CALIFORNIA
AIR RESOURCES BOARD

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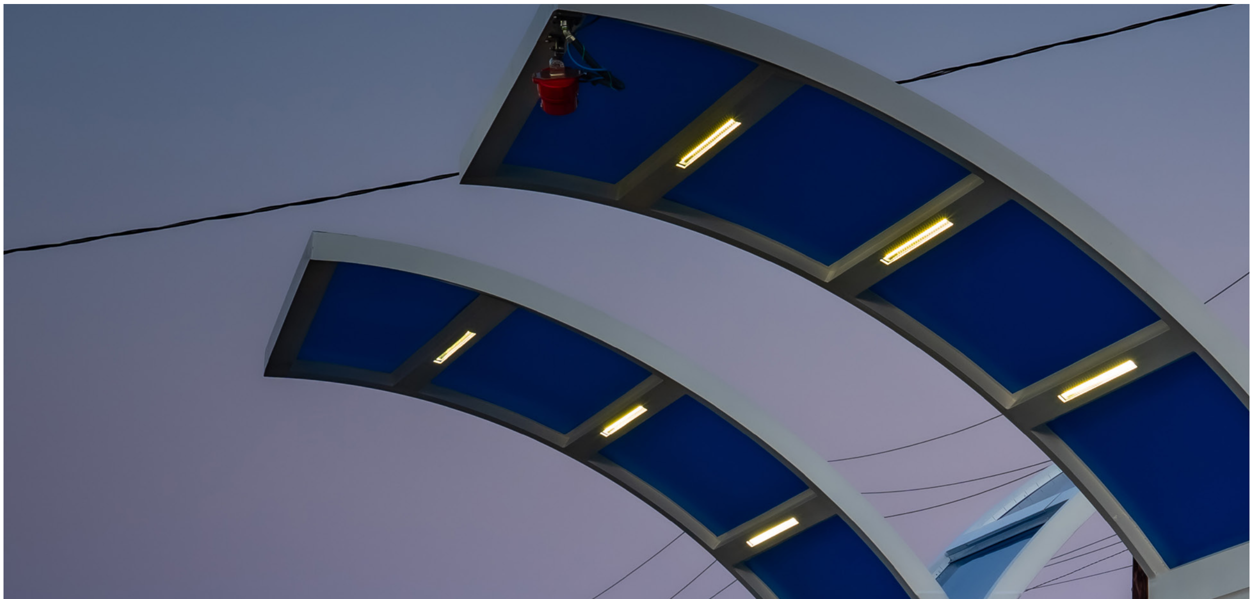


2021 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development

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

Cover image courtesy of First Element, Inc.

Courtesy of First Element, Inc. >

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.

Contents

Courtesy of California Fuel Cell Partnership.

List of Acronyms

AB 8	Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013)
AHJ	Authority Having Jurisdiction
BEV	Battery Electric Vehicle
CaFCP	California Fuel Cell Partnership
CARB	California Air Resources Board
CEC	California Energy Commission
CHIT	California Hydrogen Infrastructure Tool
DAC	Disadvantaged Community
DMV	Department of Motor Vehicles
EMFAC	CARB's EMissions FACtor model used to assess emissions from on-road vehicles
EO	Executive Order
FCEV	Fuel Cell Electric Vehicle
GFO	Grant Funding Opportunity (California Energy Commission's formal communication of a current grant program)
GIS	Geographical Information System
GO-Biz	Governor's Office of Business and Economic Development
HGV	Hydrogen Gas Vehicle
HRI	Hydrogen Refueling Infrastructure
HyStEP	Hydrogen Station Equipment Performance
ICE	Internal Combustion Engine
LCFS	Low Carbon Fuel Standard
MSRP	Manufacturers Suggested Retail Price
NFPA	National Fire Protection Association
NREL	National Renewable Energy Laboratory
PHEV	Plug-In Hybrid Electric Vehicle
SB 129	Senate Bill 129 (Skinner, Chapter 69, Statutes of 2021)
SB 1505	Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006)
SB 535	Senate Bill 535 (De Léon, Chapter 830, Statutes of 212)
SOSS	Station Operational Status System developed by CaFCP
VIN	Vehicle Identification Number
ZEV	Zero Emission Vehicle

Courtesy of Shell.

Executive Summary

California has set ambitious and aggressive targets for greenhouse gas emission reductions and air quality improvement, with a strategic focus on zero emission vehicle (ZEV) deployment as a key component of success. Building on prior executive orders (EOs) issued by Governor Brown targeting 1.5 million ZEVs on California roads by 2025 (EO B-16-12) and 5 million ZEVs on California roads by 2030 (EO B-48-18), Governor Newsom issued EO N-79-20 requiring CARB to develop and propose passenger vehicle and light truck regulations towards the target of 100 percent in-state ZEV sales for passenger vehicles by 2035, trucks and buses by 2045 everywhere feasible, and for all drayage trucks and off-road vehicles and equipment to be zero-emission by 2035 [1], [2], [3]. EO N-79-20 also requires that multiple State agencies use existing authorities to accelerate deployment of "affordable fueling and charging options for zero-emission vehicles, in ways that serve all communities and in particular low-income and disadvantaged communities [3]."

The development of supporting charging and fueling infrastructure is necessary for these goals to be realized. Assembly Bill 8 (AB 8; Perea, Chapter 401, Statutes of 2013) extended the California Energy Commission's (CEC) Clean Transportation Program (formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program), which is the State's longest-running program to support hydrogen fueling station network development that enables the deployment of light-duty fuel cell electric vehicles (FCEVs) [4]. Through the Clean Transportation Program, CEC co-funds the development of retail hydrogen fueling stations until there are at least 100 stations operating in California. The program is authorized through January 1, 2024. More recently, the Low Carbon Fuel Standard (LCFS) program administered by the California Air Resources Board (CARB) has established the Hydrogen Refueling Infrastructure (HRI) crediting provision to further support early hydrogen fueling network development [5]. In addition to the 100-station milestone of AB 8, EO B-48-18 added an additional target of 200 hydrogen stations by 2025 [2]. The State's funding programs, in parallel with private funding, contribute to achieving this goal.

Per AB 8, CARB annually completes an analysis of the current progress and projected future development of California's hydrogen fueling station network and deploying FCEVs. CARB completes these annual analyses based on information provided by auto manufacturers, station developers, and collaborating State agencies like CEC. Analyses characterize the past year of progress and identify opportunities for future hydrogen fueling network development. Specifically, annual reports discuss the location and estimated number of FCEVs currently on the road and projected for future deployment, the coverage and capacity provided by the currently available and future hydrogen fueling network (based on known projects in development), and recent developments in hydrogen fueling station technology and standards. These analyses inform recommendations provided in these reports for future hydrogen station network development. This year's report has a significant focus on the impact of new grants for station construction recently awarded by the CEC, as these awards represent the most significant development in the past year.

California has become a global leader in hydrogen fueling network development and FCEV deployment. On-the-ground development of hydrogen stations has been impacted for more than a year by the worldwide COVID-19 pandemic, but recent advancements have set California on a path that holds substantial opportunity for future growth. California's network now consists of 48 hydrogen fueling stations that are open to the public (referred to as "Open-Retail") and an estimated 7,993 FCEVs are currently active on California's roads[1]. Based on information provided by station developers, CEC, and the Governor's Office of Business and Economic Development (GO-Biz), CARB estimates that as many as 62 hydrogen fueling stations may be included in the state's hydrogen fueling network and more than 10,000 FCEVs may be on California's roads by the end of 2021. Station development over the past year has been slower than previously projected, partly due to delays in station permitting, construction, and opening caused by the COVID-19 pandemic.

Looking ahead to the future growth of the hydrogen station network, CEC's latest hydrogen station co-funding solicitation, Grant Funding Opportunity (GFO)-19-602, provides the necessary funding to complete the 100-station commitment under AB 8. On December 9, 2020 the CEC approved up to $115.7 million[2] in awards under this solicitation to co-fund the development of up to 94 new hydrogen fueling stations and upgrades to 4 existing stations [3] [6], [7]. In addition, private industry had previously begun development on 8 stations without any request of State grant funds and an additional 15 stations have since been announced through fully private financing (for a total of 23 stations planned or under development with fully private financing). The recent passage of the Budget Act of 2021, hereafter referred to as Senate Bill 129 (SB 129; Skinner, Chapter 69, Statutes of 2021), provides an opportunity for the CEC to further narrow the gap to the goal of 200 stations. These announcements have created an unprecedented outlook for hydrogen fueling station network development in California.

In total, California is expected to have more than 176[4] Open-Retail hydrogen fueling stations by 2026 and may meet the AB 8 goal of at least 100 stations by the end of 2023. The major challenges regarding stations are now to ensure that hydrogen station development can proceed on or close to station developers' current estimated schedules to close the gap between the 176 Open-Retail and planned stations and the 200-station goal of EO B-48-18.

By 2026, the total hydrogen fueling capacity in the state would be sufficient for cumulative deployment of approximately 250,000 FCEVs in California. Auto manufacturers have responded positively to this reinforced outlook for fueling network development, though many additional factors contribute in varying degree to auto manufacturers' deployment decisions. The network's planned future capacity provides opportunity for auto manufacturers to continue accelerating the planning and deployment of FCEVs in California over the coming years. Auto manufacturers' ZEV deployment plans would result in 61,100 FCEVs on the road by the end of 2027, after accounting for estimated vehicle retirements. This would be approximately one quarter of the 250,000 FCEVs the planned fueling network could ultimately support. Long-term projections, mostly in optional survey reporting periods, have consistently been higher than actual FCEV sales. In order to further accelerate the future growth of the FCEV population, multiple barriers to adoption will need to be

1 The CEC's ZEV Dashboard reports 7,129 FCEVs on the road as of the end of 2020 [16]. Nationwide industry sales estimates indicate more than 10,000 FCEVs leased or sold since 2012 [13].

2 Funding for future batches of stations may be approved for each award recipient depending on performance, funding availability, and Clean Transportation Program Investment Plan allocations.

3 This accounting is on a different basis than previously reported in the 2020 Joint Agency Staff Report on AB 8. This report's accounting separates stations privately funded (and that requested zero match share from the CEC in GFO-19-602) and counts upgrades to stations previously funded outside of the CTP as upgrades, whereas reporting in the 2020 Joint Agency Staff Report counted them as new stations since they were new to the CTP program.

4 This count is updated from prior reporting in the 2020 Joint Agency Staff Report. Uncertainty surrounding the development of some stations has been expressed by station developers. These stations are not included for the purposes of analysis in this report. The count of 176 stations represents currently known and funded stations plans and does not include the currently unknown number of stations that will be developed from funds provided by SB 129.

overcome, including limited model availability, high FCEV prices, high hydrogen fuel prices, and limited consumer awareness.

In recent months, low station reliability has also emerged as a serious concern affecting today's drivers and, if left unaddressed, could become a barrier to further FCEV adoption. Individual and groups of stations have at times been unavailable for customer fueling due to a variety of reasons including hydrogen supply chain disruptions and equipment performance and reliability issues. Some relief is expected by the end of 2021 and early 2022 as more resources for hydrogen production and delivery will come on-line. Still, station reliability is a concern that will require near-term and long-term solutions to minimize negative experiences for today's drivers and ensure this does not become a barrier to further FCEV adoption.

As in prior years, CARB has analyzed the geographic coverage of the open and planned stations to identify gaps between the network of known station locations and the estimated FCEV adopter market. Not all station locations are currently known, as awardees under GFO-19-602 are developing their networks of stations in successive batches and have been given flexibility to specify individual locations once they initiate new batches. Currently 66 new hydrogen station locations and 2 upgrade locations are unspecified. CARB finds that station developers will continue to have opportunity for further development in some of the more established hydrogen fueling markets. There is also substantial opportunity for initiating development in new markets across the state that do not currently have stations. CARB identifies 64 priority areas (all of which are located in eligible areas under GFO-19-602) that station developers should seriously consider for future development under GFO-19-602 or under their own privately financed efforts.

As all of these advances are made in network development and FCEV deployment, the State's several support programs are also proving an effective means to ensure that hydrogen used as a transportation fuel in California is low-carbon and renewably sourced. Hydrogen sourcing requirements in GFO-19-602 and the LCFS HRI program exceed the statutory minimums of 33.3 percent renewable content previously set by Senate Bill 1505 (SB 1505; Lowenthal, Chapter 877, Statutes of 2006) [8]. Eligibility requirements in GFO-19-602 referenced the LCFS HRI program's eligibility criteria, which establishes a 40 percent renewable content minimum. Due to the large number of stations participating in these programs, CARB projects that the future network will maintain a minimum 40 percent renewable content through 2027. In fact, recent reporting from station operators and through the LCFS program suggest that most of California's hydrogen network has temporarily operated at even higher renewable content. Estimates based on these reports and LCFS program data indicate that an estimated 90 percent renewable content was achieved in 2020[5]. This emphasis on renewable hydrogen appears to have been sustained, as 92 percent renewable content has been achieved in 2021 for those stations reporting to the LCFS program[6].

While AB 8 investments made to date, and therefore this report, have focused on hydrogen fueling infrastructure to support light-duty FCEVs, it is important to note that parallel efforts are also underway to enable hydrogen and fuel cell technology as a viable zero-emission option for medium- and heavy-duty transportation vehicles. Deployment of hydrogen-powered fuel cells in these sectors may offer substantial opportunity to reduce greenhouse gas and pollutant emissions, especially near communities that have historically been disproportionally impacted by the emissions of freight movement and other commercial activity. Co-development across transportation sectors may offer synergistic benefits to more quickly reduce costs for fuel cell technology and hydrogen fuel for use in light-, medium-, and heavy-duty vehicles. CARB and CEC have been working to co-fund pilot and demonstration projects with fuel cell-powered medium and heavy-duty vehicles. This includes the Shore to Store project that will bring 10 Class 8 fuel cell electric drayage trucks and hydrogen

5 The 2020 estimate was based on data from stations participating in the LCFS program and estimates of minimum renewable content at remaining stations. The 2021 estimate is limited only to stations participating in the LCFS program.

6 8 stations, representing approximately 7 percent of network fueling capacity, are not included in the LCFS HRI program. These stations must sell hydrogen with a minimum 33.3 percent renewable content.

fueling to the Ports of Long Beach and Los Angeles and the Joint Zero-Emission Drayage Truck and Infrastructure Solicitation (GFO-20-606) with a recently proposed award to the NorCAL Drayage project that plans to deploy 30 Hyundai XCIENT fuel cell electric trucks and supporting infrastructure in Northern California.

Analysis recently published by CARB demonstrates the potential for California's hydrogen fueling network to achieve financial self-sufficiency by 2030. Key factors to achieve self-sufficiency include the pace of station development and operation cost reductions, FCEV deployment rates, and State support [9]. In some respects, the network development now planned for California is similar to a path that achieves self-sufficiency as long as FCEV deployment continues to accelerate in the future. Network development and FCEV deployment beyond the current plans are key factors that will have a significant role in eventually reaching that goal.

Today's hydrogen network development plans are unprecedented in California's history and a major milestone in supporting ZEV deployment. Early goals for the fueling network and FCEV market may be within reach. With the completion of 176 total hydrogen fueling stations and acceleration of FCEV deployment, California will be well on its way to developing a viable market for FCEVs as a strategic component of meeting the State's ZEV deployment targets.

Courtesy of First Element, Inc.

Findings

Finding 1: California's hydrogen fueling network has grown to 52 stations, with 48 Open-Retail stations available for customer fueling as of June 29, 2021

Over the past year, California's network of hydrogen fueling stations has grown to a total of 52 stations. This includes 48 Open-Retail stations that are currently available for customer fueling with the exception of brief down-time events. An additional four stations are considered Temporarily Non-Operational, as they have previously achieved Open-Retail status but for individual reasons have been unavailable for customer fueling for an extended period of time. Although the time to return to retail operations at these stations is currently unknown, they are expected to become Open-Retail again in the future.

New additions to the network have been located in the San Francisco Bay Area, Greater Los Angeles Area, and Orange County regions. Figure ES 1 highlights the progress made since the 2020 *Annual Evaluation*[7], with eight newly opened stations located in Aliso Viejo, Berkeley, Campbell, Concord, Mission Hills, Placentia, Studio City, and Sunnyvale. As of the writing of this report, the Berkeley station is among the four Temporarily Non-Operational stations. Stations located in Ontario, Riverside, and San Francisco-Harrison St. are also considered Temporarily Non-Operational[8].

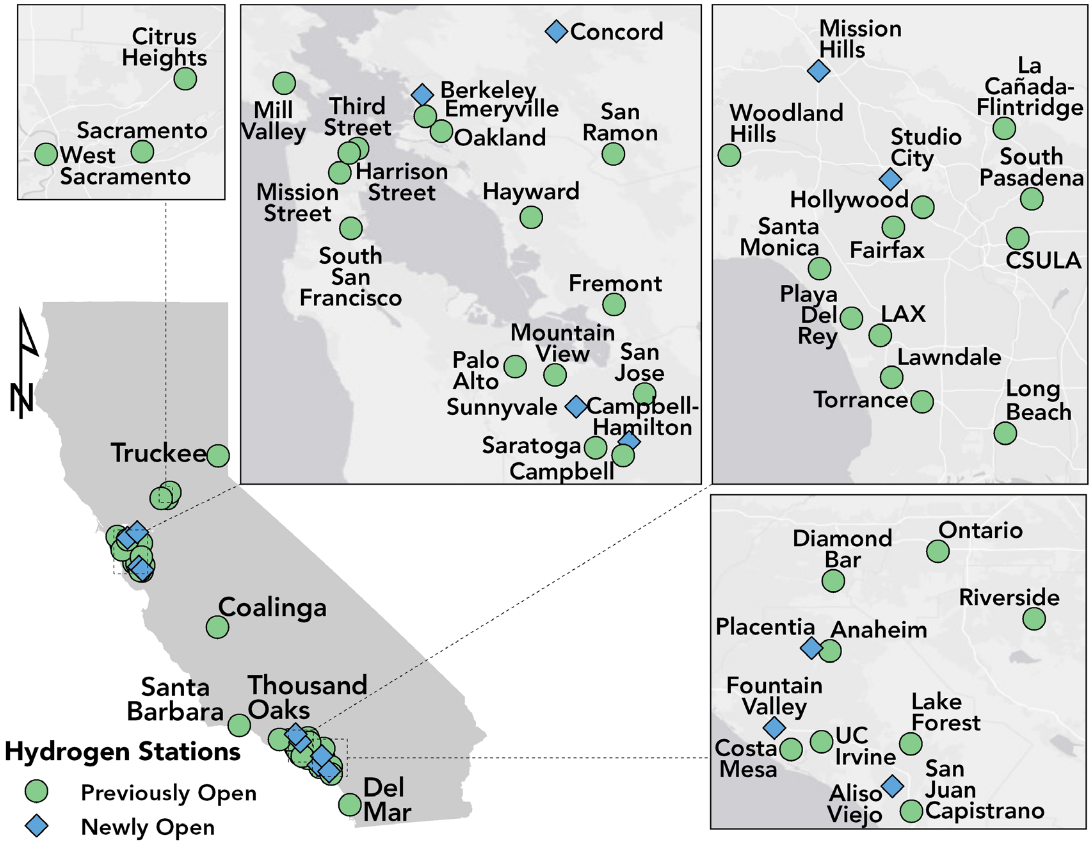
Private investment has recently begun to play an enhanced role in station network development. The currently Open-Retail station in Placentia represents a milestone in this regard. In 2018, CARB reported that the Newport Beach station was the first in the state to be upgraded completely with industry funds [10]. Now, the Placentia station is the first new station in California to open without any State grant funds. The station operator (FirstElement) has applied for and received approval for the location to participate in the LCFS HRI program, but has not requested any additional funds for the station through GFO-19-602 or other State programs[9].

7 *Link to prior Annual Evaluations*

8 As these stations resume retail sales operations, they will be counted again as Open-Retail in future reports. See "Current Open and Funded Stations" on page 24 for more information.

9 While this station requested no additional State co-funding, it did count towards the applicant's match funding, which was also considered as a scoring criterion in the GFO.

Figure ES 1: Current Open Hydrogen Fueling Station Network (as of June 22, 2021)[10]



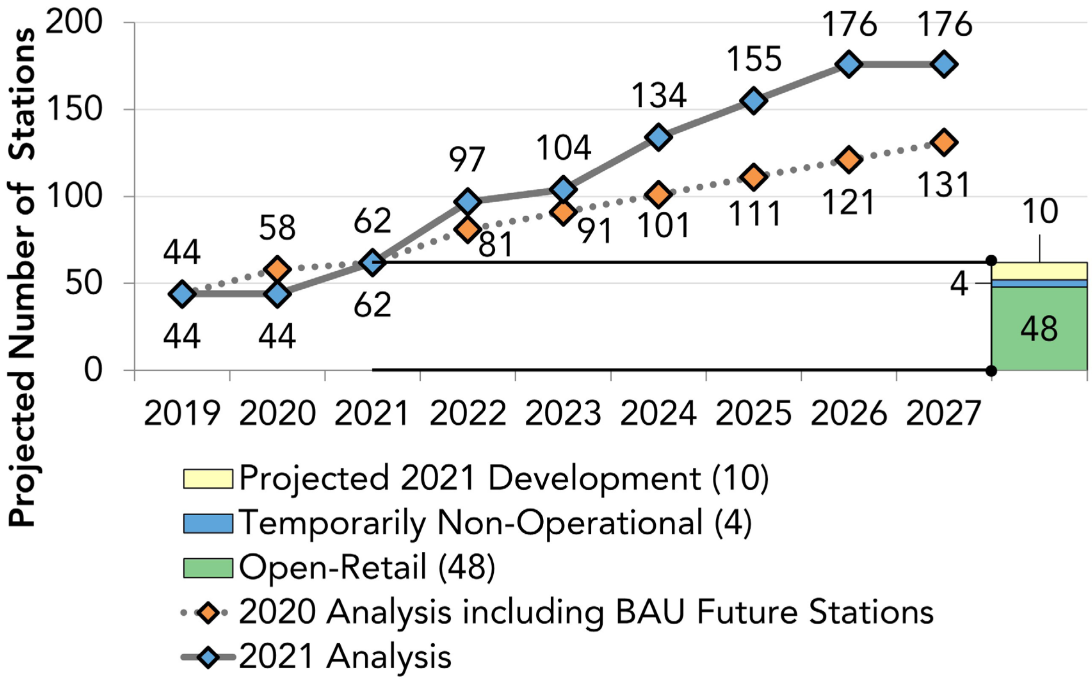
Finding 2: New station awards by the CEC have significantly advanced the outlook for future network development well beyond previous projections

The most recent projection for the schedule of all currently known station network development is shown in Figure ES 2, based on information provided by station developers, CEC, and GO-Biz. Over the next six years, awards made by the CEC through GFO-19-602 are currently estimated to add up to 94 new stations to California's hydrogen fueling network and upgrade 4 existing stations. Private funding is projected to add an additional 23 stations. Combined, based on all known investments to date, the network is anticipated to include a total of 176 stations by 2026. By the end of 2021, up to 62 hydrogen fueling stations may achieve Open-Retail status if current development schedules are maintained and Temporarily Non-Operational stations return to Open-Retail status. The pace of currently projected stations between 2020 and 2022 is faster than previously observed in California.

Through 2023, the projected pace of network development is slightly faster than estimates reported one year ago in the 2020 *Annual Evaluation.* Based on current development schedules, up to 104 stations may be open by the end of 2023. Near-term development pace (through 2023) largely reflects ongoing station development from prior awards made by the CEC. Beyond 2023, the pace of development is projected to accelerate further to 176 stations by 2026, due largely to awards made by the CEC through GFO-19-602.

10 This map does not show real-time available status. See Figure 11 for further information regarding stations that have achieved Open-Retail status but may be temporarily unavailable. Real-time status is available to drivers via the Station Operational Status System maintained by the California Fuel Cell Partnership and accessible at the website *m.cafcp.org*. In addition, Fountain Valley is included on this figure as new, though it opened prior to the 2020 Annual Evaluation. As that report noted, the station opened as the report was in review, so it did not appear as Open-Retail in maps though it was counted as Open-Retail in the narrative.

Figure ES 2: Comparison of Statewide Funded Station Projections between the 2020 and 2021 Annual Evaluations



Future development of the hydrogen fueling network will continue to see growth in private funding. In addition to the currently Open-Retail and fully privately funded station in Placentia, FirstElement has seven more stations currently in development that have similarly not requested any State grant funds. FirstElement also plans to develop an additional eight stations with this private funding structure in future batches of GFO-19-602. In addition, station developer Iwatani is also building seven stations completely through private funds.

At this time last year, CARB projected business-as-usual growth (based on indications from prior AB 8 funding that each annual allocation of $20 million could support the development of 10 new stations) to only 121 stations by the end of 2026. As Figure ES 2 demonstrates, the actual planned development will now far exceed this prior estimate assuming current estimated project schedules are accurate. Between 2023 and 2026, 20 to 30 stations are projected to open each year, which is twice as fast as the projection made in the 2020 *Annual Evaluation*.

By 2026, more than 176 total stations are currently projected to be Open-Retail, including stations with State co-funding, stations initiated through the LCFS HRI program, confirmed privately funded station projects, and stations expected to be funded through the SB 129.

