



September 2020



## 2020 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development

(Report Pursuant to AB 8; Perea, Chapter 401, Statutes of 2013)



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CARB's mission is to promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy. CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards.

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**HYDROGEN**  
WARNING  
FURNACE EXPLOSION OR BLENDING  
IN THE CASE OF A FURNACE BLEND  
OR BLENDING BLENDING BLENDING

# Acronyms

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AB 8	Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013)
AHJ	Authority Having Jurisdiction
BAAQMD	Bay Area Air Quality Management District
BEV	Battery Electric Vehicle
CARB	California Air Resources Board
CHAT	California Hydrogen Accounting Tool
CHIT	California Hydrogen Infrastructure Tool
DMV	Department of Motor Vehicles
EMFAC	CARB's EMISSIONS FACTOR model used to assess emissions from on-road vehicles
EO	Executive Order
FCEB	Fuel Cell Electric Bus
FCEV	Fuel Cell Electric Vehicle
GFO	Grant Funding Opportunity (California Energy Commission's formal communication of a current grant program)
GO-Biz	Governor's Office of Business and Economic Development
HGV	Hydrogen Gas Vehicle
HRI	Hydrogen Refueling Infrastructure
HySCapE	Hydrogen Station Capacity Evaluation
HyStEP	Hydrogen Station Equipment Performance
IEA	International Energy Agency
LCFS	Low Carbon Fuel Standard
NOPA	Notice of Proposed Award (California Energy Commission's formal communication of staff recommendations for competitive grant awardees to be confirmed at an Energy Commission Business Meeting at a later date)
PHEV	Plug-In Hybrid Electric Vehicle
SB 1505	Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006)
SOSS	Station Operational Status System developed by California Fuel Cell Partnership
TCO	Total Cost of Ownership
US DOE	United States Department of Energy
ZEV	Zero-Emission Vehicle



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Plus 3.55  
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Diesel @ 3.95

2

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# H<sub>2</sub> and FCEVs in the News

## FCEV and Hydrogen Industry Announcements Demonstrate Ongoing Commitment to FCEV Market Growth

- As early as July 2018, Toyota began publicly discussing its plans for the next phase of FCEV deployment, including a newly designed Mirai and a phased introduction of a broader range of models including SUVs, pick-up trucks, and commercial trucks [1]. The first step in that plan has now begun, as Toyota unveiled the 2021 Mirai with a completely refreshed design. The new model adopts a sportier aesthetic and is based on Toyota's premium rear-wheel drive coupe platform. It is expected to provide 30 percent greater range than its predecessor and a more powerful, engaging, and quieter driving experience. The new model will also have room to seat five, an increase from the current version's seating capacity of four (including the driver and other passengers) [2].
- Honda has made updates to its Clarity Fuel Cell for the 2020 model year. In addition to new cosmetic features and an improved pedestrian awareness system, the new model is notable for improved performance in cold-weather conditions that could be especially helpful to drivers of its FCEV in northern California [3].
- Auto manufacturer BMW has also revealed details of the FCEV powertrain that is expected to be incorporated into its future iHydrogen NEXT vehicle, projected to be available in the second half of this decade at the earliest. BMW reported that the fuel cell system will generate up to 125kw (equivalent to 170hp) with total system power of 275kW (374hp) provided by the fuel cell and a peak power battery. The vehicle will also carry six kilograms of hydrogen onboard the X5-based vehicle [4].
- Nikola Motor Company, which has recently been developing fuel cell and battery-powered heavy-duty vehicles, also announced an upcoming entry into the light-duty vehicle market. The company announced that in 2020 it will unveil the Nikola Badger, the market's first fuel cell-powered pickup truck (the Badger will also be available as a BEV). The announcement projects a 0-60 mph acceleration time of 2.9 seconds, due to specifications of 906hp and 980 ft.lbs. of torque. The Badger is expected to have an estimated 600 mile range, and the FCEV version will be able to operate in blended FCEV/BEV or BEV-only modes; the BEV-only mode provides 300 miles of range. The company expects to unveil the vehicle in September 2020 and begin taking limited reservations [5].
- Automotive components manufacturer Bosch announced that it is entering the FCEV market by establishing a cooperative development agreement with Powercell, which is already active in the area of fuel cell stack development and manufacturing. The partnership will jointly develop fuel cell stacks and the technology will be made available for license in the automotive market. Market entry is anticipated by 2022. Bosch foresees up to 20 percent of the electrified vehicle market powered by fuel cells in 2030 [6].
- Hyundai has leveraged the international star power of Korean pop band BTS as brand sponsors for their fuel cell-powered NEXO. A marketing campaign titled "Because of You" features video recordings of the seven band members with personal messages about hydrogen's role in a sustainable future. The campaign debuted on Hyundai and the band's social media accounts and in New York's Time Square (BTS is popular around the world including in the United States, where they were the first K-Pop group ever to win the Billboard Music Awards trophy for best group in 2019. The band also arrived at the 2020 Grammy Awards presentation in a NEXO vehicle [7] [8] [9].
- The latest edition of KPMG's Global Automotive Executive Survey of emerging trends in the automobile market continues to find strong emphasis on FCEVs. For the past five years, FCEVs have ranked in the top five key trends, peaking at number one last year and staying



at number three in the latest survey. The publication also found that automotive executives see FCEVs making up 23 percent of the 2040 market, which is composed of a roughly even split between FCEV, BEV, PHEV, and ICE technologies. KPMG also completed a survey of consumers, asking what powertrain they would choose if buying a car in the next five years and found that globally FCEVs share similar interest as BEVs, at nine percent and 12 percent, respectively. Within North America, customers slightly preferred the FCEV to the BEV at nine percent and four percent, respectively [10].

## FCEV and Hydrogen Station Progress Continues Across the United States

- The Fuel Cell and Hydrogen Energy Association published a roadmap for the growth of hydrogen-powered industry across all sectors, including transportation, residential and commercial buildings, power generation, and industry feedstock and fuel. Highlight findings include estimates that by 2030, hydrogen could provide one percent of total energy in the US, and 100 percent of the necessary hydrogen could be produced domestically. The overall economic impact could be \$140 billion in revenue and 700,000 jobs. By 2050, hydrogen could grow to 14 percent of total energy, remain 100 percent domestically produced, grow to \$750 billion in revenue and 3.4 million jobs while reducing CO<sub>2</sub> emissions by 16 percent and NO<sub>x</sub> by 36 percent [11].
- On February 24, 2020, the New Jersey Assembly passed Assembly Bill A741, establishing a New Jersey Fuel Cell Task Force. The task force will be charged with developing a plan to increase the use of fuel cells in the state of New Jersey and provide information and educational resources towards that goal. The task force will also be charged with developing an infrastructure strategy to support the use of fuel cells [12]. The bill is currently under review in the state's Senate.
- Energy solutions corporation and hydrogen station developer Iwatani Corporation of America has announced a collaborative agreement with electrolysis technology provider ITM Power. The agreement focuses on the deployment of multi-megawatt electrolyzer-based hydrogen energy systems in North America. End users include transportation, energy storage, and the renewable energy sectors, with particular interest in California's hydrogen fueling station market and large-scale renewable hydrogen production for domestic use and export [13].
- The Champaign-Urbana Mass Transit District in Illinois has awarded a contract for two Fuel Cell Electric Buses (FCEBs) to New Flyer for their sixty-foot Xcelsior CHARGE H<sub>2</sub> transit buses. This is the first commercial order of 60-foot articulated fuel cell-powered buses. The buses are expected to enter service at the University of Illinois [14], [15].
- Auto manufacturer Hyundai has entered a new research and technology demonstration partnership with the US Department of Energy, focused on fuel cell technology demonstration and infrastructure testing under real-world operating conditions. Hyundai will additionally provide five NEXO vehicles to the United States Department of Energy (US DOE) for testing across the United States and will also contribute to funding the installation of a SimpleFuel small-scale hydrogen fueling station in the Washington, DC area. (The SimpleFuel device previously won the US DOE's H<sub>2</sub> Refuel H-Prize) [16].

## FCEVs and Hydrogen Continue to Expand into Other Sectors alongside Light-Duty Vehicles

- Heavy-duty engine and vehicle provider Cummins has advanced its entry into the fuel cell vehicle industry by acquiring fuel cell and hydrogen technology provider Hydrogenics. The acquisition will help Cummins launch product into commercial markets as vehicle electrification continues to be adopted across the transportation sector [17].
- Automakers Daimler and Volvo announced a new shared venture in developing and commercializing fuel cell technology for heavy-duty and other applications. The new effort will consolidate all of Daimler's fuel cell activities into the newly formed joint venture. The effort is expected to reduce costs in development and production of the fuel cell systems and accelerate market introduction. While the new venture is focused on heavy-duty vehicles, development for light-duty vehicles and other applications will continue within the venture [18].
- In 2019, fuel cell provider PlugPower launched a new 30kw fuel cell system solution targeted for delivery vans and light/medium cargo box trucks [19]. The ProGen 30kw engine has now been followed by the launch of a 125kw fuel cell solution for heavy-duty applications, including Class 6, 7, and 8 trucks, transit buses, and various port applications [20].
- Automobile manufacturers Honda and Isuzu have reportedly launched a collaborative effort to develop hydrogen-powered trucks. The cooperation was born of Isuzu's desire to expand its portfolio of powertrains for future heavy-duty applications combined with Honda's aim to expand the use of fuel cell technology into other sectors in support of a vision for a future hydrogen society [21].
- Mercedes-Benz's innovation unit, Lab1886, has announced a collaborative pilot project with Rolls-Royce Power Systems to demonstrate the application of automotive fuel cell systems to stationary power systems. The project will focus on developing independent emergency power systems for applications that currently rely primarily on diesel generators for backup power, like data centers. The first units are expected to begin construction in early 2020 [22].
- Horizon Fuel Cell Technologies, a Singapore-based provider of fuel cell power solutions, announced a Memorandum of Understanding with undisclosed partners to supply 1,000 fuel cell units for heavy-duty applications. The fuel cell stacks are based on the company's automotive fuel cell technology and are all expected to be 100kW or greater in power. Delivery of the systems will occur over three years, with the first delivery scheduled for the end of 2019 [23].
- Toyota and container terminal operator Fenix Marine Services launched the world's first hydrogen fuel cell electric Utility Tractor Rig (UTR) at the Port of Long Beach in 2019. The Tractor Rig is powered by the same fuel cell technology as the Mirai and is tied to Toyota's larger Project Portal, which will also see the deployment of Class 8 heavy-duty trucks based on Toyota's fuel cell technology and the development of supporting hydrogen fueling infrastructure across Southern California [24].
- Toyota has also begun demonstrating application of the fuel cell technology of its Mirai to stationary power. The company has installed a fuel cell system at its plant in Toyota City. The system is based on the integration of two Mirai fuel cell stacks and a secondary battery. The unit is expected to provide 24-hour power at 100kW to the company's Honsha Plant [25].
- Hyundai has announced its intent to develop a hydrogen-powered tram by 2022. Technology development is a shared venture between Hyundai Motor and Hyundai Rotem, the company's locomotive subsidiary. The tram is expected to have a range of 200 km (124 miles) with a maximum speed of 70 km/hr (43 mph) [26].

- Electrolyzer equipment provider ITM Power has announced that it has secured the lease to develop the world's largest electrolyzer production facility. The company expected to enter the building in March 2020 (an update has not yet been made publicly available). The facility, located in Sheffield, UK, will have an annual production capacity of 1GW per year [27].
- The Orange County Transportation Authority recently opened the largest hydrogen fueling station in the United States to support the operation of 10 new FCEBs it purchased from New Flyer (though the station can support up to 50 buses). The station was built through a partnership between industrial gas company Air Products and Chemicals, Inc. and commercial fueling station operator Trillium. The project was organized by the Center for Technology and the Environment and supported by funds from CARB's Climate Investments program [28].
- The San Bernardino County Transportation Authority recently announced that it has signed a contract to procure a hydrogen passenger locomotive for a new rail line currently under construction between Redlands and San Bernardino. The train could become the first hydrogen-powered train in service in the United States when it enters service as early as 2024. The train will operate on the 9-mile route with capacity for 108 passengers and a top speed near 80 mph [29].

## Markets across the Globe Signal Rising Interest and Activity in Hydrogen and FCEVs

- The German government has recently announced significant steps to strengthen its role in the development of the global hydrogen industry and act as a world leader in the sector. On June 3, 2020, the German government announced a €130 billion economic recovery stimulus package that included €7 billion in investment to support market development of hydrogen technologies for use domestically and an additional €2 billion for international partnerships focused on hydrogen. The investment plan envisions as much as 5GW of hydrogen production capacity, with a goal for 10GW total production capacity as early as 2035 but no later than 2040. One week later, on June 10, 2020, the German government followed up with the release of a new national strategy for investment in hydrogen technology and established a National Hydrogen Council to lead the effort [30] [31].
- On June 17, 2020, Mitsui and Japan Bank for International Cooperation (JBIC) announced investments of \$25 million and \$23 million, respectively, in California hydrogen fueling station developer and operator FirstElement. The investments are intended to strengthen an existing investment and partnership between Mitsui and FirstElement to reduce costs and expand business into new market opportunities. The announcement from JBIC meanwhile highlighted that the funds will support Japanese FCEV manufacturers' international efforts and competitive stance [32] [33].
- The government of South Korea recently announced that it now plans to develop 1,200 hydrogen fueling stations by 2040 as part of its strategy to cement hydrogen as the country's main source of energy [34].
- The Hydrogen Council recently published a new report assessing the cost-based market competitiveness of hydrogen in a broad range of applications across sectors. The report emphasizes the outsized role of growth in market scale to achieving necessary cost reductions and finds that cost-competitive hydrogen is feasible in many applications by 2030. At 600,000 vehicles produced per year, the report estimates that the Total Cost of Ownership for vehicles falls by 45 percent and that cost-competitiveness for many light-duty platforms could occur prior to 2030 or shortly thereafter. The report also estimates a worldwide investment (combined public and private) of \$70 billion to achieve these goals [35].
- As part of an effort to accelerate technology development and deployment in China, Toyota has entered into an agreement to provide fuel cell components to Chinese auto makers FAW and Higer Bus. The components will be used to develop fuel cell-powered buses for the Chinese market [36].

- A project to deploy and fuel the world's largest fuel cell electric mining truck has recently taken shape in South Africa. Electrolyzer equipment supplier Nel ASA will provide a 3.5MW unit to be deployed to fuel a mining truck at a platinum mine operated by Anglo American. The truck will weigh 290 tons and incorporate a hybrid fuel cell-battery drive train with 1,000 kWhr of energy storage onboard and capability for regenerative braking [37] [38].
- The Australian government has approved the development of the world's largest "Hydrogen Superhub," a facility with 50MW of electrolysis capacity (up to 9,000 metric tons of hydrogen per year). The facility is meant to demonstrate the coordinated use of several renewable energy technologies and includes 125MW of wind and 150MW solar electricity generation with a 130MW Li-ion battery electric energy storage unit [39].
- The first system for commercial hydrogen production in Switzerland has commenced planning. A 2MW electrolysis system has been under construction at a local hydropower plant, with the goal of providing hydrogen supply for a fleet of fuel cell-powered trucks provided by Hyundai Hydrogen Mobility [40].
- The government of Denmark has launched an initiative to develop two hydrogen-based large-scale renewable energy storage projects, with a total value of \$19M. The two funded projects are expected to complete development within the next five years and are seen as a stepping stone on the path to developing green hydrogen fuel for transportation applications [41].



# Executive Summary

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California's hydrogen fueling station network has continued to add new, highly capable stations in the past year while the number of Fuel Cell Electric Vehicles (FCEVs) on-the-road continued to increase. Growth in these industries continued despite significant events within and outside the industry (most recently the onset of COVID-19) that led to a slower development pace than previously estimated. There have been observable impacts on progress over the past year due to these stressors, but State and industry members have continued to move beyond these challenges and build a foundation for accelerated growth.

The hydrogen fueling industry is responding favorably to the State's maturing support mechanisms. The California Air Resources Board (CARB)'s Low Carbon Fuel Standard's (LCFS) Hydrogen Refueling Infrastructure (HRI) credit provision has initiated the development of nine additional stations. The California Energy Commission released its latest Grant Funding Opportunity (GFO) 19-602 to solicit applications to co-fund new hydrogen fueling stations, with awards expected to be announced imminently. The new solicitation is a multi-year effort designed expressly to enable multi-year network plans expected to help station designer/operators make larger purchase orders, support development of the upstream station equipment supply chain, and unlock economies of scale. These are necessary steps to move California's hydrogen fueling and FCEV industries out of the current early adopter phase and into the broader mass-market.

California has set hydrogen infrastructure targets with the goal of developing and growing FCEV and hydrogen fueling market scale. Assembly Bill 8 (AB 8; Perea, Chapter 201, Statutes of 2013) requires the establishment of at least 100 hydrogen fueling stations to launch the FCEV market in the state [42]. In addition, AB 8 requires assessment by CARB and the Energy Commission of State support to enable industry growth to the point of financial self-sufficiency. More recently, Executive Order B-48-18 (EO B-48-18) tasked these same agencies with working towards a network of 200 stations by 2025. Achieving the goal of 200 stations by 2025 puts the state on a path to achieve economies of scale and future growth that does not depend on State incentives. Recent estimates point to the AB 8 grant process enabling the establishment of as many as 122 stations in California's hydrogen fueling market [43]. The combination of LCFS HRI credits and GFO 19-602 are the State's strongest support mechanisms for reaching the 200-station goal.

Industry stakeholders continue to take action toward larger hydrogen markets within California. Hydrogen fuel providers have invested in expansion of hydrogen fuel production and distribution facilities to serve California's developing FCEV market. Collaborative hydrogen industry organizations have announced efforts to increase the use of renewable, low-carbon, and sustainable resources in the production of hydrogen. For example, the Hydrogen Council has identified a goal of 100 percent decarbonized hydrogen for transportation by 2030 [44]. Several new companies have become involved in California's hydrogen fueling market and public-private cooperative efforts in recent years, including Chevron, Cummins, Iwatani, Shell, Toyota Tsusho, and United Hydrogen [45], [46].

The challenge before the public and private stakeholders of California's hydrogen and FCEV industries now is to ensure that progress not only continues but accelerates. Meeting the State targets for hydrogen station development requires close adherence to current estimates of station development schedules and acceleration of the process for future stations. The FCEV market in California continues to be an integral piece of the State's vision toward electrified zero-emission transportation and requires accelerated vehicle deployment alongside fueling network expansion. Transition from market establishment to large-scale growth and wide-spread adoption of hydrogen and FCEVs in California will therefore need to be a priority of the AB 8 program going forward.

Successful expansion of the FCEV market will rely on several complementary factors in addition to the development of hydrogen fueling infrastructure. New supply chains and manufacturing capacity,

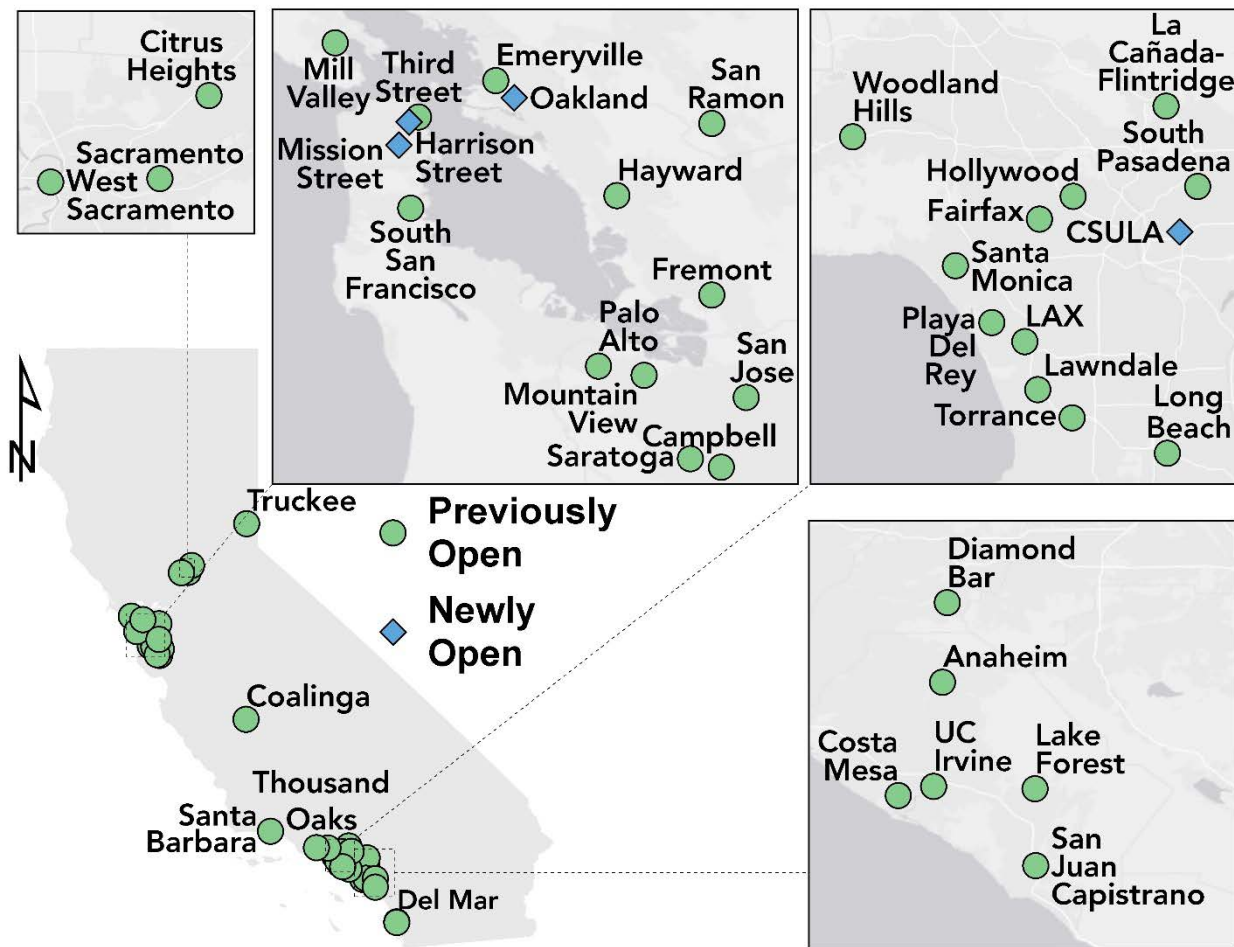
especially at large scale to support market acceleration, need to develop. Consumer awareness and acceptance of the new technology needs to grow. The network of facilities that produce hydrogen fuel (especially renewable hydrogen) specifically for transportation uses needs to expand and mature, enabling lower prices paid by the consumer and building resiliency of supply. Consumer incentives may need to fill the affordability gap as the market matures.

This report provides CARB's analysis of the current status and near-term projections of FCEV deployment and station network development and the actions necessary to maintain progress and enable continued future expansion. This report provides recommendations to the Energy Commission regarding future station development co-funding through AB 8 that ensures positive retail customer experiences and supports further FCEV deployment. Of particular importance, CARB finds that the FCEV market may soon experience an acceleration out of the earliest market development phase, and that the shift to broader consumer adoption depends on expanded and accelerated station network deployment. Furthermore, since the passage of AB 8, Governor Brown established EO B-48-18 that calls for 200 hydrogen stations by 2025. CARB therefore recommends that the Energy Commission fully leverage all funds available for hydrogen fueling station development through its current multi-year funding solicitation GFO 19-602.

# Findings

**Finding 1: California’s hydrogen fueling network includes 42 Open-Retail stations due to a mix of growth and contraction in the past year while the network under development has expanded through the LCFS HRI program**

**FIGURE ES 1: CURRENT OPEN HYDROGEN FUELING STATION NETWORK (AS OF JULY 3, 2020)<sup>1</sup>**



As of July 3, 2020, California’s hydrogen fueling network includes 42 Open-Retail stations, one more than this time last year. Figure ES 1 shows the location of all Open-Retail stations in the network, with new additions in San Francisco, in Oakland, in Fountain Valley, and at California State University-Los Angeles (CSULA). This is the net effect of five new stations opening, one station permanently closing (the site owner of the West LA station sold the property for redevelopment), and temporarily recognizing three previously Open-Retail stations as a separate category due to an extended period of halted operations without a known resolution date<sup>2</sup>. Four of the new stations are representative of the latest generation of technology and design with multiple fueling positions capable of filling

<sup>1</sup> One station in Fountain Valley became Open-Retail while this report was in review and is not shown on the map.  
<sup>2</sup> As these stations resume retail sales operations, they will be counted again as Open-Retail in future reports. See “Current Open and Funded Stations” for more information.

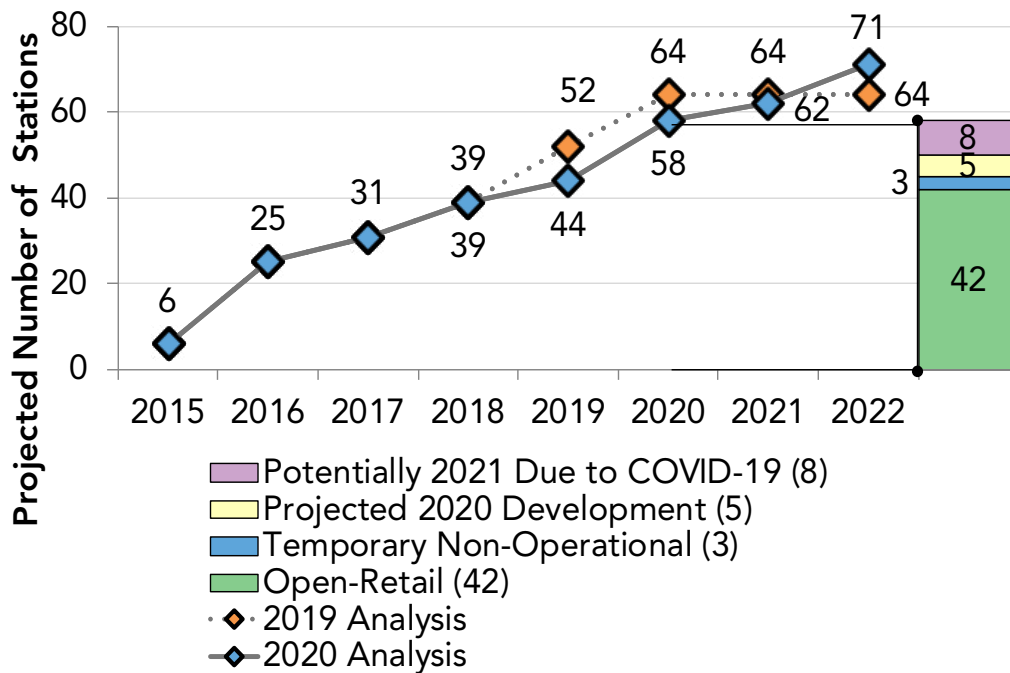
vehicles simultaneously, increased daily fueling capacity, and designs for improved operational resiliency and reliability.

Over the past year, the funded station network has also grown. Nine new station projects across northern and southern California, including one in Palm Springs, have begun planning and development as indicated by their inclusion in the LCFS HRI program. Together with the five newly opened stations and ongoing progress at the remaining stations in development, these have been positive advancements in the network over the past year. At the same time, the developer of the proposed Santa Nella station gave notice that the project will not move forward. The total network grew to 71 open and planned station projects (counting stations funded by AB 8 and stations initiated by the LCFS HRI provision).

## Finding 2: All stations funded and in development are projected to be Open-Retail by the end of 2022, even though progress in the past year exhibited delays and may be further affected by COVID-19

While important new additions were made to the Open-Retail station network over the past year, the pace of development was slower than previously projected. Figure ES 2 shows that eight fewer stations achieved Open-Retail status by the end of 2019 than were previously estimated. The station network did experience significant operational challenges over the summer of 2019 due to a disruption in the hydrogen supply network for California. This meant that several stations struggled to secure hydrogen fuel for customers and many temporarily ceased retail operations until the supply disruption was resolved. Therefore, the stations that were already open were most severely impacted by the supply disruption. However, there may have been some additional impacts on stations that were still in development. Station operators that were managing the impacts of the supply disruption on fueling customers were also often the same entities developing new stations at the same time and therefore faced elevated strain on their organizational resources to address several challenges at once. At the end of 2019, 44 stations (including the three awaiting a return to Open-Retail status) were included in California’s hydrogen fueling network instead of the projected 52.

**FIGURE ES 2: COMPARISON OF STATEWIDE FUNDED STATION PROJECTIONS BETWEEN 2019 AND 2020 ANNUAL EVALUATIONS<sup>3</sup>**



<sup>3</sup> Includes 62 stations funded by AB 8 and nine additional stations initiated by the LCFS HRI provision.



There may be further delays related to the COVID-19 pandemic that has affected economies worldwide. The latest pre-COVID projections show that up to 58 stations may achieve Open-Retail status by the end of 2020. Four more stations may open in 2021 and an additional nine in 2022. However, some station developers have indicated that COVID-19 may cause some near-term delays of up to six months, especially for station development projects under permitting review or stations awaiting equipment delivery from regions heavily affected by COVID-19. Using this as a worst-case estimate, CARB finds that up to eight stations that may have opened in 2020 under business-as-usual assumptions may therefore open in 2021 instead. Projections for additional station openings in 2020 are between six and fourteen. Estimates for new stations opening in 2021 are between four and twelve. The curve labeled 2020 Analysis in Figure ES 2 shows the maximum potential growth for 2020, while the corresponding bar chart indicates the potential delays due to COVID-19.

### **Finding 3: Auto manufacturer projections for FCEV deployment have shifted one year compared to prior estimates while maintaining the projected pace of acceleration**

Based on Department of Motor Vehicles (DMV) registration data, CARB estimates that the on-road FCEV fleet is 7,172<sup>4</sup> as of April 1, 2020. Based on the most recent survey of auto manufacturer FCEV deployment projections, California's FCEV fleet will grow to 27,000 and 48,900 in 2023 and 2026, respectively. These data are summarized in Figure ES 3. Red triangles show April registration data, with the most recent information highlighted by the large triangle. Data from auto manufacturer surveys are shown by the blue and orange shaded areas for Range of Mandatory and Optional Period data and the most recent values are highlighted by the corresponding diamonds labeled as End-of-Period Estimates. The ranges for each period represent the range of projections for each year based on the data from all past surveys that addressed that year. For example, projections for the year 2021 are addressed by Mandatory Periods in survey years 2018-2020 and Optional Periods in survey years 2015-2017.

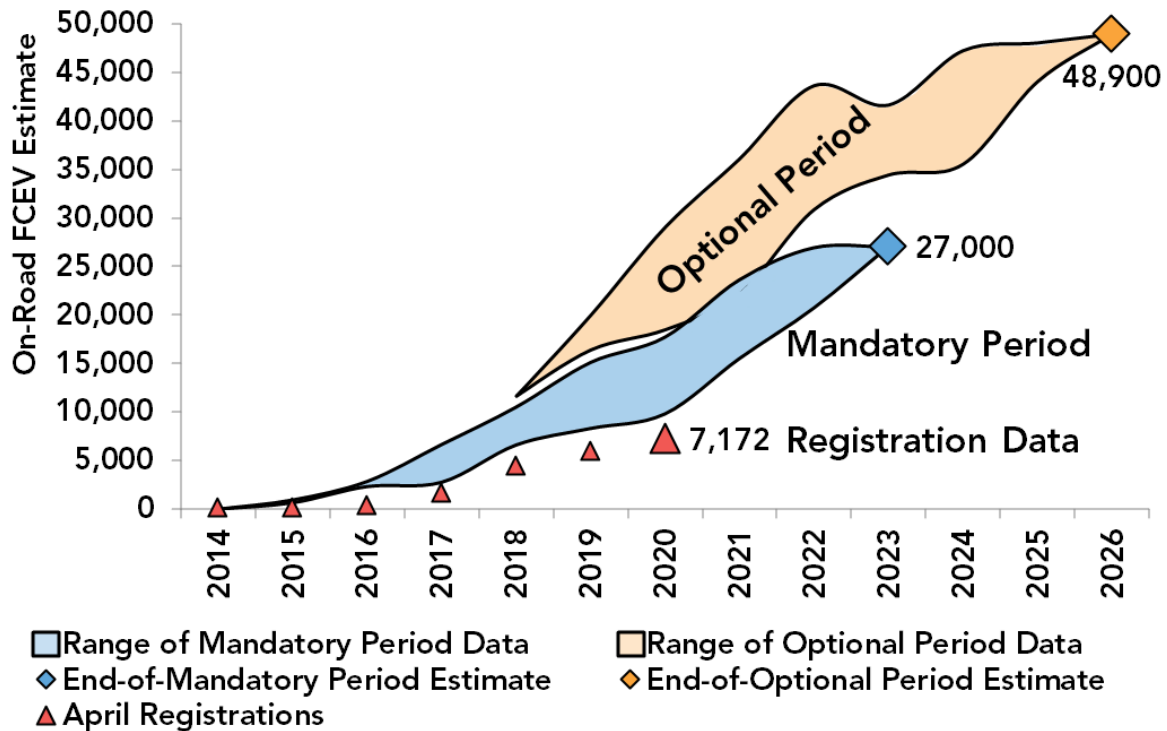
The latest projections for future deployments based on auto manufacturer survey responses continue last year's trend of anticipating FCEV deployment growth one year later than previously projected. Whereas observed shifts in projections were previously focused on the Optional Period, the most current survey anticipates this shift in both the near-term Mandatory and mid-term Optional Periods of the survey. While the schedule of projected deployment has changed, the pace of acceleration on the shifted schedule remains similar to prior years.

The rate of vehicle deployment between April 2019 and April 2020 was also 20 percent lower than the prior year according to the registration data. FCEV registrations in April and October have historically been lower than projections. This is true also for April 2020 registrations, though the situation is likely influenced by the difficulties presented by the hydrogen supply disruption in the second half of 2019 and the onset of the COVID-19 pandemic in early 2020. Even though registration data so far maintain a gap between actual and previously projected deployments, the match has been improving over time as April registrations in the period 2014 to 2020 have grown closer to the range of Mandatory Period projections for the same year. Registrations in April 2015 were only 27 percent of prior end-of-year projections; in 2020, April registrations are 73 percent of prior end-of-year projections.

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4 Industry estimates provided by the California Fuel Cell Partnership indicate cumulative sales of 8,363 across the United States as of June 1, 2020 [56]. The vast majority of these sales are in California and may differ from DMV registrations due to differences in the nature and timing of the data. CARB has also confirmed that California Fuel Cell Partnership data likely do not adjust fully for vehicle attrition.

**FIGURE ES 3: CURRENT AND PROJECTED ON-ROAD FCEV POPULATIONS AND COMPARISON TO PREVIOUSLY COLLECTED AND REPORTED PROJECTIONS<sup>5</sup>**



### Finding 4: Auto manufacturer survey responses align with projected station deployment

Since the publication of the California Fuel Cell Partnership’s A California Road Map, private and public stakeholders have recognized that FCEV deployment pace is in part dependent on the pace of station network development. State efforts to support hydrogen fueling station network growth, including AB 8, have adopted this thesis. The program was built upon the concept that fueling infrastructure development leads to FCEV deployment. Seven years into the program, it appears that auto manufacturer intentions for future FCEV deployment largely confirm this philosophy.

During the summer of 2019, CARB began a process of formal interviews with individual auto manufacturers. These interviews were prompted by CARB’s desire to review the 2019 auto manufacturer survey results and gain a more detailed understanding of the factors that affect on-the-road FCEV deployment and projections for future FCEV deployment. Through these interviews, multiple auto manufacturers commented that they remain committed to FCEVs in California and globally as a priority within their overall ZEV strategies. However, deployment projections are often led by auto manufacturers’ own evaluation of station development progress and projections of future station development pace. Deployment projections for FCEVs in any market are assessed on this basis and consider the context of similar developments in markets around the world. Auto manufacturers clearly state that changes in station network development pace (positive or negative) and other events that affect the network health (such as the 2019 hydrogen supply shortage) directly impact the associated projections of future FCEV deployments in California.

