


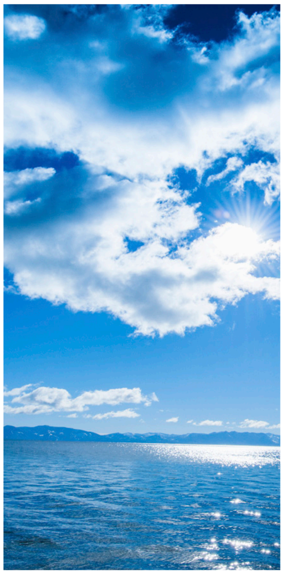


2015 Annual Evaluation of

Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development

California Environmental Protection Agency
Air Resources Board

2015 Annual Evaluation of

Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development

Pursuant to AB 8, Statutes of 2013

July 2015

List of Acronyms

AB 8	Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013)
AmEx	American Express
ARB	California Air Resources Board
AHJ	Authority Having Jurisdiction
ARFVTP	Alternative and Renewable Fuel and Vehicle Technology Program
BEV	Battery Electric Vehicle
CaFCP	California Fuel Cell Partnership
CEC	California Energy Commission
CES	Consumer Electronics Show
CHAT	California Hydrogen Accounting Tool
CHIT	California Hydrogen Infrastructure Tool
CNG	Compressed Natural Gas
CSA	Canadian Standards Association
CTEP	California's Type Evaluation Program
CVRP	Clean Vehicle Rebate Project
DMS	California Department of Food and Agriculture's Division of Measurement Standards
DMV	Department of Motor Vehicles
DOE	U.S. Department of Energy
EPAS	Equivalent Present Average Stations
FCEV	Fuel Cell Electric Vehicle
FY	State's Fiscal Year
GHG	Greenhouse Gas
GIS	Geographical Information System
GO-Biz	Governor's Office of Business and Economic Development
H2FIRST	Hydrogen Fueling Infrastructure Research and Station Technology
H2NIP	Hydrogen Network Investment Program
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
IrDA	Infrared Data Association
LCFS	Low Carbon Fuel Standard
LEV	Low Emission Vehicle
LEV III	Low Emission Vehicle regulations through model year 2025, including criteria pollutant and greenhouse gas standards
MAG	Market Assurance Grant
NIST	National Institute of Standards and Technology
O&M	Operations and Maintenance
PON	Program Opportunity Notice (California Energy Commission's formal communication of a grant program)
NREL	National Renewable Energy Laboratory
PHEV	Plug-in Hybrid Electric Vehicle
SB 1505	Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006)
SERA	Scenario Evaluation, Regionalization, and Analysis developed by NREL
SMR	Steam Methane Reformer
SOSS	Station Operation Status System developed by CaFCP
STREET	Spatially and Temporally Resolved Energy and Environment Tool developed by Advanced Power and Energy Program at the University of California, Irvine
WEX	Wright Expressw
ZEV	Zero Emission Vehicle

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Executive Summary

In 2015, California continues to be a national and global focal point for commercializing fuel cell electric vehicles (FCEVs) and hydrogen fueling stations. Assembly Bill 8 (AB 8; Perea, Chapter 401, Statutes of 2013) remains a crucial driver to ensure California is prepared for commercial launch of FCEVs from multiple auto manufacturers by providing a specific focus on development of the state's hydrogen fueling station network. This focus will enable hydrogen FCEVs, along with other zero emission vehicle (ZEV) technologies, to play a significant role in meeting multiple policy objectives established by Governor Brown and the Legislature. Reducing climate change emissions 40 percent by 2030, cutting petroleum use up to 50 percent by 2030 and achieving California's health-based air quality standards as required under federal law will require a fundamental transformation of the vehicles and fuels we use today [1,2]. California's vehicle fleet will need to be comprised of significantly increasing numbers of ZEVs, including FCEVs, in order to meet these goals. Governor Brown's Executive Order B-16-2012 and the subsequent 2013 Zero-Emission Vehicle Action Plan lay out the vision and actions needed to support market launch and commercial growth [3]. 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 emerging hydrogen fueling station network and early FCEV deployments.

To support success of the early FCEV market, the State of California is co-funding the initial network of hydrogen fueling stations, in advance of vehicle launches, through the Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). The station network will enable potential FCEV customers to be confident they can take full advantage of the FCEV's capabilities; long driving range and fast fueling allow FCEVs to seamlessly integrate into drivers' daily lives.

AB 8 provided the framework to ensure the necessary infrastructure will be available where it is needed and properly timed to the auto manufacturers' FCEV market plans. Infrastructure planning and deployment is one of many crucial developments (including industry advancement and successful marketing to consumers, continued FCEV and station technology development, and ongoing policy actions that support FCEVs) that need to be in place to ultimately achieve a successful FCEV market launch. ARB is charged with annually evaluating the progress and projected growth in FCEV deployments and fueling infrastructure development and providing an assessment of the needs to be addressed in future Energy Commission solicitations for hydrogen infrastructure deployment. This report is the 2015 Annual Evaluation and provides an update of analyses conducted in 2014 based on information, lessons learned, and insights gained over the past year.

"The first generation hydrogen fuel cell vehicles, launched between 2015 and 2020, will be critical. [Their launch will require] a concerted effort and unconventional collaboration between automakers, government regulators, academia and energy providers."

Bob Carter
Senior Vice President
for Automotive Operations for Toyota
at the Consumer Electronics Show
(CES) 2015, discussing the Mirai
and its patents.

> *"Over the past year, Hyundai's Tucson Fuel Cell owners are showing the world today that this technology represents the next generation of zero-emissions transportation... Building momentum for fuel cell vehicles and their real-world applications, these customers are sharing their experiences of how the Tucson fits seamlessly into their daily lives."*
>
> Mike O'Brien
> Vice President
> Corporate and Product Planning
> Hyundai Motor America

FCEVs and hydrogen stations have demonstrated significant advancements since ARB published the 2014 Annual Evaluation. Advancements have spurred momentum to continue strong FCEV and hydrogen developments in California. Through the annual auto manufacturer survey of FCEV deployment plans, analysis of progress in station development, assessment of station capabilities and further development of tools and methods used to understand the needs of early FCEV markets, ARB has determined the following:

- 179 FCEVs are currently registered with Department of Motor Vehicles (DMV), a growth of 43% from the previous year's estimate as of late 2013.
- Auto manufacturer projections indicate that California's FCEV fleet will grow to 10,500 by the end of 2018 and 34,300 by the end of 2021, representing a near doubling from the previously reported projections of 18,465 FCEVs in 2020 [4].
- A total of 44 stations are now expected to be in operation statewide by the end of 2015, with all 51 currently funded and operational stations available by the end of 2016. These 51 stations will have a fueling capacity of 9,400 kilograms per day, equivalent to an expected demand of approximately 13,500 FCEVs.
- The 2015 auto manufacturer survey results suggest the FCEV market may grow faster than previously projected based on the 2014 survey. As a result, currently funded stations will support hydrogen demand of California's FCEV fleet out to 2018. After 2018, the number of vehicles expected to be on the road may need more fuel than can be provided by the number of hydrogen stations that can be built with currently available public funding, assuming funding levels and station capacity remain unchanged.
- Addressing the expected gaps in hydrogen capacity and coverage may require exploring innovative actions to maximize the utility of public investment and rapidly accelerate industry momentum to expand the fueling network.
- Station technical capabilities must continue to advance to satisfy customer expectations for a retail fueling experience, including meeting current fueling protocols and expanding capacity to fuel growing numbers of FCEVs.
- ARB's analysis finds that the full $20 million annual allocation (for FY 2016/17) available from ARFVTP funding under AB 8 is necessary to support additional hydrogen stations. Innovative approaches to utilize this funding could help meet projected accelerating demand for hydrogen fuel from a growing FCEV fleet.

ARB staff developed nine principle findings addressing hydrogen station coverage, fuel capacity, and station technical capabilities. The body of this report presents the detailed findings, discusses analysis methods including modifications to last year's method and introduction of a new market and coverage gap analysis tool, presents implications of the analyses, describes current and needed technical capabilities of stations, and evaluates next steps to ensure the State can properly assess and advance station performance in commercial operation.

> *"I believe this technology is going to change our world; and sooner rather than later."*
>
> Toyota Managing Officer
> discussing Toyota's FCEV technology.

Each chapter identifies the required reporting provisions of AB 8 as they are addressed. The report builds on these provisions to provide the reader a complete and holistic view of FCEV deployment and hydrogen station network development over the past year, and highlights actions needed to keep the coordinated roll-out of this important zero emission vehicle and fuel technology well on track.

Progress Highlights

Auto manufacturer actions confirm their commitment to fuel cell technology and demonstrate significant progress toward FCEV development and launch goals in California and the United States

- Hyundai marked the one year anniversary of the Tucson Fuel Cell launch, with deliveries to 70 Southern California customers who have accumulated nearly 500,000 zero emission miles.
- Toyota revealed the production version of the Mirai, along with the locations of the first eight dealerships in California to sell and lease the vehicle. To date Toyota has received 1,500 orders for the Mirai in Japan, and California is anticipating the arrival of the first vehicles at the end of 2015.
- The Toyota Mirai's driving range was recently estimated by the United States Environmental Protection Agency at 312 miles, which is the longest range of any ZEV on the market and provides an estimated 67 miles per gallon equivalent. The Mirai was also recently revealed to include a "Power Take-Off" system, which allows the Mirai's on-board fuel cell system to provide power to the vehicle owner's home.
- Honda presented their evolved concept "FCV," demonstrating progress towards the final design to be launched after 2015.
- Audi announced the concept A7 h-tron Quattro sportback at the 2014 Los Angeles Auto Show.
- Toyota announced financial backing for hydrogen infrastructure developer First Element and separately a partnership with Air Liquide to deploy 12 hydrogen fueling stations in the Northeast states.
- Honda joined with Toyota in supporting First Element's planned network of hydrogen fueling stations.

Hydrogen fueling stations are making the shift from the demonstration phase to being commercially available

- Through a new dispenser accuracy testing device and program administered by the California Department of Food and Agriculture's Division of Measurement Standards (DMS), the hydrogen fueling station at the California State University Los Angeles became the first in the world to be certified to sell hydrogen by the kilogram directly to retail customers.
- The Diamond Bar hydrogen station dispenser received DMS type certification, and stations in West Sacramento and Newport Beach received temporary use permits through the DMS program.

The State and federal governments, and other key stakeholders, continue to advance programs and initiatives addressing the most pressing challenges for deployment of FCEVs

- ARB has received 57 rebate applications from leases of the Hyundai Tucson Fuel Cell through the State's Clean Vehicle Rebate Project (CVRP), providing $5,000 to these drivers to incentivize FCEV adoption.
- Because of station development progress in the past year and strong indications of confidence in expected operational dates, the Energy Commission has announced Notices of Proposed Awards for Operations & Maintenance grants to 11 hydrogen fueling stations since June 2014.

- The U.S. Department of Energy (DOE) formally announced the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project. H2FIRST is a public-private partnership leveraging the expertise of the DOE's national laboratories to address the most immediate technical challenges to hydrogen station commercialization.
- The DOE expanded a hydrogen safety and emergency response training program established and implemented by the CaFCP and Pacific Northwest National Laboratory to a national online training resource available to first responders across the country, demonstrating the growth of the hydrogen fueling infrastructure nationwide.
- Sandia National Laboratory in partnership with H2FIRST released an assessment of 70 California retail gasoline stations and found 14 could host hydrogen stations, and with property expansion an additional 17 could house hydrogen fueling equipment while adhering to present National Fire Protection Agency guidelines.

Collaboration remains a key driver for success

- H2USA and DOE released two tools to support broader investment and deployment of hydrogen fueling stations. The Hydrogen Refueling Station Analysis Model (HRSAM) helps assess the impact of station design on performance and cost, and the Hydrogen Financial Analysis Scenario Tool (H2FAST) provides in depth financial analysis including cash flow and return on investments for hydrogen fueling stations based on key financial inputs such as station capital cost, operating cost, and financing mechanisms.
- The California Fuel Cell Partnership (CaFCP) published its Hydrogen Progress, Priorities, and Opportunities report. The document assessed the accomplishments of the State's infrastructure deployment in terms of the Road Map published in 2012. Remaining challenges and potential actions were identified and may serve as a valuable guide for the State.

While California remains a focal point for FCEV and hydrogen infrastructure deployment, national and global actions by government and industry indicate markets are developing worldwide

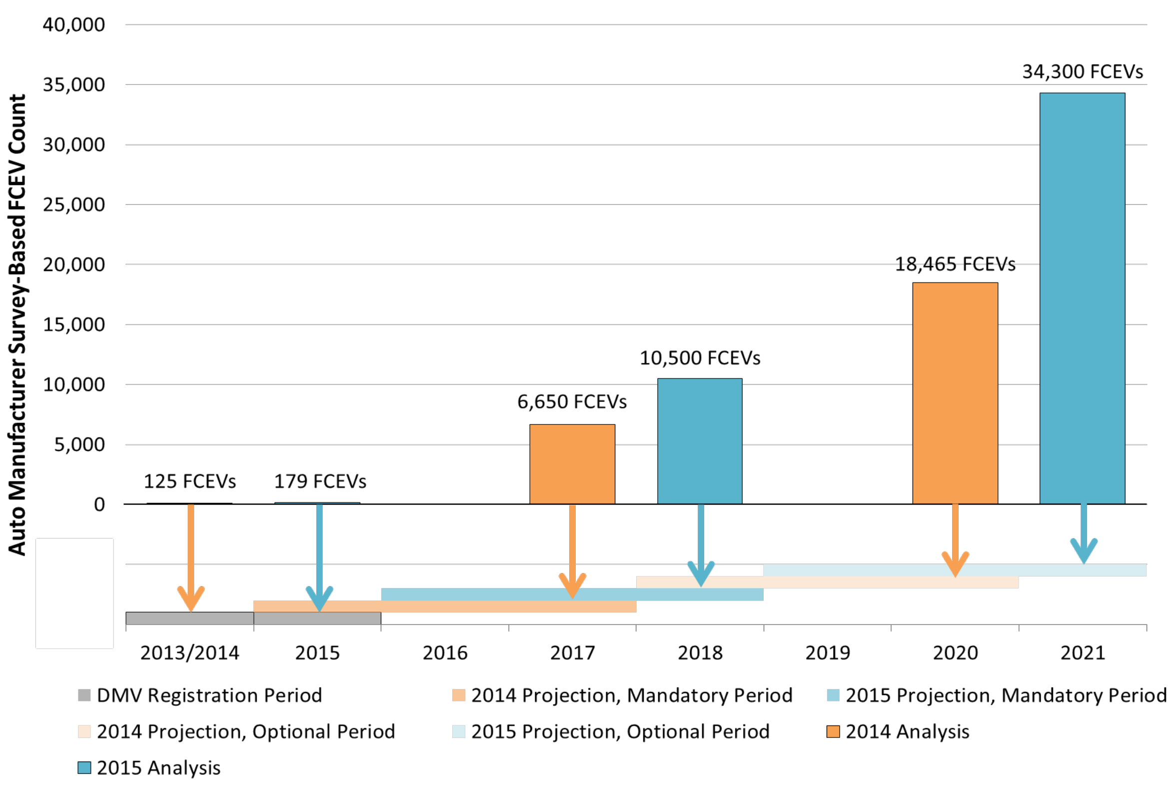
- H2USA has published maps showing potential hydrogen fuel cell transportation applications in the Northeast states to address readiness for fuel cell and hydrogen infrastructure in a broad set of applications including light-duty vehicles [5].
- The German Ministry of Transport and the industry partners Air Liquide, Air Products, Daimler, Linde and Total Germany signed a letter of intent to jointly develop a network of fueling stations. By the end of 2015, there will be 50 hydrogen fueling stations in Germany [6].
- The government of Japan released a Strategic Road Map for hydrogen and fuel cells, including light-duty vehicles and fueling infrastructure; auto manufacturers Toyota, Nissan, and Honda announced their intention for collaborative effort to support the Strategic Road Map goals [7].
- The Korean government announced plans to deploy 1,000 FCEVs and 10 stations for its public sector fleets.
- Toyota announced Mirai launches in 2016 for Europe, Denmark, and the United Kingdom in addition to their previously announced California and Japan launches.
- Hyundai launched its Tucson Fuel Cell in Australia and opened the country's first hydrogen fueling station at the company headquarters near Sydney.

Findings

Finding 1: Post-2018, FCEV deployment is anticipated to accelerate more rapidly than previously projected.

Auto manufacturers' responses to ARB's 2015 survey indicate much larger numbers of planned vehicle deployments over the next six years than previously projected in the 2014 Annual Evaluation. In the 2014 Annual Evaluation, 6,650 and 18,500 vehicles were projected for 2017 and 2020, respectively. This 2015 Annual Evaluation projects 10,500 by the end of 2018 and 34,300 vehicles by the end of 2021. Figure ES1 provides a side-by-side comparison of the FCEV populations projected from the 2014 and 2015 analyses. The horizontal bars below the columns display the years for which ARB collected data in the 2014 and 2015 surveys. Each survey includes two periods: a mandatory period spans three model years after the survey date and provides vehicle deployments on a county and annual basis. An optional period spans the next three model years and provides aggregate vehicle deployments statewide as a single sum for those three years. Orange represents the reporting periods and vehicle projections developed from the 2014 survey and blue represents the same for the 2015 survey. AB 8 also requires an annual assessment of DMV registrations, which are analyzed each year during the evaluation process.

Figure ES1: Current and Projected On-Road FCEV Populations



From these numbers, it is clear that auto manufacturers not only anticipate releasing increasing numbers of vehicles in the coming years, but they also anticipate a rapid acceleration in the rate of vehicle deployment over the same time. FCEV registration grew 43% since the close of 2013, due in large part to the release of the Hyundai Tucson Fuel Cell vehicle. Given the anticipated release of Toyota's Mirai FCEV at the end of 2015, another significant increase in on-the-road vehicles is expected within the coming year.

Finding 2: Overall, deployment progress of the station network has remained largely on track. Early evidence indicates some recently funded stations are progressing at accelerated rates, while others previously projected to be operational in 2015 are now projected for 2016.

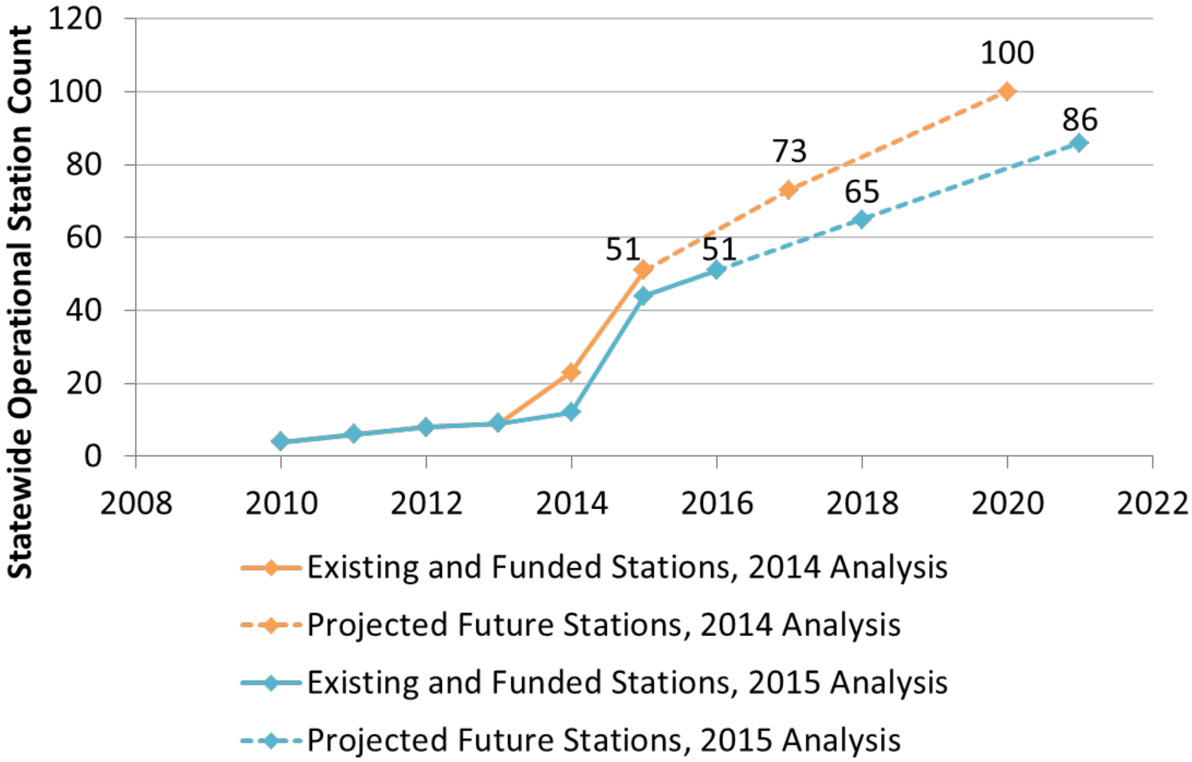
The Energy Commission and GO-Biz have spent significant effort in the past year coordinating with station developers to advance station progress. Time has been spent with each developer to stress the incentives for early project completion from Program Opportunity Notice (PON) 13-607. Because of these efforts, this year the State has a clearer picture of expected operational dates for the most recently funded stations. As a result, revised projections indicate 44 of the 51 stations will be operational before the end of 2015. The remaining seven are projected to become operational in 2016.

Overall, the progress of recently funded stations has remained largely on track. Although some individual station projections have moved back, many others have remained on schedule. While stations previously expected to be operational in 2014 have been delayed, there are early indications that newer station projects have been progressing at a faster pace than previously witnessed. Factors contributing to this acceleration may include: improved workflows and institutional knowledge within the developer organizations, increased experience within local permitting and zoning agencies, and the financial incentive provided by the structure in the most recent grant solicitation. Station designs are becoming more modular and best practices are beginning to materialize, allowing for quicker implementation of a variety of available footprints. A more in depth analysis of this trend will be included in a future joint Energy Commission-ARB report to be published in December 2015.

Finding 3: AB 8 directs the Energy Commission to invest $20M annually in hydrogen stations until California reaches at least 100 stations. Increased demand for crucial Operations and Maintenance (O&M) grants directly impacts funding available for new stations. As a result, the annual new station deployment rate is projected to be lower than last year's projection.

In this 2015 Annual Evaluation, projections of future hydrogen fueling station deployment rates have been adjusted to a slower pace to properly account for the use of AB 8 funds for eligible station O&M costs. The Energy Commission offered O&M grants in 2014 to provide operations support to early market station developers to compensate for projected negative revenues from hydrogen sales during the initial years of commercial vehicle launch until station use rates ramp up to commercially viable levels. The 2014 grant program allowed station developers to apply for grants of up to $100,000 per year for up to three years. These grants have received a great deal of support from stakeholders and played a key role in generating increased interest in the Energy Commission's most recent PON. However, the 2014 Annual Evaluation did not account for the funds to support O&M grants when projecting the rate at which new stations could continue to be co-funded by the State. Since that time, there have been indications from station developers that the State should expect a high rate of subscription for O&M grants, emphasizing their importance. Assuming that the Energy Commission's current capital funding support remains constant, an updated and more robust assessment accounting for O&M grant funds indicates the potential rate of State co-funding for new stations will decrease by an estimated four stations per year. Under these assumptions, 14 new stations are expected to be funded by 2018, and 35 by 2021, as shown in Figure ES2.

Figure ES2: Cumulative Existing, Funded, and Projected Publicly Funded Station Counts



Finding 4: In order to provide coverage to the most likely areas of early market adoption, San Francisco, Berkeley, San Diego, Greater Los Angeles, Torrance, and other areas with a high market potential should receive priority. Stations in Lebec and Los Banos are needed to strengthen the planned connector on I-5 in Coalinga.