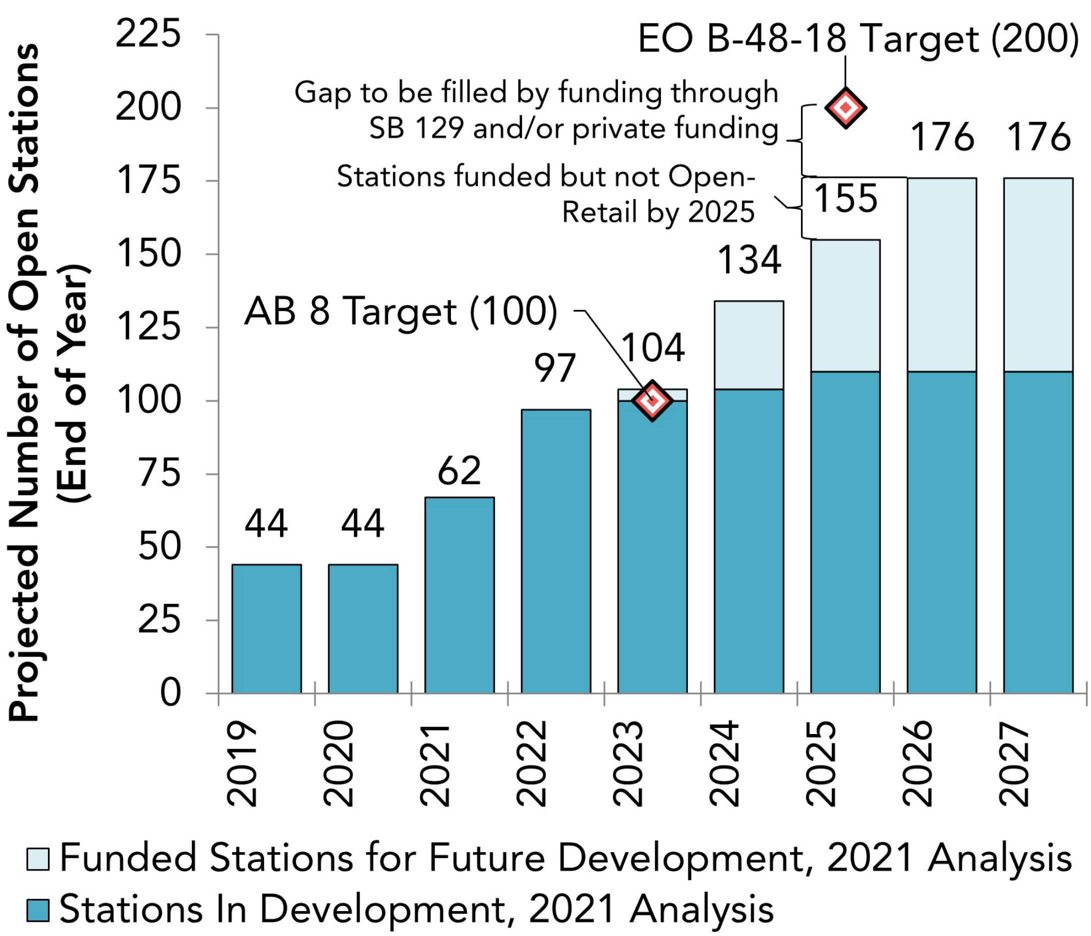
Finding 3: Planned network development will achieve the goals of AB 8 and narrow the gap to the target of Executive Order B-48-18

The pace of station network development over the next several years is a significant step in advancing hydrogen fuel availability in California. As noted in the 2020 *Annual Evaluation* and CARB's recently published *Self-Sufficiency Analysis*, sequentially reaching the State's station targets in parallel with accelerating FCEV deployment are important steps on the path to achieving a financially self-sufficient hydrogen fueling network in California [11], [9]. This includes the target of AB 8 (100 stations) and the target of EO B-48-18 (200 stations by 2025).

With the latest station development awards made by the CEC through GFO-19-602 and current estimated development schedules, the 100-station goal of AB 8 will be met in 2023. In fact, as shown in Figure ES 3, 104 stations could be Open-Retail by the end of 2023. This is a significant advancement in the past year. Figure ES 2 shows prior estimates of only 91 Open-Retail stations by the end of 2023 and the 2020 *Annual Evaluation* reported that station development schedules needed to accelerate to meet the goals of AB 8.

CARB currently counts 176 total stations as either Open-Retail or in development through either State co-funding or completely private funding, which is short of the 200-station goal set by EO B-48-18. SB 129 provides additional one-time funding to support ZEV market development by dedicating funding to ZEV deployment and infrastructure. In combination with private funding and the LCFS HRI program, the one-time funding provided by SB 129 can help close the gap to 200 stations.

Figure ES 3: Projected Station Deployment Compared to AB 8 and EO B-48-18 Goals

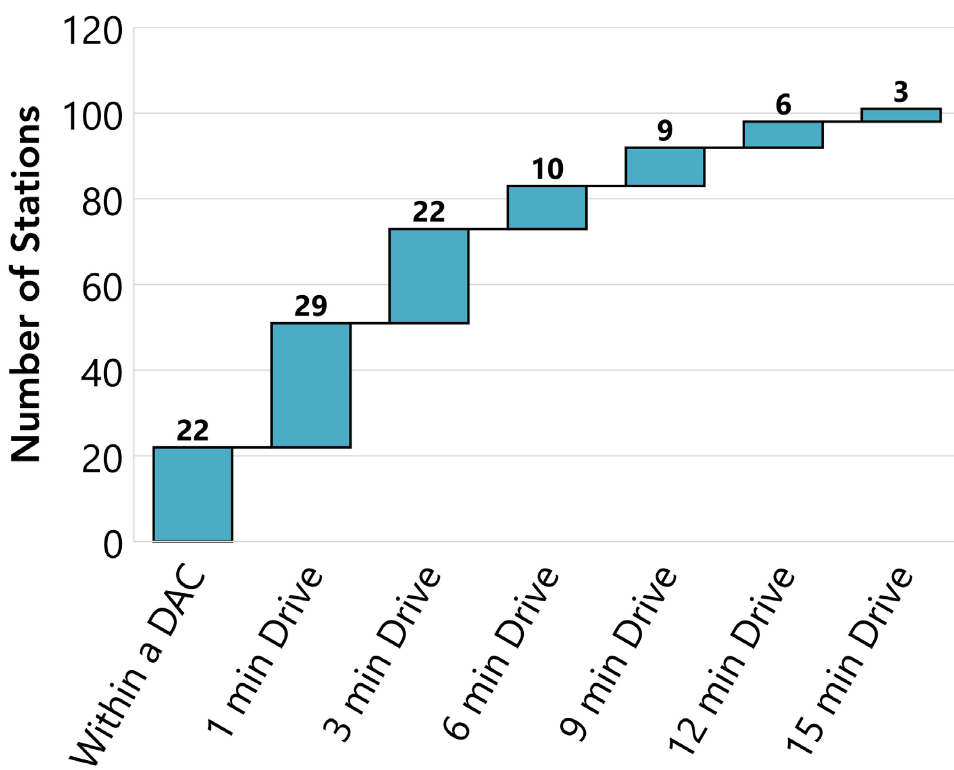


Finding 4: California's planned hydrogen fueling network will provide convenient fueling access to residents of disadvantaged communities

State efforts to support ZEV infrastructure development strive to ensure that development is equitable for all Californians and that communities that have historically faced disproportionate environmental burdens and/or socio-economic barriers materially benefit from these efforts. CARB and CEC investments in medium- and heavy-duty FCEVs and infrastructure also offer significant potential for air quality improvements in California's disadvantaged communities (DACs).

A significant portion of the currently Open-Retail and planned hydrogen fueling network is also located within a convenient driving distance of populations in DACs. As shown in Figure ES 4, analysis of network coverage finds that 83 planned stations (75 percent) would be located within a six-minute drive of a DAC, which matches the convenience provided by today's gasoline station network. In addition, convenient access to hydrogen fueling appears to be equivalent between DAC residents and the general population. Thirty-four percent of both DAC residents and the general statewide population live within a six-minute drive of a station. Stations awarded through GFO-19-602 and the planning completed by station developers to date has ensured that communities across California will have convenient access to hydrogen fueling.

Figure ES 4: Hydrogen station proximity to DACs



Finding 5: Future station development through GFO-19-602 and other efforts should consider focusing on opportunities in both established and emerging markets

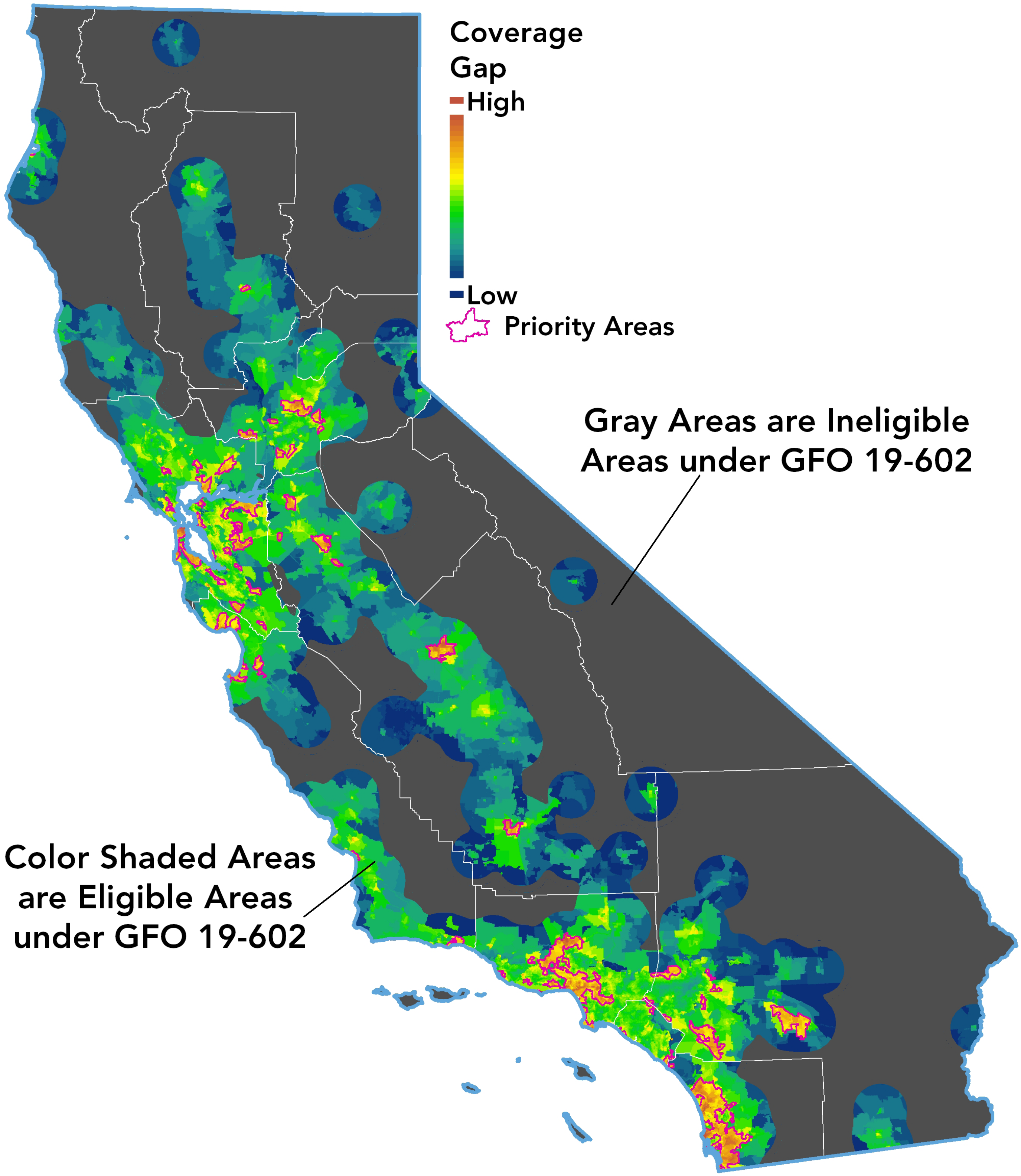
Compared to previously known plans described in the 2020 *Annual Evaluations*, as many as 94 new stations and 4 station upgrades are expected to be developed through the awards made in GFO-19-602. The structure of the funding program requested proposals from applicants for multi-year development plans and allowed applicants to request funds for stations in batches. All awardees anticipate at least three batches each. At the time of application, only addresses in the first batch were required to be specified, though some awardees also provided addresses in at least one future batch. Altogether, 28 of the 94 new stations and 2 of the planned upgrades currently have a known address. This leaves 66 new stations and 2 planned upgrades with addresses yet to be determined for future network development.

As in prior years' analyses, CARB utilized its geographic information system (GIS)-based California Hydrogen Infrastructure Tool (CHIT) to evaluate the coverage and capacity of the known hydrogen station network and identify geographically defined gaps in the planned fueling network. Figure ES 5 shows the current evaluation of coverage and highlights the areas where more stations are most needed based on the gaps between existing coverage and the local FCEV adopter market. In locations where the coverage gap is high, there remains opportunity to develop hydrogen fueling stations to meet local market demand by establishing or bolstering fueling station coverage.

Much of the completed or planned development has been focused in the San Francisco Bay Area, Greater Los Angeles, Orange County, San Diego County, and Sacramento regions. Figure ES 5 shows that there continues to be significant need for additional coverage in some parts of these regions. However, because of the amount of development already planned for these areas, an equally significant need for development is apparent in markets that have not previously been highlighted by annual evaluations in terms of coverage gap.

New markets in the San Joaquin Valley, including Bakersfield, Fresno, Stockton, and other cities are identified as Priority Areas in the most recent coverage gap analysis. Since the previously planned Palm Springs station is no longer moving forward, this area also now appears as a Priority Area. Cities along the Central Coast like Monterey, San Luis Obispo, Santa Barbara, and Santa Cruz are in need of coverage. Chico and Eureka in northern California are also possible regions for opportunity to establish a local fueling market and enable FCEV deployment. Station developers building hydrogen fueling stations co-funded by the CEC through GFO-19-602, LCFS HRI, or completely private efforts should seriously consider this more geographically diverse set of regions for further expansion of the network.

Figure ES 5: Coverage Gap Analysis to Inform Future Station Development



The geographic distribution of planned fueling capacity matches well to projected fueling demand assuming that auto manufacturers will only seek to sell or lease FCEVs to consumers living near the currently planned stations. However, the coverage gaps in Figure ES 5 highlight that there may be a significant portion of the potential market that is not yet served by the planned network of stations with known addresses. Future station development in these areas, whether as part of the unspecified locations in GFO-19-602 or private funding efforts, can help expand the population for which FCEV adoption is a viable choice.

A reference scenario provided by the California Fuel Cell Partnership's (CaFCP) *Revolution* document and assessed in CARB' *Self-Sufficiency Analysis* is more regionally diverse than the planned network of known station locations and demonstrates promising potential for FCEV adoption and hydrogen station network self-sufficiency[11] [9], [12]. Based on the self-sufficient network scenario in those reports, California's hydrogen fueling network needs expanded coverage as shown in Figure ES 5 and capacity expansion that is similarly regionally diverse. Opportunities remain for capacity expansion in the established markets like the Greater Los Angeles Region but there is also significant need for capacity in the other regions around the state, especially the regions of the San Joaquin Valley, Central Coast, and Sacramento Area.

Finding 6: Auto manufacturer projections for future FCEV deployment show more long-term growth than prior surveys

Based on Department of Motor Vehicles (DMV) records of active FCEV registrations, California had 7,993 on-road FCEVs as of April 1, 2021[12]. Similar to reporting in prior years, the latest industry estimates indicate a larger number of cumulative FCEV sales, at 10,665 in the United States by June 1, 2021[13] [13]. The COVID-19 pandemic significantly decreased sales across the automotive industry in 2020. Based on industry estimates, 2020 FCEV sales dropped more than 50 percent from any of the prior three years of sales and were the lowest since 2015 [13]. Hydrogen supply constraints in 2020 and 2021 may have also played a role in reducing vehicle sales.

Although sales were markedly lower in 2020 due to the ongoing COVID-19 pandemic, the industry appears to be on a path to recovery in 2021. Through June 1, 2021, industry estimates report 1,734 FCEV sales [13]. The FCEV sales volume to date in 2021 is already equal to 185 percent of the sales in all of 2020 and 83 percent of the sales in all of 2019. The first quarter of 2021 was also the best-selling quarter since industry tracking began in 2012 [13]. Stronger sales in 2021 are likely influenced by the release of the redesigned 2021 model year Toyota Mirai.

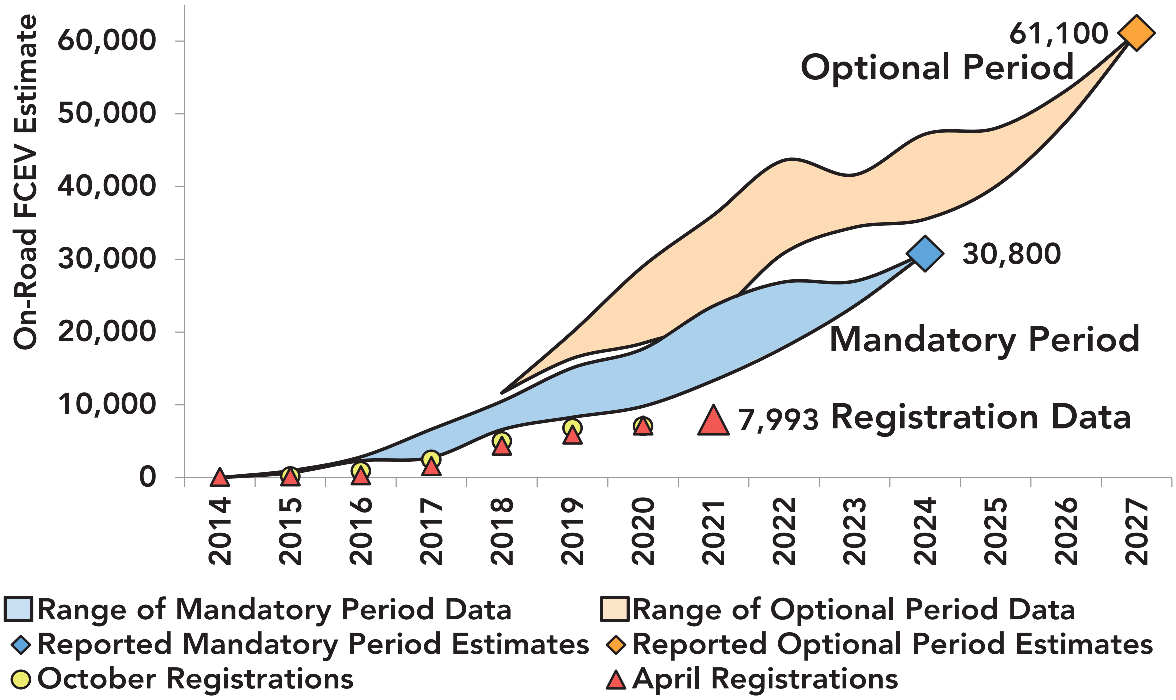
The CEC's December 2020 approval of awards in GFO-19-602 significantly strengthened the outlook for hydrogen fueling infrastructure in California and could encourage a more aggressive auto manufacturer outlook for future FCEV sales. Based on the most recent survey of auto manufacturers, the industry appears to have regained confidence in sales potential through 2027. Updated estimates project 30,800 FCEVs on the road as early as 2024 and 61,100 as early as 2027 as shown in Figure ES 6. The near-term pace of deployment (through 2025) is similar to estimates based on the 2020 survey, while projections for 2025 through 2027 have accelerated. In the past, long-term projections (mostly in the Optional Period) have been higher than actual FCEV deployment while near-term projections have been more accurate.

11 The scenario in these documents envisions development of a network of 1,000 stations through 2030 that enables the deployment of 1,000,000 FCEVs.

12 The CEC's ZEV Dashboard reports 7,129 FCEVs on the road at the end of 2020 [16].

13 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 CaFCP data likely do not adjust fully for vehicle attrition.

Figure ES 6: Current and Projected On-Road FCEV Populations and Comparison to Previously Collected and Reported Projections



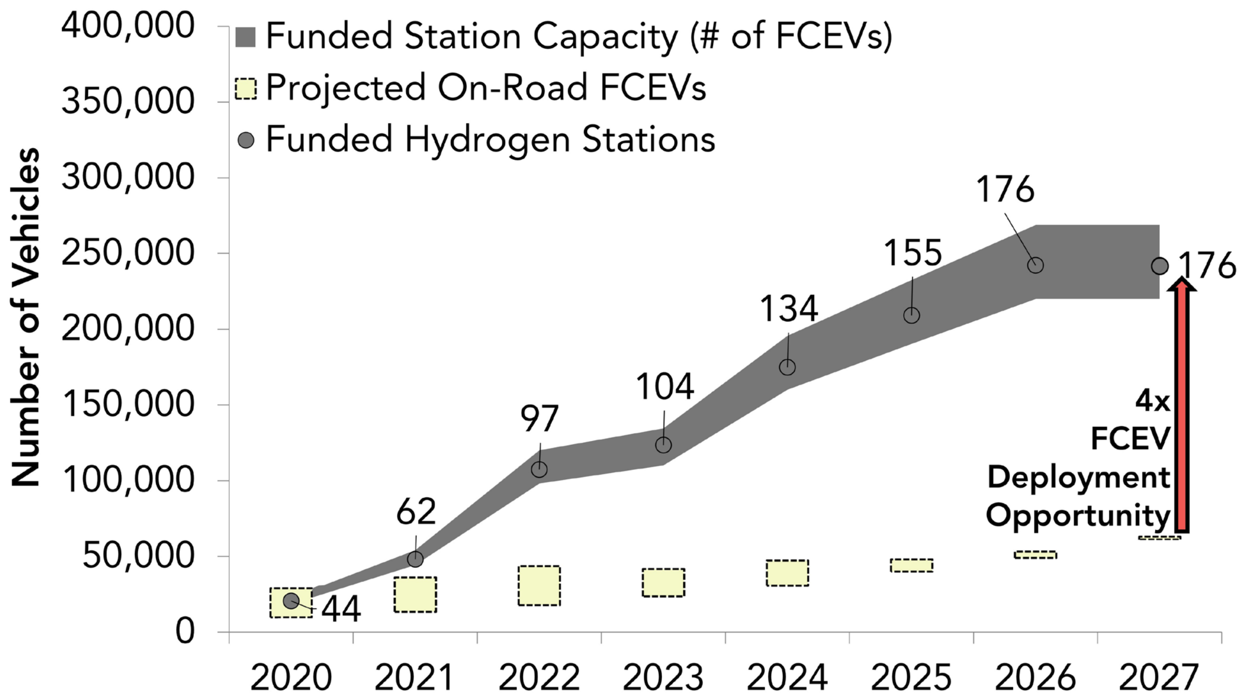
These estimates for FCEVs on-the-road in 2024 and 2027 are shown by the large diamonds in Figure ES 6. The shaded areas in the figure also show the ranges of all past projections for vehicle deployment since 2014, based on analyses of the annual surveys of auto manufacturers. Responses to each survey are split into two periods: a mandatory response period with projections for FCEV deployment three years into the future, and an optional response period covering an additional three years into the future. Finally, estimates of the number of FCEVs on the road per DMV registration data are shown by the triangle (April data) and circle (October data) symbols.

Finding 7: The current and planned station network provides auto makers an opportunity to deploy as many as four times the FCEVs currently indicated through industry surveys

The most recent survey of auto manufacturer FCEV deployment projections indicates continuing growth in California's fleet in the future if future FCEV sales, which will require sustained auto manufacturer investments, closely match current projections. The estimated on-road fleet of 61,100 FCEVs in 2027 is the largest projection to date. While this shows important expectations of growth in California's FCEV fleet, the projections are now significantly less than the opportunity provided by the funded and developing network.

In the 2020 *Annual Evaluation*, CARB noted that then-current projections for FCEV deployment nearly matched the capacity of the known network, based on standard assumptions that FCEV drivers consume 0.7 kg/day of fuel. Based on current network growth plans, this is no longer the case and the funded network could support the fueling needs of 250,000 FCEVs. Auto manufacturers now have the opportunity to deploy up to four times the number of FCEVs currently projected, as highlighted by the gap between the network capacity and FCEV projections in Figure ES 7.

Figure ES 7: Projected Hydrogen Demand and Fueling Capacity



This opportunity for future deployment is unprecedented in California's history of efforts to develop an in-state hydrogen fueling network. For the funded hydrogen stations, the challenge will be maintaining the development schedules as currently estimated. Should that happen, auto manufacturers should be able to further accelerate their future projections of FCEV deployment (and actual FCEV sales) in the state well beyond current estimates.

