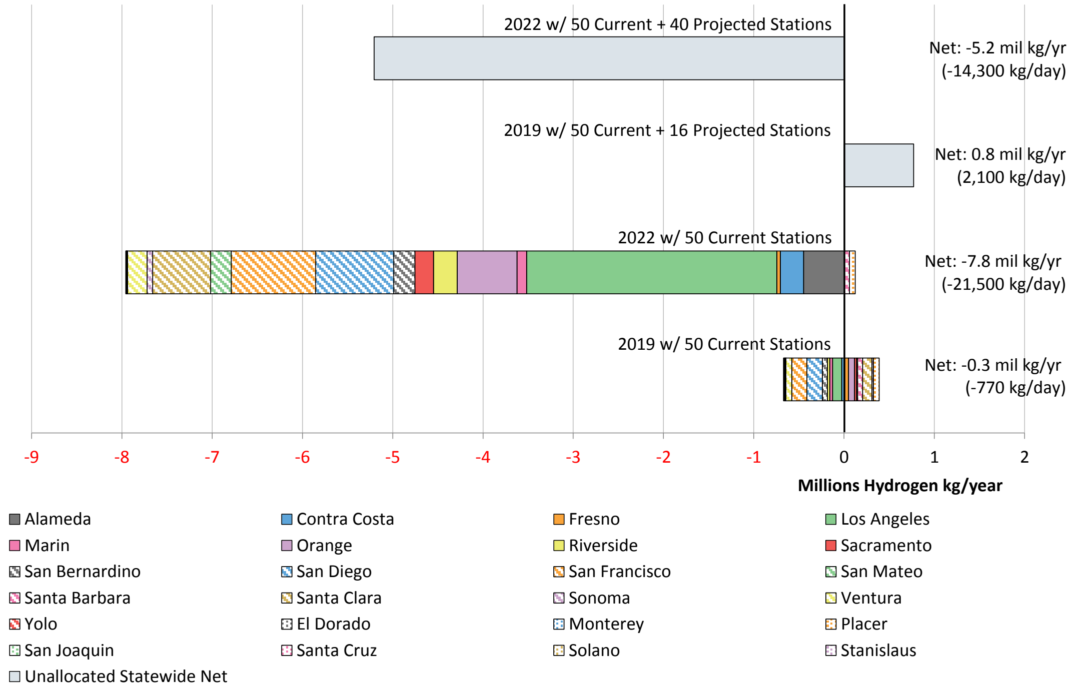
ARB utilized elements of CHIT to make this assessment. All counties within a 15-minute drive of each station were identified. The capacity for each station was then distributed among the identified counties proportional to their projected demand, presented in Table 3. Table 3 is similar in derivation to the final column in Table 1, except that it additionally considers the demand from current DMV registrations. Additionally, values in Table 3 are rounded; some entries of 0.00% are non-zero in the full calculation. For the example of the West Sacramento station, Sacramento and Yolo counties are reachable within a 15 minute drive. Based on the ratios of Demand Share in 2019 for these two counties, 99.3% of the West Sacramento station's demand would be attributed to Sacramento County FCEV drivers, with the remainder serving Yolo-based drivers. In the prior Annual Evaluation, the entirety of the West Sacramento station's capacity was considered as serving customers from Yolo County.

Table 3: County-Based Demand Distribution for Allocation of Hydrogen Supply to Meeting Market Needs

	Demand Share in 2019	Demand Share in 2022
Alameda	5.95%	6.01%
Contra Costa	2.56%	2.92%
El Dorado	0.01%	0.00%
Fresno	0.67%	0.93%
Los Angeles	34.92%	35.23%
Marin	0.92%	0.99%
Monterey	0.11%	0.03%
Orange	13.15%	10.79%
Placer	0.05%	0.01%
Riverside	2.28%	2.85%
Sacramento	2.82%	2.97%
San Bernardino	2.10%	2.27%
San Diego	8.15%	8.84%
San Francisco	8.79%	9.76%
San Joaquin	0.20%	0.04%
San Mateo	3.85%	3.20%
Santa Barbara	0.27%	0.06%
Santa Clara	10.03%	10.05%
Santa Cruz	0.11%	0.03%
Solano	0.13%	0.03%
Sonoma	0.86%	0.97%
Stanislaus	0.13%	0.03%
Ventura	1.91%	1.99%
Yolo	0.02%	0.00%

The resulting county and statewide projected net capacity balances are shown in Figure 23. As in the 2015 Annual Evaluation, continued station investment is necessary to meet short-term demand, but long-term demand will outpace the forecasted capacity growth. Without additional stations, many counties would be without sufficient fueling capacity by 2019. Counties with the largest potential deficit in 2019 include San Diego, San Francisco, Los Angeles, Ventura, and San Bernardino. Statewide fueling capacity would fall short of demand by nearly 800 kg/day (approximately two to four stations' worth). With business-as-usual State investment through 2019, the statewide capacity could be sufficient to meet the need (with a 2,100 kg/day margin). Without additional stations, counties with the greatest deficit in 2022 include Los Angeles, San Francisco, San Diego, Orange, Santa Clara, and Alameda. Assuming business-as-usual growth through 2022, the projected statewide capacity deficit is 14,300 kg/day. Figure 24 provides a comparison of the larger county-wide deficits in 2019 and 2022.

Figure 23: Estimated Balance of Hydrogen Fueling Capacity by County and Statewide in 2019 and 2022



Compared to the 2015 Annual Evaluation, both the short-term and long-term hydrogen deficits are projected to continue growing as years pass. In the 2015 Annual Evaluation, without additional stations, the 2018 net hydrogen balance was projected to be positive; the new 2019 projection indicates insufficient hydrogen in a large number of counties and for the state overall. Even though the assumed annual rate of capacity growth is larger in this Annual Evaluation, the 2019 capacity margin with business-as-usual growth is roughly half of the 2018 margin previously reported. The 2022 deficit with business-as-usual growth is almost twice as large as the previously reported 2021 deficit, at 5.2 million kg per year. By these estimates, an additional 20 to 40 stations will need to open between 2021 and 2022 alone. In brief, regardless of slight differences in methodologies between the 2015 and 2016 Annual Evaluations, both reports find that there is a demonstrable need to continue building additional hydrogen fueling capacity throughout the state and the need for new capacity is expected to accelerate, especially in 2020 and later years.

Figure 24: County-Based Hydrogen Fueling Deficit in 2019 and 2022 with 50 Currently Funded Stations