In 2015, ARB assessed the anticipated growth of hydrogen demand and capacity with the same accounting tool as in the 2014 Annual Evaluation. ARB has also developed a new Geographical Information System (GIS)-based tool to help analyze the potential FCEV market and where gaps exist between existing station coverage and needed coverage. The new tool provides greater resolution and detail in assessment, reduces ambiguity, and fills in some voids of knowledge vital to a full assessment. Using these tools together, ARB has adjusted its recommendations from the previous evaluation. These recommendations can inform the next funding solicitation that the Energy Commission is currently in the process of developing.

Table ES1: Primary Suggested Areas for Further Hydrogen Fueling Infrastructure Investment

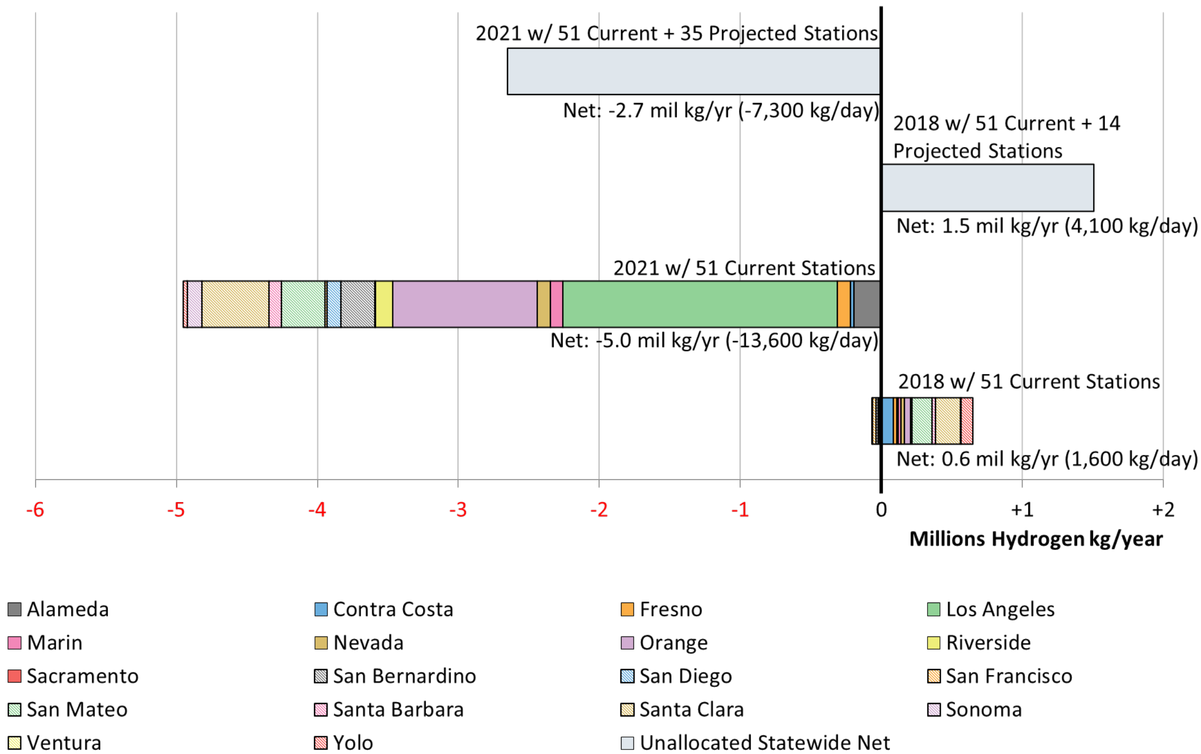
		Area	Purpose
First Priority	1	San Francisco	Establish Core Market
	2	Berkeley/Oakland/Walnut Creek/ Pleasant Hill	Establish Core Market
	3	San Diego/La Mesa	Expand Core Market Coverage
	4	Greater Los Angeles/Sherman Oaks/Granada Hills/Glendale	Core Market Capacity
	5	South San Diego/Coronado	Expand Core Market Coverage
	6	Torrance/Palos Verdes/Manhattan Beach/Redondo Beach	Core Market Capacity
	7	Pasadena/San Gabriel/Arcadia	Expand Core Market Coverage
	8	Long Beach/Huntington Beach/Buena Park/Fullerton	Expand Core Market Coverage
	9	Santa Cruz	Future Market
	10	Encinitas/Carlsbad	Connector/Future Market
	11	Fremont	Future Market
	12	Sacramento/Land Park	Expand Core Market Coverage
	13	Sacramento/Carmichael	Expand Core Market Coverage
	14	Thousand Oaks	Future Market
Connector	27	Lebec	Support Existing I-5 Connector
	28	Los Banos	Support Existing I-5 Connector

ARB recommends the areas listed in Table ES1 as the next targets for increasing fueling station coverage in areas with high likelihood of FCEV adoption. In addition, connector stations in Lebec and Los Banos along the I-5 will be important for strengthening the reliability of the north-south connector route. Each priority area is listed along with the role that new stations in the area may fill. Some will establish the first coverage in an area with projected high interest in FCEVs; others will help expand the capacity or coverage in markets with existing, but limited, coverage. ARB has also developed an extended list including high priority areas for further investment in later years to provide a basis for long term network planning. Refinement and further discussion of the geographical boundaries of priority areas will be presented in future public workshops and documents.

Finding 5: By 2020, accelerated hydrogen demand from FCEVs may outpace the rate of hydrogen fueling capacity provided by publicly funded stations.

Findings 1 and 3 represent two key factors that have dramatically altered the assessment of statewide and local hydrogen fueling capacity balance. The 2014 evaluation found that the existing and funded stations, together with continued deployment of stations through State co-funding programs, would be sufficient to provide necessary refueling capacity until at least 2020. In this updated evaluation, the combination of accelerated vehicle deployment and less money available for new stations (assuming current funding structures continue) leads to the conclusion that by 2020, there may not be sufficient hydrogen capacity, either on a local county level or statewide. The bottom two bars in Figure ES3 show county level balances of hydrogen (with capacity shortfalls on the left of the y axis and sufficient capacity on the right) for the existing and planned network of 51 stations for 2018 and 2021, respectively (following Figure ES2). The top two bars show statewide balances for scenarios including new stations projected to be built by 2018 and 2021, respectively. This analysis shows even with 35 additional stations by 2021, business as usual in State funding programs and station technology will result in a statewide hydrogen capacity shortfall. Alameda, Sacramento, San Francisco, and Ventura counties may need additional capacity before 2018, given demand in these areas may outpace capacity around 2018.

Figure ES3: Estimated Balance of Hydrogen Fueling Capacity by County and Statewide in 2018 and 2021



Finding 6: With a projected shortfall in hydrogen fueling capacity anticipated after 2020, it will be important for the State to explore and consider a diverse range of options to increase the impact of public investments and maximize fueling capacity of future hydrogen stations.

AB 8 provides up to $20 million annually to spur an initial network of at least 100 hydrogen fueling stations. The State has been and will continue to consider the appropriate balance between building new stations and supporting O&M of the stations necessary for this initial network. The current grant program structure is designed to support this balance and ensure stations stay open in this early market stage. However, as the market develops out of this early phase, the program can and should explore appropriate alternative approaches to financing this transition.

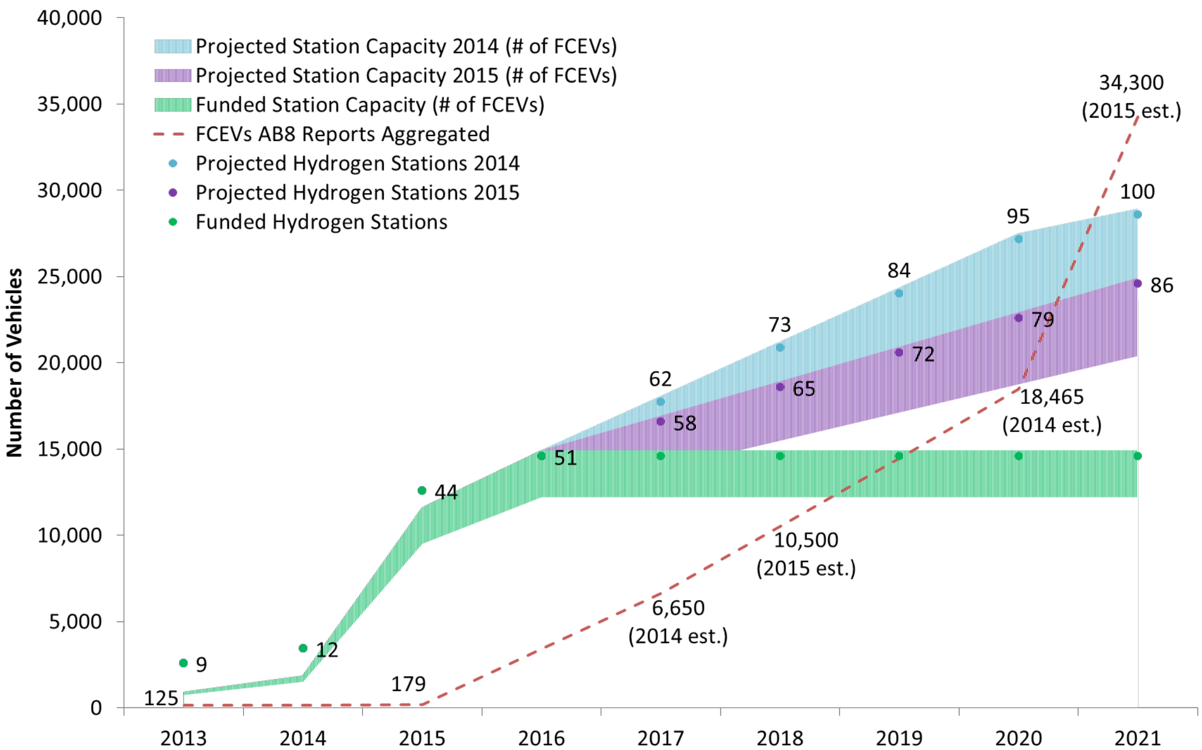
The current structure of capital grant programs and O&M funding, along with the current typical or average station specifications, are central to the analysis supporting Finding 5. However, alternative financing approaches that may develop in the coming years will have a marked impact on this evaluation. Figure ES4 provides an analysis of the number of FCEVs that could be supported under three scenarios:

1. A base case analysis for the currently funded and operational 51 stations
2. Continued station deployment according to the rate indicated by the 2015 analysis in Figure ES2
3. Continued station deployment according to the rate indicated by the 2014 analysis in Figure ES2.

Based on Figure ES4, assuming the current State funding structure and average station capacity remain unchanged, it is clear that the State's ability to address the projected growth in hydrogen demand would be limited and would not meet the projected need.

There are multiple objectives that must be achieved with limited public funding currently available. There is a need to keep current stations viable during this early phase, expand the capacity of existing stations, build new stations, and ensure they all perform to meet minimum fueling standards. To maximize the State's ability to meet these needs, thoughtful evaluation of alternative support options in some instances may be needed. Following are a number of preliminary ideas that could guide mid- to long term program improvement. Proper implementation of these or any similar ideas will require robust research and evaluation, as individual needs may require different financing tools and approaches. A thoughtful program evolution is needed before 2020, when vehicle demand is projected to outpace fuel supply. These suggestions, and others that may be developed, require further discussion, feedback, and consideration through stakeholder and public engagement in meetings and workshops before implementation in any future funding program.

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



As technology advancements, cost reductions, and increasing supply chain development materialize in the near future, the State may have an opportunity to provide incentives or priority for higher capacity stations.

As technologies and project designs advance, there may be an opportunity for the State to avoid the projected shortfall by incentivizing innovative station projects with capabilities and capacity that exceed the standard observed to date. To meet the projected demand in 2021 with only 86 stations, the average station for the next five years would need to have a capacity of 390 kilograms per day, more than double the current average. If the State and station developers can reduce costs so that the rate of deployment returns to a total of 100 stations by 2021, then the average new station capacity would need to be 280 kilograms per day, a size that is more readily achievable with today's technology. By pursuing options beyond the business-as-usual case, the State may be better equipped to address the projected increase in demand.

As the business case for hydrogen fueling stations improves, diverse financing mechanisms can be explored, particularly in order to meet expansion and O&M needs.

In future years, it may be appropriate to support expansion of existing stations located in high fuel demand locations using low/no cost loans, loan guarantees, tax breaks, Market Assurances Grants (MAGs) as outlined by Energy Independence Now, or other options [8]. In addition, focusing on larger, more scalable new stations may address both the need for additional capacity as well as the need for additional coverage while establishing stations that have a higher potential to self-fund upgrades and expansions.

Future stations co-funded by the State, especially those with smaller capacity, could be required to demonstrate a clear technical path to expand capacity with their existing footprint and a financial path or business case independent of O&M grants.

Given the need to direct funds to new, larger capacity stations there will be a need for increased scrutiny toward long term viability of stations funded through future grant programs. The rapid acceleration of the FCEV market and the need for fueling capacity will likely continue in the future. This will potentially place further strain on the network capacity. To stay ahead of future hydrogen demand, station developers will need to emphasize their furthest looking plans and designs. Competitive grants for co-funding need to continue to prioritize the business case and provide incentives for developers to think critically about how their plans and designs for expansion and upgrade can most easily and cost-effectively be implemented.

Given the rapid increase in projected FCEV sales, the State has an opportunity to develop plans and take action to engage private industry and encourage private investment in additional hydrogen fueling infrastructure to complement the network backbone of State co-funded stations.

Outreach and information sharing sessions with private investors and venture capitalists could develop awareness and motivate action by the investor community. Further coordination between the State and existing public-private partnerships, like CaFCP and H2USA, could leverage and help guide ongoing efforts to increase investor participation. If enough interest is generated within private industry to address capacity needs in areas that already include coverage and show a robust emerging market for FCEVs, the State may then focus on expansion of the network coverage into additional connector, destination, and future core markets. In this way, the State could continue to act as the initial seed investor, accepting the greatest risk and easing entry into the market by private investors who may typically avoid early markets due to increased risk. As market coverage by the State funded initial network progresses and the risk to investors correspondingly decreases, the State will also need to evaluate the option of increasing match fund requirements in the mid- to long term future so that more funds can be available to establish coverage in future markets.

Finding 7: Stations funded by future grant programs should be required to adhere to the SAE J2601 standard for the fueling protocol. Additionally, there is an urgent need to upgrade some previously funded stations that may not yet have this capability.

Beyond capacity, future stations must offer improved technical capabilities to support accelerated vehicle deployment, including accuracy and fueling protocols. Stations must be able to conduct consecutive fills with short fueling times for each fill and minimal wait time between fills. The specifications for achieving (and therefore measuring the ability to achieve) these requirements are outlined in the SAE J2601: 2014 fueling protocol. This protocol was completed and published in the last year and was therefore not a requirement of stations funded in previous grant programs. Retail customers will likely expect stations to perform at least as well as outlined in SAE J2601. Upgrades of existing stations to the most recent published version of SAE J2601 will improve customer acceptance and the State should investigate no or low cost options to enable these upgrades. O&M grants can also cover the expense of the standards compliance work that calibrates the system to the standard without permanent equipment changes. Additionally, if the State does decide to invest in a station upgrade, the upgraded station should be required to have the capability to follow SAE J2601. Finally, all hydrogen stations funded in the future should have compatibility with the current version of SAE J2601 as a requirement for grant eligibility.

Finding 8: The State of California is successfully implementing and further developing tools and devices to ensure station performance standards will provide increased assurance of station performance, accuracy, and reliability.

Significant progress in assessing and certifying station capabilities has been achieved in the past year. DMS, along with ARB, Energy Commission, and others, has developed a set of standards, field tested measurement techniques, and a program to certify the accuracy of individual hydrogen fueling station dispensers utilized in California. This program has resulted in the first stations in the world to be certified to dispense hydrogen accurately enough to allow sale of the hydrogen to the public at "point of sale" hydrogen dispensers. From the momentum of this precedent, a number of similar efforts are underway to develop the very first tools, techniques, and programs to assess and certify other aspects of hydrogen fueling station operation. These include certifying the fueling protocol and monitoring hydrogen quality. These capabilities are absolutely necessary to ensure that stations perform to customer expectations and will continue to do so throughout their lifetimes.

Finding 9: With more stations coming on line, together with the expected increase in vehicle numbers, there is an urgent need for trained personnel and specialized tools for station commissioning. This includes multiple devices for protocol testing and validation, certification of dispensing accuracy, hydrogen quality monitoring and overall fueling performance evaluation.

Even with the recent progress in capabilities to certify station performance, there remains an urgent need to enhance these capabilities. Certification of dispenser accuracy is currently achieved with the use of a single device providing service to all stations throughout California. The schedule for the single device is currently stressed, and demand will only increase in the next 12 months as many more stations are completed. There is a clear need for State investment in additional devices and personnel to support the expected growth in demand. Additionally, although efforts are underway to develop devices to address other station characteristics, these projects will likely need to receive additional priority attention in the coming months in an effort to accelerate project completion. These devices will be just as necessary as the existing accuracy testing device to ensure satisfactory retail customer experiences at hydrogen fueling stations.

Conclusions

The State of California's commitment to invest in early hydrogen fueling station development as embodied in AB 8 has created market confidence, enabling automakers to launch early commercial FCEVs and allowing hydrogen fuel providers to invest private capital. 2015 is an exciting and pivotal year as new FCEV models come to market and hydrogen fueling stations open for business. Projections of FCEVs continue to increase and demonstrate an accelerating pace. Hydrogen station developers are showing reduced time from project funding to station completion. Agencies are implementing new incentives to support the early market. Anticipating strong growth, California now faces new challenges and opportunities. Increased FCEV projections mean growing demand for hydrogen could exceed the State's ability to support the early market with current public funding levels. More communities need hydrogen station coverage to provide consumers the choice of purchasing or leasing a FCEV. While California can achieve 100 stations by 2023 with funding allocated under AB 8, these stations will need to be larger than previously funded. Innovative approaches to investing State funds can help the State support this growing early market. As this early market becomes increasingly robust, California must thoughtfully explore opportunities to increase private investment in stations.

While this report demonstrates strong progress in planning and executing FCEV and hydrogen station deployment, California has much work remaining to ensure stations adhere to performance and reliability standards needed to meet consumer expectations. Station commissioning processes currently depend on auto manufacturer and station developer testing and confirmation. These processes must become faster and more streamlined so stations can move from operational to open more quickly and at lower cost. With federal and local government partners, the State is beginning to develop the tools and programs needed to accomplish this goal and transition hydrogen into a mainstream fuel market. California needs additional focus and resources to accomplish this important transition over the coming years.

To meet California's goals for ZEVs and achieve deep reductions in greenhouse gases, petroleum use, and air pollution, FCEVs and hydrogen fueling stations operating over the next few years must set the stage for and build toward a self-sustaining commercial market. The data and analysis in this report reveal indicators of this future transition.

I: Introduction

In 2015, California continues to be a national and global focal point for commercializing fuel cell electric vehicles (FCEVs) and hydrogen fueling stations. By providing a specific focus on development of the state's hydrogen fueling station network, AB 8 remains a crucial driver to ensure California is prepared for commercial launch of FCEVs from multiple auto manufacturers. This focus will enable hydrogen FCEVs, along with other ZEV technologies, to play a significant role in meeting multiple policy objectives established by Governor Brown and the Legislature. Reducing climate change emissions 40 percent by 2030, cutting petroleum use up to 50 percent by 2030, and achieving California's health based air quality goals as required under federal law will require transformation of the vehicles and fuels we use today [1,2]. California's vehicle fleet will need to be comprised of significantly increasing numbers of ZEVs, including FCEVs, in order to meet these goals. Governor Brown's Executive Order B-16-2012 and the subsequent 2013 Zero-Emission Vehicle Action Plan lay out the vision and actions needed to support market launch and commercial growth [3].

AB 8 directs ARB and the Energy Commission to plan and fund development of a network of at least 100 publicly available hydrogen fueling stations to support projected FCEV deployments in California. Under their ARFVTP, the Energy Commission has issued awards totaling over $92 million to build or upgrade 49 hydrogen stations and one mobile refueler. Including currently operating stations, California will have over 50 publicly available hydrogen stations once all new and upgraded station projects are completed in 2015 and 2016.

To support funding levels for hydrogen fueling stations, AB 8 requires that:

1. ARB aggregate and make available current DMV registration counts of FCEVs and auto manufacturer projections of future vehicle placements.
2. Beginning June 2014, ARB provide the Energy Commission an evaluation of the need for additional hydrogen fueling stations, quantity of fuel needed, geographic areas of need, station coverage, and minimum operating standards.
3. Beginning December 2015, the Energy Commission and ARB jointly review and report on the annual progress toward establishing the state's hydrogen fueling station network.

The 2015 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development uses auto manufacturer FCEV projections aggregated from responses to ARB's 2015 survey and current station status and projections for the funded hydrogen fueling station network. ARB staff further developed analytical tools used in the 2014 Annual Evaluation to reflect more rigorous geographical criteria, and developed a set of new analytical tools and methods, the California Hydrogen Infrastructure Tool (CHIT), to better understand and assess the regional variation in the potential FCEV market, independent of the auto manufacturer survey.

In a broad sense, the past year has presented significant progress toward the goal of developing a well-planned, sustainable hydrogen fueling station network ready to address the near term needs of a rapidly growing FCEV fleet. Staff from the ARB, Energy Commission and GO-Biz along with other state agencies closely coordinate and work with other government and industry stakeholders to take actions that support expedited hydrogen station development and enable growing FCEV placements with California customers. Working with Energy Commission staff and station developers, the ZEV Infrastructure Project Manager in GO-Biz has helped speed station development times by reaching out to local community officials, business owners and the public to proactively address potential issues.

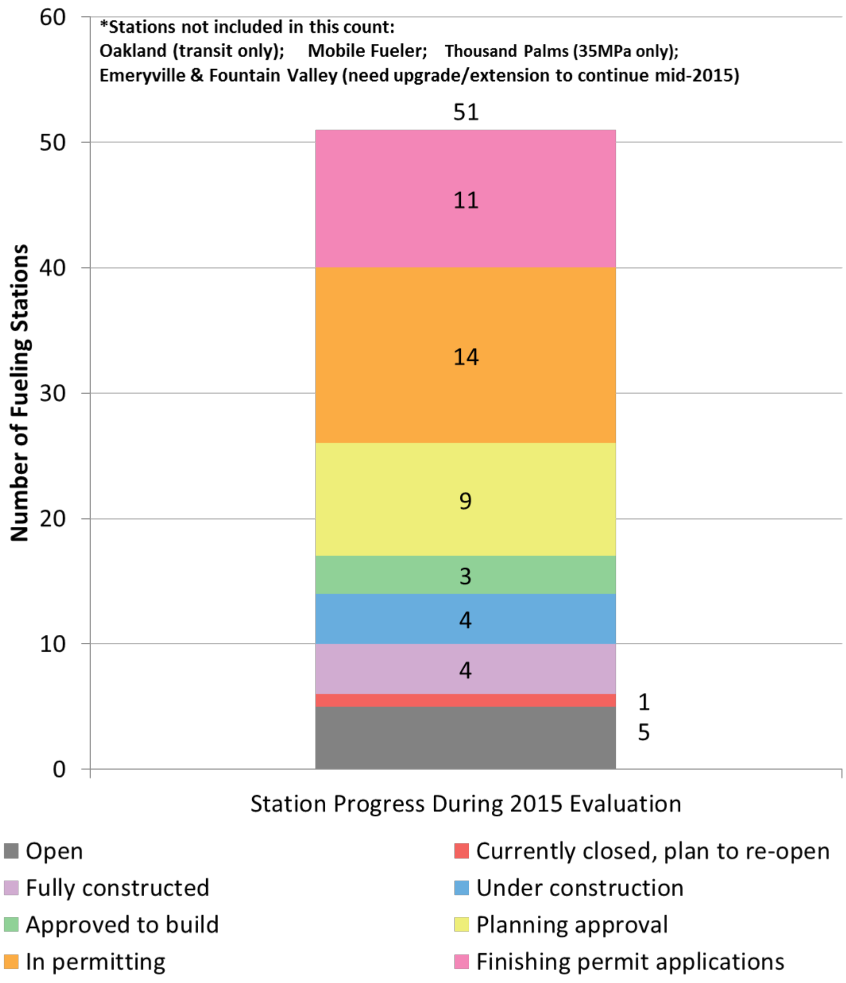
DMS implemented the Hydrogen Field Standard (HFS) device at several stations, resulting in two type certified hydrogen dispensers and two dispensers with temporary approval to legally sell hydrogen directly to individual consumers at the pump, on a per kilogram basis. The Energy Commission has proposed the award of eleven grants for O&M expenses at hydrogen fueling stations during the past year, in addition to four grants proposed prior to the previous evaluation. This has helped provide confidence to station developers that want to build a business case as FCEV volumes grow. ARB worked with US DOE and other government and industry partners to design the Hydrogen Station Equipment Performance (HyStEP) device to validate hydrogen station fueling protocols, and plan for California implementation beginning fall 2015. These and concomitant industry actions support accelerated FCEV and hydrogen market development in California, and foster collaboration that will be necessary for continued growth.