In addition to direct discussion with auto manufacturers, CARB finds that the history of FCEV deployment and station development projection data demonstrate a strong correlation. For example, the Road Map highlighted a total open station count around 60 (specifically 68 in the

<sup>5</sup> Please refer to prior year’s *Annual Evaluations* in order to obtain numerical values for all historical data points.

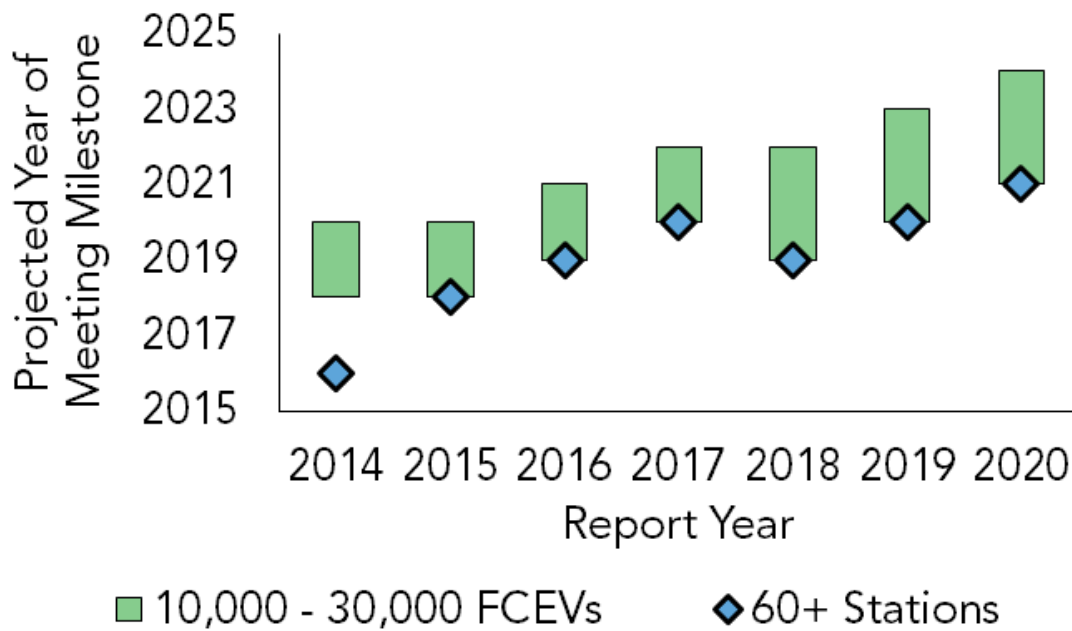
Road Map) as an important marker of significant station network development [47]. This magnitude of network development was characterized as the minimum number of stations to launch FCEV deployment and was associated with a notional cumulative vehicle deployment potential of 10,000-30,000 FCEVs.

Using these milestone markers, Figure ES 4 demonstrates how FCEV deployment projections closely track station network development projections. The expected date of achieving the 60+ station milestone has been revised from 2016 (as reported in 2014) to the current estimate of 2021. The development of this trend over time is similar to the progression of the projected date at which 10,000 - 30,000 FCEVs would be deployed; the bottom of the green bars indicates the projected year of achieving 10,000 FCEVs on the road while the top of the bar corresponds to 30,000 FCEVs.

For example, the 2015 Annual Evaluation estimated that 60+ stations would be achieved in 2018. In addition, the 10,000 FCEV milestone was projected to be crossed at the same time (2018), while 30,000 FCEVs were projected for 2020. In each of the next two reporting years (2016 and 2017), the projected date for achieving all three of these milestones increased by one year. In several years, the changes in the trends of these milestones are identical. For the milestone of 10,000 FCEVs, the projected date matches exactly with 60+ stations for all reporting years except 2014.

The correlation between these trends in projection data, in combination with confirmation through formal discussions with auto manufacturers, underscores the impact of station network development on the ability to deploy FCEVs in the future.

**FIGURE ES 4: PROJECTIONS OF ACHIEVING HYDROGEN STATION AND FCEV MILESTONES IN SUCCESSIVE ANNUAL EVALUATIONS**

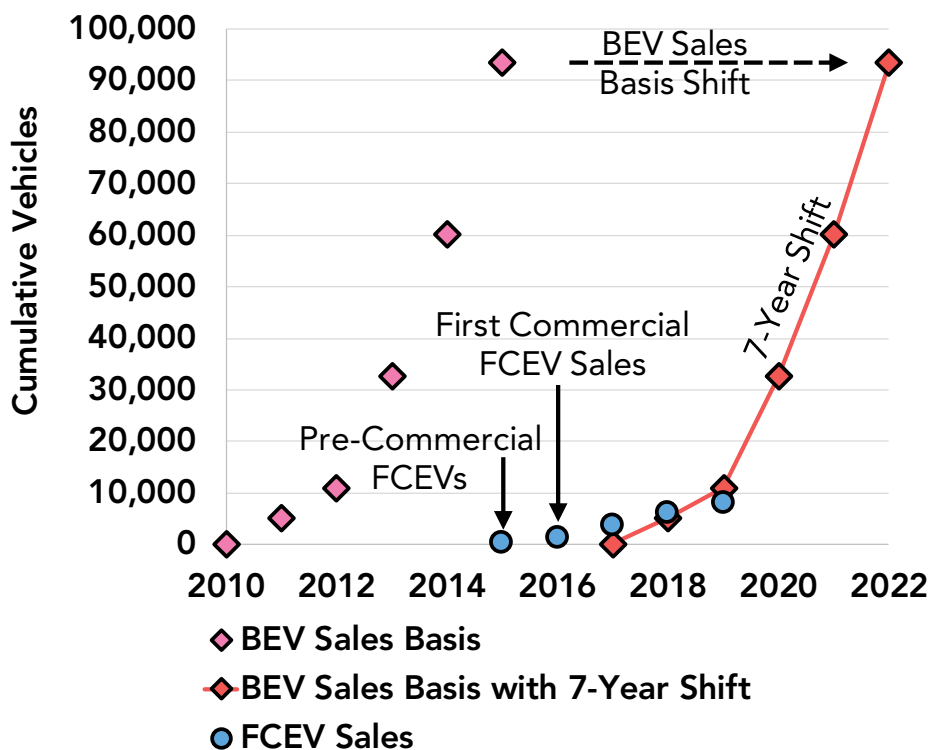


## Finding 5: Historical FCEV deployment data appear to follow a similar new technology adoption trend as battery electric vehicles and validate State efforts to continue funding hydrogen fueling stations

New technologies typically follow phased adoption that moves from a limited market of first adopters to broad, mass-market potential<sup>6</sup>. Deployment of the new technology typically exhibits points of acceleration as the market develops through successive phases of adoption. The current generation of Battery Electric Vehicles (BEVs) first launched in late 2010 with the introduction of the Nissan Leaf, and historical deployment data exhibit at least two of these accelerations. FCEVs were first broadly available to California consumers in 2016 and are currently in the earliest adoption phase. Significant State investment in hydrogen fueling station development has helped enable this early market deployment and further investments will provide the greatest benefit if FCEVs exhibit similar progression through market development phases. CARB has analyzed historical FCEV deployment trends and future FCEV projections based on annual survey data to assess whether each of these phases correlate well to the market development example presented by historical BEV deployment.

Figure ES 5 displays results of CARB’s analysis and highlights that the historical pace of FCEV deployment is similar to BEV deployment in the earliest market development years. The deployment curves are similar to date, only shifted in time. Historical FCEV deployment volumes on average are most similar to BEV deployment volumes seven years earlier, when BEVs were in the same deployment phase as the current FCEV market. For both technologies, cumulative deployment volumes grew to around 10,000 vehicles over the course of a few years during initial market launch.

**FIGURE ES 5: ANALYSIS OF HISTORICAL FCEV AND BEV EARLY-MARKET DEPLOYMENT RATES**



<sup>6</sup> See Chapter II of the 2014 *Annual Evaluation* for more detail.

Success of the FCEV market will depend on transitioning out of the earliest adopter phase and into more widespread appeal, just as the BEV market has achieved. The critical feature of this transition is an acceleration of deployment, or a “bend in the curve.” Acceleration of deployment indicates successful transition to a new phase of market development through broadening consumer acceptance. The California market for BEVs achieved the first such bend within four to five years after launch. Looking into the future, responses to annual auto manufacturer surveys indicate an acceleration in FCEV deployment over the next few years. If these vehicles are delivered to California on schedule as indicated by auto manufacturers, then the FCEV market will make a crucial acceleration in deployment as BEVs did seven years prior. The two technologies may target or eventually achieve different market sizes in terms of vehicle volumes and have different growth rates, but a successful and sustained technology launch requires accelerating market progression to increasingly larger groups of adopters, and both ZEV technologies exhibit this potential.

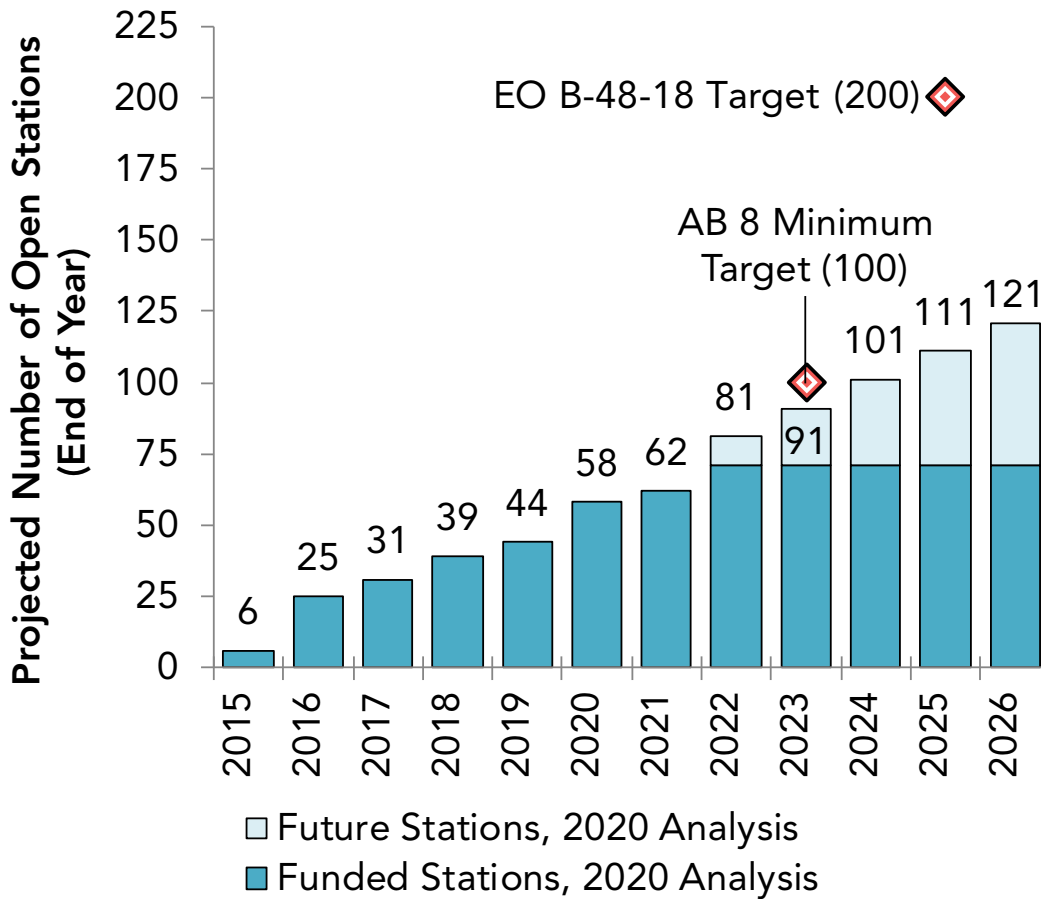
Both the historical record and projections demonstrate that the FCEV market development is accelerating according to a schedule that would be expected based on the example provided by BEVs seven years earlier. Ensuring that the FCEV market continues to expand and develop out of the earliest first-adopter phase and into the broader consumer market will depend on several supporting factors, including: station deployment, expansion of available FCEV makes and models, reduction in hydrogen sale price, and availability of consumer incentives.

Given the magnitude and pace of the light-duty fleet turnover that will be required to meet California’s various climate change mitigation and air quality improvement goals, the State continues to need to invest in all ZEV technologies that show promise of market growth and long-term success. BEVs and FCEVs remain complementary technologies in this regard and similarly demonstrate market expansion potential. FCEVs continue to show promise as part of the overall ZEV strategy for public and private stakeholders. Turning that promise into reality depends fundamentally on many factors including station development.

## **Finding 6: Acceleration of station network development is essential in the immediate future to reach State and industry goals**

The newly released GFO 19-602 is expected to help the State make considerable progress towards the goals of AB 8 and has the potential to deliver more than the minimum 100 station target. CARB also sees potential for the LCFS HRI program to work with the AB 8 grant funding mechanism and provide a means to reach the goal of 200 stations by 2025 outlined in Executive Order B-48-18. However, this potential progress will require strict adherence to station development timelines, especially given the short time left in the AB 8 program and the typical time required for stations to achieve Open-Retail status. Even achieving the minimum 100 stations by January 1, 2024 leaves little room for station development delays. As Figure ES 6 shows, achieving the goal of 200 stations by 2025 requires significant acceleration. Supporting broader targets such as the California Fuel Cell Partnership’s Revolution goal of 1,000 stations by 2030 requires a pace of development not yet seen within the industry. Mechanisms to accelerate station development appear necessary. The new structure of GFO 19-602 will help make funds available on a pace that helps support this acceleration more directly than past funding cycles, but there is also significant effort necessary to shorten station construction and permitting.

**FIGURE ES 6: PROJECTED STATION DEPLOYMENT TO MEET AB 8 AND EO B-48-18 COMPARED TO BUSINESS-AS-USUAL**

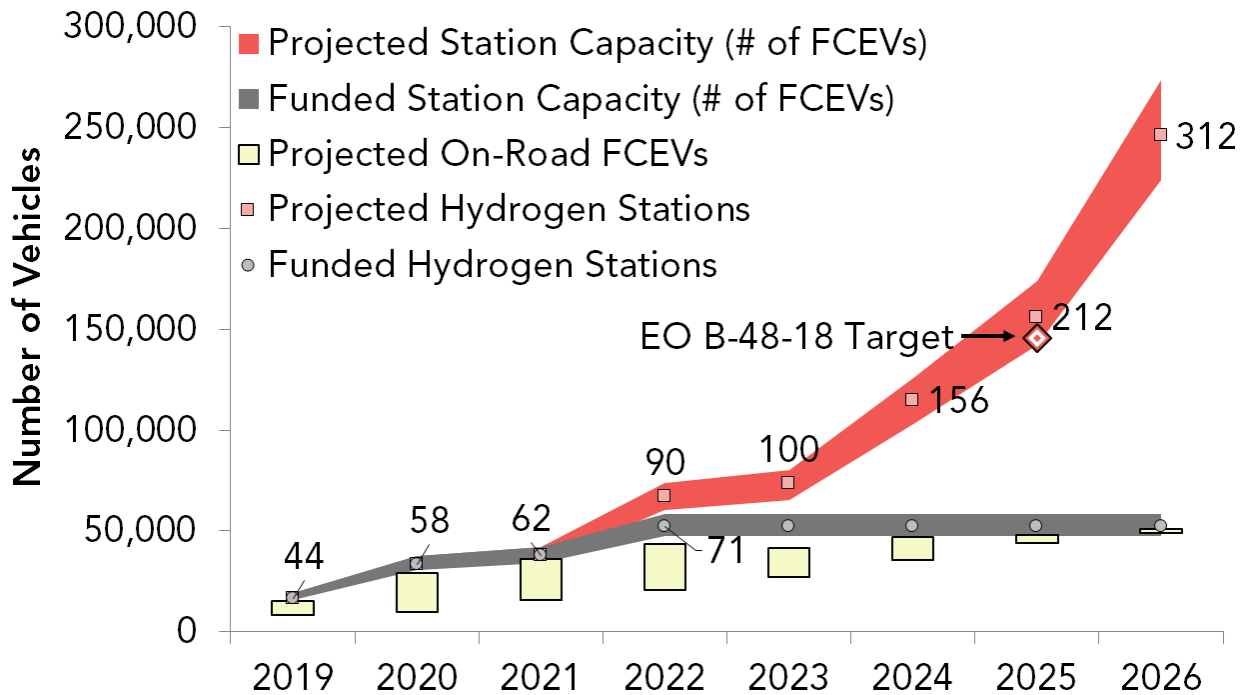


**Finding 7: Additional station funding remains necessary to achieve hydrogen station targets and enable vehicle deployments beyond current projections**

The aggregate statewide capacity of the 71 open and funded hydrogen fueling station network is closely matched to the fueling needs of the projected FCEV fleet through 2026, as shown in Figure ES 7.<sup>7</sup> The growth in individual station capacity and increased numbers of fueling positions in recent years (from early stations at 200 kg/day to the most recent stations at 1,200 or more kg/day) has had a significant impact on total hydrogen dispensing capacity in the state. Figure ES 7 also displays projected hydrogen station network development based on the pace required to meet or exceed the target of 200 stations in 2025 per Executive Order B-48-18 and maintaining a trajectory towards 1,000 stations as early as 2030. These projected station counts and capacity growth match the California Fuel Cell Partnership’s Revolution scenario, with details of the scenario development published in the 2018 Annual Evaluation.

<sup>7</sup> This finding is markedly different from the 2019 *Annual Evaluation*. Prior estimates demonstrated projected FCEV fuel demand outpacing funded station development. Updates to the capacities of most stations according to the new HySCapE tool have a significant effect on this difference.

**FIGURE ES 7: PROJECTED HYDROGEN DEMAND AND FUELING CAPACITY**



Since the total statewide capacity of the funded network is closely matched to the projected FCEV deployment, it implies that the funded station network does not support the deployment of more vehicles than projected. Since 2014, all Annual Evaluations have similarly demonstrated that the hydrogen demand associated with auto manufacturer FCEV projections matches or exceeds funded network capacity. This directly implies that the funded network capacity represents a restriction on the number of FCEVs projected in annual surveys and is a clear indication that additional station funding remains necessary through the AB 8 program.

The close match between network capacity of the 71 funded stations and projected FCEV fuel demand also implies that auto manufacturers' projections of future FCEV deployment potential do not account for additional network growth beyond the 71 funded stations through either the LCFS program or GFO 19-602, which is currently under review for grant awards for future station development. Taken together, these station funding mechanisms have the potential to increase the number of stations within the time horizon of the survey to at least 100 stations, but these considerations do not appear to be reflected in the responses. This is congruent with discussions CARB completed with auto manufacturers about their 2019 survey responses and more general FCEV plans<sup>8</sup>.

At more finely detailed regional and county levels, projections indicate that localized capacity deficits will occur by 2023 and extend into 2026 without adding new fueling capacity. As the network has developed over time and new markets are activated, the need to continue growth in these areas has increased. Core market areas in the Greater Los Angeles, Orange County, San Diego County, San Francisco Bay Area, and Sacramento regions see a need for additional station coverage and capacity even as development has progressed the most in these areas. Additional coverage and capacity needs are becoming apparent in the San Joaquin Valley, Central Coast Range, and Inland Desert regions<sup>9</sup>. A new priority area around the popular vacation and destination city of Palm Springs has also been identified. Needs for capacity growth in these areas may be partially or fully addressed by new stations funded under GFO 19-602, depending on where applicants choose to focus their efforts.

<sup>8</sup> See "Enhanced Review of 2019 Projections" for further details.

<sup>9</sup> See page 40 for the definitions of these regions. See Figure 20 and Figure 29 for maps of these localized coverage and capacity needs.

If the AB 8 program at least meets the minimal required 100 stations by the close of 2023, CARB estimates the full network will enable approximately 10,000 to 20,000 more vehicles to be deployed in California beyond current projections. However, greater acceleration is required to achieve the goals of EO B-48-18; the AB 8 and LCFS HRI programs serve as the primary means available to achieve these goals and both must be leveraged to develop as many stations as possible. Maximizing the funding available through GFO 19-602 and funding more than 100 stations total through AB 8 remains necessary to improve the chance of successfully meeting goals outlined in EO B-48-18. CARB estimates that a station network of 200 stations could enable up to 175,000 FCEVs on the road by 2025. This rate of growth is congruent with a market development pace and scale necessary to ultimately achieve fueling network self-sufficiency within the decade.

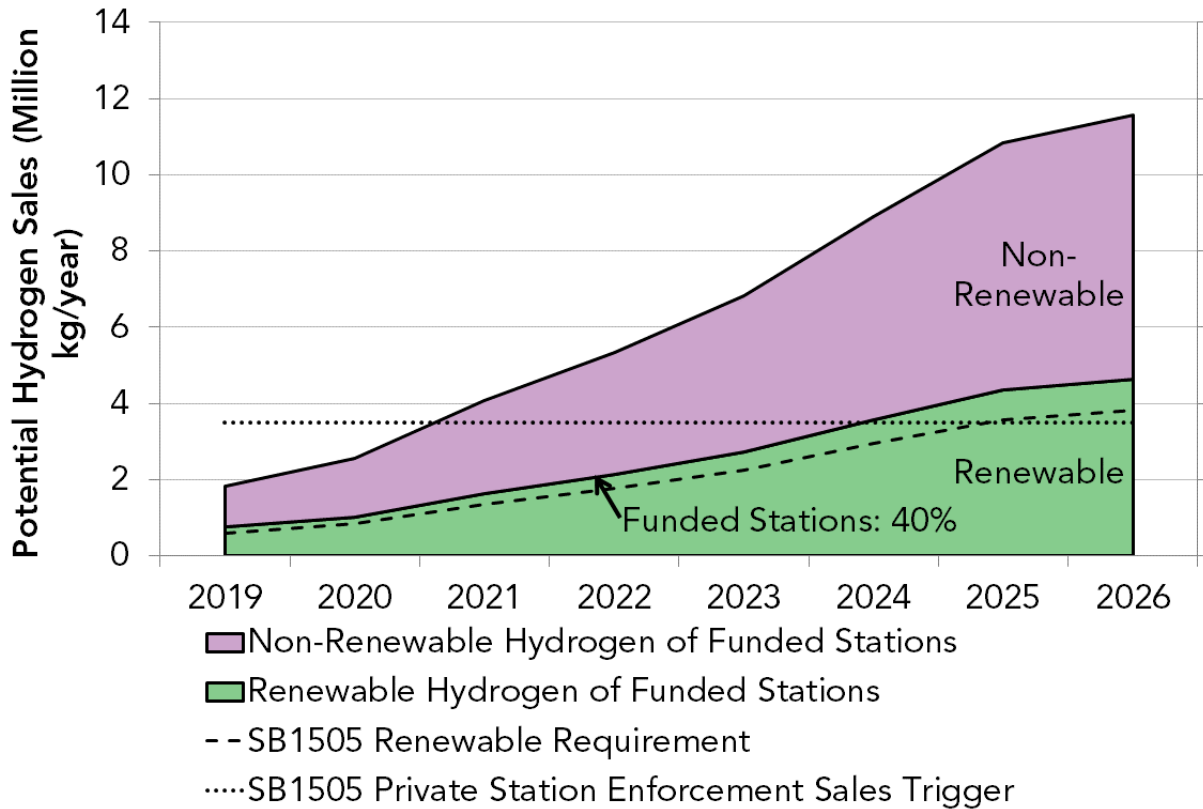
## **Finding 8: Sourcing of renewable energy and feedstocks to support California's growth in hydrogen fuel demand continues to grow due to industry efforts and State incentives**

Evaluation of the minimum renewable content of fuel sold at California's retail hydrogen fueling station network continues to demonstrate compliance with the 33 percent renewable requirement of Senate Bill 1505 (SB 1505; Lowenthal, Chapter 877, Statutes of 2006) [48]. Station operators have historically met or exceeded this requirement, and revised evaluations continue to find this to be the case presently and for the near future. Partly due to the requirements of the LCFS HRI program, the current open and funded station network is expected to dispense at least 40 percent renewable hydrogen, as shown in Figure ES 8. This is expected to continue, as the minimum renewable content required for both GFO 19-602 and the LCFS HRI program is 40 percent. As the hydrogen fueling station industry has largely embraced the LCFS program (especially the HRI provision), CARB expects that most stations in the future will continue to enroll in the program and dispense hydrogen with at least 40 percent renewable sourcing. Some operators of Open-Retail stations have recently reported that they've achieved 100 percent renewable implementation at all their stations in California in recent quarters. While this cannot yet be assumed for future operations, the combined capacity of these operators' stations demonstrates that California's network has recently been dispensing up to 90 percent renewable hydrogen [49] [50]. Given that station operators indicate this may be a temporary situation, Figure ES 8 does not depict the recent quarters of 90 percent renewable implementation. Instead, the figure depicts the minimum renewable amount guaranteed by requirements of AB 8 funding solicitations and the LCFS HRI program as appropriate for each funded station.

A minimum requirement of 33 percent renewable content per SB 1505 is currently only applicable to stations receiving State funding, but will apply to all stations in the State regardless of funding source once the total annual hydrogen fuel dispensed in the state exceeds 3.5 million kilograms in a year. Accounting for the revised station capacities and future vehicle projections, CARB now estimates the 3.5 million kilogram threshold will be reached near the end of 2021, not accounting for any fuel dispensed to vehicles outside the light-duty vehicle market.



**FIGURE ES 8: EVALUATION OF MINIMUM RENEWABLE HYDROGEN CONTENT IN CALIFORNIA'S FUELING NETWORK<sup>10</sup>**



## Conclusions

The period of June 2019 to June 2020 has been challenging for developing the hydrogen fueling and consumer FCEV industries in California. Progress has continued in these markets, but prior estimates of station development pace have not been met in some cases and FCEV deployment appears likely to continue at a slightly slower pace than previously projected based on annual auto manufacturer surveys. Despite challenges encountered over the past year, the on-the-road FCEV population has grown and auto manufacturers continue to communicate their intentions that the market will continue to grow into the future. Station network development continues to be a driving force in auto manufacturers' considerations for future FCEV market potential in the state, and discussions with these companies provide assurance that difficulties experienced in the early market may be overcome with accelerated network growth in the present and future.

The hydrogen fueling station network is expected to continue to grow over the next few years, which will enable FCEVs to be deployed at least at the pace that auto manufacturers have most recently indicated through the annual survey process, if not more. Ongoing discussions with industry representatives indicate that accelerated station deployment can result in future FCEV population growth faster than has been communicated to date. Auto manufacturers continue to express their commitment to deployment of FCEVs, but acknowledge that station development continues to be the primary consideration in their vehicle plans. Continued and accelerated development of hydrogen fueling stations will be necessary for auto manufacturers to act with increased confidence

<sup>10</sup> Note that this analysis is statewide and does not consider the details of individual station utilization. The methodology considers the capacity of stations to be funded and built in the future, but attributes sales to funded stations before future stations. Because of the noted match between funded capacity and projected vehicle demand, the analysis this year becomes based solely on funded stations. CARB does expect future station capacity to be utilized, even though it is not shown in the figure.

in California's market and plan on deploying larger numbers of FCEVs in the state. Applications to the Energy Commission's latest solicitation, focused on accelerating towards hydrogen station industry economies of scale (GFO 19-602), are currently under review. As funding awards are announced and station development begins, the auto manufacturers may see greater opportunity for future FCEV deployment within the state.

California's goals for hydrogen fueling stations and ZEV deployment are the most aggressive in the country. Given the status of network development and FCEV deployment, achieving these targets requires considerable effort. AB 8 has set a goal of at least 100 Open-Retail hydrogen fueling stations by January 1, 2024 and EO B-48-18 expands that goal to 200 stations by 2025. Both of these targets require acceleration of station network support programs and the on-the-ground station development process. CARB recommends utilizing AB 8 funds to support the development of as many stations as possible beyond the 100 station minimum target in order to advance the California station network as close as possible to the 200 station goal of EO B-48-18. It also appears that additional innovation in both the private and public sectors may be necessary to ensure these targets remain achievable. Developments over the next year may provide further insight into the mechanisms and efforts that will prove successful and may illuminate a path towards greater FCEV market expansion through and beyond the current early adopter market phase.



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# Introduction

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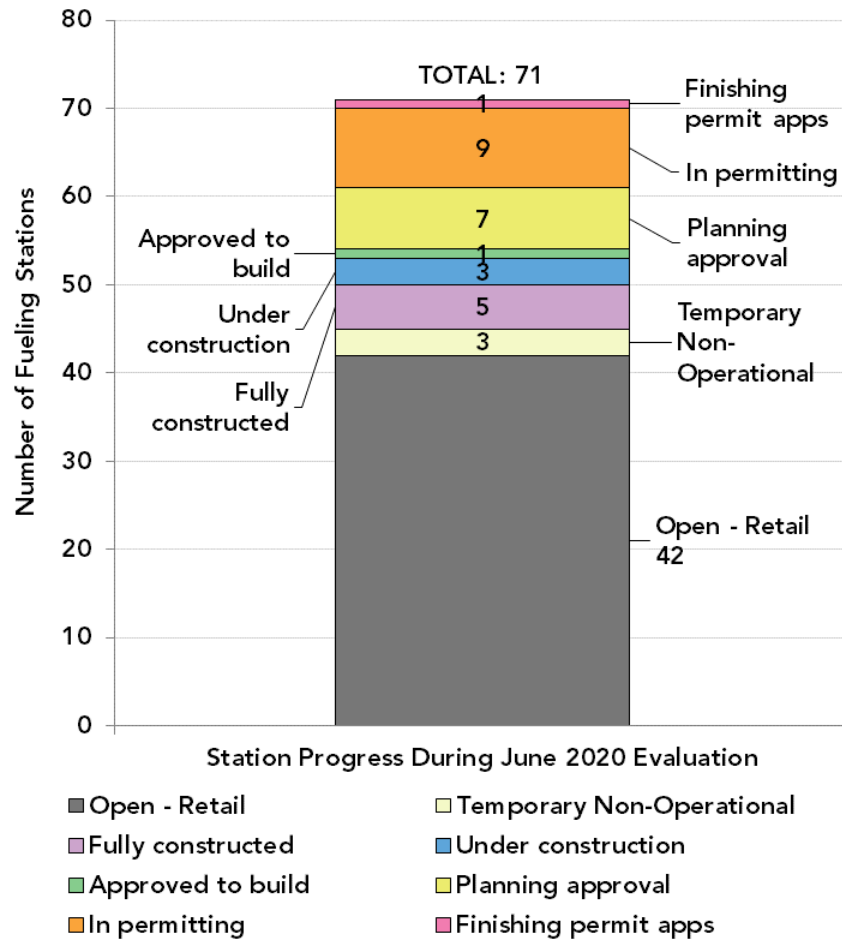
Hydrogen fueling network development and FCEV deployment have continued to progress in the past year, even in the face of significant local and global challenges. Both vehicle deployment and station network development have appeared to slow in the past year compared to prior published estimates, but progress has nonetheless continued. Both these trends are likely to have been influenced by the hydrogen fuel supply shortage of late 2019 and the current COVID-19 pandemic affecting industries across the globe. These challenges come at a critical point in the market development of hydrogen transportation fuel and FCEVs. Even in California, these industries remain in the earliest stages of commercial operation and are currently developing around the earliest adopter market.

The jump from launching the commercial market to reaching the demands of all first-adopters and moving towards the broader mass-market takes time for all new technologies, and every step of progress is critical along this path. CARB and industry stakeholders continue to see the potential for this jump on the horizon, especially as new station network funding opportunities are now available through GFO 19-602 and the LCFS HRI program. Auto manufacturers with commercial products have announced imminent growth in production capacity on the scale of ten times what was available for first-generation vehicles like today's Honda Clarity and Toyota Mirai, and the pre-commercial market Hyundai Tucson Fuel Cell [51], [52]. Hydrogen fuel providers have announced plans for fuel production facilities that strengthen the supply chain for California's FCEV market and provide enough additional capacity to enable market growth even beyond the most recent FCEV deployment projections [53], [54]. While there have been significant challenges faced in the past year, these remain equally substantial signals that momentum continues in the FCEV and hydrogen fueling sectors.

This report is the seventh edition of CARB's Annual Evaluation, covering the period of June 2019 through June 2020. The analyses and findings represent CARB's most recent assessment of the status and future outlook of FCEV deployment and hydrogen fueling station network development in the state of California through 2026. CARB's work is informed by collaborative efforts with fellow State agencies, such as the California Energy Commission, and several individual businesses and collective organizations within the hydrogen fueling and FCEV markets. CARB's assessments most directly address the current status, ongoing development, and future needs to support in-state light-duty FCEV deployment. Analysis focuses especially on the metrics of hydrogen fueling station network coverage and capacity and how these compare to the current and projected needs of retail hydrogen fuel consumers. However, as in prior Annual Evaluations, CARB provides additional context with respect to other sectors where fuel cells and hydrogen are currently being developed and for additional concerns and analyses pertinent to light-duty FCEV deployment.

# Station Network Progress

**FIGURE 1: HYDROGEN FUELING STATION NETWORK STATUS AS OF JULY 3, 2020**



Over the past year, station network development has continued to progress. Four additional stations have achieved Open-Retail status. However, CARB and the Energy Commission now identify three previously open stations as temporarily non-operational with an unknown or uncertain date for resuming retail hydrogen stations. One of these stations (Newport Beach) is in the process of a privately funded upgrade; the other two stations (Riverside and Ontario) have ceased operations due to equipment and supplier difficulties and a resolution date is not yet apparent. At the same time, one Open-Retail station (West LA) has closed since the owner of the host location sold the land for redevelopment. Thus, the total number of Retail-Open hydrogen fueling stations is 42 because CARB currently reports the three non-operational stations in a separate category. (Note that the Station Operational Status System (SOSS) managed by the California Fuel Cell Partnership lists the CSULA station as a Legacy Retail station distinct from the remaining Open-Retail stations; CARB does not make this distinction).

In addition to the newly opened stations, development has continued for most of the remaining funded stations. Many stations that had previously been in the Planning Approval phase a year ago have now advanced closer to opening for public retail operations. In addition, nine new stations have been added to the planned network since they have been approved to participate in the LCFS HRI provision and had not previously received a grant from the Energy Commission through the AB 8 program. On the other hand, the Santa Nella station previously awarded grant funding by the Energy Commission is no longer expected to proceed. There has also been one station that has

been proposed to be replaced by a project in another location. Thus, the total number of stations open and under development in California's network has grown from 64 to 71. The latest status of network development is shown in Figure 1. In addition to the 42 currently Open-Retail and the three identified as Temporary Non-Operational, six stations have completed construction and an additional three have construction underway. Seventeen stations are in some phase associated with the planning approval and permitting process while the final station is completing permitting applications and documents for submittal to the local Authority Having Jurisdiction (AHJ).

## Energy Commission GFO 19-602 Launched

On December 26, 2019, the California Energy Commission officially released GFO 19-602, the latest grant solicitation for light-duty hydrogen fueling stations. The final solicitation was largely similar to the Draft Solicitation Concepts released on January 23, 2019. In particular, GFO 19-602 focuses on helping to advance the hydrogen refueling industry within California towards economies of scale. Several features of the structure and process of the solicitation enable a focus on achieving that goal.

First, the solicitation is structured as a multi-year award, enabling successful applicants to plan the development of their own hydrogen fueling sub-network over the course of the remaining years of the AB 8 program. This provides the ability for equipment purchases at larger volume and greater self-determination of total business potential. Applicants provide an overall multi-year plan for the development of a tranche of stations, with these stations divided into sequential batches to be developed together. Only the first batch is required to be fully specified with addresses and capacities for all stations at the time of application and award. Subsequent batches are specified and awarded as applicants complete development of each batch in sequence in their tranche.