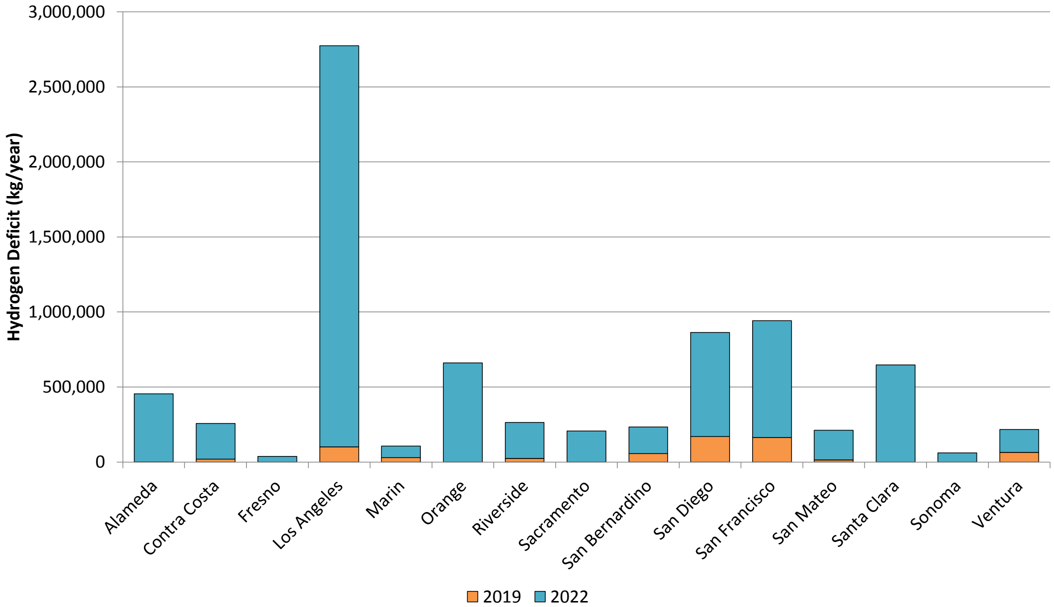
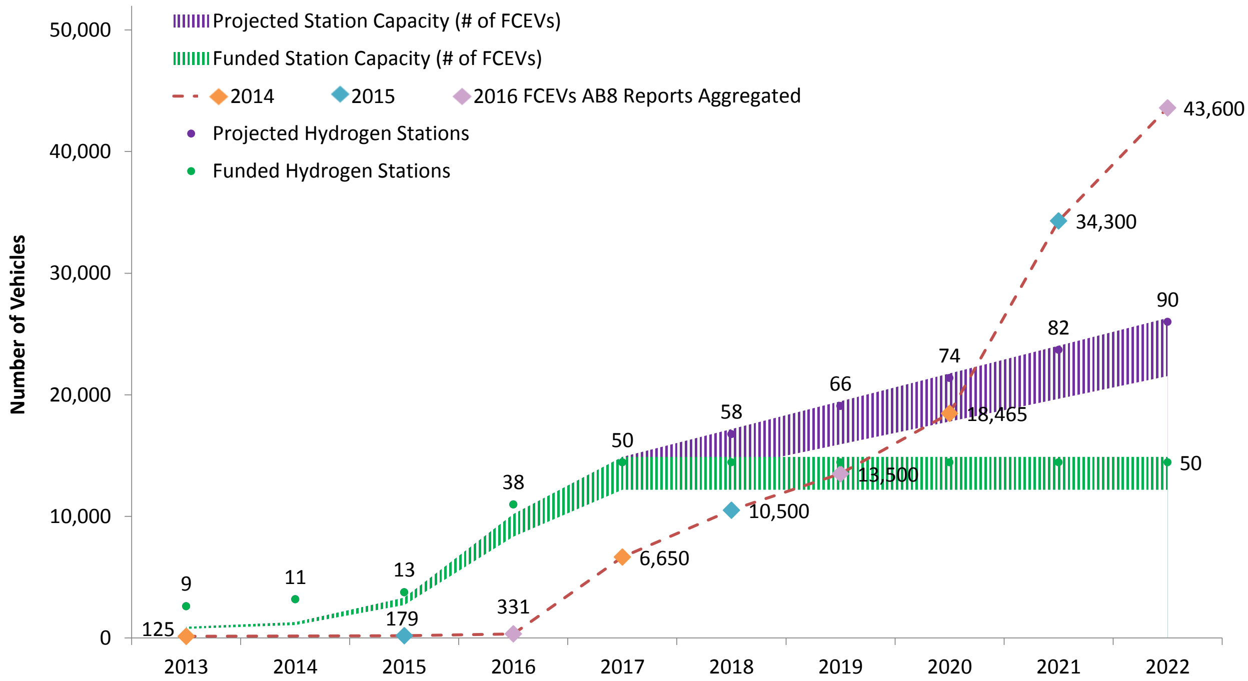


Figure 25 compares the vehicle fueling capability of the projected station network to the number of FCEVs projected to be on the road in this Annual Evaluation. Fuel consumption in this presentation is not based on the same calculations as in Figure 23; the shaded areas are determined assuming a central average of 0.7 kg/day consumed per vehicle with uncertainty bounds of +/- 10%. As presented above, the currently funded infrastructure will be insufficient to support the capacity needs of the FCEVs projected to be on the road in the 2019-2020 timeframe. By 2022, approximately 20,000 vehicles' worth of hydrogen demand would be unmet by the installed capacity assuming current costs to the State per kilogram of installed dispensing capacity. As first described in the 2015 Annual Evaluation, there is a need to identify mechanisms enabling public investments to leverage greater degrees of private investment going forward.

Figure 25: Need for Continued Station Investments and Increased Average Capacity to Support Future FCEV Fleet, Given Business as Usual Assumptions in State Incentive Programs (Averaged New Station Funding Rate of Eight per Year)



Hydrogen Fueling Station Performance Standards and Technology

AB 8 Requirements: Evaluation and determination of minimum operating standards for hydrogen fueling stations

ARB Actions: Assess the current state of hydrogen fueling station standards, including planning and design aspects. Identify and recommend needed additional standards. Provide recommendations for methods to address these needs through hydrogen fueling station funding programs.

As with all fuels, customers expect hydrogen fueling to be safe, reliable, and convenient. Developing a robust and self-sustaining hydrogen fueling market requires the network design considerations of the previous chapters be complemented with equally rigorous planning and assessment of individual station performance. Even a perfectly-designed network of stations will ultimately fail to catalyze widespread FCEV adoption if the stations cannot provide performance that meets customer expectations. Essential competencies include equipment reliability and station availability (up-time), dispensed hydrogen fuel quality, accurate metering of dispensed hydrogen mass, and dynamic station performance (e.g., fill protocol and consecutive fill capability). Through its AB 8 funding programs, the Energy Commission strives to ensure that funded station designs include the most capable technology. The State has also initiated several efforts to provide independent testing, and in some respects certification, of hydrogen fueling station equipment. Substantial progress has been made in the past year, but new challenges have also been identified as retail stations enter the network.

Hydrogen Station Performance and Retail Fueling Experience

Establishing a fully retail hydrogen fueling network involves a number of technical challenges. Station equipment providers must develop cutting-edge technology with hydrogen compression, storage, and dispensing solutions that offer consistent reliability and performance. Station developers must ensure optimized integration, operation, and status reporting for the equipment on their sites. The State needs to develop testing methods, devices, and certification programs to provide the industry and FCEV customers with certainty and confidence in new fueling stations. Stakeholders are currently addressing these challenges through several cooperative efforts.

Expectations of Open Retail Stations

FCEV drivers fueling at California's newest hydrogen stations should be able to fill their vehicle with hydrogen fuel at least as conveniently, quickly, easily, reliably, and safely as drivers of gasoline-fueled vehicles. Several performance criteria ensure the retail experience matches customer expectations and must be met before a station can be designated as Open-Retail. The five main requirements are as follows (and shown in Figure 26):

1. The station operator has fully commissioned the station and has declared it fit to service retail FCEV drivers. This includes declaration that that station meets appropriate SAE fueling protocols required in California.

2. The station passed final inspection by the appropriate AHJ and has a permit to operate in the city. This permit often comes in the form of a certificate of occupancy.

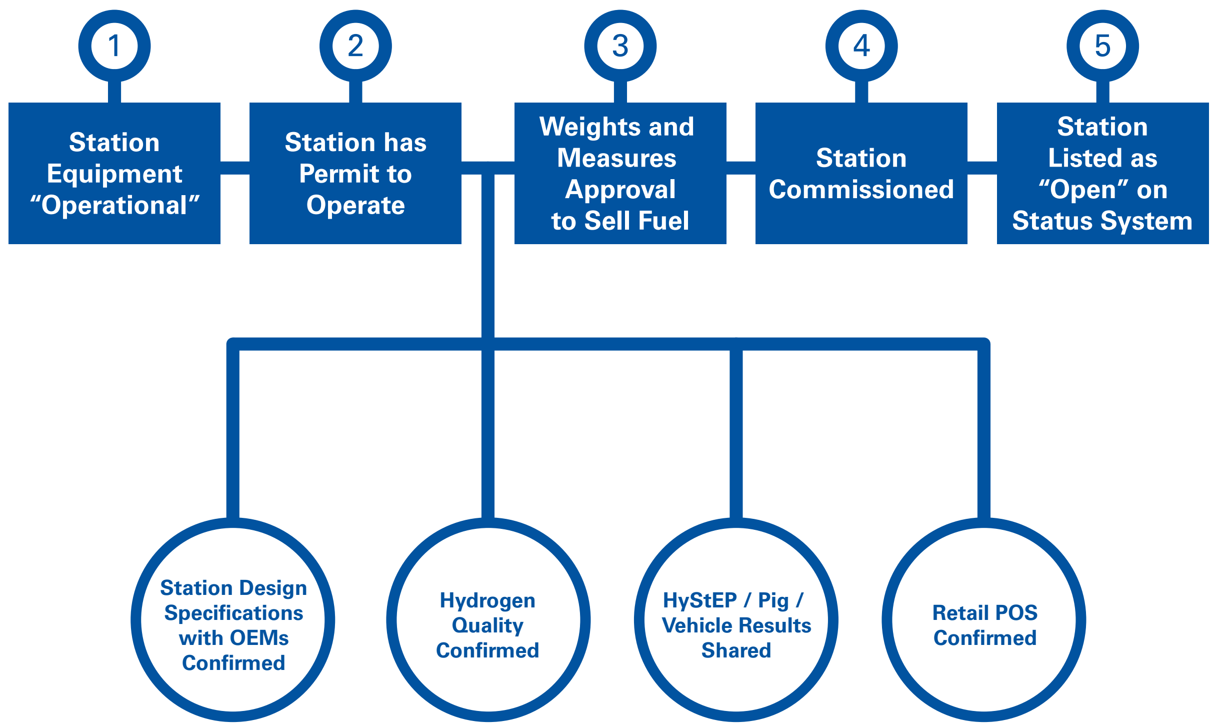
3. An appropriate Weights and Measures authority or service agent has verified dispenser performance, enabling the station to sell hydrogen by the kilogram (pursuant to CCR Title 4, Division 9, Chapter 1). For new dispensers seeking type certification, the appropriate agency is the Division of Measurement Standards, after which the dispenser is listed through CTEP. Later installations of dispensers listed in CTEP may then be certified by county or local agencies. To date, all local certifications have been done in conjunction with RSAs who are certified to operate verified testing equipment. In this case, the local official witnesses and verifies RSA generated results.