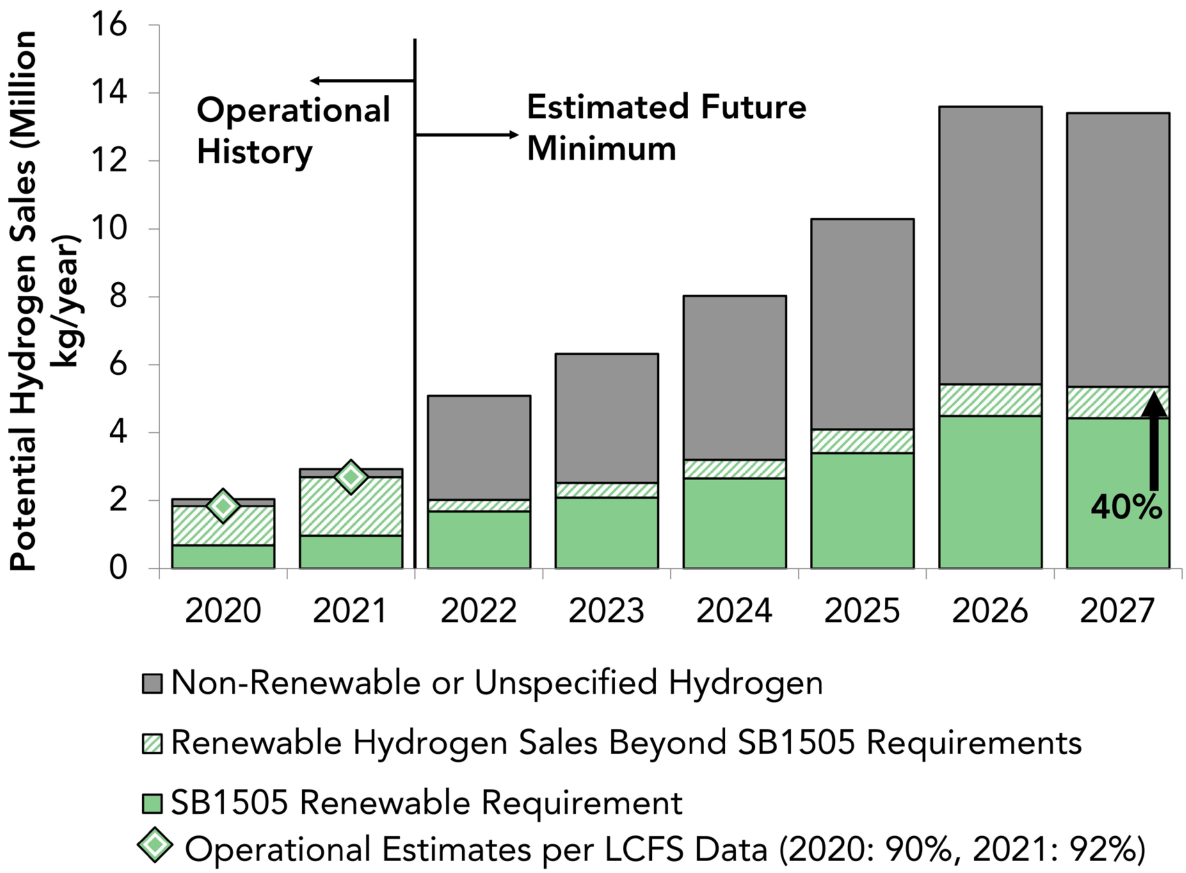
The projected network buildout and vehicle deployments through 2026 compare well with the ambitious scenario to 1,000 stations presented in the CaFCP's *Revolution* document and CARB's *Self-Sufficiency Analysis*. Based on current schedules, total network capacity will actually grow earlier than the scenario presented in those reports. As noted in CARB's *Self-Sufficiency Analysis*, an accelerated network development schedule and accelerated FCEV sales beyond current projections can be key components of achieving hydrogen station network financial self-sufficiency. Future FCEV deployments and station funding plans will determine whether the pace of network development can continue to match projections that ultimately achieve self-sufficiency. Accelerated network buildout and vehicle deployment beyond current projections will be needed to maintain a path to self-sufficiency.

As noted in Finding 5, the reference scenario of a self-sufficient hydrogen fueling network is more geographically dispersed than the current set of known station locations. Funded stations are also individually larger on average than stations in the self-sufficient scenario. In 2026, the planned network will have approximately the same capacity as this reference case. At that time, the funded network is projected to include 176 stations while the self-sufficient scenario considered 312 stations for the same network capacity. This could be a positive indicator that the CEC's implementation of GFO-19-602 accomplished the goal of improving economies of scale in station development. CARB's *Self-Sufficiency Analysis* finds that larger stations generally demonstrate better economic potential. A greater number of large stations for a given network capacity could indicate strong potential for network self-sufficiency, though it does also imply fewer opportunities to expand network coverage into a larger number of communities across the state.

Finding 8: California's hydrogen network is on track to maintain at least 40 percent renewable hydrogen implementation

California's programs to support hydrogen fueling network development continue to emphasize renewable and low-carbon hydrogen as preferred sources for hydrogen fuel sales. Today, all stations that receive State co-funding must dispense hydrogen with a minimum 33.3 percent renewable content, per SB 1505. Once the annual volume dispensed reaches 3.5 million kilograms, this requirement will apply to all stations regardless of funding source. Due to the eligibility requirements of GFO-19-602 and the LCFS HRI program, the majority of California's hydrogen fueling network is expected to dispense hydrogen with at least 40 percent renewable content (as demonstrated in Figure ES 8[14]), which exceeds the minimum set forth by SB 1505.

Figure ES 8: Evaluation of Minimum Renewable Hydrogen Content in California's Fueling Network[15]



In practice, California's hydrogen fueling network has in recent years exceeded not only the minimum requirement of SB 1505 but also the projected estimate of 40 percent. In the 2020 *Annual Evaluation*, CARB reported that data obtained through the LCFS program indicated that more than 90 percent of fuel dispensed in California's hydrogen station network was generated from

14 Renewable content in this analysis is based on the portfolio of individual station developers' networks. For example, station developers participating in the HRI program do not need to demonstrate 40 percent renewable sales at each individual station location, but across the portfolio of all their stations. Some stations may then dispense at less than 40 percent, while others dispense at more than 40 percent renewable. Renewable content is evaluated per the definitions in the LCFS regulation, California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 10, Article 4, Subarticle 7, §95841 (a)(131) "Definitions- Renewable Hydrogen".

15 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, and divides demand between funded and future stations proportionally to the total capacity within each group. This is a slightly different methodology from prior reports.

renewable resources for several months (accounting for the minimum renewable amount of hydrogen sold at stations not in the LCFS program). Evaluation of data provided only by the participating entities in the HRI program shows so far in 2021 they are dispensing hydrogen with on average 92 percent renewable content and multiple individual operators are operating at or near 100 percent renewable content. Communications with station operators have indicated that long-term planning and contracts have not yet been put in place to ensure this high level of renewable implementation continues in the future. However, the continued use of such large proportions of renewable hydrogen in California's network is a notable milestone and supports the State's focus on renewable and low-carbon hydrogen fuel.

Conclusions

The past year and a half of hydrogen station network development and FCEV deployment have undoubtedly been challenged by the statewide and global effects of the COVID-19 pandemic. In 2020, station network development was slower than expected and FCEV sales were significantly lower than in recent years. However, recent progress in both network development and FCEV sales signal a recovery is potentially underway. In addition, new station awards announced by the CEC through GFO-19-602 and recently announced plans for private development of additional stations have significantly improved the outlook for 2021 and beyond. Sales of FCEVs in the first quarter have already been nearly as much as all of 2019 and California's network of Open-Retail hydrogen stations will continue to grow in 2021.

Future development of stations is currently projected to exceed prior expectations. This year's report is the first to find that the 100-station target of AB 8 could be met by the end of 2023 based on stations that are currently Open-Retail or under development. Significant growth in the network is projected through 2026, to more than 176 stations across California. Auto manufacturers have improved their reported outlook on FCEV deployment potential and indicate more confidence in FCEV deployment potential than a year ago. By some metrics, the additional investments through GFO-19-602 and private efforts have also put the state's hydrogen fueling network on a path similar to published scenarios estimated to lead to the hydrogen fueling industry's financial self-sufficiency. Continued FCEV deployments will also be critical to maintaining this progress.

As much promise as these indicators provide, significant work remains to ensure that network development remains on schedule, FCEV deployments accelerate, and that future opportunities for growth are realized. The more than 176 total station projects that are currently Open-Retail, under development, or expected for future development are unprecedented in California's history. One-time funding provided by SB 129 will help close the gap to the 200-station goal of EO B-48-18. In addition, while auto manufacturers' outlook for FCEV deployment in California has noticeably improved, the latest vehicle projections are, as of now, below the estimated total fueling potential provided by California's developing network. As policymakers consider future investment decisions, tracking vehicle deployment projections will be important.

CARB sees significant potential for hydrogen fuel and FCEVs to contribute meaningfully to the State's aggressive ZEV deployment and decarbonization goals, especially with the assurance provided by the latest station development plans. Hydrogen fueling station development and FCEV deployment have long been characterized as a chicken-and-egg problem. With AB 8, California took the first step to provide a solution to this problem by leading with fueling network development. With the addition of stations co-funded by the CEC under GFO-19-602 and through private funding, California now appears to have a chance to transform what was once considered a problem into an opportunity. Ensuring that success is met will require public and private stakeholders to aim for significantly accelerated market development, built on the foundation of the sizeable hydrogen fueling station network that is now underway.

Introduction

The outlook for hydrogen fueling network development over the next several years has markedly improved from prior evaluations. While industry efforts were impacted by the COVID-19 pandemic, progress was made in several areas of network planning and financing. On-the-ground hydrogen station development continued and progress was made in the Open-Retail hydrogen fueling network, especially in the first half of 2021. At the same time, more than one hundred new hydrogen station development projects are now planned for future construction. The impact of these new station announcements is one of the most significant advancements in the history of hydrogen fueling station network development in California. This and a few other noteworthy developments over the past year play a major role in the analyses presented in this year's *Annual Evaluation*.

Station Network Progress

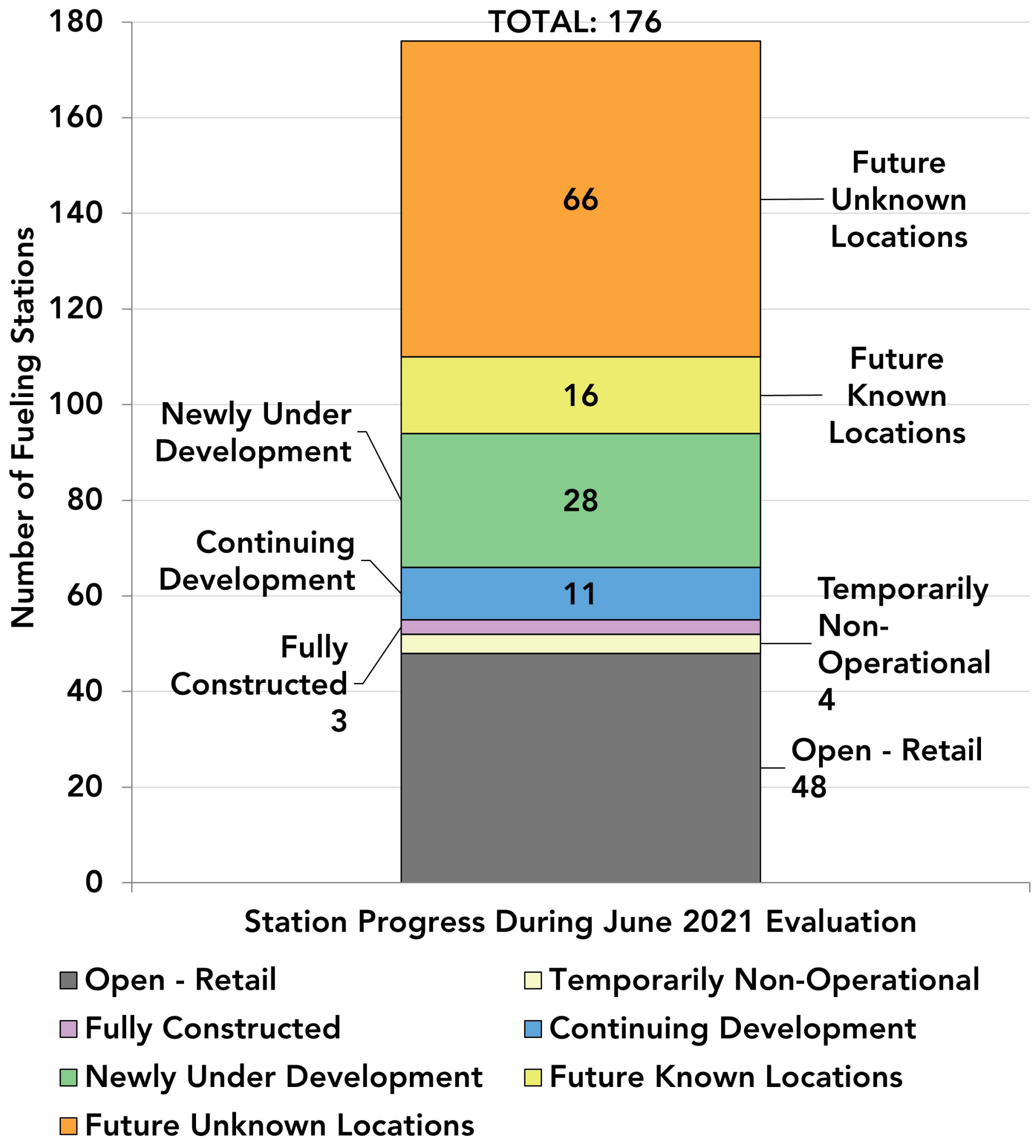
Since the publication of the 2020 *Annual Evaluation*, development has progressed in California's hydrogen fueling network at a slower pace than expected. In the early days of the COVID-19 pandemic, station developers did not anticipate long-term impacts on their station development schedules. In many cases, a six-month delay was the maximum expected, as reported in the 2020 *Annual Evaluation*. This potential impact was accounted for in reporting and the worst-case estimate at the time was that 50 stations would be Open-Retail by the end of 2020[16]. As the global pandemic continued to worsen in the summer of 2020, station development became more deeply affected than expected. Some developers reported slower permitting and construction processes as the COVID-19 pandemic caused the state's economy to slow down. Other reports also indicated difficulties maintaining station equipment delivery schedules as overseas production facilities and shipping similarly faced more restricted operating conditions.

At the end of 2020, the total count of Open-Retail stations remained at 44, though some new stations had entered the network. As some new stations achieved Open-Retail status, others entered into the Temporarily Non-Operational status. The net effect was that 2019 and 2020 closed with the same count of Open-Retail stations.

However, the closing months of 2020 and the first half of 2021 have shown a remarkable change in direction in the COVID-19 pandemic. Individual regions and the state as a whole have been able to take progressively larger steps to return to pre-pandemic conditions. Several stations have been able to achieve Open-Retail status early in 2021 and development continues on a large number of additional stations. As shown in Figure 1, there are 48 Open-Retail stations in California as of May 24, 2021. An additional three stations are fully constructed and proceeding through station testing and commissioning. Eleven more are continuing development from prior years, and an additional 28 stations are currently under development due to awards made in GFO-19-602 and fully private funding efforts. All told, as many as 10 more stations may achieve Open-Retail status by the end of 2021.

16 At the time, an additional three stations were considered Temporarily Non-Operational with an unknown date of returning to Open-Retail status.

Figure 1: Hydrogen Fueling Station Network Status as of June 22, 2021



If the recent progress in overcoming the COVID-19 pandemic is maintained, it appears that the next six years will see vastly more hydrogen station network development than any time in California's history. In addition to the stations under development now, there are an additional 16 stations with known locations funded through GFO-19-602 and anticipated for development in future station batches to be constructed once the current batches are complete. On top of that, the awards in GFO-19-602 indicate up to an additional 66 stations for future development that have not yet been assigned to a specific location[17]. One-time funding through SB 129 will provide opportunity for CEC to co-fund the development of additional stations. There are therefore more than 176 total hydrogen station development projects (Open-Retail, Temporarily Non-Operational[18], currently in development, or expected for future development) in California. The station awards in GFO-19-602 also anticipate up to four station upgrades that CARB counts in the Open-Retail category.

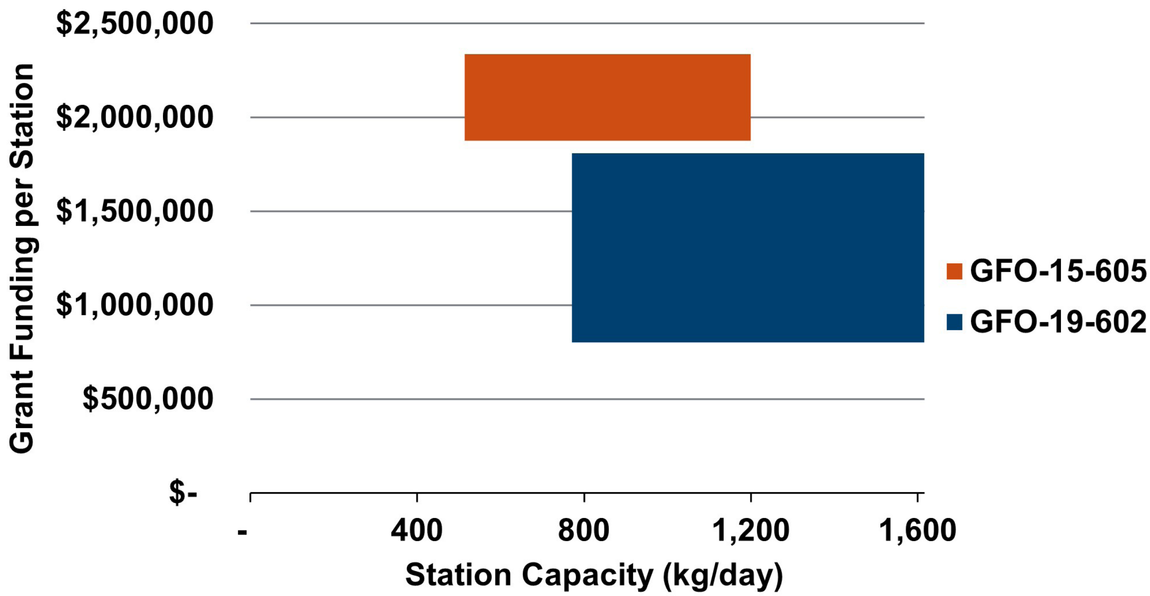
17 Funding for future batches of stations may be approved for each award recipient depending on performance, funding availability, and Clean Transportation Program Investment Plan allocations.

18 CARB began reporting station status with this classification in the 2020 Annual Evaluation. Temporarily Non-Operational indicates stations have previously achieved Open-Retail status but have not been available for fueling for an extended period of time due to some operational difficulty at the station. The specific cause has varied from one station to the next. The timeline to resume Open-Retail status is unknown, though the stations are expected to return to Open-Retail operation.

Energy Commission GFO-19-602 Awards

The announcement of awards in the CEC's GFO-19-602 has fundamentally changed the outlook of hydrogen fueling network development in California. The solicitation was the first in California specifically designed to encourage the development of economies of scale in California's hydrogen fueling industry. The solicitation aimed to achieve this primarily through its structure that requested applicants submit multi-year and multi-station plans. As reported in the 2020 *Joint Agency Staff Report on AB 8*, the results of the solicitation appear to indicate that the solicitation was successful is advancing economies of scale [14]. Figure 2 demonstrates how stations in GFO-19-602 are not only larger than the previous solicitation (GFO-15-605), but the grant funding amount per station has also decreased. Average grant funding amounts per kilogram/day of fueling capacity have dropped 65 percent between the last two solicitations. Stations awarded in GFO-15-605 received an average grant award of $2,445 per kg/day fueling capacity; stations awarded in GFO-19-602 received an average grant award of $847 per kg/day fueling capacity[19].

Figure 2: Improved Economies of Scale through GFO-19-602 [14]



In addition to significantly advancing economies of scale in the hydrogen fueling station industry, station development awards made through GFO-19-602 have created the largest opportunity to date for future FCEV deployment. As noted in the 2020 *Annual Evaluation*, all annual analyses since reporting began in 2014 have found that the projected hydrogen demand (based on auto manufacturer reported FCEV deployment projections) has exceeded or been equal to the total planned network fueling capacity. Until the announcement of awards in GFO-19-602, there had never been a time when the planned capacity exceeded the projected hydrogen fueling demand. Now that situation has changed significantly, with planned fueling capacity exceeding projected demand. There now exists an opportunity for auto manufacturers to begin reassessing their FCEV deployment plans now that California's network of currently planned stations may support 250,000 FCEVs on the road when fully built out.

19 These calculations include the capacity of privately funded stations that are considered match funding under GFO-19-602. In addition, GFO-19-602 only considers capital equipment expenses as eligible costs for grant funding. GFO-15-605 and earlier solicitations considered additional project costs (like engineering) as eligible for grant funding.

Expanded Private Station Funding

In all prior editions of CARB's *Annual Evaluations*, almost all stations in development or operating in the network were initiated through a State co-funding program. In 2020, the first set of new station development without State co-funding commenced. Station developer and operator FirstElement submitted eight station locations for approval to generate credits under the newly launched HRI provision within the LCFS regulation. These high-capacity stations (1,616 kg/day, but limited to credit generation under LCFS HRI at a maximum 1,200 kg/day) have since begun development and FirstElement will not receive any additional funds for these stations through GFO-19-602[20]. Aside from future revenue that these stations may receive through the sale of LCFS credits, the stations have received no financial support from the State and have been financed completely by private funds. FirstElement also plans for an additional eight stations to follow this financing structure for later batches under GFO-19-602. The first of these fully private new stations has now achieved Open-Retail status; the Placentia station opened to the public on May 7, 2021.

Station developer Iwatani Corporation of America (Iwatani) is also now developing seven stations financed completely through private funds. Iwatani was the third of three developers to receive awards through GFO-19-602. Due to the amount of funds requested by the first and second award recipients, the CEC was unable to co-fund the full network of stations that Iwatani had originally proposed. As Iwatani and the CEC negotiated to adjust the scope of the awarded project, Iwatani secured private financing to develop several stations included in their original proposal. Iwatani is therefore now continuing to develop those stations with the private funds outside of the GFO. This is another major milestone as it helps maintain the significant amounts of current and future development that are highlighted in this report.

Several new station developers have announced intentions to develop hydrogen stations in California through news reports and press releases over the past year. These developers are not included in GFO-19-602 and not yet participating in the LCFS program. CARB is not yet aware of any detailed plans or schedules that are available from these entities. At the moment, CARB does not consider these announcements in its analysis. If more definitive information becomes available in the future, CARB will include those stations in analyses as appropriate.

20 FirstElement did list these stations in their application to GFO-19-602, but indicated a zero-dollar funding request for each station. The effect was that these stations' development costs count as match funding for FirstElement's entire set of station development under GFO-19-602, which was considered part of scoring criteria. In addition, the stations are subject to station data reporting requirements. Data provided to the National Renewable Energy Laboratory through these data reporting requirements is essential in tracking status and providing insights into California's hydrogen fueling network development.

LCFS HRI Program Update

The LCFS HRI program (and its parallel for DC Fast Charging of electric vehicles) was launched in 2019 with the intent to support ZEV infrastructure development. Prior to these additions, hydrogen station operators were eligible to generate LCFS credits based on the amount of hydrogen sold at their station(s). This presented a scenario with limited near-term potential to generate LCFS credits, given the small number of FCEVs currently on the road. With the implementation of the HRI provision, participating station operators are able to generate additional LCFS credits based on the difference between station capacity and fuel sales. The net effect is that participating hydrogen stations generate a total number of LCFS credits based on the station capacity. This is a constant credit generation opportunity that significantly exceeds the expected near-term opportunity based on fuel sales alone.

Individual stations are subject to certain limitations that affect the maximum number of credits they may generate through the HRI provision and stations are only eligible for these credits for a limited period of 15 years. In addition, the total effect on the LCFS program is capped in order to ensure the overall LCFS program can still deliver on its expected greenhouse gas reductions. The HRI program thus far appears to be an effective tool to support the development of hydrogen stations in California. There are also indications that the program has had a role in station developers being able to develop larger stations, and more of them, than previously anticipated. Some new high-capacity stations participating in the program have also reduced the price that customers pay at the pump by approximately 20 percent.

The HRI program has continued to attract station developer interest. Today, 61 stations are participating in the program as outlined in Table 1. Many of the participating stations are currently Open-Retail and eligible to generate credits through the HRI provision and the standard LCFS provisions based on fuel sales. Others are currently approved, but have not yet achieved Open-Retail status and do not yet generate credits in the LCFS program. A few additional stations had previously been included in the program but have since dropped out as their development is no longer expected to proceed.