Second, while \$45.7 million are available immediately through GFO 19-602, the solicitation also makes its intent clear to make up to \$115.7 million available through the end of the AB 8 program, pending appropriations to the Clean Transportation Fund and allocations guided by the program's Advisory Board enable these allocations. This would represent the maximum available to hydrogen fueling stations through the end of the program at the allowable \$20 million per year provided by AB 8.

Third, evaluation of station location within the solicitation adopts CARB's recommended streamlined pre-calculated method reported in the 2019 Annual Evaluation. Through this method, applicants must verify that their locations are in an eligible area and meet minimum capacity requirements as determined by an analysis that incorporates current network development and the 2030 network potential portrayed in the California Fuel Cell Partnership's California Fuel Cell Revolution. At the outset of the solicitation, there are very few locations for which stations with larger capacity (greater than 450 kg/day) and corresponding higher numbers of fueling positions (three or more) are more strongly recommended. As the network grows and future batches are completed, locations recommended for higher capacity will become more common. As long as an applicant's stations are verified to be in agreement with the pre-calculated requirements, they are eligible for award and scoring will be based in part on the degree to which stations exceed these metrics and the additional narrative justification the applicant provides.

Finally, the solicitation encourages economic competition. There is no set maximum award amount for equipment costs covered by the solicitation, other than a limit that no single awardee can receive more than 50 percent of the total funds available. In addition, project budget and project readiness are emphasized in application scoring. This structure encourages applicants to carefully consider the competitiveness of their bids and the total financial request they make for State funds.

Applications were due May 22, 2020 and are currently under review. The Energy Commission's most recently posted schedule anticipates announcements of awards in July of 2020.

## Allocation of Volkswagen Environmental Mitigation Trust Funds to Hydrogen Infrastructure

The Environmental Mitigation Trust is an element of the settlement with auto manufacturer Volkswagen for its use of an illegal defeat device in certain diesel vehicles, and provides approximately \$423 million for California to fully mitigate the lifetime excess oxides of nitrogen emissions caused by those vehicles. Appendix D of the Consent Decree approved by the United States District Court, Northern District of California, identifies the eligible mitigation actions that can be funded by the Trust. Eligible actions include heavy-duty scrap and replace projects as well as light-duty infrastructure development. As the Lead Agency for implementing California's Trust allocation, CARB developed California's Beneficiary Mitigation plan that details eligible mitigation actions California will fund with this money [55]. In 2018, CARB selected the Bay Area Air Quality Management District (BAAQMD) to administer, on a statewide basis, \$10 million of California's Trust funds for light-duty ZEV infrastructure projects (equally allocated between electric vehicle charging stations and hydrogen refueling stations). On February 20, 2020, the Energy Commission approved an agreement with BAAQMD that \$5 million from this fund will be used for the development of hydrogen refueling stations under the currently open GFO 19-602. Under the Consent Decree, these funds must be in addition to the funds already available for GFO 19-602 and are expected to help the solicitation fund a greater number of hydrogen refueling stations<sup>11</sup>. The Energy Commission has highlighted that cooperation with BAAQMD, to implement CARB's mitigation plan, will ensure that hydrogen refueling infrastructure decisions are optimized to meet the complementary objectives of the BAAQMD and the Energy Commission.

## LCFS HRI Program Update

In Q1 2019, the LCFS program launched its HRI provision. The provision allows station developers to generate additional LCFS credits based on the difference between the station capacity and the station's sales of hydrogen. The sale of LCFS credits represents an additional income stream and present a constant generation potential for each station. Combined with the AB 8 station grant program, this provision aims to help the State achieve the 200 station goal of Executive Order B-48-18. Because of the structure of the LCFS program and the HRI provision eligibility, it may also achieve one or more additional goals, including: 1) deploying larger stations earlier in network development, 2) accelerating the use of renewable energy in hydrogen production, 3) accelerating the reduction of carbon emissions associated with hydrogen fuel production, and 4) reducing the consumer-facing price of low-carbon hydrogen.

At the time that the 2019 Annual Evaluation was written, 31 stations had been approved to generate HRI credits in the LCFS program. All 31 of those stations had been funded by the Energy Commission's grant funding program, and most of them had been open to the public at the time of the report. As of May 6, 2020, there are now 48 stations participating in the HRI provision, as shown in Table 1. Notably, nine of those stations (eight from station developer and operator FirstElement Inc. and one from United Hydrogen) are the first stations to participate in the program without having first received grant funding through the Energy Commission. In total, over 31,000 kilograms of daily dispensing capacity are currently approved, nearly triple the capacity of a year ago.

**TABLE 1: STATIONS APPROVED FOR LCFS HRI CREDIT AS OF MAY 6, 2020**

Applicant Entity	Station Name	Station Address	City	HRI Refueling Capacity (Kg/day)	Effective Date Range for HRI Crediting
First Element Inc.	Truckee	12105 Donner Pass Rd	Truckee	266	04/01/2019 - 03/31/2034
First Element Inc.	Coalinga	24505 W Dorris Ave	Coalinga	266	04/01/2019 - 03/31/2034
First Element Inc.	Santa Barbara	150 South La Cumbre Rd	Santa Barbara	266	04/01/2019 - 03/31/2034
First Element Inc.	Thousand Oaks	3102 E Thousand Oaks Blvd	Thousand Oaks	266	04/01/2019 - 03/31/2034
First Element Inc.	Mill Valley	570 Redwood Hwy	Mill Valley	266	04/01/2019 - 03/31/2034
First Element Inc.	Playa Del Rey	8126 Lincoln Blvd	Los Angeles	266	04/01/2019 - 03/31/2034
First Element Inc.	Hollywood	5700 Hollywood Blvd	Los Angeles	266	04/01/2019 - 03/31/2034
First Element Inc.	Del Mar	3060 Carmel Valley Rd	San Diego	266	04/01/2019 - 03/31/2034
First Element Inc.	Fremont (Grimmer)	41700 Grimmer Blvd	Fremont	266	04/01/2019 - 03/31/2034
First Element Inc.	Hayward	391 W A St	Hayward	266	04/01/2019 - 03/31/2034
First Element Inc.	South San Francisco (Airport)	248 S Airport Blvd	South San Francisco	266	04/01/2019 - 03/31/2034
First Element Inc.	South Pasadena	1200 Fair Oaks Ave	South Pasadena	206	04/01/2019 - 03/31/2034
First Element Inc.	Campbell (Winchester)	2855 Winchester Blvd	Campbell	266	04/01/2019 - 03/31/2034
First Element Inc.	La Canada Flintridge	550 Foothill Blvd	La Cañada Flintridge	266	04/01/2019 - 03/31/2034
First Element Inc.	Lake Forest	20731 Lake Forest Dr	Lake Forest	266	04/01/2019 - 03/31/2034
First Element Inc.	Costa Mesa	2050 Harbor Blvd	Costa Mesa	266	04/01/2019 - 03/31/2034
First Element Inc.	Long Beach	3401 Long Beach Blvd	Long Beach	266	04/01/2019 - 03/31/2034
First Element Inc.	Saratoga	12600 Saratoga Ave	Saratoga	198	04/01/2019 - 03/31/2034
First Element Inc.	San Jose	2101 N 1 <sup>st</sup> St	San Jose	266	04/01/2019 - 03/31/2034
Shell Inc.	3 <sup>rd</sup> St	551 3 <sup>rd</sup> St	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	Bernal Rd	101 Bernal Rd	San Jose	513	04/01/2019 - 03/31/2034



Applicant Entity	Station Name	Station Address	City	HRI Refueling Capacity (Kg/day)	Effective Date Range for HRI Crediting
Shell Inc.	Citrus Heights	6141 Greenback Lane	Citrus Heights	513	04/01/2019 - 03/31/2034
Shell Inc.	Fair Oaks	3510 Fair Oaks Blvd	Sacramento	513	04/01/2019 - 03/31/2034
Shell Inc.	Harrison	1201 Harrison St	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	Mission St	3550 Mission St	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	University Berkeley	1250 University Ave	Berkeley	513	04/01/2019 - 03/31/2034
Air Liquide Hydrogen Energy US LLC	LAX	10400 Aviation Blvd	Los Angeles	200	04/01/2019 - 03/31/2034
First Element Inc.	Sherman Oaks	14478 Ventura Blvd	Sherman Oaks	808	07/01/2019 - 06/30/2034
First Element Inc.	Oakland	350 Grand Ave	Oakland	808	07/01/2019 - 06/30/2034
First Element Inc.	Studio City	3780 Cahuenga Blvd	Studio City	808	07/01/2019 - 06/30/2034
Air Liquide Hydrogen Energy US LLC	Palo Alto	3601 Camino De Real St	Palo Alto	136	07/01/2019 - 06/30/2034
Air Liquide Hydrogen Energy US LLC	Santa Nella	12754 State Hwy 33	Santa Nella	275	10/01/2019 - 09/30/2034
First Element Inc.	Sunnyvale	1296 Sunnyvale Saratoga Rd	Sunnyvale	1200	10/01/2019 - 09/30/2034
First Element Inc.	Campbell (Hamilton)	337 East Hamilton Ave	Campbell	1200	10/01/2019 - 09/30/2034
First Element Inc.	Culver City	11284 Venice Blvd	Culver City	1200	10/01/2019 - 09/30/2034
First Element Inc.	Fountain Valley	18480 Brookhurt St	Fountain Valley	1200	10/01/2019 - 09/30/2034
First Element Inc.	Mission Hills	15544 San Fernando Mission Blvd	Mission Hills	1200	10/01/2019 - 09/30/2034
First Element Inc.	San Diego	5494 Mission Center Rd	San Diego	1200	10/01/2019 - 09/30/2034
First Element Inc.	Redwood City (Whipple)	503 Whipple Ave	Redwood City	1200	01/01/2020 - 12/31/2034
First Element Inc.	Concord	605 Contra Costa Blvd	Concord	1200	01/01/2020 - 12/31/2034
First Element Inc.	Aliso Viejo	26813 La Paz Rd	Aliso Viejo	1200	01/01/2020 - 12/31/2034
First Element Inc.	Baldwin Park	14477 Merced Ave	Baldwin Park	1200	01/01/2020 - 12/31/2034

Applicant Entity	Station Name	Station Address	City	HRI Refueling Capacity (Kg/day)	Effective Date Range for HRI Crediting
First Element Inc.	Costa Mesa (Bristol)	2995 Briston St	Costa Mesa	1200	01/01/2020 - 12/31/2034
First Element Inc.	Cupertino	21530 Stevens Creek Blvd	Cupertino	1200	01/01/2020 - 12/31/2034
First Element Inc.	Orange	615 S Tustin St	Orange	1200	01/01/2020 - 12/31/2034
First Element Inc.	Placentia	313 W. Orangethrope Ave	Placentia	1200	01/01/2020 - 12/31/2034
First Element Inc.	San Jose (Snell)	3939 Snell Ave	San Jose	1200	01/01/2020 - 12/31/2034
First Element Inc.	San Diego (W. Washington)	1832 W. Washington St	San Diego	1200	01/01/2020 - 12/31/2034
United Hydrogen	Palm Springs	20 <sup>th</sup> Ave - Indian Canyon & I-10	Palm Springs	783	01/01/2020 - 12/31/2034

## Hydrogen Fueling Network Self-Sufficiency Assessment Update

In addition to the annual assessment and reporting of the Annual Evaluations and Joint Agency Staff Reports, AB 8 directs CARB and the Energy Commission to evaluate network development conditions that lead to industry financial self-sufficiency. Evaluation is directed towards estimating the State investment timeline that supports market growth and maturity to a point where additional State assistance is no longer needed and further development can be fully privately funded. The effort is focused on quantifying the total amount of funds that might be necessary to achieve this goal in various future scenarios of network development and the time horizon through which the funds may be needed. CARB has continued to make progress on this assessment over the past year. As reported in the 2019 Annual Assessment and prior reports, CARB and the Energy Commission have completed several steps in this multi-year process, including:

- Surveyed and interviewed over a dozen stakeholder companies on various aspects of the hydrogen station network business, key metrics of a profitable station, and considerations that affect the overall financial evaluation for continued investment. Results were reported in Annual Evaluations and Joint Agency Staff Reports in 2017 through 2018.
- Developed a “version 1” financial model, presented to industry and government stakeholders, and solicited feedback from interested companies through written communication and a second round of interviews. Major features of the methodology and preliminary findings were reported in the 2019 Annual Evaluation.
- Based on feedback to “version 1” and further refinements, CARB developed “version 2” and completed sensitivity studies and investigations of select policy-informing considerations.

CARB is currently in the process of developing a draft technical report of the methodology and findings of this effort. The draft report may be completed in the fall of 2020, with an accompanying public release. CARB anticipates a period of public comment and will invite third-party expert review of the study’s methodologies following release of the draft final report. If appropriate, CARB will make adjustments to the study methods and/or complete additional investigations and analyses.

## COVID-19 IMPACTS AND HOW THEY HAVE BEEN ADDRESSED IN THIS REPORT

The onset of the COVID-19 pandemic has had an undeniable impact on daily life in 2020, and many experts anticipate lasting impacts to several sectors of the US and global economies. The automotive sector has already reported extensive impacts as the virus first spread across the globe in March and April of 2020 [56]. The total long-term effects are yet to be seen but there is potential that outside of any other influence, the automotive industry may be impacted for some time. More likely than not, this will affect FCEVs just as much as conventionally fueled vehicles and other alternative fuel vehicles like BEVs. There is little clarity at this time, but there may be similar impacts on the hydrogen fueling station and hydrogen fuel supply and distribution industries, as well.

The magnitude and scope of total impacts on the industry and future development within California are difficult to predict, especially for a situation that remains in flux at the moment. CARB has not attempted to make any predictions related to the potential impacts of COVID-19 on the deployment of hydrogen fueling stations and FCEVs in the coming years. However, a few accommodations have been made in order to provide some sense of the potential near-term impact:

- Information that comes directly from industry members (like auto manufacturer survey responses, or one-on-one discussions about station development status) are assumed to already include the industry's best estimate of the impact of COVID-19.
- CARB understands from discussions with industry members that there are potential station development impacts due to COVID-19. CARB has estimated the potential impact as a 6-month delay for all stations currently in development. This is reflected in Figure ES 2.
- The nine stations initiated through the HRI program are the most recent additions to the planned hydrogen fueling network. Given their early stage of progress and the historical uncertainty in station development schedules, CARB has adopted a conservative estimate for their Open-Retail date. In this report, CARB assumes the latest completion date allowable under the regulation for these stations to remain eligible to generate credits, which is 2022.

## ENERGY COMMISSION SELECTS HYDROGEN ENERGY STORAGE PROJECTS FOR CO-FUNDING

On April 8, 2020, the Energy Commission announced a Notice of Proposed Award (NOPA) for two hydrogen energy storage projects under GFO 19-305. The solicitation was part of a larger effort to raise the Technology Readiness Level of emerging energy storage technologies, with the goal of accelerating their progress towards commercialization and expanded market penetration. Energy storage is seen as a key enabler of increasing the use of renewable electricity generation to power many sectors of the economy, including residential, commercial, and industrial buildings and zero-emission vehicle fuel. The intermittency of renewable electricity generation technologies like solar photovoltaic and wind power presents a challenge for maintaining electric grid stability since the electric generation potential of these technologies is not controllable and does not always match the timing of demand. Energy storage is a potential solution with promise for bridging this gap; renewable electricity can be stored at times when it is generated but not needed and then later used when demand is greater than generation.

When surveying the available energy storage technology solutions and assessing the State's need for solutions, the Energy Commission found that future energy storage demands "cannot be met with currently fielded technologies alone, because they do not have the energy density, daily cycle capability, longevity, safety, and price to be viable for the diverse set of applications that will be needed in the State [57]. Noting that "[t]he timing is right for supporting emerging technologies that can out-perform existing energy storage technologies because a substantial amount of the energy storage in California was installed in the last few years and will need to be upgraded or replaced in the next 7-15 years," the Energy Commission developed GFO 19-305 as an opportunity to develop new solutions to this pending challenge [57]. GFO 19-305 specifically focused on developing non-lithium ion energy storage technologies and included a category for green electrolytic hydrogen storage systems. The Energy Commission received eight applications for these green electrolytic hydrogen energy storage projects and proposed awards for two finalists.

One award, to be completed by T2M Global, is for a technology development project with the goal of helping the company validate its technology and develop designs for large-scale (100 kW) units. T2M proposes the development of a waterless Advanced Electrolyzer System (AES); the electrolyzer is powered by renewable electricity and dilute hydrogen streams provided by waste-to-gas facilities such as biomass gasifiers or the tri-generation technology previously demonstrated at the Orange County Sanitation District facility in Fountain Valley. The AES incorporates both an electrolyzer and fuel cell to offer a packaged solution to address intermittent renewable electricity management, provide direct-current (DC) power needs to microgrids and disadvantaged communities in more remote and fire-prone areas, and potentially supply fuel for FCEVs. The target system design will be capable of producing up to 250 kg of hydrogen per day and operate with a low electrical energy requirement of 10 kWh/kg (compared to current water-based electrolyzers that require 50 or more kWh/kg).

The second award has been proposed for a technology demonstration project to be completed by DasH2Energy in cooperation with the Palmdale Water District. The project partners will demonstrate a wind-to-hydrogen energy storage system, claimed to be the state's first integrated power-to-power electricity storage system based on green electrolytic hydrogen. The project's energy storage system will be integrated with an existing 1 MW wind power installation. Southern California Edison and the California Independent System Operator will also participate in demonstrating several potential benefits of the installation, including: voltage support, state-of-charge management, demand charge reductions, backup power, time-of-use bill management, increased solar photovoltaic use, 24-hour backup power during wildfire season, and hydrogen's potential role in distribution deferral and public safety power shutoff events.

# Location and Number of Fuel Cell Electric Vehicles

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

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

## Information Sources for FCEV Projections

As required by statute in AB 8, CARB bases its analysis of current and future FCEV deployment on two data sources: current registration data from the California DMV and a survey distributed annually to auto manufacturers for information related to their future projections for deploying alternative fueled vehicles including Plug-In Hybrid Electric Vehicles (PHEVs), BEVs, and FCEVs. CARB utilizes the DMV registration data to estimate the current number of FCEVs on California's roads, based on the number of vehicles with currently active registration status. Registration data are collected with spatial resolution at the ZIP code level and reported in aggregate at the county, region, and statewide levels.

Future deployment data provided on the auto manufacturer survey are requested only at the statewide aggregate level. CARB utilizes information about the spatial distribution of the currently planned and Open-Retail hydrogen fueling network and the future development scenario detailed in Appendix D of the 2018 Annual Evaluation to estimate the spatial distribution of vehicles deployed in the future. CARB's annual survey of auto manufacturers requests data covering seven model years, including the current and subsequent six model years. Data requests in the current and next three model years are considered a mandatory reporting obligation of the auto manufacturers. Data in the final three model years of the survey are considered optional reporting and are therefore provided voluntarily by the auto manufacturers. Auto manufacturers' participation in the optional reporting period (individually and in aggregate) may vary from year-to-year and with each of the alternative fuel technologies.

In order to aid auto manufacturers in completing the FCEV-related portions of the annual survey, CARB provides a list of all known station projects in the state (currently open and in development), along with details of their location and capacity. CARB also provides auto manufacturers with a map of all these projects and the most recently available information for the dates that stations have achieved or will achieve Open-Retail status. For the 2020 survey, CARB indicated the funding source(s) for each station on this map. The data provided to auto manufacturers in the 2020 survey are reproduced in Appendix C: Auto Manufacturer Survey Material. Note that data in Appendix C were current as of the time of survey distribution and may differ from other data presented throughout this report.

Surveys in prior years have also asked auto manufacturers to voluntarily provide information about future FCEV deployments in other regions outside of California. These have primarily focused on states in the northeast, where a privately funded hydrogen fueling network has been under development, and other states that have participated in CARB's ZEV program. CARB has observed that participation rates for these voluntary data have been too low to garner meaningful insights, so these questions were not included on the 2020 survey.

## Analysis of DMV Registrations and Auto Manufacturer Survey Responses

CARB analyzes all vehicle registration entries in the DMV database for vehicles with VIN patterns matching known FCEV models. CARB performs several processing steps on these data to filter out records that should not be counted. Sometimes vehicles have multiple records in the database (usually when their registration status has changed multiple times in the past year); CARB resolves these repeat entries by determining the most appropriate to evaluate as the current status. CARB also checks for invalid data, such as registration ZIP codes outside the state, to remove any suspect vehicles from its analysis. Finally, CARB also limits its accounting of FCEVs on the road to records with a status reasonably indicating current and active registration. Once these data processing steps are complete, aggregated counts of active registrations for each Model/Model Year combination in each ZIP code are entered into CARB's California Hydrogen Accounting Tool (CHAT) for long-term record-keeping, exported as data layer inputs for the GIS-based California Hydrogen Infrastructure Tool (CHIT), and used for other analyses.

CARB's annual survey to auto manufacturers requests data for future vehicle deployments on the basis of model and model year at the statewide aggregate level. By definition, model years are not matched to the January-December calendar year; in addition, CARB performs geospatial analyses on resolutions finer than the statewide basis. Thus, CARB also completes a series of data processing steps for the auto manufacturer survey responses.

**TABLE 2: COUNTY-BASED ALLOCATION OF FUTURE NEW FCEV DEPLOYMENT**

County	2020	2021	2022	2023	2024	2025	2026
Alameda	8.21%	6.75%	4.72%	4.36%	2.78%	2.01%	2.49%
Butte	0.00%	0.00%	0.00%	0.00%	1.01%	0.73%	0.87%
Colusa	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Contra Costa	5.78%	4.75%	3.32%	3.07%	1.96%	2.24%	3.74%
El Dorado	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.12%
Fresno	0.99%	0.81%	0.57%	0.53%	1.22%	0.88%	1.08%
Glenn	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Humboldt	0.00%	0.00%	0.00%	0.00%	0.88%	0.64%	0.52%
Imperial	0.00%	0.00%	0.00%	0.00%	0.69%	0.50%	0.43%
Inyo	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Kern	0.00%	0.00%	0.00%	0.00%	1.01%	1.87%	2.75%
Kings	0.00%	0.00%	0.00%	0.00%	0.44%	0.64%	0.41%
Lake	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Lassen	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Los Angeles	26.57%	30.34%	27.36%	26.46%	22.16%	19.23%	16.90%
Madera	0.00%	0.00%	0.00%	0.69%	0.44%	0.32%	0.41%
Marin	0.99%	0.81%	0.57%	0.53%	0.34%	0.79%	0.85%
Mendocino	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.12%
Merced	0.00%	0.00%	0.00%	0.00%	0.88%	0.64%	0.61%
Monterey	0.00%	0.00%	0.75%	0.69%	1.20%	1.74%	1.62%

County	2020	2021	2022	2023	2024	2025	2026
Napa	0.00%	0.00%	0.75%	0.69%	0.44%	0.64%	0.41%
Nevada	0.99%	0.81%	0.57%	0.53%	0.78%	0.56%	0.36%
Orange	12.09%	14.68%	20.57%	19.00%	13.24%	10.41%	9.56%
Placer	0.00%	0.00%	0.00%	0.69%	0.88%	0.96%	0.61%
Riverside	0.37%	0.31%	2.64%	2.44%	5.78%	10.95%	7.70%
Sacramento	3.83%	4.21%	2.95%	2.73%	2.49%	4.27%	3.75%
San Benito	0.00%	0.00%	0.00%	0.00%	0.00%	0.32%	0.20%
San Bernardino	0.37%	0.61%	0.43%	1.09%	2.46%	2.65%	2.41%
San Diego	5.47%	5.56%	6.47%	6.37%	6.58%	6.18%	7.40%
San Francisco	7.04%	6.86%	4.80%	5.62%	3.58%	2.59%	2.69%
San Joaquin	0.00%	0.00%	0.00%	0.00%	3.03%	2.74%	2.61%
San Luis Obispo	0.00%	0.00%	0.00%	2.77%	1.77%	1.60%	1.01%
San Mateo	7.29%	7.06%	4.95%	4.57%	2.91%	2.11%	2.03%
Santa Barbara	0.99%	0.81%	0.57%	0.53%	1.35%	1.29%	2.01%
Santa Clara	16.70%	13.72%	15.50%	14.32%	9.12%	8.84%	7.73%
County	2020	2021	2022	2023	2024	2025	2026
Santa Cruz	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.57%
Shasta	0.00%	0.00%	0.00%	0.00%	0.76%	0.73%	0.67%
Siskiyou	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Solano	0.00%	0.00%	0.00%	0.00%	0.44%	1.69%	2.81%
Sonoma	0.00%	0.00%	1.18%	1.09%	1.89%	1.37%	2.15%
Stanislaus	0.00%	0.00%	0.00%	0.00%	2.27%	2.19%	2.38%
Sutter	0.00%	0.00%	0.00%	0.00%	0.44%	0.32%	0.20%
Tehama	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.12%
Tulare	0.00%	0.00%	0.00%	0.00%	0.88%	1.28%	1.16%
Tuolumne	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.12%
Ventura	0.99%	0.81%	0.57%	0.53%	2.23%	2.34%	4.27%
Yolo	1.31%	1.07%	0.75%	0.69%	1.64%	1.19%	0.75%
Yuba	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.41%

Based on prior investigation of historical DMV registration data, CARB translates model year into calendar year by assuming one-third of all vehicles of a given model year become registered and are in use during the preceding calendar year. The remaining two-thirds of vehicles are assumed to be placed on the road in the calendar year matching the model year.

Next, CARB estimates the geospatial distribution of all vehicles indicated on the auto manufacturer survey by blending the stations currently open and in development with the future station network scenario shown in Appendix D of the 2018 Annual Evaluation and described in the California Fuel Cell Partnership’s Revolution document. Future deployment of new vehicles was distributed to counties proportionally to the percent of statewide capacity in each year according to this blended scenario. The new vehicle deployment rates by county and year are shown in Table 2. Finally, for

all projections of future on-the-road FCEV counts, CARB assumes an attrition rate matching its Emissions FACTor (EMFAC) model of a 15-year half-life for all vehicles. This accounts for the typical rate of vehicles falling out of the on-road fleet due to external causes like accidents or owners transferring the vehicle out of state.

Current active FCEV registrations in each county and region are shown in Figure 3 (region definitions are shown in Figure 2). The Greater Los Angeles and San Francisco Bay Area Regions have the largest number of currently active FCEV registrations. More specifically, Los Angeles, Orange, and Santa Clara Counties have the largest FCEV populations. Compared to the same time last year, noticeable growth has occurred in Santa Clara, San Luis Obispo, and El Dorado counties.

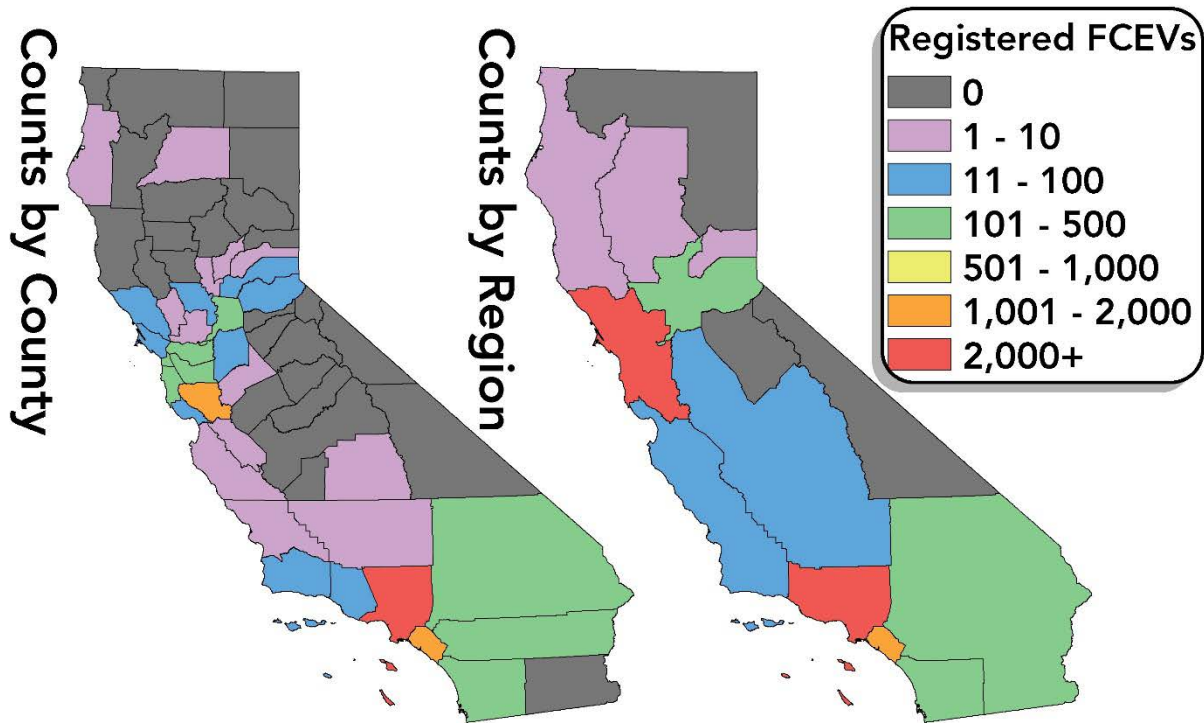
**FIGURE 2: DEFINITIONS OF ANALYSIS REGIONS**

Analysis Region	Constituent Counties
Central Coast Range	Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz
Greater Los Angeles	Los Angeles, Ventura
High Sierra	Alpine, Inyo, Mono
Inland Deserts	Imperial, Riverside, San Bernardino
North Central Valley	Butte, Colusa, Glenn, Shasta, Tehama
North Coastal Region	Del Norte, Humboldt, Lake, Mendocino, Trinity
North Interior Region	Lassen, Modoc, Plumas, Siskiyou
Orange Country	Orange
Sacramento Region	El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba
San Diego County	San Diego
San Francisco Bay Area	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
San Joaquin Valley	Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare
Sierra Foothills	Amador, Calaveras, Mariposa, Tuolumne
Sierra Nevada	Nevada, Sierra





**FIGURE 3: DISTRIBUTION OF CURRENT FCEV REGISTRATIONS AS OF APRIL 1, 2020**



In total, CARB estimates that there are 7,172 active FCEV registrations as of April 1, 2020. This is an increase of approximately 1,200 vehicles over the same time last year. CARB notes that the current year’s DMV data contain a larger proportion of non-active status codes (“Not Currently Registered” and “Planned Non-Operation”) for valid registration data records than in prior years. Approximately 12 percent (equivalent to roughly 1,000 vehicles) of the 2020 DMV data indicated these status codes, which CARB does not include in counts of currently active FCEV registrations. This is similar to the rate of non-active status codes for all vehicles in DMV data in the past two years (including all fuel types), but is also higher than prior rates for FCEVs specifically. The proportion of FCEV entries with these status codes was eight percent and five percent in October 2019 and April 2019, respectively.

The regions with largest number of non-active records include Greater Los Angeles, San Francisco Bay Area, and Orange County. However, as a proportion of total records, all regions with more than a few FCEV registrations fell into a range of 10-15 percent non-active registrations. The hydrogen supply shortage of 2019 affected stations across the state, but most severely impacted those in northern California. The fairly even distribution of non-active registration records does not strongly reflect the regional focus of the supply shortage, but it may be the case that the situation affected drivers’ usage more generally. Other possible explanations include owners’ delays in filing their registration paperwork or data processing delays due to COVID-19 and owners deciding to park their vehicles temporarily while stay-at-home orders are in place. The increase from April 2019 to October 2019 may in particular be related to the hydrogen supply disruption of 2019.

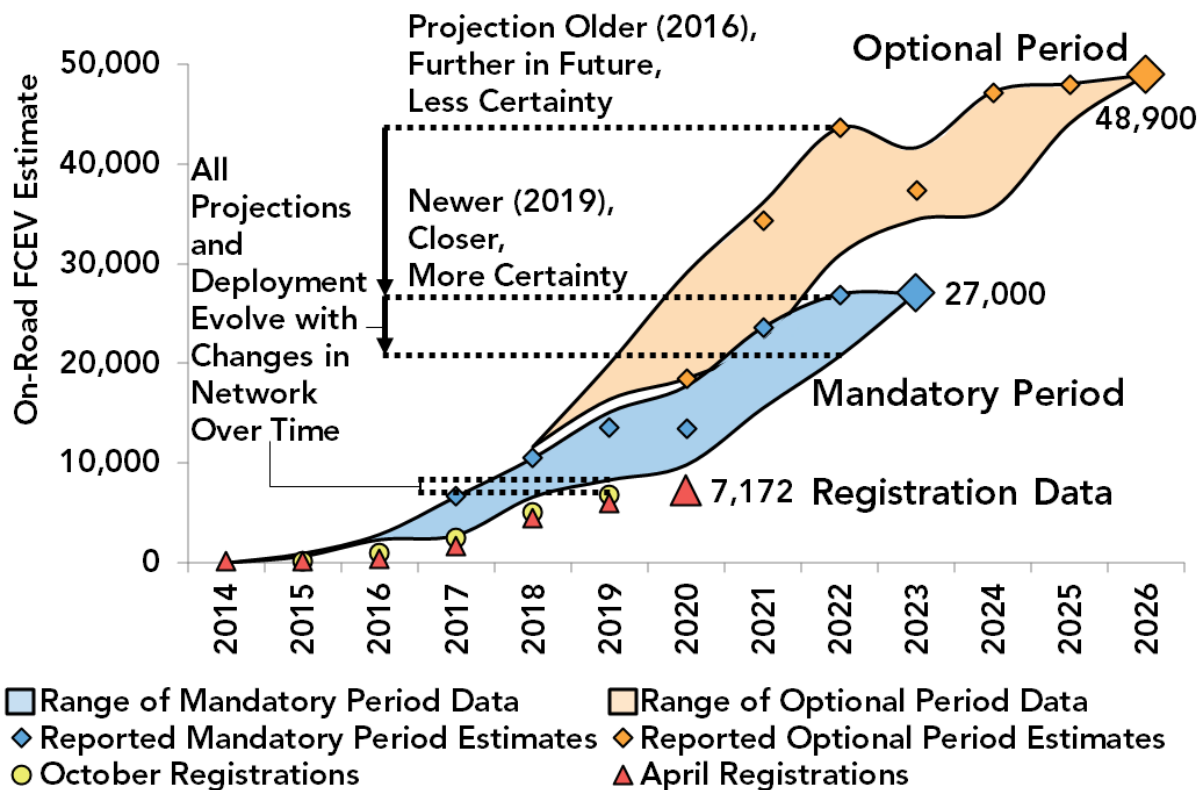
Based on the current count of 7,172 active registrations, the rate of growth over the past year has slowed compared to the period between April 2018 and 2019, when FCEV registration grew by 1,500. The slight reduction in deployment pace may have been influenced by two primary events in the past year. First, the hydrogen fuel supply disruption of summer and fall 2019 may have had an impact on the current FCEV market, including the potential for customers to decide to terminate or not renew leases due to the inconvenience of severely constrained hydrogen fuel availability for an extended period of time. In addition, it has been widely reported that the automotive industry has

been severely impacted by the recent worldwide COVID-19 pandemic. Sales and leases have been reported to have declined up to 40 percent for individual auto manufacturers' brands [56].