4. At least two auto manufacturers with vehicles currently on the market or coming within the next year have confirmed that the station meets protocol expectations, and their customers can fuel at the station. Confirmation is tracked via coordination with GO-Biz.

5. The station is connected to SOSS, maintained by CaFCP.

These requirements are a step beyond those for operational status per the Energy Commission's last set of hydrogen station grants (PON-13-607). In GFO-15-605, the Energy Commission will require awardees to demonstrate a viable plan to achieve Open-Retail status within 180 days of becoming operational. However, even these requirements do not address ongoing needs for the in-operation station and do not ensure all technical performance expectations are met, such as the ability to fuel multiple vehicles back-to-back in a given timeframe.

Figure 26: Process Flow for Hydrogen Fueling Stations to Achieve Open Status[10]



10 OEM in the figure stands for Original Equipment Manufacturer and in this context is synonymous with auto manufacturers.

Additional Challenges in the Early Retail Station Network

The process outlined in Figure 26 ensures that hydrogen fueling stations have the technical capability to provide fueling service to retail customers. However, these tests are inherently limited and seek a balance between swiftly opening the station and thorough testing. Over the past year, issues have arisen at the new retail stations that appear to be beyond the process shown above. For example, station reliability cannot be thoroughly tested without repeated testing over several months that would delay a station's opening. At times, new hydrogen fueling stations have exhibited equipment failures, resulting in increased downtime and an overall loss of reliability in the fueling network. Other times, intermittent issues with the point-of-sale system and other consumer-facing components have given some drivers partial fills, required several fill attempts, or billed the customer incorrectly.

These issues detract from the overall customer experience and must be resolved to achieve parity with gasoline fueling stations. Some of these issues are technical in nature and will require development and advancements in technology or quality control on the part of station equipment providers. Others may be changes in operation, signage, or system integration that can be addressed by equipment integrators and station developers. Yet there are still others, such as demonstrating reliability, which can only be proven with time. Experience gained through continued operation of the retail station network can provide useful lessons for future station development and potentially avoid these issues altogether.

Some of the customer-facing issues can be directly addressed through improved communication and education. As the retail hydrogen fueling network grows, it will be necessary to capitalize on growing network redundancy in core markets. One crucial step in this direction has been taken over the past year with the method of reporting station status through SOSS. Beginning with the University of California, Irvine station's upgrade, any station achieving Open- Retail status is now first declared to be Soft Open. This is a temporary status to alert FCEV drivers that although the station has completed commissioning and confirmation testing, it must still prove its long-term reliability through operation. Drivers are advised that they can fuel at these stations, but may experience temporary and intermittent difficulties or outages. This allows drivers to make an informed decision on whether to visit a station in Soft Open status or to choose another station, ideally one that is nearby and provides a measure of redundancy to the Soft Open station. Stations are able to move out of Soft Open and into full Open- Retail status after 60 days.

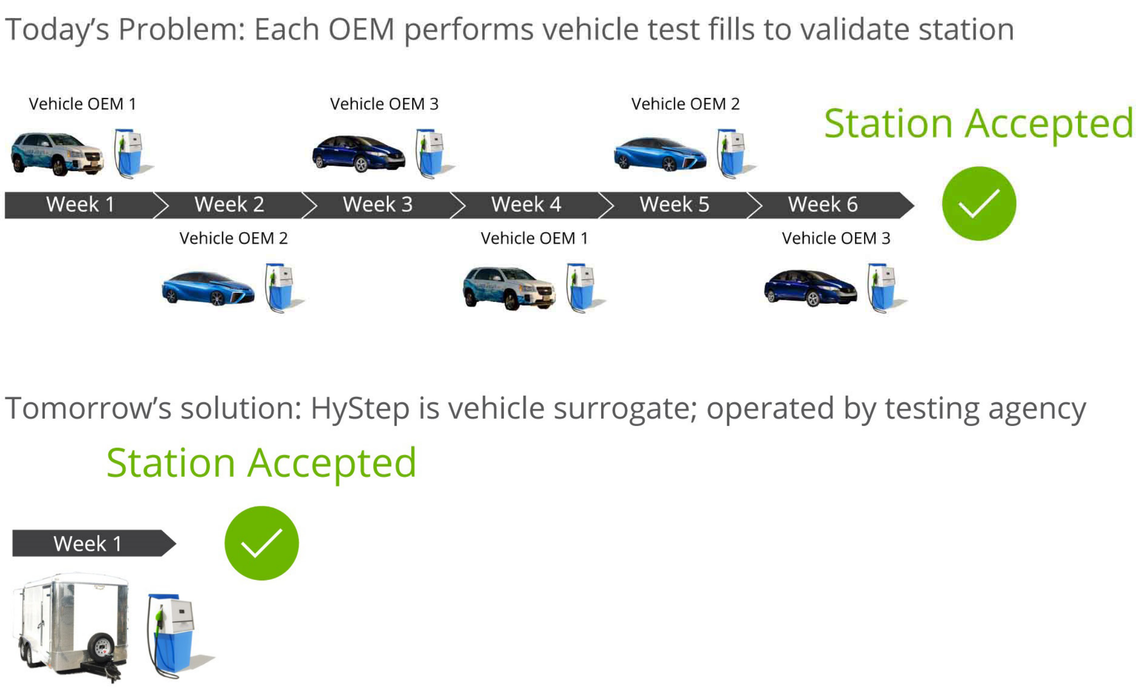
These advancements are helping to address many of the challenges that have been uncovered in retail operations. However, additional mechanisms are needed to ensure expected performance can be met, including a certification program to carry out station commissioning tests and continuous monitoring of fuel quality. By implementing a station verification process using the HyStEP device and subsequently defining and implementing a station certification program, the State aims to decrease the time needed to move stations from operational to open, reduce the number of individual auto manufacturer confirmation tests, and build confidence in station performance. The State and its federal colleagues are also currently working to develop a project plan and identify funding for construction of a prototype device able to continually monitor hydrogen quality at or near the point of dispensing.

Hydrogen Station Equipment Performance Device (HyStEP)

Hydrogen fueling stations being built in California today are required to meet fueling protocols established in the Society of Automotive Engineers SAE J2601 – 2014 standard. Although the standard exists, there is currently no entity that formally certifies or lists a station as being compliant with SAE J2601. To date, station protocol confirmation has been performed by each auto manufacturer individually conducting its own testing and verification process.

With funding provided by the DOE Fuel Cell Technology Office under the H2FIRST project, SNL and the National Renewable Energy Laboratory (NREL) contracted with Powertech Labs to develop and build the HyStEP device. The primary purpose of the HyStEP device is to be used by a certification agency to measure the performance of hydrogen dispensers with respect to the required fueling protocol standard. Specifically, the device has been designed to carry out the test methods of CSA HGV 4.3 to measure that stations follow SAE J2601-2014, including IrDA communications per the vehicle-station communications protocol SAE J2799. The HyStEP device was delivered to California in 2015, and has since undergone its first validation tests at the Santa Barbara and Diamond Bar stations. Additionally, on May 27, the auto manufacturer advisory group of the CaFCP issued a letter declaring their confidence in the HyStEP device's data quality and support for integrating HyStEP into current station validation testing alongside auto manufacturer testing [39]. Ongoing evaluation of the device, acceptance as a surrogate for auto manufacturer individual assessments, and integration into new stations' commissioning process are expected to be major milestones achieved in 2016.