Table 1: Stations Approved for LCFS HRI Credit as of April 21, 2021[21] [15]

Applicant	Address	City	Capacity (kg/day)	Effective Date Range
First Element Inc.	12105 Donner Pass Road	Truckee	266	04/01/2019 - 03/31/2034
First Element Inc.	24505 W Dorris Avenue	Coalinga	266	04/01/2019 - 03/31/2034
First Element Inc.	150 South La Cumbre Road	Santa Barbara	266	04/01/2019 - 03/31/2034
First Element Inc.	3102 E Thousand Oaks Boulevard	Thousand Oaks	266	04/01/2019 - 03/31/2034
First Element Inc.	570 Redwood Highway	Mill Valley	266	04/01/2019 - 03/31/2034
First Element Inc.	8126 Lincoln Boulevard	Los Angeles	266	04/01/2019 - 03/31/2034
First Element Inc.	5700 Hollywood Boulevard	Los Angeles	266	04/01/2019 - 03/31/2034
First Element Inc.	3060 Carmel Valley Road	San Diego	266	04/01/2019 - 03/31/2034
First Element Inc.	41700 Grimmer Boulevard	Fremont	266	04/01/2019 - 03/31/2034
First Element Inc.	391 W A Street	Hayward	266	04/01/2019 - 03/31/2034
First Element Inc.	248 S Airport Boulevard	South San Francisco	266	04/01/2019 - 03/31/2034
First Element Inc.	1200 Fair Oaks Avenue	South Pasadena	206	04/01/2019 - 03/31/2034
First Element Inc.	2855 Winchester Boulevard	Campbell	266	04/01/2019 - 03/31/2034
First Element Inc.	550 Foothill Boulevard	La Cañada Flintridge	266	04/01/2019 - 03/31/2034
First Element Inc.	20731 Lake Forest Drive	Lake Forest	266	04/01/2019 - 03/31/2034
First Element Inc.	2050 Harbor Boulevard	Costa Mesa	266	04/01/2019 - 03/31/2034
First Element Inc.	3401 Long Beach Boulevard	Long Beach	266	04/01/2019 - 03/31/2034
First Element Inc.	12600 Saratoga Avenue	Saratoga	198	04/01/2019 - 03/31/2034
First Element Inc.	2101 N 1st Street	San Jose	266	04/01/2019 - 03/31/2034
Shell Inc.	551 3rd Street	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	101 Bernal Road	San Jose	513	04/01/2019 - 03/31/2034
Shell Inc.	6141 Greenback Lane	Citrus Heights	513	04/01/2019 - 03/31/2034

21 LCFS staff have received notice that the Palm Springs location will not be developed. The data in this table are updated on a quarterly basis and do not yet reflect this information

Applicant	Address	City	Capacity (kg/day)	Effective Date Range
Shell Inc.	3510 Fair Oaks Boulevard	Sacramento	513	04/01/2019 - 03/31/2034
Shell Inc.	1201 Harrison Street	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	3550 Mission Street	San Francisco	513	04/01/2019 - 03/31/2034
Shell Inc.	1250 University Avenue	Berkeley	513	04/01/2019 - 03/31/2034
Air Liquide Hydrogen Energy US LLC	10400 Aviation Boulevard	Los Angeles	200	04/01/2019 - 03/31/2034
First Element Inc.	14478 Ventura Boulevard	Sherman Oaks	808	07/01/2019 - 06/30/2034
First Element Inc.	350 Grand Avenue	Oakland	808	07/01/2019 - 06/30/2034
First Element Inc.	3780 Cahuenga Boulevard	Studio City	808	07/01/2019 - 06/30/2034
Air Liquide Hydrogen Energy US LLC	3601 Camino De Real Street	Palo Alto	136	07/01/2019 - 06/30/2034
First Element Inc.	1296 Sunnyvale Saratoga Road	Sunnyvale	1,200	10/01/2019 - 09/30/2034
First Element Inc.	337 East Hamilton Avenue	Campbell	1,200	10/01/2019 - 09/30/2034
First Element Inc.	11284 Venice Blvd	Culver City	1,200	10/01/2019 - 09/30/2034
First Element Inc.	18480 Brookhurst Street	Fountain Valley	1,200	10/01/2019 - 09/30/2034
First Element Inc.	15544 San Fernando Mission Blvd	Mission Hills	1,200	10/01/2019 - 09/30/2034
First Element Inc.	5494 Mission Center Road	San Diego	1,200	10/01/2019 - 09/30/2034
First Element Inc.	503 Whipple Ave	Redwood City	1,200	01/01/2020 - 12/31/2034
First Element Inc.	605 Contra Costa Blvd	Concord	1,200	01/01/2020 - 12/31/2034
First Element Inc.	26813 La Paz Road	Aliso Viejo	1,200	01/01/2020 - 12/31/2034
First Element Inc.	14477 Merced Ave	Baldwin Park	1,200	01/01/2020 - 12/31/2034
First Element Inc.	2995 Bristol Street	Costa Mesa	1,200	01/01/2020 - 12/31/2034
First Element Inc.	21530 Stevens Creek Blvd	Cupertino	1,200	01/01/2020 - 12/31/2034
First Element Inc.	615 S Tustin Street	Orange	1,200	01/01/2020 - 12/31/2034

Applicant	Address	City	Capacity (kg/day)	Effective Date Range
First Element Inc.	313 W. Orangethorpe Ave	Placentia	1,200	01/01/2020 - 12/31/2034
First Element Inc.	3939 Snell Ave	San Jose	1,200	01/01/2020 - 12/31/2034
First Element Inc.	1832 W. Washington St	San Diego	1,200	01/01/2020 - 12/31/2034
United Hydrogen	20th Avenue - Indian Canyon & I-10	Palm Springs	783	01/01/2020 - 12/31/2034
Iwatani Corporation of America	830 Leong Drive	Mountain View	349	07/01/2020 - 06/30/2035
Iwatani Corporation of America	26572 Junipero Serra Road	San Juan Capistrano	394	07/01/2020 - 06/30/2035
Iwatani Corporation of America	4475 Norris Canyon Road	San Ramon	393	07/01/2020 - 06/30/2035
Iwatani Corporation of America	1515 South River Road	West Sacramento	394	07/01/2020 - 06/30/2035
HTEC Hydrogen & Energy Corporation	17287 Skyline Boulevard	Woodside	68	01/01/2021 - 12/31/2035
Cal State LA	5151 State University Dr.	Los Angeles	51	01/01/2021 - 12/31/2035
Iwatani Corporation of America	1100 N Euclid St	Anaheim	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	616 Paseo Grande	Corona	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	11807 E Carson St	Hawaiian Gardens	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	13550 S Beach Blvd	La Mirada	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	2714 Artesia Blvd	Redondo Beach	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	16880 Slover Ave	Fontana	1,200	04/01/2021 - 03/31/2036
Iwatani Corporation of America	2120 E McFadden Ave	Santa Ana	808	04/01/2021 - 03/31/2036

Draft Hydrogen Fueling Network Self-Sufficiency Analysis Published

AB 8 provides funding for hydrogen station network development and outlines the requirements of semi-annual reporting through *Annual Evaluations* and *Joint Agency Staff Reports*. In addition to these annual actions outlined in AB 8, the statute also references the concept of financial self-sufficiency. The language of AB 8 provides funding to support the development of hydrogen fueling stations until CEC and CARB determine that "the private sector is establishing publicly available hydrogen-fueling stations without the need for government support." This language pointed to a need to understand the economics of hydrogen station network development, evaluate the circumstances under which State support may no longer be needed, and estimate the time it would take for the network to reach the point of self-sufficiency. A study was completed to evaluate the industry's ability to continue hydrogen station network development and operations without additional State support under several market conditions.

CARB staff initiated a study of current and potential future hydrogen network economics. Staff developed a scenario analysis methodology to consider many possible paths forward for hydrogen station network development in California. Staff utilized these tools to evaluate a wide array of scenarios with varying economic inputs and assumptions of station development and FCEV deployment pace.

In November 2020, CARB staff published the draft version of the *Self-Sufficiency Analysis*. After publication, staff invited the public to review the document and provide feedback. Staff also convened a panel of independent experts to provide an in-depth review and set of comments. CARB staff collected written comments from the panel and convened a half-day workshop to discuss all comments with the expert review panel.

The report provides detail of the modeling methodology employed, descriptions of the scenarios considered, and synthesis of the results into several major conclusions. Primary among these is the finding that self-sufficiency can be achieved in most cases for California's light-duty hydrogen fueling network by 2030 with up to an additional $300 million in State support beyond AB 8 and continued FCEV deployment. The report finds that the two most important success factors are generating economies of scale (building more and larger stations at a faster pace) and the rate of FCEV deployment, though reductions in station development and operation costs are also needed. Although beyond the scope of the self-sufficiency report's analysis, other market developments will help ensure consumer uptake of FCEVs that can contribute to developing a self-sufficient hydrogen network. This includes increased choice and diversity of FCEV models, consumer education, and development of resilient hydrogen production and delivery infrastructure. Consumers of hydrogen fuel also stand to benefit from ongoing market development, as broader network deployments generate economies of scale and lower costs.

The economics of California's network of hydrogen fueling stations are complex and intrinsically dependent on the pace of network development and FCEV deployment. Historically, the hydrogen station industry has relied, for the most part, on CEC funding and programs such as LCFS. Throughout the implementation of the CEC's station funding program, it has been clear that the hydrogen station industry as a whole has not yet demonstrated financial self-sufficiency. The emergence of privately funded stations in the past year is a promising sign that developers view the financial performance of individual stations as improving and, in some cases, State financial support in the form of grants may not be needed. However, more data and demonstration of successful privately funded stations is necessary to assess network-wide self-sufficiency in California. It is the shared goal of private and public stakeholders alike that the industry can eventually continue growth and network operations without relying on sustained public co-funding.

Location and Number of Fuel Cell Electric Vehicles

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

Each year, CARB estimates current and future counts of FCEVs on the road based on two primary data sources outlined in AB 8. For estimates of vehicles currently on the road, CARB analyzes DMV registration data. Registration records are received in early April and analyzed by CARB staff to estimate the number and location (by ZIP code) of active in-state FCEV registrations. For future on-road vehicle projections, CARB additionally relies on information provided in an annual survey of auto manufacturers.

The annual survey asks auto manufacturers to provide estimates of their future deployment of plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs), and FCEVs in California. Every survey requests information about future vehicle deployment over a span of at least seven years, divided into two separate periods. Responses from auto manufacturers are mandatory for the first period, which covers the remainder of the current model year and the next three model years. For the 2021 survey, this period is model years 2021 through 2024. Responses in the second period are optional and cover a further three model years. For the 2021 survey, this period is model years 2025 through 2027. Information provided in the optional period can help CARB complete more accurate analyses and recommendations of long-term ZEV infrastructure development needs.

Fueling infrastructure is a critical parameter, among others, when considering ZEV deployment. Other considerations are the need for more FCEV models available at lower purchase price, the need for less expensive hydrogen that approaches parity with gasoline, and the need to bolster consumer awareness about ZEVs, in general, and FCEVs.

Each year, CARB provides auto manufacturers with updated information regarding electric charging and hydrogen fueling infrastructure development in California. For hydrogen fueling infrastructure, CARB also provides a map of all hydrogen fueling stations in California that are open or in development. Appendix C displays the map that was shared with auto manufacturers for the 2021 survey. This year, CARB also provided auto manufacturers with an interactive online map[22] that included all station information that was known as of January 14, 2021.

For both the mandatory and optional periods, auto manufacturers provide estimated statewide deployment volumes for each model that will be released in the future. In addition, auto manufacturers may optionally provide technical specifications, including the vehicle class (e.g. compact car, pickup truck, medium sport utility vehicle, etc.) and design parameters like fuel cell power, motor power, battery capacity, hydrogen storage capacity, and others. Response rates vary among auto manufacturers, especially for optional information. In some years, a given auto manufacturer may respond to all information requests and in others the same manufacturer may only respond to mandatory information requests.

22 *Map of Hydrogen Stations Provided to Auto Manufacturers*

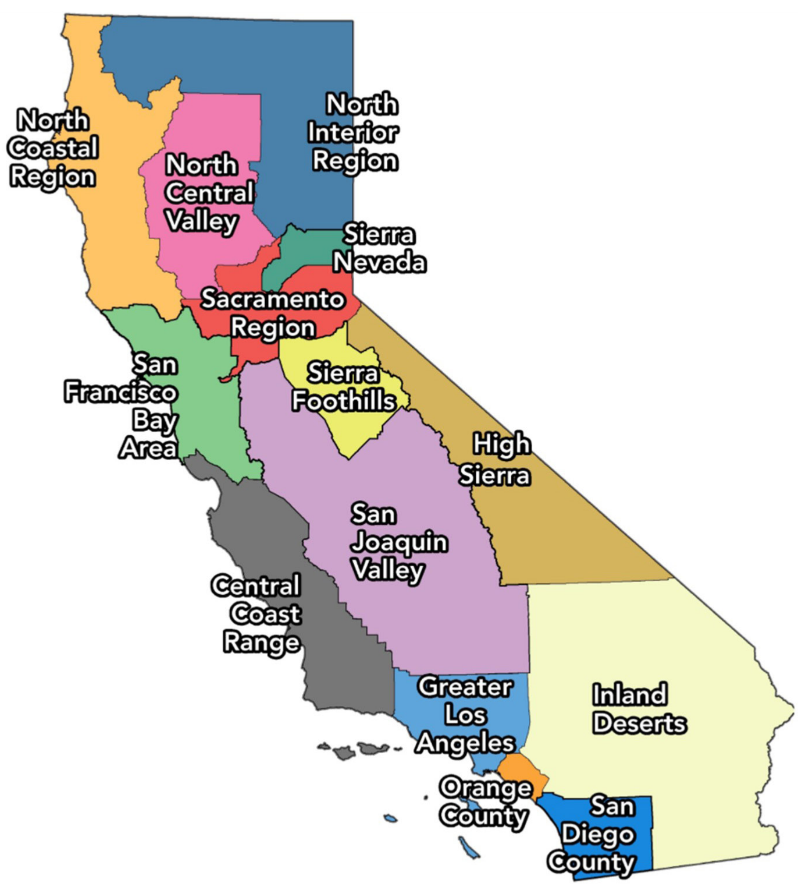
Each year, CARB may also request supplemental information outside of the standard mandatory and optional period vehicle deployment data. Governor Newsom's EO N-79-20 has placed increased emphasis on rapid scale-up of California's ZEV fleet. California's agencies are working to establish a path forward to meet these aggressive targets on schedule. These efforts will require informed decision-making based on the latest information about the evolving ZEV market. For the 2021 survey, CARB asked auto manufacturers to provide new supplemental information about their expectations for vehicle sales in 2030 and 2035. For each of these years, auto manufacturers were asked about their expectation for sales of each of four different powertrain technologies: PHEVs, BEVs, FCEVs, and internal combustion engines (ICEs). CARB's request included estimated percentages of California sales and number of models within each powertrain technology. For this survey year, the response rate was too low in this supplemental portion to provide insight. CARB may repeat this or other supplemental data requests in future surveys to track changes in long-term ZEV deployment plans beyond the six years normally captured in the survey.

Analysis of Current On-The-Road FCEVs

Several data processing steps are required to translate DMV registration data and auto manufacturer survey responses into estimates of current and future FCEVs on the road and their geographic placement. CARB searches DMV registration data for active FCEV registrations based on eight-digit vehicle identification number (VIN) patterns associated with each FCEV model that is or has been available for sale and lease in California. Because of the nature of the DMV registration database, a single vehicle may have multiple entries with different registration status, vehicles may be registered to ZIP codes out of state, or the current registration status may be non-active. CARB analyses resolve any duplicate entries for individual vehicles by taking the most recent status as the current status. All remaining out-of-state entries and non-active data records are then removed from CARB's count of FCEVs currently on the road.

Figure 3: 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 Bernadino
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 County	Orange
Sacramento Region	El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba
Sand 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



CARB then takes the remaining entries of active and in-state registrations and aggregates them at multiple geographic resolutions in order to complete general and detailed analyses of current on-the-road FCEVs. In particular, CARB assesses registration data at the ZIP code level, the county level, and on a regional level. In recent *Annual Evaluations*, CARB has adopted the set of regional definitions shown in Figure 3. The definitions of these regions were developed through consideration of the history of FCEV registrations and analysis of potential future fueling network development scenarios as discussed in CARB's *Self-Sufficiency Analysis* and the CaFCP's *Revolution* document.

Based on DMV data from April 2021, CARB estimates there are 9,463 unique registration records in California. Of these, 7,993 have a registration status indicating the vehicle's registration is currently active and part of the on-road fleet. This represents an increase of 864 on-road FCEVs over the CEC's 2020 end-of-year estimate of 7,129 FCEVs [16]. CARB's analysis includes vehicles marked as "Not Currently Registered" or "Planned Non-Operational" in the group of non-active registrations. Vehicles may be included in the Not Currently Registered category for several reasons, including late or incomplete registration and payment of fees. Vehicles in the Planned Non-Operational category have been designated by their registered owners as not planned to be driven on California's roads for a period of one year starting from the date of registration. Vehicles with non-active registration status may change to an active registration status in the future.

As CARB has repeatedly noted in recent years, a significant number of FCEV registrations in California are in a non-active status. As of April 2021, 1,470 (or 15.5 percent) of unique in-state registration records indicate a non-active status. This is a higher proportion of vehicles than previously reported based on April 2020 DMV registration data, which was then the highest proportion to date. The growth in non-active vehicle registrations over the past two years may have been due in part to the COVID-19 pandemic and several shifts in the economy to telework and generally reduced travel. Additional factors specific to FCEVs (such as station availability) may also have affected the proportion of non-active registrations, since the non-active proportion for other vehicle types was 9.3 percent in April 2021 DMV data. As the state recovers from the COVID-19 pandemic, there may be some enduring impacts on transportation and work trends. CARB will continue to track the patterns in active status DMV registration data.

Total active vehicle registrations are also notably lower than industry estimates for cumulative FCEV sales to date, as reported by the CaFCP. As of June 1, 2021, industry estimates indicated 10,665 total FCEV sales in the United States [13]. A few hydrogen stations exist outside of California to support sales, but the vast majority of the reported sales are expected to be within California. In addition, the sales data do not completely account for vehicles that have been sold but are no longer registered and actively being driven. Since CARB's in-state estimates rely on more up-to-date vehicle use status, industry estimates are typically greater than CARB analyses indicate, as shown in Figure 4.

FIGURE 4: COMPARISON OF FCEV REGISTRATION DATA AND INDUSTRY SALES ESTIMATES

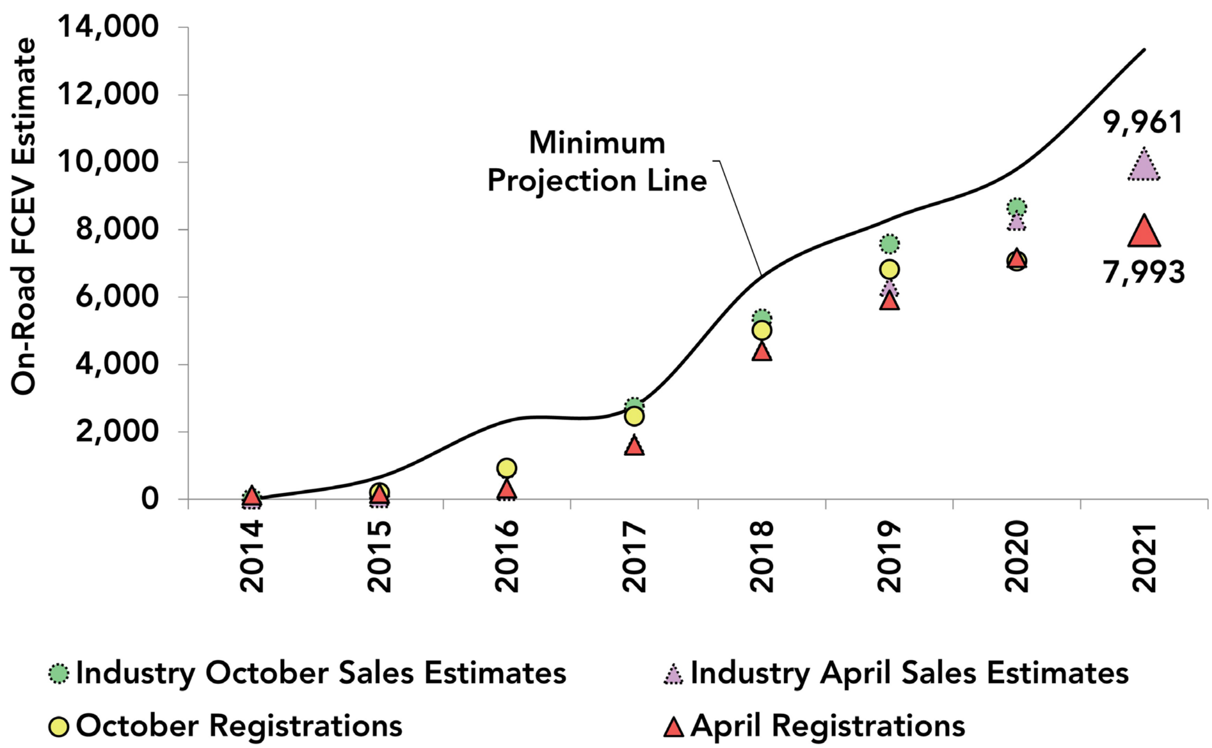


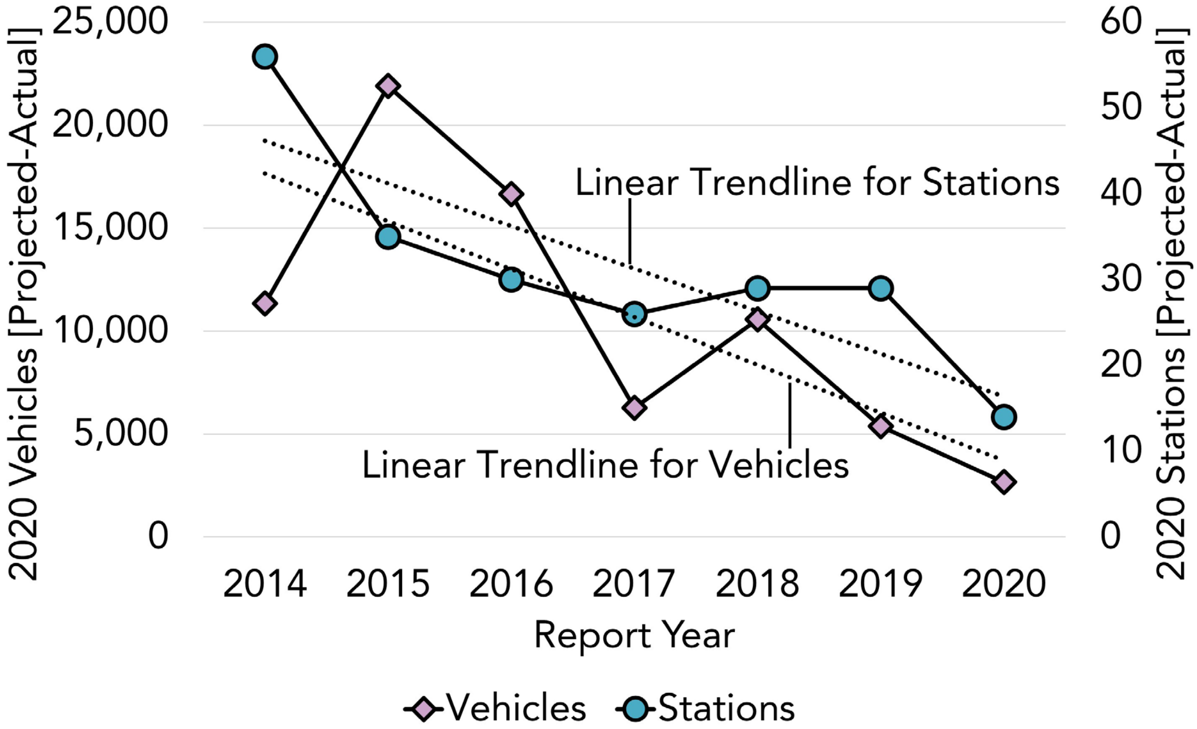
Figure 4 also demonstrates that projections for future FCEV deployment are typically higher than DMV registration data and industry cumulative sales data. The Minimum Projection Line in Figure 4 corresponds to the lower edge of the Mandatory Period area in Figure 8. It is the lowest projection for each year on the x-axis among all reports when that year was included in the Mandatory Period of an auto manufacturer survey. The Minimum Projection Line is typically based on the responses to the auto manufacturer survey from the same year as that projection.

The overall rate of FCEV sales (and expected future deployment) is affected by many factors, including consumer awareness of FCEV technology, consumer preferences for vehicle design and features, the price of hydrogen fuel, and the availability of hydrogen fueling stations. Year-over-year shifts in survey-based projections for future FCEV deployment have been observed in prior reports to be similar to shifts in the projected pace of on-the-ground station network development, as demonstrated in Figure 5. As station development schedules have extended with later-than-anticipated Open-Retail dates, similar shifts in projected vehicle deployment to later years have been observed[23] [11]. During in-person interviews held by CARB in 2019, auto manufacturers relayed that their own projections of station development schedules play a role in year-to-year changes to annual survey responses. However, auto manufacturers may also have evolving perspectives on the future possibilities for other factors, including potential future reductions in the price of fuel, future reductions in the cost to build FCEVs, or shifts in consumers' vehicle preferences.

Figure 5 shows the difference between projected and actual end-of-year vehicle deployments and stations counts. These differences between projections and historical data are shown for the year 2020, based on all prior *Annual Evaluations*. The year 2020 is used as a basis in this figure because it is the most recent year for which end-of-year vehicle deployment data are available, which can be compared to corresponding end-of-year projections made in *Annual Evaluations*. In this example, differences between projected and actual data tend to decrease as the future draws nearer. This is illustrated by the general downward trend moving from left to right in the graph.

23 See Finding 4 and associated discussion of the 2020 Annual Evaluation for more detail.

Figure 5: Demonstration of Correlated Vehicle and Station Projection Adjustments, Based on Past Projections for 2020



This general downward trend is apparent for both vehicles and stations. The figure also displays the linear trendline for these data, which are nearly parallel. This demonstrates that uncertainty about the pace of future FCEV and fueling market development similarly affects vehicle deployment and station development. For example, station development timelines have been affected by unforeseen hurdles in securing a host site or completing the permitting process. At the same time, station developers face uncertainty in the rate of future consumer acceptance and FCEV availability, which could drive their overall strategy and timelines for individual station and broader network development.

Similar parallel trends are also observed for the difference between projected and actual station and vehicle data for the years 2017 to 2019 (though not shown in the figure). The similar effect observed in the two datasets for these past years may imply a correlation that vehicle deployments (and the variation from projections) are related to station development (and similar variation from projections), though other factors may also have a similar effect[24].

As with any consumer market, multiple factors may affect the total rate of consumer adoption. This analysis demonstrates a general correlation between FCEV sales and network development, though other factors are relevant. The total FCEV adoption rate is affected by several variables, including network development, the availability of a variety of FCEV models that meet consumer needs, reliable availability of hydrogen fuel at prices acceptable to the consumer, and general consumer awareness of the available technology.