The ultimate magnitude and length of the market impact of these stressors is currently unknown and CARB has not attempted to estimate a long-term market impact for future FCEV projections. CARB assumes that the auto manufacturers' survey responses account for these impacts to the best of their ability. The current registrations and projections of future on-the-road FCEVs as determined by the combination of current DMV registration data and auto manufacturer survey responses is shown in Figure 4. Updated estimates of future FCEVs on the road are 27,000 in 2023 and 48,900 in 2026. These projections therefore appear to anticipate an acceleration of FCEV deployment within the next 3 years that is sustained throughout the survey reporting period.

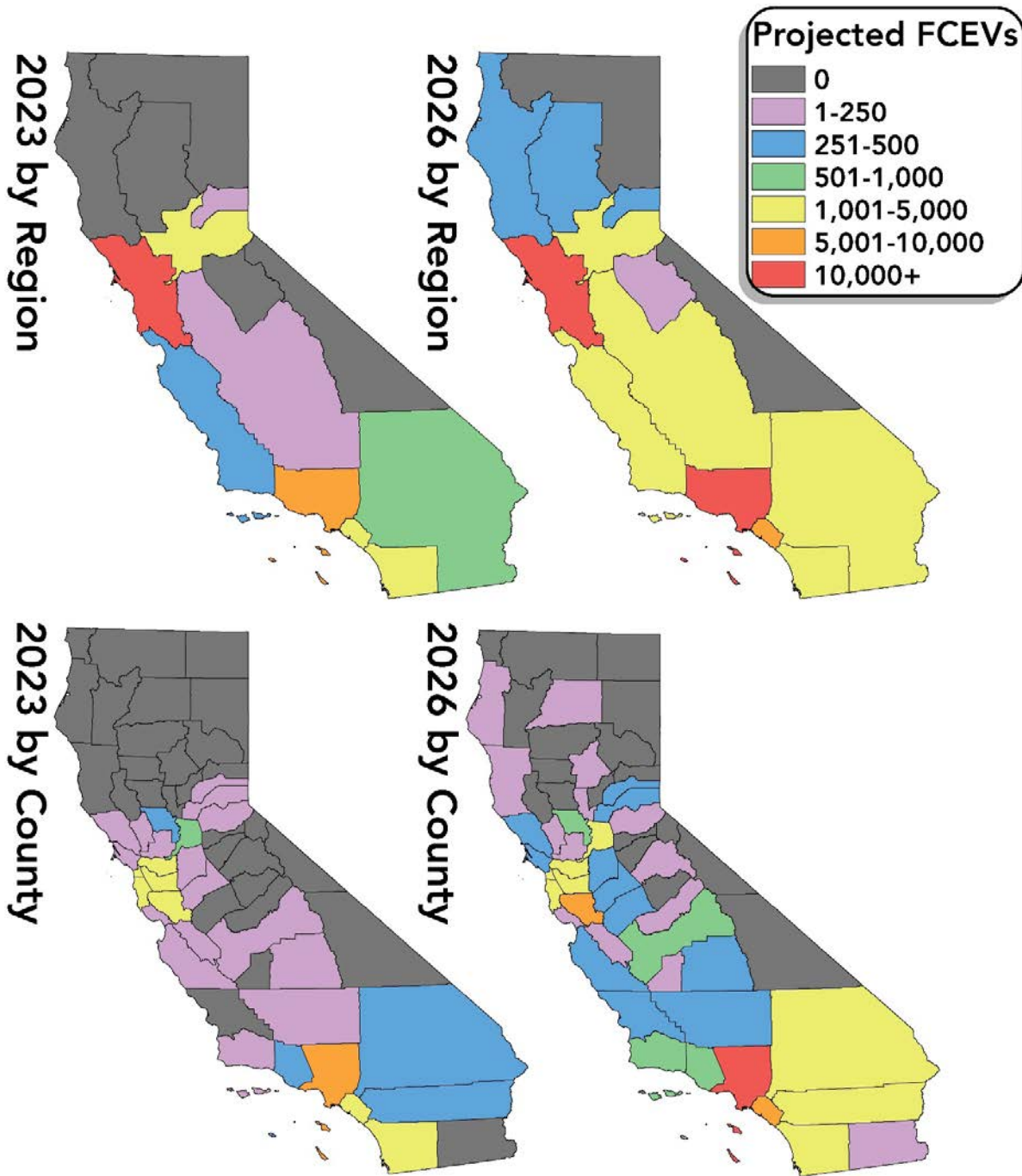
However, these estimates are also similar to the estimates for one year prior, based on 2019 survey responses. Therefore, the 2020 survey responses indicate a nearly exact one-year delay in responses compared to 2019. Unlike vehicle deployment shifts noted in prior years, this shift applies to both near-term and long-term vehicle sales. CARB staff note that the potential fuel consumption of the long-term 48,900 vehicle estimate is closely matched to the fueling capacity of the currently open and funded network of 71 fueling stations (see later Chapters for further detail). All of these stations are expected to be completed within the survey period. It is possible that auto manufacturers are therefore basing their survey responses entirely on the known open and funded stations and not estimating the potential addition of new stations through either GFO 19-602 or the LCFS HRI program. As station awards are announced for GFO 19-602 and development begins, the response of auto manufacturers on the 2021 survey could further illuminate their approach.

**FIGURE 4: COMPARISON OF ON-THE-ROAD VEHICLE COUNTS IN 2014-2020 ANNUAL EVALUATIONS**



The projected spatial distribution of 27,000 FCEVs in 2023 and 48,900 FCEVs in 2026 are shown in Figure 5. Future distribution of vehicles is impacted by current registrations, the location of open and funded hydrogen fueling stations, and the projected development outlined in Appendix D of the 2018 Annual Evaluation and the California Fuel Cell Partnership’s Revolution document. Revised analysis based on these updated data show more concentration of future FCEV deployment in the San Francisco Bay Area, led by increases in Santa Clara County in particular. While the North Interior Region no longer shows any vehicles in the future, this is due to the loss of current registered vehicles in the region. On the other hand, other regions further from the currently Open-Retail hydrogen fueling stations are now expected to have increased deployment over the coming years, due in part to projected and estimated hydrogen fueling station development in these regions.

**FIGURE 5: GEOGRAPHIC DISTRIBUTION OF ON-THE-ROAD FCEVs FOLLOWING REVOLUTION SCENARIO**



## Insights for FCEV Deployment Potential from the BEV Example

BEVs and FCEVs have been deployed into California's light-duty vehicle market for several years. A first wave of BEVs began deployment in the early 1990s, with a second wave of more significant sales beginning in 2010 with the release of the Nissan Leaf. FCEVs began consumer market deployment more recently, with the launch of the Toyota Mirai in 2016. BEVs have been deployed in larger numbers to date due to their earlier market launch and lower requirements for public and retail fueling infrastructure development among other factors. Given that new technologies tend to follow similar phased adoption trends from first adopters to eventual mass market<sup>12</sup>, the history of the BEV deployment projections and sales experience may provide insights and inferences relevant to the developing FCEV market. By assessing prior auto manufacturer survey and third-party sales data, CARB finds the history of FCEV deployment and projections have thus far followed a path similar to the early deployment phase of BEVs. Though projections for FCEVs and BEVs appear to be handled differently by auto manufacturers, both technologies appear to be following closely to the expected trends for new technology early adopters.

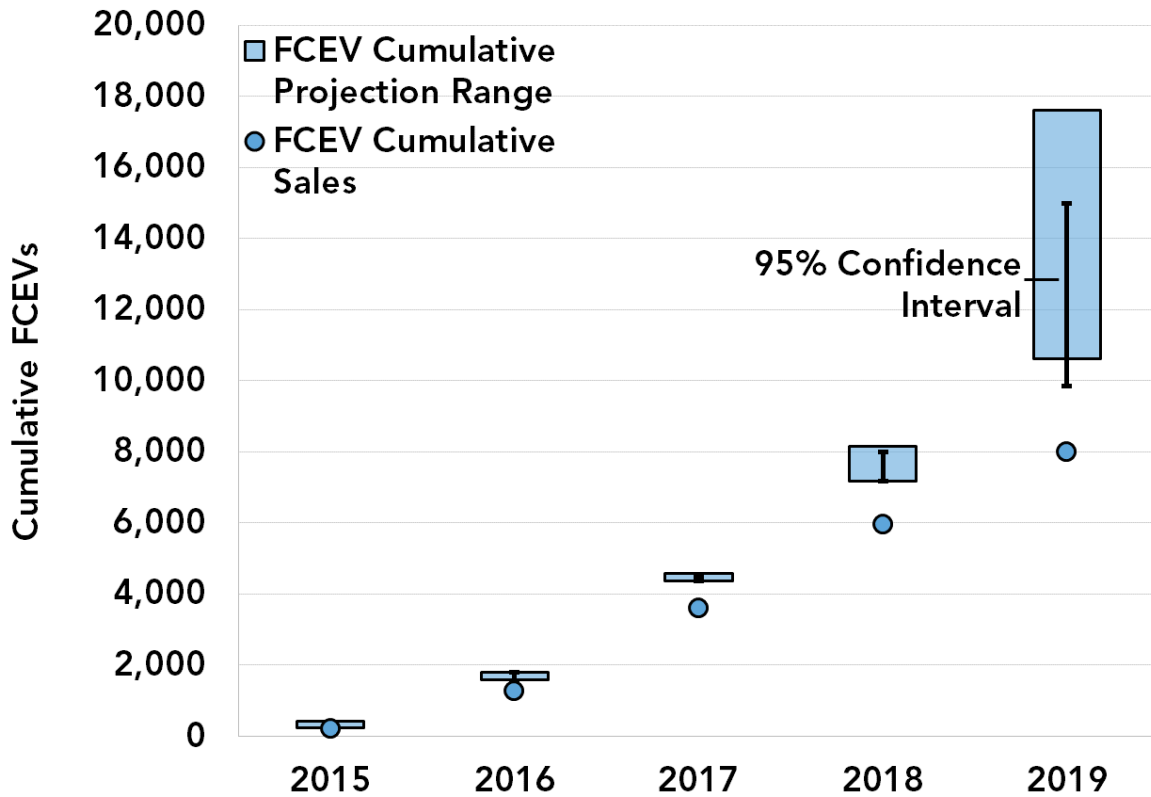
CARB has collected data on auto manufacturers' projected ZEV deployment (including BEV, PHEV, and FCEV) since 2014. Even at that date FCEVs and BEVs were in different phases of deployment, with BEVs well into the Early Adopter phase and FCEVs in a pre-commercial testing and demonstration phase. Several factors may similarly affect the development of the BEV and FCEV markets and be considered in auto manufacturer projections for both technologies, such as development of new supply chains and manufacturing capacity and building consumer acceptance of new technology. These factors may impact the two technologies similarly at the same point in market development, but may be exhibited at different points in time for each technology due to the difference in their respective market launch dates. This could lead to sales and projection data for both technologies that demonstrate market expansion into broader sets of technology adopters, but these shifts occur at different points in time due to the differences in market launch date.

Auto manufacturer responses for FCEVs and BEVs on past surveys seem to reflect the difference in deployment phase, as approaches to responses appear to vary by vehicle technology. For responses related to future FCEV deployment, those auto manufacturers who do plan on deploying vehicles typically provide projections for both the mandatory and optional periods. In addition, the aggregate deployment volume typically accelerates near the transition from the mandatory to the optional period. By contrast, responses for BEV deployments have typically been extremely limited in the optional period until the most recent survey year and projected volumes of BEV deployment have more consistently grown over time.

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12 See Chapter III of the 2014 Annual Evaluation for more information on the theory of dispersion of new technologies as it relates to automobile drivetrains

**FIGURE 6: COMPARISON OF FCEV SURVEY PROJECTIONS AND SALES**

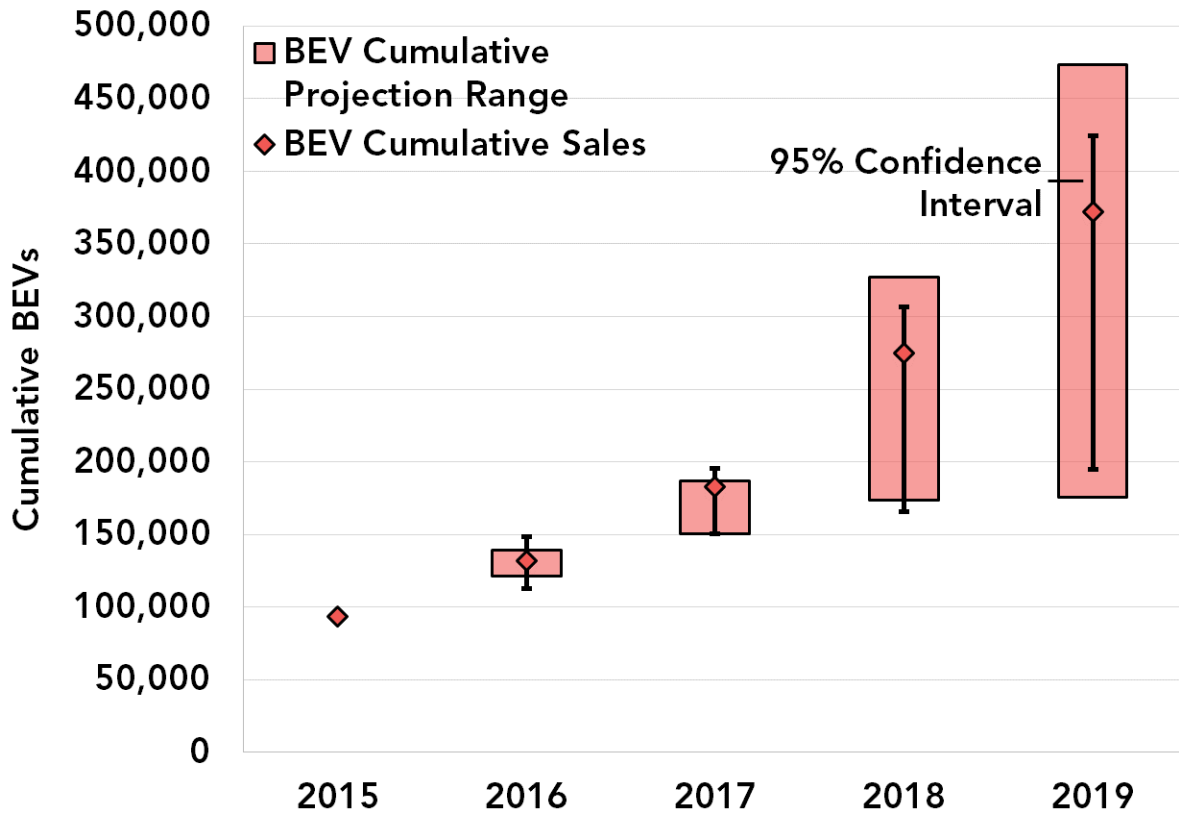


As with all projections, uncertainty and external variables play an important role in the auto manufacturers’ survey responses. In general, these may be greater for a technology with a relatively newer market entry, as seems apparent when comparing the survey responses to actual sales. Figure 6 and Figure 7 compare survey data to Polk<sup>13</sup> sales data for FCEVs and BEVs, respectively [58]. The indicated cumulative projection range is estimated based on all survey years’ data to date and assumes the prior-year Polk sales data are correct. As the figures show, FCEV projections are fairly consistently higher than actual sales; while there is an outlier in 2019 of 120 percent overestimation from one of the earliest surveys, FCEV survey responses typically indicate 11 percent to 50 percent greater vehicle deployment than Polk sales data. By contrast, BEV survey responses both over- and under-estimate future sales. While the range looks large, much of the under-estimation is simply due to the fact that BEV survey responses do not typically garner much response in the optional period, especially in early years of the survey. Other than these points, BEV survey responses usually deviate from actual sales data by up to 30%.

The greater agreement between BEV sales and projections may indicate that auto manufacturers have a more complete understanding of future BEV deployment potential. Further underscoring this difference, an analysis of confidence intervals for survey response data finds that the actual FCEV sales are always outside of the 95 percent confidence interval, while the actual BEV sales are always within. This indicates a strong difference between FCEV deployment projections and sales that is not apparent for BEVs and is likely related to the earlier deployment phase of FCEVs. Other potential factors for the greater variation in FCEV projections include the need to account for hydrogen station network development, differences in federal incentive support, and consumer-facing factors like the price of hydrogen fuel.

<sup>13</sup> Based on IHS Markit New Registrations of Electric Cars and Light Trucks in California for 2010 through March 2019. Low speed vehicles are excluded.

**FIGURE 7: COMPARISON OF BEV SURVEY PROJECTIONS AND SALES**



Although survey responses seem to indicate that there are different approaches to vehicle deployment projections based on vehicle technology, historical sales data can illuminate whether there have been significant differences to date in adoption trends. CARB compared the pace of FCEV and BEV deployment using historical sales data per Polk in order to assess whether FCEVs are in any sense delayed compared to the BEV early deployment experience. Sales data are available for both technologies as early as 2010, capturing both technologies’ earliest deployment phases, and inherently carry less uncertainty than reported projections of future deployment.

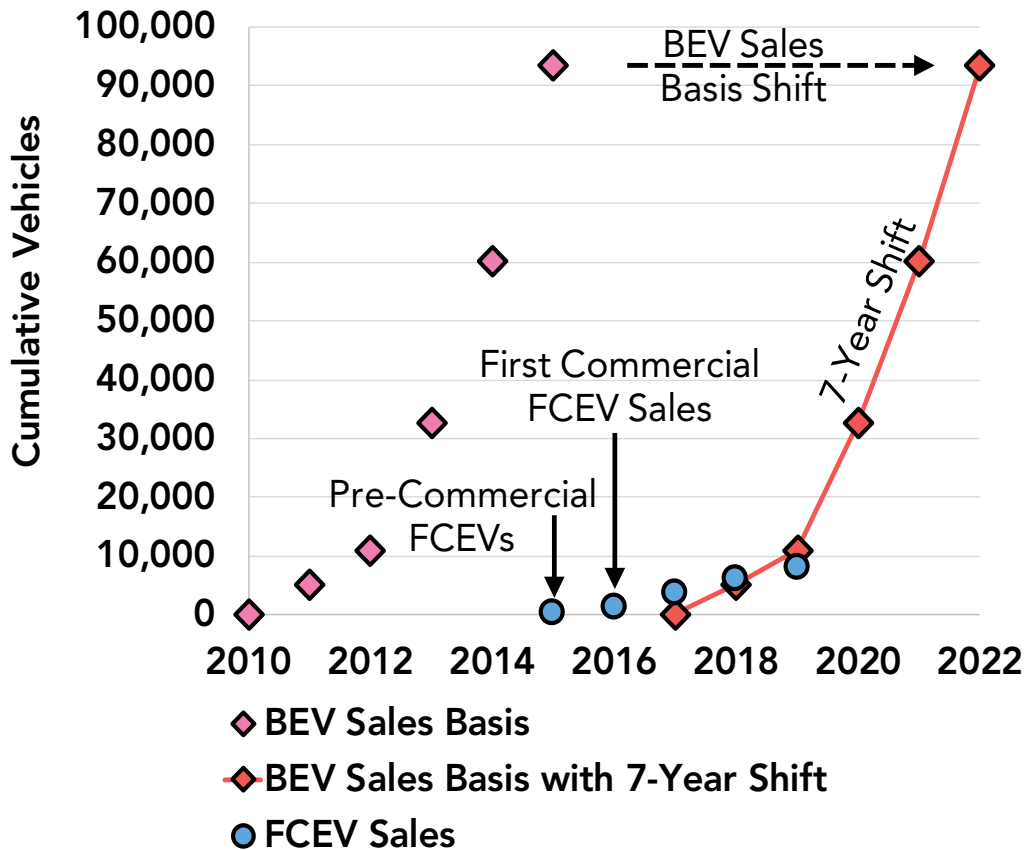
CARB’s analysis compares the deployment trajectory of the two technologies in two separate time periods. First, historical deployment rates are compared to assess whether the earliest years of vehicle deployment are similar to each other in pace or if the FCEV deployment data to date indicate a lag compared to the BEV historical record.

Figure 8 demonstrates CARB’s analysis of historical deployment data. As shown, both BEV and FCEV deployments were near or below 10,000 cumulative vehicles in the first few years after the date considered to be the onset of widespread commercial sales of either technology. The highlighted seven-year shift is the best fit to the historical FCEV record. A seven-year shift is similar to the six-year difference between BEV and FCEV widespread market availability, so FCEV deployments to date have been on track with the new vehicle technology adoption trend modeled by BEVs.

Figure 8 also hints at the second phase of deployment that CARB analyzed. Based on the seven-year shift, it is clear that FCEV deployment should accelerate significantly in the next few years in order to model the timing of acceleration in market development that was observed with BEVs in 2013. The projections provided by auto manufacturers on annual surveys indicate an imminent acceleration in the next few years. CARB utilized similar methods to assess whether the timing of the acceleration indicated on auto manufacturer surveys supports the determination that FCEV deployments will also exhibit expected market development timing in the future.

One method to assess this is to analyze the year-over-year growth of the two technologies. Year-over-year growth analyses provide an assessment of the relative growth rate of the two technologies independently. This relative analysis is helpful to understand whether the technologies are going through similar market development phases on similar schedules, independent of the total size of their respective markets. It is not necessary to prove that FCEVs and BEVs reach the same total volume on the same schedule in order to assess whether they are shifting into new market development phases (indicated by “bends in the curve” in data presentations like Figure 8) on similar schedules.

**FIGURE 8: ANALYSIS OF HISTORICAL FCEV AND BEV EARLY-MARKET DEPLOYMENT RATES**



For example, consider the worldwide market share of iOS and Android operating systems for mobile devices. For many years, the relative market shares have been approximately 20 percent and 80 percent, respectively. Yet, there is no question that both technology options have been great successes. The situation is similar with BEV and FCEV in the ZEV space. In fact, the most ambitious published target of one million FCEVs by 2030 from the California Fuel Cell Partnership’s Revolution document is 20 percent of the State’s 2030 ZEV goal per EO B-48-18. This is a direct indication that at least for the near- to mid-term, FCEV and BEV stakeholders do not anticipate their markets to be the same size, even though they will likely mature through the same adoption phases and State and auto manufacturer stakeholders continue to emphasize the complementary nature of these two technologies in the overall ZEV strategy. It is therefore reasonable to compare these technologies on their own relative growth bases.

**FIGURE 9: COMPARISON OF YEAR-OVER-YEAR GROWTH IN HISTORICAL BEV AND PROJECTED FCEV DEPLOYMENT**

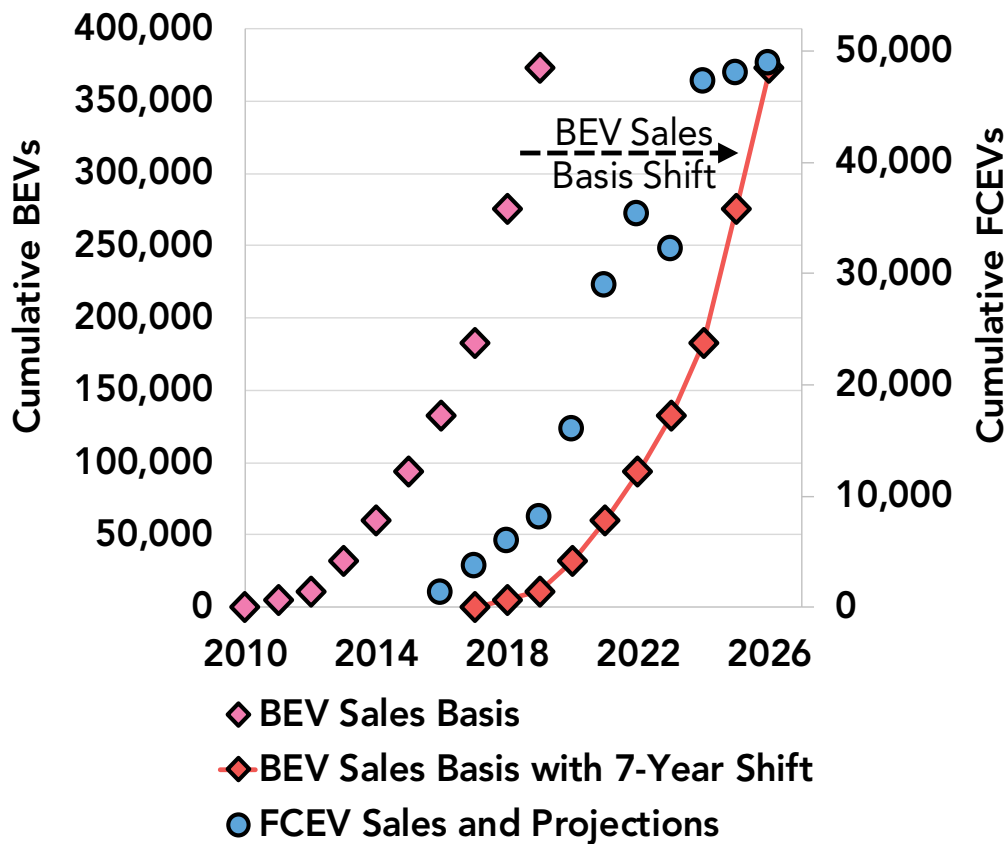


Figure 9 provides a summary of this analysis for BEV historical sales and FCEV historical and projected sales (note the differing dates of the secondary x-axis at the top of each chart). As Figure 9 demonstrates, both technologies experienced an initial spike in year-over-year growth (an artifact of starting at very low deployment numbers in the first few years- small increases translate to large percentage change at this time). However, after a period of four to five years, both technologies exhibit a more consistent growth rate year-over-year. In the case of BEVs, this appears to be around 40 percent; for FCEVs, it appears to be slightly smaller around 30 percent<sup>14</sup>. Figure 10 provides a visual confirmation of the similar timing of market growth in both technologies, with FCEV projections matching well to BEV data between five and seven years prior. It is also worth noting that the FCEV data inherently contain more uncertainty; BEV data are based on historical deployment, while FCEV data are based on estimated projections.

<sup>14</sup> The drop-off in growth for FCEVs in 2026 is related to the observation that FCEV deployment projections have likely been limited by funded station capacity and the fact that total FCEV deployments in the last three annual surveys have been similar.



**FIGURE 10: ASSESSMENT OF RELATIVE FUTURE FCEV DEPLOYMENT TRENDS COMPARED TO HISTORICAL BEV DEPLOYMENTS<sup>15</sup>**



CARB therefore finds that both the historical FCEV deployment record and the current projections for future FCEV deployment indicate that market development is occurring on the expected schedule as exhibited by the example of historical BEV market development. California’s goals to mitigate climate change and improve air quality have been found to require complete turnover of the state’s light-duty vehicle fleet to ZEV options on a rapid schedule. The state will need to support the deployment of every ZEV possible. Efforts need to be directed towards technologies that are proving the opportunity for long-term success. Based on this analysis, CARB finds that FCEVs thus far demonstrate that promise and should continue to be supported through hydrogen fueling infrastructure development to the greatest extent allowed by AB 8.

### Enhanced Review of 2019 Projections

After the publication of the 2019 Annual Evaluation, CARB completed a series of formal individual interviews with auto manufacturers. These interviews were initiated by the desire to understand why the 2019 survey responses indicated a one-year shift in FCEV deployment compared to projections made one year earlier. CARB was also interested in understanding the factors that lead to developments in on-the-road FCEV deployment volumes and changes in pace for future FCEV deployment over time.

Interviews also focused on broader context of the auto manufacturers’ responses to the annual survey over the years and specifically in 2019, perspectives on recent developments regarding the LCFS HRI credits and the Energy Commission’s then-draft solicitation, and perspectives on

<sup>15</sup> The FCEV sales curve is based on data from Figure 4. For years with both a reported optional and mandatory period estimate, CARB used the average of the two values.

California's FCEV and ZEV market with respect to other global market and technology developments. CARB took this step of additional one-on-one review with representatives from individual automakers in order to more clearly understand the factors that may have influenced the noted delay in vehicle deployment projections observed in the 2019 Annual Evaluation. These discussions helped illuminate factors that are not easily communicated through the survey and further expand on the auto manufacturers' commitments to FCEV deployment in California and globally.

Individual auto manufacturers' discussions are considered confidential business information. However, CARB has considered the discussions and aggregated the information gained into four main messages that are representative of the industry as a whole. These messages and their implications for considering FCEV projections (for 2019 and other years) are as follows:

### **Message 1: Industry Commitment to FCEV Market Development Remains a Priority**

Several auto manufacturers have shown commitment to FCEV technology development or deployment and remain significantly committed to FCEVs. Commonly cited benefits of FCEVs (ease of integration into large vehicle platforms in combination with the ability to provide longer range with fast fueling, and the existence of market segments particularly sensitive to these requirements) all remain major reasons that auto manufacturers see a need to continue FCEV development and deployment. This perspective is commonly supported by decisions and vision at the highest executive levels of the auto companies. In addition, no auto manufacturer cited a fundamental reason why any particular ZEV platform or use case could not be powered by fuel cells. Auto manufacturers also remain committed to their ongoing collaborations with respect to FCEVs and the overall staff effort and investment in these partnerships remain consistent for manufacturers in active partnerships.

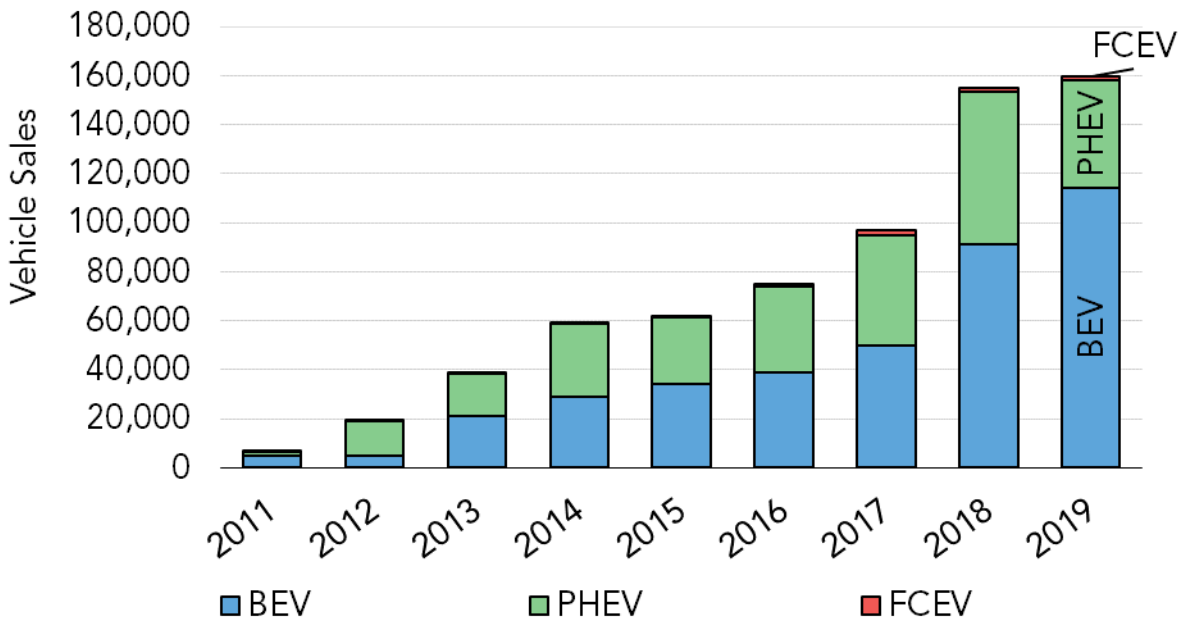
As shown in Figure 4, aggregate deployment projections from the current and prior years point to a near-term acceleration beginning as soon as 2020. This corresponds to the general mood of the industry as remaining positive on the potential and need for FCEVs in an overall ZEV strategy. While responses to the survey in any individual reporting year may fluctuate, the existing commitments remain in place.

### **Message 2: FCEVs and BEVs Together Remain the Overall ZEV Strategy**

Auto manufacturers collectively recognize a significant challenge lies ahead in order for the world's several automotive emissions targets and goals to be achievable, especially as concerns the development of new ZEV markets. Several auto manufacturers continue to envision that FCEVs and BEVs together will be necessary to meet the total future need for ZEV deployment. Even if auto manufacturers are not currently active in deployment, multiple manufacturers are anticipating introduction of the technology in the second half of the decade, assuming sufficient supporting infrastructure and market signals.

While both FCEV and BEV technology remain active parts of auto manufacturers' development efforts, market development for these two technologies is expected to proceed at differing paces. Survey responses and follow-up interviews indicate potential FCEV deployment acceleration phases post-2020 and post-2025. CARB notes that this stepwise progression is similar to the BEV experience in California, which has already significantly accelerated in both 2013 and 2018 as shown in Figure 11.

**FIGURE 11: HISTORICAL ANNUAL NEW SALES OF ZEV TECHNOLOGIES (BASED ON AND UPDATED FROM [59])**



While auto manufacturers continue to say that they see both technologies as ultimately necessary, they must still carefully manage their costs for developing novel markets for both FCEVs and BEVs. Both technologies continue to be seen as requiring significant development, especially with respect to consumer purchase prices and Total Cost of Ownership (TCO). Auto manufacturers plan to address the role of the vehicle cost in TCO through technology and design development as well as building scale of manufacturing capability. Building scale of new manufacturing is typically a costly venture and in the case of the automotive industry is dependent not only on the auto manufacturers themselves but also an extensive network of suppliers and distributors. In addition, TCO for both technology options is seen as heavily dependent on progress in the respective vehicle fueling/charging markets and the ability for companies in those industries to contain consumer-facing prices now and in the long-term. Supportive public policy decisions at several levels are reported to also play a significant role.

Auto manufacturers report that developing such a new industry has proven costly and budgets for these endeavors are not unlimited. In some cases, prioritization of funds for vehicle and market development has led year-to-year decisions on spending for FCEV and BEV respectively, with decisions to focus investments more heavily on one technology proving necessary. In addition, auto manufacturers highlight there is necessarily some lag time between market introduction of a product and the ability to determine its success, both in terms of market acceptance and the impact on reducing development and manufacturing costs. This implies that focused investment strategies must be pursued for some extended period of time in order to prove themselves.

These combined stressors are reported to lead auto manufacturers to focus investments and development more heavily into one technology or the other in order to accelerate the drive to manufacturing at scale. Given that auto manufacturers collectively continue to see FCEVs and BEVs as necessary to a successful ZEV future, this implies that future investment decisions may shift proportionally towards FCEVs as the BEV market matures and sufficient manufacturing scale is established.

### **Message 3: Survey Responses are Driven by Internal Deliberations and Affected by Uncertainties in Pace of Network Development**

CARB provides station development information as a resource for auto manufacturers to consider in their vehicle deployment projections. However, in the course of completing their due diligence in providing survey responses, auto manufacturers typically complete a separate internal analysis of the historical and potential future network development pace. Many times, auto manufacturers find that their analysis leads to conclusions that station development pace is slower than projections provided in either the CARB-issued survey or the Annual Evaluations. This in itself presents a potential discrepancy in timing between the station deployment expectations in CARB's analyses and the basis of analysis used by auto manufacturers. In addition, auto manufacturers note the difficulty of providing future estimates based on limited information available at a single point in time (a difficulty common to the development of the Annual Evaluations). This is especially true for projections five years or more in the future, given the increased uncertainty inherent to making estimates further ahead in time. Even with these uncertainties, auto manufacturers expressed that no station development delays in the past have put the future deployment of FCEVs at risks and that they are largely viewed as growing pains instead of roadblocks.

### **Message 4: ZEV (including FCEV) Deployment Projections are Driven by Global and Local Markets and Policies**

While California is home to the world's largest FCEV market and one of the largest overall ZEV markets, decisions affecting deployment of BEVs and FCEVs in California are made within the context of the overall global market. Requirements for other regions like China and Europe affect the deployment of vehicles in California, and vice-versa. While the automotive market remains globally focused, auto manufacturers maintain an emphasis that State policy and support programs strongly affect their deliberations. This implies that auto manufacturers are anticipating the need to make global deployment decisions for FCEVs in the future and base these decisions on the relative progress within each of the target markets. Opportunity therefore continues to exist to accelerate in-state FCEV market development by accelerating station network and other critical infrastructure development. Auto manufacturers see this already happening within the state, but see a need for the effort to continue in order to remove infrastructure as an overall FCEV deployment barrier.