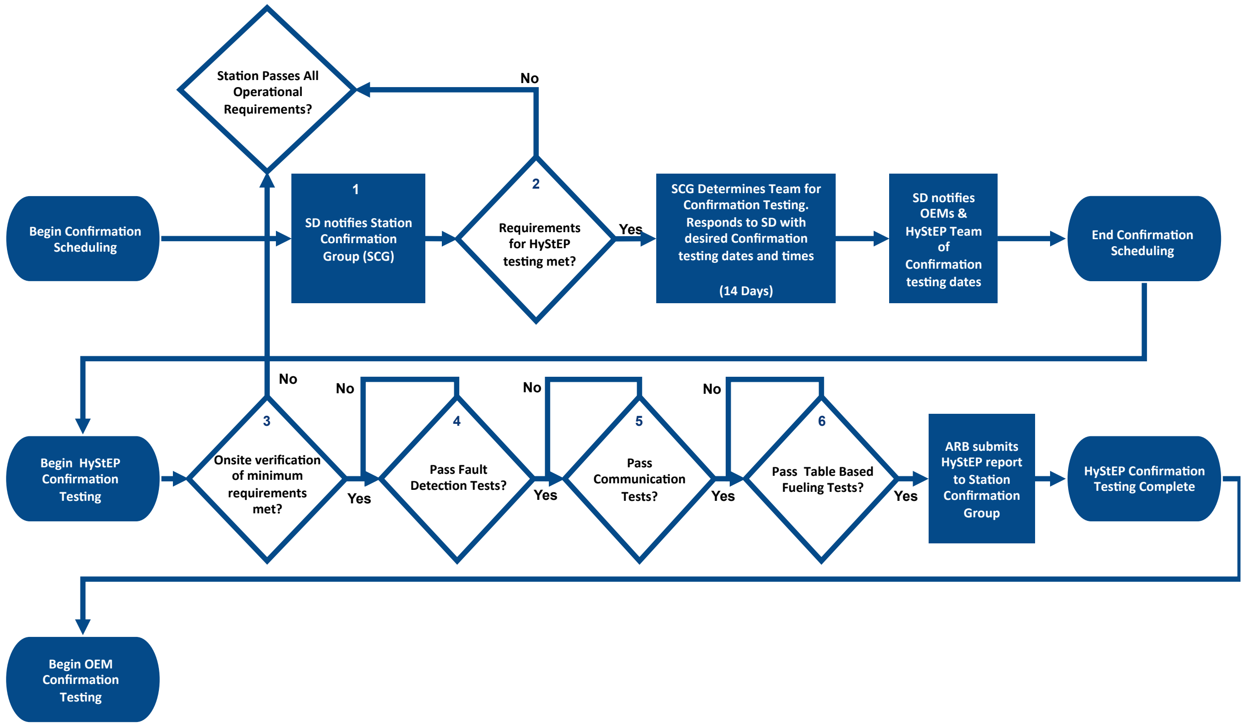
Figure 27: Current Station Confirmation Process vs. Future Process with HyStEP[11]



The HyStEP device was developed to help reduce the time to commission a hydrogen station. The current practice of hydrogen station acceptance can take many weeks to several months because each auto manufacturer conducts serial testing and evaluation of stations, and any necessary changes to the station take time to implement. This process is not practical or sufficient to support the timely development of California's hydrogen station network. As many as 13 new stations are scheduled to be commissioned in the remainder of 2016. To meet this need, the HyStEP device will be a safe, technically effective, and user friendly surrogate for auto manufacturers' FCEVs to verify station performance in significantly less time than today's serial auto manufacturer testing, as demonstrated in Figure 27. Figure 28 provides an overview of the how the HyStEP device is currently proposed to be integrated into the station confirmation process. This process is designed for concurrent station testing through HyStEP and auto manufacturer vehicles until a process relying primarily on the HyStEP device is developed to formally acknowledge that a station is operating properly.

11 Reproduced with permission of Terry Johnson from Sandia National Lab; originally created by Terry Johnson, Pacific Northwest National Lab, and the H2Tools program (https://h2tools.org/)

Figure 28: Interim HyStEP Process Flow[12]



With SAE J2601 protocols, a hydrogen station fills according to a series of tables that include procedures for dispensers outfitted with and without IrDA communication. The fill protocol also varies according to ambient temperature and initial tank pressure. Process limits are included that describe maximum hydrogen flow rate, rate of pressure increase, and predicted end pressure or hydrogen density. The SAE J2601 protocol includes two pressure classes, H35 and H70, three fuel delivery temperatures (-40°C, -30°C, and -20°C), and compressed hydrogen storage systems ranging from 49.7 to 248.6 liters.

Stations most recently built in California are designed to fuel according to SAE J2601 -2014 at 2 to 10 kg capacity for H70-T40, and 2.4 to 6.0 kg for H35-T20. Each station needs to be tested according to the combination of functions featured at the station. A station featuring communication and non-communication functions, both H35 and H70, both T40 and T20, and different compressed hydrogen storage system classes would require a combination or matrix of tests be performed. Generally speaking, every combination of functions does not need to be tested individually as long as each function is tested at least once. This adds complexity and significant time to the station commissioning schedule when stations are tested by each auto manufacturer in series. Table 4 provides an overview of the range of tests that could be included in a HyStEP evaluation of a newly built station.

12 SD in the figure stands for Station Developer.

Table 4: Sample HyStEP Test Matrix for Hydrogen Fueling Stations

Fault Detection	Communications	Fueling Protocol
CHSS capacity range test Ambient temperature test Minimum fuel delivery temperature test Maximum CHSS gas temperature test Minimum CHSS initial pressure test Maximum CHSS pressure test Maximum state of charge test	Abort signal test Halt signal test Data loss test and then resumed fueling test Invalid CRC communication test Invalid defined data value test • Protocol Identifier (ID) • Software Version Number (VN) • Tank Volume (TV) • Receptacle Type (RT) • Fueling Command (FC) • Measured Pressure (MP) • Measured Temperature (MT)	Non-comm fueling tests Comm fueling tests Repeated table test No fueling test High pressure capacity test Pre-cooling capacity test Fallback test Top-off fueling test Cold dispenser test

Notes: CHSS = compressed hydrogen storage system; CRC = Cyclic Redundancy Check

The HyStEP device has the potential to accelerate the station commissioning process, and the State and its industry partners are working to develop a consensus-based program for its implementation as a station certification tool. Currently, HyStEP is utilized in parallel with auto manufacturer testing and does not provide official determination of certified performance. Instead, HyStEP performs testing of new stations in series with the auto manufacturers' own testing. Collaborative industry review of the HyStEP results by a public-private team of experts evaluates the device's output as compared to the auto manufacturers' accepted test data. This helps all parties evaluate the accuracy and precision of HyStEP while also providing insight of the new station's performance. As more evaluations are completed with HyStEP, the experience gained by its operators and growing industry familiarity build the case for an independent certification program built upon implementation of the device.

A certification program using only HyStEP, as a complete surrogate for auto manufacturer tests, should help accelerate the station confirmation process to an even further degree. ARB will commence a public process in late 2016 to define an appropriate station certification program. In addition, although HyStEP has been designed to replace individual auto manufacturer testing, there are some station performance capabilities not yet included in the HyStEP testing procedures since they are not part of the CSA HGV 4.3 specification. The State and its partners are monitoring and providing feedback for the ongoing development of the standard, anticipating the eventual development of a complementary device to HyStEP. As additional aspects of the station performance testing standard are completed, they will guide the direction of development of that future device.

Ensuring Consistent Hydrogen Quality

Purity of hydrogen delivered to FCEVs is another primary concern in the overall performance of hydrogen fueling stations. Currently, the Energy Commission requires that all hydrogen fueling stations receiving State grants (funded under GFO-15-605) perform hydrogen quality tests and analysis every three months at a minimum. The Energy Commission also requires that the hydrogen quality be tested every time the hydrogen lines are potentially exposed to contamination due to maintenance or other activities. Contaminants in the hydrogen at a station can come from a variety of sources and be composed of a variety of species. Table 5 provides an overview of common contaminant species and sources, as outlined in the hydrogen quality standard SAE J2719. Detection of the full spectrum of potential contaminants can require multiple laboratory tests and extended periods of time to complete. Testing at a minimum of every three months is an appropriate frequency for the full suite of contaminants, given the extensive analysis necessary. It also provides a base assurance for long-term consistency of hydrogen delivered by the station's fuel source.

However, even with the hydrogen quality requirements specified in the Energy Commission GFO, there have been occasions when FCEV drivers have received fuel for their vehicles that contains contaminants. In some cases, the contaminants have been concentrated enough to cause the fuel cell system to shut down and not be able to generate any power. The degree of impact on FCEV performance varies by species and concentration. Species that can completely deactivate the fuel cell, especially at low concentrations, require the most attention. Introduction of these species into an FCEV's storage tank could leave a driver stranded, and auto manufacturers must spend considerable time and effort purging the fuel cell system and recovering the power generating performance.