Station Development Progress

Station developers continue the push to achieve the most aggressive operational dates. For stations funded under PON 13-607, those that are operational before October 31, 2015 (as most plan to be) will be eligible for the highest cost share and highest O&M grants. Experience with the newest stations indicates these two features of the most recent funding program are accelerating hydrogen fueling station development.

Figure 1 illustrates a summary of the most recent progress reached by stations currently operating or funded, based on information obtained by the Energy Commission and GO-Biz from station developers. The figure presents a snapshot in time as of June 1, 2015 and shows multiple planning and construction stages, from preparing permit applications to achieving open status. The number of stations in a given category (provided within or to the side of each category's color bar, with the total given at top) shift weekly as stations proceed through the development process. While in the past stations have taken months and even years to move from design to permitting and approval to build, current projects provide preliminary evidence that development timelines are becoming shorter and more predictable. Station developers are meeting with planning and permitting agencies earlier and learning to anticipate and plan for potential hurdles. Local planning and permitting agencies are becoming increasingly well versed in hydrogen fueling station technology and are becoming more confident in its safety and commercial acceptance. Continued improvements in the station development process will be crucial as the State continues to expand the early hydrogen fueling network and industry builds a new business enterprise.

Figure 1: Detailed Station Progress as of June 1, 2015 per GO-Biz and Energy Commission



New Analytical Tools

Network planning requires thoughtful synthesis of all available information, a necessity implicitly acknowledged by the assessment and reporting requirements outlined in AB 8. In order to complete the 2015 Annual Evaluation, ARB made a number of additions and changes to analytical processes and methods used in the 2014 Annual Evaluation. The details of these changes are presented in the relevant chapter(s). These changes allow ARB to perform a more informed analysis and provide recommendations to the Energy Commission that are more specific than provided in the previous evaluation. The new developments in the method allow for a more consistent transfer of information and data between the various steps of ARB's process. In particular, the following features are new for the 2015 Annual Evaluation:

1. In 2014, ARB surveyed auto manufacturers regarding their projected vehicle placement using a spatial allocation following the CaFCP-led cluster definition. In 2015, ARB redesigned the survey to request vehicle placement by county. The use of a legally defined geometry reduces uncertainty in the interpretation of auto manufacturer responses. As a direct consequence, on road vehicle count, station count, station capacity, and hydrogen balance are now presented only by county and as a statewide total; cluster, expanded network, and air district designations are no longer used for reporting purposes in the 2015 Annual Evaluation.

2. The tool utilized for aggregating auto manufacturer responses and station information has been similarly redesigned to perform analyses and provide output with geographical resolution based on counties. In addition, this tool has now been formalized as one half of a pair of in house analysis tools. ARB refers to this tool as the California Hydrogen Accounting Tool (CHAT).
3. The conversion calculation between model year supplied on auto manufacturer surveys and calendar year in CHAT's calculations has been modified according to an ARB study of DMV records. The previous evaluation's assumption of a 50% shift of vehicle counts in a given model year to be placed in the prior calendar year has been adjusted to a 33% shift.
4. ARB developed CHIT, a Geographical Information System (GIS) based tool, that builds from the pioneering work of other similar tools, for example Spatially and Temporally Resolved Energy and Environment Tool (STREET), Scenario Evaluation, Regionalization, and Analysis (SERA) and published work by other researchers identifying the potential FCEV market and identifying areas with the greatest potential need for additional stations to provide coverage for the expected market [9-13]. CHIT allows ARB to project the potential market for FCEVs where the practical limitations of the auto manufacturer survey cannot provide sufficient data. Currently, the main goal of CHIT is to analyze coverage, but work is ongoing to add capability for local (below the county level) capacity analysis and future versions may enable analysis of need for connector and destination stations. Full technical details of CHIT will be presented in future public workshops and written documents.
5. As stations have come on line during the past year, government agencies, auto manufacturers, station developers and other stakeholders have recognized two milestone dates for station completion – operational and open. An operational date is strictly defined as the date a station is expected to be completed per the terms of its funding agreement, which for the majority of stations is outlined in the Energy Commission's PON 13-607 requirements. The open date represents a later time, after which auto manufacturers have conducted additional testing and more than one of those manufacturers has accepted the station for their customers' use. ARB has adopted the operational date as the reference point for CHAT analyses.

II: 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.

To project the number and location of hydrogen FCEVs, ARB uses results of an annual automaker survey conducted each April. Under the Low Emission Vehicle regulations (LEV, October 2014), automakers must report the number of alternative fueled vehicles for the next three model years. ARB requests additional voluntary information regarding projections of three additional model years beyond those required to more adequately project future infrastructure requirements and alternative fuel demand.

2015 Auto Manufacturer Survey

For the 2015 survey, auto manufacturers were asked to provide county level resolution[1] of their current (model year 2015) and near term projected (model year 2016-2018) FCEV placements. For the longer term (model year 2019-2021), auto manufacturers were asked to voluntarily provide their projections of total statewide FCEV placement. Surveys were sent to 17 auto manufacturers (including surveys for battery electric [BEV] and plug-in hybrid electric vehicles [PHEV]), and the 16 obligated auto manufacturers provided responses (including some responses that indicate no plans for vehicles within the timeframe of the survey).

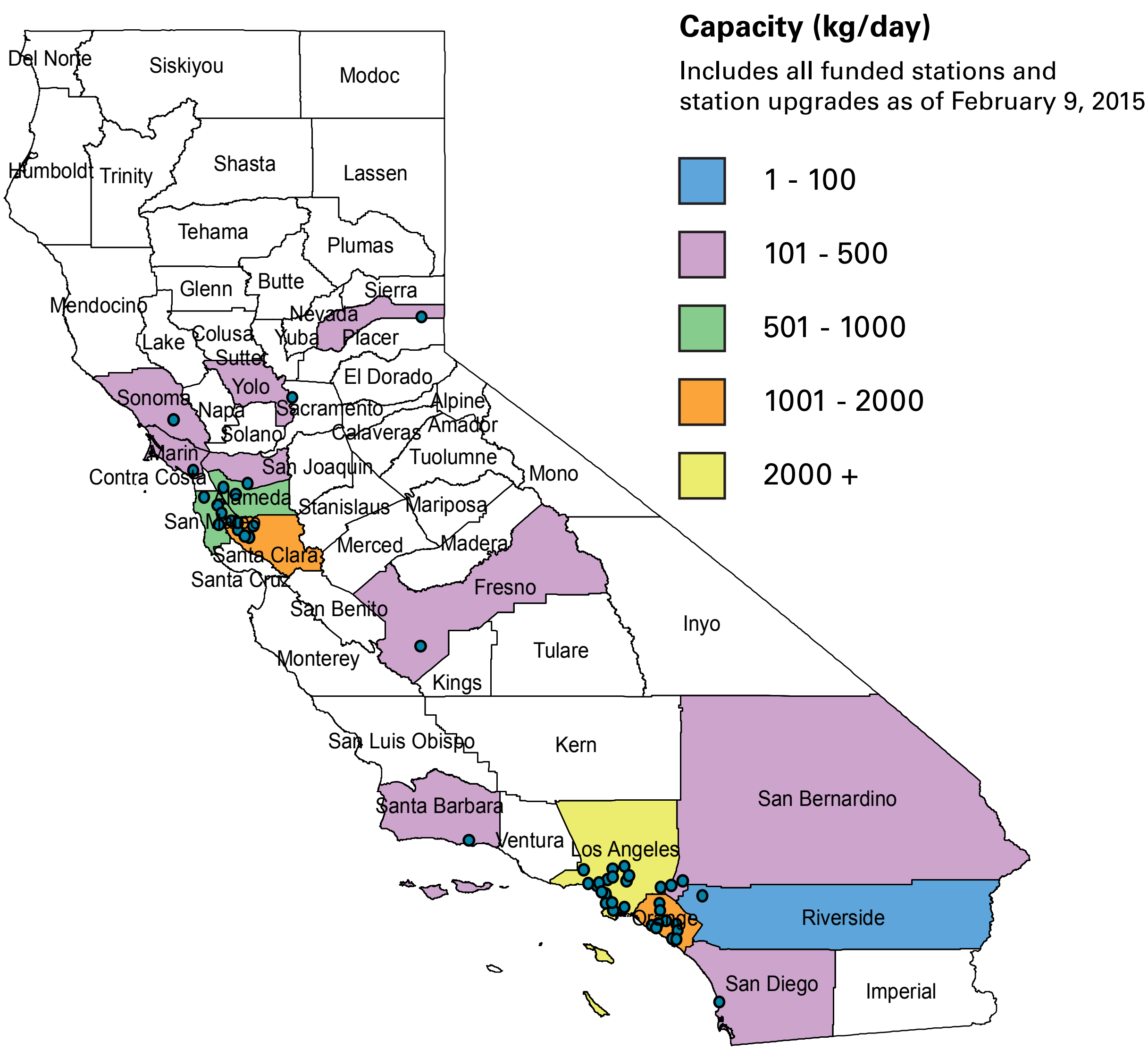
Automakers generally indicate their plans for future vehicle launches are heavily reliant on hydrogen station availability in a given location (along with market factors indicating a potential customer base). To simplify the survey process, ARB included only a subset of California's 58 counties on the survey. Any county that currently has at least one station existing or funded for construction was included on the survey: Alameda, Contra Costa, Fresno, Los Angeles, Marin, Nevada, Orange, Riverside, San Bernardino, San Diego, San Mateo, Santa Barbara, Santa Clara, Sonoma, and Yolo. Neighboring counties that ARB understands may be of future interest to the auto manufacturers were also included: Napa, Sacramento, San Francisco, Solano, and Ventura. Auto manufacturers were able to indicate geographical distribution as well as a statewide total, which could indicate some counties where manufacturers expect to deploy vehicles were not included in the survey, or manufacturers are uncertain about location of future FCEV placements. Some manufacturers did project vehicles to be located in neighboring counties that do not currently have hydrogen infrastructure plans, indicating that some of these counties are indeed target areas for initial FCEV deployment.

In order to ensure a consistent basis of feedback from the auto manufacturers, ARB provided the following information with the survey form:

1 ARB has shifted the geographical basis of analysis from the previously used cluster/expanded network/air district set to a county basis. This switch was motivated by a desire to utilize an unambiguous geographical resolution as the basis for analysis.

1. A map of the state, indicating the counties with existing or funded hydrogen infrastructure, the locations of these stations, and the range of hydrogen dispensing capacity within those counties. The figure provided with the survey is reproduced in Figure 2.
2. A detailed list of station specifics organized by county, including street address, capacity, and projected open and operational dates. This table is reproduced in Appendix C, for reference.
3. A web link to information on station project status, maintained by GO-Biz. The web link provides more detailed station information, including current development phase, percent of project completed, funding source, and various other project specific details. The website is updated monthly as GO-Biz interacts with the project developers; however, during the time period of the survey, no changes in the operational or open date projections were made in order to ensure the responses to the survey were informed by a consistent set of data. The data from this site are also used to regularly update the CaFCP station map, where it is presented in a more user friendly and interactive form [14].

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

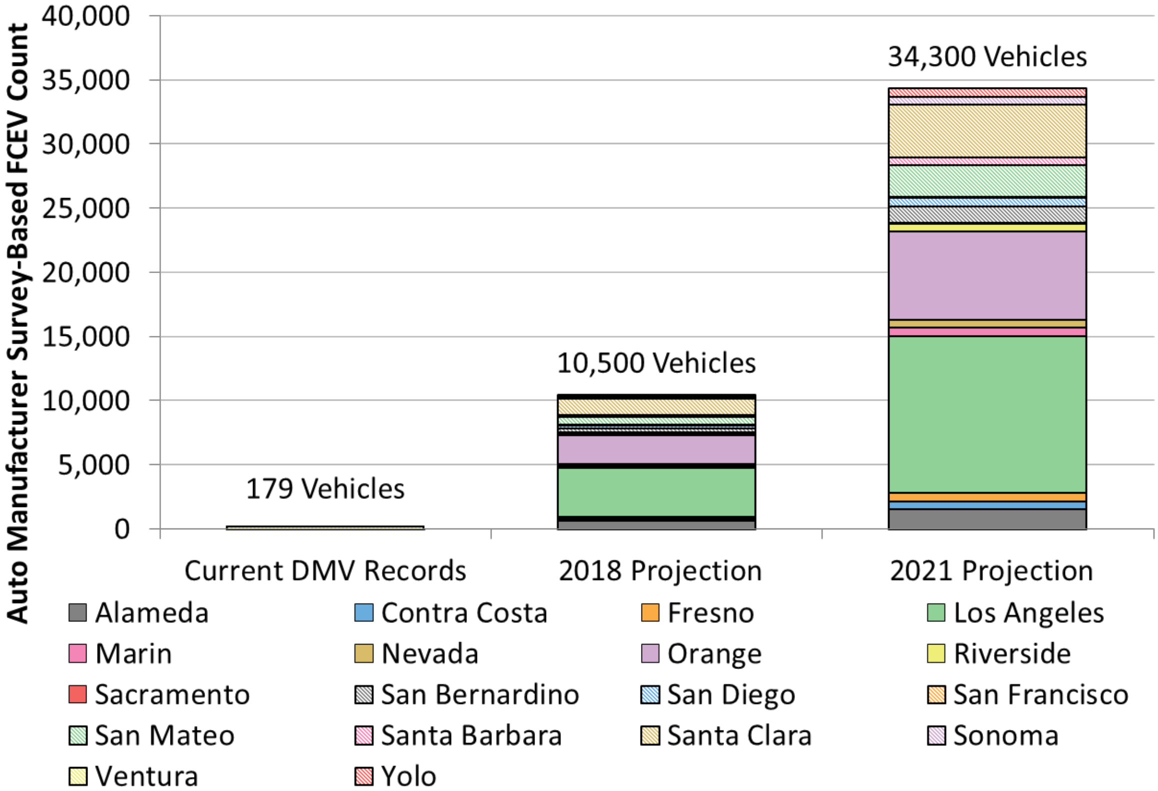


For the purposes of analysis in the 2015 Annual Evaluation, ARB has chosen to use the projected operational date as the basis for station deployment. Although there is uncertainty inherent to both dates, the additional process to meet the open date requirements is currently still significant and highly variable; using the operational date definition minimized uncertainty.

ARB Analysis of Auto Manufacturer Survey Reponses

Based on the guidance provided in the map, station table, and online status reporting system, auto manufacturers were expected to provide projections of vehicle placement from model year 2016 to model year 2021. As discussed in the 2014 Annual Evaluation, model year does not necessarily translate directly to the first year of on the road service. For the 2014 Annual Evaluation, ARB assumed half of all vehicles in a given model year were actually placed on the road in the prior calendar year (for example half of all 2016 model year vehicles were counted as appearing on the road in calendar year 2015). For the 2015 Annual Evaluation, ARB performed a brief study of DMV records of all new vehicle registrations from calendar years 2007-2012. The study indicated that on average, the proportion of vehicles placed in the calendar year prior to the model year has been closer to 33%. A similar study of alternative fueled vehicle registrations from Polk indicated a slightly smaller ratio, though the data used for the Polk analysis were a smaller set and may therefore be a subset of the full DMV data. However, the Polk data did enable a comparison of alternative fueled vehicles (AFV) to their conventional internal combustion engine (ICE) counterparts; this analysis found that ICE and AFVs have similar relationships between model year and calendar year of placement. Thus, the data from the auto manufacturer survey were adjusted to include a 1/3 vehicle count shift to the calendar year prior to model year before entry as input to CHAT.

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



As in the 2014 Annual Evaluation, not all auto manufacturer supplied data were provided with a geographical distribution. Following the general indication that vehicles will likely be placed near existing stations, all statewide (undistributed) counts of future vehicle placements were distributed among the counties with existing or funded stations, according to the counties' proportional count of stations compared to the statewide count. For example, Los Angeles County currently has 18 of 51 stations existing or planned and therefore ARB attributed 18/51 of the vehicles reported in any manufacturer's statewide total to Los Angeles County.

As in the 2014 Annual Evaluation, ARB relied on CHAT to provide on-the-road vehicle count projections for future years. CHAT determines on-the-road counts by assuming the average vehicle attrition rate prescribed in ARB's EMFAC model. To assess the current FCEV population, ARB analyzed the DMV's registration records from April 2015.

Figure 4: County Level Vehicle Projections Based on DMV Records, Auto Manufacturer Surveys and Station Distribution

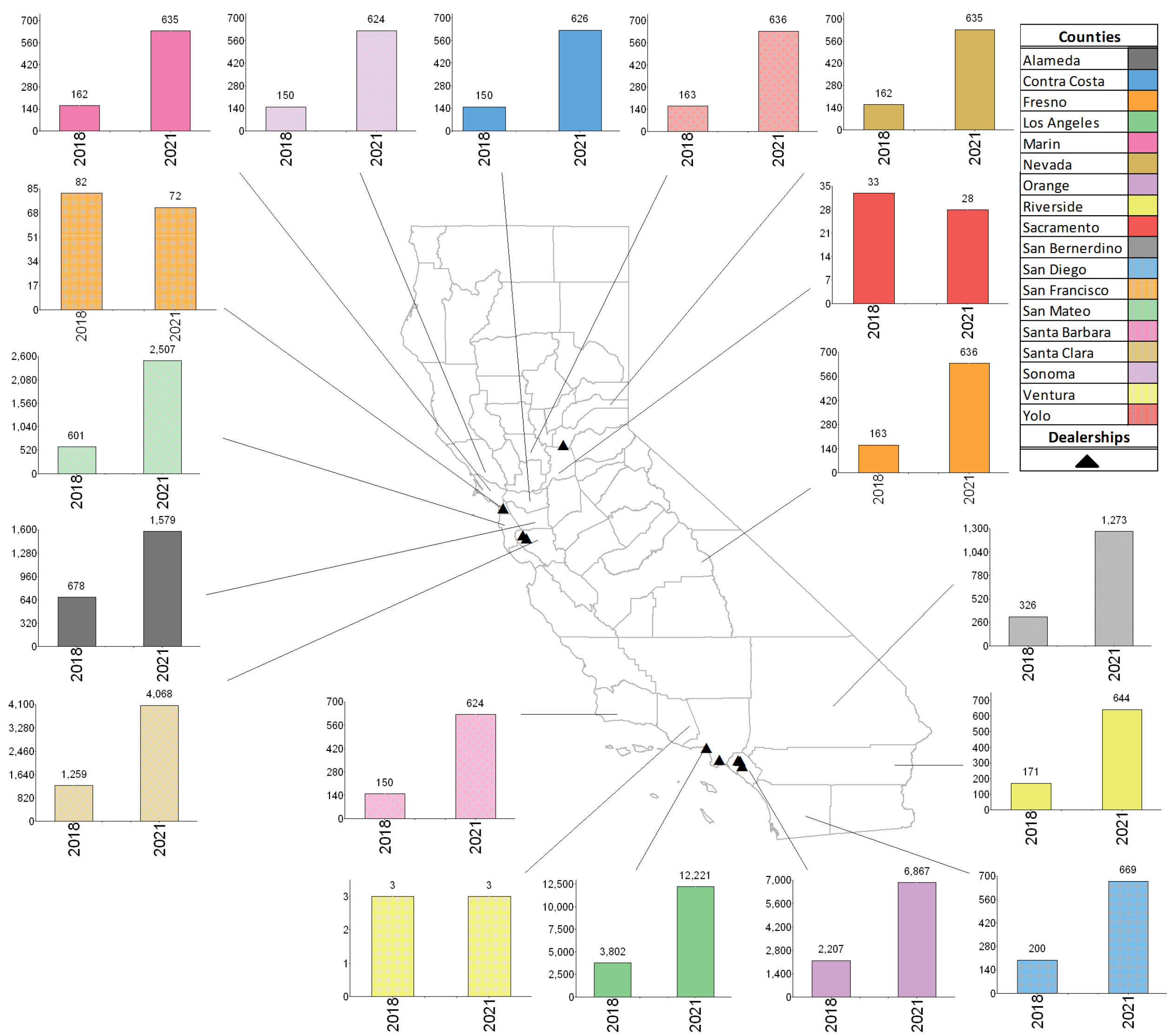


Figure 3 and Figure 4 display the current registered FCEV count and the future on-the-road projections of FCEVs as indicated by the data sources and methods outlined above. To demonstrate regional sources of vehicles, the black triangles in Figure 4 show locations for the known dealerships that currently or will soon offer a FCEV. Figure 3 provides projected cumulative statewide on-the-road FCEV projections and a projection of vehicles that may be placed in the various counties. Figure 4 provides additional detail of the individual county projected FCEV counts in 2018 and 2021 as computed by CHAT; note that the y axis scales in Figure 4 vary by county in order to more clearly display the projected FCEV population.

Vehicle Projections Compared to 2014 Analysis

Compared to registrations at the end of 2013, current registrations have increased by more than 55 vehicles, a gain of 43%. This change represents the aggregate effect of new vehicles (many likely from the launch of Hyundai's Tucson Fuel Cell) and retirement of pre-commercial vehicles.

Through 2018, FCEVs are projected to be concentrated in the Alameda, Los Angeles, Orange, San Mateo, and Santa Clara counties. Only Napa and Solano counties were projected to have zero FCEVs in 2018 or 2021, as neither county currently includes a station and no auto manufacturers indicated they project vehicles located in these counties through 2021. Although the geographical basis is somewhat different from the 2014 analysis, the largest deployment counties in 2018 (Los Angeles and Orange) agree well with the clusters and air districts projected in the 2014 Annual Evaluation to have the most FCEVs.

With the new county based survey, the distribution of vehicles within a region has become more diverse. For example, vehicles previously indicated as generally in the South Coast Air Quality Management District can now be more specifically proportioned to the counties making up that district; namely, Los Angeles, Orange, Riverside, and San Bernardino. The effect is even greater for the Bay Area Air Quality Management District. By contrast, the 2014 Annual Evaluation distributed vehicles by air district to fill a gap where vehicle and station placement did not match the survey geographies.

Results project FCEVs in Sacramento and San Francisco counties decreasing from 2018 to 2021. This is the direct result of input from the auto manufacturer survey and the analysis method of CHAT. This decrease is not expected to materialize because further analysis, described in chapter IV, demonstrates these two counties to have some of the highest priority areas for future FCEV deployment. The decrease shown in Figure 4 is due to CHAT's method of placing vehicles that are not allocated by auto manufacturers (predominantly those in the voluntary reporting period) according to current and planned fueling infrastructure[2]. This artifact of the survey results and CHAT's method of analysis demonstrate the need for a more sophisticated method of determining locations for future FCEV deployment. The new analysis tool, CHIT, addresses this need.

Overall, the number of FCEVs projected to be on the road has increased in both the required and voluntary reporting periods, when compared to the 2014 projections. Figure 5 compares on-the-road FCEV projections for both the 2014 and 2015 Annual Evaluations. Based on the auto manufacturer survey responses, the numbers of FCEVs on the road are projected to grow by more than 60% between 2017 and 2018 and nearly double between 2020 and 2021. Given the current growth rate of approximately 43% the projected increase in growth rate is consistent with a number of possibly contributing factors:

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2 Currently, no stations are built or planned in Sacramento or San Francisco counties, though there are stations in nearby counties. In counties with no stations, CHAT will not project vehicles in later years. Even without stations currently planned within the boundaries of these counties, at least one auto manufacturer indicated vehicle deployment within these counties in the mandatory reporting period. The decreasing on-the-road FCEV projection in Sacramento and San Francisco is due to the assumed vehicle attrition rate and CHAT not projecting unallocated vehicles for counties with no stations.