In addition to these main messages above, auto manufacturers emphasized that the survey process involves certain limitations. One limitation has been discussed in prior years' Annual Evaluations, which proposed that survey responses in any given year may be affected by actions that take place at the same time the survey is being completed. A noted example was the prior announcement of Stop Work Orders on some station development, which may have contributed to a lower FCEV projection in 2017 than prior years. Thus, individual years' responses may not be indicative of the auto manufacturers' general perspective throughout the entire year. Similarly, auto manufacturers indicated that the quantitative nature of the survey doesn't provide an opportunity to share contextual information like the topics covered in the follow-up interviews.

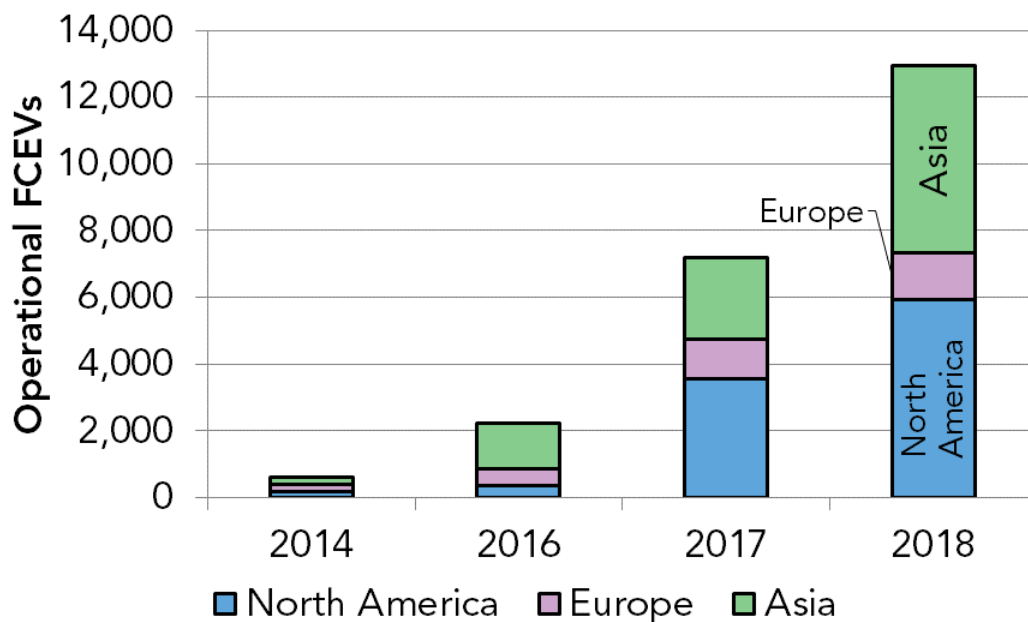
### **Global FCEV Markets and California's Impact**

While California currently leads the world with the most-developed light-duty FCEV market, many nations around the globe are currently pursuing the deployment of hydrogen and fuel cell technology for transportation and other uses. Each country typically has its own set of motivations with varying degrees of emphasis (renewable energy implementation, steady fuel supply, fuel diversity, pollutant emissions reductions, greenhouse gas emissions reductions, technology leadership, strategic economic leadership, and others). Individual countries also tend to approach the evolving timeline for implementation of hydrogen across different industries differently. Some focus on light-duty vehicles early on, some have begun their first deployments at scale with buses

and medium-duty vehicles, and others like Japan have looked to develop several sectors' use of hydrogen all at once, including light-duty vehicles, residential power, and the overall national energy system.

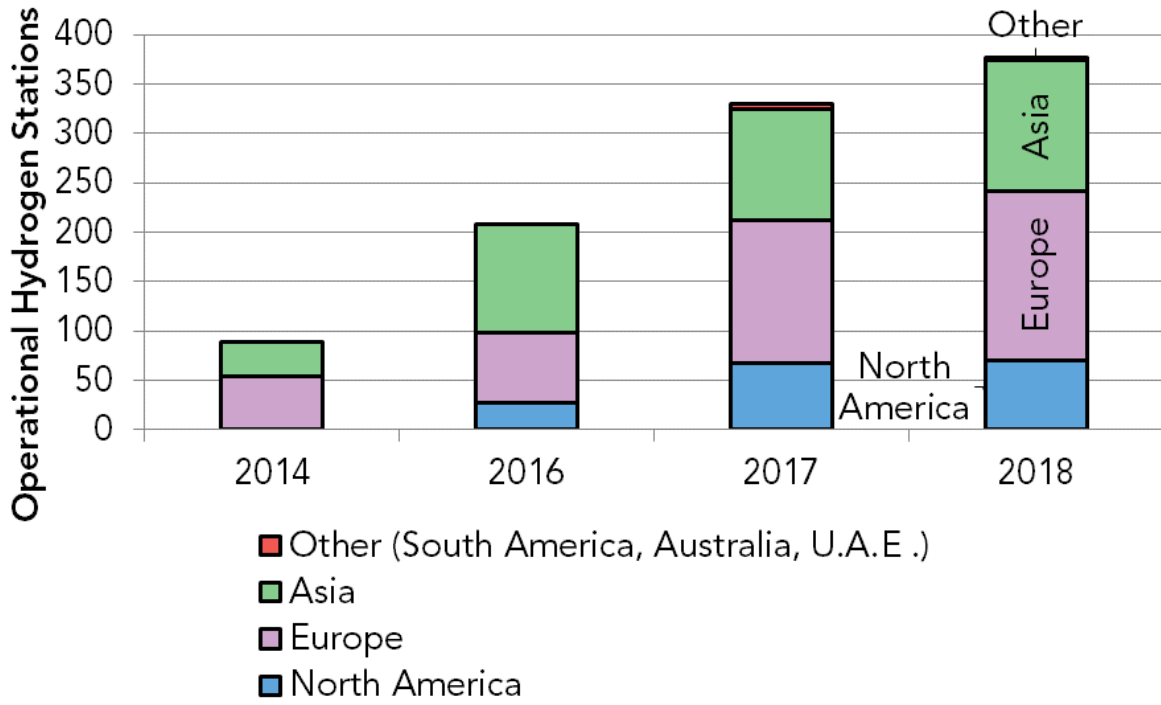
As these global efforts continue to mature, there will be an increased need for CARB and Energy Commission staff to track the latest status of the overall global market development. Larger global markets have the possibility of accelerating industrial scale and reducing overall costs to participating companies and to the consumer. Understanding these trends will be important to regulatory efforts as well as tracking progress towards the ultimate goal of hydrogen station network financial self-sufficiency. In addition, as more FCEV markets become mature across the globe, auto manufacturers may have to prioritize deployments regionally, accounting for the pace at which vehicles can be manufactured and delivered, regulatory obligations, consumer market demand, and the status of the local hydrogen fueling network. It will be important for the State of California to be able to assess these considerations for the FCEV and hydrogen fueling market within California and globally so that future deployment projections within California are informed by the evolving global context.

**FIGURE 12: GLOBAL FCEV MARKETS, AS REPORTED BY IEA [60]-[61]**



Currently, there are few resources available for consolidated information about markets across the globe. CARB and the Energy Commission do typically meet with international representatives throughout the year and can integrate insight from those meetings into their analyses. In addition, the International Energy Agency (IEA) has begun collecting more detailed information on hydrogen fueling stations and FCEV deployment in recent years [60] [62] [63] [61]. Figure 12 and Figure 13 display their findings for FCEV deployment and hydrogen fueling station development (note that 2016 data represents a combined 2015/2016 report and that North America numbers are primarily indicative of the California market). It is clear that the FCEV market is growing in all regions where it has launched, and that station network development correlates well with FCEV deployment. Future analysis and reporting by CARB and the Energy Commission will look to expand on these available resources and perform rigorous analysis to ascertain the effect that California's growing FCEV network is having on global market-scale growth and how global developments are improving the market economics for development within California.

FIGURE 13: GLOBAL HYDROGEN FUELING NETWORK STATUS, AS REPORTED BY IEA [60]-[61]



# Location and Number of Hydrogen Fueling Stations

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## AB 8 Requirements: Evaluation of hydrogen fueling station network coverage

**CARB 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.**

## Current Open and Funded Stations

California's hydrogen fueling station network has continued to evolve over the past year. Four stations newly achieved Open-Retail status: CSULA, Harrison Street and Mission Street in San Francisco, and Oakland. All of these stations with the exception of CSULA are part of the latest generation of fueling stations, with high daily dispensing capacity and offering multiple simultaneous fueling positions at each location. In addition to these new Open-Retail stations, several other changes have occurred within the network:

- Nine new stations in development have been added to the network through CARB's LCFS HRI provision. These stations are located in: Aliso Viejo, Baldwin Park, Costa Mesa, Cupertino, Orange, Placentia, San Jose, San Diego, and Palm Springs. The Palm Springs station is under development by United Hydrogen, a new entrant to California's hydrogen fueling network. The remaining eight stations are under development by FirstElement Inc., which built and operates the largest number of stations in California's network.
- The station previously proposed for award in Irvine has been approved to be replaced by a station in Laguna Beach (the 2019 Annual Evaluation previously reported that the Irvine station was proposed to be replaced by a station in Concord).
- The station previously proposed for award in Beverly Hills has been approved to be replaced by a station in Concord.
- The West LA station has permanently closed, due to the site owner's sale of the property for redevelopment.
- The developer of the Santa Nella station has given notice that the project will no longer proceed.
- Three stations that had previously achieved Open-Retail status are currently considered in a new category of "Temporary Non-Operational." The Newport Beach, Ontario, and Riverside stations have had an extended period of closure and dates for resuming Open-Retail status and operations are currently unclear. In the case of Newport Beach, the station is undergoing a privately funded upgrade; the other two stations have reported difficulties with equipment and a resolution date is not yet known. CARB has removed these stations from the current Open-Retail counts (such as Figure ES 1 and Figure 1), but has not removed them from presentations of historical data and the end-of-year forecasts of Open-Retail stations for 2020 and later years. CARB has received indications that one or more of these stations could re-open in 2020 or 2021.

In addition to these development status changes, the projected dates at which several of the remaining stations in development will achieve Open-Retail status have been updated, mostly to later dates. The past year has included several challenges that may have affected these stations' development timelines. As reported in the December 2019 Joint Agency Staff Report on AB 8, a long-term hydrogen supply disruption during the spring and summer of 2019 affected fuel deliveries to operating stations with some disruptions continuing into the fall and winter as the supply facility resumed operations. However, this supply disruption event may have also caused additional strain on station network development workloads, as many of the station operators were simultaneously

addressing fuel supply challenges at their open stations and managing ongoing hydrogen station development projects.

In addition, the onset of the COVID-19 pandemic in early 2020 has been reported by some developers to have impacted the ability to maintain development pace at some sites. Since hydrogen fueling stations were deemed an essential business, development at sites under construction was largely able to continue as much of the state’s businesses stopped operations in March and April [64]. However, other aspects of station development, such as permitting and equipment acquisition were impeded as a result of physical distancing and stay-at-home orders within California and in the home countries and jurisdictions of equipment suppliers around the globe. In addition, some stations that completed construction were not able to complete confirmation testing as originally scheduled due to the unavailability of the Hydrogen Station Equipment Performance (HyStEP) device during the COVID-19 crisis. However, for those stations so far affected by HyStEP availability, their open date was only moved to a later date within the same calendar year.

As a result of these experiences and changes over the past year, the total number of stations open at the end of 2019 was 43, eight stations fewer than was projected in the previous Annual Evaluation. Future projections for the end of 2020, 2021, and 2022 are 58, 62, and 71 Open-Retail stations, respectively. The most current projections of Open-Retail station counts aggregated by analysis region and based on stations currently under development is shown in Figure 14 (for historical Open-Retail counts in 2015-2018, please see Figure 6 in the 2019 Annual Evaluation). Table 3 provides these same projections aggregated by county.

**TABLE 3: HISTORICAL AND PROJECTED COUNTS OF OPEN-RETAIL STATIONS BY COUNTY**

County	2015	2016	2017	2018	2019	2020	2021	2022
Alameda	0	1	2	3	4	5	5	5
Contra Costa	0	0	1	1	1	2	2	2
Fresno	1	1	1	1	1	1	1	1
Los Angeles	2	9	12	13	14	18	20	21
Marin	0	1	1	1	1	1	1	1
Nevada	0	1	1	1	1	1	1	1
Orange	2	5	5	6	6	7	8	12
Riverside	0	0	1	1	1	1	1	2
Sacramento	0	0	0	1	2	2	2	2
San Bernardino	0	0	0	1	1	1	2	2
San Diego	0	1	1	1	1	2	2	3
San Francisco	0	0	0	0	2	3	3	3
San Mateo	0	1	1	1	1	3	3	3
Santa Barbara	0	1	1	1	1	1	1	1
Santa Clara	0	3	3	5	5	8	8	10
Ventura	0	0	0	1	1	1	1	1
Yolo	1	1	1	1	1	1	1	1
<b>Total</b>	<b>6</b>	<b>25</b>	<b>31</b>	<b>39</b>	<b>44</b>	<b>58</b>	<b>62</b>	<b>71</b>

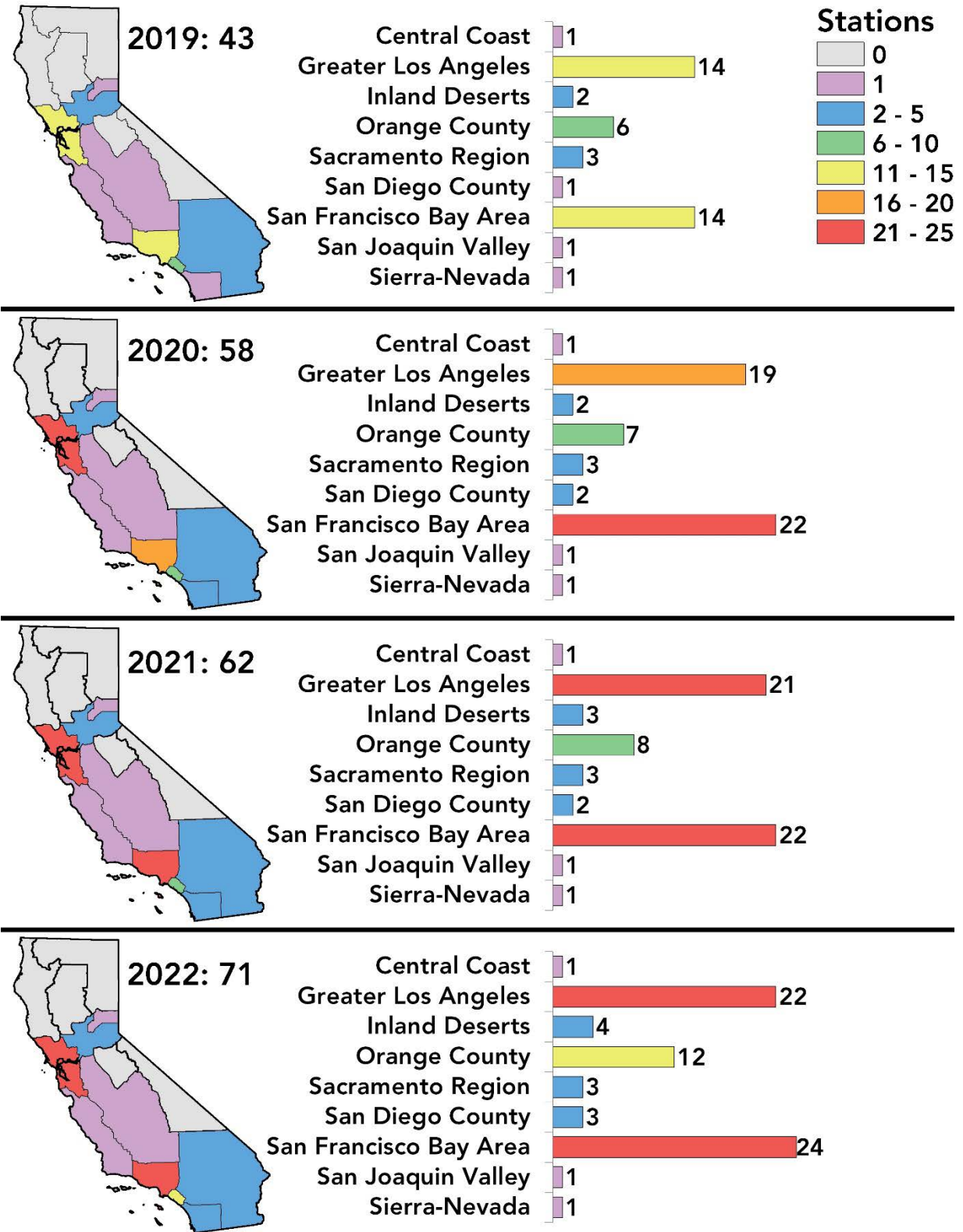


At the end of 2019, the Greater Los Angeles and San Francisco Bay Areas both had 14 Open-Retail hydrogen fueling stations. Orange County, adjacent to Greater Los Angeles, had the second largest number of stations at six. Other areas of the state, including the Sacramento Region, San Diego County, the Inland Desert, Central Coast, Sierra-Nevada and San Joaquin Valley areas had between one and three stations each. Looking forward, by the end of 2020, the Greater Los Angeles, San Francisco Bay Area, and Orange County are projected to have 19, 22, and seven Open-Retail stations, respectively. The remaining areas will maintain their current counts. When all stations currently under development are complete by 2022, the San Francisco Bay Area and Greater Los Angeles will continue to have the most Open-Retail stations at 24 and 22, respectively. Orange County will have 12 Open-Retail stations, and the Inland Deserts and San Diego County will each gain an additional station in 2022. These projections do not include any stations that may be proposed in the currently open GFO 19-602. The Energy Commission’s latest Application Manual anticipates award approval in September 2020 and indicates an expectation of station operations within 30 months of that date, which implies a nominal expected opening date in 2023 for any newly funded stations.

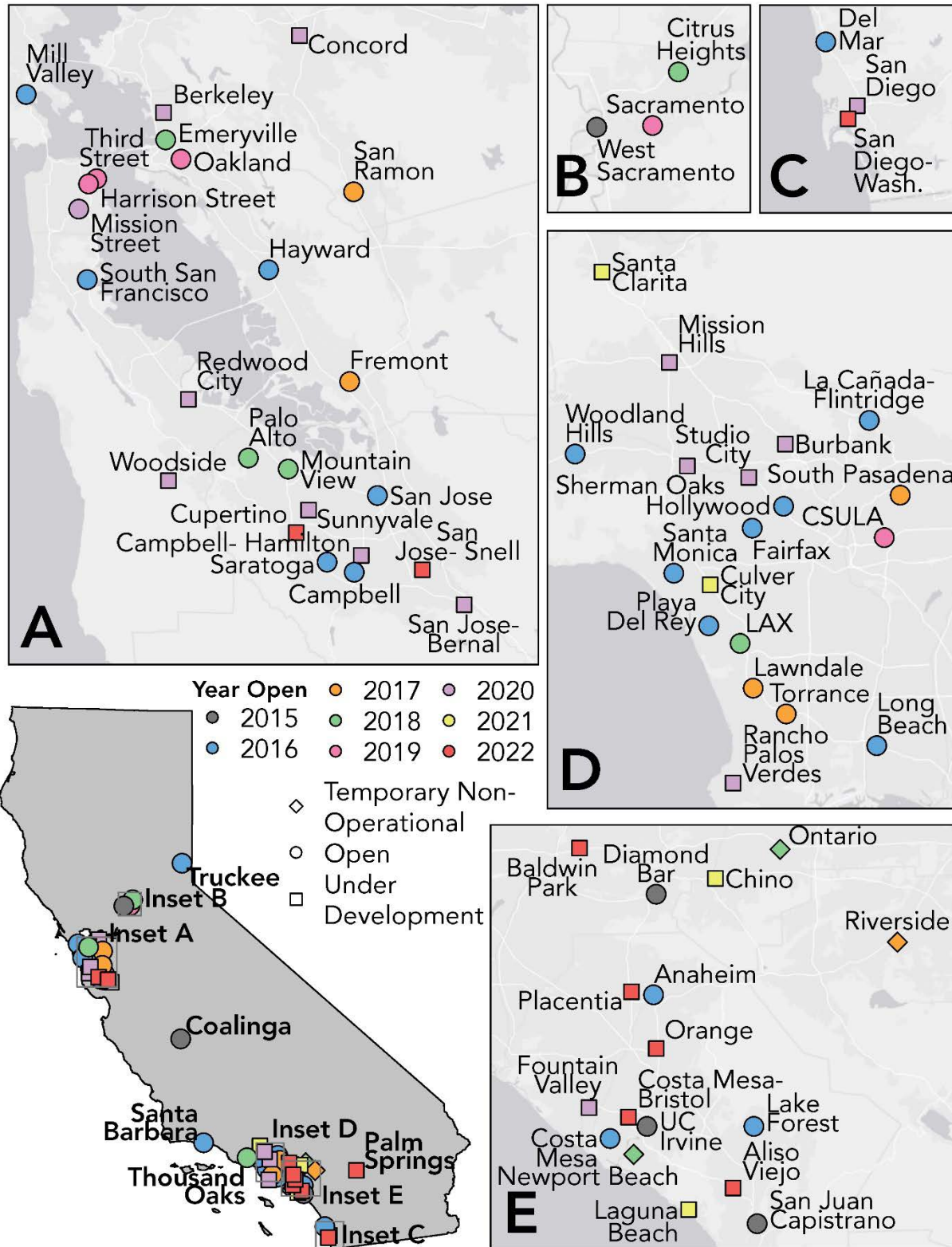
Figure 15 provides further detail for individual stations and maps the location of all hydrogen fueling stations currently in the network, their historical or projected opening date, and their current status as either Open-Retail, In Development, or Temporary Non-Operational. Similar maps in Appendix C, distributed with the annual survey to auto manufacturers, also display the funding source (GFO, HRI, Private, or a combination of sources) for each station.



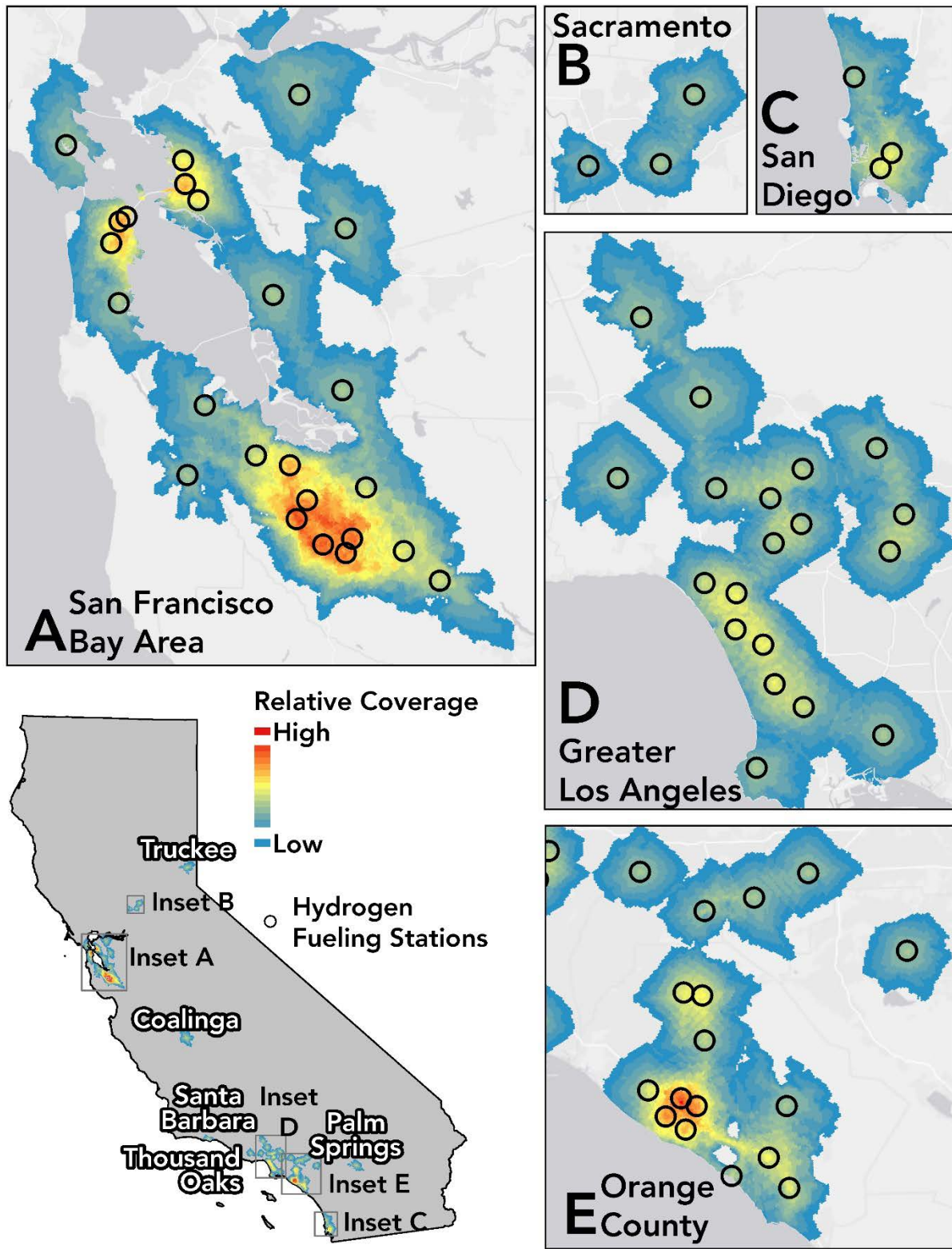
**FIGURE 14: END OF YEAR STATION COUNTS BY REGION (AS OF JULY 3, 2020)**



**FIGURE 15: HISTORY AND PROJECTIONS FOR OPEN AND FUNDED HYDROGEN STATION NETWORK**



**FIGURE 16: ASSESSMENT OF COVERAGE PROVIDED BY OPEN AND FUNDED HYDROGEN STATION NETWORK**

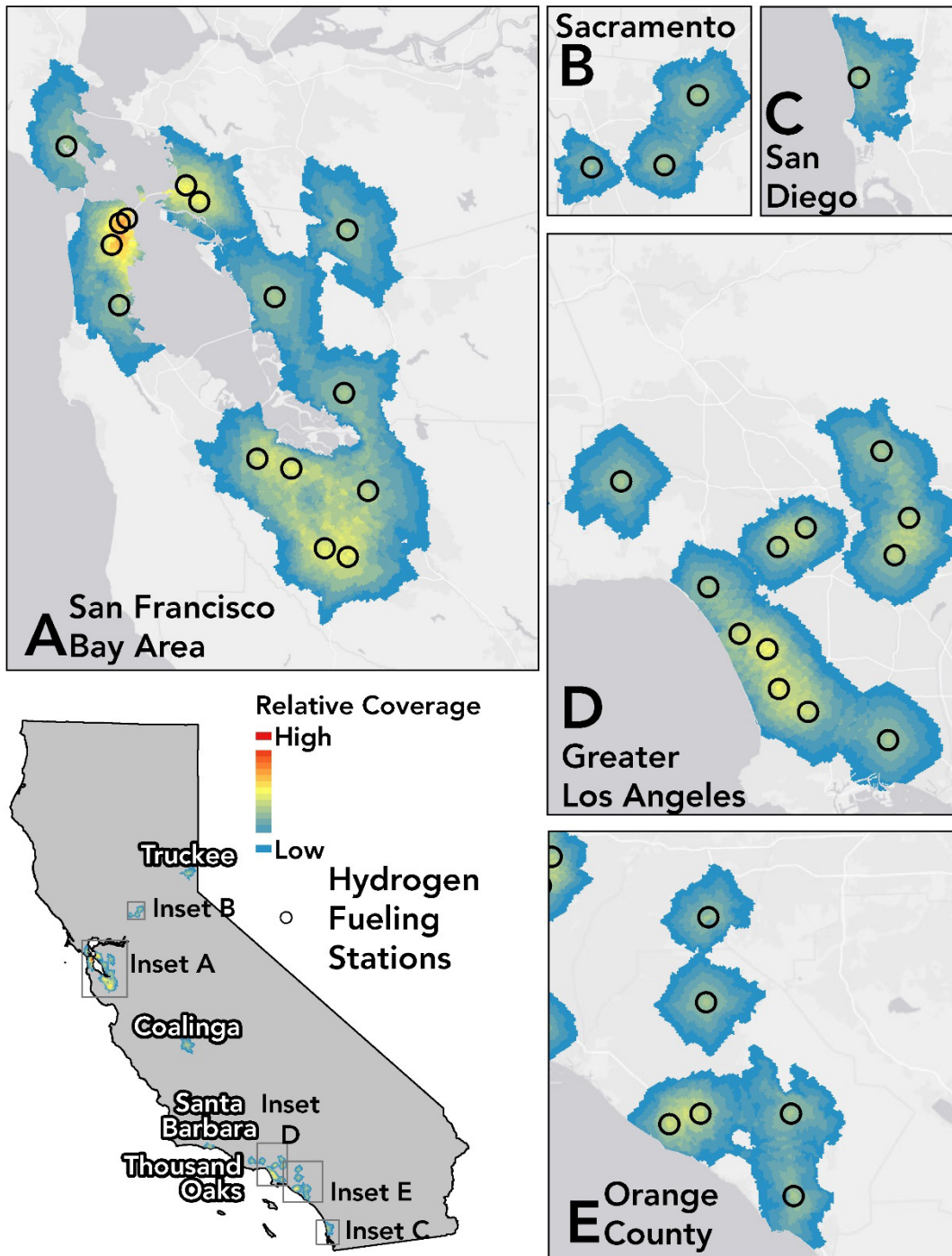


An evaluation of the coverage provided by these 71 stations is provided in Figure 16. As in previous years, CARB has utilized CHIT to perform its assessment of relative coverage. With the West LA and Beverly Hills stations no longer in the network, the coverage provided in the area of West Los Angeles has noticeably decreased relative to other areas across the state. New stations identified through the HRI process are concentrated in the southern portion of the San Francisco Bay Area and Orange County, with new additions in and near areas that had already been hotspots of high relative coverage. In Orange County, the highest coverage is centered on Irvine and Costa Mesa. In the San Francisco Bay Area, a wide stretch from Mountain View to Campbell defines a contiguous area of high coverage.

These new stations have intensified the relative degree of coverage in locations that already had high coverage values. As a result, some areas like the city of San Francisco and the Alameda county cities of Oakland, Berkeley, and nearby areas still provide relatively high degrees of coverage to drivers in these areas, but they are no longer among the highest coverage areas in the state. The new station in San Diego on Washington Street will provide a large degree of overlapping coverage to the previously funded San Diego station on Mission Center Road. A similar overlap of coverage is provided by the new Placentia station and the Open-Retail Anaheim station. The new Baldwin Park station also extends an area of contiguous coverage through Diamond Bar and Chino and out to the station in Ontario.

The coverage provided by the 42 currently Open-Retail stations is also extensive, though more limited in geographic extent. The coverage provided by the 42 Open-Retail stations is mapped in Figure 17; the color shading for the degree of coverage in Figure 17 is coordinated with the scale in Figure 16, allowing for direct comparison. With the currently Open-Retail network of stations, there are several areas where coverage will be initiated by stations still in development, particularly: between San Mateo and Redwood City; near Concord; south of San Jose; north of Los Angeles, between Sherman Oaks and Santa Clarita; around Rancho Palos Verdes; between Pomona and Riverside; around downtown San Diego; and in the destination location of Palm Springs. In addition, some areas that currently have coverage will gain even greater, overlapping coverage from the stations remaining in development, in particular: the southwest end of the San Francisco Bay Area between Redwood City and San Jose and in Orange County in the area around Costa Mesa and Irvine.

**FIGURE 17: ASSESSMENT OF COVERAGE PROVIDED BY 41 CURRENTLY OPEN-RETAIL HYDROGEN STATION NETWORK (AS OF APRIL 13, 2020)<sup>16</sup>**



16 The Fountain Valley station became Open-Retail while this report was in review; its coverage is not shown in the figure.

## Suggestions for Future State Co-Funding

In the 2019 Annual Evaluation, CARB described the formulation and details of a streamlined method for evaluating the location of stations proposed for future funding in the AB 8 program. The method was built on evaluation of the then-current open and funded hydrogen fueling network and the expected geographical reach of network development required to support a broad consumer market of FCEVs by 2030. The Energy Commission adopted that streamlined process into GFO 19-602 and CARB is currently participating with the Energy Commission on verifying station proposals with respect to a system of Area Classifications.

Area Classifications account for the current state of local network development and the expected need for more and larger stations in the future. Stations that are identified in Connector or Destination areas are expected to include at least one fueling position in their designs. Stations in any other eligible area are required to include at least two fueling positions capable of fueling vehicles simultaneously. In addition, CARB identifies areas where there is a high degree of redundant coverage and even larger stations (with three or more simultaneous fueling positions) are likely needed sooner than in other areas. Station developers would be encouraged to seriously consider designing stations in these regions with the highest capacity feasible for the site.

As new stations are funded through successive batches of GFO 19-602 over the following years, the map of Area Classifications and minimum capacity requirements will be modified to reflect the latest information on current market development. This information is expected to be considered in combination with applicants' own narrative demonstrating potential demand at each proposed location and its ability to support current network health and enable greater market expansion. CARB continues to support this method for assessing proposed hydrogen fueling stations with respect to the remainder of the open and funded network.

Evaluation of both the current and future coverage needs and network growth are based on the use of CHIT. CHIT is a geographic information system-based analysis tool built in the ArcGIS environment. Its core features are demonstrated by Figure 18. The tool takes as input several demographic and vehicle registration data along with simulated traffic data to develop a statewide estimate of the local market potential for FCEV adoption in the first-adopter market (shown as step 1). CHIT then compares this to the coverage assessment (shown as step 2) and develops as outputs assessments of the localized coverage and capacity gap (shown as steps 3 and 5). Further geostatistical analysis is possible with the tool to identify the geographic extent of the contiguous areas of highest need called Priority Areas (shown as step 4); CARB typically applies this step only with respect to coverage but it can be equally utilized for capacity or a hybrid indicator of the two.

Figure 19 displays the current evaluation of coverage gap based on the 71 open and funded stations. The color shading of the maps in the figure indicate areas of high need in bright red, orange, and yellow and areas of low need in darker greens and blues. As shown by the Priority Area determinations in Figure 20, areas of high need for additional coverage are found across the state, including in the first early development markets in the Greater Los Angeles, Orange County, San Diego, Sacramento, and San Francisco Bay Area Regions. Additional areas of high need are visible in the San Joaquin Valley Region, especially in and near cities along the CA-99 corridor. There is also a noticeable area of significant coverage gap near Palm Springs and in coastal cities within the Central Coast Range.