Over the past year, there has been considerable effort towards the development of an inline hydrogen contaminant detector. ARB is currently working with DOE and the national labs on a draft proposal to design, build, and field test a prototype in-line contaminant detecting device. ARB is offering in-kind and direct financial support for development and field testing in California. ARB is currently working with colleagues at DOE to develop a project plan that may result in a prototype device's construction, testing, and field deployment within a year of the project's start. This detector would be able to only test for one or two species that indicate the presence of contaminants with the greatest potential to damage the fuel cell. Eventually, multiple device types may be designed in order to more narrowly address the most likely contaminants based on the hydrogen production method. For example, carbon monoxide (CO) may be a more important issue for stations with an onsite reformer than for a station with an onsite electrolyzer. DOE has completed a preliminary feasibility study for the design of such an inline detector and found that off-the-shelf components are not currently available. This presents a major challenge and requires specialized component or system design to build such a device. Several agencies and stakeholders are currently working together to develop a project scope for creating an inline detector design and potentially a prototype device.

Table 5: Hydrogen Contaminant Species per SAE J2719

Impurity Source	Typical Contaminant
Air	N_2, NO_X, (NO, NO_2), SO_X (SO_2, SO_3), NH_3, O_3
Reformate hydrogen	CO, CO_2, H_2S, NH_3, CH_4
Bipolar metal plates (end plates)	Fe_3+, Ni_2+, Cu_2+, Cr_3+
Membranes (Nafion)	Na+, Ca_2+
Sealing gasket	Si
Coolants, DI water	Si,Al, S, K, Fe, Cu, Cl, V, Cr
Battlefield pollutants	SO_2, NO_2, CO, propane, benzene
Compressors	Oils

Dispensing Meter Accuracy and the California Type Evaluation Program (CTEP)

Over the course of the past year, DMS has continued to implement its California Type Evaluation Program (CTEP) for certifying the accuracy of hydrogen fueling dispensers. This first-of-its-kind program has enabled the retail sale of metered hydrogen in California on a dollar per kilogram basis. There are now four hydrogen dispenser design types that have been approved for use in California, as shown in Table 6 (note that 5743a-15 is an update to and supersedes 5743-15). Type approved dispensers can be installed in new hydrogen fueling stations throughout the state with notification of the installation to the local county weights and measures official. These additional installations of approved dispensers undergo abbreviated testing to verify conformance to the device's approved accuracy class. Registered Service Agencies and their licensed agents may complete the verification of accuracy class testing process at these additional installations with the local weights and measures official witnessing the test. Successful testing results in the placement of the local county seal which is required before retail sale of hydrogen is allowed at the dispenser. Coordination with local agencies is typically quicker than scheduling device testing or witnessing with a State authority like DMS. Private companies can enter the hydrogen dispenser installation and servicing business by becoming Registered Service Agents (RSAs) and licensing their employees as registered service agents. To date, one station developer, FirstElement Fuel, has opted to become an RSA with licensed agents and now performs installed dispenser initial verification tests at its own stations and offers its services to other developers installing type approved dispensers.

Table 6: Dispensers Currently Listed with Type Certification through CTEP[13]

Certificate Number	Company	Models	Effective Date
5743-15	Bennett Pump Company	H10	6/10/15
5743a-15	Bennett Pump Company	H10	12/22/15
5741-15	CSULA	112892	4/29/15
5778-16	Equilon Enterprises LLC dba Shell Oil Products	RHM08 Mass Flow Sensor, RHE08 Mass Flow Transmitter	2/22/16
5774-15	Quantum Fuel Systems Technologies Worldwide	113892	11/25/15

Harmonization of Station Standards and Specifications

The State of California's work to develop programs to ensure that stations meet published SAE standards for hydrogen fueling is occurring within a broader context of worldwide standards development. The International Organization for Standardization (ISO), the Research Association of Hydrogen Supply/Utilization Technology (HySUT), CSA, and others have been developing standards and testing methods to address many of the performance specifications and issues discussed in this and previous Annual Evaluations. Much of this work is occurring in parallel, and at times may be specific to hydrogen station designs in a particular region of the world. This will ultimately present difficulty in optimizing supply chains, decreasing costs of stations, and ensuring common technical expectations across the industry. California agencies are considering how to best ensure these standards become harmonized with one another and station designs coming to California are working within their guidelines. In particular, many of the standards undergo revisions over the years as more data become available through testing, real-world experience, and operation of stations. It would be in the State's interest to avoid setting requirements and expectations of station designs that may preclude them from meeting future or revised requirements in published standards. One or more State agencies will need to take a more active role in standards development working groups in order to remain informed and influence developments.

Station Availability and Online Status

The use of the Soft Open designation discussed above is an effort to provide the best available information to the earliest FCEV drivers about real-time station status. A major expected outcome is to help drivers stay informed of stations' latest demonstrated reliability. The Soft Open status provides drivers with information regarding which stations may be in the final stages of troubleshooting, and enables those who do not want to take the risk of an unsuccessful fill to choose an alternative station. This will be helpful, but will also rely heavily on accurate and trusted reporting of station status.

13 All certificates issued to date have been for the 5% accuracy class.

Currently, SOSS is integrated into several customer-facing outlets for station status. This includes the mobile page[14] of the direct SOSS status updates and in-vehicle applications designed in cooperation with the auto manufacturers. SOSS currently receives and reports station status on a 15-minute interval. This has been sufficient for the pre-retail network experience, but it is quickly becoming apparent that a shorter reporting interval may be necessary as the number of vehicles and stations grows. CaFCP is currently in the process of upgrading SOSS, including its data management capabilities and the reporting interval. As these changes are rolled out, they will need to be evaluated against customer experience to ensure the enhancements continue to meet drivers' needs.

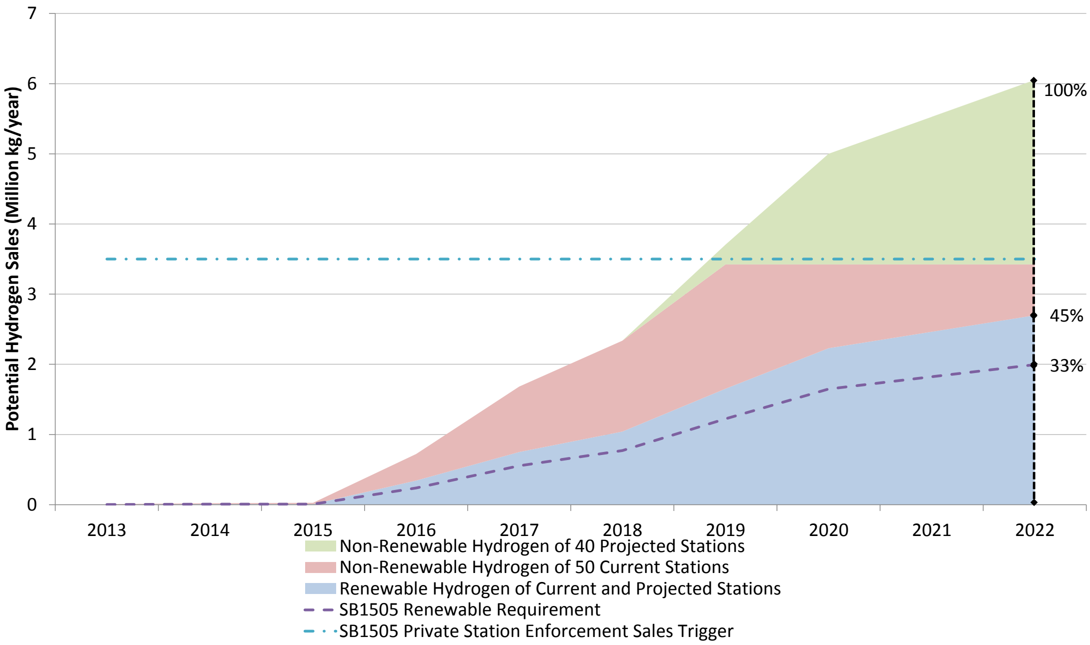
In addition, there are now multiple station developers who have expressed an interest in developing their own station status reporting applications. These applications have been discussed for use to report status only for the developer's own stations, or in some cases for all developers' stations that choose to adopt the application. Adopting such a system will require both hardware and software changes to individual station designs, so it is not yet clear what degree of acceptance may ultimately develop for systems introduced by individual station developers. As these applications develop and potentially enter the market, there will likely need to be a careful coordination among station developers, auto manufacturers, CaFCP, and the State. Standards for monitoring and reporting may need to be developed in a collaborative setting to ensure consistency of the drivers' experience across reporting platforms and within and between various developers' station networks.