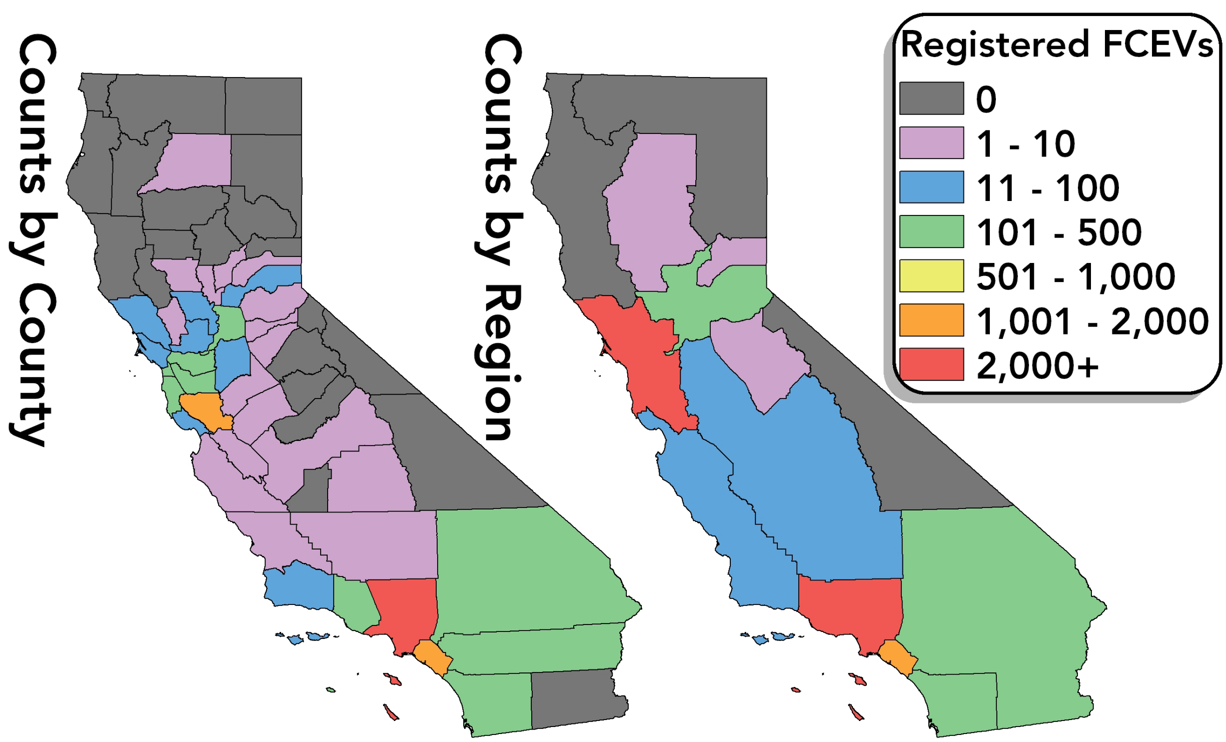
24 One unknown in this analysis is how long FCEV drivers keep their vehicles. CARB's analysis of auto manufacturer surveys assumes a rate of vehicle attrition similar to the general vehicle population. The actual length of time that individual FCEVs remain in the on-the-road population may be shorter than the assumption used in CARB's analysis. This would increase the discrepancy between projections and registration data.

While these variations in projections and deployments have occurred over the years, the general trend of FCEV deployment has been positive. Until disruptions in 2019 and 2020 caused by a hydrogen supply shortage and the COVID-19 pandemic respectively, average station utilization had consistently grown. The network overall was approaching 40 percent utilization in late 2018 and multiple stations have reported dispensing greater than 100 percent daily capacity on multiple occasions. The steady growth in average utilization over time indicated that vehicle deployment was faster than station network growth. After mid-2019, FCEV deployment and network utilization slowed but some station operators have reported their sales recently exceeded pre-pandemic levels.

Even with projections of future vehicle deployment provided by auto manufacturer surveys, uncertainty will remain in actual vehicle sales and some variation will continue between projections and historical data. However, the overall trend of FCEV deployment has been positive with a growing population of in-state vehicles and generally positive trends in network utilization.

Growth in FCEV registrations appears to have slowed between April 2020 and April 2021 by approximately one-third. Industry sales data show a similar trend, as estimated sales dropped from 2,089 in 2019 to 937 in 2020 [13]. The ongoing COVID-19 pandemic likely had a significant impact on new vehicle sales and registrations during this period. However, there are indications that a recovery may be underway. In 2020, active FCEV registrations were nearly identical between April and October. This indicated some combination of reduced FCEV sales and increased attrition (or planned non-operation of FCEVs already leased or owned by consumers). Active registrations have now grown between October 2020 and April 2021 by 926 FCEVs. This is the second-fastest growth rate yet reported between October and April registration data. In addition, industry sales data estimate that more than 1,000 FCEVs were sold in the first quarter of 2021 alone, which is more than all sales in the entire year for 2020. The first half of 2021 was also the best-selling quarter for FCEVs since sales reporting began in 2012, with 1868 total FCEV sales [13]. If this pace of sales is maintained through the remainder of 2021, the on-road FCEV fleet in California could grow by approximately 40 percent.

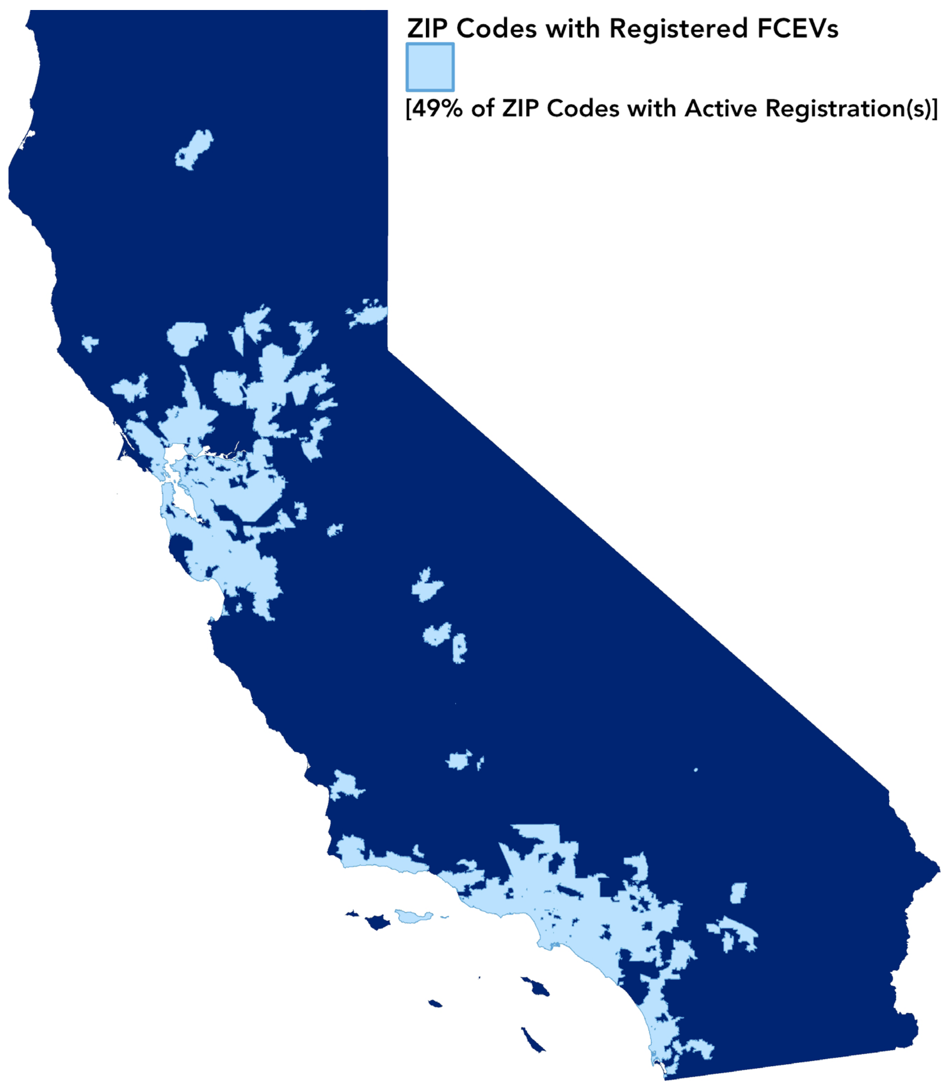
Figure 6: Distribution of Current FCEV Registrations as of April 1, 2020



The number of current active FCEV registrations in each county and region is shown in Figure 6. Overall, the distribution of registered FCEVs across California is similar to the distribution reported in 2020. Most registrations are focused in the Greater Los Angeles and San Francisco Bay Area regions. Specifically, Los Angeles, Orange, and Santa Clara counties have the largest numbers of FCEV registrations, in that order. Active registrations in counties in the northern third of the state have shifted a bit since last year, and there are more active registrations now in counties that make up the Sacramento, San Joaquin Valley, and Sierra Foothills regions.

All ZIP codes with at least one active FCEV registration are shown in Figure 7. The geographic distribution of FCEV registrations is fairly extensive, especially considering the relatively low number of active vehicle registrations. Nearly half of the state's ZIP codes (49 percent) have a least one active FCEV registered. Some of these ZIP codes are notably distant from the currently open hydrogen fueling network (see Figure ES 1 for open hydrogen station locations). Approximately two-thirds of the active registrations are located in regions in the southern half of California, with the remaining in the northern half of the state.

Figure 7: ZIP Codes with Active FCEV Registrations



In 2013, the CaFCP outlined a plan for a network of 68 stations to launch in-state sales of FCEVs [17]. The plan was focused on fueling network development in five main "clusters" in West Los Angeles and Santa Monica, Torrance and surrounding cities, coastal Orange county cities, the southwestern portion of the San Francisco Bay area, and Berkeley. The plan did anticipate stations outside of these clusters (which CARB has since termed the "Expanded Network"), but most stations were anticipated to be located in these clusters. Today, the open and planned network of stations has significantly deviated from these cluster designations and the active FCEV registrations have followed suit.

Table 2: Station Network and Registered FCEVs with Respect to Cluster Defintions

Cluster	Number of Planned Stations in Cluster	Planned Capacity in Cluster (kg/day)	Percent of Planned Stations	Percent of Planned Capacity	Percent of FCEV Registrations in Cluster
Expanded Network	67	56,652	61%	60%	57%
South SF/Bay	14	9,920	13%	11%	13%
Coastal/ South OC	12	12,686	11%	13%	17%
Torrance	7	6,930	6%	7%	6%
Berkeley	6	6,519	5%	7%	2%
West LA/SM	4	1,396	4%	1%	7%

Table 2 demonstrates that the majority of network development is planned outside of the clusters (the currently open stations are slightly less heavily skewed to the Expanded Network). Approximately sixty percent of the planned stations and fueling capacity are outside of the original clusters, and an approximately equal proportion of current registrations are located outside of the original clusters as well. Within the clusters, the South SF/Bay and Coastal/South OC clusters are nearly equal in planned network development, at slightly more than 10 percent of the network each. Registered FCEVs again have a similar proportion in these regions, though the Coastal/South OC cluster appears to have slightly more registered FCEVs than expected based on planned network development. All other clusters make up less than ten percent of planned network development and FCEV registrations.

Similar relationships are observed at the finer resolution of ZIP codes. Approximately 96 percent of registered vehicles are located in a ZIP code that is within a 15-minute drive of an open or planned station[25]. Approximately 90 percent of registered vehicles are located in a ZIP code that is within a 15-minute drive of a station that is currently Open-Retail. These data demonstrate that FCEV registrations tend to be located near fueling stations, but that there may be a few drivers willing to travel significant distances to reach their nearest fueling station. For these drivers, the lack of a station near home may indicate that they have to make special trips to fuel their vehicle. Alternatively, these drivers' typical routes (such as commuting to and from work) may regularly bring them near a station along the route but far from home.

Finally, actual network development and FCEV deployment have been significantly more regionally diverse than anticipated within the original CaFCP *Roadmap*. This may imply opportunities already exist for network development and FCEV deployment to expand to new markets and regions in California.

25 There is some uncertainty inherent to these estimates. The values stated include all registered vehicles in a ZIP code that either fully or partially overlaps with the extent of a 15-minute drive time to any station. The exact location of each vehicle within a ZIP code is not known in this analysis and therefore some vehicles may be located more than 15 minutes away from a station but are counted in this analysis because a portion of the ZIP code is within the 15-minute boundary. For example, an analysis that only counts registrations in ZIP codes fully contained within the drive time boundary provides an estimate that 67 percent of all registrations are within a 15-minute drive of an open or planned station. The true value is likely between 67 percent and 96 percent.

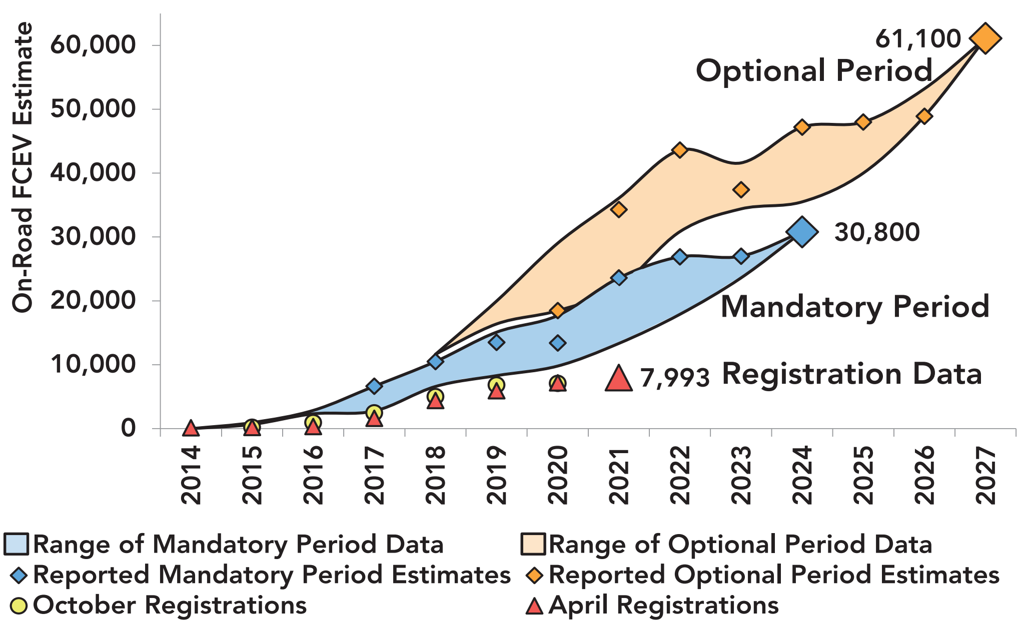
Analysis of Future On-The-Road FCEVs

Estimates of future on-road FCEVs consider currently registered FCEV data alongside responses from the annual auto manufacturer survey. As with the DMV registration data, CARB performs some data analysis steps on auto manufacturer survey responses in order to develop projections of on-the-road FCEVs[26].

Responses to the 2021 auto manufacturer survey indicate a notably optimistic turnaround from prior reporting. In 2020, both the mandatory and optional period data indicated delays of auto manufacturer deployment plans by one year. These reported delays were in addition to a one-year delay in optional period plans previously reported in 2019. The 2021 survey marks the first time since 2018 that both the near-term and long-term outlooks for FCEV deployment potential have improved from the prior year.

Auto manufacturer survey data are considered to be annual sales data for each model year aggregated at the statewide geographic resolution. CARB first translates model year into calendar year by assuming that one-third of all vehicles for an indicated model year are sold in the prior calendar year. For example, if an auto manufacturer anticipates selling 1,200 FCEVs in model year 2025, CARB estimates that 400 of these will be sold in calendar year 2024 and 800 will be sold in calendar year 2025. The proportion of vehicles sold in the prior calendar year is based on prior analysis of historical DMV data.

Figure 8: Comparison of On-the-Road Vehicle Counts in 2014-2021 Annual Evaluations



CARB also considers vehicle attrition when generating estimates of the future on-road FCEV population. For any vehicle on the road, several circumstances may lead to that vehicle dropping out of the active fleet. These include non-repairable collisions, non-repairable wear, vehicles being sold or moved out of state, and other causes. Based on assumptions used in CARB's EMission FACtor

26 AB 8 requires CARB to report and perform analysis based on "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," which is the annual survey discussed in this report.

(EMFAC) model of on-road emission sources, CARB applies a vehicle attrition rate to all current FCEV registration data and future FCEV sales in its estimates of on-road vehicles. This attrition rate is modeled as an exponential decay with a half-life of 15 years. That is, if 1,000 FCEVs are sold in 2021, 500 of those would be modeled to still be on the road in 2036, and 250 on the road another 15 years afterward.

Statewide estimates for past, current, and future on-road FCEV counts are shown in Figure 8. Data from all past *Annual Evaluations* are represented on the figure. The lower blue shaded area represents all on-road FCEV estimates for years that have fallen into the mandatory reporting period of auto manufacturer surveys. The upper orange shaded area represents all on-road FCEV estimates for years that have fallen into the optional reporting period of auto manufacturer surveys. Any given calendar year can be a part of the mandatory period for at most four years and a part of the optional period for at most three years.

For example, the year 2021 was first part of the mandatory reporting period in 2018 and was first part of the optional reporting period in 2015. For the 2018 *Annual Evaluation*, 2021 was the end of the mandatory reporting period. The estimate reported in 2018 for the number of on-road FCEVs in 2021 is included in the blue shaded area above the year 2021. The year 2021 has since been included in the mandatory period on surveys in 2019 through 2021. The span of the blue shaded area represents all four estimates for on-road FCEV counts generated for *Annual Evaluations* in 2018 through 2021. Data for the optional period of reporting is displayed similarly on the figure through the orange shaded area. Registration data are also shown on the figure, with April registrations represented by red triangles and October registrations represented by yellow circles.

Based on the responses to the 2021 auto manufacturer survey, the outlook for FCEV deployment in California is notably improved from the same time last year. Total deployment in the mandatory and optional periods has increased. The on-road FCEV population is estimated to grow to 30,800 by 2024 and continue to expand to 61,100 by the end of 2027. These are the largest volumes estimated to date for each period and represent an acceleration of deployment through 2024 with a further acceleration through 2027. Projections provided by auto manufacturers for future vehicle deployment include an amount of uncertainty and evolve over time. Typically, projections further in the future involve more uncertainty but have historically reported high vehicle deployments. Projections for more near-term future years are lower and tend to be much closer to actual vehicle deployment data. For example, projections for vehicle deployment in 2021 would generally be higher in surveys completed in 2015-2017 and lower in surveys completed in 2018-2021, with the most accurate projections for 2021 from the survey completed that same year. Projections for on-road FCEVs made in 2015 and 2018 were 34,300 and 23,600, respectively.

After translating auto manufacturer survey data from model year to calendar year, CARB also generates county-based estimates of the geographic placement of all vehicles. In past years, CARB has utilized data from prospective scenarios of future network development to determine the proportion of vehicles assigned to each county in future years of deployment. The analysis performed this year is fundamentally different from prior methods. The awards for new station development through GFO-19-602 are significant and outnumber the previously open and planned network. In addition, the development schedules for the 94 new stations funded through GFO-19-602 extend into 2026. Development schedules for stations that currently have an address identified extend into 2025.

Because of the significant role these stations will play in network growth and the ability to deploy FCEVs, CARB based geographic placement of future FCEVs on the network of Open-Retail stations and stations currently in development. Using these station data, the proportion of vehicles assigned to each county was set equal to the proportion of network capacity among stations located within the county. This methodology inherently assumes that the regional distribution of FCEV deployment will closely follow the regional distribution of the fueling network, as demonstrated in Table 2. The resulting county-based allocations are shown in Table 3.

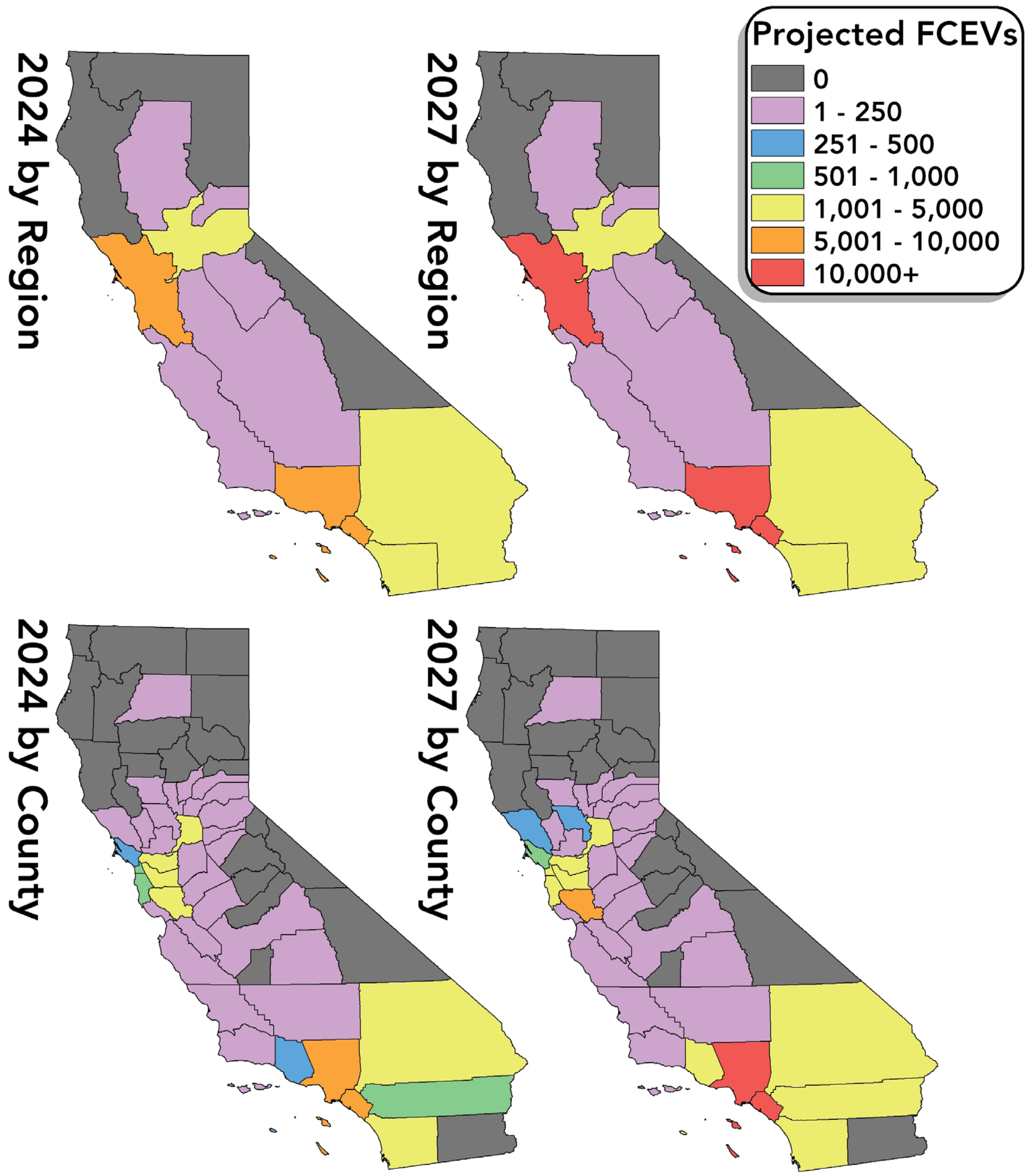
Table 3: County-Based Allocation of Future New FCEV Deployment

County	2021	2022	2023	2024	2025+
Alameda	5.48%	5.04%	4.89%	6.43%	5.76%
Contra Costa	3.85%	4.18%	4.05%	3.74%	5.07%
Fresno	0.66%	0.35%	0.34%	0.31%	0.28%
Los Angeles	24.14%	29.32%	28.45%	30.10%	30.43%
Marin	0.66%	0.35%	1.33%	1.22%	1.10%
Nevada	0.66%	0.35%	0.34%	0.31%	0.28%
Orange	28.98%	21.12%	20.49%	20.84%	18.69%
Riverside	2.63%	1.39%	1.35%	1.25%	2.83%
Sacramento	2.55%	2.37%	3.28%	3.03%	2.72%
San Bernardino	0.50%	6.42%	6.23%	5.76%	5.16%
San Diego	3.65%	8.80%	8.54%	7.88%	7.07%
San Francisco	3.83%	2.03%	1.97%	1.82%	1.63%
San Mateo	3.99%	2.12%	2.06%	1.90%	1.70%
Santa Barbara	0.66%	0.35%	0.34%	0.31%	0.28%
Santa Clara	16.23%	15.01%	14.56%	13.45%	12.07%
Sonoma	0.00%	0.00%	0.00%	0.99%	0.91%
Ventura	1.86%	0.66%	0.35%	0.34%	0.31%
Yolo	2.45%	0.87%	0.46%	0.45%	0.41%
All Other Counties	0.00%	0.00%	0.00%	0.00%	0.00%

Estimated on-road FCEV populations by county and analysis region are presented in Figure 9 for the end of the mandatory (2024) and optional (2027) survey periods. The future geographic distribution of on-road FCEVs significantly differs from similar analysis in the 2020 *Annual Evaluation*. This is due to the difference in allocation of future FCEV deployment to each county. The method used in this year's analysis is more geographically constrained than the method used in the prior analysis. However, the analysis presented in the 2020 *Annual Evaluation* was more hypothetical. CARB expects that the distribution shown for 2024 may be more accurate than the distribution shown for 2027, as station developers are expected to announce locations for at least 66 additional stations through GFO-19-602 that should become Open-Retail by 2027. These additional station locations could alter the allocation of estimated FCEV sales to counties in future analyses.