- Increasing numbers of auto manufacturers will be releasing vehicles as the years progress
- Increasing numbers of stations will become available to support the vehicle deployments
- Rates of deployment may increase as the vehicles gain market acceptance
- Rates of deployment may increase as manufacturers gain experience in marketing the vehicles

The expected growth in vehicles apparent in these county and statewide projections will have significant impact on the analysis of hydrogen capacity balance, as will be discussed in Chapter IV.

Figure 5 also shows when the 2014 and 2015 projections are taken together, the data fit reasonably well to a power function, potentially providing an early indication of the expected growth rate in vehicle deployment. This is further supported in Figure 6 where the data of Figure 5 between the 2014 and 2015 Annual Evaluations have been translated to a presentation of vehicle growth rate as a function of on-the-road vehicles, consistent with a power model and the factors listed above. Such a model would imply that as the FCEV population grows, its growth rate would accelerate; the data shown in the figure exhibit such a trend and the observed fit to a power function is very good. It is likely that the power function growth characteristic will only be valid for a limited duration during the early adopter phase of the FCEV launch; as the market progresses, a more steady trend may eventually develop. Note that the lines connecting data points in Figure 5 and Figure 6 are not to be interpreted as modeled trajectories; they are only included to aide visualization and identification of the potential trend.

Figure 5: Comparison of FCEV On-The-Road Vehicle Counts between the 2014 and 2015 Annual Evaluations

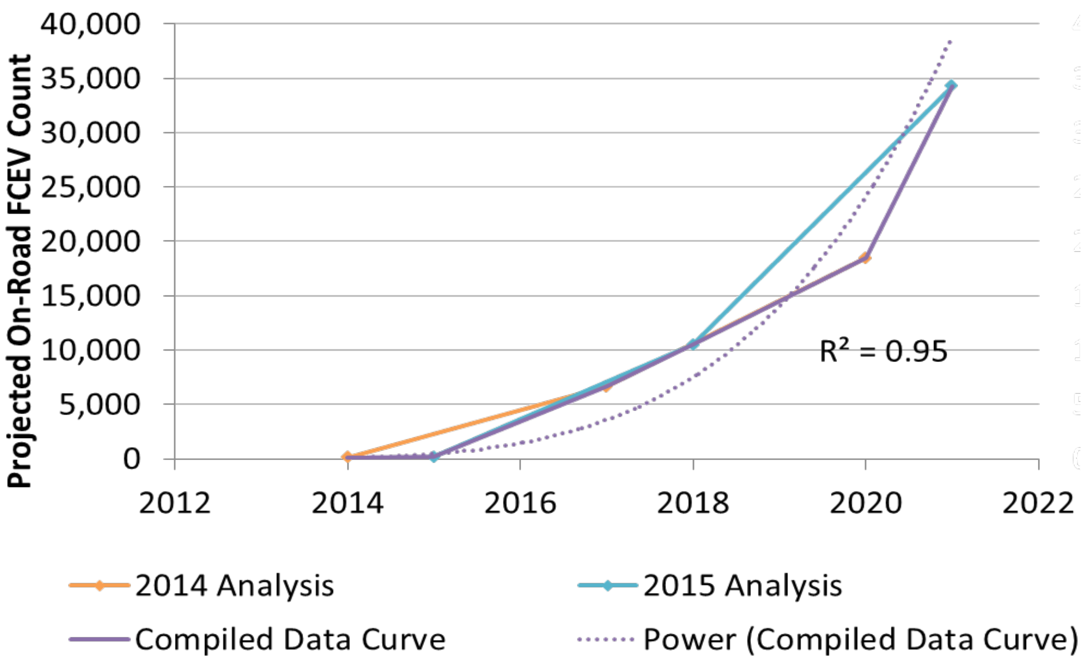
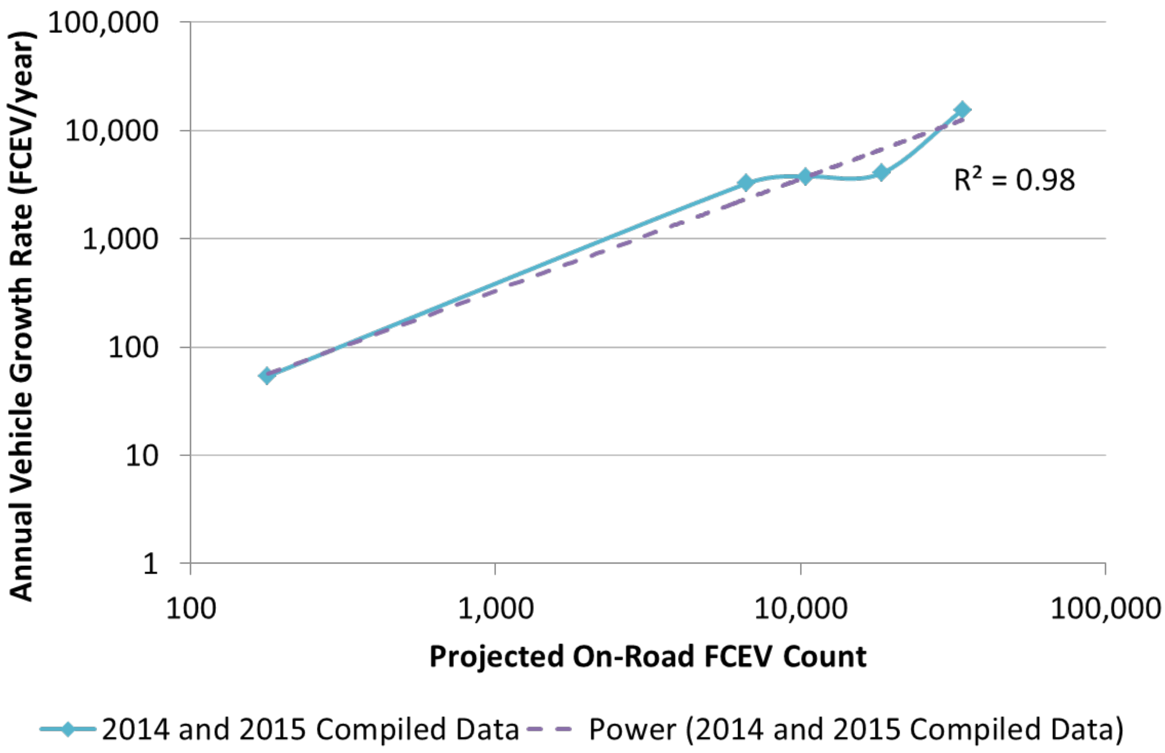


Figure 6: Projected Growth Rate of On-The-Road FCEVs



III: 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

The 2014 Annual Evaluation provided an extensive overview of the concept of coverage. In brief, it is widely recognized that planning for hydrogen fueling station deployment needs to address two key metrics: capacity and coverage. While planning for capacity ensures there will be enough hydrogen available for the vehicles projected to be on the road, planning for coverage ensures that hydrogen fueling stations will be located where they can best serve early market customers. Planning for capacity alone is ineffective if stations are in locations with no potential FCEV customers. In order for drivers to adopt FCEVs and hydrogen as a vehicle fuel they must feel secure there are adequate stations conveniently located to their homes and/or common travel routes. Ensuring proper coverage can help ensure a successful market launch and impact consumer adoption.

Current Operational and Funded Station Coverage

During the past year, station developers awarded in PON 13-607 and prior funding programs have made significant progress toward completing their hydrogen station projects. However, given the early nature of the industry, these projects often encounter unforeseen and unpredictable delays due to any one of a number of potential causes from various sources. Once funding is secured, site specific business agreements, technical specifications ,and architectural designs can be completed. Only then can permitting, community approval, construction, and commissioning begin. Each of these steps towards project completion presents its own challenges and potential for delays. Many of the stations previously projected to be operational in 2014 have been delayed.

In the 2014 Annual Evaluation, particular emphasis was placed on the stations funded in PON 13-607, two months prior to the release of that report. At the time, station projects under that program were still in a pre-development phase, as formal approval by the full commission occurred on July 22, 2014 at a publicly noticed Energy Commission Business Meeting. At the time of release of the 2014 Annual Evaluation, there was not sufficient information to determine individual projections of operational or open date for the 28 funded stations. As a result, station projections in that evaluation assumed all stations would be operational by October 31, 2015, given the significant financial incentive provided in PON 13-607 to be operational by that date.

Over the course of the past year, GO-Biz and the Energy Commission have remained in close contact with station developers and have built a significant knowledge base of their individual progress. This has enabled GO-Biz and the Energy Commission to project station operational dates with increased confidence, and it has become clear that many but not all stations are likely to be operational by October 31, 2015. The analysis presented here therefore shows a slower progression of station deployment than presented in the 2014 Annual Evaluation. However, some developers are showing progress that indicates station development seems to be substantially faster than previous experience suggests and some of the newly funded stations are showing promise of an operational date well in advance of October 31, 2015. The current analysis is simply better informed than in 2014 because the generalized assumption used in last year's analysis was not applicable to all individual stations.

The revised projections of operational stations by county and statewide are shown in Figure 7, with operational dates matching the GO-Biz and Energy Commission data as of May 12, 2015[3] [15]. A detailed view of individual station operational year projections is provided in Figure 8. Note that station counts in Figure 7 represent the full historical record. In Figure 8, only current and future stations expected to provide a retail experience are included; closed and early demonstration and research stations are not displayed.

All analyses related to station availability in the 2015 Annual Evaluation acknowledge the distinction between operational and open status, and present all data in the figures according to operational counts. The definition of the operational date ensures that a station fulfills the technical capability requirements of the funding program, while the open date accounts for additional time for additional auto manufacturer validation testing and endorsement for use by their FCEV customers. These requirements may include additional or extended tests of fill protocol repeatability, back to back fill capability, point of sale operation, and other technical capabilities of the station. The process from operational to open tends to vary with each individual station; however, due to the volumes of stations being deployed in the coming years and the similarity in design of some of these stations, the timing may become more uniform in the near future. California is involved in the development of a number of devices and protocols (most importantly the HFS and HyStEP devices) that will make the process more uniform and accurate in the near future.

Although there is uncertainty inherent to both dates, the additional process to meet the open date requirements is currently still significant and highly variable; using the operational date definition minimized uncertainty and is used in the auto manufacturer surveys. Since station status is aggregated on an annual basis, and many of the projected station operational dates are in the fourth quarter of their respective year, open station counts would be more heavily weighted towards later years than they are presented here. However, open dates are inherently less certain, so the presentation within this evaluation provides more confidence than an analysis based on open dates.

3 The definition of "operational" relies on the requirements set out by the PON under which the Energy Commission funded a given station. For the majority of the stations in the current network, the requirements are therefore defined by PON 13-607, which states:

> *"The operational date is defined as the date by which the station has a hydrogen fuel supply and all station/dispenser components are installed. Further, the station shall have all of the required permits from the local jurisdiction and agency. The station shall also have a completed, successful hydrogen quality test (see Section IV.A.), shall also have successfully fueled one fuel cell vehicle with hydrogen, and shall be open to the public."*

Figure 7: End of Year Station Projections by County and Statewide

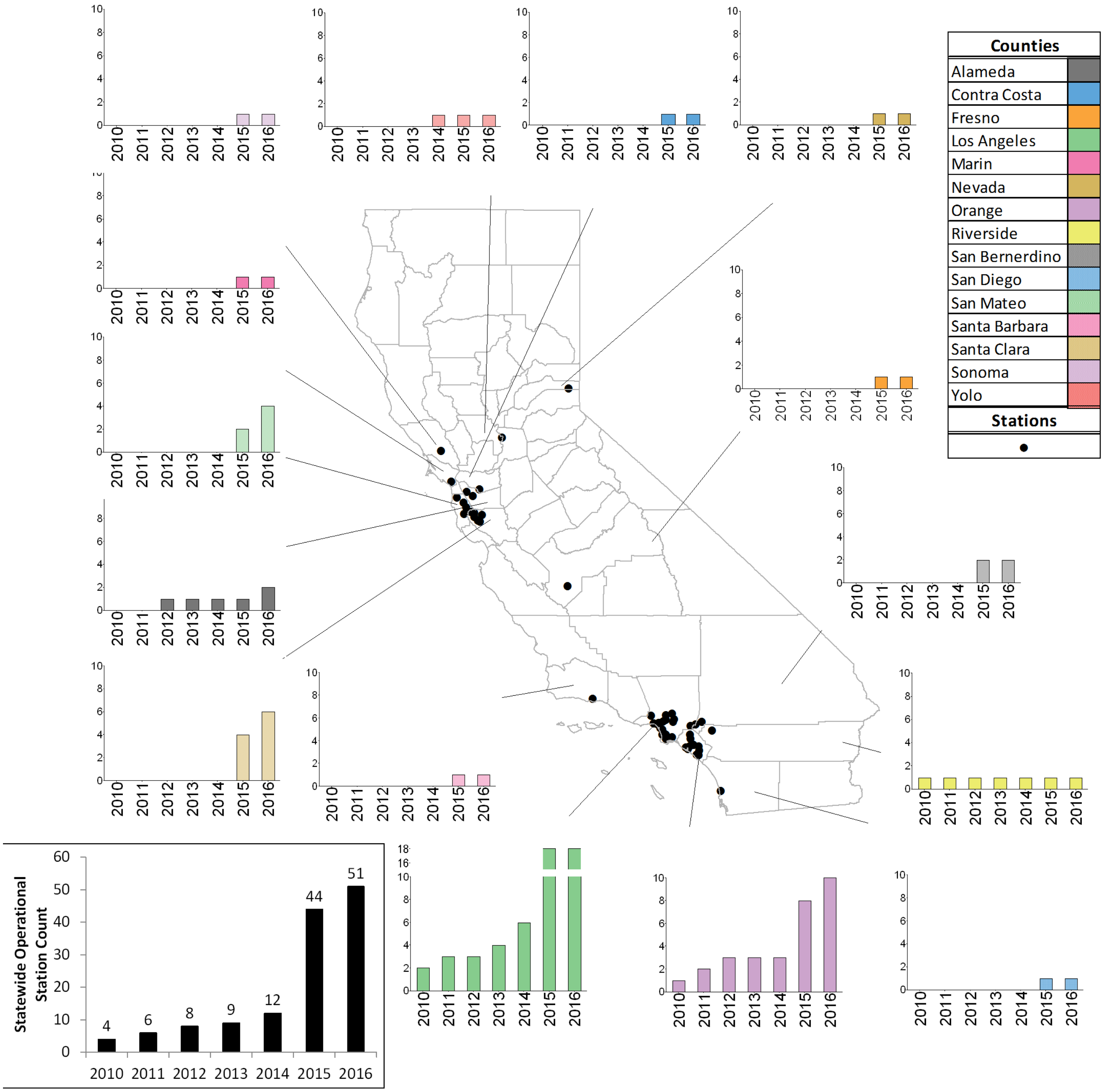


Figure 8: Individual Station Operational Year History and Projections (as of May 2015)

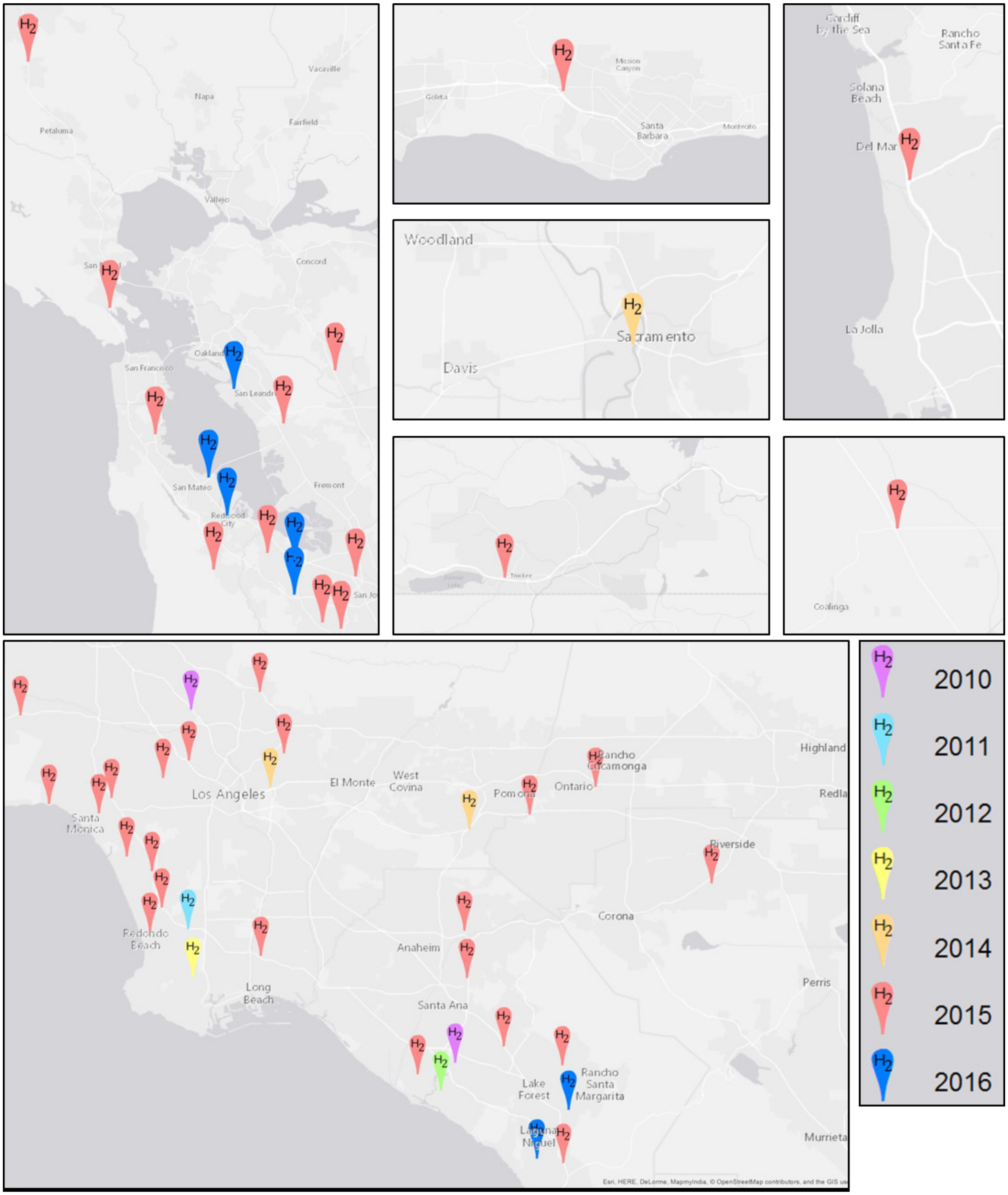


Figure 9: Comparison of Statewide Operational Station Projections between First Annual (2014) and Second Annual (2015) Evaluations

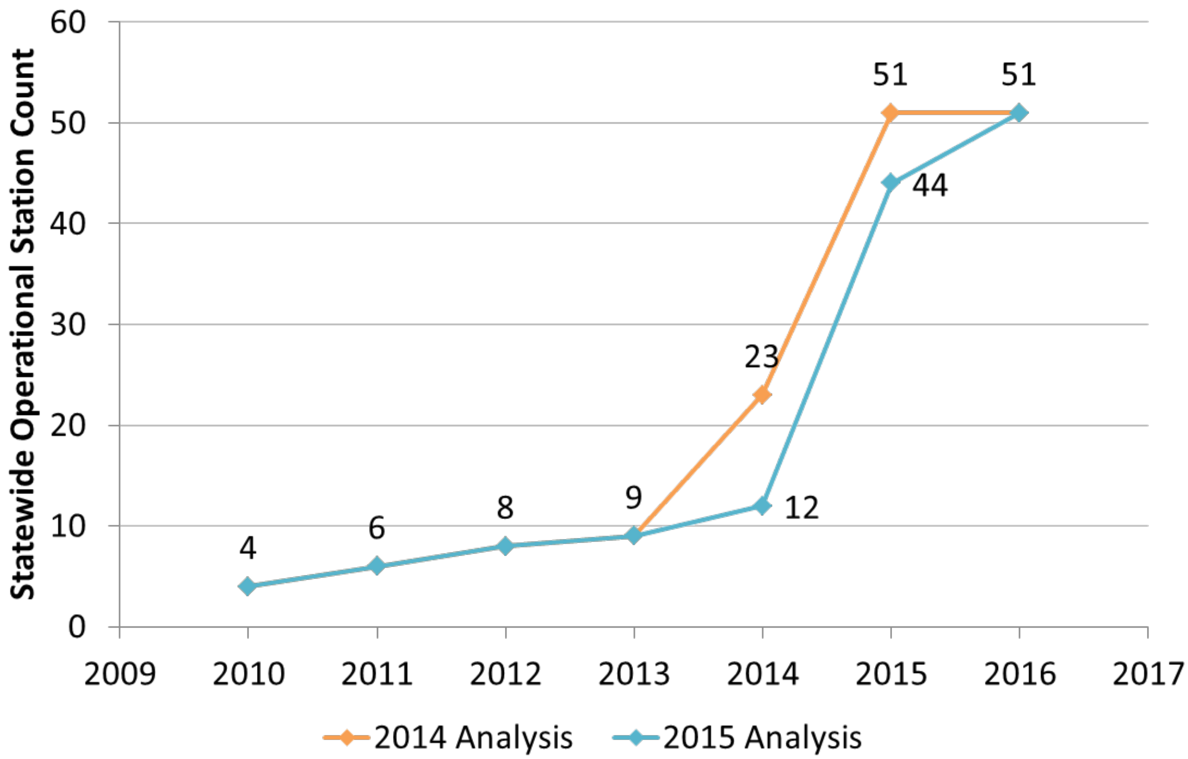


Figure 9 compares the projections from the 2014 Annual Evaluation and 2015 Annual Evaluation. Although this comparison indicates some stations will take longer to become operational than previously projected, all stations are still projected to be complete by 2016; it is the rate of progress between 2013 and 2015 that has been adjusted. Significantly more stations are projected to be operational by the end of 2015 compared to the numbers that were operational at the end of 2014. This significant growth matches well with the step change exhibited in auto manufacturer vehicle projections, immediately following these projected station operational dates. Taken together, these observations corroborate the message that the auto manufacturers plan their vehicle launches closely to expected infrastructure availability, and that stations necessarily precede vehicles in that planning.

Continued Station Deployment Rates

At the time of the 2014 Annual Evaluation, the Energy Commission and ARB estimated an average of 11 stations could potentially be funded each year by the ARFVTP. The Energy Commission has since received a significant number of applications for its provisional O&M grants. These grants are awarded to stations that meet specified operational date criteria. Each O&M grant provides up to $100,000 per year for up to three years. The Energy Commission has adjusted its accounting analysis to set aside an appropriate budget to cover these expected future costs. As a result, subtracting funds allotted to O&M, the 2015 Annual Evaluation estimates an average of seven stations can potentially be cofunded by the ARFVTP each year, assuming that the amount of capital equipment expenditures and O&M funding remain unchanged.