Carbon Intensities and Resource Consumption

Although the number of stations has changed slightly since the last Annual Evaluation, there has not been a significant shift in the projected renewable fueling proportion of the funded hydrogen fueling network. Assuming business-as-usual based on the funded network, the hydrogen fuel dispensed in California is expected to contain on average 45% renewably-sourced hydrogen. This is substantially greater than SB 1505's requirement of 33% for all stations receiving State funding. Additionally, the projected throughput of the 50 currently funded stations is less than 3.5 million kilograms per year. If the capacity were above this threshold, SB 1505 would require that any privately-funded hydrogen fueling stations also comply with the 33% renewable hydrogen requirement. Figure 29 shows the updated evaluation of the State's projected renewable hydrogen content, which is nearly identical to the same analysis in the 2015 Annual Evaluation

14 *http://m.capcp.org*

Figure 29: Evaluation of Compliance with SB 1505 Renewables Requirement and Trigger for Enforcement of the Requirement on Stations without State Co-funding



While the analysis of the expected renewable hydrogen dispensed in the State has not changed, there have been important advancements for renewable hydrogen programs in the last year. The first milestone came in November of 2015, when ARB's LCFS staff provisionally certified the renewable hydrogen pathway currently in use at the Emeryville station as compliant for participation in the credit generating and trading program. LCFS staff determined that the Emeryville station's use of an on-site, dedicated solar power resource for generating hydrogen via an electrolyzer qualified for a carbon intensity value of 0.00 gCO_2/MJ. With this certification, the Emeryville station has become the first opt-in participant in the LCFS program utilizing a hydrogen fuel pathway in order to generate credits.

In addition, in December of 2015, the LCFS program certified four fuel pathway applications submitted by LyTen, LLC. The various fuel pathways utilize a hydrocarbon cracking process to convert renewable biogas feedstocks into compressed hydrogen. Certified carbon intensity factors ranged from a maximum of 29.84 gCO_2/MJ to a minimum -46.91 gCO_2/MJ. The two pathways with a certified negative carbon intensity therefore act as a net reduction in carbon emissions, offsetting carbon emissions from other uses of the same feedstock. In fact, LyTen's two pathways with a negative carbon intensity are the second and third lowest in the entire LCFS program. Finally, in January of 2016, Fuel Cell Energy's trigeneration system, which was demonstrated at the now decommissioned Fountain Valley station, also received a negative carbon intensity of -0.82 gCO_2/MJ.

Development of certified hydrogen pathways, and participation by hydrogen providers, in the LCFS program is currently viewed as a substantial opportunity for an additional revenue stream tied to hydrogen fueling stations. This can decrease the operating costs significantly and make the business case for fueling stations more attractive to private investors. It can also help ensure the long-term viability of stations that have been co-funded by the State.

Table 7 shows the potential value of each kilogram sold through a sample of the pathways mentioned above. Values in the table are for a station operating in 2020 with a trading price of $100 per credit, which is roughly the average price in recent trading. Note that renewable hydrogen pathways can generate credits even with a positive carbon intensity, as long as it is still lower than the reference gasoline carbon intensity. A credit value of roughly $2-$3 per kilogram of hydrogen can have a significant effect on operating costs and consumer prices at the pump. In the December Joint Agency Staff Report, LCFS credit values were found to have a significant effect on station cash flow and viability, even with assumed credit revenue of $0.50 per kg [10]. If revenue such as those shown in Table 7 can be realized, this will undoubtedly be an important factor in the success of California's hydrogen fueling network and FCEV deployment.

Table 7: LCFS Credit Values for Recently-Certified Hydrogen Pathways

			Assumed Value per Credit $100
Fuel Pathway	**Applicant**	**Carbon Intensity (gCO2/MJ)**	**LCFS Value ($/kg)**
HYGN009	LyTen	29.84	$2.30
HYGN006	AC Transit	0	$2.66
HYGN011	Fuel Cell Energy	-0.82	$2.67
HYGN008	LyTen	-46.91	$3.22

Conclusions and Recommendations

AB 8 Requirements: Provide evaluation and recommendations to the Energy Commission to inform future funding programs

ARB Actions: Recommend funding level for next Energy Commission program. Recommend priority locations to meet coverage needs in next Energy Commission program. Recommend minimum operating requirements and station design features to incentivize in next Energy Commission program.

The State should maintain its commitment to developing the initial hydrogen fueling network. Over the past year, hydrogen fueling network development has continued to make much-needed progress. Although development has been slower than previously projected, the past year has provided stakeholders with many important lessons learned about the challenges of opening and operating retail hydrogen fueling stations. It is expected that many of these issues will be able to be resolved more quickly or avoided altogether in the future. Extended station development schedules have likely been the cause of a one-year delay in vehicle deployment. However, long-term confidence in the fueling network remains strong and auto manufacturers continue to project significant growth in FCEV deployment in 2020 and beyond. Taken altogether, the developments over the past year continue to demonstrate that the State should maintain its commitment to developing the initial hydrogen fueling network.

Based on the analyses and information presented in this Annual Evaluation, ARB staff makes the following recommendations:

- Projections of the on-the-road FCEV fleet show strong growth for 2020 and beyond. The fueling demand from these vehicles will exceed the capabilities of the currently-funded stations. As a result, there is a clear need for the State to continue providing the maximum support available to continue growing the nascent hydrogen network's coverage and capacity. ARB therefore recommends that the full $20 million available to the Energy Commission be utilized in GFO-15-605 and subsequent funding programs.
- The hydrogen fuel demand of the projected FCEVs is expected to also exceed the fueling capacity of the network under business-as-usual growth. ARB recommends that methods to maximize the capacity leveraged by Alternative and Renewable Fueled Vehicle and Technology Program (ARFVTP) funds be identified and implemented. Furthermore, new funding sources, whether private or public, need to be identified and directed to the challenge of growing the hydrogen fueling network in 2020 and beyond at a pace commensurate with the expected FCEV fueling demand.
- Markets in the Bay Area, Los Angeles, Orange County, and San Diego counties remain the highest priority for new station development. These areas were identified in the 2015 Annual Evaluation and new vehicle projection data confirms their importance.

- The current swell of emphasis on the customer experience in the planning and development of the hydrogen fueling network needs to remain a central focus for State efforts. Continuing cooperation with industry stakeholders and remaining informed of real-world fueling experiences will help the State most effectively determine the ongoing needs of the network. Reducing the number and duration of down-time incidents, improving response time and level of service for customers encountering difficulty at the pump, and continuously improving communication about real-time station status are all enhancements that the State should work with station developers to ensure.
- The State will need to develop a station certification program built on the learnings and accomplishments of deployment of the HyStEP device. The goal of the program will be to provide consistent station evaluation methods, increase customer and stakeholder confidence in station performance and reliability, and enable swifter station validation schedules.
- The State will need to devote resources to worldwide station equipment standardization efforts currently underway. As a worldwide leader in the deployment of hydrogen fueling equipment, California needs to remain informed and could provide valuable insight for ensuring consistent standards development.
- The State has been working with collaborators on the development of a prototype inline hydrogen contaminant device. Such a device is already an immediate need, and the proposed effort could be complete within a little more than a year. ARB staff that have been involved in this effort should remain key players in the development of the contaminant detection device.

ARB expects that developments in the coming year may have even greater import for the future direction of the hydrogen fueling network and consumer FCEV market. The Energy Commission's GFO-15-605 is anticipated to fund a new set of stations that will strategically place coverage and capacity in areas of high need. Out of this funding program, the State may gain new insights into the latest developments in station equipment design and performance. Many stations from past funding programs will complete construction and begin providing retail hydrogen fueling service in the next year. Experience gained by these first stations in the network will likely continue providing important lessons to the stakeholder community and only improve the stations that enter the network in the future. Many State efforts to test, validate, and ensure station performance and customer retail experience will continue to develop and move closer to programmatic implementation. As the fueling network continues to develop, the prospects for wide-spread consumer adoption of FCEVs will improve and the long-term viability of the fueling network will become increasingly evident. Ultimately, these accomplishments will help the State meet its ongoing climate, sustainability, air quality, and energy security goals.