The future geographic distribution of on-road FCEVs shown in Figure 9 is similar to the current geographic distribution of registered vehicles shown in Figure 6. Specifically, the Greater Los Angeles, Orange County, and San Francisco Bay Area regions show the largest FCEV deployment. The Sacramento, San Diego, and Inland Desert regions also demonstrate large numbers of FCEV deployment though deployment is estimated at less than half the volume of the top three regions. Los Angeles, Orange, and Santa Clara counties are similarly estimated to have the highest rates of FCEV deployment. San Diego, Riverside, San Bernardino, Sacramento, and several counties in the San Francisco Bay Area are also anticipated to see significant FCEV deployment. Later chapters will discuss the potential for network development outside of current plans. If station developers adopt this report's recommendations, then FCEV deployment could be less geographically concentrated than shown in Figure 9.

Figure 9: Estimated Geographic Distribution of On-the-Road FCEVs



Location and Number of Hydrogen Fueling Stations

AB 8 Requirements: Evaluation of hydrogen fueling station network coverage CARB Actions: Determine the regional distribution of hydrogen fueling stations in earlytarget 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

In addition to the increase in the total number of Open-Retail stations in the past year, there have been several broad changes in the operating and planned network since the 2020 *Annual Evaluation*. The most significant change has been the addition of up to 94 new planned stations and 4 planned upgrades through grant awards made in GFO-19-602 and announcements of 23 privately funded station developments by some grant awardees. The major changes that have occurred in the Open-Retail and planned hydrogen fueling network are as follows:

Changes in Open-Retail and Temporarily Non-Operational Stations:

- Eight stations have newly achieved Open-Retail status in the past year[27]. Four are located in the San Francisco Bay Area region- Berkeley, Campbell- Hamilton, Concord, and Sunnyvale. Two are located in the Greater Los Angeles region- Mission Hills and Studio City. Two are located in Orange County- Aliso Viejo and Placentia.
- The Placentia station is the first new retail hydrogen fueling station in California to open without any grant funds provided by the State.
- One station (Newport Beach) has been moved from Temporarily Non-Operational to In Development, since a significant upgrade is planned for the station as a result of awards in GFO-19-602
- Two stations have moved from Open-Retail status to Temporarily Non-Operational- Berkeley (the same station that first became Open-Retail in the past year) and San Francisco- Harrison Street. Two additional stations (Riverside and Ontario) remain in Temporarily Non-Operational status.

27 The Fountain Valley station previously opened while the 2020 Annual Evaluation was under review. It was therefore not included on maps as Open-Retail but was accounted for in the narrative reporting. This report shows it as new in Figure ES 1 to highlight the change since the similar figure provided last year.

Changes in Planned Stations:

- As a result of grant awards made in GFO-19-602 and private financing efforts, a total of 109 new stations are now planned for development through 2027. Grant awards through GFO-19-602 will provide co-funding for up to 94 of these new stations. The remaining stations will be developed through completely private financing (though they may apply to participate in the LCFS program, including the HRI provision). Six of these stations had first been identified through an application to GFO-19-602. These stations are Anaheim- N. Euclid, Corona, Hawaiian Gardens, La Mirada, Redondo Beach, and Santa Ana.
- One additional station that is not participating in any State grant program (Seal Beach) has been added to the LCFS HRI program and is now considered under development.
- Two existing stations have been identified (Newport Beach and Torrance) to receive a significant upgrade as a result of awards through GFO-19-602. An additional two stations that have not yet been identified are expected to receive upgrades through GFO-19-602.
- The Palm Springs station approved under the LCFS HRI program is no longer in development.
- Due to uncertainties with some stations, they are not included for the purposes of analysis in this report.

In total, CARB is now tracking 176 station development projects, with 48 of these projects currently in Open-Retail status and 4 more in Temporarily Non-Operational status. The remainder are currently under development or planned for future development. Based on current estimates, the last of these stations will become Open-Retail in 2026 and the last station that currently has a known address will do so in 2025. The currently anticipated schedule of station development by county is shown in Table 4, with counts by region shown in Figure 10 and expected Open-Retail dates for individual stations with a known address shown in Figure 11. Individual station information is also provided in Appendix B: Station Status Summary. Additional stations that may be developed with funding from the SB 129 have not been identified in this analysis.

As in prior years, these estimates are valid as of the date indicated for the data. The history of hydrogen fueling station development in California has demonstrated uncertainty in project timelines should be expected. Some stations are likely to experience development delays due to changing circumstances at the host site or unforeseen permitting, construction, and commissioning challenges. In some cases, the challenges are so significant that the developer will opt to abandon development at one proposed site and initiate development at a new location that has not yet been identified. In addition, two stations proposed in awarded projects through GFO-19-602 must find a new location due to a proximity limitation because these stations were within one linear mile of another station that had been proposed for award. CARB is also aware that a few stations that were previously under development have recently been identified as potentially non-viable by their developers. New locations and revised schedules have not yet been provided by the developers of these stations. CARB has not yet changed its accounting of these stations due to the remaining uncertainty. As new information is made available, the data shown in Table 4, Figure 10, and Figure 11 are likely to shift. These shifts will be reflected in future reporting, including the 2021 *Joint Agency Staff Report* that will be published by the CEC later this year.

Table 4: Historical and Projected Counts of Open-Retail Stations by County as of May 12, 2021

County	2020	2021	2022	2023	2024	2025	2026 & 2027
Alameda	4	5	6	6	7	7	7
Contra Costa	1	2	3	3	3	4	4
Fresno	1	1	1	1	1	1	1
Los Angeles	13	17	31	31	33	35	35
Marin	1	1	1	2	2	2	2
Nevada	1	1	1	1	1	1	1
Orange	6	12	16	16	17	17	17
Riverside	1	1	2	2	2	3	3
Sacramento	2	2	3	4	4	4	4
San Bernardino	1	1	5	5	5	5	5
San Diego	1	2	6	6	6	6	6
San Francisco	3	3	3	3	3	3	3
San Mateo	1	2	3	3	3	3	3
Santa Barbara	1	1	1	1	1	1	1
Santa Clara	5	9	13	13	13	13	13
Sonoma	0	0	0	1	1	1	1
Ventura	1	1	1	1	1	3	3
Yolo	1	1	1	1	1	1	1
Future Stations (Location TBD)	0	0	0	4	30	45	66
Total with Known Location	44	62	97	100	104	110	110
Total for All Stations	44	62	97	104	134	155	176

Most of the planned development continues to focus on areas where stations have been under development in prior years. Of the 110 known locations, the majority will be developed in the Greater Los Angeles (38 Open-Retail stations by 2025) and the San Francisco Bay Area (33 Open-Retail stations by 2025) regions. Orange County will also receive significant development, with 17 Open-Retail stations by 2024. The Sacramento Area will continue network growth in the near term; three stations are currently Open-Retail and an additional two are expected to open by 2023. San Diego County is similarly expected to have large near-term growth, expanding from one Open-Retail station today to six Open-Retail stations by 2022.

There is additional development expected in some areas that have not been the focus of network growth in the past. The Inland Deserts region is expected to grow from two to eight Open-Retail stations by 2025. This includes notable newly planned development in Riverside and San Bernardino counties, indicating a recognition by station developers that this could be a near-term focus for further market development. In addition, new stations in Ventura and Camarillo will provide more fueling options along the coast between Santa Barbara and stations located in the Greater Los Angeles region. In San Diego county, development is also planned to expand beyond the coastal communities with a new station expected in Rancho Bernardo.

Figure 10: End of Year Station Counts by Region as of May 12, 2020

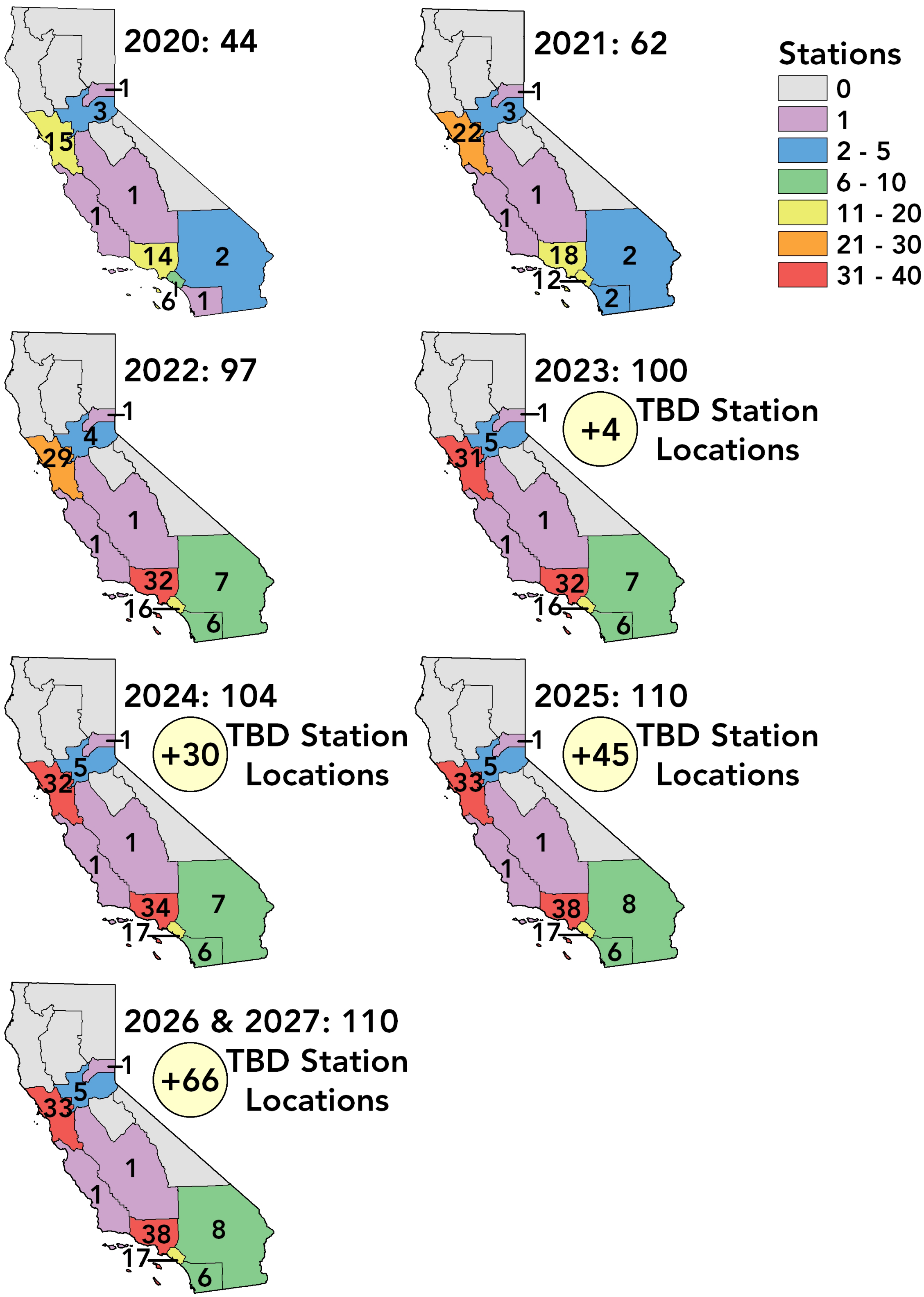
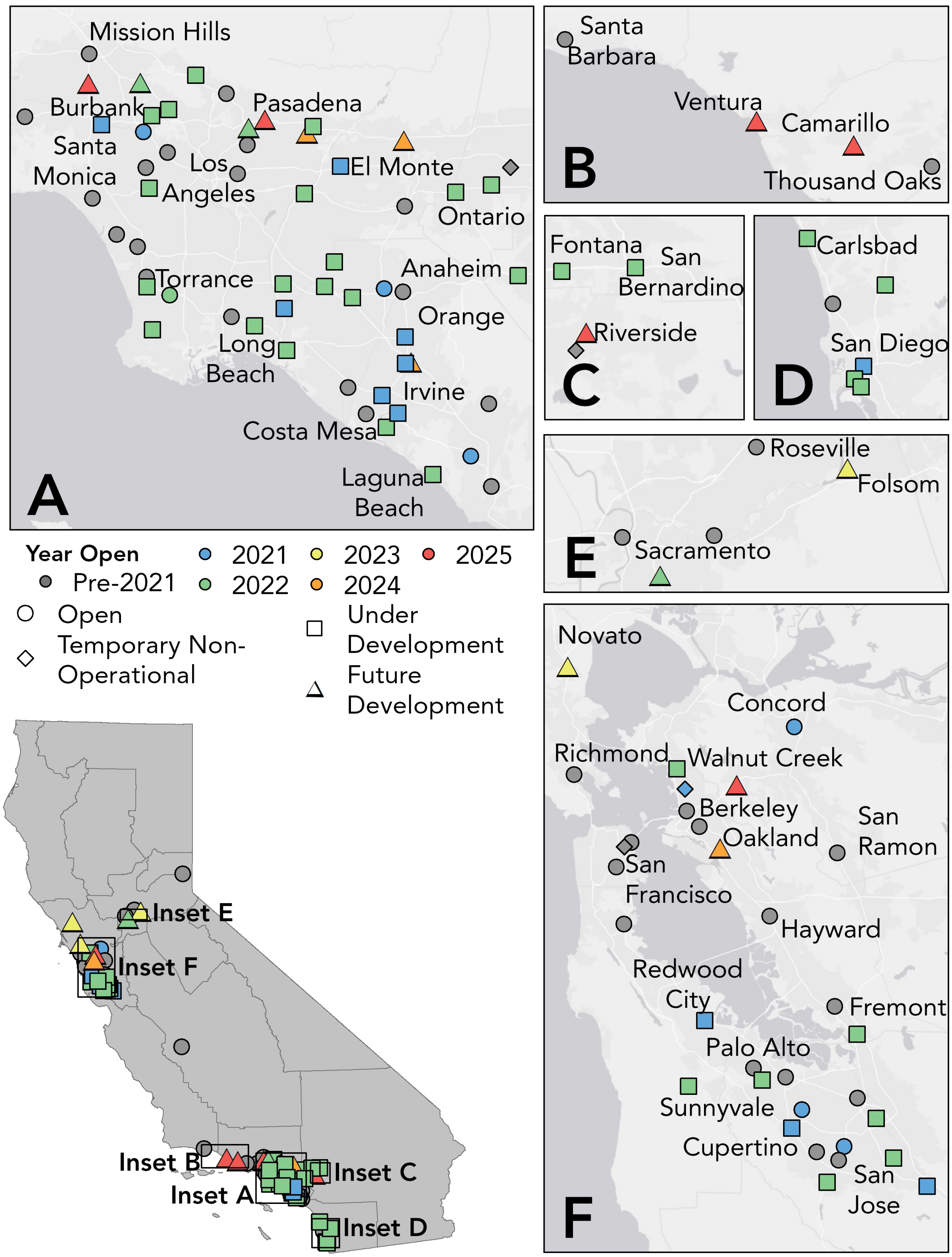


Figure 11: History and Projections for Open and Funded Hydrogen Station Network as of May 12, 2021



CARB utilizes its GIS-based tool CHIT[28] to assess the open and planned network coverage and identify areas of need for future network growth. CHIT provides a method to perform quantitative analysis of coverage provided by hydrogen fueling station networks. Coverage is a measure of convenient access to hydrogen fueling in terms of driving time to reach one or more hydrogen stations. Higher coverage values are associated with locations that are close to multiple hydrogen fueling stations. Lower coverage values are associated with locations that are further from or near a limited number of hydrogen fueling stations.

Coverage provided by the currently Open-Retail station network (not including Temporarily Non-Operational stations) is shown in Figure 12. Coverage provided by the entire network of open and planned hydrogen fueling stations is shown in Figure 13. Dark blue shading indicates low coverage, yellow shading indicates medium coverage, and bright red shading indicates high degrees of coverage. Note that Figure 12 does not show any areas with high coverage as the shading is presented in Figure 12 on the same scale as Figure 13.

The highest degree of coverage is currently provided by Open-Retail stations in the south western portion of the San Francisco Bay Area, in Campbell and surrounding cities. Other high-coverage areas are found in Orange County around Irvine and Costa Mesa and in the Greater Los Angeles region between Torrance and Playa Del Rey.

28 See the following section, Suggestions for Future State Co-Funding, for further details on the structure and operations of CHIT. All CHIT data and information can be accessed at: *CARB's Hydrogen Infrastructure Analysis*

Figure 12: Assesment of Coverage Provided by 48 Currently Open-Retail Hydrogen Station Network as of June 22, 2021

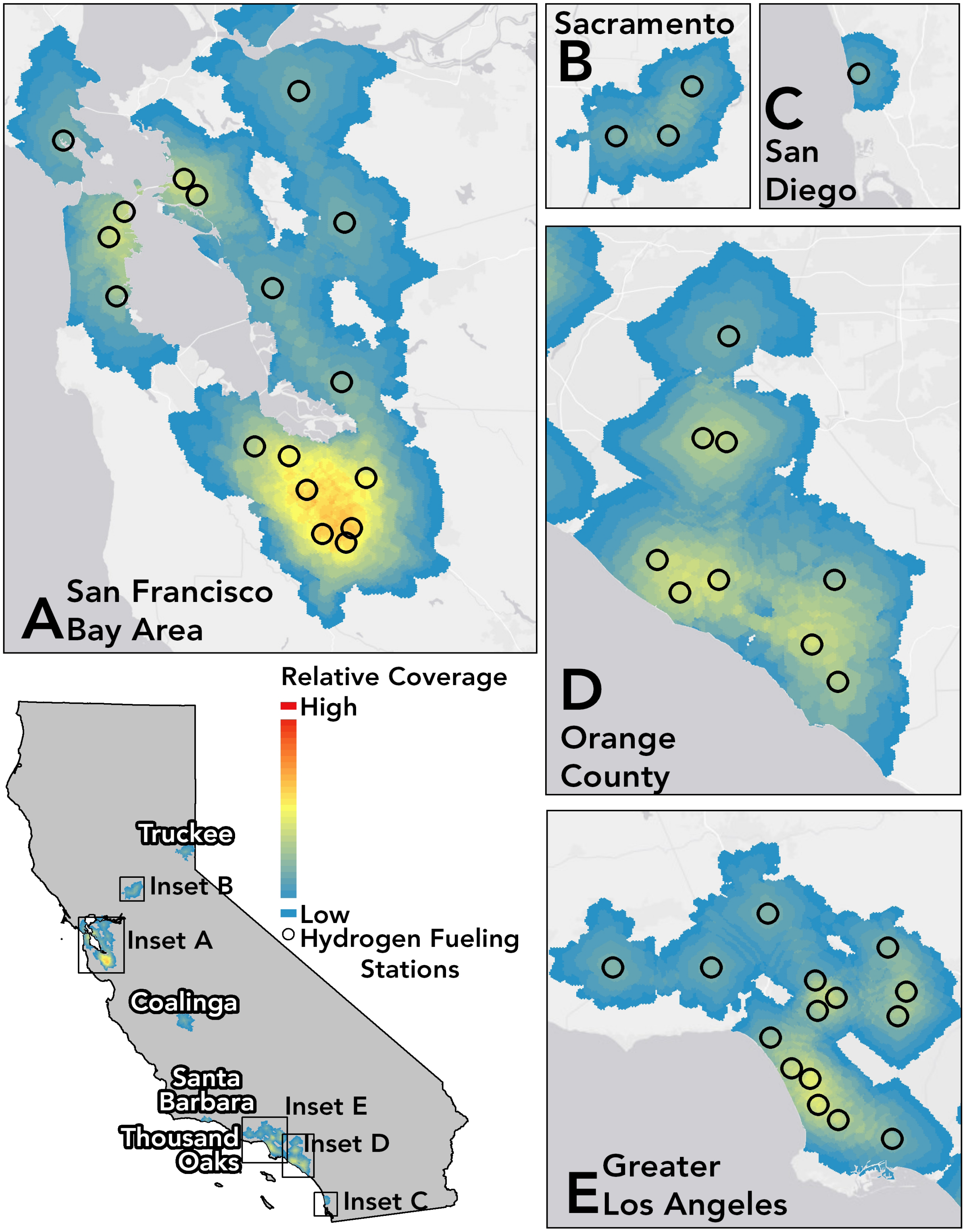
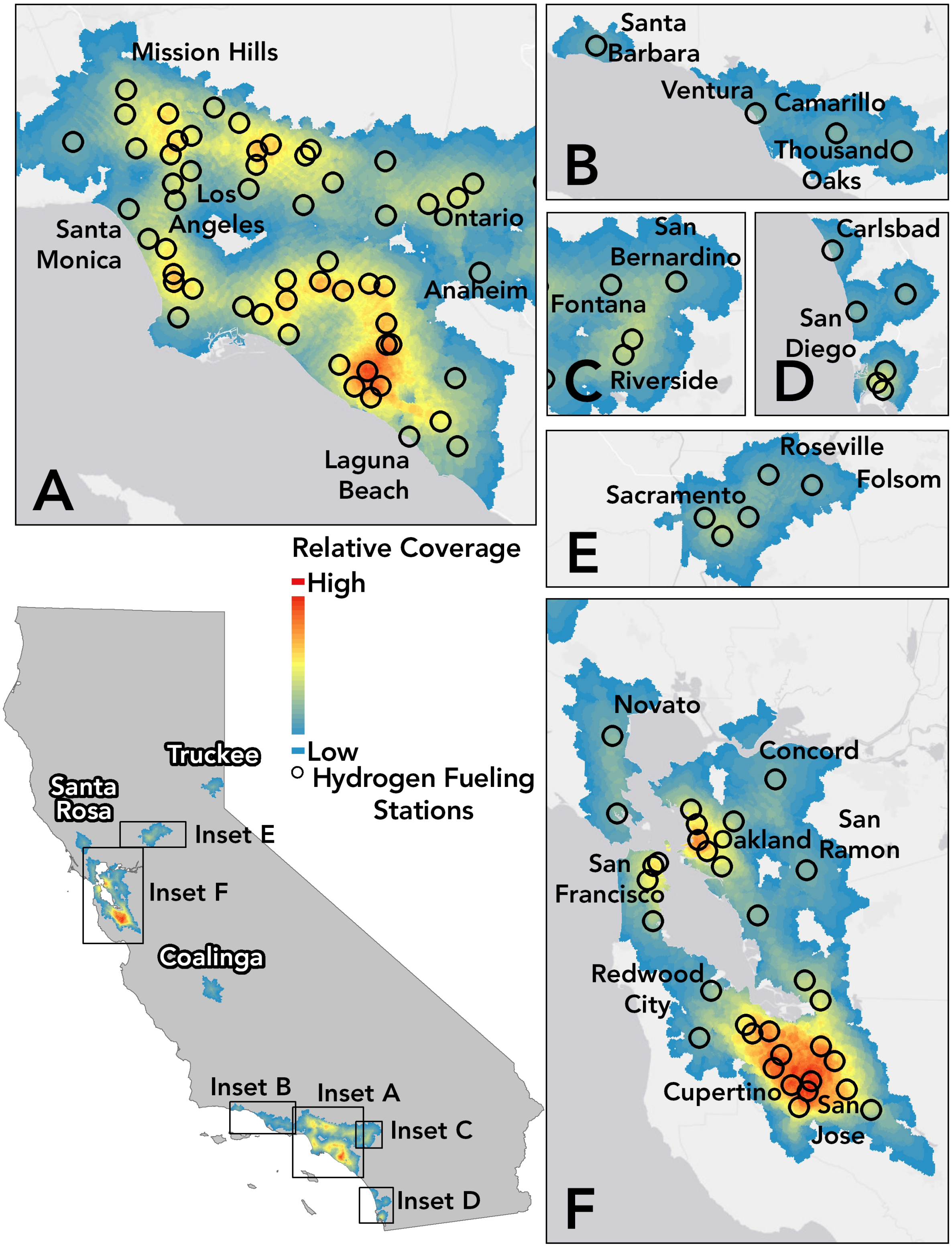


Figure 13: Assessment of Coverage Provided by Open and Funded Hydrogen Station Network as of May 12, 2021



When all stations with an identified address are completed, the areas of highest coverage will be in the southwestern San Francisco Bay Area in Campbell and surrounding cities, in Orange County in and around Irvine, and in Oakland and surrounding cities in the San Francisco Bay Area. Other mid-to-high coverage areas will be in San Francisco and across much of Orange County and the Greater Los Angeles area, especially along a stretch between Long Beach and Anaheim, in cities between Burbank and Pasadena, and in areas around Torrance and Tustin. Significant growth to new areas is also expected. Coverage in the Sacramento region will extend to Folsom. New coverage in Santa Rosa will be established. Drivers in southern California will be able to reach a station within 15 minutes in a large interconnected region extending from Ventura to San Bernardino and south along the coastline to San Juan Capistrano. An additional 66 stations funded through GFO-19-602 have not yet been identified. As the locations of these stations are selected by their developers, the map of projected coverage could significantly shift in future years.

The coverage provided by the planned stations is extensive and will provide access for many communities to one or more hydrogen fueling stations within a 15-minute drive or less. State efforts to support ZEV infrastructure development also work to ensure that development is equitable for all Californians and that communities that have historically faced disproportionate environmental burdens and/or socio-economic barriers materially benefit from these efforts. Application scoring in GFO-19-602 included consideration of the benefits that proposed station locations could provide to those living in communities identified as disadvantaged communities (DACs).