Figure 10: Cumulative Existing, Funded, and Projected Publicly Funded Station Counts

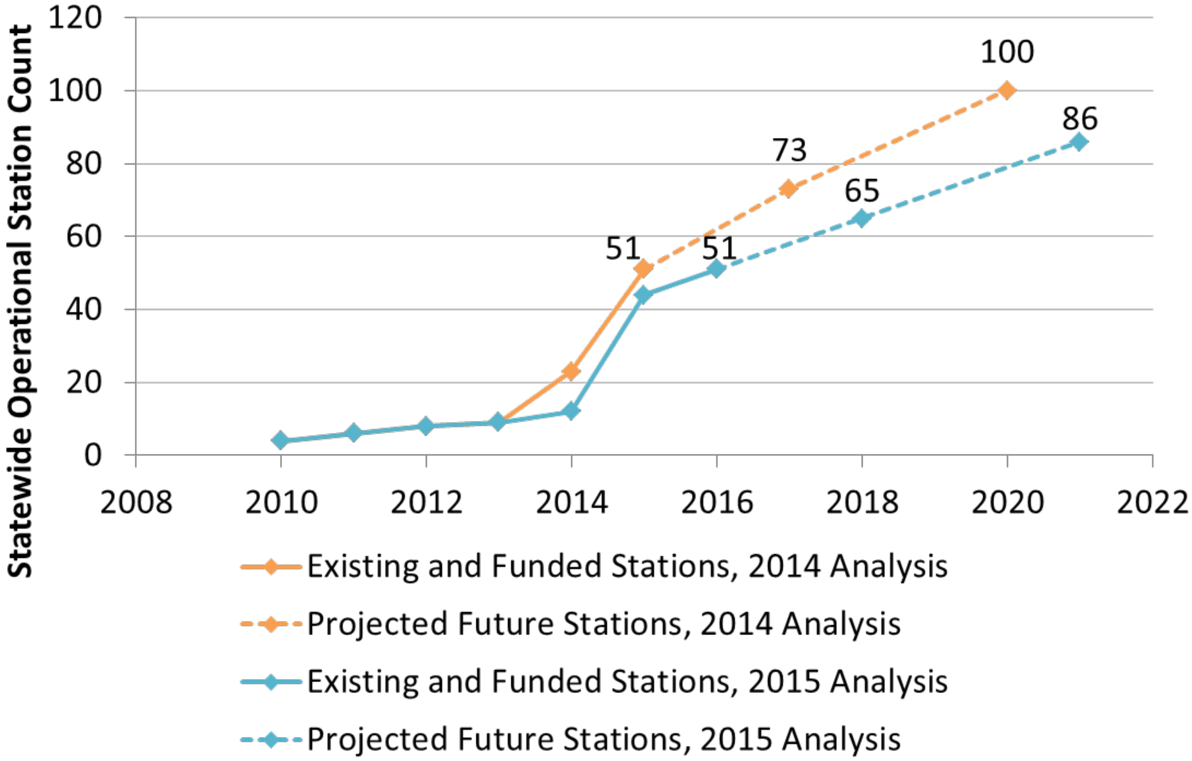
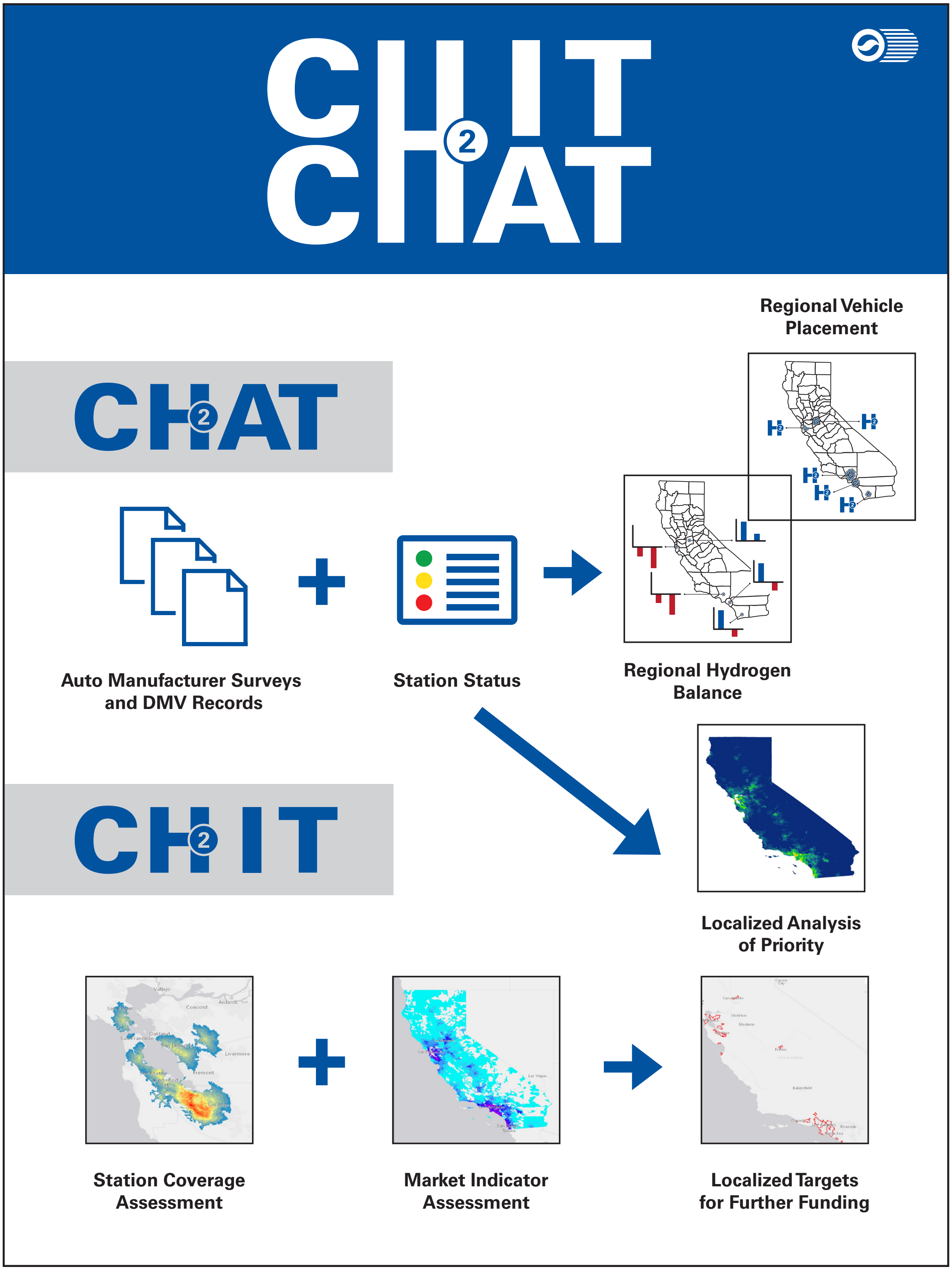


Figure 10 shows the effect of this change on future projections of statewide station counts. AB 8 specifically calls for at least 100 stations to be funded by the ARFVTP; based on projected FCEV demand, the 2014 Annual Evaluation indicated this could be achieved by 2020. With the updated budgetary analysis, the earliest this could be achieved is 2023. However, it should be noted that while the budgetary analysis was modified to account for O&M grants, it remains a conservative estimate by assuming no decrease in costs to the State for each station in the coming years. While it is expected that costs should decline for a similarly designed station of comparable capacity, increased FCEV demand for hydrogen also points to a need for larger stations in the future. Per station costs could therefore remain relatively flat. As the hydrogen station network develops, ARB will update projections for future station growth given evolving budget and station cost information.

Figure 11: Thematic Overview of CHIT/CHAT Tools, Input Data, and Output Goals



Analysis Tool for Future Station Needs

ARB conducted the analyses presented above using CHAT, an ARB developed database tool that performs simple accounting of hydrogen fueling supply, demand, and balance. ARB updated CHAT this year to correlate directly with the county based geography of the auto manufacturer survey. ARB also added a new tool in 2015, CHIT. CHIT is a GIS–based tool intended to complement the capabilities of CHAT and provide further analysis capabilities for ARB's annual evaluations. Figure 11 provides a high level overview of the differences and commonalities between these two tools' data sources and analysis goals. Several motivations guided the development of CHIT:

Finer resolution and less ambiguity in station location recommendations

While the auto manufacturer survey and CHAT utilize county based geographical representation, it is not expected that FCEV deployment and adoption rates will be uniform within each county. Rather, it will be necessary to identify the sub-county and possibly cross-county geographies where FCEVs are most likely to be adopted. While this was achieved at least in part by the previous concept of clusters, the clusters were highly subjective and their boundaries were ambiguous. The use of a GIS-based analysis allows ARB to utilize finer analytical resolution and provide recommended station deployment areas that may be smaller than counties, potentially cross counties, and be presented with a clear, unambiguous definition.

Analyze and understand the projected market

The auto manufacturer surveys and DMV records that inform CHAT analyses are informative for a snapshot of the historical record of the FCEV market development and how the auto manufacturers view the market in the future. However, this provides ARB with a limited view of the potential need for development, as the underlying assumptions behind the auto manufacturer survey responses are confidential and not fully available to the ARB due to the sensitive nature of their competitive analyses and future market plans. In order for ARB to generate complete, informed recommendations, ARB needs in house tools and expertise to understand and assess the potential FCEV market.

Provide area specific analysis capability for long term projections

One shortcoming of the auto manufacturer survey and the analysis methods of CHAT is that the longer term vehicle projections (in this annual evaluation, this includes vehicle deployment projections for the years 2019-2021) do not provide any geographical resolution. ARB allocates vehicles according to county wide station counts when auto manufacturers supply only a statewide projection. This inherently limits the reliability of long term projections of coverage using CHAT. Given the pace of hydrogen infrastructure development combined with the time required for open and public grant solicitations, it is necessary to look beyond a three year planning horizon. CHIT is designed to analyze the potential FCEV market, enabling a longer term projection.

Enable analysis and consideration of State goals associated with hydrogen infrastructure

Responses from the auto manufacturer survey necessarily represent each manufacturer's assessment of how their market knowledge and priorities would dictate their strategy for FCEV deployment in the coming years. This information is vital to ARB as an indicator of the market, given that the auto manufacturers have a deep understanding of the market. However, the auto manufacturers' business related strategies are not the only priorities that the State must consider. Impacts on regional air and water quality, global climate, and environmental justice can play a role in the State's determination of how best to use the funds available to hydrogen fueling stations. ARB may also need to assess the effect of its recommendations, and the eventual station awards, on these types of goals, many of which require fairly detailed geographical resolution. With an in house tool like CHIT, ARB will have the option readily available to complete these types of analyses.

Prioritize and develop suggested schedules for station location recommendations

The analysis methods utilized in CHAT do not provide ARB with a process of assessing which of the areas with projected capacity needs would be more ideal for hydrogen station deployment from the perspective of likely market acceptance. Prioritization with CHAT can only be provided on the basis of regional net hydrogen balances. As mentioned above, this metric is inherently uncertain due to a lack of market information in parts of the auto manufacturer survey. CHIT is intended to allow consideration of likely market acceptance, likely hydrogen consumption (through redistribution of CHAT statewide projections), and refined assessment of the current hydrogen fueling network.

Determine coverage as a factor independent of broad area capacity and assess its interaction with the market projection

Finally, CHAT can only provide a high level assessment of coverage provided by stations, given the county wide geographical resolution of its input data. With CHAT, coverage can only be assessed in terms of whether or not hydrogen fueling capacity exists within an area. It cannot assess how much of a projected market within that area the stations will likely service. Nor can it assess local differences in the convenience provided by the existing and/or planned hydrogen fueling stations. CHIT is designed to allow a much more local assessment of coverage, independent of the net balance of hydrogen within a county.

Overview of CHIT

For the 2015 Annual Evaluation, CHIT has been implemented to refine the analysis provided by CHAT and provide a set of prioritized recommendations for future station deployment areas. An introduction to the designed capabilities, data sources, and outputs is presented here as an overview. ARB will present a full detailed discussion of the tool at a public workshop in the coming months, and will make publicly available a detailed written description.

Although it represents a new tool and analysis capability within ARB, the development of CHIT has relied heavily on observations and guidance from a number of various and sometimes similar tools and studies in the existing literature. Models like STREET developed by the Advanced Power and Energy Program at the University of California, Irvine and the National Renewable Energy Laboratory's (NREL) SERA model, along with the analysis results of researchers like the University of California Davis' Dr. Michael Nicholas and Arizona State University's Michael Kuby provided insight that directed many of the fundamental assumptions and ideas represented within CHIT [9-13].

The concept of coverage is inherent to the analysis methods employed by CHIT/CHAT. Within CHAT, the concept of coverage is analyzed at a high level, providing quick determination of relative coverage between counties. CHAT also addresses the question of capacity at a similarly high geographic level by matching the coverage and capacity specifications of stations to expected vehicle deployment, per the auto manufacturer survey. CHIT addresses the question of coverage in a more localized and explicit way, looking to assess potential factors indicating where the early market might exist based on socioeconomic parameters, comparing this to a measure of coverage provided by existing and potential stations, and finally determining and prioritizing the gaps in current coverage.

Therefore, the goal of CHIT is to estimate the preferred placement of future fueling stations, prioritizing areas according to coverage gaps in areas near the potential adopters. This model of prioritization is intended to enhance vehicle sales through providing early adopters with highly visible, preferably robust and redundant, fueling options in locations convenient to their homes. CHIT does not analyze the need or prioritization for vacation/destination or connector stations; however, these stations are still viewed as vital to the network as a whole. Connector and destination stations are likely to be fewer in number than early adopter coverage stations and are likely to require simpler analyses to determine; thus, their determination is simply left to other methods for now and potential future development in CHIT if deemed necessary.

The analysis routines estimate the location and potential relative intensity of the FCEV ownership market utilizing a number of demographic indicators. Many of the indicators are supplied by the U.S. Census Bureau's American Community Survey, using five year estimates of 2009-2013 vintage. Other information from the Energy Commission, DMV, and ARB internal models and data resources are built into the analysis and assessment routines. These data sources are synthesized and combined to determine a market score, a coverage score, and an overall coverage gap score that combines the two. The market and coverage scores are further broken down into a number of determining factors. CHIT's operation consists of the following major steps:

1. Obtain and spatially represent local demographic data that determine the market score factors.
2. Calculate the existing coverage factor, determined by the currently operational and planned fueling stations and analysis of roadway data. An example is shown in Figure 12.
3. Calculate the potential coverage factor, determined by roadway data and geographical distribution of population, to assess the localized coverage impact of potential future station deployment.
4. Calculate the coverage and market scores, determined by the weighted sum of their respective factors.
5. Calculate the relative local coverage gap score across California as the product of the market score and the coverage score.
6. Utilize the coverage gap score map to determine the contiguous areas of hot spots that are the highest ranking on average in the state; the average score in an area determines its "priority" (though not necessarily the order of station placement).
7. Filter the prioritized areas interactively (for example, enforce requirements of minimum area). Re-rank priority areas as necessary.
8. Utilize the CHAT-determined statewide on-the-road vehicle counts, population data, and the market score map to determine the number of Equivalent Present Average Stations (EPAS) necessary in each prioritized area. An EPAS is a station with fueling capacity equivalent to the current average, or 180 kilograms per day for this analysis.

Roadway data are crucial input for many of the calculation steps in CHIT. In particular, CHIT analyzes roadway speeds (based on an analysis of Municipal Planning Organizations' transportation data and models for peak traffic hours) to determine the physical extent of coverage provided by stations, taking all locations within a specified drive time as served equally by existing station coverage. This analysis is independent of the actual route(s) driven within the coverage areas and defines coverage based on proximity between stations and drivers' homes. Other models have been developed that emphasize route analysis and seek to prioritize station locations based on the likely areas that a majority of the intended vehicle market will drive past on their daily travels [12-13,15]. By this method, determination of needed coverage may instead be defined on the basis of nearness to travel routes instead of the drivers' homes. This type of model has the potential to be more precise and add an extra dimension of information input, but the necessary datasets are typically large, require significant computing power, and may not yet be comprehensive enough to provide a sufficient level of certainty and detail for analysis across the entire state of California. ARB considered this type of model, but determined that development of CHIT should focus on determination of the areas where the close to home stations will need to be placed for the early FCEV adopters.

While ARB plans to use CHIT for all annual evaluations going forward, all eight of the above steps do not necessarily need to be conducted every year. For example, the existing coverage (step two) only needs to be recalculated when new stations are funded or stations (semi-)permanently change their operational status. The demographic data (step one) that inform the market factors also don't necessarily need to be updated every year; rather, they should be evaluated on a periodic basis to ensure data continue to accurately represent the population. Thus, it is likely that only steps five through eight will need to be carried out every year going forward.

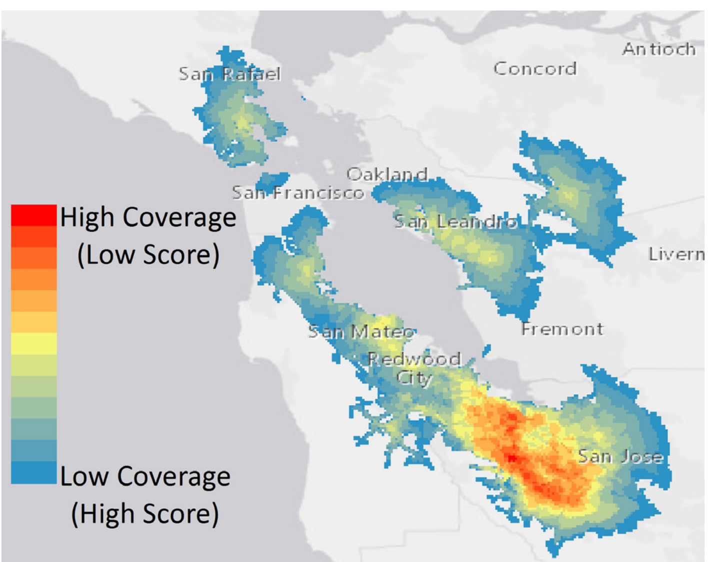
This implementation process implies that each year, a new set of prioritized station placement areas will need to be calculated. This may be due to improving knowledge from year to year. However, it will also be necessary to complete this evaluation process every year to assess the network effect of newly funded stations from annual Energy Commission funding cycles. ARB developed CHIT with a secondary goal of providing scenario evaluation capability in order to assess the potential network effect of its own suggested areas and potentially of proposed locations from funding program applications or other sources of information.

Further details of the individual market and coverage factors, calculation methods, evaluation assumptions, and the overall evaluation process will be provided in workshops and documentation for full public access.

Determination of Prioritized Areas with CHIT

For this 2015 Annual Evaluation, ARB has followed the eight steps of the CHIT evaluation process, utilizing a set of reasonable and standard input assumptions to inform recommended future station locations. The 2014 Annual Evaluation recommended future station locations based on CHAT alone, and these were more general than the evaluation provided by CHIT. Note there have been no new stations awarded since the 2014 Annual Evaluation.

Figure 12: Evaluation of Coverage provided by Existing Stations in Bay Area (Areas without Coverage have No Color and Score Highest)



This chapter provides outputs of steps in the CHIT process along with the final evaluation to demonstrate the capabilities and key results of implementing CHIT. Figure 12 provides a sample of the evaluation of existing coverage in the Bay Area. The evaluation represents an assessment of the coverage provided by the multiple stations in the area. The algorithm for this assessment provides a way of measuring the coverage provided by a multitude of stations at various distances (defined as time to drive to the stations) from a given point. For example, a neighborhood within a 3 minute drive time of two stations would be considered to have more coverage than a neighborhood only within a 15 minute drive time of a single station. In Figure 12, red indicates a higher coverage, blue a lower coverage, and areas with no coloration have no coverage provided by existing stations. In evaluation of the coverage score, areas with high coverage are assigned a lower value than those with little or no coverage. This existing coverage factor represents one half of the coverage score that partially determines the final coverage gap score.

Figure 13: Evaluation of State of California's FCEV Early Adopter Market Indicators and Existing Coverage

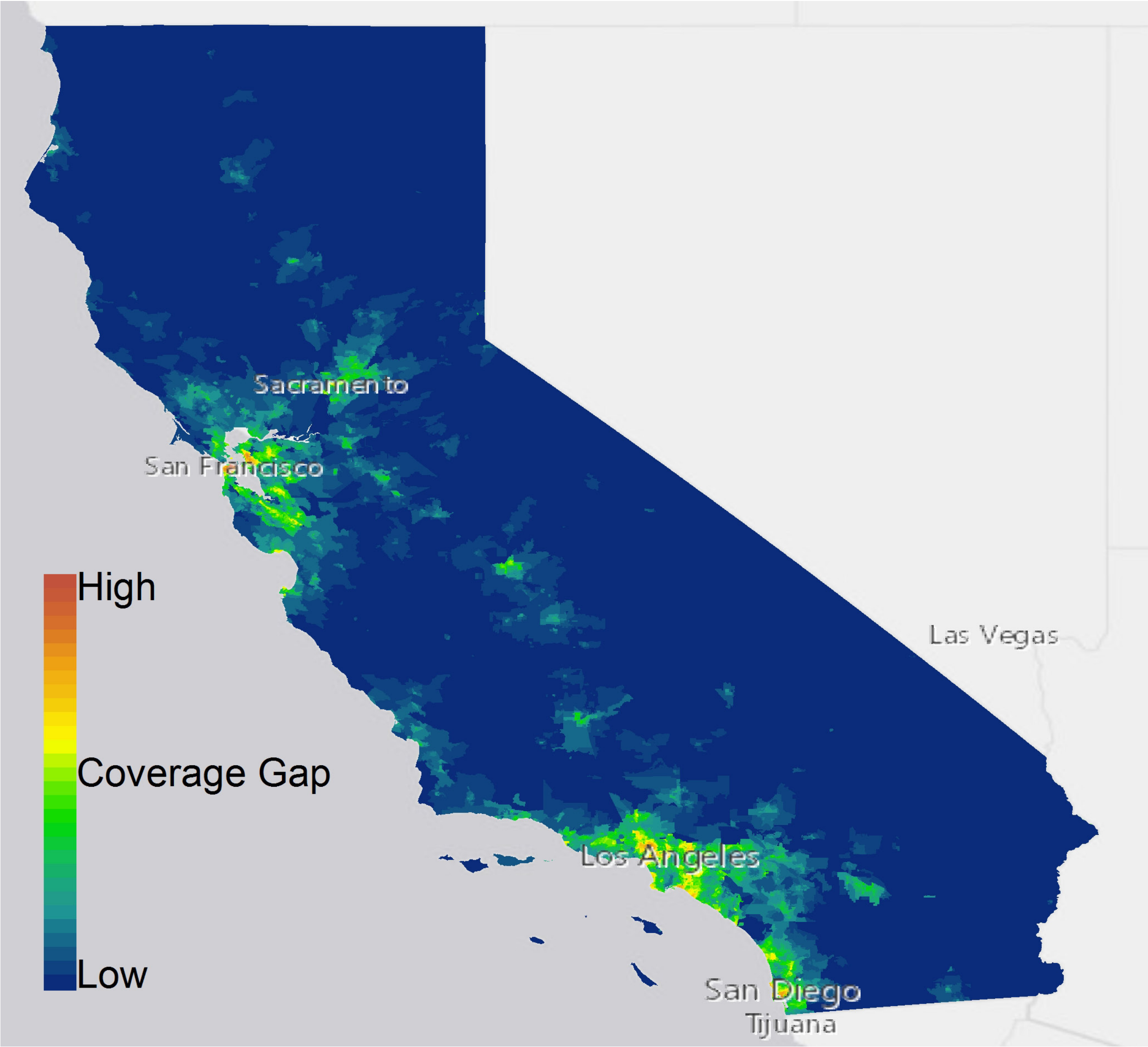


Figure 13 depicts the statewide determination of the coverage gap score. In the figure, dark blue is a very low score, and bright red is a very high score. The coverage gap score is the result of considering the likely market and the existing and potential for market coverage together. It should be noted that the score shown in this map is fundamentally intended to represent the desirability of fueling station location to serve a local residential market of FCEV early adopters. Locations that would be good candidates for connector or destination stations will not appear in this figure with a very high score unless those locations also have a high score under the local neighborhood coverage paradigm. Given that Figure 13 represents a gap analysis between the existing coverage and the estimated FCEV market, some high priority markets actually score low because they also have a correspondingly high existing coverage. Figure 13 should not be interpreted as displaying all the areas likely to have high FCEV adoption rates.