FIGURE 18: CHIT EVALUATION PROCESSES

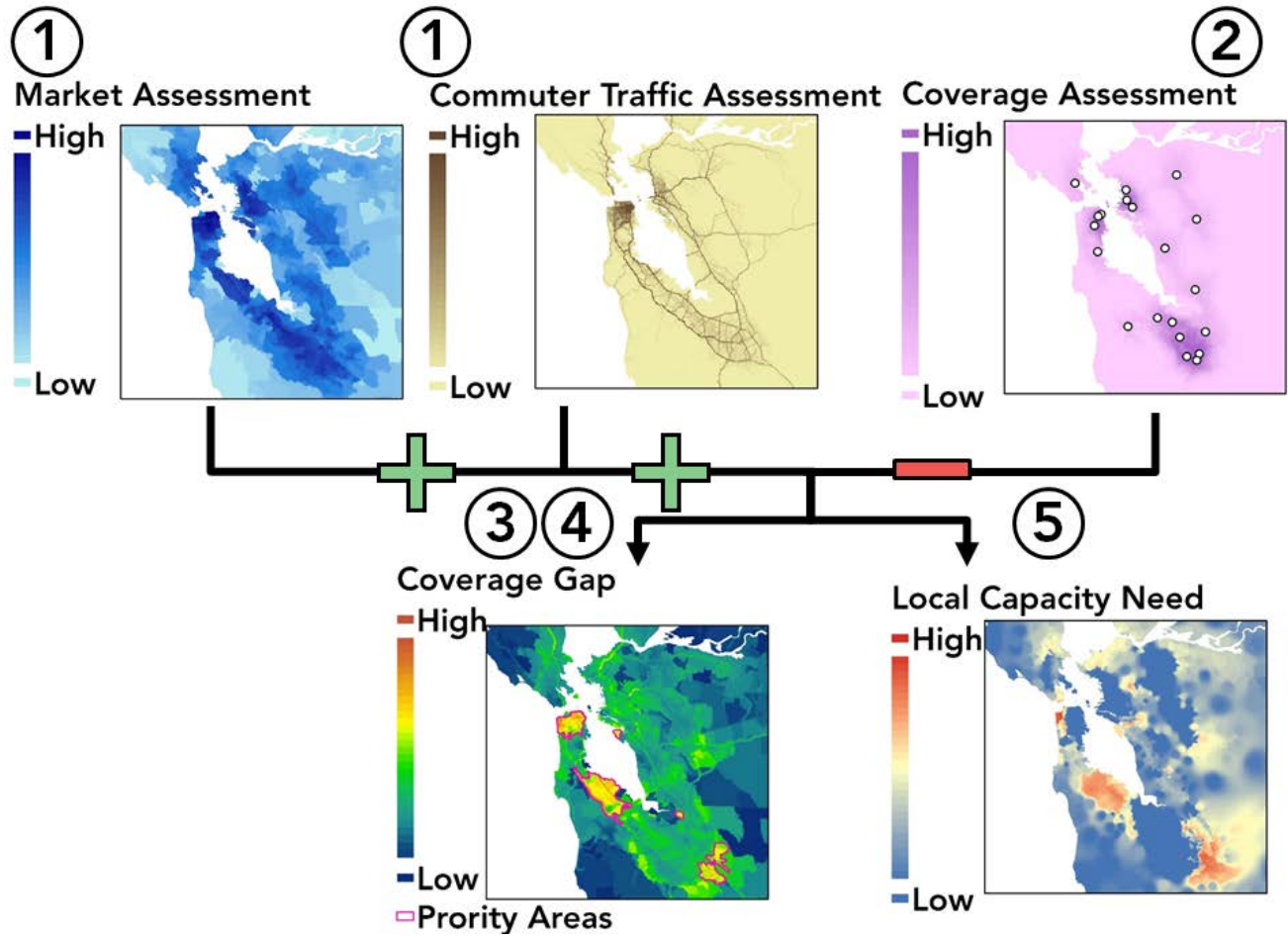
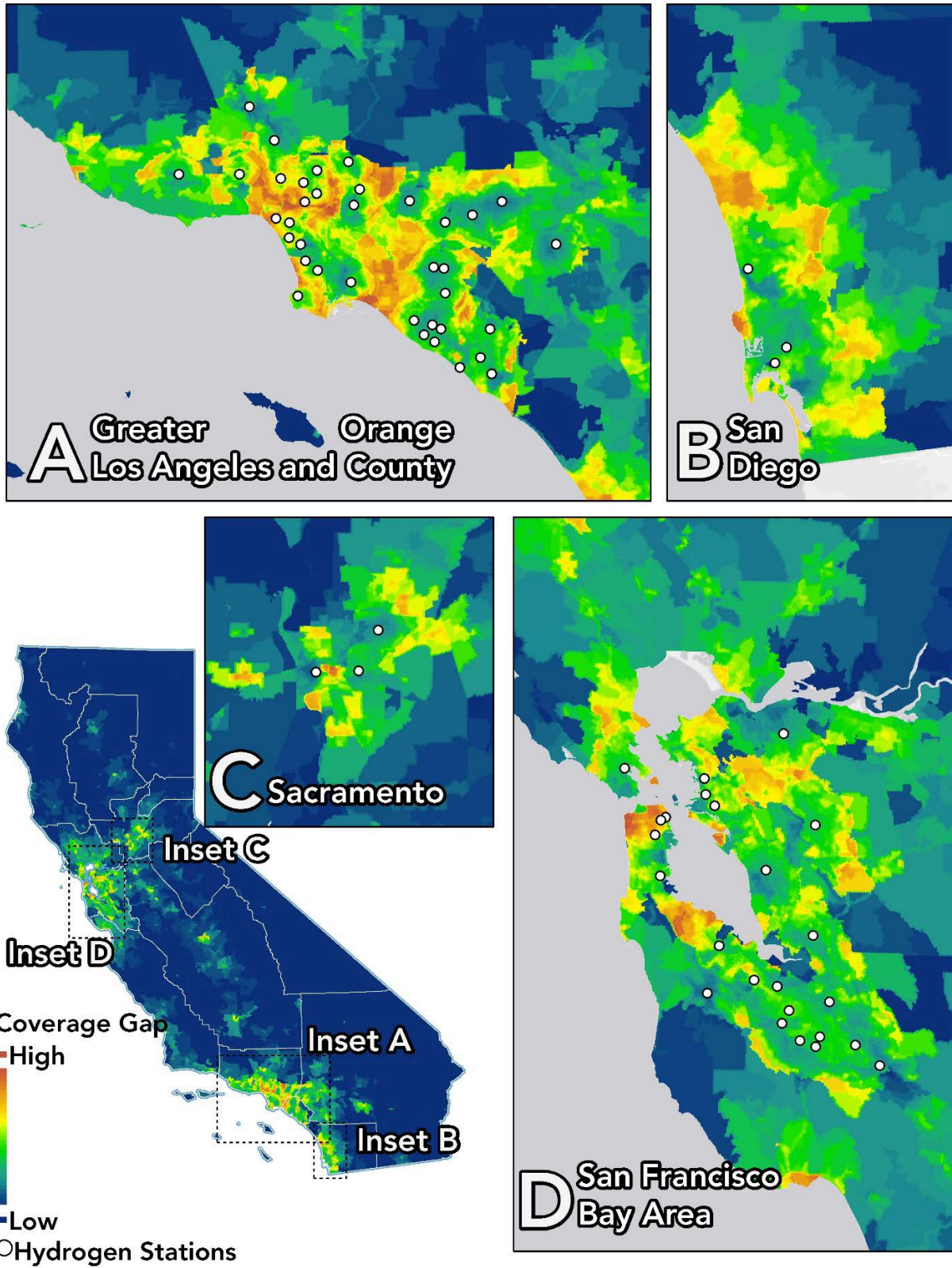
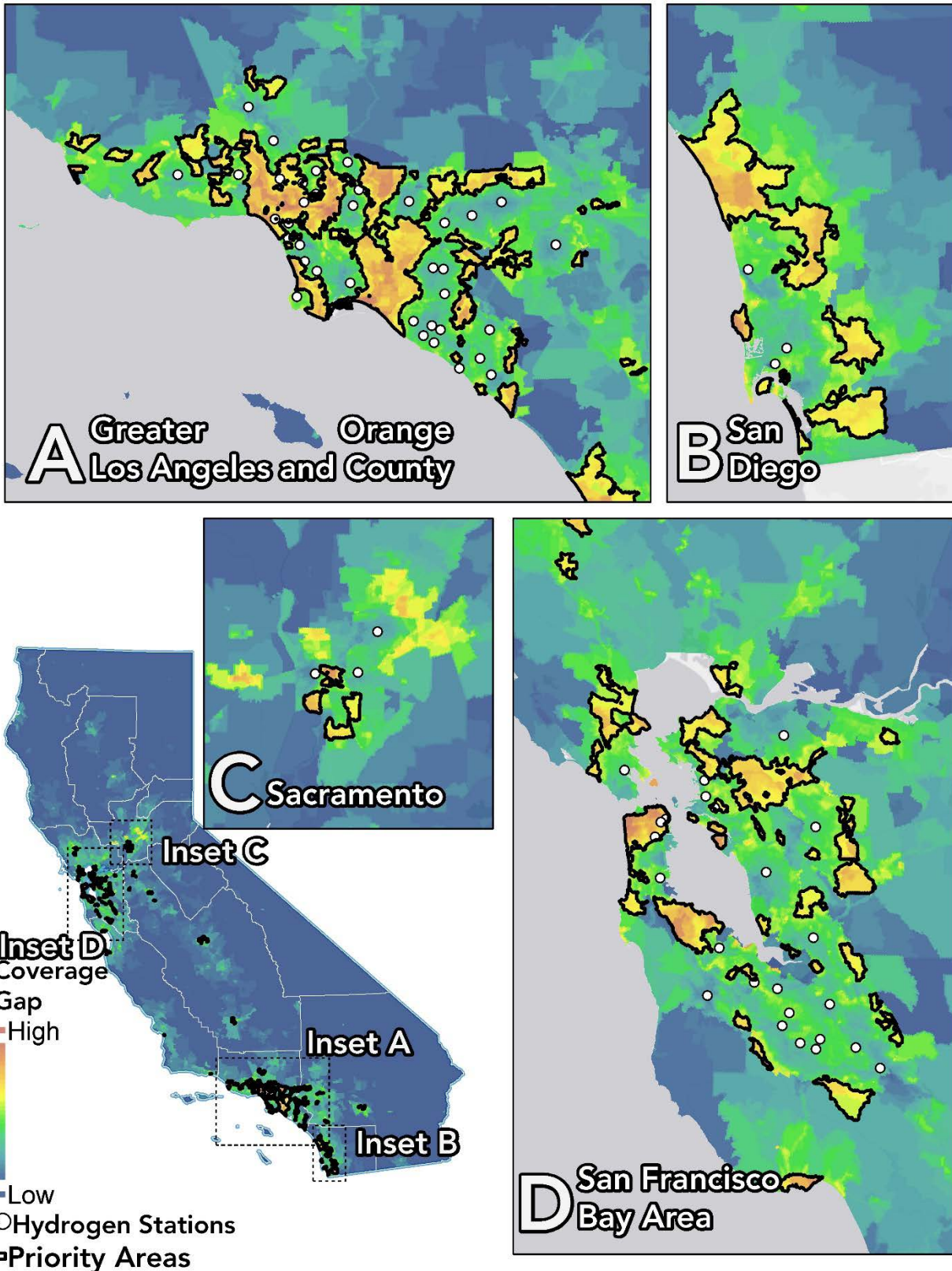




FIGURE 19: COVERAGE GAP ANALYSIS, AS OF JULY 3, 2020



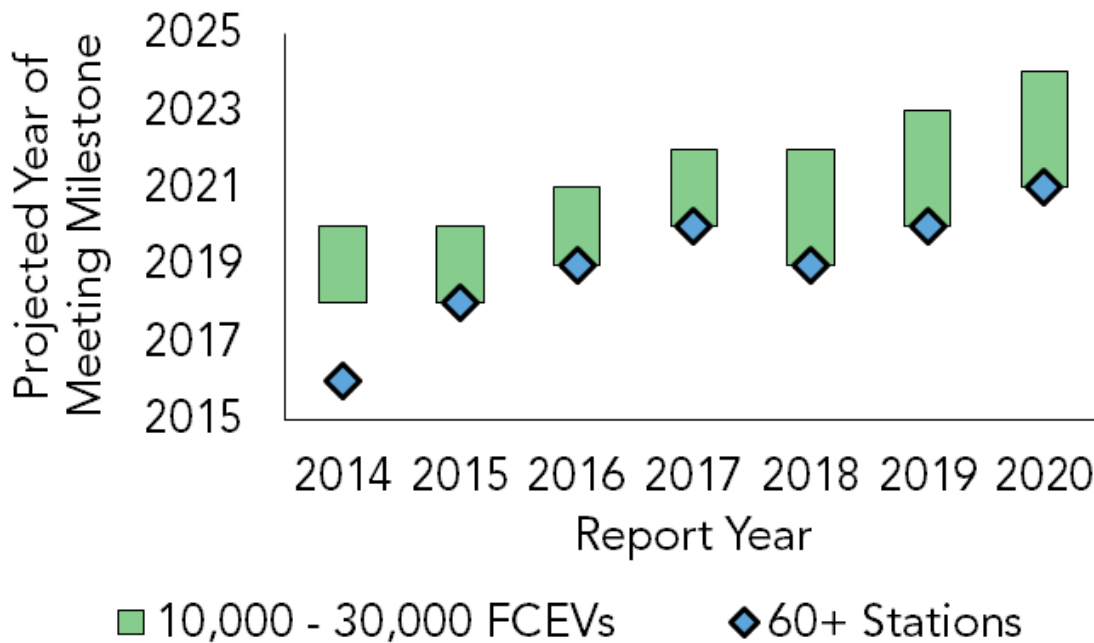
**FIGURE 20: PRIORITY AREAS FOR FUTURE STATION DEVELOPMENT**



## Station Network Development with Respect to Industry Strategy Milestones

Since the publication of the California Fuel Cell Partnership’s A California Road Map, [47] achieving a total open station count around 60 (specifically 68 in that report) has been an important marker of significant station network development. In the Road Map, this was characterized as the minimum number of stations to launch FCEV deployment and was associated with the potential to deploy a notional cumulative 10,000-30,000 FCEVs.

**FIGURE 21: PROJECTIONS OF ACHIEVING HYDROGEN STATION AND FCEV MILESTONES IN SUCCESSIVE ANNUAL EVALUATIONS**



Today, the network contains more than 40 Open-Retail hydrogen fueling stations and current projections indicate 62 stations will be Open-Retail at the end of 2021 at the earliest. Using the milestone markers of 60+ stations and 10,000-30,000 FCEVs, Figure 21 demonstrates how FCEV deployment projections closely track station network development projections. The expected date of achieving the 60+ station milestone has increased from 2016 (as reported in 2014) to the current estimate of 2021. The development of this trend over time is similar to the progression of the projected date at which 10,000 - 30,000 FCEVs would be deployed; the bottom of the green bars indicates the projected year of achieving 10,000 FCEVs on the road while the top of the bar corresponds to 30,000 FCEVs.

For example, the 2015 Annual Evaluation estimated that 60+ stations would be achieved in 2018. In addition, the 10,000 FCEV milestone was projected to be crossed at the same time (2018), while 30,000 FCEVs were projected for 2020. In each of the next two reporting years (2016 and 2017), the projected date for achieving all three of these milestones increased by one year. In several years, the changes in the trends of these milestones are identical. For the milestone of 10,000 FCEVs, the projected date matches exactly with 60+ stations for all report years except 2014. The correlation between these trends underscores the impact of station network development on the ability to deploy FCEVs in the future.

Over the course of the past seven years of reporting, there have been many factors that influenced the projections of station development pace. The following list indicates particular considerations that had an important role in that year's station development projections:

**2014:** Beginning of the retail station reporting program. Station developers indicated optimism in achieving target station development dates per grant funding contracts. Experience with Energy Commission solicitation budgets indicated potentially large numbers of stations could be funded with annual \$20 million allocations.

**2015:** Reporting in 2015 began to make adjustments for in-development stations based on improved station developer projections. Operations and Management grants from the Energy Commission proved popular and helped ensure operations of funded stations in early years of vehicle deployment. Accounting for the additional incentive resulted in adjustments to the number of new stations that could be funded in each \$20 million allocation.

**2016:** Continued adjustment for in-development stations based on further improved station developer projections. Data based on experience first became much more reliable and influential in future network development projections.

**2017:** Station developers concentrated efforts at stations that had encountered unanticipated delays. Some station development projects funded by the Energy Commission had been issued Stop Work Orders to protect the expenditure of State funds, but these were later lifted as developers demonstrated continued progress despite the additional challenges.

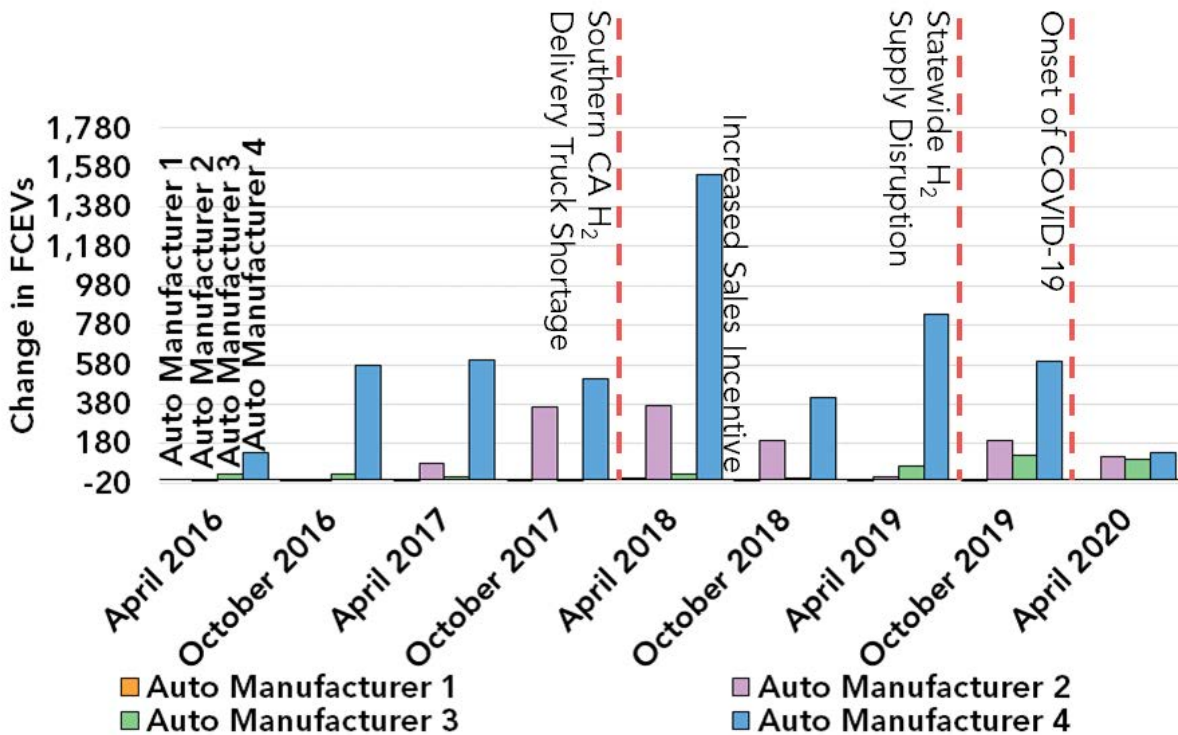
**2018:** Individual station development projects remained largely on track with their expected progress from the year before. In addition, the Energy Commission completed selection of awards under GFO 15-605, which added enough stations with an expected completion date early enough to accelerate the projected achievement of 60+ stations by one year.

**2019:** Regular updates to the progress of stations in development indicates some adjustments to projections of Open-Retail dates.

**2020:** Regular updates similar to 2019, though complicating factors of the hydrogen supply shortage in the summer of 2019 and the worldwide COVID-19 pandemic likely play a significant role.

In addition to the effects of changes in estimated station network development, FCEV deployment remains susceptible to industry-wide disruptions. Figure 22 displays the history of change in FCEV registrations per auto manufacturer between April and October registration data from 2016 onward. The figure is also labeled showing the approximate start date of events that likely affected both station development and operations and FCEV deployment. In February 2018, the hydrogen fueling network (especially in southern California) experienced a shortage of available fuel delivery trucks. This potentially impacted sales, though the impact appears masked by a large short-term increase in sales from one auto manufacturer due to a sales incentive program initiated at that time. Instead, the effect of the southern California truck shortage may be more visible in October 2018 since the change in FCEVs for all auto manufacturers in that period was lower than at least the two prior semi-annual reporting periods. Thus, the registration data may exhibit a delay of up to one year in market effects like hydrogen supply disruptions.

**FIGURE 22: CHANGE IN FCEV REGISTRATIONS BETWEEN SEMI-ANNUAL ANALYSES WITH RESPECT TO NOTABLE EVENTS**



This appears to be true also for the more recent statewide hydrogen supply disruption that began in June of 2019. The growth in total FCEV registration in October 2019 appears similar to the average rate for prior periods in the registration data. However, there is a severe drop-off in the April 2020 registration data. Therefore, April 2020 registration data may exhibit a delayed impact from the June 2019 supply disruption. It may also be affected by the more recent onset of COVID-19, which has been reported to affect the automobile industry globally. There may also be masked effects from model year change-over at various points throughout these data as auto manufacturers decelerate deliveries of older model or model year vehicles in preparation to increase delivery of newer vehicles. Some auto manufacturers have also initiated recalls over time, which could affect their sales rate of new vehicles. All of these factors likely impact the observed changes in registered vehicles over time. The sensitivity of registration data to these factors emphasizes the early market nature of FCEVs.

## Trends of Station Deployment Rates

The pace of development of stations funded but not yet open has been slower than projected at this time last year. Figure 23 highlights this difference, as projected open station counts for 2020 and 2021 are significantly lower in this year's analysis than in the past. This implies that a greater acceleration in new station development will be necessary to achieve the target of at least 100 stations open through the AB 8 program by January 1, 2024. In addition, increased acceleration will similarly be required to achieve the goal of 200 stations by 2025 per EO B-48-18. There are indications that the combination of AB 8 and the LCFS HRI program will enable growth towards the target of 200 hydrogen fueling stations (with the AB 8 program most recently estimated to fund as many as 122 stations [43]), but the ultimate number of stations that can be enabled by these programs combined has yet to be determined.

**FIGURE 23: COMPARISON OF STATEWIDE STATION PROJECTIONS BETWEEN 2019 AND 2020 ANNUAL EVALUATIONS**

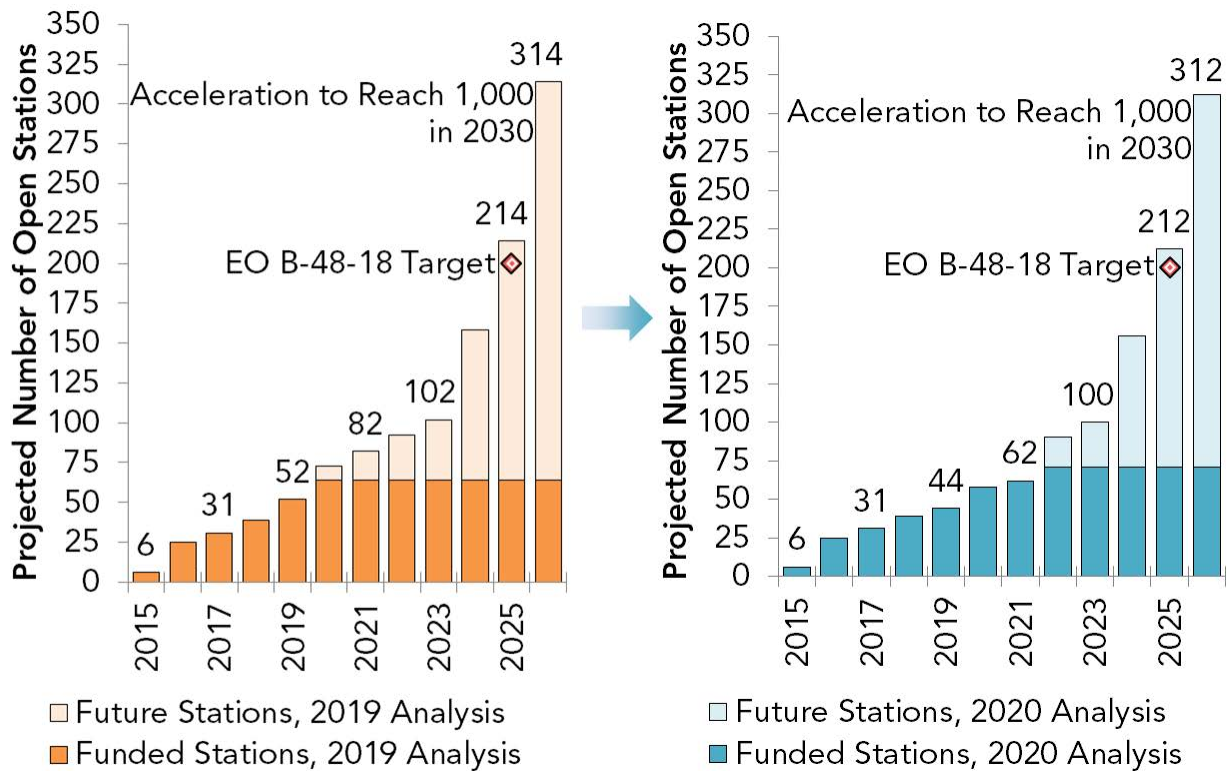
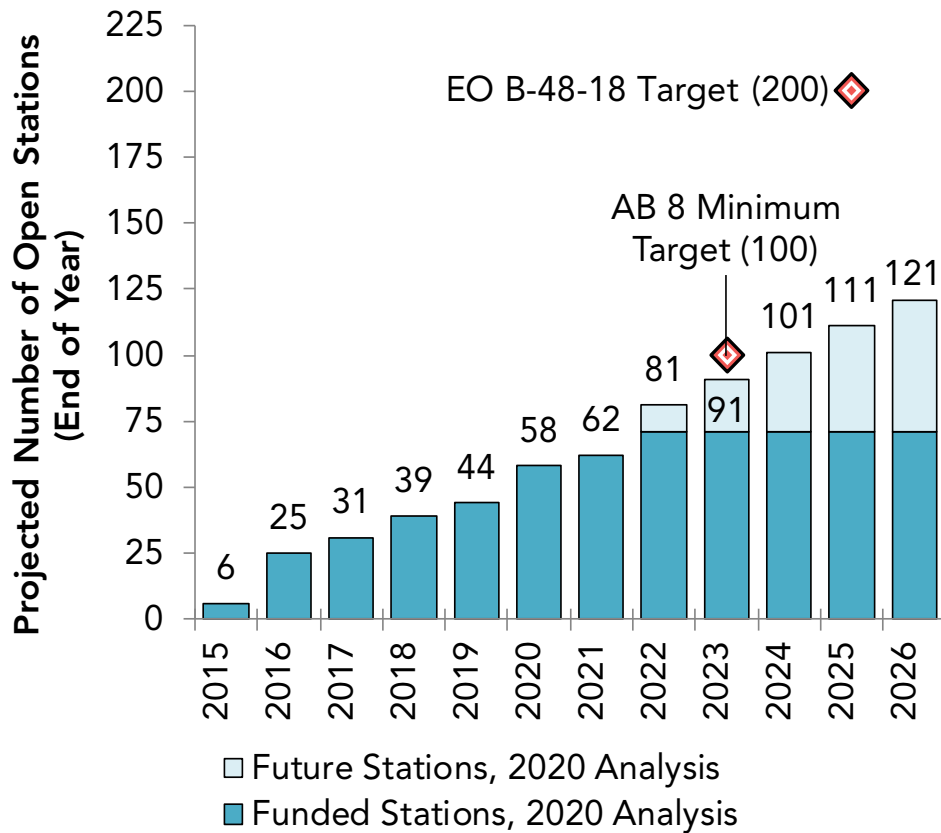


Figure 23 also highlights the immense challenge of station network development understood to be necessary to keep pace towards the goal of achieving economies of scale and keeping a healthy pace of industry development towards eventual financial self-sufficiency. In order to enable an ambitious target like one million FCEVs as in the California Fuel Cell Partnership’s Revolution, the station network growth will need to continually accelerate in the coming years to achieve the necessary size of approximately 300 stations by 2026.

**FIGURE 24: END-OF-YEAR CUMULATIVE STATION DEPLOYMENT WITH HYPOTHETICAL BUSINESS-AS-USUAL PACE**



Acceleration to meet the near-term AB 8 target and progress towards future goals is not a matter of pace of funding alone. Meeting any of these milestones will require strict adherence to projected station development timelines and likely require future stations to develop at a more rapid pace than has been experienced in the past. This is demonstrated in Figure 24, which uses the historical pace of station development (a function of funding pace and on-the-ground development pace) to project future station deployment. The figure clearly shows that the historical business-as-usual pace (based on approximately 50 stations expected to achieve Open-Retail status between 2015 and 2020) implies that the AB 8 program’s target may not be achievable by January 1, 2024 without some amount of acceleration. Likewise, the target set forth by EO B-48-18 is out of reach by a wide margin.

CARB does not expect this to be the actual pace of development given the structure of GFO 19-602 and the additional opportunities now presented by the LCFS HRI program. However, this analysis underscores the need for station development in the future to proceed as quickly as possible. One potential area for improvement continues to be the local process of permitting. Traditionally, station developers and the State (especially the staff of the Governor’s Office of Business and Economic Development, or GO-Biz) have worked diligently to help local officials expedite the permitting process for hydrogen stations as much as possible while fulfilling their need for due diligence and accuracy of engineering and technical evaluation. However, as shown by an analysis of station development time in the 2019 Joint Agency Staff Report on AB 8, the time required for the permitting and construction phases has recently grown [43]. Thus, innovative solutions may be required to shorten the length of time required to complete these two phases of development.

# 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.

**CARB 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.

### Assessment and Projections of Hydrogen Fueling Capacity in California

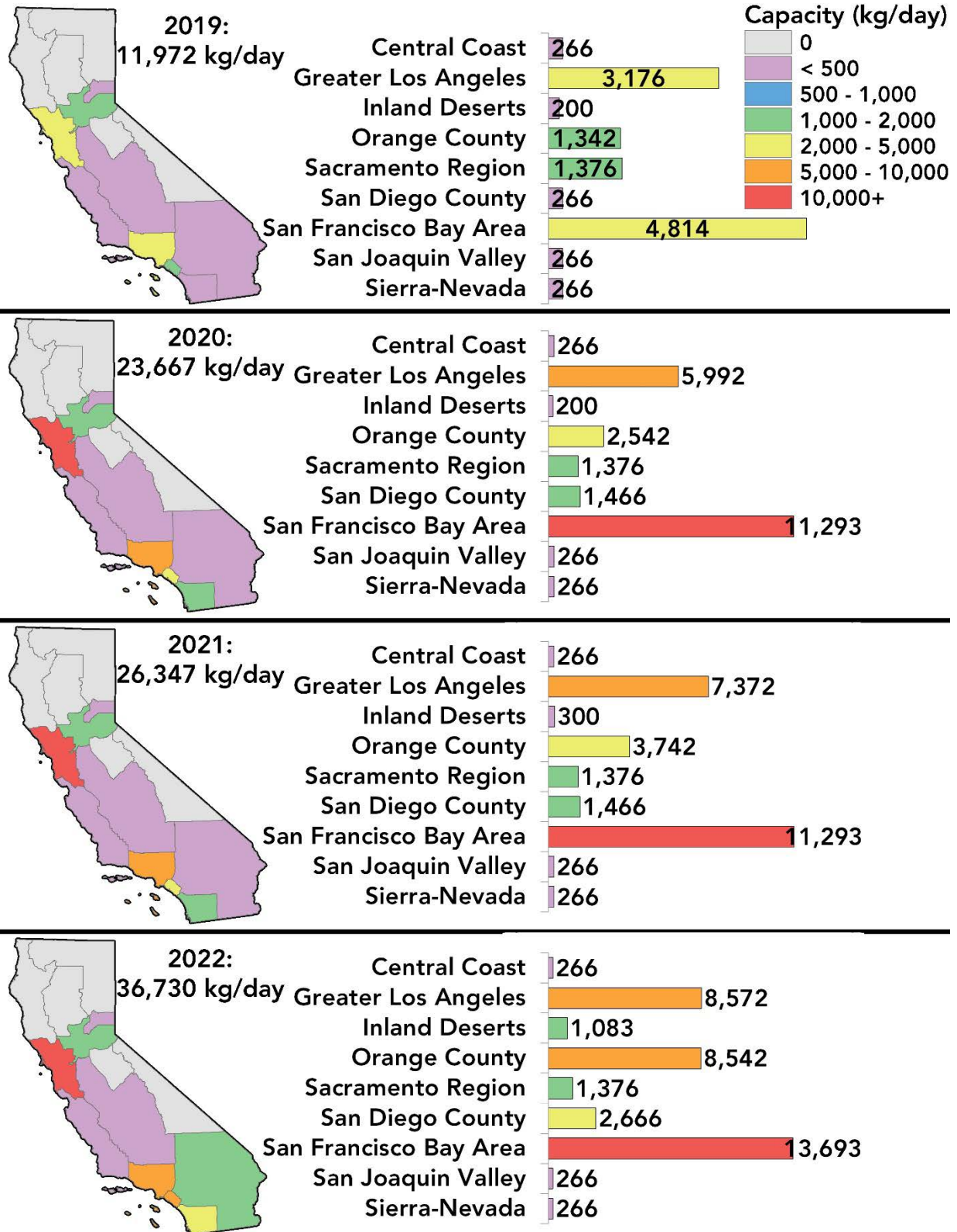
The progression of open fueling capacity in California’s hydrogen fueling station network for the years 2019 through 2022 is shown in Figure 25, aggregated by region and across the full state<sup>17</sup>. For this year’s analyses, CARB has updated the majority of the station capacities according to evaluations it has received using the Hydrogen Station Capacity Evaluation (HySCapE) model required for the LCFS HRI program. There are currently 48 of the 71 funded stations in the program; each has an associated updated capacity per evaluation with HySCapE due to the requirements of the application and crediting process. Since the majority of stations are now included in the program, CARB adopted these capacities for all stations when available. The station capacity indicated by the HySCapE tool is typically larger than prior years’ reporting because it is based on a 24-hour evaluation period and potentially accounts for additional midday deliveries. Prior accounting of capacity was based on nominal 12-hour capacity as indicated by station developers and may or may not have included the midday fuel delivery.