DACs are identified through a joint effort of CARB and the Office of Environmental Health Hazard Assessment, as required by the Global Warming Solutions Act (SB 535; De Léon, Chapter 830, Statutes of 212) [18]. The agencies have worked together to create the CalEnviroScreen tool, which assesses the pollution burden and socio-economic barriers faced by communities (grouped by census tracts) across California [19]. The top 25 percent of communities that face the greatest challenges for a healthy local environment as indicated by these factors, or face the top 5 percent of pollution burdens, are identified as DACs.

While it is not a complete indicator of benefit to residents of DACs, proximity of ZEV fueling infrastructure to these communities can provide a starting point for gauging equitable development across California. Figure 14 details the proximity of all known hydrogen fueling station locations to DACs identified by CalEnviroScreen. The vast majority of stations (101) will be within a 15-minute drive of a DAC, which is considered the limit of coverage. However, most of these stations will actually be located within a much more convenient distance. Twenty-two stations will be located directly within a DAC and 83 will be within a six-minute drive of a DAC, which is often considered the limit of convenient access based on the example of California's network of gasoline fueling stations [20].

Figure 14: Hydrogen Station Locations at Various Proximities to a Disadvantaged Community

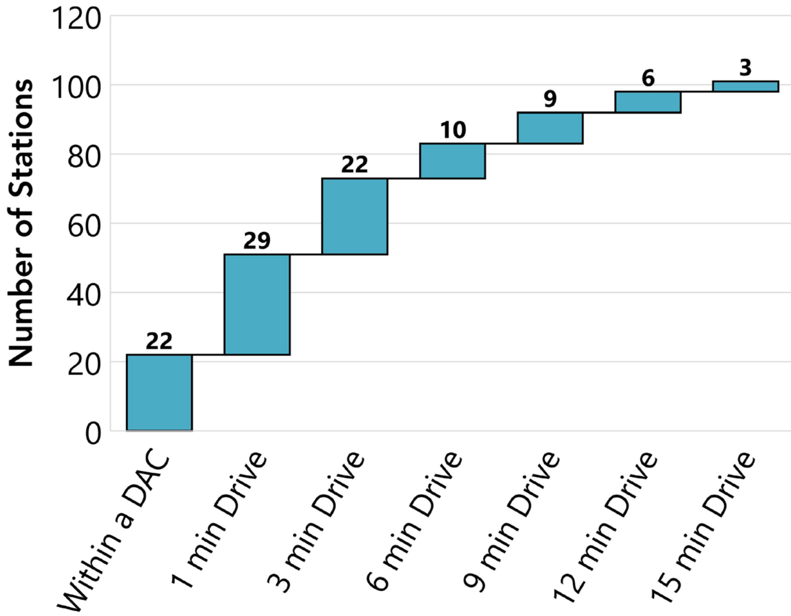


Table 5: Analysis of Population Proximity to Hydrogen Stations

Station Proximity to a DAC	Count of Stations	Percent of Known Locations	Percent of DAC Population	Percent of Statewide Population
Within a DAC	22	20%	N/A	N/A
1 min Drive	51	46%	4%	5%
3 min Drive	73	66%	14%	15%
6 min Drive	83	75%	34%	34%
9 min Drive	92	84%	49%	49%
12 min Drive	98	89%	60%	57%
15 min Drive	101	92%	67%	62%

The metrics of station proximity to DACs shown in Figure 14 indicate that significant hydrogen fueling station development is expected in or near DACs, which may be a benefit to drivers living in these communities. These stations may play a role in enabling residents to purchase FCEVs or generally displacing polluting combustion engine vehicles that normally travel through their neighborhoods. Table 5 provides a side-by-side comparison of planned network coverage provided to residents of DACs and to the general statewide population of California. The analysis shown in Table 5 is more precise than Figure 14 as it evaluates community populations based on census blocks, which is the finest resolution of population data available through the United States Census Bureau. In this analysis, the full population of a given census block is counted at the geographic center of the census block.

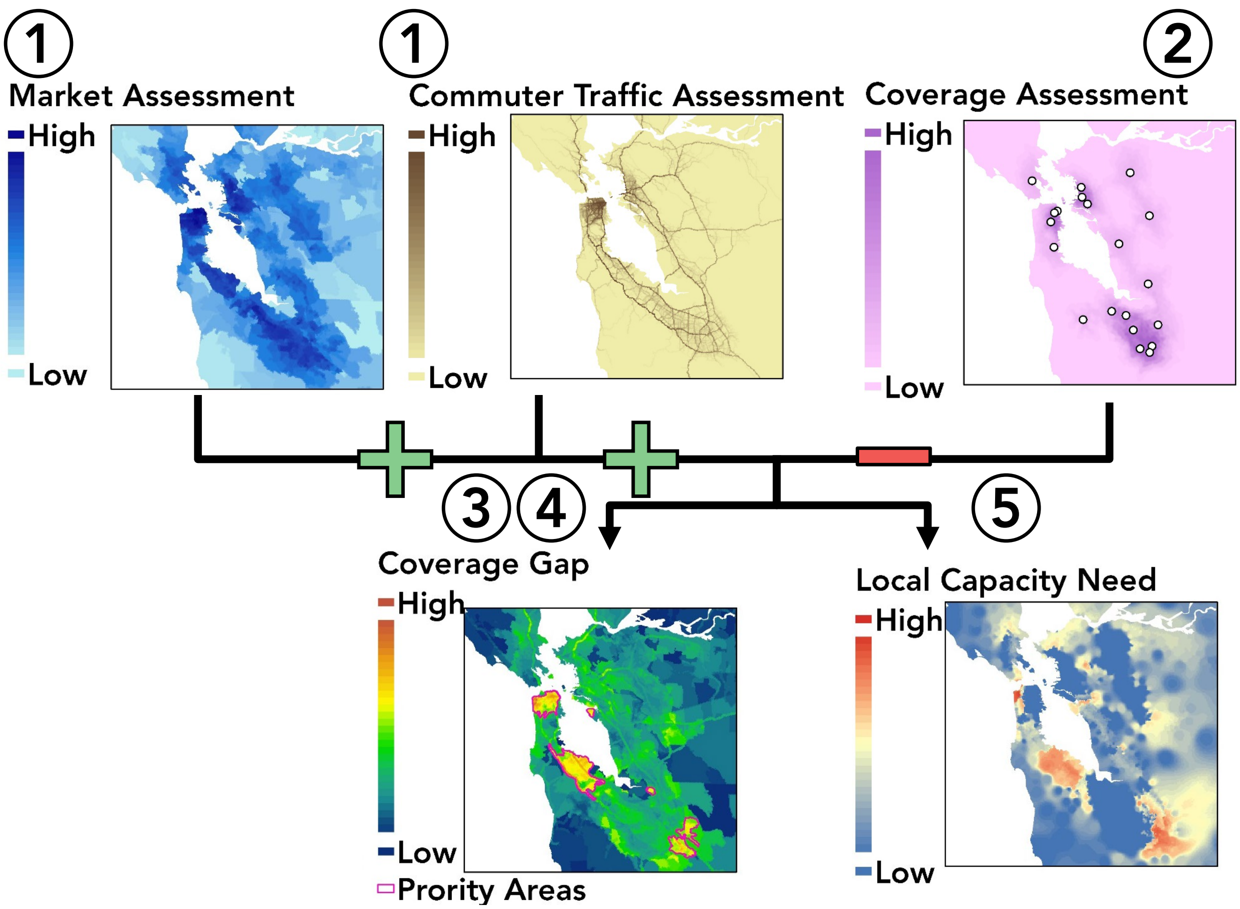
As Table 5 demonstrates, the proportions of the populations that live within various distances of a station (expressed as a drive time) are nearly identical between residents of DACs and the general population of California. With the 110 stations that are currently specified with an address, approximately one-third of DAC residents and the general California population live within an estimated six-minute drive of a hydrogen fueling station. Approximately two-thirds of DAC residents (67 percent) and the general California population (62 percent) live within the limits of coverage at 15 minutes from a hydrogen fueling station.

Suggestions for Future State Co-Funding

Each year, CARB utilizes its CHIT tool to perform geospatial analysis of the potential market for FCEV adoption across California and the coverage and capacity provided by the network of known Open-Retail stations and stations currently under development. CHIT is utilized to compare the market assessment with network coverage and capacity assessments in order to identify locations where a development gap may exist in network coverage, capacity, or both. CARB has also utilized this tool to complete scenario analysis, as presented in the CaFCP's *Revolution* document and CARB's *Self-Sufficiency Analysis*.

The major features and process steps of CHIT are presented in Figure 15. First, an assessment of potential demand for hydrogen fuel is developed based on a local adopter market assessment combined with a commuter traffic assessment. These market assessments are built on the fundamental principle that stations must be located near the home locations or along the typical driving paths of FCEV adopters in order to reinforce consumer selection of FCEVs when they lease or purchase a new vehicle. The portion of the assessment that estimates the location of potential FCEV adopters' homes relies on demographic and vehicle registration data available through the United States Census Bureau and the DMV. The portion of the assessment that estimates potential FCEV adopters' commute routes is based on simulated traffic previously outlined in the 2017 *Annual Evaluation* [21].

Figure 15: CHIT Evaluation Processes



Combined, these near-home and traffic-based assessments provide a way to estimate the localized potential demand for access to hydrogen fueling stations across the state, at a resolution of approximately 0.04 square miles[29]. CHIT compares this market assessment to an evaluation of network coverage, as shown in Figure 12 and Figure 13. Gaps in coverage are then identified as areas where the relative coverage provided by the hydrogen fueling network is less than relative the strength of the local FCEV market. Contiguous areas with a high coverage gap score that are also statistically significant compared to surrounding areas are then identified as priority areas for new development of network coverage. Gaps in capacity are also evaluated through CHIT by assessing scenarios of future FCEV deployment (such as the projected 61,100 FCEVs by 2027 shown in Figure 8) and assuming FCEV deployment should be distributed according to the localized FCEV market demand assessment.

Updates to CHIT

CHIT began development in 2014 to support analysis in the 2015 *Annual Evaluation*. The tool was also first provided for public use in 2015. Development of CHIT continued and the CEC relied on CHIT directly in evaluating applications to GFO-15-605. In 2017, a revised version was released for public use that updated data input parameters and expanded functionality with several new tools that had been developed to support GFO-15-605 and reporting through CARB's *Annual Evaluations*. One of the major new features in the 2017 Release Version of CHIT was the inclusion of traffic data that has now become a standard portion of CARB's annual analyses[30].

As the CEC developed GFO-19-602, CARB also utilized CHIT to analyze potential future network development scenarios in support of the CaFCP's *Revolution* document and CARB's *Self-Sufficiency Analysis*. The CEC incorporated this vision of future network development into GFO-19-602 through the adoption of Area Classifications that determine minimum fueling station capacity and number of fueling positions for stations proposed within the solicitation. The Area Classification system is intended to streamline approval of proposed stations in future batches of GFO-19-602 while remaining dynamic and able to provide updated guidance as the planned hydrogen fueling network evolves.

In the past year, CARB has worked to update the CHIT model and may soon release the updated version for public use. The most significant change is that CARB has opted to move the CHIT model out of the ArcGIS ArcMap application and into the new ArcGIS Pro application. Based on information provided by ESRI (the creator of ArcGIS programs), ArcMap may not be supported in the future, necessitating a move to ArcGIS Pro. CARB has rebuilt all CHIT evaluation tools in the ArcGIS Pro environment. In addition, CARB has updated several of the input data files that are used in CHIT evaluations:

- **TIGER-ITN Roadway Dataset:** One of the key features of CHIT is a finely detailed roadway dataset that incorporates accurate estimates of actual travel speeds. Prior to CHIT, many similar tools used limited roadway datasets that only included highways and major roads and/or assumed posted speed limits for actual traffic speeds. CARB created the TIGER-ITN roadway dataset to improve on prior efforts.
  TIGER databases maintained by the United States Census Bureau provide a detailed geospatial dataset of all known roads in the United States. While the dataset is highly detailed in its geography, it contains no traffic information.
  ITN is CARB's Integrated Transportation Network dataset. It is generated by combining observed and modeled traffic data stitched together from the many Metropolitan Planning Organizations around California. ITN contains significant amounts of traffic data, including traffic speed and traffic volume, aggregated for various times of day. However, ITN is intended to be a simplified traffic model to accommodate large calculations and evaluation of

29 Most evaluations in CHIT are completed on a statewide mesh of hexagons approximately 0.125 miles on each side, or 0.04 square miles in area.

30 *Link to CARB Infrastructure Analysis website to access all current CHIT documentation*

statewide traffic. It therefore is not as geographically complete as TIGER.
CARB created TIGER-ITN by combining the two datasets and capitalizing on their relative strengths. The resulting roadway data is geographically detailed like TIGER while containing real-world traffic information from ITN. CARB created the first version in 2015 and updated the data in 2017. This year, CARB has again updated the data to generate a version based on 2020 data.

- **Demographic Data:** CHIT evaluations of potential FCEV market adoption rely on several demographic indicators. Data pertaining to annual income and household education are incorporated into CHIT market evaluations. These data are based on American Community Survey estimates from information collected over the last five years of surveys. CARB has updated these input data to the latest (2020) versions available, aggregated at the census tract resolution.
- **Vehicle Purchase Data:** CHIT market evaluations also consider trends in vehicle adoption. Two of these datasets quantify luxury vehicle sales in the last five years and sales of vehicles in the last five years with manufacturer suggested retail prices (MSRP) matching the observed MSRP of FCEVs sold and leased in California. These data are obtained from DMV registration data and only consider the first time an individual vehicle is purchased or leased in the state of California. CARB has updated these datasets based on the latest available DMV records as of April 1, 2021.

These updates ensure CARB's recommendations for future hydrogen fueling network growth are based on up-to-date market indicators. CARB intends to use these updated data for future *Annual Evaluations* and may periodically update them again as necessary. At the same time, CARB is maintaining its data and access to the 2017 Release Version of CHIT. CARB will need to maintain this version until all stations funded through GFO-19-602 are complete, as the evaluation of Area Classifications was first based on the 2017 Release Version of CHIT and all future adjustments must similarly be based on this version.

The updated data are not likely to cause wholesale changes in CHIT evaluations, though some localized differences are expected. For example, the new version of TIGER-ITN indicates local shifts in traffic patterns. In the Sacramento area, traffic speeds during PM peak traffic have noticeably increased on many streets since 2017. At the same time, traffic speeds have noticeably decreased in and around San Diego. These localized differences can be seen by comparing the Open-Retail network coverage in Figure 13 to the similar figure in the 2020 *Annual Evaluation*. Similar localized shifts can be expected in the demographic and vehicle purchase data. CARB compared the final output of coverage gap generated with the 2017 Release Version of CHIT and the newly updated version and found that some small local differences were apparent, but the general conclusions remain the same.

Evaluation of Network Coverage

Coverage gap analysis completed with the latest version of CHIT is shown in Figure 16. Since GFO-19-602 is expected to be the major station funding source in the near future, the figure highlights eligible areas for further network development under the solicitation (as defined by Figure 1 of the GFO-19-602 solicitation manual). The figure displays the relative coverage gap across the state, with low gaps in deep blue, mid-range gaps in green and yellow, and high coverage gap in orange and red. Priority areas suggested for further development are outlined in magenta. More detailed maps of individual regions containing priority areas are provided in Figure 17.

The analysis of coverage gaps reveals new station development is needed across much of the state, in a significantly more diverse set of communities than the locations of stations that are currently open and under development. This year's evaluation points to a new phase in hydrogen fueling network development. While opportunities for further development still clearly exist in and near the established markets in the Greater Los Angeles, Orange County, Sacramento Area, San Diego County, and San Francisco Bay Area regions, a notable amount of development is also needed in nearby communities and even in some communities more remote from the currently planned network. This year's evaluation finds a total of 64 individual priority areas of various sizes (each at least 5 square miles in area) where new coverage is most needed and may be good candidates for station developers to include in future development under GFO-19-602.

Target areas for development that are more distant from the currently planned network are located in Palm Springs, San Luis Obispo, Monterey and Santa Cruz, in San Joaquin Valley cities like Bakersfield, Fresno, and Stockton, and even in cities in the northern portions of the state where no infrastructure has yet developed, including Chico and Eureka. These more geographically diverse areas have previously been found to be good candidates for network development at some point in California's future, as evidenced by projected network development in these areas under the scenarios developed for the CaFCP's *Revolution* document and CARB's *Self-Sufficiency Analysis*. The analysis shown in Figure 16 and Figure 17 indicates that coverage provided by the planned network is now so strong in the areas with open and planned stations that the lack of coverage in these new areas has become an equally strong consideration as the need to continue development in more established areas. In general, areas with the highest coverage as shown in Figure 13 show limited need for additional coverage in Figure 17.

As station developers propose new stations for development under GFO-19-602 or to be developed through other financing plans, they should seriously consider the opportunities presented by all areas identified in Figure 17. Some may present opportunities for development immediately after the stations currently under construction are completed. Others may be more appropriate in later phases of development, but all should be considered seriously. As station developers continue to build stations through GFO-19-602 and other efforts, these recommendations may also evolve.

Figure 16: Coverage Gap Analysis, as of April 29, 2021

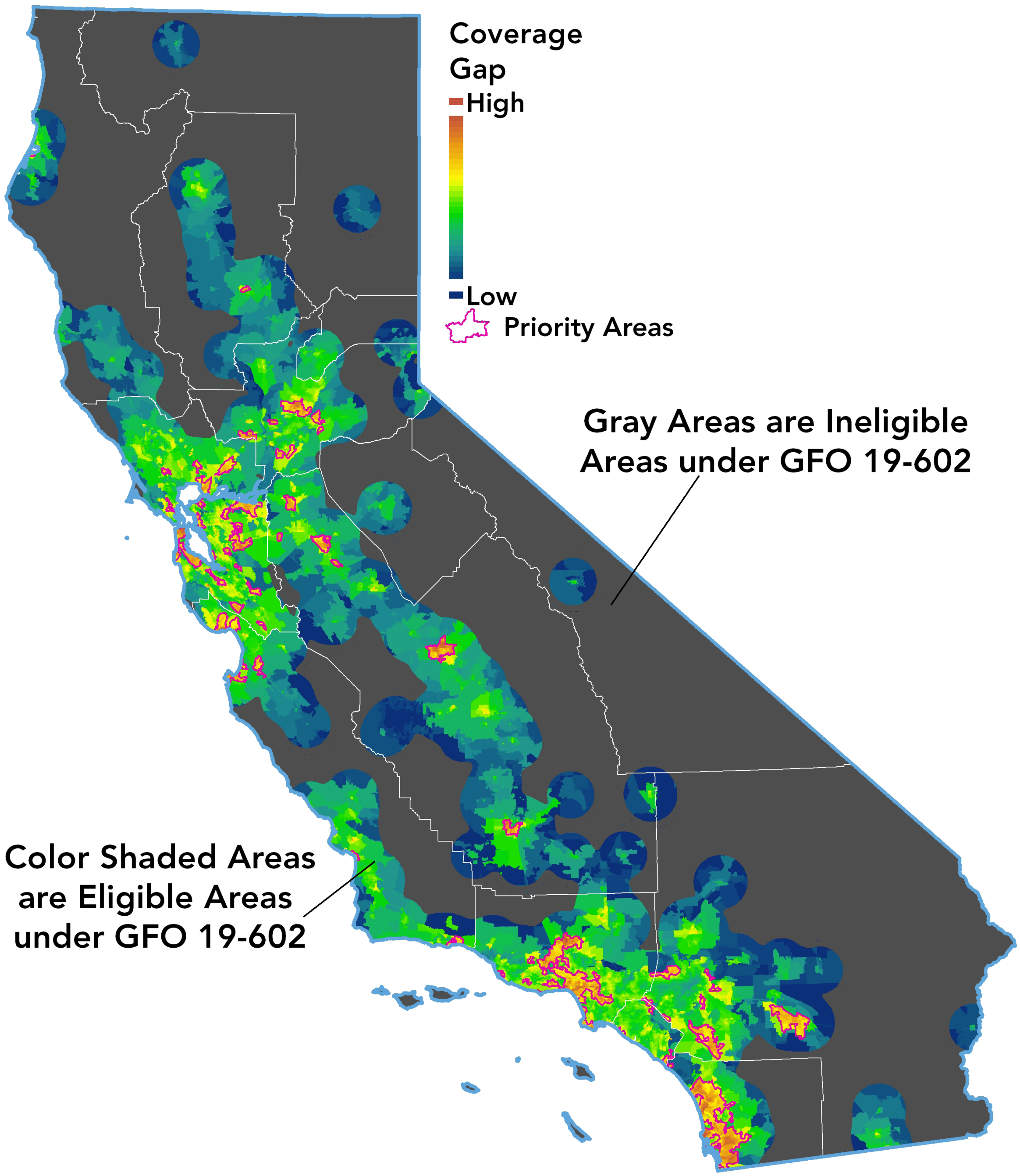
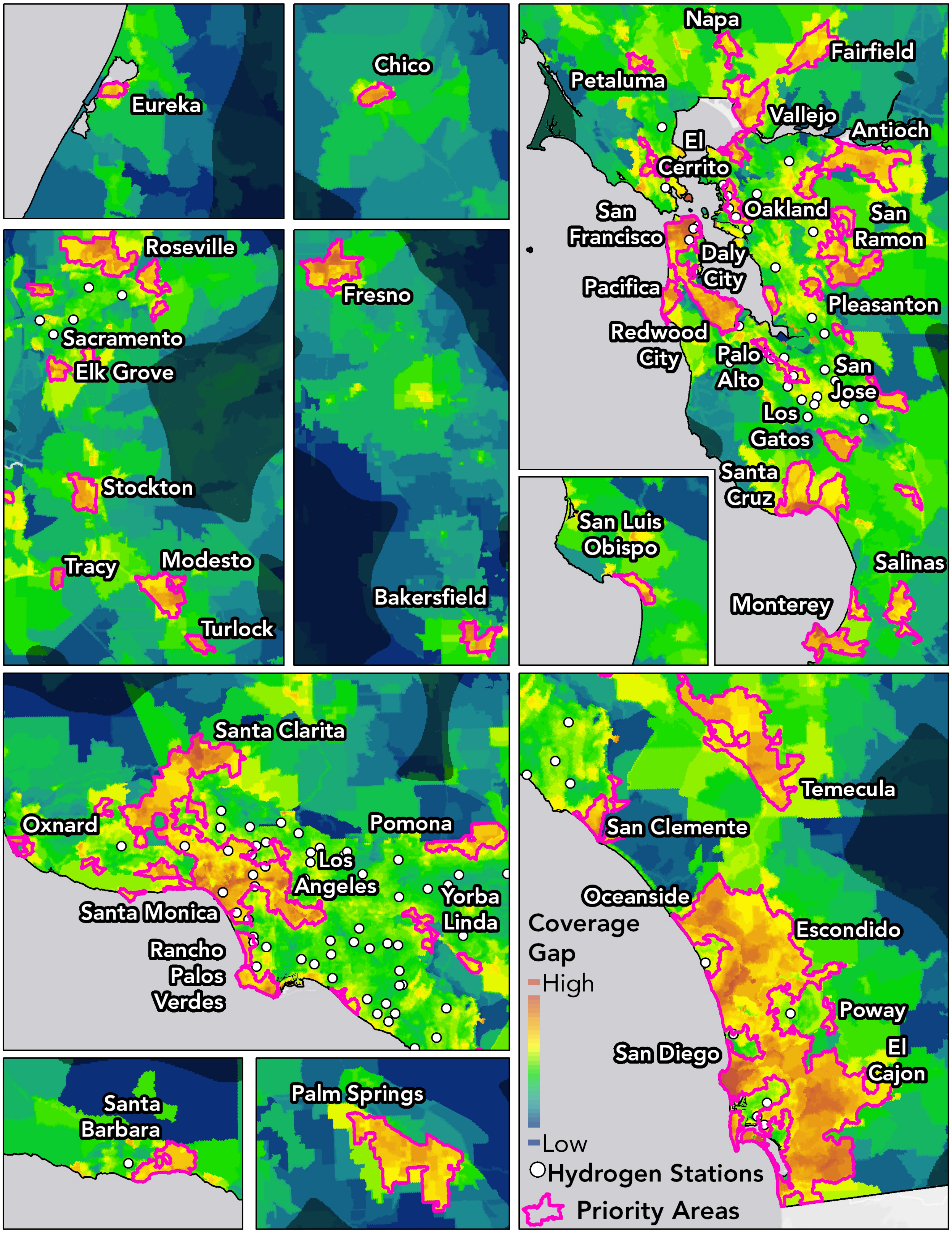
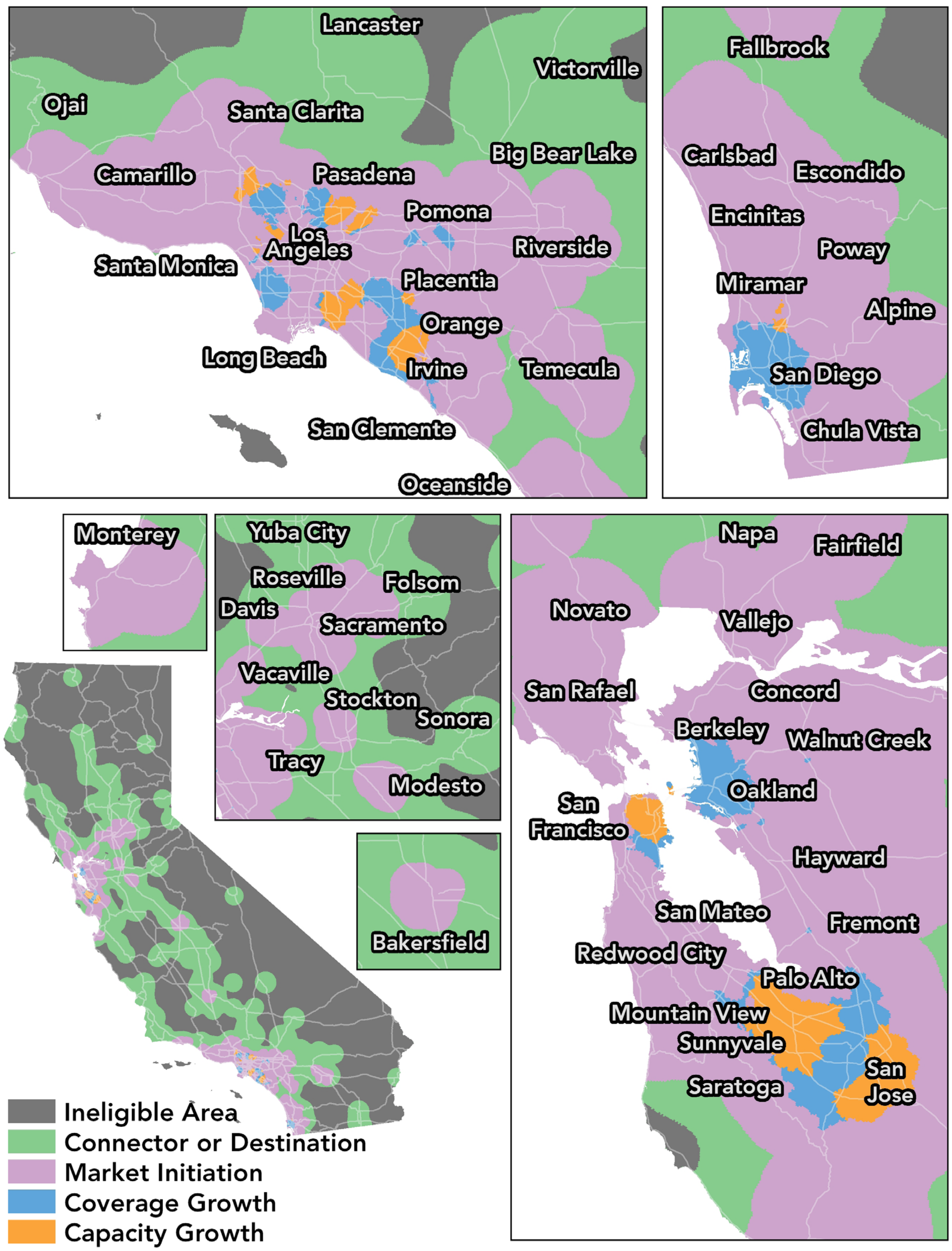


Figure 17: Priority Areas Detail for Future Station Development



In addition, station developers will need to ensure that their proposed stations match requirements of the Area Classification system. The Area Classification system of GFO-19-602 is intended to be re-evaluated as individual batches of stations are completed. This re-evaluation identifies areas where the hydrogen station network has moved beyond the Market Initiation phase and provides guidance on areas where the highest-capacity stations are needed most. Figure 18 provides an updated evaluation of Area Classifications, considering the network coverage provided by all stations in developers' first batches under GFO-19-602 and all privately funded stations. This figure is provided for information purposes only; station developers may be provided a different figure based on updated information at the time they are ready to submit their next batch of stations for approval.