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Appendix A:
Station Status Summary

List of Known and Projected Hydrogen Fueling Station Status (2010-2020), as of June 17, 2016

Station Name	Open Date	Capacity (kg/day)	County	Notes
Burbank	2010, Q1	100	Los Angeles	
Thousand Palms	2010, Q1	30	Riverside	
UC Irvine	2010, Q1	30	Orange	
West LA #1	2010, Q1	30	Los Angeles	
Torrance	2011, Q2	60	Los Angeles	
Fountain Valley	2011, Q3	100	Orange	100% Renewable
Emeryville	2012, Q2	60	Alameda	100% Renewable
Newport Beach	2012, Q3	100	Orange	
Harbor City	2013, Q2	60	Los Angeles	
CSULA	2014, Q2	60	Los Angeles	100% Renewable
West Sacramento	2015, Q2	350	Yolo	
Diamond Bar	2015, Q3	180	Los Angeles	
Coalinga	2015, Q4	180	Fresno	
San Juan Capistrano	2015, Q4	350	Orange	
UC Irvine	2015, Q4	150 add'l	Orange	Capacity Upgrade
West LA #2	2015, Q4	180	Los Angeles	
Costa Mesa	2016, Q1	180	Orange	
La Cañada-Flintridge	2016, Q1	180	Los Angeles	
Lake Forest	2016, Q1	180	Orange	
Long Beach	2016, Q1	180	Los Angeles	
San Jose	2016, Q1	180	Santa Clara	
Santa Monica	2016, Q1	180	Los Angeles	
Saratoga	2016, Q1	180	Santa Clara	
South San Francisco	2016, Q1	180	San Mateo	
Beverly Hills	2016, Q2	180	Los Angeles	
Hayward	2016, Q2	180	Alameda	
Mill Valley	2016, Q2	180	Marin	
Ontario	2016, Q2	100	San Bernardino	100% Renewable
Riverside	2016, Q2	100	Riverside	
Santa Barbara	2016, Q2	180	Santa Barbara	
Truckee	2016, Q2	180	Nevada	
Woodland Hills	2016, Q2	180	Los Angeles	
Anaheim	2016, Q3	100	Orange	

Campbell	2016, Q3	180	Santa Clara	
Lawndale	2016, Q3	180	Los Angeles	
Playa Del Rey	2016, Q3	180	Los Angeles	100% Renewable
San Diego	2016, Q3	180	San Diego	
West Hollywood	2016, Q3	180	Los Angeles	100% Renewable
Chino	2016, Q4	100	San Bernardino	100% Renewable
Emeryville	2016, Q4	290 add'l	Alameda	Moved from former Oakland Airport
Orange	2016, Q4	130	Orange	100% Renewable
Rohnert Park	2016, Q4	130	Sonoma	100% Renewable
South Pasadena	2016, Q4	180	Los Angeles	
Mountain View	2017, Q1	350	Santa Clara	
San Ramon	2017, Q1	350	Contra Costa	
Woodside	2017, Q1	140	San Mateo	
Encinitas	2017, Q4	180	San Diego	Moved from former Mission Viejo
Fremont	2017, Q4	180	Alameda	Moved from former Redwood City
LAX	2017, Q4	180	Los Angeles	
Los Altos	2017, Q4	350	Santa Clara	
Newport Beach	2017, Q4	250 add'l	Orange	Moved from former Foster City
North Hollywood	2017, Q4	130	Los Angeles	Moved from former Pacific Palisades; 100% Renewable
Palo Alto	2017, Q4	180	Santa Clara	
Palos Verdes	2017, Q4	180	Los Angeles	Moved from former Redondo Beach
Santa Clarita	2017, Q4	180	Los Angeles	Moved from former Irvine North
Thousand Oaks	2017, Q4	180	Ventura	Moved from former Laguna Niguel
Torrance	2017, Q4	140 add'l	Los Angeles	Capacity Upgrade

Station Name	Close Date	Capacity Removed (kg/day)	County	Notes
Thousand Palms	2015, Q1	-30	Riverside	Non-Retail; Limited 35Mpa Service
West LA #1	2015, Q1	-30	Los Angeles	Decommissioned
Fountain Valley	2016, Q2	-100	Orange	Decommissioned

Appendix B:
AB 8 Excerpt

The following is an excerpt of AB 8, with the language from section 43018.9 relevant to this report.

Section 43018.9 is added to the Health and Safety Code, to read:

43018.9.

(a) For purposes of this section, the following terms have the following meanings:

(1) "Commission" means the State Energy Resources Conservation and Development Commission.

(2) "Publicly available hydrogen-fueling station" means the equipment used to store and dispense hydrogen fuel to vehicles according to industry codes and standards that is open to the public.

(b) Notwithstanding any other law, the state board shall have no authority to enforce any element of its existing clean fuels outlet regulation or of any other regulation that requires or has the effect of requiring that any supplier, as defined in Section 7338 of the Revenue and Taxation Code as in effect on May 22, 2013, construct, operate, or provide funding for the construction or operation of any publicly available hydrogen-fueling station.

(c) On or before June 30, 2014, and every year thereafter, the state board shall aggregate and make available all of the following:

(1) The number of hydrogen-fueled vehicles that motor vehicle manufacturers project to be sold or leased over the next three years as reported to the state board pursuant to the Low Emission Vehicle regulations, as currently established in Sections 1961 to 1961.2, inclusive, of Title 13 of the California Code of Regulations.

(2) The total number of hydrogen-fueled vehicles registered with the Department of Motor Vehicles through April 30.

(d) On or before June 30, 2014, and every year thereafter, the state board, based on the information made available pursuant to subdivision (c), shall do both of the following:

(1) Evaluate the need for additional publicly available hydrogen-fueling stations for the subsequent three years in terms of quantity of fuel needed for the actual and projected number of hydrogen-fueled vehicles, geographic areas where fuel will be needed, and station coverage.

(2) Report findings to the commission on the need for additional publicly available hydrogen-fueling stations in terms of number of stations, geographic areas where additional stations will be needed, and minimum operating standards, such as number of dispensers, filling protocols, and pressures.

(e) (1) The commission shall allocate twenty million dollars ($20,000,000) annually to fund the number of stations identified pursuant to subdivision (d), not to exceed 20 percent of the moneys appropriated by the Legislature from the Alternative and Renewable Fuel and Vehicle Technology

Fund, established pursuant to Section 44273, until there are at least 100 publicly available hydrogen-fueling stations in operation in California.

(2) If the commission, in consultation with the state board, determines that the full amount identified in paragraph (1) is not needed to fund the number of stations identified by the state board pursuant to subdivision (d), the commission may allocate any remaining moneys to other projects, subject to the requirements of the Alternative and Renewable Fuel and Vehicle Technology Program pursuant to Article 2 (commencing with Section 44272) of Chapter 8.9.

(3) Allocations by the commission pursuant to this subdivision shall be subject to all of the requirements applicable to allocations from the Alternative and Renewable Fuel and Vehicle Technology Program pursuant to Article 2 (commencing with Section 44272) of Chapter 8.9.

(4) The commission, in consultation with the state board, shall award moneys allocated in paragraph (1) based on best available data, including information made available pursuant to subdivision (d), and input from relevant stakeholders, including motor vehicle manufacturers that have planned deployments of hydrogen-fueled vehicles, according to a strategy that supports the deployment of an effective and efficient hydrogen-fueling station network in a way that maximizes benefits to the public while minimizing costs to the state.

(5) Notwithstanding paragraph (1), once the commission determines, in consultation with the state board, that the private sector is establishing publicly available hydrogen-fueling stations without the need for government support, the commission may cease providing funding for those stations.

(6) On or before December 31, 2015, and annually thereafter, the commission and the state board shall jointly review and report on progress toward establishing a hydrogen-fueling network that provides the coverage and capacity to fuel vehicles requiring hydrogen fuel that are being placed into operation in the state. The commission and the state board shall consider the following, including, but not limited to, the available plans of automobile manufacturers to deploy hydrogen-fueled vehicles in California and their progress toward achieving those plans, the rate of deployment of hydrogen-fueled vehicles, the length of time required to permit and construct hydrogen-fueling stations, the coverage and capacity of the existing hydrogen-fueling station network, and the amount and timing of growth in the fueling network to ensure fuel is available to these vehicles. The review shall also determine the remaining cost and timing to establish a network of 100 publicly available hydrogen-fueling stations and whether funding from the Alternative and Renewable Fuel and Vehicle Technology Program remains necessary to achieve this goal.

(f) To assist in the implementation of this section and maximize the ability to deploy fueling infrastructure as rapidly as possible with the assistance of private capital, the commission may design grants, loan incentive programs, revolving loan programs, and other forms of financial assistance. The commission also may enter into an agreement with the Treasurer to provide financial assistance to further the purposes of this section.

(g) Funds appropriated to the commission for the purposes of this section shall be available for encumbrance by the commission for up to four years from the date of the appropriation and for liquidation up to four years after expiration of the deadline to encumber.

(h) Notwithstanding any other law, the state board, in consultation with districts, no later than July 1, 2014, shall convene working groups to evaluate the policies and goals contained within the Carl Moyer Memorial Air Quality Standards Attainment Program, pursuant to Section 44280, and Assembly Bill 923 (Chapter 707 of the Statutes of 2004).