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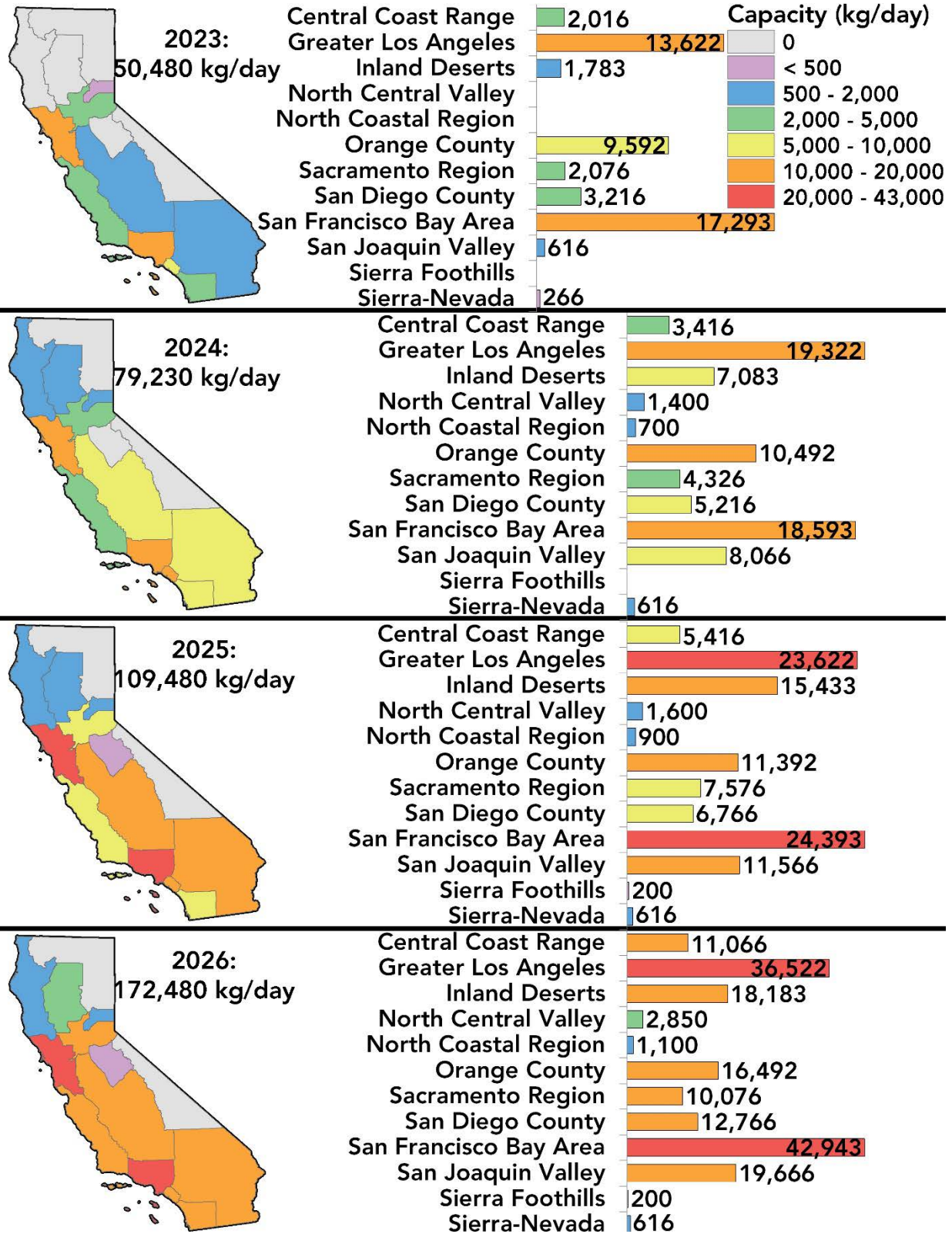
<sup>17</sup> For historical capacity evaluations for years prior to 2018, please see prior years’ *Annual Evaluations*



**FIGURE 25: PROJECTED HYDROGEN FUELING CAPACITY OF 71 FUNDED STATIONS AGGREGATED BY REGION**



**FIGURE 26: FUTURE HYDROGEN CAPACITY BY REGION FOLLOWING REVOLUTION SCENARIO**



This has led to an overall increase in the regional and statewide capacities compared to prior years' evaluations. As indicated in Figure 25, the statewide capacity is expected to grow from almost 12,000 kg/day at the end of 2019 to nearly 37,000 kg/day by the end of 2022. Greater Los Angeles and the San Francisco Bay Area had the highest capacities at the end of 2019. This continues through 2022, with the San Francisco Bay Area having the higher capacity of the two regions, and Orange County growing to similar capacity as the Greater Los Angeles region in 2022.

Continued regional capacity growth in a hypothetical scenario matching the California Fuel Cell Partnership's Revolution through 2026 is shown in Figure 26. In this scenario, station deployment rate and individual station capacity growth accelerate after the end of the AB 8 program at the end of 2023. Statewide capacity grows from more than 50,000 kg/day in 2023 to more than 170,000 kg/day in 2026. In addition, the geographic extent of the network expands into the North Central Valley, North Coastal, and Sierra Foothills regions during this timeframe. Greater Los Angeles and the San Francisco Bay Area regions remain the focal points for projected capacity growth, with the Orange County, Inland Deserts, and San Joaquin Valley forming a group of secondary focus. San Diego County, the Sacramento Region, and the Central Coast have slightly less growth. Even in 2026, the North Coast, North Central Valley, Sierra Foothills, and Sierra-Nevada regions are only beginning to develop hydrogen fueling capacity and the North Interior and High Sierra regions contain no stations.

Regional, county-wide, and local priorities for continued station development are explored in Figure 27, Figure 28, and Figure 29, respectively. For these analyses, vehicle deployment has been assumed to be geographically dispersed proportional to the open and funded stations only. This differs from Figure 5, which adopts the network development of the Revolution scenario through 2026. The Revolution station development pre-supposes the result of future funding, so it is necessary not to include these stations in order to understand the capacity needs as they currently stand.



**FIGURE 27: PROJECTED HYDROGEN FUELING CAPACITY BALANCE BY REGION**

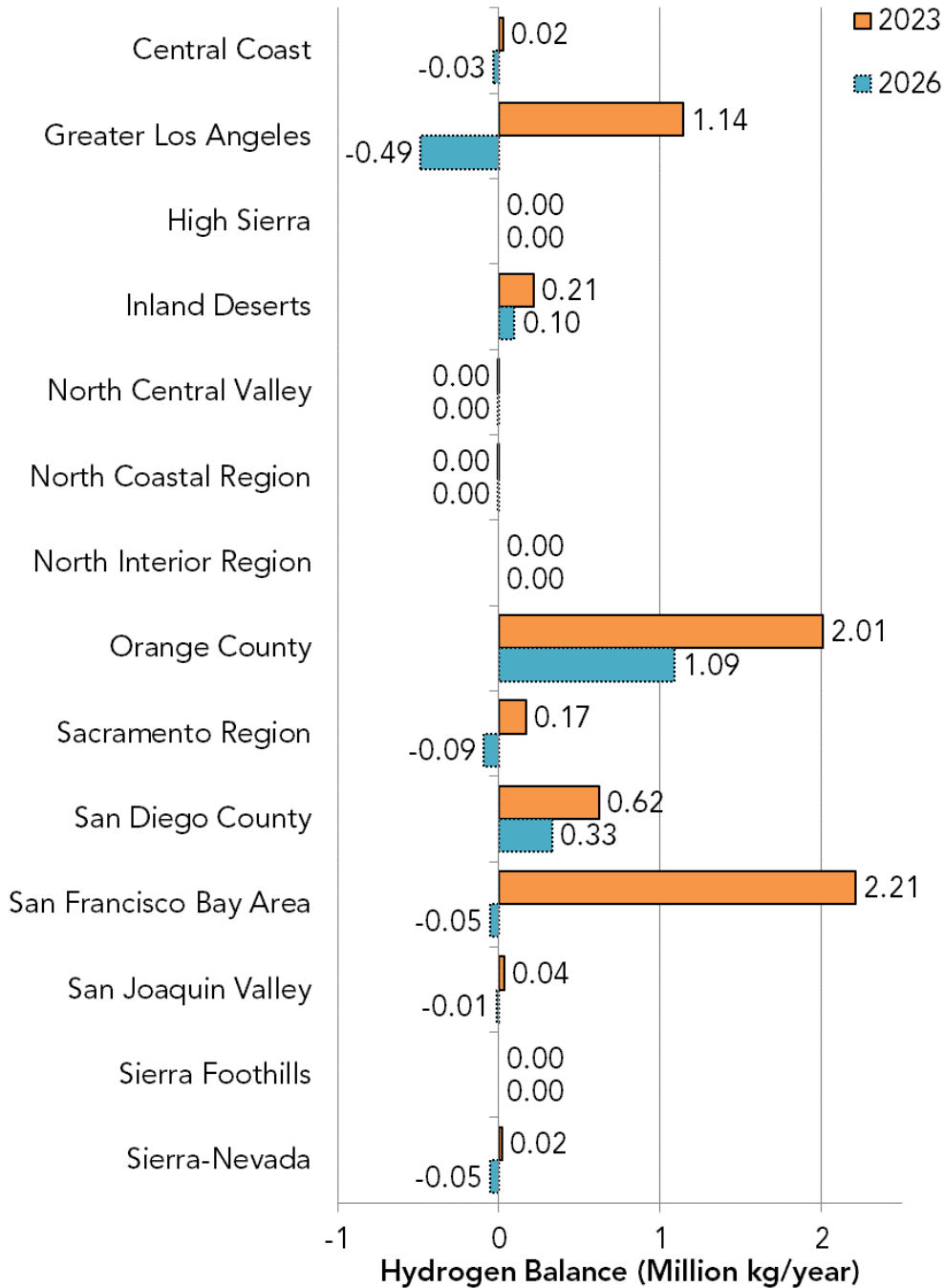


Figure 27 may give the impression that in the near term through 2023, all regions have sufficient hydrogen supply and that further development through 2026 is only necessary in a few regions: Greater Los Angeles, Sacramento, San Francisco Bay Area, Central Coast, and Sierra-Nevada. However, balancing such hydrogen fueling supply and demand over such wide regions may mask more localized capacity shortfalls. Figure 28 uncovers some of the more local projected deficits at the county level. For development through 2023, projected FCEV market growth in Marin, San Bernardino, Ventura, and Yolo counties require the most attention (note that Marin and San

Bernardino are outside the regions identified by Figure 27)<sup>18</sup>. Through 2026, the need to emphasize network growth to support FCEV market advancement in counties in the Greater Los Angeles region becomes apparent. Additional needs in counties around the San Francisco Bay Area also become more apparent.

Figure 29 illustrates the areas of greatest need for future hydrogen fueling capacity per the projected FCEV population in 2026 of 48,900 as determined by CHIT. The figure shows area of high need for capacity growth as bright yellow, orange, and red. Areas with low need for capacity growth are shown in blues and greens, with dark blue indicating no additional need for capacity to support the projected deployment. Note that capacity growth needs could be greater with a larger target FCEV population.

The figure confirms the need for capacity growth in the counties most prominent in Figure 28 and again emphasizes the much larger magnitude of long-term development need in Los Angeles County compared to other areas. In addition, the figure demonstrates the more localized targets for development around the San Francisco Bay Area and in other counties demonstrating need around the state. The figure also makes clear that concentrated capacity growth is necessary in Orange and San Diego counties. These findings are only possible through an analysis with fine geographic detail like the resolution provided by CHIT.

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18 At the county and finer resolutions, the balance of demand and capacity is calculated on the basis of the local FCEV market and accounts for the possibility that FCEV owners near the edge of one county may utilize the capacity of stations in neighboring counties. For county-based calculations, stations in this situation have their capacity distributed to markets in appropriate counties according to the relative proportion of their anticipated FCEV market strength. This method was described more fully in Appendix C of the 2016 *Joint Agency Staff Report on AB 8* [64].

**FIGURE 28: PROJECTED HYDROGEN FUELING CAPACITY DEFICITS BY COUNTY**

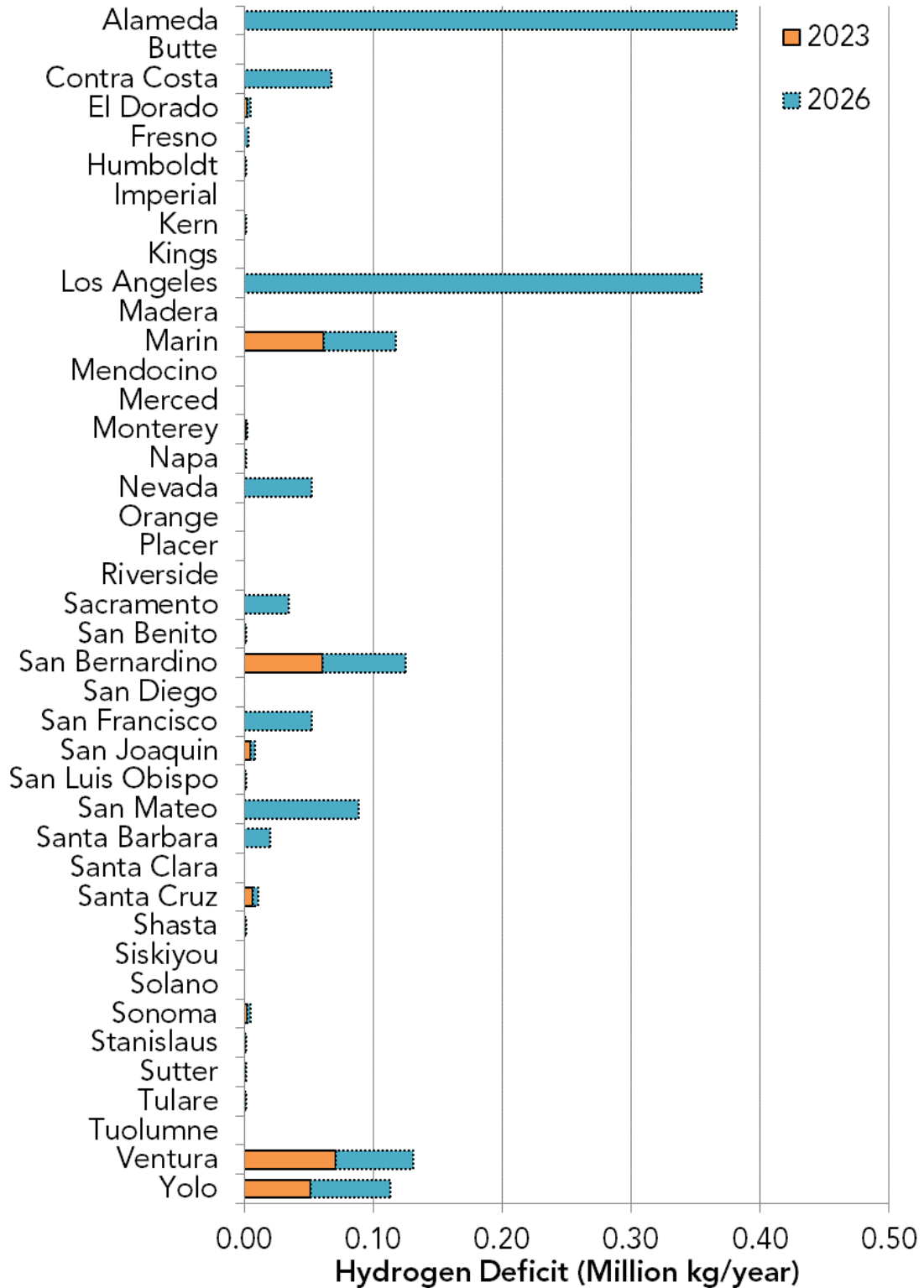
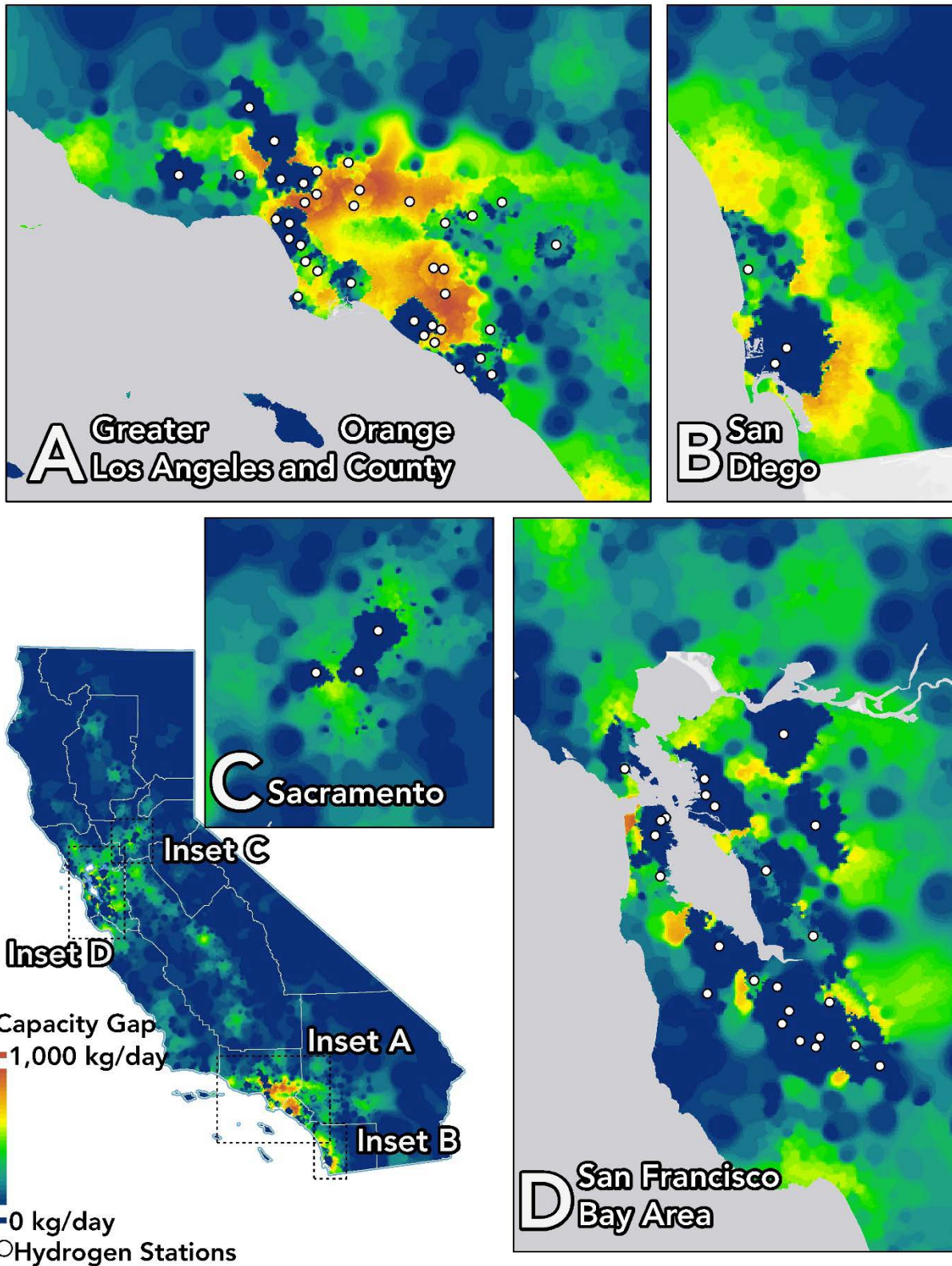
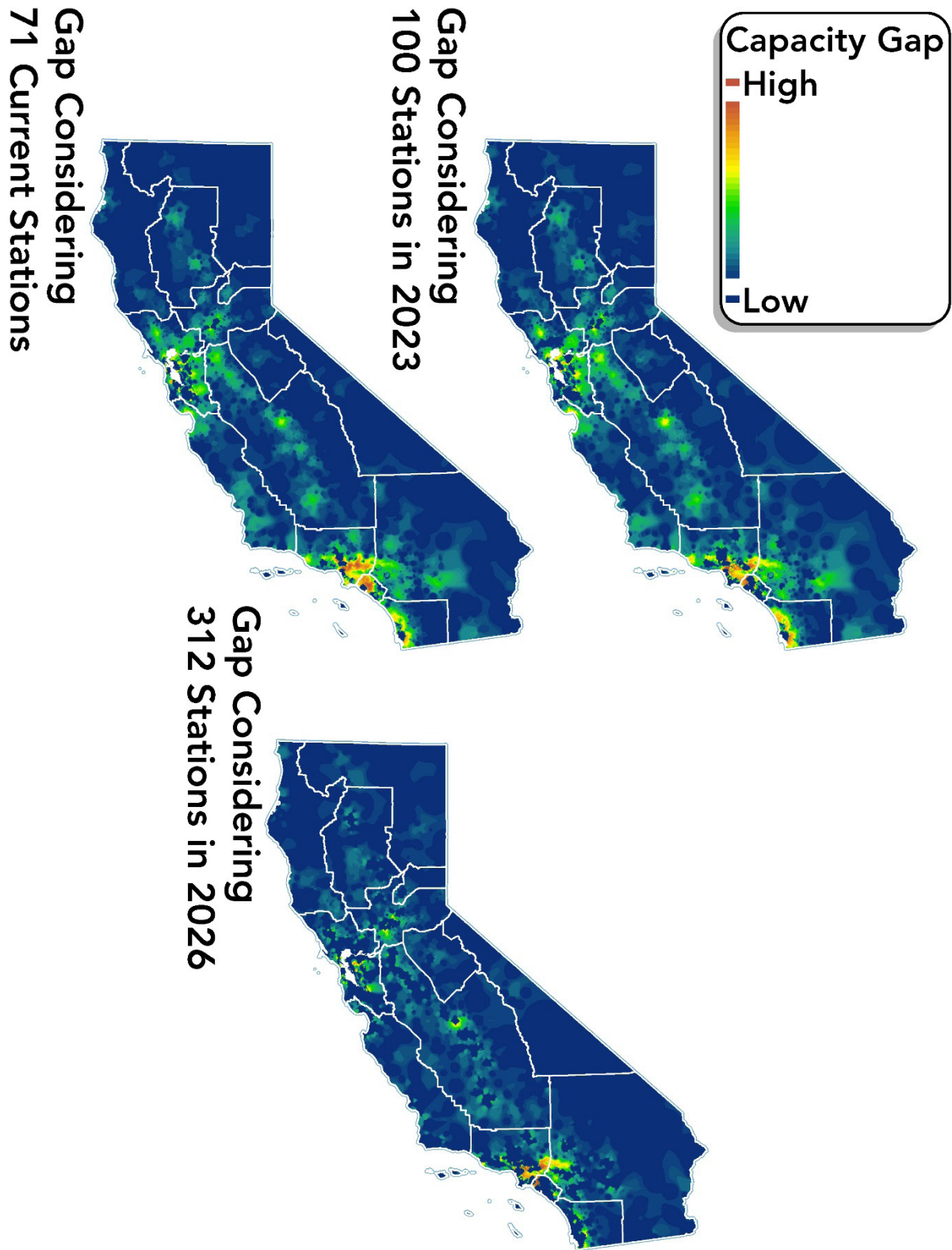


FIGURE 29: CURRENT CAPACITY GAP EVALUATION FOR ESTIMATED 2026 FCEV POPULATION



**FIGURE 30: DEMONSTRATION OF SHIFTING GEOGRAPHIC PRIORITIES FOR CAPACITY GROWTH FOLLOWING REVOLUTION SCENARIO**





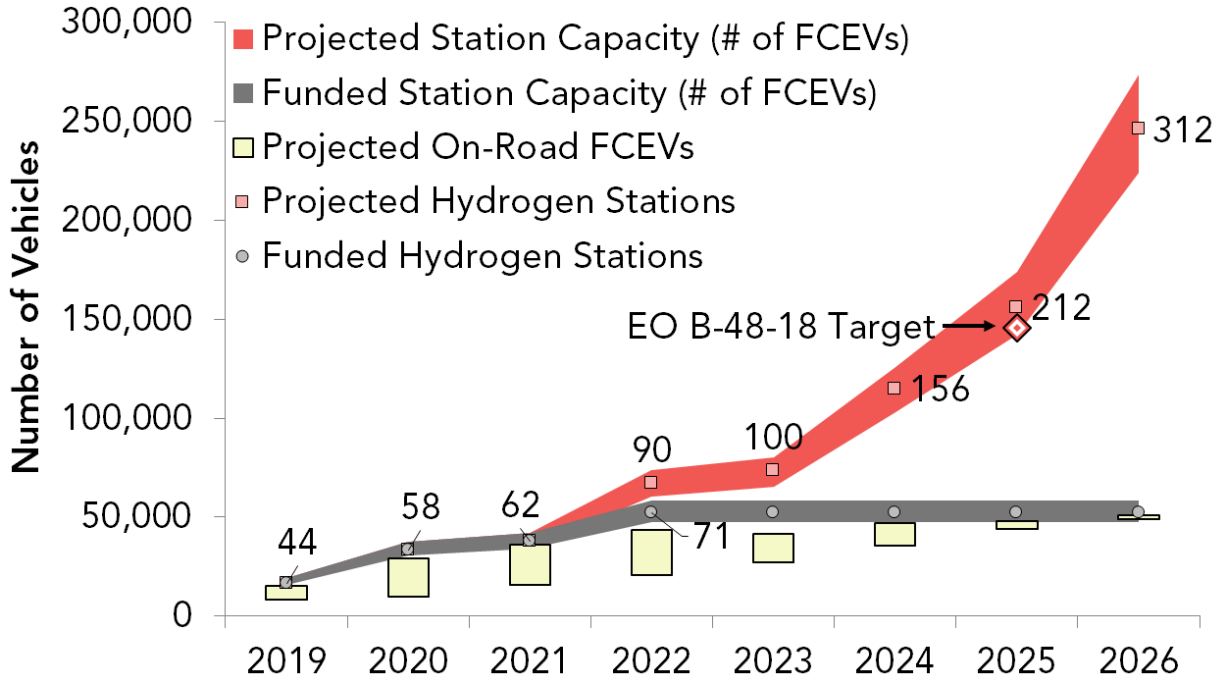
The county-wide and local capacity need determinations of Figure 28 and Figure 29 are estimated based on today's 71 open and funded stations evaluated against the estimated distribution of demand for 48,900 FCEVs projected by 2026. However, network development beyond these 71 stations is expected to continue in the meantime, especially due to GFO 19-602 and the LCFS HRI program. As network expansion continues, areas of greatest need for new capacity will shift over time. Figure 30 demonstrates this shift over time if future network development follows the scenario in the California Fuel Cell Partnership's Revolution. As stations are placed in areas of greatest need (considering both coverage and capacity) the highest current capacity gaps are shown to shift out of the Los Angeles metro area, into the Inland Desert Region, the Sacramento Region, the San Joaquin Valley, and the eastern counties of the San Francisco Bay Area. This situation is currently hypothetical but may be a near estimate if continued development follows the areas of estimated greatest need. It also represents a trajectory that expands fueling network coverage into the next markets to initiate development after the successfully launch of the first core market areas. This will provide new opportunities for FCEV deployment in an expanded array of communities across California, including underserved communities.

A direct comparison of projected FCEV deployment and the statewide fueling network capacity is provided in Figure 31 and Figure 32. In the first of these figures, the capacity of all stations in the network is assessed at the full value determined by HySCapE or developer self-reporting. In the latter figure, the capacity of the network is assessed as 80 percent of this maximum value, approximating commonly reported rules of thumb for balancing revenue potential and customer queuing time and fueling position access. These figures demonstrate that the projected FCEV fleet is essentially at the limit of the of total network's fueling capacity. Any shortages of fueling capacity are smaller in magnitude than those shown previously in Figure 27 and Figure 28, highlighting the nuance necessary in analyzing a statewide fueling network.

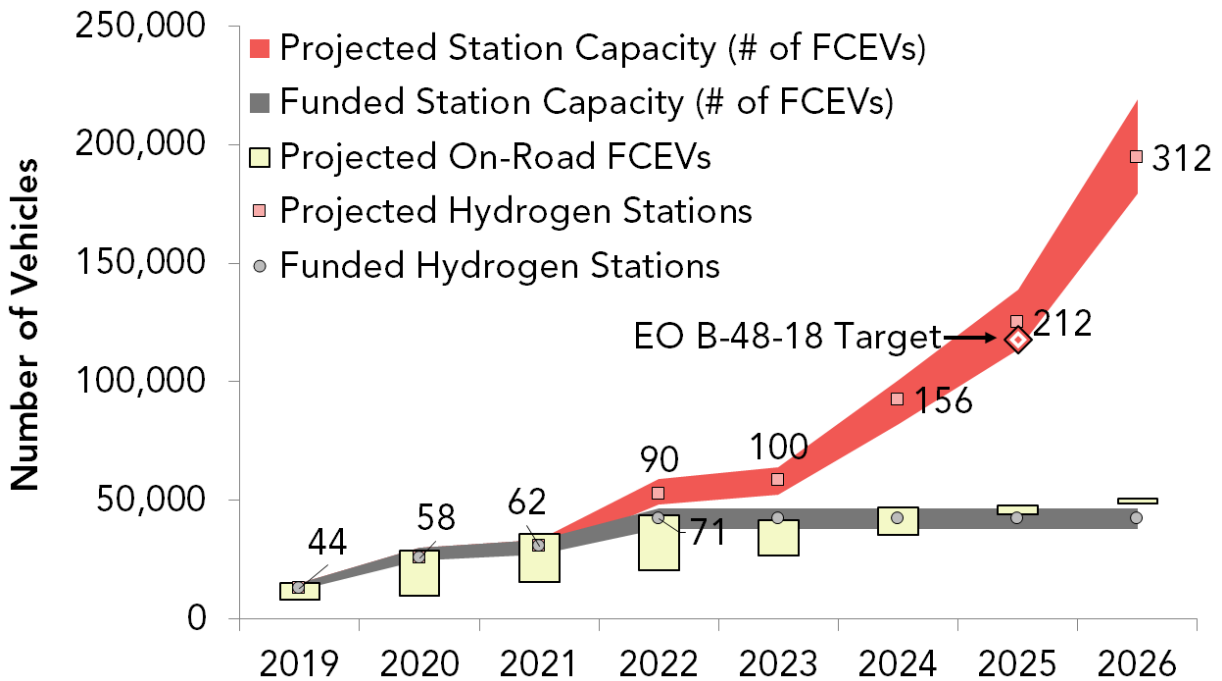
Growth to at least 100 stations by January 1, 2024 will provide a minimal buffer of excess capacity equivalent to the demand of 10,000 to 20,000 additional FCEVs. Network growth meeting EO B-48-18 could support 175,000 FCEVs on the road by 2025 but would require substantial acceleration of station network growth.

CARB is currently investigating the needs of network development to achieve a long-lasting, economically viable and self-sufficient fueling industry. This self-sufficiency analysis considers a broader set of variables including vehicle deployment and others driven directly by the pace of network growth. While the network capacity growth provided by the currently funded and open stations and potentially the 100 or more stations funded by AB 8 could support the most recent vehicle deployment projections, this may not be sufficient to enable economies of scale and develop industry financial self-reliance. Bridging the gap between the apparent historical and near-term projected pace of network growth and the pace required to more quickly accelerate network self-sufficiency is a challenge that requires resolution and planning within the next few years by both industry and government sectors.

**FIGURE 31: COMPARISON OF PROJECTED VEHICLE DEPLOYMENT AND NETWORK NAMEPLATE CAPACITY**



**FIGURE 32: COMPARISON OF PROJECTED VEHICLE DEPLOYMENT AND POTENTIAL OPTIMAL (80 PERCENT OF NAMEPLATE) CAPACITY**



## Renewable Content of California's Hydrogen Fueling Network

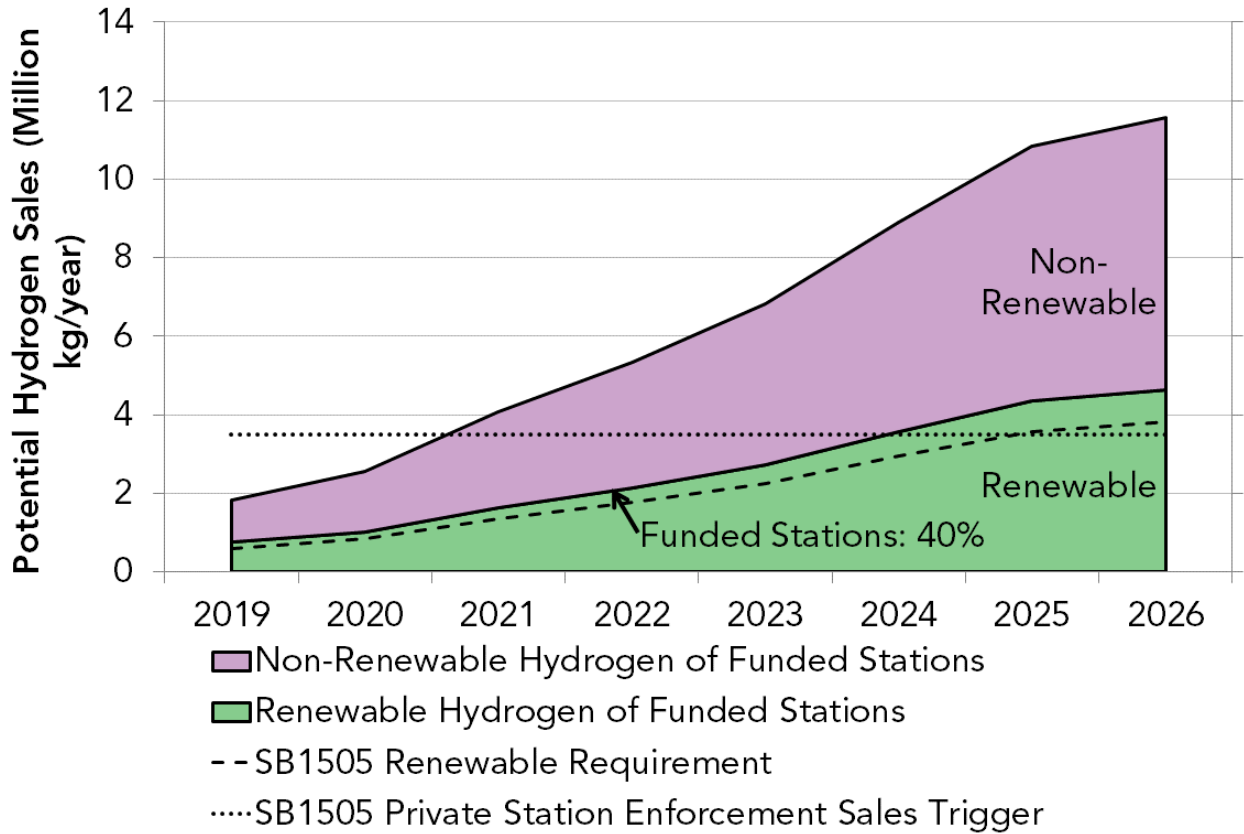
Over the past year, nearly 20 additional hydrogen fueling stations (both open and in development) have entered the LCFS HRI program, increasing the minimum renewable content expected to be dispensed in California's network given the 40 percent requirement for eligibility in the HRI program. This requirement is in excess of the 33 percent minimum required for stations receiving State funding per SB 1505. In addition, many stations' capacity estimations have increased due to the use of the HySCapE tool implemented by the HRI program. At the same time, future on-the-road FCEV volumes have continued to shift as noted previously in this report. Altogether, these changes affect projections of future renewable implementation in California's hydrogen fueling network.

In order to estimate the future amount of renewable hydrogen fuel dispensed in California's network, CARB considers both the demand of the projected FCEV fleet and the capacity of open and funded stations as well as estimates for projected future stations. For the open and funded stations, full capacity and renewable content implementation are known or estimated from LCFS HRI and AB 8 grant funding program data. For future stations, CARB uses the same network development estimates as shown in Figure 26 and Figure 31. For these future stations, CARB estimates the minimum renewable content of their dispensed fuel is 40%, as this matches the current requirements of both the LCFS HRI program and GFO 19-602. When calculating dispensed hydrogen, CARB considers the lesser of capacity and demand as the dispensed amount. This allows for either capacity or demand to be the limiting factor as appropriate. In addition, CARB assumes hydrogen to be first dispensed from open and funded stations before accounting for any hydrogen potentially dispensed from future stations.

Due to the increased capacity of the open and funded network and the continued shift in on-the-road FCEV projections, analyses of future renewable hydrogen content now rely only on the open and funded network; no additional station dispensing needs to be considered. For this reason, Figure 33 does not indicate any dispensing from future stations within the analysis timeframe. This is a parallel result to Figure 31, which shows the open and funded network capacity to be sufficient on a statewide basis for the projected on-the-road FCEV fleet.

In addition, Figure 33 indicates that the open and funded station network currently dispenses hydrogen with a 40 percent or greater renewable content and will continue to do so in the future. This is in excess of the 33 percent requirement currently required of all State co-funded stations per SB 1505. Statute also requires that once the amount of hydrogen dispensed statewide in a given year exceeds 3.5 million kilograms, the requirement of at least 33 percent renewable content will apply to all stations in the state regardless of funding source. CARB had previously estimated that this threshold could be reached sometime in 2020; due to shifts in FCEV deployment, CARB now expects this threshold to be met sometime after the end of 2021.