The map presented in Figure 13 is the result of CHIT analysis steps 1-5 described previously. In order to utilize the map to provide recommendations of areas to prioritize station deployment, steps 6-8 were also implemented. The goal of these steps is to analyze the distribution of coverage gap score across the state, and determine the areas that significantly demonstrate the greatest need for new stations. Once these areas are identified, they are compared to each other based on their average coverage gap score and prioritized accordingly. The areas that have the greatest demonstrated need for coverage are assigned the highest priority. Finally, the average market score and the population contained within each area form the basis of redistribution of the CHAT-determined annual statewide FCEV deployment. With this estimate of the number of FCEVs assigned to a priority area, and an estimate of coverage from existing stations (keeping in mind that an area with high coverage can still have a high coverage gap score if the projected market is large enough), a hydrogen balance can be calculated for the area and the number of stations determined with basic assumptions.

The method of identifying the highest scoring areas incorporates a statistical analysis method that identifies areas with scores that stand out above the background of scores in neighboring regions (e.g. "hot spots"). The method also allows for consideration of variation of the coverage gap score within the priority areas that are identified. A priority area may have interior neighborhoods that present a greater gap in coverage than other neighborhoods also within the priority area. Though there is variation between these interior neighborhoods, the analysis will consider them as part of the same priority area if they all still score significantly higher than the neighborhoods outside of the priority area and are statistically indistinguishable from one another when all neighborhoods interior to the priority area are considered together.

By the analysis methods and formulation of CHIT, it does appear that the San Diego area, which was previously reported as a region that could be classified as both early adopter and destination, is a high priority early adopter region. It seems even clearer in this year's analysis that the San Diego area is a high priority for developing an early market. Also, the 2014 Annual Evaluation suggested that the Berkeley area was a high priority for fueling station deployment, and this conclusion is echoed in the results provided by CHIT, with Berkeley contained in the second highest priority area. New to the results this year is the San Francisco area, which has a significantly higher priority than the previous evaluation estimated.

It should be noted that a number of the areas determined by the CHIT process are outside of the areas where stations have been funded. This does not mean that the existing and funded stations are in areas that are not considered to be a priority. Rather, CHIT is designed specifically to avoid identifying areas where existing and funded stations already provide sufficient coverage of the projected market. Therefore, these areas may not appear as high priority from the CHIT analysis. Additionally, some of the funded stations are connector or destination stations, which cannot be addressed by the analysis methods developed for CHIT so far. A further more detailed explanation of processes and outputs of the CHIT analysis and mapping tool will be presented in future workshops.

Suggested Station Counts and Locations for Next Funding Program

Considering the information provided by the output of the CHIT/CHAT tools, last year's analysis, and working knowledge of the activities in the past year, ARB has developed a slightly revised list of recommended station location priorities and numbers of potential stations or hydrogen capacity in that area for the next hydrogen station grant programs from the Energy Commission. Since the analysis of CHIT assigned high priority ranks to many of the areas described in last year's recommendations, the revisions in this year's assessment are few.

Table 1 provides the list of suggested areas along with the recommended number of stations and the conceptual need that will be filled by the station. The list further categorizes areas into First Priority for market development and/or expansion, Additional Priority areas that present opportunities for market establishment or growth, and a pair of high priority Connector stations. In total, 26 priority areas are defined with 37 stations suggested for this set of areas, in addition to the two connector station areas. The two connector stations are directly adopted from auto manufacturer recommendations published by the CaFCP [17]. Twenty-six of the market area stations are located in the First Priority set. Given the previous discussion, these station area and number recommendations are not meant to be viewed as a suggestion for a single grant program. Rather, the set listed in Table 1 is provided to allow for flexibility in designing future grant programs and to provide the Energy Commission, ARB, and other State agencies a longer term proposal to discuss and develop in the following years. Definitions for the Purpose of each station are as follows:

Establish Core Market

The area is known from ARB analysis and outside information to have the highest potentials for early market adoption of FCEVs. However, the area does not yet have any fueling station coverage, and so the fueling market must be established.

Expand Core Market Coverage

The area is known from ARB analysis and outside information to have the highest potentials for early market adoption of FCEVs. Some coverage within the market currently exists or is planned, but the area requires further augmentation of that coverage.

Core Market Capacity

The area is known from ARB analysis and outside information to have the highest potentials for early market adoption of FCEVs. Coverage exists within the market; more may be helpful, but the core market is projected to also face a challenge with capacity that should additionally be emphasized.

Future Market

The ARB analysis indicates this area has a high potential for early market adoption of FCEVs, though it is not amongst the highest. Additionally, there may be outside indications that this area could be a significant market that develops once significant infrastructure exists in the core markets. However, these indications are typically not as strong as for the core markets.

Connector

A station in this area could provide fueling service for FCEV drivers travelling long distances between core and/or future markets. These stations maximize the utility of FCEV's 300+ mile driving range by providing sufficient fueling opportunity to drivers on routes longer than 300 miles.

Destination (not listed)

These stations are sited in areas anticipated to be desirable vacation, recreation, or other types of destination locations frequently reached by automobile. Stations in these locations ensure sufficient fueling opportunity on the drives to and from the destination location and during the FCEV drivers' stay at the destination location.

The station count provided within each priority area is based on the assumption that average station capacity remains at the current average of 180 kilograms per day. If larger stations are built in an area, then fewer stations may be necessary than indicated in the list. However, coverage of the area will still be a priority, and CHIT may be used to aid the State's decision process if presented with options between larger and smaller capacity stations for a given area. The number of stations presented for each area is a target over multiple funding cycles. While the prioritization indicates which areas may need to be addressed first, the full station count indicated does not need to be addressed all at once. For example, ARB has not determined that six stations must be built in the San Francisco area before all others. Rather, the equivalent of six 180 kg/day stations should be built in San Francisco over a number of years alongside the remaining stations listed. However, San Francisco should likely receive highest consideration to ensure that it is one of the first areas to receive a new station.

The Palo Alto/Mountain View/Cupertino/Campbell area is listed as requiring zero stations. The evaluation behind the list of priorities looks out beyond even the 37 stations listed in the priority areas and projects the number of stations that may be needed to meet demand each year from 2016 to 2021, based on statewide on-the-road vehicle counts determined by CHAT. Table 1 lists the full set of areas that were identified by CHIT, but limits the suggested number of stations to a subset in the earliest years. Thus, the Palo Alto etc., area is projected to have a need for additional stations, but that need will not be as imminent as calculated for the other regions.

Finally, the function and design of the analysis that leads to the list of suggested priority areas and station counts is dependent on known (existing and planned) infrastructure. This makes the evaluation dynamic, requiring reevaluation each year as more stations are awarded and built or planned stations are relocated. While the list present in Table 1 represents a target set of stations, it is possible that stations outside of this set will be developed, either through State grants or private funding. The coverage provided by those future stations will alter the analysis and provide results that vary from those presented in this 2015 Annual Evaluation.
Future recommendations may be expected to vary somewhat from those presented here.

Table 1: Working Recommendations for Station Funding in Future Hydrogen Fueling Infrastructure Grant Program(s)

		Area	Stations	Purpose
First Priority	1	San Francisco	6	Establish Core Market
	2	Berkeley/Oakland/Walnut Creek/ Pleasant Hill	3	Establish Core Market
	3	San Diego/La Mesa	3	Expand Core Market Coverage
	4	Greater Los Angeles/Sherman Oaks/Granada Hills/Glendale	3	Core Market Capacity
	5	South San Diego/Coronado	1	Expand Core Market Coverage
	6	Torrance/Palos Verdes/Manhattan Beach/Redondo Beach	1	Core Market Capacity
	7	Pasadena/San Gabriel/Arcadia	1	Expand Core Market Coverage
	8	Long Beach/Huntington Beach/Buena Park/Fullerton	2	Expand Core Market Coverage
	9	Santa Cruz	1	Future Market
	10	Encinitas/Carlsbad	1	Connector/Future Market
	11	Fremont	1	Future Market
	12	Sacramento/Land Park	1	Expand Core Market Coverage
	13	Sacramento/Carmichael	1	Expand Core Market Coverage
	14	Thousand Oaks	1	Future Market
Additional Priority	15	Monterey/Pacific Grove	1	Future Market
	16	Carmel-by-the-Sea	1	Future Market
	17	Oxnard	1	Future Market
	18	Palo Alto/Mountain View/Cupertino/Campbell	0*	Core Market Capacity
	19	Poway/Rancho Santa Fe	1	Future Market
	20	San Clemente	1	Expand Core Market Coverage
	21	Santa Clarita	1	Connector/Future Market
	22	San Rafael	1	Future Market
	23	Fresno	1	Connector/Future Market
	24	Laguna Beach	1	Expand Core Market Coverage
	25	Pleasonton	1	Future Market
	26	Southeast San Jose	1	Future Market
Connector	27	Lebec	1	Support Existing I-5 Connector
	28	Los Banos	1	Support Existing I-5 Connector

* High market priority but may not need additional stations in next grant program.

IV: 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.

While station location remains a vitally important aspect of planning hydrogen fueling stations, ultimate success of FCEV adoption will also require sufficient refueling capacity is well planned throughout the state. Figure 14 shows the most recent information for the historical and projected fueling capacity by county and statewide. The capacities shown in the figure are informed by the most recent available information on projected station operational dates discussed previously and the updated projection of station grants available in future State funding opportunities. As in the 2014 Annual Evaluation, all projected future stations have been assumed to have a capacity equal to the current average of State co-funded stations, 180 kilograms per day.

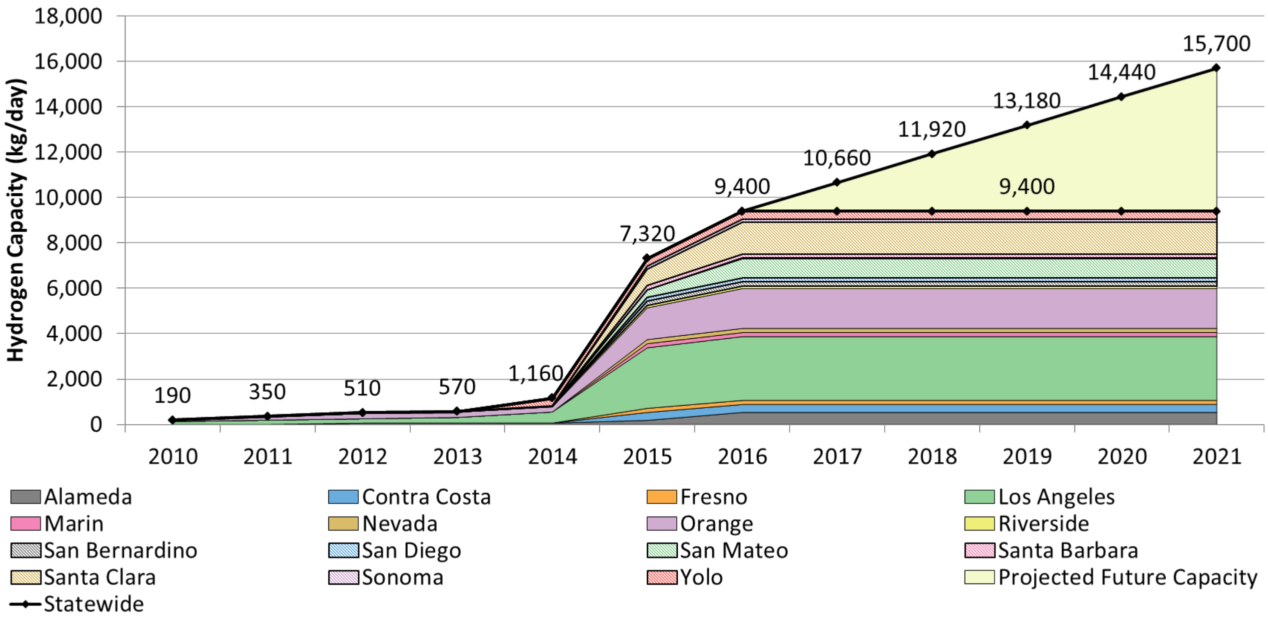
Projections are only carried out to 2021, as that is the latest year for which vehicle projections are also available and a capacity balance can be assessed. However, AB 8 provides for at least 100 stations to be funded through the ARFVTP. This analysis is based on the expectation that 86 stations will be funded by 2021, assuming current station technology, costs and State funding structures remain unchanged. Thus, the capacity and hydrogen balance projections shown in the 2015 Annual Evaluation likely do not extend to the full life of the ARFVTP program and AB 8 funding of hydrogen fueling infrastructure.

The major changes between the 2014 and 2015 Annual Evaluations are:

1. Updated station operational dates for stations currently funded and under development
2. Updated number of projected future stations funded in ARFVTP annual grant programs

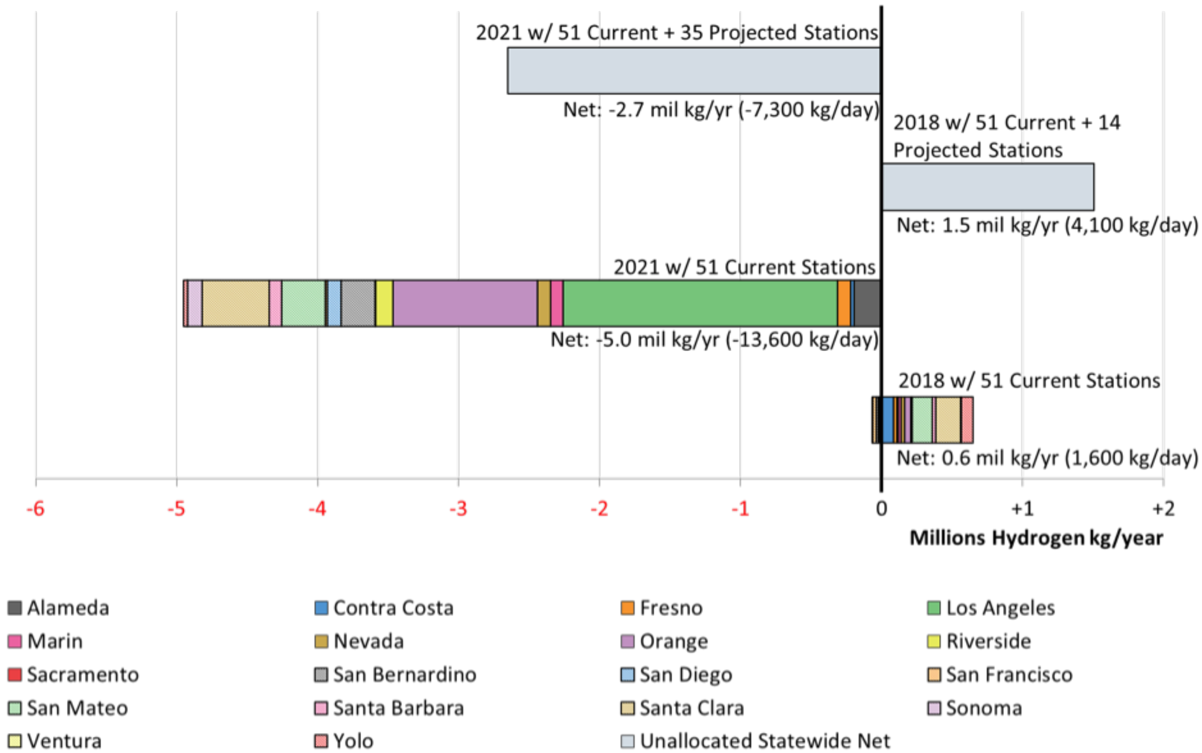
Neither the capacities of fueling stations currently in development or projected for the future have changed between evaluations; only the timing and number have changed.

Figure 14: Statewide and By County Hydrogen Fueling Capacity



Taking the updated hydrogen fueling capacity projections together with the updated vehicle release projections provides for a much different assessment of the hydrogen fueling balance than in 2014. Figure 15 provides the assessment of net hydrogen capacity in 2018 and 2021. In the figure, any county on the left of the y axis represents a county where there is projected to be insufficient hydrogen capacity to meet the needs of the vehicles on the road. Any county to the right of the axis will have sufficient hydrogen fueling capacity for the projected vehicles. The statewide balance is indicated by the net difference between counties on either side of the axis. To aide interpretation of the figure, statewide net balances are provided with each bar, in terms of millions of kilograms per year and kilograms per day. As in the 2014 Annual Evaluation, two scenarios are presented: hydrogen capacity limited only to currently built and/or funded stations and hydrogen capacity including continued funding of seven stations per year. For the scenario including future station funding, the capacity has been unallocated and only the statewide net capacity is shown, since it is not yet known where the additional capacity will ultimately be placed in the coming years.

Figure 15: Estimated Balance of Hydrogen Fueling Capacity by County and Statewide in 2018 and 2021



In the 2014 Annual Evaluation, the assessment of hydrogen net balance demonstrated that near term hydrogen fueling supply could meet demand on both the local (cluster) and statewide scales. However, future hydrogen fueling capacity was shown to only be able to meet projected demand with the continual addition of fueling stations. With the updated information forming this 2015 Annual Evaluation and the assumption that future growth of the station network follows the current State funding structure, the data of Figure 15 portray a much different future scenario. First, although there is projected to be sufficient hydrogen fueling capacity statewide in the near term (with or without additional funding programs in the future), a handful of counties will be unable to meet the demand of their projected vehicles. These counties include Santa Clara, San Mateo, Orange, Ventura, and Nevada.

Some of these counties do have very small negative balances and others may not exhibit as much shortfall as projected; for example, Nevada County is home to the Truckee station, which is envisioned as a destination station. The usage profile at the Truckee station is likely to be fundamentally more intermittent and characterized by a single significant weekend peak than stations in more urban areas like Los Angeles. The analysis methods utilized in this evaluation are not sensitive to that distinction and are therefore conservative (erring on the side of projecting more need) in cases like Truckee. In other cases, vehicles that are eventually placed in locations like Ventura County may be near the border with another county with capacity that could serve that area (like Los Angeles County in the case of Ventura); again, the analysis method in this evaluation does not account for this type of usage pattern.

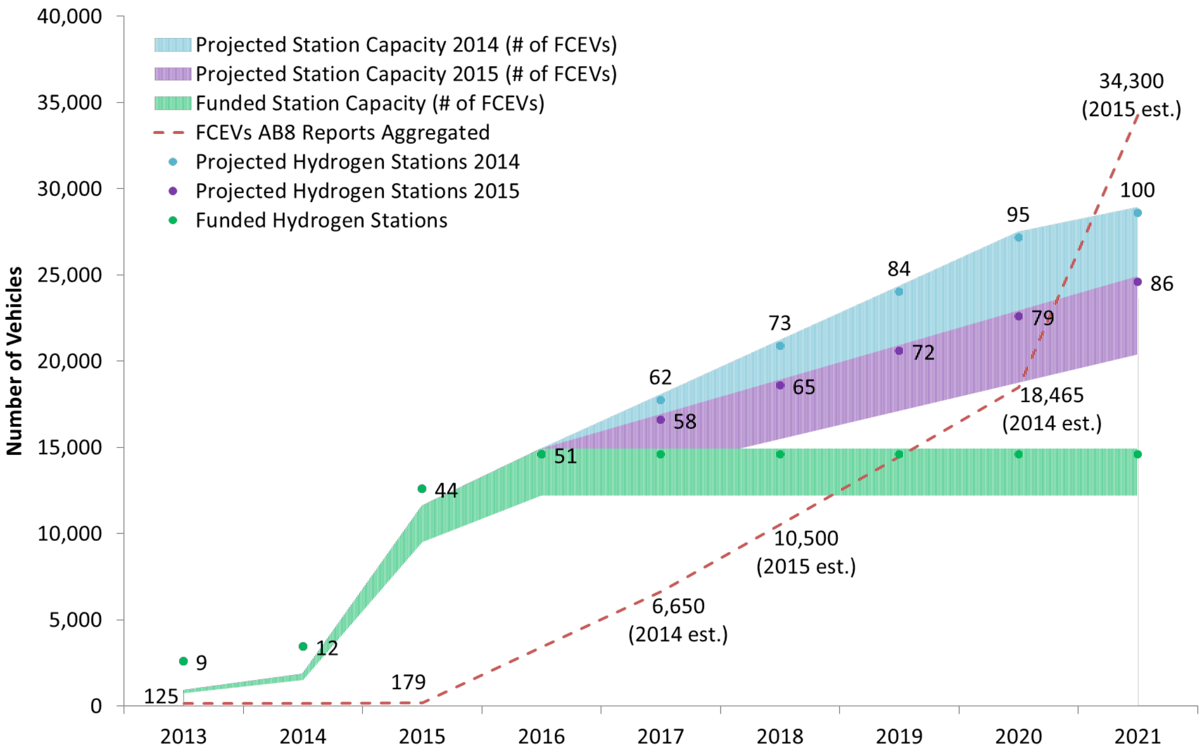
Although the near term analysis includes inherent uncertainties for the locally assigned hydrogen balances, the long term analysis presents a much larger imbalance even on the local scale that likely outweighs the uncertainty. As shown in Figure 15, without any further investment in hydrogen fueling stations, the statewide imbalance would be large, with a shortfall of 13,600 kilograms per day of capacity. Including the projected stations out to 2021, there is still a statewide shortfall of more than 7,000 kilograms per day. Moreover, there are very large deficits in the individual counties, especially Orange and Los Angeles. Of course, some of the projected capacity can fill much of the local needs in these two counties, but it is worth noting that it cannot satisfy all the unanswered demand in Los Angeles and Orange Counties, and there are numerous other counties with significant shortfall in 2021 as well.

With the updated analysis of this 2015 Annual Evaluation, it appears that continued funding in hydrogen fueling stations is necessary, but current projections for State funded infrastructure will not be sufficient to keep up with the coming demand from FCEV drivers. One potential solution would be to increase the minimum hydrogen capacity required for all future State grant programs. However, note that the shortfall even with 35 projected stations is roughly equivalent to an additional forty 180 kilogram per day stations. Thus, funding programs beginning in 2016 would essentially need to require a minimum hydrogen fueling capacity of 390 kilograms per day in order to sufficiently address the need. While long term analyses typically point to larger stations as being more profitable, it is not yet certain that many station developers would have sufficient access to resources to build stations of this size on a regular basis. Additionally, it is not yet known if the entire supply chain has the volume capacity for this magnitude of station equipment orders. A potential alternative may be to utilize varying minimum capacity requirements in future funding programs. For example, stations in Los Angeles and Orange Counties may be required to have a greater fueling capacity, or be able to demonstrate a viable path of expansion to high capacity, than stations in other areas, given the large projected shortfall and the (comparatively) greater coverage provided by stations in this region compared to other counties.

Another potential interpretation of the data presented in Figure 15 is that the projected shortfall indicates an opportunity for substantial private investment in station development. AB 8 and the ARFVTP are intended to ensure that the initial rollout of FCEVs is supported by a sufficient early network of stations, which was defined as at least 100 stations. However, the projected rate of deployment may outpace the State's prescribed rate of investment. The State will still provide the necessary backbone of needed infrastructure, but it may be the case that additional opportunities beyond the initial network are beginning to present themselves. As noted, at current fueling station daily capacities the State would essentially need to double the number of hydrogen stations developed annually for the next five years. In order to achieve this, either costs would need to be cut in half by next year (not a feasible solution) or another source of funding would need to be accessed as a financial resource for the remaining station need. AB 8 places an upper limit on the funds that can be put towards hydrogen fueling stations, all of which is already assumed in the projections presented in this evaluation. Therefore, there may be a need for outside funds to supplement what is already accounted for in this analysis. That need for infrastructure could present an investment opportunity given the projected acceleration of FCEV deployment.

Figure 16 displays the need for additional resources to deploy hydrogen fueling stations out to 2021. In the figure, points show counts of stations, the dotted red line shows auto manufacturer survey based vehicle projections, and the shaded regions show estimates of the number of vehicles that can be served by the corresponding station counts. For these regions, a small band of uncertainty in average daily fuel consumption is built into the calculation. The green shaded area depicts the demand that can be met by currently built and funded stations; it is clear that somewhere between 2018 and 2019 and thereafter, these stations will not be able to meet demand alone. This conclusion reflects the previous estimate described in the 2014 Annual Evaluation. However with updated information, even with continued funding through ARFVTP, the purple shaded region shows that fueling capacity may be insufficient sometime between 2020 and 2021. In the 2014 Annual Evaluation, this was not the case. Moreover, the blue shaded region shows that even if the structure of funding opportunities for the ARFVTP were adjusted such that 100 stations were built by 2021 (similar to the 2014 Annual Evaluation's scenario), there would still be insufficient supply to meet all of the projected demand.