(i) This section shall remain in effect only until January 1, 2024, and as of that date is repealed, unless a later enacted statute, that is enacted before January 1, 2024, deletes or extends that date.

Appendix C: Auto Manufacturer Survey Material[15]

Guidance [as of February 2016] for Projected Hydrogen Station Status*, Calendar Years 2016-2017`

Alameda County		Capacity: 240 kg/day
Station Name	Open Year	Capacity (kg/day)
Oakland- 1019 Langley St[1]	-	-
Hayward- 391 West A St	2016	180
Emeryville- 1152 45th St[1]	2016	60
Contra Costa County		**Capacity: 350 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
San Ramon- 2451 Bishop Dr	2016	350
Fresno County		**Capacity: 180 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Coalinga- 24505 W Dorris Ave	2015	180
Los Angeles County		**Upgraded Capacity: 2810 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Beverly Hills- 7751 Beverly Blvd	2016	180
Burbank- 145 W Verdugo Ave	2010	100
Burbank Upgrade	2016	100
CSULA- 5151 State University Dr	2014	60
Culver City- 8126 Lincoln Blvd	2016	180
Diamond Bar- 21865 E Copley Dr	2015	180
Harbor City- 25826 S Western Ave	2013	60
La Canada-Flintridge- 550 Foothill Blvd	2016	180
Lawndale- 15606 Inglewood Ave	2016	180
LAX- 10400 Aviation Blvd	2017	100
Long Beach- 3401 Long Beach Blvd	2016	180
Pacific Palisades- 17301 Pacific Coast Hwy	2017	130
Redondo Beach- 1200 Beryl St	2017	180
Santa Monica- 1819 Cloverfield Blvd	2016	180
South Pasadena- 1200 Fair Oaks Ave	2016	180
Torrance- 2051 W 190th St	2011	60
Torrance Upgrade	2016	200
West Hollywood- 5700 Hollywood Blvd	2016	180
West LA #2- 11261 Santa Monica Blvd	2015	180
Woodland Hills- 5314 Topanga Canyon Blvd	2016	180

15 The station named Culver City in the survey material is called Playa Del Rey in the remainder of this report. The station address has not changed. In recent months, the developer has indicated that the station would be more appropriately named Playa Del Rey based on its location.

Marin County		Capacity: 180 kg/day
Station Name	**Open Year**	**Capacity (kg/day)**
Mill Valley- 570 Redwood Highway	2016	180
Nevada County		**Capacity: 180 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Truckee- 12105 Donner Pass Rd	2016	180
Orange County		**Upgraded Capacity: 1760 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Anaheim- 3731 E La Palma Ave	2016	100
Costa Mesa- 2050 Harbor Blvd	2016	180
Irvine North- 5410 Walnut Ave	2017	180
Laguna Niguel- 30081 Crown Valley Pkwy[2]	2017	180
Lake Forest- 20731 Lake Forest Dr	2016	180
Mission Viejo- 21522 Marguerite Pkwy	2017	180
Newport- 1600 Jamboree Rd	2012	100
Orange- 1914 East Chapman Ave	2016	130
San Juan Capistrano- 26572 Juniper Serra Rd	2015	350
UC Irvine- 19172 Jamboree Rd	2010	30
UCI Upgrade	2015	180
Fountain Valley- 10844 Ellis Ave[3]	-	-
Riverside County		**Capacity: 100 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Riverside- 8095 Linocln Ave	2016	100
San Bernardino County		**Capacity: 200 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Chino- 12600 East End Ave	2016	100
Ontario- 1850 Holt Blvd	2016	100
San Diego County		**Capacity: 180 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
San Diego- 3060 Carmel Valley Rd	2016	180
San Mateo County		**Capacity: 850 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Foster City- 390 Foster City Blvd	2017	350
Redwood City- 690 Veterans Blvd[2]	2017	180
South San Francisco- 248 S Airport Blvd	2016	180
Woodside- 17287 Skyline Blvd	2016	140
Santa Barbara County		**Capacity: 180 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Santa Barbara- 150 S La Cumbre Blvd	2016	180
Santa Clara County		**Capacity: 1420 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
Campbell- 2855 Winchester Blvd	2016	180
Los Altos- 2300 Homestead Rd (Los Altos was formerly Cupertino)	2017	350
Mountain View- 830 Leong Dr	2017	350
Palo Alto- 2200 El Camino Real	2017	180
San Jose- 2101 N First St	2016	180
Saratoga- 12600 Saratoga Ave	2016	180

Sonoma County		Capacity: 130 kg/day
Station Name	**Open Year**	**Capacity (kg/day)**
Rohnert Park- 5060 Redwood Dr	2016	130
Yolo County		**Capacity: 350 kg/day**
Station Name	**Open Year**	**Capacity (kg/day)**
West Sacramento- 1515 S River Rd	2015	350

* Note: All years referenced herein are calendar years (Jan 1 through Dec 31)

1 Discussions are underway for a location change between these stations
2 California Energy Commission is currently conducting an internal investigation for a proposed location change
3 Station may currently be open but has an uncertain status for continued operation as of the time of this letter

Appendix D: Station Status Definition Details

The definition of an **Operational** station is adopted from Energy Commission GFO-15-605 (note that the definition included in previous Energy Commission grant programs like PON-13-607 may have different provisions). The current definition includes the following:

1. Has a hydrogen supply.
2. Has an energized utility connection and source of system power.
3. Has installed all of the hydrogen refueling station/dispenser components identified in the Energy Commission agreement to make the station functional.
4. Has passed a test for hydrogen quality that meets standards and definitions specified in the California Code of Regulations, Title 4 Business Regulations, Division 9 Measurement Standards, Chapter 6 Automotive Products Specifications, Article 8 Specifications for Hydrogen Used in Internal Combustion Engines and Fuel Cells, Sections 4180 and 4180 (i.e., the most recent version of SAE International J2719).
5. Has successfully fueled one FCEV with hydrogen.
6. Dispenses hydrogen at the mandatory H70-T40 (700 bar) and 350 bar (if this optional fueling capability is included in the proposed project).
7. Is open to the public, meaning that no obstructions or obstacles exist to preclude any individual from entering the station premises.
8. Has all of the required state, local, county, and city permits to build and to operate.
9. Meets all of the Minimum Technical Requirements (Section VI) of GFO-15-605.

The definition of **Open- Non-Retail** does not have a prescribed set of conditions, other than that it is a station funded under an early research and/or demonstration grant program (not originally intended to provide retail fueling service) but is nonetheless able to continue providing fueling service to early adopters of FCEVs. Approval for FCEV drivers to fuel at these stations varies according to the individual manufacturer of the vehicle. Some of these stations are expected to be upgraded so they can provide retail service, at which time they will need to demonstrate that all requirements of the Open- Retail definition have been met.

The definition of an **Open-Retail** and all in-progress station statuses are adopted from the GO-Biz effort to define a set of station status definitions with stakeholder consensus across the State agencies and FCEV and hydrogen fueling industries.

Open-Retail stations are defined by:

1. The station passed final inspection by the appropriate AHJ and has a permit to operate.
2. The station operator has fully commissioned the station, and has declared it fit to service retail FCEV drivers. This includes the operator's declaration that the station meets

appropriate SAE fueling protocol, as required in California.

3. Two auto manufacturers have confirmed that the station meets protocol and fueling interface expectations (including point-of-sale), and their customers can fuel at the station.
4. The dispenser metering performance has been verified, enabling the station to sell hydrogen by the kilogram (pursuant to CCR Title 4, Division 9, Chapter 1).
5. The station is connected to SOSS.

The remainder of the status definitions are as follows:

Fully Constructed: Construction is complete and Station Developer has notified AHJ.

Under Construction: Construction at the site has started and is currently active.

Approved to Build: The station developer has approval from the AHJ to begin construction. Depending on the station developer or individual project, construction may begin immediately or a pre-mobilization effort to select construction crews and deliver equipment may first be necessary.

Planning Approval: The site plan for the station has been approved, which indicates that a hydrogen station can exist on the site, subject to meeting all building, fire, and electrical codes and standards.

In Permitting: The permit application is currently under review by the AHJ planning agency.

Finishing Permit Apps: The station developer is preparing site layout, engineering, and other documents for submittal to the AHJ. This process is often iterative and may actually occur several times throughout the permitting process. In this Annual Evaluation, a station is reported as Finishing Permit Apps if it has not yet submitted this material for the first time (after first submittal, the station is moved to In Permitting, even if new documents are submitted later).

Establishing Site Control: The station developer is actively seeking a new site and/or negotiating a new site lease agreement.

For more information, contact:

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