**FIGURE 33: EVALUATION OF MINIMUM RENEWABLE HYDROGEN CONTENT IN CALIFORNIA'S FUELING NETWORK**



# Hydrogen Fueling Station Performance Standards and Technology

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

**CARB 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.**

Publicly available retail hydrogen fueling stations are expected to meet several requirements (or standards) in order to ensure they effectively serve the state's FCEV market while providing safe, reliable, and predictable operations. Some of the requirements are related to planning for the state's future FCEV population, such as minimum capacity and fueling position requirements. Others more directly address the fueling performance, like meeting standards for hydrogen fuel quality and the hydrogen fueling protocol that are built upon years of research and industry cooperative development. Still others are necessary to protect the retail fueling environment and ensure that both consumers and fuel retailers receive fair treatment in their transactions.

Over the past several years, CARB has outlined the evolution of operation and design standards and programs associated with ensuring new hydrogen fueling stations meet these expectations. These recommendations have typically been incorporated into the development of the Energy Commission's several grant solicitations within the AB 8 program. At the time of this report's writing, the Energy Commission currently has a solicitation open in the application review period. Stations that are built from the first batch of eventual grant awards already have their design and operation standards and expectations set by the Energy Commission's current grant solicitation technical requirements. Thus, there is little need this year to develop new recommendations for the Energy Commission. Instead, this Annual Evaluation aims to provide a brief update on material changes in related programs over the past year. Future Annual Evaluations will provide more thorough updates as necessary. For descriptions of other related topics discussed in the past, and for which the current recommendations still stand, please see the 2019 Annual Evaluation.

## Updates to Fueling Protocol SAE J2601

SAE J2601 is the industry-consensus standard describing the expected process of filling the onboard hydrogen tank of a light-duty FCEV in a manner that is fast, safe, and repeatable, resulting in assurance of longevity of the tank. Filling a tank with a cold, high-pressure gas is a very different process from filling a gasoline tank with liquid at essentially ambient temperature and pressure. Because of the differences in the process requirements and the physical properties of hydrogen and gasoline respectively, controlling the hydrogen filling process requires accounting for and periodically checking several variables during vehicle fueling. Ambient temperature, the temperature of the tank at the start of fill, the pressure and temperature of hydrogen entering the tank through the dispensing nozzle, and other variables are all essential parameters considered in the SAE J2601 protocol.

The SAE J2601 protocol was updated to its 2020 version on May 29, 2020. Major changes in the 2020 version include:

- Addition of protocol specifications for tanks larger than 248.6 liters (equivalent to tanks capable of holding 10 or more kg of hydrogen) for high-pressure (70 MPa) fills. The fill temperature ranges applicable to other tanks sizes covered by J2601 (-40°C, -30°C, and

-20°C) also apply to the newly included larger tanks. The updated J2601 standard does not address fills for tanks larger than 248.6 liters for low-pressure (35MPa) fills. Other protocols within the SAE J2601 collection (most specifically J2601-2) may address 35MPa fills for these larger tanks.

- Additional requirements on the startup time of the fueling process.
- Modifications to accounting for leak checks in all fueling process calculations.
- Several corrections and clarifications of definitions in order to improve consistent application of the standard across the industry.

Potential future work may include development of protocols for tanks with a capacity of less than 1.2 kg of hydrogen and for filling processes with hydrogen temperatures of -10°C or even ambient temperature. The current standard covers fueling with hydrogen in the temperature range of -40°C to -20°C. CARB recommends that to the extent possible, future hydrogen fueling stations should be required to follow the 2020 version of J2601. If any further revisions occur in the future, they should be considered and evaluated for incorporation into station co-funding efforts. In addition a new protocol, SAE J2601-4, may be published in the coming years. This protocol will be applicable to fills without pre-chilling, at ambient temperature. CARB does not currently recommend use of this forthcoming protocol for retail hydrogen fueling stations as it requires a longer fill time than customers expect from hydrogen fueling stations.

## Standards and Test Methods Evolve to Aid Station Development

All light-duty FCEVs sold in California are designed to fuel using the SAE J2601 fueling protocol. This fueling protocol was developed by an SAE industry work group comprised of auto makers, equipment manufacturers, and station developers to safely fill vehicles as quickly as possible, while adjusting for ambient temperature and vehicle conditions. Currently, the majority of fueling is done through communication between the vehicle and dispenser so that the dispenser can adjust or terminate fueling if process limits are exceeded. Using a known, dynamically controlled fueling protocol protects the hydrogen tanks onboard vehicles from undue and repeated stresses. The SAE J2601 protocol describes both static (table-based) and dynamic (termed the MC method) fueling methods as options for fueling protocols at stations, and a new version was recently published with additional modifications mostly broadening the scope .

It is in the interest of all parties involved to ensure stations correctly implement the SAE J2601 fueling protocol. To that end, a test procedure (ANSI/CSA HGV 4.3) was developed for protocol verification. However, as mentioned above, the fueling protocol is being updated. Therefore, after the revised protocol is published, work will commence on an updated test procedure to validate the updated protocol. This work is expected to be completed in mid-2021.

Today, testing to verify station performance according to ANSI/CSA HGV 4.3 is primarily completed in the field using the HyStEP device. This process consists of the following steps:

- [1] A station developer self-declares that equipment is operational.
- [2] An AHJ provides the station with a permit to operate.
- [3] The California Department of Food and Agriculture's Division of Measurement Standards validates the station meter accuracy and issues a dispenser sticker indicating approval to sell fuel.
- [4] Station performance is confirmed by CARB through complex field testing using HyStEP equipment
- [5] Review of HyStEP testing data occurs with the station developer and auto manufacturers. Station modifications and/or additional testing may occur.
- [6] The station is listed as Open on SOSS.

The current process has been integral to launching the current generation of retail hydrogen fueling stations, but may require additional measures in order to support more widespread and

rapid deployment of hydrogen fueling stations in California. With the HyStEP-led process, each dispenser at each station must be individually field tested. This is labor intensive and involves many stakeholders, including CARB, auto manufacturers, station operators, and others. Fortunately, with updates to the test procedure (ANSI/CSA HGV 4.3), it is anticipated that pre-installation or factory testing, evaluation, and declaration will be considered for dispensers.

Factory type certification of dispensers will allow for a specific dispenser design to undergo much, if not all, testing in a factory setting. Although only one unit may be tested, the certification will apply to all dispensers manufactured using the same design, specifications, and materials. This allows repeat deployments of the same unit to require less testing on-site when it is installed at a retail hydrogen station. This structure is similar to how the California Type Evaluation Program requires testing of meter accuracy for one dispenser design that then applies to repeat installations of the same dispenser design. Adopting a similar program, potentially through a regulatory process, for fueling protocol evaluation is expected to reduce costs, shorten station development time, improve quality, and enhance the customer experience.

Courtesy of ITM Power



# Conclusions and Recommendations

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

**CARB Actions: Recommend station network development targets 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's hydrogen fueling network has continued to advance over the past year towards achieving the goals of AB 8. At the same time, it is becoming increasingly clear that acceleration in network development and FCEV deployment are necessary in the coming years in order to meet State and industry targets for both zero-emission infrastructure development and ZEV deployment. Establishment of these industries within California has been a first-of-its-kind milestone, but the future challenges indicate significantly greater work is necessary in the years ahead. Ensuring a lasting, durable, and expanding hydrogen fueling and FCEV industry within the State is becoming a top priority among public and private stakeholders.

Historical rates of progress have been meaningful and created many opportunities for new ZEV-related business within the state, but they are not likely to enable the kind of large-scale adoption and growth of business scale in the hydrogen fueling industry that is necessary for the next phase of FCEV adoption. Moving out of the first-adopter market appears to require continued and coordinated industry and State support. Achieving economies of scale for upstream station equipment suppliers, hydrogen fuel suppliers, and FCEV-producing auto manufacturers will be necessary in order for customer-facing FCEV ownership costs to fall and make it possible for a wider segment of California's population to adopt this important ZEV technology.

The latest efforts by CARB and the Energy Commission, especially GFO 19-602 and the LCFS HRI provision, appear to have the potential to begin addressing the needed transitions in future hydrogen fueling station support. These programs are likely to meet the AB 8 milestone of at least 100 stations by 2024 (assuming adherence to current estimates of station development rates) and may make significant progress towards the 200 station milestone in 2025 of EO B-48-18. However, new assessments and continued coordination with industry will be useful to inform efforts to reach the ultimate goal of a financially self-sufficient hydrogen fueling network with the ability to support FCEV ownership costs on par with or below conventional vehicles.

Given the analyses and discussion of the preceding pages, CARB makes the following recommendations:

- **Ensure the AB 8 and LCFS HRI programs together achieve the goals of 100 stations by January 1, 2024 and 200 stations by 2025.** The Energy Commission's current plan to utilize the remaining funds through the end of the AB 8 program in 2024 for the deployment of light-duty hydrogen fueling stations is necessary to enable the State to meet station deployment milestones in AB 8 and EO B-48-18. CARB and the Energy Commission currently rely on grant funding through AB 8 and the HRI provision of the LCFS program to provide necessary incentives for station developers to accelerate network growth. Together, these programs have the potential to achieve the targets of 100 and 200 stations by 2024 and 2025 respectively. However, neither of these programs can achieve these goals alone so it remains necessary for both programs to develop as many stations as quickly as possible through all means available. Funding through AB 8 should be committed to the development of more than the minimum 100 station target and be used to develop as many stations as possible through the end of the program.
- **Maintain a balanced approach of expanding coverage and capacity in California's hydrogen fueling network.** The Energy Commission's GFO 19-602 encourages station



developers to consider hydrogen fueling station development in communities across the state. The structure of evaluation also encourages greater capacity growth in the most highly developed local hydrogen fueling networks. This approach appropriately balances the needs for increased capacity in markets with high potential volume of FCEV demand with expansion of network coverage to reach an expanding proportion of the state's population. This strategy remains necessary as today's 71 funded stations are primarily focused on the earliest adopter markets. In the long term, these markets will remain important but other markets in the San Joaquin Valley, Inland Deserts, North Central Valley, and North Coastal Regions are projected to become increasingly important in FCEV market development. By 2026, the San Joaquin Valley in particular may be the third-largest market based on potential demand. Expansion of the hydrogen fueling network into these new regions provides new market growth opportunities and supports equitable dispersion of zero-emission technology to all of California's communities.

- **Continue to assess station development pace and address bottlenecks.** California's hydrogen fueling and FCEV markets remain in the early adopter phase of new technology development. The Energy Commission's new GFO 19-602 aims to help accelerate market development by enabling economies of scale and enabling funding and planning of a larger number of new hydrogen stations than previously available. As stations are funded and developed through this effort, CARB and the Energy Commission should continue to assess ongoing and projected station development in order to ensure that a transition out of the early adopter phase and into a broader market is made possible within the decade. CARB and the Energy Commission may need to partner with industry members and other agencies like GO-Biz in order to identify bottlenecks in station development and the upstream supply chain with the goal to develop innovative solutions.
- **Leverage the self-sufficiency analysis to inform a transition to reducing State funding of stations.** As market expansion continues for FCEVs and hydrogen fueling and current funding programs near their termination date, it will become increasingly important to understand critical milestones and State support that can help transition to a financially self-sufficient hydrogen fueling industry. CARB and the Energy Commission have been working on an analysis addressing this question since 2016 and a draft evaluation report is anticipated by the end of 2020. The findings of this report should help inform future discussions of the potential role of the State in the ongoing hydrogen fueling network development.
- **Ensure sufficient hydrogen fuel supply to support network growth.** Hydrogen fuel producers supplying the FCEV market in California have previously made announcements of their intent to expand operations and build new facilities that would strengthen the supply chain of hydrogen for California's light-duty FCEV market. These are important and large steps, but it is clear that acceleration of station network growth to meet future State and industry targets will likewise require growth of the upstream hydrogen supply in order to ensure fuel availability for customers and enable economies of scale within the hydrogen fuel production industry that may translate into favorable station economics. Fuel availability and fuel price have been primary concerns in the early market launch and will likely necessitate greater focus as the FCEV fueling market grows. CARB and the Energy Commission will need to continue to collaborate with each other, industry members, and other State agencies to ensure that hydrogen fuel production and distribution do not restrict hydrogen station network growth and FCEV deployment in the future.
- **Support increased use of renewable hydrogen.** Implementation of renewable and low-carbon energy sources in the production of California's hydrogen transportation fuel continue to meet and exceed the objectives of SB 1505. In addition, several industry members and partnership organizations have expressed willingness and outlined roadmaps towards even greater renewable implementation in developing hydrogen industries across the globe. California's State agencies should remain focused on increasing the renewable implementation for hydrogen sold within the State, looking for opportunities to enable the levels of participation expressed by industry statements and analyses.

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## Appendix A: 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 B: Station Status Summary

## Hydrogen Fueling Station Data as of April 10, 2020

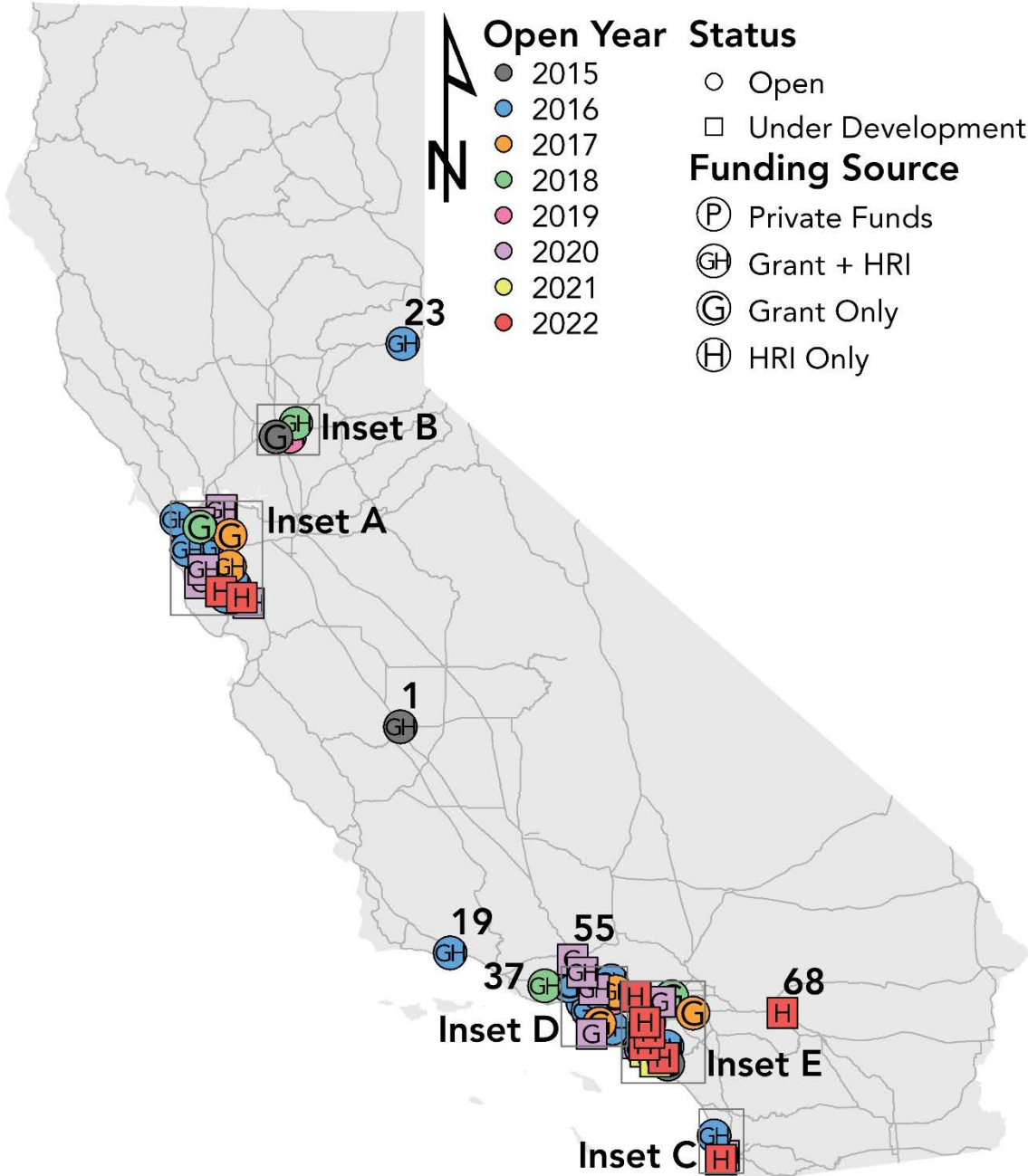
Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Coalinga	24505 W Dorris Ave	Coalinga	266	2015	Fresno	40%
Diamond Bar	21865 E Copley Dr	Diamond Bar	180	2015	Los Angeles	33%
San Juan Capistrano	26572 Junipero Serra Rd	San Juan Capistrano	350	2015	Orange	33%
UC Irvine	19172 Jamboree Rd	Irvine	180	2015	Orange	33%
West Sacramento	1515 S River Rd	West Sacramento	350	2015	Yolo	33%
Anaheim	3731 E La Palma Ave	Anaheim	180	2016	Orange	33%
Campbell	2855 Winchester Blvd	Campbell	266	2016	Santa Clara	40%
Costa Mesa	2050 Harbor Blvd	Costa Mesa	266	2016	Orange	40%
Del Mar	3060 Carmel Valley Rd	San Diego	266	2016	San Diego	40%
Fairfax	7751 Beverly Blvd	Los Angeles	180	2016	Los Angeles	33%
Hayward	391 West A St	Hayward	266	2016	Alameda	40%
Hollywood	5700 Hollywood Blvd	Los Angeles	266	2016	Los Angeles	40%
La Cañada-Flintridge	550 Foothill Blvd	La Canada Flintridge	266	2016	Los Angeles	40%
Lake Forest	20731 Lake Forest Dr	Lake Forest	266	2016	Orange	40%
Long Beach	3401 Long Beach Blvd	Long Beach	266	2016	Los Angeles	40%
Mill Valley	570 Redwood Hwy	Mill Valley	266	2016	Marin	40%
Playa Del Rey	8126 Lincoln Blvd	Los Angeles	266	2016	Los Angeles	40%
San Jose	2101 North First St	San Jose	266	2016	Santa Clara	40%
Santa Barbara	150 S La Cumbre Rd	Santa Barbara	266	2016	Santa Barbara	40%
Santa Monica	1819 Cloverfield Blvd	Los Angeles	180	2016	Los Angeles	33%
Saratoga	12600 Saratoga Ave	Saratoga	198	2016	Santa Clara	40%
South San Francisco	248 S Airport Blvd	South Francisco	266	2016	San Mateo	40%
Truckee	12105 Donner Pass Rd	Truckee	266	2016	Nevada	40%
Woodland Hills	5314 Topanga Canyon Blvd	Woodland Hills	180	2016	Los Angeles	33%
Fremont	41700 Grimmer Blvd	Fremont	266	2017	Alameda	40%
Lawndale	15606 Inglewood Ave	Lawndale	180	2017	Los Angeles	33%
Riverside	8095 Lincoln Ave	Riverside	100	2017	Riverside	33%
San Ramon	2451 Bishop Drive	San Ramon	350	2017	Contra Costa	33%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
South Pasadena	1200 Fair Oaks Ave	South Pasadena	206	2017	Los Angeles	40%
Torrance	2051 W 190 <sup>th</sup> St	Torrance	200	2017	Los Angeles	33%
Citrus Heights	6141 Greenback Ln	Citrus Heights	513	2018	Sacramento	40%
Emeryville	1152 45 <sup>th</sup> St	Emeryville	350	2018	Alameda	100%
LAX	10400 Aviation Drive	Los Angeles	200	2018	Los Angeles	40%
Mountain View	830 Leong Drive	Mountain View	350	2018	Santa Clara	33%
Newport Beach	1600 Jamboree Rd	Newport Beach	100	2018	Orange	33%
Ontario	1850 Holt Blvd	Ontario	100	2018	San Bernardino	100%
Palo Alto	3601 El Camino Real	Palo Alto	136	2018	Santa Clara	40%
Thousand Oaks	3102 Thousand Oaks Blvd	Thousand Oaks	266	2018	Ventura	40%
CSULA	5151 State University Dr	Los Angeles	60	2019	Los Angeles	100%
Harrison St	1201 Harrison St	San Francisco	513	2019	San Francisco	40%
Oakland	350 Grand Ave	Oakland	808	2019	Alameda	40%
Sacramento	3510 Fair Oaks Blvd	Sacramento	513	2019	Sacramento	40%
Third St	551 Third St	San Francisco	513	2019	San Francisco	40%
Berkeley	1250 University Ave	Berkeley	513	2020	Alameda	40%
Burbank	145 W Verdugo Rd	Burbank	100	2020	Los Angeles	33%
Campbell-Hamilton	337 E Hamilton Ave	Campbell	1200	2020	Santa Clara	40%
Concord	605 Contra Costa Blvd	Concord	1200	2020	Contra Costa	40%
Fountain Valley	18480 Brookhurst St	Fountain Valley	1200	2020	Orange	40%
Mission Hills	15544 San Fernando Mission Rd	Mission Hills	1200	2020	Los Angeles	40%
Mission St	3550 Mission St	San Francisco	513	2020	San Francisco	40%
Rancho Palos Verdes	28103 Hawthorne Blvd	Rancho Palos Verdes	180	2020	Los Angeles	33%
Redwood City	503 Whipple Ave	Redwood City	1200	2020	San Mateo	40%
San Diego	5494 Mission Center Rd	San Diego	1200	2020	San Diego	40%
San Jose- Bernal	101 Bernal Rd	San Jose	513	2020	Santa Clara	40%
Sherman Oaks	14478 Ventura Blvd	Sherman Oaks	808	2020	Los Angeles	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Studio City	3780 Cahuenga Blvd	North Hollywood	808	2020	Los Angeles	40%
Sunnyvale	1296 Sunnyvale Saratoga	Sunnyvale	1200	2020	Santa Clara	40%
Woodside	17287 Skyline Blvd	Woodside	140	2020	San Mateo	33%
Chino	12610 East End Ave	Chino	100	2021	San Bernardino	100%
Culver City	11284 Venice Blvd	Culver City	1200	2021	Los Angeles	40%
Laguna Beach	104 North Coast Hwy	Laguna Beach	1200	2021	Orange	33%
Santa Clarita	24551 Lyons Ave	Santa Clarita	180	2021	Los Angeles	33%
Aliso Viejo	26813 La Paz Rd	Aliso Viejo	1200	2022	Orange	40%
Baldwin Park	14472 Merced Ave	Baldwin Park	1200	2022	Los Angeles	40%
Costa Mesa-Bristol	2995 Bristol St	Costa Mesa	1200	2022	Orange	40%
Cupertino	21530 Stevens Creek Blvd	Cupertino	1200	2022	Santa Clara	40%
Orange	615 South Tustin St	Orange	1200	2022	Orange	40%
Palm Springs	I-10 and North Indian Canyon Dr	Palm Springs	783	2022	Riverside	40%
Placentia	313 West Orangethorpe Ave	Placentia	1200	2022	Orange	40%
San Diego-Washington	1832 West Washington St	San Diego	1200	2022	San Diego	40%
San Jose- Snell	3939 Snell Ave	San Jose	1200	2022	Santa Clara	40%

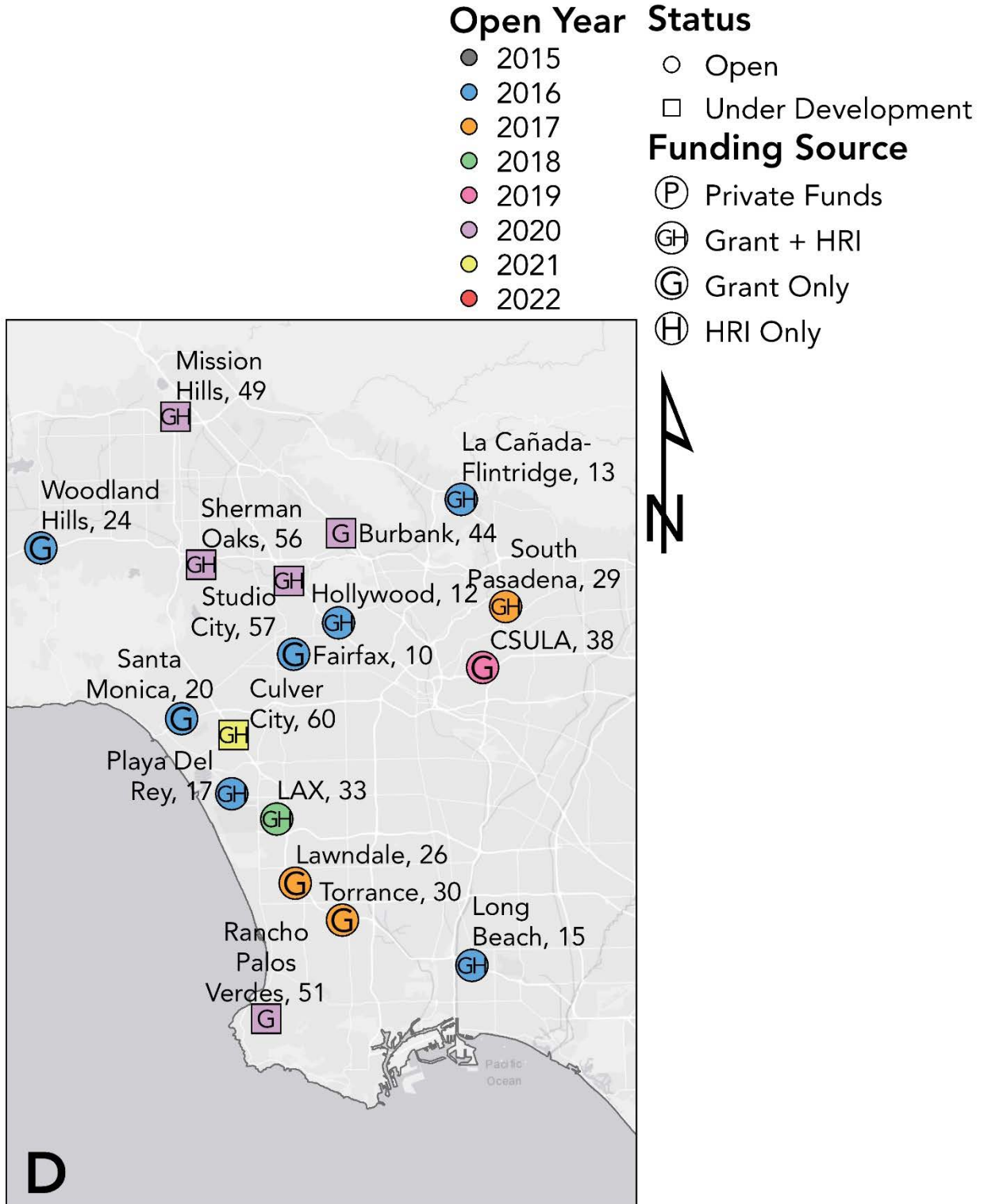
# Appendix C: Auto Manufacturer Survey Material

FIGURE 34: STATEWIDE STATION MAP FOR 2020 SURVEY

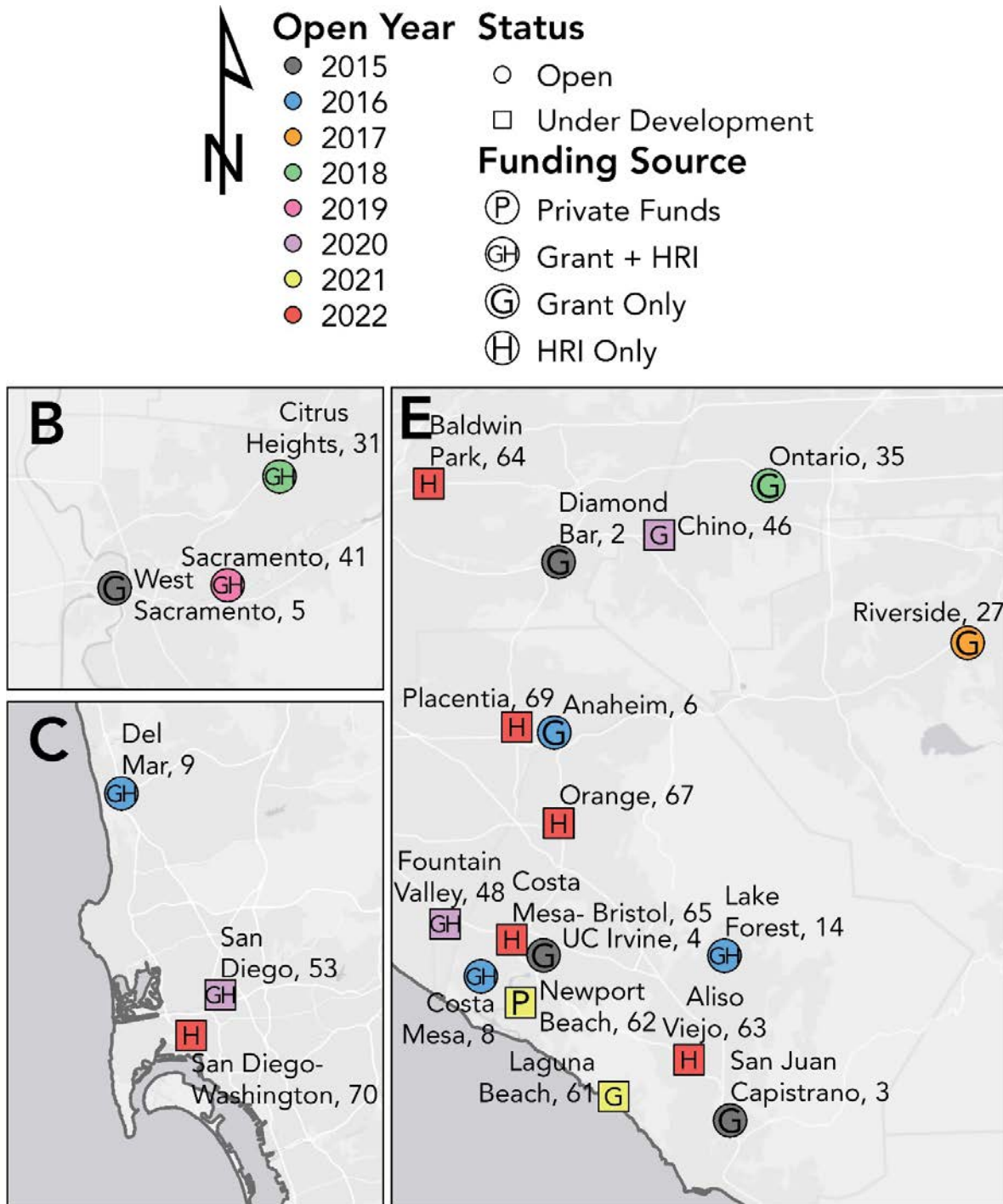




**FIGURE 36: LOS ANGELES AREA STATION MAP FOR 2020 SURVEY**



**FIGURE 37: SACRAMENTO, ORANGE COUNTY, AND SAN DIEGO STATION MAPS FOR 2020 SURVEY**



## Appendix D: Station Status Definition Details

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

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

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

**Open-Retail** stations are defined by:

- [1] The station has passed local inspections and has operational permit
- [2] The station is publicly accessible
- [3] The station operator has fully commissioned the station, and has declared it fit to service retail FCEV drivers. This includes the station operator's declaration that the station meets the appropriate SAE fueling protocol, and three auto manufacturers have confirmed that the station meets protocol expectations and their customers can fuel at the station, and it has passed relevant hydrogen quality tests.
- [4] Weights and Measures has verified dispenser performance, enabling the station to sell hydrogen by the kilogram (pursuant to CCR Title 4, Division 9, Chapter 1).
- [5] The station has a functioning point of sale system.
- [6] The station is connected to the Station Operational Status System (SOSS), maintained by the California Fuel Cell Partnership.

The remainder of the status definitions are as follows:

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

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

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

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

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



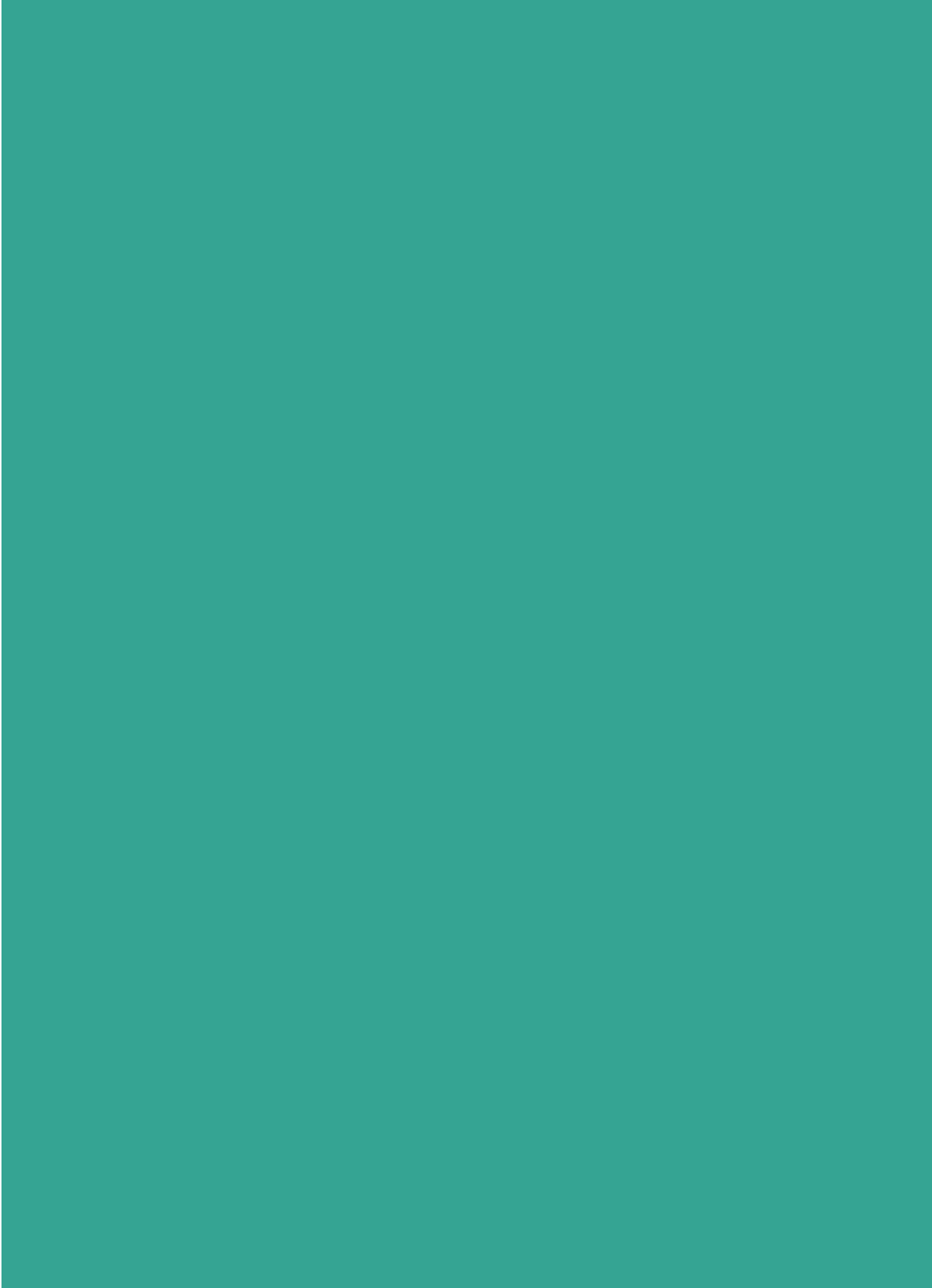
**Finishing Permit Apps:** The station developer is preparing site layout, engineering, and other documents for submittal to the AHJ. This process is often iterative and may actually occur several times throughout the permitting process. In this Annual Evaluation, a station is reported as Finishing Permit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

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



Courtesy of First Element, Inc.





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