Figure 16: Need for Continued Station Investments and Increased Average Capacity to Support Future FCEV Fleet, Given Business as Usual Assumptions in State Incentive Programs



This last point underscores the magnitude of the need for additional financial resources to fund supporting infrastructure for FCEV launches out to 2021. Unless capital equipment and construction costs per kilogram of installed daily fueling capacity significantly decrease over the next few years, there will be a gap of at least 5,100 kg per day of fueling capacity. The gap is approximately equivalent to 3,500 FCEVs' worth of daily fuel. Even in this scenario of accelerated State funding, there exists an opportunity for 28 180-kilogram per day stations to be built through private investment or additional State funding. If this projected demand were to be met only with 31 additional stations co-funded by the State, all of those stations would need to have a capacity of at least 390 kilograms per day, a size not yet seen and far from the typical design. If the State were able to adjust the funding program (perhaps due to declining costs per station), such that 100 stations were built by 2021, the average capacity of all new stations would be 280 kilograms per day, still above the current average capacity but within the range of station capacities witnessed to date. Adjustment of the funding program structure may enable the State to better incentivize cutting edge station designs and more completely ensure that projected growth in demand is met with corresponding growth in fueling capacity.

Given these considerations, it is clear from the analysis that stations with a higher daily throughput capacity need to become the norm for funding programs going forward, especially in areas with the greatest anticipated need. However, these insights also have implications for strategies that should be pursued in funding station upgrades. The first is that the State will need to make available as much funding potential as possible for expanding the coverage of the existing network. Funding of station upgrades may need to follow a different structure than the approach for funding new stations. AB 8 provides the Energy Commission with flexibility in the financial structuring of its incentive programs; concepts like no cost and zero interest short term loans or loan guarantees may present attractive options for upgrading stations. In this way, the Energy Commission can over the long term maintain a maximum amount of funds dedicated to new station development but also provide relief in the short term to existing stations looking to increase their role in the network.

If the Energy Commission funds larger new stations (or stations with strong potential to expand) from the outset, the stations may have a more favorable business case compared to a smaller station. A higher capacity allows higher throughput and potentially higher gross revenue; this could in turn lead to a shorter time until the station operation can self-fund an expansion. The ideal situation would be for Energy Commission grant programs to help station developers and owner/operators address the upfront costs of entering the hydrogen fueling market, while avoiding the need for O&M support or cost share of an expansion. The viability of this model would be highly dependent on local FCEV market adoption, so there may need to be some assessment on a case by case basis to determine whether Energy Commission funds for a larger station could be maximally utilized towards the goal of kick starting a station project that will have a high chance of becoming self-sufficient for future expansion.

V: 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.

The 2014 Annual Evaluation provided a detailed analysis of the then current trends and norms in technical capabilities and design of the State's co-funded hydrogen fueling network. In addition, suggestions were made for goals to improve upon the technology and practices that have been developed to date. The 2015 Annual Evaluation presents a similar assessment. Progress has been made in the past year, but there has also been a growing awareness of the complexity and magnitude of challenges that remain and the State will be soon facing. The discussion below provides an updated explanation and emphasis of technical capabilities that will need to be advanced within the coming years.

Station Classifications Based On Customer Usage Habits

While the majority of the stations co-funded by the State will be targeted to high priority areas with a high potential for a large FCEV market, not all stations will encounter the same usage profile. At one end of the potential usage profiles are what were termed High Use Commuter stations in the 2014 Annual Evaluation. These stations will be located in areas with highest demand, requiring high installed capacity to accommodate high potential daily throughput. This high level of utilization would severely strain smaller, less technically capable designs. The High Use Commuter station would therefore likely need to have multiple dispensers and be able to provide the most advanced capabilities for back to back and simultaneous fills, potentially exceeding even minimum requirements in SAE International standards and Energy Commission grant programs.

At the opposite end are intermittent stations, most likely located in vacation destinations and along long distance connector routes. These stations are not likely to see consistent baseline utilization; instead traffic will likely be limited to short lived but large peaks in demand at certain times during the day and/or week. Depending on the particular location, these high demand times may still require highly capable stations, but it is more likely that on average these stations could provide sufficient fueling performance with fewer numbers of pumps and minimum required back to back and simultaneous fill capability. Somewhere in between these two ends lies the Low Use Commuter, with a consistent usage profile similar to the High Use Commuter but at lower volumes. This type of station would still likely require multiple dispensers and some of the more advanced fueling capabilities. Table 2 provides a somewhat qualitative representation of these categories, as in the 2014 Annual Evaluation.

Table 2: Recommended Station Classifications Based on Customer Habits

Classification	Daily Throughput	Hourly Peak Throughput	Dispensers	Technical Capabilities
High Use Commuter	High	High	More than 2	Back to back, simultaneous fills
Low Use Commuter	Low-Intermediate	Low	2	Simultaneous fills
Intermittent	Low, Intermittent	Low	1-2	Limited fuel capabilities

Recently, the public/private partnership H2FIRST, along with H2USA, the National Renewable Energy Laboratory, and Sandia National Laboratories published a guidance document for station developers, describing potential designs, layouts, and costs for various hydrogen fueling station types [18]. This first of its kind document outlines the full bill of materials and design constraints based on a combination of private and institutional knowledge, modeling, and stakeholder input. In developing the set of recommended reference station designs, the team that assembled the report referenced the 2014 Annual Evaluation's station classification system and expanded on the definitions, providing additional detail and more specific technical specifications. Table 3 (directly from the Reference Station Design Report) displays one version of the authors' summary results, indicating station classification, design details, and their estimated costs. Note that the station sizes from the work match well with some of the recommendations provided in Chapter IV. The Reference Station Design report could be an invaluable resource for private investors looking for detailed information on the potential costs of entering the hydrogen fueling station market.

Table 3: H2FIRST/H2USA/Sandia Stations Classification System and Estimated Costs

Station Number	Hydrogen Delivery Method	Daily Capacity (kg)	Target Market	Site Type	Installed Capital Cost ($K)	Fuel Cost ($/kg)
1	Gaseous	300	High Use	Gas Station or Greenfield	$1,265	$6.03
2	Gaseous	200	Low Use		$1,179	$5.83
3	Gaseous	100	Intermittent		$1,098	$13.28
4	Liquid	300	High Use	Greenfield	$2,007	*
5	Future Liquid	300	High Use		$1,551	$7.46

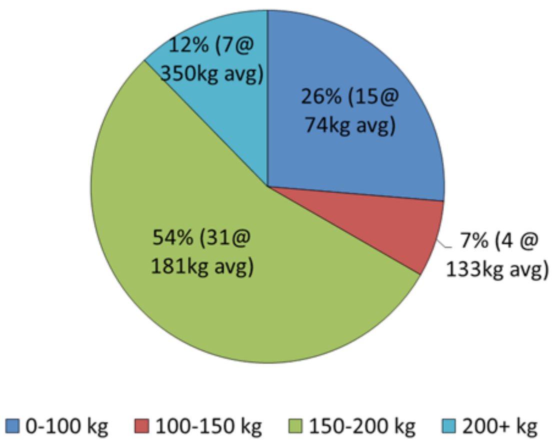
* This station type was not available in HRSAM as of this analysis and fuel cost could not be estimated. It will be included in a future version of the model.

Higher Capacity Stations

The discussion in Chapter IV provides a clear indication that station capacity will need to increase rapidly. Currently, station capacity averages 180 kilograms per day, with individual station capacity distributed as shown in Figure 17. The distribution remains the same as in the previous evaluation since it is based on the same set of stations. This evaluation recommends that stations funded under future grant programs should at least have 280 kilograms of daily fueling capacity, potentially as high as 390 kilograms of daily fueling capacity. From Figure 17, it is obvious that a shift to stations at this high of a capacity will represent a sea change in the standard station design. Currently, only 12% of stations are built or planned near this size. In fact, all seven of these stations have a capacity of 350 kg per day. A nearly 400 kilogram per day station would represent a new class of station not yet seen in California.

The need to progress over the coming years to such a large station capacity presents an opportunity to engage private investment funds to support hydrogen fueling infrastructure growth. With increased participation from private investment funds to address local capacity shortfalls in core markets that may have more reliable income streams, the State will be able to continue co-funding stations in expanding markets and select destination and connector locations. These State investments will therefore support development in areas that carry higher risk, but may lay the groundwork for future private investment and expansion. At the same time, the State may be able to emphasize the coverage provided by its co-funded stations, thereby more fully supporting the capabilities of the FCEV technology. Moreover, the capacity share taken up by private funding would ease the requirements for State co-funded stations and help keep the minimum capacity required to sizes that may be more easily achieved with current and near future technology. All of these together would be factors indicating increased likelihood of success for the State's co-funded hydrogen fueling network.

Figure 17: Hydrogen Fueling Station Capacities by Range, Count, Proportion, and In-Group Average Capacity (Total of 99% due to rounding)



Increased Dispenser Count per Station

The ability to fuel multiple FCEVs simultaneously, either through multiple dispensers located at a single station or multiple dispensing hoses integrated into a single dispenser, remains a rarity in the currently built and funded fueling station network. The 2014 Annual Evaluation explored potential decision making guidance available from an analysis of the example of fueling infrastructure for Compressed Natural Gas (CNG) vehicles. In the analysis previously presented, the conclusion was drawn that by 2020, individual stations may need to be able to provide three fills simultaneously, through three separate dispensers if necessary. The need for developing station designs and economically favorable business cases for stations with capability for simultaneous fills remains just as high priority in this year's evaluation. In particular, the previous evaluation also noted that larger capacity stations would especially need multiple dispensers in order to maximize the utility of their capacity storage and provide maximum opportunity to capitalize on the potential high throughput utilization at the location. Given the additional emphasis in this year's evaluation on the need for higher capacity stations than are currently the norm, the previously stated need for multiple dispensers and simultaneous fills should be considered to be even more urgent.

Overall Hydrogen Fueling Performance

The 2014 Annual Evaluation recognized an imminent need to maintain focus on, and potentially accelerate, State efforts to provide certainty in fueling station performance and proper fuel delivery to the FCEV driver. As schedules for in process stations have become more clearly defined over the past year, and auto manufacturer launches draw nearer, these testing, validation, and certification capabilities have become increasingly important and urgent. Detailed planning for the coming FCEV and fueling station launches has clearly demonstrated that although the State has made significant progress in this area, the magnitude of the challenge will quickly overcome the State's current capacity to address these needs. The sections below provide overviews of the progress made in the last year, the issues and concerns that are still outstanding, progress expected in the near term, and when appropriate suggestions for further action to fill any identified gaps.

Demand Response Validation

There is an urgent need to reduce the time required to test and validate hydrogen station fueling protocols from months to weeks, and eventually days. The current practice of having each individual auto manufacturer perform repeated tests does not result in timely commissioning of stations. Time is wasted with scheduling and delays around the availability of test vehicles, engineers, and station technicians.

In 2014, DOE through H2USA and H2FIRST and in partnership with industry and ARB, awarded the design and build of a HyStEP testing device. The trailer mounted unit will test stations to help ensure that FCEV drivers receive safe, fast and full fills. The HyStEP device will validate station performance by carrying out key tests defined in Canadian Standards Association (CSA) Hydrogen Gas Vehicle (HGV) 4.3, 2015. Some tests include Infrared Data Association (IrDA) communication, fault and abort detection, and communication and non-communication fill at both 35 and 70 megapascal pressures (H35 and H70, respectively).

The device design has been reviewed and the device itself is being assembled, with completion expected in August. The device will undergo extensive testing and validation this fall at NREL's Energy Systems Integration Facility in Colorado. Following the NREL evaluation, it will be transported to California to undergo field validation and verification testing by ARB, DMS, and the auto manufacturers at two stations. If the device performs to expectations and specifications, and stakeholders indicate confidence in its implementation, a certification program similar to what has recently been developed to certify dispenser accuracy (discussed below) may be developed for either a State agency or independent third party to execute.

Once the device is received and vetted, there will be a need to address resources for its implementation. The first issue that must be addressed is training of personnel within the State and/or local agencies to operate the device, interpret its results, and make certification recommendations. A training program and a certification process will need to be developed. ARB recommends an appropriate first step towards this goal is to issue and collect responses to a multi-audience stakeholder survey. Government agencies and Authorities Having Jurisdiction (AHJs) would be asked about their current staffing capacity and an inventory of in house skills and expertise related to high pressure gases and devices typically found at hydrogen fueling stations. Station developers would be surveyed on details of station design and operation that could guide staff training programs. Finally, auto manufacturers would be surveyed for anticipated needs at FCEV servicing and maintenance centers.

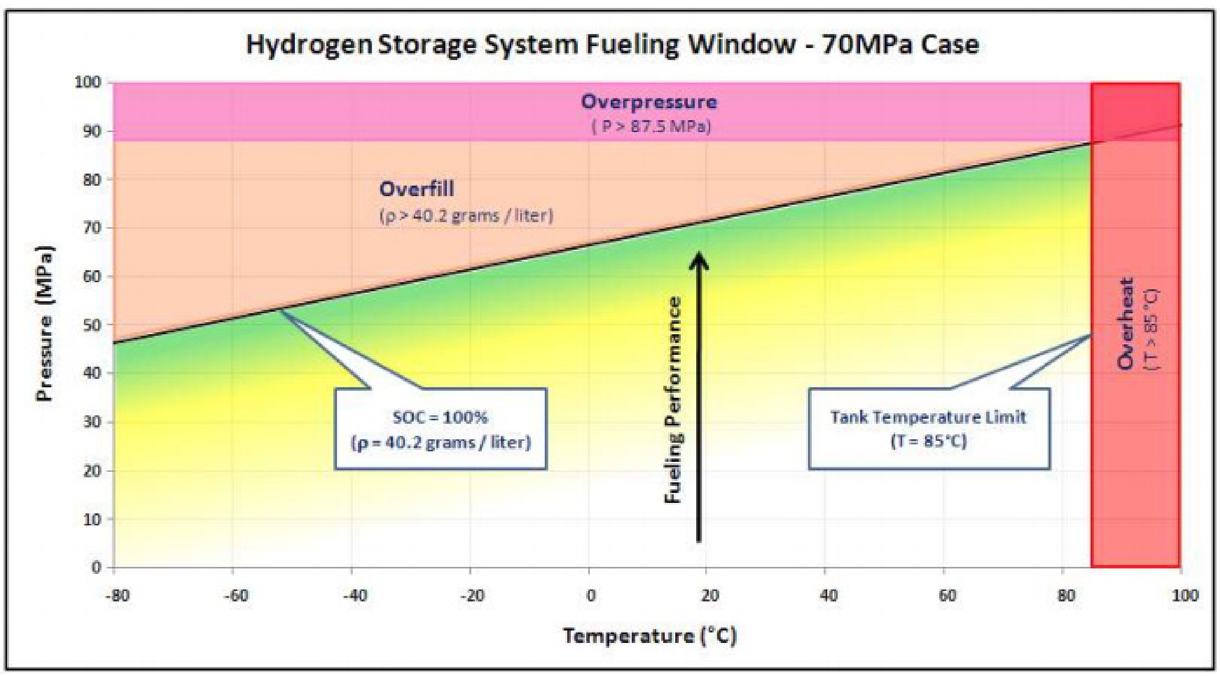
The single device that will be delivered to the State will eventually need to be one of a number of similar devices that could be deployed to meet the demands of a rapidly growing hydrogen fueling station network. Multiple devices will be necessary to perform station certification during the commissioning process and to perform periodic checks that ensure proper fill performance is maintained, especially after significant maintenance and/or upgrade work is completed at a station.

Off-Design Applications

Light-duty hydrogen infrastructure co-funded by the state of California must be publicly accessible and utilize a point of sale transaction similar to any other fueling station. By design, these stations are optimized to fill according to SAE J2601 protocols, the focus of which is light-duty vehicles. Certain design choices and expectations inherent to the assumption of filling for light-duty vehicle hydrogen tanks guide several parameters of operation for the hydrogen dispenser and other equipment at the station. Figure 18, developed in support of work by SAE International, provides a brief glimpse of the operating conditions that should be avoided, along with general ideas of the system parameters that delineate these undesirable operating conditions. Though the preferred operating regions displayed may be suitable to other applications, they have not typically been entirely vetted for applications beyond the light-duty vehicles that are developed by the major auto manufacturers. Thus, there will likely need to be discussion and investigation of J2601's broader applicability and methods to address any application gaps.

Currently, discussions are ongoing with stakeholders regarding how to most effectively extend the capabilities of these stations to safely fill other non-vetted light-duty vehicles and devices. It may be that some stations with minor programming changes could utilize related J2601 fueling protocols allowing differing flowrates and capacities. In addition, to help protect consumer and product safety, discussions have begun regarding what appropriate inspections, evaluations, testing and certification process or program would best suit such devices. Progress in this area is anticipated in the near future, and will be necessary to continue to more broadly ensure safe operation at hydrogen fueling stations in the future. California will need to remain a key stakeholder in these developments, providing input and guidance based on the experiences gained and lessons learned from the fueling station network currently in development and in operation.

Figure 18: SAE International Conceptual Diagram of J2601 Protocol Design [19]



Quality

The successful rollout of fuel cell electric vehicles is dependent upon the successful rollout and consistent reliability of the hydrogen fueling stations. One area of great concern is the assurance that fuel cell quality hydrogen is dispensed at all times at every station. Automotive fuel cells are sensitive to a number of contaminants that can be inadvertently introduced into the storage, compression, and dispensing system. Quality assurance and quality control methods are employed by the industry to ensure hydrogen product quality, but are not completely comprehensive and can fail at various points in the hydrogen pathway, from production to dispensing. This leaves open the possibility of a station unknowingly dispensing harmful contaminants including particulates to a FCEV that, depending on the contaminant, may affect performance or durability of the fuel cell stack and has the potential to cause permanent damage.

Currently, California requires hydrogen dispensed at stations to meet hydrogen purity standards detailed in SAE J2719. Hydrogen quality testing must take place at commissioning, at six month intervals thereafter, and when such maintenance is performed that could introduce contaminants into the fueling path. Still, with these requirements in place, in the last year contaminated hydrogen was dispensed at delivered gas, pipeline and onsite Steam Methane Reformer (SMR) stations. More work is clearly needed in this area.

To adequately protect the consumer and the FCEV, an in-line, real time hydrogen contaminant detector is needed. Ideally, such a device would sample and analyze every fill, and provide immediate warning to the station operator. The device would signal a fuel quality abnormality, and if serious enough, shut down fuel dispensing to prevent damage to vehicles. Particulate filters should be checked and replaced regularly; California is in discussions with DOE and its National Laboratories in partnering on potential projects that may lead to bringing pilot onsite gas analysis devices to stations in the state. The *H2FIRST Hydrogen Contaminant Detector Project, deliverable 1 – requirements Document and market Survey* conducted research and presented a gap analysis of available and needed analyzers [20]. Progress continues on development of a detector device, and staff at ARB anticipate an active role for the State of California in collaborating on the design, specifications, and field testing of this much needed tool.

For 2016, it is suggested that the frequency of full suite J2719 testing be increased to a quarterly basis. Staff at ARB have also been in discussions with state and local government labs who are investigating conducting increased random or spot check sampling as budget, laboratory availability, and personnel allow. Currently available resources (laboratory equipment and space and trained personnel) to complete spot checks and perform full spectrum quality analyses will also need to be augmented in order to provide sufficient service while in-line detectors are developed and vetted. To help speed the integration of in-line hydrogen detectors into future stations, future stations featuring onsite generation, or onsite clean up systems should include hydrogen sample, power, and data ports in their process plans at two locations: as physically near the dispenser as feasible and just downstream of the hydrogen generation/delivery point. Technical specifications of the additional equipment will be available to station developers as the H2FIRST effort proceeds.

Accuracy

A dispenser must be verified as being accurate before it can dispense fuel on a retail, point of sale basis to the public. The National Institute of Standards and Technology (NIST) accuracy class (which California has adopted) for hydrogen dispensing specifies a tolerance of 1.5% for acceptance (commissioning) and 2.0% for maintenance (continued in use operation) in NIST Handbook 44. Existing mass measurement methods do not meet this standard over all temperature, pressure, and flow conditions. To support the initial commercialization of hydrogen fuel sales, DMS adopted regulations to establish three expanded accuracy classes on a temporary basis, with acceptance tolerances of 2, 4 and 5% and maintenance tolerances of 3, 5, and 10% respectively.

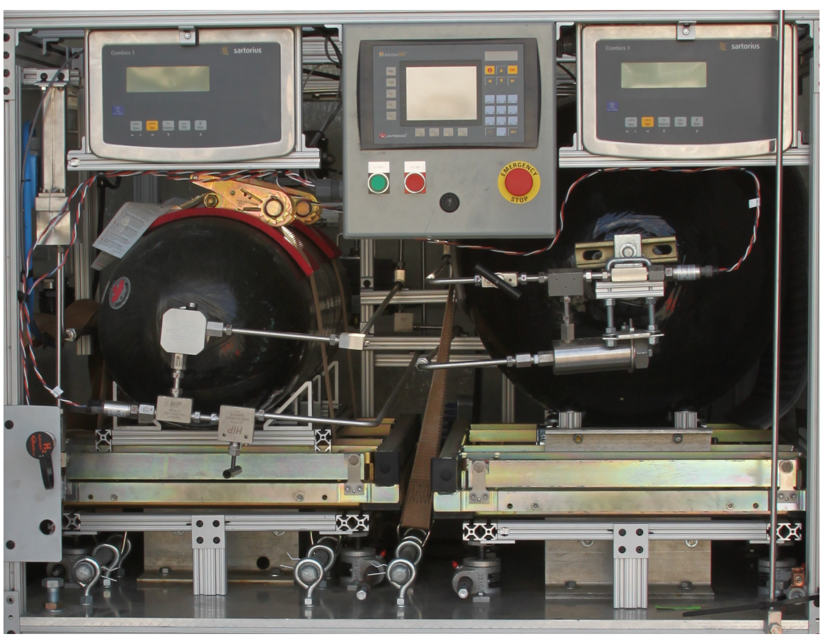
In 2014, the California Hydrogen Dispenser Data Collection and Type Certification Field program kicked off to test dispenser accuracy. ARB designed the testing program and organized the effort to coordinate multiple agencies to fund the program. Using the Energy Commission funded HFS testing device, staff from DMS began testing and evaluating pre-commercial and commercial stations/dispensers in California to determine conformance to the existing and newly adopted accuracy classes. The device itself is pictured in Figure 19, with a view of a portion of the operator interface provided in Figure 20. Over 15 weeks of testing, over two hundred test fills were performed at ten different stations at both H35 and H70 pressures.

Although specific station test results are confidential the following summarizes the analyses:

- No current dispensers met the NIST standard of 1.5% acceptance / 2% maintenance
- Stations featuring the pressure/volume/temperature mass measurement method did not meet even the least stringent 10% accuracy class
- Two dispensers successfully passed California's Type Evaluation Program (CTEP), with the best observed accuracy at 5%
- Two stations qualified for temporary use permits allowing them to dispense and charge for hydrogen on a temporary basis, pending a successful full certification

At least one dispenser manufacturer, who passed the CTEP requirements, has built multiple identical dispensers and is installing them in other stations in California. Device evaluations clearly indicate that current dispenser technology can only achieve the tolerances in the expanded accuracy classes. Although this testing program has allowed the retail sale of hydrogen by the kilogram in a few stations, it is clear that continuing collaboration between public and private stakeholders will be required to develop more accurate metering and dispensing designs in the future.

Figure 19: Hydrogen Field Standard Dispenser Accuracy Testing Device

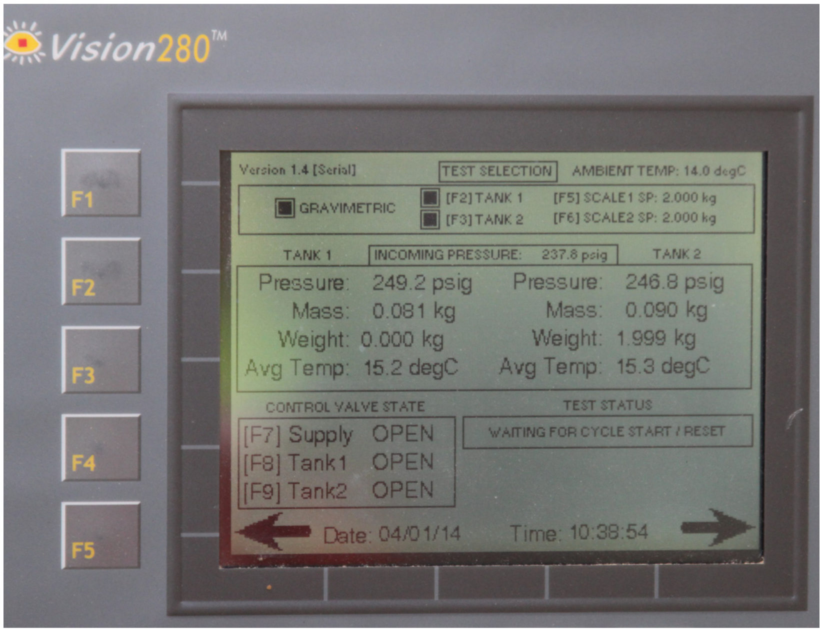


Up to a dozen additional HFS devices and appropriately trained personnel will be needed in the next few years as dispenser testing is typically done by local authorities. Devices may be needed in the greater San Diego, Los Angeles, San Francisco and Bay Area, and in the Central Valley. A program will need to be developed to address training and maintenance of the HFS device and other hydrogen station testing and certification devices for local officials. Similar actions described for implementation of the HyStEP device and certification process will need to be taken for the continued use of the HFS device and the expansion of CTEP.

Operations Interface

Most hydrogen stations in California have made the transition from one off demonstration stations to modular, pre-commercial, full retail stations. As such all future station operations should be publicly accessible, without restriction, and with no liability or access agreement requirements of any kind. To the maximum extent possible, the stations should be open 24 hours per day, 365 days a year. The retail "point of sale" system should accept all major credit cards (e.g.: MasterCard™, Visa™, AmEx™), as well as the most common fleet fueling cards (e.g.: Voyager™, WEX™). In these early days, when infrastructure coverage is still relatively sparse, stations should have the capability to provide station status notification to the latest version of the CaFCP Station Operation Status System (SOSS). This will help inform the FCEV customer of the operational status of stations at a glance.

Figure 20: Hydrogen Field Standard Device Operator Interface



Pressure

Future hydrogen fueling station solicitations should retain the requirement to dispense both H70 and H35 pressures. Currently, H70 fueling is primarily limited to light-duty passenger vehicles. However, H35 has been used in a wide variety of applications that can help increase throughput at the station and grow the hydrogen economy. In the transport sector, the lower pressure has been used for lift trucks, freight trucks, buses, scooters, motorcycles, and boats. Portable fuel cells have been used in military soldier applications, auxiliary power units, refrigeration units, and personal electronics. There is also a potential market for portable emergency refueling devices that could fill stranded vehicles that have run out of hydrogen. Moreover, depending on station design, H35 fueling capability may provide a fallback option to achieve at least a partial fill when higher pressure components may be offline for maintenance or repair. Given these concerns, there appear to be sufficient secondary reasons to continue including H35 in addition to H70 capabilities in State co-funded stations.

Carbon Intensities and Resource Consumption

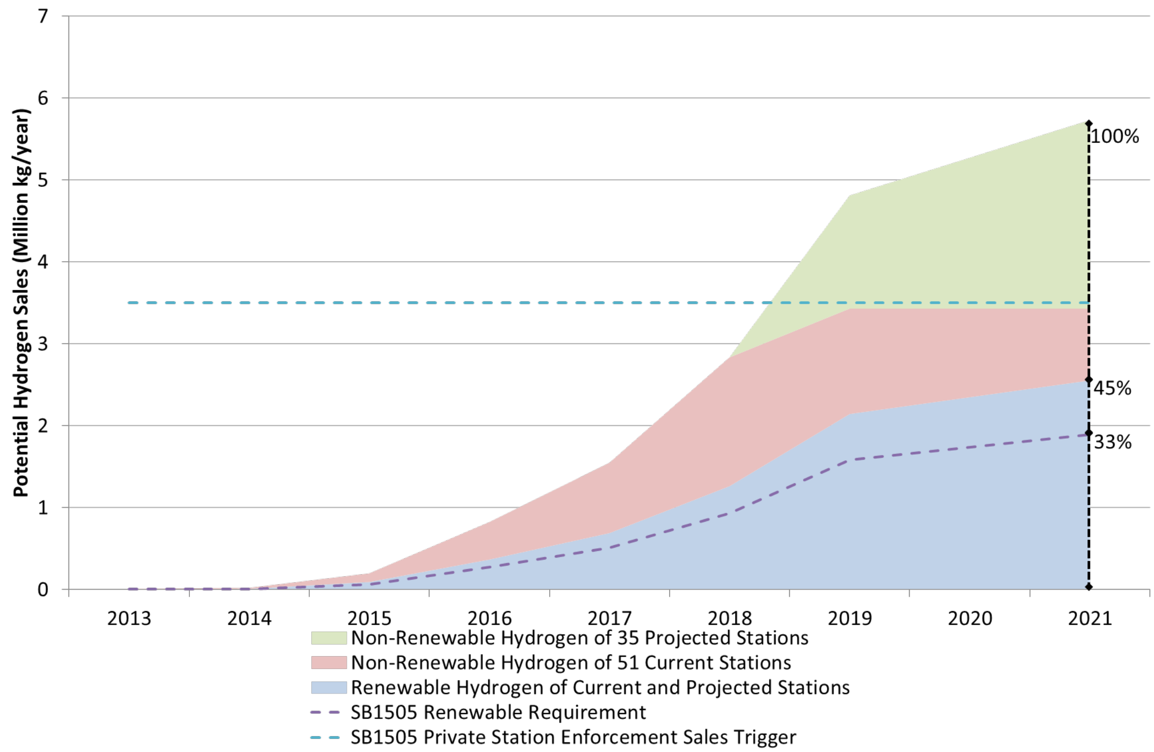
As discussed in the 2014 Annual Evaluation, provisions in the language of AB 8 correlate well to requirements set for hydrogen production by Senate Bill 1505 (SB 1505; Lowenthal, Chapter 877, Statutes of 2006). In particular, both pieces of legislation require monitoring and enforcement of maximum allowable well-to-wheels greenhouse gas (GHG) generation from production fuel grade hydrogen for FCEVs. Both also require monitoring and enforcement of minimum amounts of renewable energy used in the production of that hydrogen. While AB 8 provides general direction for GHG reductions and renewable hydrogen requirements, SB 1505 is more specific: on a well-to-wheel basis, GHGs from hydrogen use for vehicles must be 30% below the average for gasoline and all hydrogen produced for FCEVs must be made from at least 33.3% renewable energy resources. Given the early market status of hydrogen and FCEVs, SB 1505 makes these requirements immediately enforceable only for State funded stations; any completely privately funded stations are not required to meet the same specifications until 3,500 metric tons (3.5 million kg) of hydrogen are sold in the state.

These requirements have been integrated into Energy Commission funding programs for fueling stations as a basis for scoring (GHG production) and condition of eligibility (renewables). The Energy Commission has put these requirements in place for currently funded stations and encouraged surpassing the minimum requirements by providing additional funding incentive for stations supplied by hydrogen from 100% renewable resources. (Stations that source their hydrogen from 100% renewable energy resources are indicated in the Notes column of Appendix A: Station Status Summary; all other stations meet the 33% requirement either individually or as part of a developer's network). Figure 21 shows the historical and projected trend of renewable hydrogen content in the state as a result of these policies. For projections beyond 2016 (the latest projected operational date for the 51 existing and funded stations), the average network renewable content is assumed to be the same as in 2016. Additionally, the statewide capacity for hydrogen fueling follows the data shown in Figure 14. It should be noted that since there have been no new awards since the 2014 Annual Evaluation, Figure 21 is based on nearly the same data as a similar figure in the prior report. Only small changes in select stations have occurred in the past year.

As in the previous evaluation, Figure 21 shows that with only the current 51 existing and funded stations, the maximum statewide hydrogen sales would not exceed the minimum required in SB 1505 to enforce GHG and renewable requirements on privately funded stations. With additional stations built in the coming years, the SB 1505 sales trigger would be met in 2018, similar to last year's analysis. The only major difference in this year's analysis is the amount of hydrogen (renewable and non-renewable) in this year's analysis is supply limited, given the conclusions of the hydrogen balance discussion above. Since there will be more projected demand than supply, throughput was assumed to be capped by supply limitations. In the 2014 Annual Evaluation, the opposite was true; continued station funding was found to ensure supply exceeded demand in future years and throughput was therefore capped by demand.

The statewide renewable hydrogen content is essentially the same as in the previous report, expected to be 45% when all funded stations are built. Small corrections in data and changes to a limited number of stations have occurred since the previous reported value of 46%. State funded stations significantly exceed the minimum requirement for renewable energy resource utilization. Moreover, the historical trend also shows renewable resource utilization for hydrogen has always exceeded the requirement. The minimum renewable content was 38% in 2010, peaked at 52% in 2012, and will be 47% at the end of 2015. Small duration peaks and valleys from one year to the next, especially for projected stations, are only a matter of the timing of individual stations' operational date projections and are not indicative of the general trend over many years.

Figure 21: Evaluation of Compliance with SB 1505 Renewables Requirement and Trigger for Enforcement of the Requirement on Stations without State Co-funding



Station Availability, Maintenance Readiness, and Online Status

Finally, the 2014 Annual Evaluation stressed the importance of the coming mobile fueler, station operator readiness plans and technician networks, and online station status reporting. All of these features remain crucial to improving the customer experience. Current FCEV customers too often experience stations being unavailable due to equipment malfunction or other issues, and clear communication of station status remains a challenge. Improved status reporting, more reliable backup fueling capability that will be afforded by the mobile fueler, and full time dedicated personnel to react to station malfunctions are needed to improve the convenience and FCEV driver satisfaction with the hydrogen fueling station network.

VI: 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.

California has made significant progress in planning and developing hydrogen fueling infrastructure over the past year. Vigorous work of station developers gives promise for an extensive, well connected network of stations by late 2015, with additional coverage being completed in 2016. Auto manufacturers indicate more FCEVs coming to market, and an accelerating pace of vehicle deployments. Continued and increased investment is needed to expand station coverage and capacity to meet projected growing consumer demand for hydrogen fuel. New funding approaches could increase the State's ability to build the station network with limited resources. Future funding programs will need to emphasize improved technical capabilities of stations, especially to site equipment that can provide much larger throughput than the current standard.

Given the vehicle deployments projected by auto manufacturers and the anticipated rate at which State funds can be directed toward continued hydrogen fueling station development through the ARFVTP, ARB staff recommends the following:

- Investments in hydrogen fueling stations need to continue at the maximum feasible pace to address the anticipated fuel demand; ARB recommends allocating the full annual funding level of $20 million in future grant programs. ARB also recommends exploring innovative funding options to achieve the maximum hydrogen fueling station growth from these investments.
- The largest hydrogen station coverage gaps appear to exist in San Francisco, Berkeley and Oakland, Greater Los Angeles, and San Diego. These areas should remain the highest priority for State funding of hydrogen stations to serve FCEV early adopter markets.
- Additional market areas like Fremont, Sacramento, Long Beach, Pasadena, inland Orange County, coastal cities, San Jose, and others will also need expanded station coverage in the next few years.
- Connector stations in Lebec and Los Banos are necessary to solidify the north-south connector route along I-5 that has been established by the Coalinga station currently in development.
- The State has an opportunity to engage private industry to further invest in hydrogen fueling infrastructure, emphasizing the business opportunity arising from accelerating FCEV projections and growing demand for hydrogen.

- The State may need to explore funding alternatives to capital cost share for O&M and station upgrades; the maximum amount of ARFVTP funding should be retained for supporting new stations that provide additional coverage.
- Larger daily hydrogen capacity should be incentivized in upcoming funding programs. Larger stations could address projected capacity shortfalls and help make stations more economically viable in areas with a strong early adopter market.
- Stations should be required to follow the SAE J2601 fueling protocol to be eligible for funding, including O&M and station upgrades.
- The State should place priority and additional resources toward ongoing work to validate dispenser accuracy, fill protocol, and fuel quality at hydrogen fueling stations. Long term planning to meet growing needs will be vital as hydrogen transitions to the mainstream fuel market.
- Station capabilities that provide a consistent, reliable retail experience, such as point of sale and status reporting systems, should remain a priority and be integrated as requirements for future grant programs.

The success of the FCEV launch will be heavily reliant on a number of policy, market, and consumer factors, including successful planning and implementation of the fueling network. ARB will continue working with the Energy Commission to implement these recommendations, providing an open and public process for upcoming grant programs. With these recommendations, ARB aims to advance a developing station network that continues to expand coverage and provide consumer confidence to ever growing portions of the FCEV early adopter market. Expanding station coverage, capacity, reliability and technical capabilities will advance FCEV adoption by consumers, and continue to bring the State closer to meeting its ZEV, greenhouse gas, petroleum reduction, and regional air quality goals.

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Appendix A: Station Status Summary

List of Known and Projected Hydrogen Fueling Station Status (2010-2020), as of 05.12.15

Station Name	Operational	Capacity (kg/day)	County	Market Role	Note
Burbank- W Verdguo	2010, Q1	100	Los Angeles	Early Station/Demo	
Thouasnd Palms- Harry Oliver	2010, Q1	30	Riverside	Early Station/Demo	
Thousand Palms- Harry Oliver	2015, Q1	30	Riverside	Early Station/Demo	Non-Retail; Limited 35MPa Service
Irvine - Jamboree	2010, Q1	30	Orange	Early Station/Demo	
Irvine- Jamboree	2015, Q3	150 add'l	Orange	Early Station/Demo	Upgrade
Torrance- W 190th	2011, Q2	60	Los Angeles	Early Station/Demo	
Torrance- W 190th	2016, Q1	140 add'l	Los Angeles	Early Station/Demo	Upgrade
Fountain Valley- Ellis	2011, Q3	100	Orange	Early Station/Demo	100% Renewable
Fountain Valley- Ellis	2015, Q2	100	Orange	Early Station/Demo	Closed; Continuation effort underway
Emeryville- 45th	2012, Q2	60	Alameda	Early Station/Demo	100% Renewable
Emeryville- 45th	2015, Q3	60	Alameda	Early Station/Demo	Non-Retail; Continuation effort underway
Newport Beach- Jamboree	2012, Q3	100	Orange	Early Station/Demo	
Harbor City- S. Western	2013, Q2	60	Los Angeles	Early Station/Demo	
Los Angeles- State University	2014, Q2	60	Los Angeles	Early Market/ Expansion	100% Renewable
Diamond Bar- E Copley	2014, Q3	180	Los Angeles	Market Expansion	
West Sacramento- South River	2014, Q3	350	Yolo	Future Market	
Los Angeles- Aviation	2015, Q1	100	Los Angeles	Early Target Market	
Los Angeles- Santa Monica	2015, Q2	180	Los Angeles	Early Target Market	
Campbell- Winchester	2015, Q3	180	Santa Clara	Early Target Market	
Chino- East End	2015, Q3	100	San Bernardino	Market Expansion	100% Renewable
Coalinga- W Dorris	2015, Q3	180	Fresno	Connector	
Lake Forest- Lake Forest	2015, Q3	180	Orange	Early Target Market	
Los Angeles- Beverly	2015, Q3	180	Los Angeles	Early Target Market	
Los Angeles- Cloverfield	2015, Q3	180	Los Angeles	Early Target Market	
Mill Valley- Redwood	2015, Q3	180	Marin	Market Expansion	
Redondo Beach- Beryl	2015, Q3	180	Los Angeles	Early Target Market	
San Juan Capistrano- Junipero Sera	2015, Q3	350	Orange	Early Target Market	
Santa Barbara- S La Cumbre	2015, Q3	180	Santa Barbara	Destination	
Saratoga- Saratoga	2015, Q3	180	Santa Clara	Early Target Market	

South Pasadena- Fair Oaks	2015, Q3	180	Los Angeles	Market Expansion	
South San Francisco- S Airport	2015, Q3	180	San Mateo	Early Target Market	
Truckee- Donner Pass	2015, Q3	180	Nevada	Connector/ Destination	
Woodland Hills- Topanga Canyon	2015, Q3	180	Los Angeles	Market Expansion	
Anaheim- E La Palma	2015, Q4	100	Orange	Market Expansion	
Costa Mesa- Harbor	2015, Q4	180	Orange	Early Target Market	
Hayward- West A	2015, Q4	180	Alameda	Market Expansion	
Irvine- Walnut	2015, Q4	180	Orange	Early Target Market	
La Cañada-Flintridge- Foothill	2015, Q4	180	Los Angeles	Market Expansion	
Lawndale- Inglewood	2015, Q4	180	Los Angeles	Early Target Market	
Los Angeles- Lincoln	2015, Q4	180	Los Angeles	Early Target Market	100% Renewable
Los Angeles- Hollywood	2015, Q4	180	Los Angeles	Early Target Market	100% Renewable
Ontario- Holt	2015, Q4	100	San Bernardino	Connector	100% Renewable
Orange- East Chapman	2015, Q4	130	Orange	Market Expansion	100% Renewable
Pacific Palisades- Pacific Coast Highway	2015, Q4	130	Los Angeles	Early Target Market	100% Renewable
Palo Alto- El Camino Real	2015, Q4	180	Santa Clara	Early Target Market	
Riverside- Lincoln	2015, Q4	100	Riverside	Market Expansion	
Rohnert Park- Redwood	2015, Q4	130	Sonoma	Market Expansion	100% Renewable
San Diego- Carmel Valley	2015, Q4	180	San Diego	Future Market	
San Jose- North First	2015, Q4	180	Santa Clara	Early Target Market	
San Ramon- Bishop	2015, Q4	350	Contra Costa	Market Expansion	
Long Beach- Long Beach	2015, Q4	180	Los Angeles	Market Expansion	
Woodside- Skyline	2015, Q4	140	San Mateo	Early Target Market	
Foster City- Foster City	2016, Q1	350	San Mateo	Early Target Market	
Laguna Niguel- Crown Valley	2016, Q1	180	Orange	Early Target Market	
Los Altos- Homestead	2016, Q1	350	Santa Clara	Early Target Market	
Mission Viejo- Marguerite	2016, Q1	180	Orange	Early Target Market	
Mountain View- Leong	2016, Q1	350	Santa Clara	Early Target Market	
Oakland- Langley	2016, Q1	350	Alameda	Connector	
Redwood City- Veterans	2016, Q1	180	San Mateo	Early Target Market	

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

Guidance [as of February 2015] for Projected Hydrogen Station Status*, Calendar Years 2015-2016

Alameda County			**Capacity: 530 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Oakland - 1019 Langley St	2016	2016	350
Hayward - 391 West A St	2015	2016	180
Emeryville - 1152 45th St1	-	-	-
Contra Costa County			**Capacity: 350 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
San Ramon - 2451 Bishop Dr	2015	2016	350
Fresno County			**Capacity: 180 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Coalinga - 24505 W Dorris Ave	2015	2015	180
Los Angeles County			**Capacity: 2670 kg/day Upgraded Capacity: 2810 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Beverly Hills - 7751 Beverly Blvd	2015	2015	180
Burbank - 145 W Verdugo Ave	2010	2010	100
Burbank Upgrade	2015	2015	100
CSULA - 5151 State University Dr	2014	2015	60
Culver City - 8126 Lincoln Blvd	2015	2015	180
Diamond Bar - 21865 E Copley Dr	2014	2015	180
Harbor City - 25826 S Western Ave	2013	2013	60
Harbor City Upgrade	2015	2015	60
La Canada - Flintridge- 550 Foothill Blvd	2015	2016	180
Lawndale - 15606 Inglewood Ave	2015	2016	180
LAX - 10400 Aviation Blvd	2016	2016	100
Long Beach - 3401 Long Beach Blvd	2015	2015	180
Pacific Palisades - 17301 Pacific Coast Hwy	2015	2016	130
Redondo Beach - 1200 Beryl St	2015	2015	180
Santa Monica - 1819 Cloverfield Blvd	2015	2015	180
South Pasadena - 1200 Fair Oaks Ave	2015	2015	180
Torrance - 2051 W 190th St	2011	2011	60
Torrance Upgrade	2015	2015	200
West Hollywood - 5700 Hollywood Blvd	2015	2015	180
West LA #2 - 11261 Santa Monica Blvd	2015	2015	180
Woodland Hills - 5314 Topanga Canyon Blvd	2015	2016	180
Marin County			**Capacity: 180 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Mill Valley - 570 Redwood Highway	2015	2015	180

Nevada County			Capacity: 180 kg/day
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Truckee - 12105 Donner Pass Rd	2015	2015	180
Orange County			**Capacity: 1610 kg/day Upgraded Capacity: 1760 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Anaheim - 3731 E La Palma Ave	2015	2015	100
Costa Mesa - 2050 Harbor Blvd	2015	2016	180
Irvine North - 5410 Walnut Ave	2015	2015	180
Laguna Niguel - 30081 Crown Valley Pkwy	2016	2016	180
Lake Forest - 20731 Lake Forest Dr	2015	2015	180
Mission Viejo - 21522 Marguerite Pkwy	2016	2016	180
Newport - 1600 Jamboree Rd	2012	2012	100
Orange - 1914 East Chapman Ave	2015	2016	130
San Juan Capistrano - 26572 Juniper Serra Rd	2015	2015	350
UC Irvine - 19172 Jamboree Rd	2010	2010	30
UCI Upgrade	2015	2015	180
Fountain Valley - 10844 Ellis Ave[1]	-	-	-
Riverside County	**Capacity: 100 kg/day**		
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Riverside - 8095 Linocln Ave	2015	2015	100
Thousand Palms - 32505 Harry Oliver Tr[2]	-	-	-
San Bernardino County			**Capacity: 200 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Chino - 12600 East End Ave	2015	2015	100
Ontario - 1850 Holt Blvd	2015	2015	100
San Diego County			**Capacity: 180 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
San Diego - 3060 Carmel Valley Rd	2015	2016	180
San Mateo County			**Capacity: 850 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Foster City - 390 Foster City Blvd	2016	2016	350
Redwood City - 690 Veterans Blvd	2016	2016	180
South San Francisco - 248 S Airport Blvd	2015	2016	180
Woodside - 17287 Skyline Blvd	2015	2016	140
Santa Barbara County			**Capacity: 180 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Santa Barbara - 150 S La Cumbre Blvd	2015	2016	180
Santa Clara County			**Capacity: 1420 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Campbell - 2855 Winchester Blvd	2015	2015	180
Los Altos - 2300 Homestead Rd (Los Altos was formerly Cupertino)	2016	2016	350
Mountain View - 830 Leong Dr	2016	2016	350
Palo Alto - 2200 El Camino Real	2015	2016	180
San Jose - 2101 N First St	2015	2016	180
Saratoga - 12600 Saratoga Ave	2015	2015	180

Sonoma County			Capacity: 130 kg/day
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
Rohnert Park - 5060 Redwood Dr	2015	2016	130
Yolo County			**Capacity: 350 kg/day**
Station Name	**Operational Year**	**Open Year**	**Capacity (kg/day)**
West Sacramento - 1515 S River Rd	2014	2015	350

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

1 Station may be currently operational but has an uncertain status for continued operation as of the time of this letter

2 Station currently provides only 350 bar fueling capability without a known upgrade plan as of the time of this letter

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