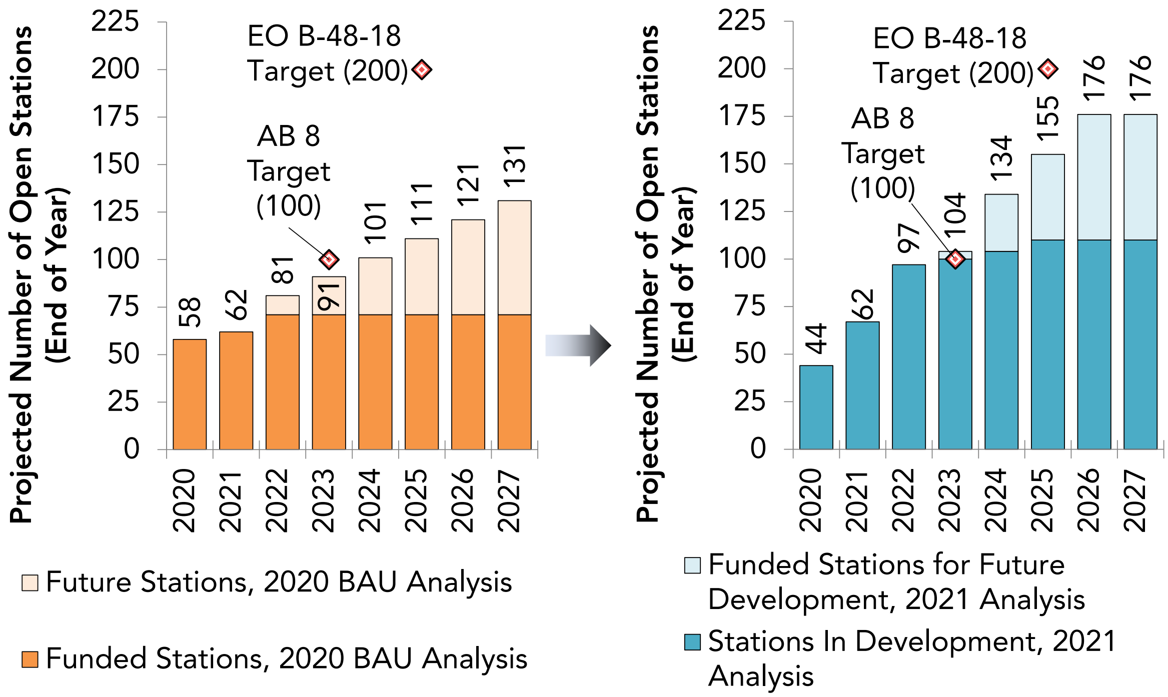
Figure 18: Temporary Updated GFO-19-602 Area Classifications



Trends of Station Deployment Rates

The outlook for future hydrogen fueling station network development has noticeably improved over the past year. In the 2020 *Annual Evaluation*, CARB noted that network development would need to accelerate to meet the 100-station target outlined in AB 8 and would need further acceleration in order to reach the 200-station target of EO B-48-18, as shown in the left panel of Figure 19. Based on the latest updated projections of station development, California may have more than 100 hydrogen fueling stations operating at Open-Retail status by the close of 2023. California's station network development therefore has the potential to meet the target set by AB 8. This significant change in outlook is due to the addition of new stations under development through GFO-19-602 and new privately funded stations.

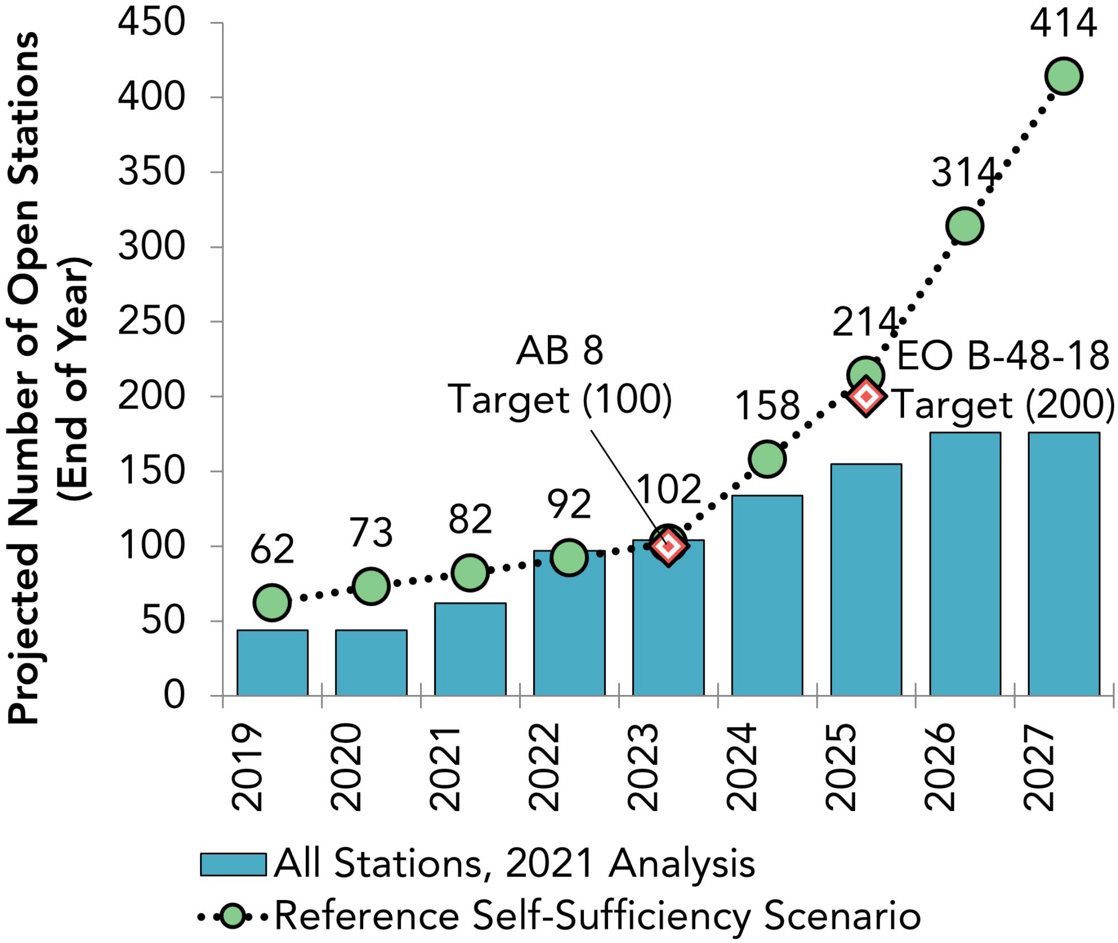
Figure 19: Comparison of Statewide Station Projections between 2020 and 2021 Annual Evaluations



The projected station network development pace has improved from last year. Additional funding under SB 129 will help close the gap to achieving the 200-station target of EO B-48-18. CARB currently counts 176 active station projects either open, under development, or planned for future development.

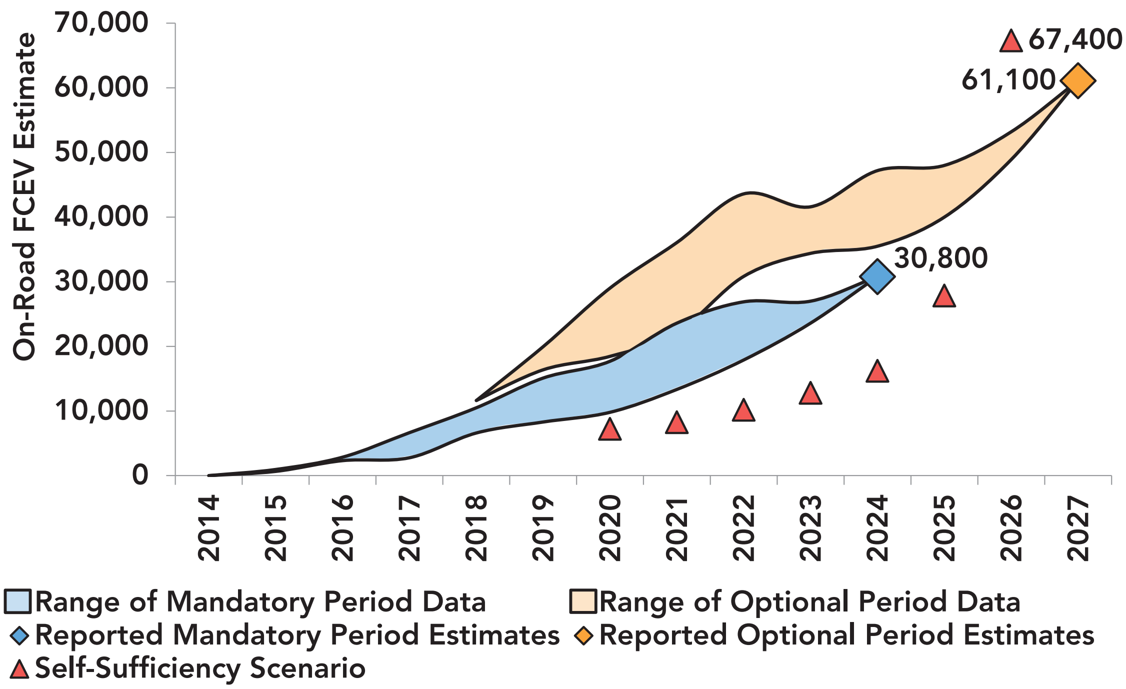
Further development in 2025 and beyond would also need to accelerate in order to set the network on a path to self-sufficiency as outlined in CARB's *Self-Sufficiency Analysis*. Figure 20 demonstrates that projected network development through 2023 matches the station network growth of the *Revolution*-based scenario analyzed in the *Self-Sufficiency Analysis*. However, planned network development deviates from that path in 2024 and the gap continues to grow at a steady pace from 2025 to 2027. Acceleration beyond 2025 would be necessary to match the self-sufficiency reference scenario. Public and private partners likely need to continue cooperating to identify actions that help the state achieve the self-sufficiency goal.

Figure 20: Comparison of Current Station Projections and Reference Self-Sufficiency Scenario



FCEV deployment will similarly need to accelerate in order to maintain favorable financial performance at hydrogen fueling stations. As has been observed in the real-world deployment data, analysis of scenarios that achieve self-sufficiency assume individual station and network-wide utilization grow over time. FCEV deployment needs to be commensurate with network capacity to achieve self-sufficiency, but a gradual growth to network capacity is sustainable. As shown in Figure 21, current projections for FCEV deployment match reasonably well through 2026 to the assumed vehicle deployment in scenarios that achieve self-sufficiency. This match is apparent in terms of total numbers of FCEVs on the road and as a proportion of total network capacity. Beyond 2026, FCEV deployment will need to grow at a notably accelerated pace compared to current projections in order to reach 1,000,000 FCEVs by 2030 as outlined in the Self-Sufficiency analysis. Continued analysis of FCEV deployment projections, the registered vehicle population, and overall market conditions that enable FCEV adoption will be necessary to maintain a complete picture of how California's hydrogen fueling network moves towards self-sufficiency in the future.

Figure 21: Comparison of Projected FCEV Deployments and Reference Self-Sufficiency Scenario



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 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 estimated progression of hydrogen network fueling capacity by region is shown in Figure 22 and Figure 23. The regional distribution of projected capacity growth has significantly shifted from last year's evaluation. This is mostly due to the fact that the evaluation presented in 2020 was based in part on the scenario analysis presented in the CaFCP's *Revolution* document and CARB's *Self-Sufficiency Analysis*. This year's evaluation is instead based on known station development through GFO-19-602 and private development. Over the next several years, hydrogen fueling capacity is expected to grow in several regions across California. Notably, all regions that are expected to see capacity growth currently contain at least one hydrogen fueling station. A few regions do not yet have additional stations planned beyond those that are already Open-Retail, including the Central Coast Range, San Joaquin Valley, and Sierra-Nevada regions. These are all areas that CARB suggests station developers seriously consider for further development through GFO-19-602 or private efforts, as shown in Figure 17.

Figure 22: Projected Fueling Capacity By Region, 2020-2023

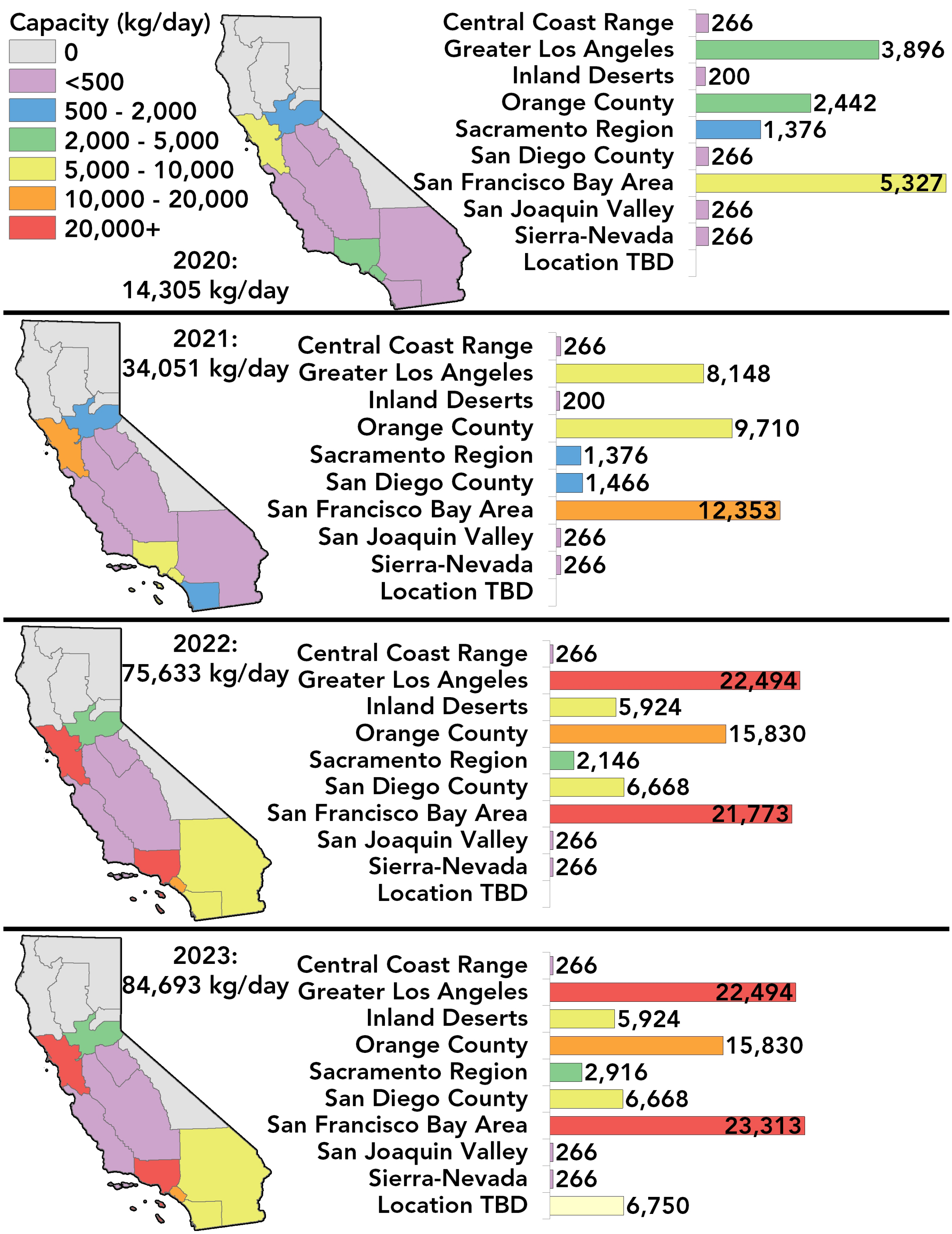
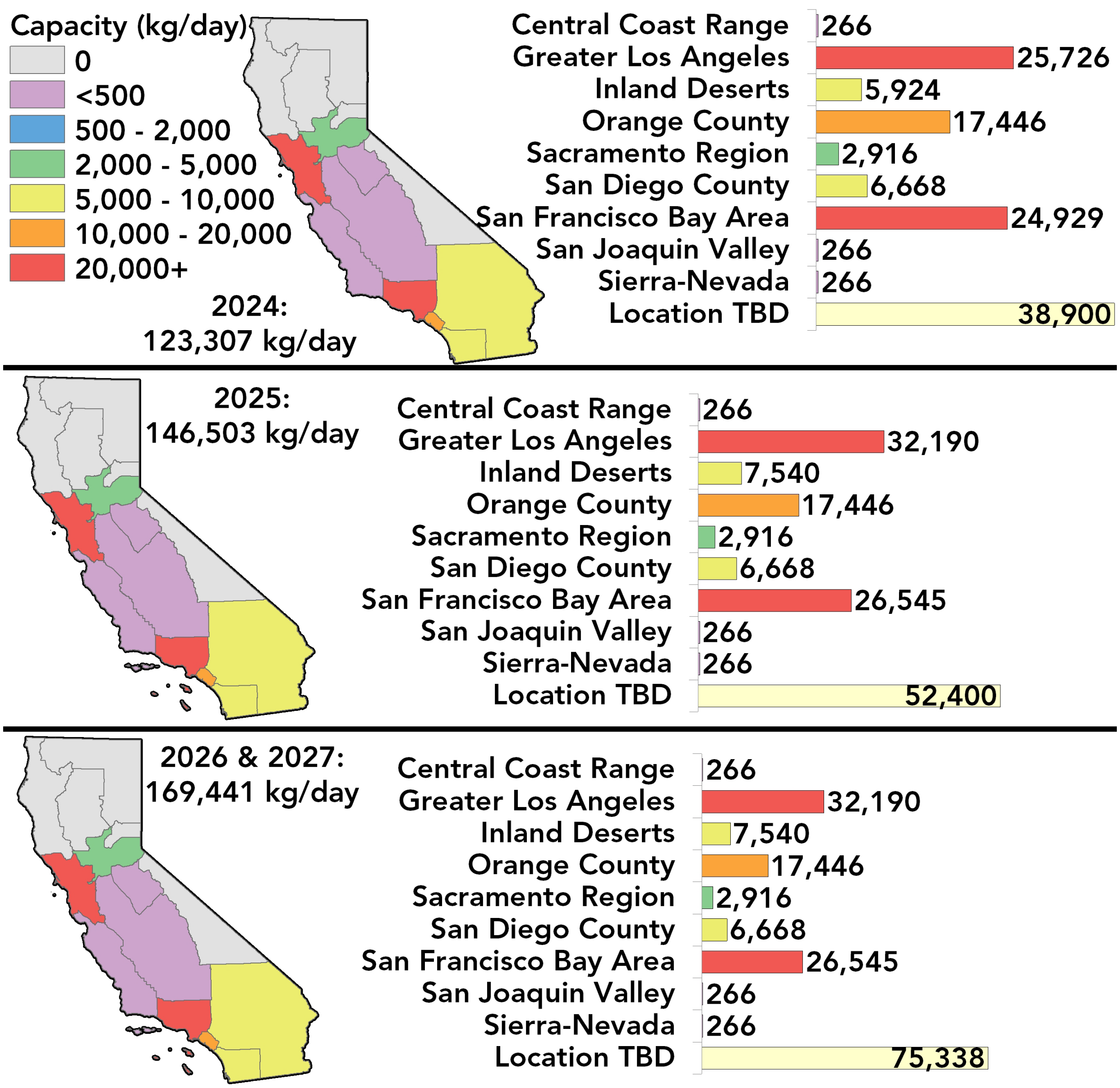


Figure 23: Projected Fueling Capacity By Region, 2024-2027



The Greater Los Angeles and San Francisco Bay Areas are expected to see the largest growth in hydrogen fueling capacity, with faster initial acceleration in the San Francisco Bay Area region, but the most total capacity planned for Greater Los Angeles. Based on the 110 station locations included in this analysis, the Greater Los Angeles region is expected to have the most fueling capacity by 2025, with 19 percent (32,190 kg/day) of statewide fueling capacity, followed by the San Francisco Bay Area at 16 percent (26,545 kg/day) and Orange County at 10 percent (17,446 kg/day). The Inland Deserts, Sacramento, and San Diego regions will see limited growth, each accounting for 2-4.5 percent of capacity by 2025.

A major unknown for the future distribution of hydrogen fueling capacity is the location of the remaining 66 new hydrogen fueling stations and two unspecified upgrades under GFO-19-602 (in addition to any stations that may change their planned location in coming years). By 2026, the capacity of these stations will make up approximately 44 percent (75,338 kg/day) of the statewide total. This group of stations will undoubtedly have a significant impact on the geographic distribution of future hydrogen fueling capacity, as will any stations developed with one-time funding from SB 129.

The hydrogen fueling capacity of the currently planned market is well-balanced compared the projected FCEV deployment shown in Figure 9. This is expected as this year's analysis directly assumed the distribution of planned hydrogen stations would guide the deployment of FCEVs because the market impact of stations awards under GFO-19-602 and the privately funded stations is expected to be significant. In addition to this primary assumption, when evaluating capacity at the county and regional level, CARB analyses consider the possibility that FCEV drivers may fuel at stations in their home county or at stations in an adjacent county if the station is also within the 15-minute extent of coverage.[31] Based on these considerations, all regions are expected to have sufficient hydrogen fuel availability in 2024 and 2027, as shown in Figure 24. This is a first in California's hydrogen fueling network planning and analysis. The Greater Los Angeles, Orange County, and San Francisco Bay Area regions will have significantly greater capacity available than projected demand.

The coverage gap analysis shown in Figure 17 demonstrates that there are markets across California with significant potential for FCEV deployment that are not yet met with commensurate hydrogen fueling station network development plans. The analysis of coverage gap demonstrates that there is a need to begin establishing network coverage in these markets. CARB investigated the additional capacity needs that are currently not addressed by the planned hydrogen fueling station network, based on CHIT analysis of localized market strength and the projected FCEV deployments shown in Figure 8.

31 In these analyses, each station's capacity is distributed to counties within a 15-minute drive of the station 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* [22].

Figure 24: Hydrogen Fueling Capacity Balance by Region According to Current Known Stations

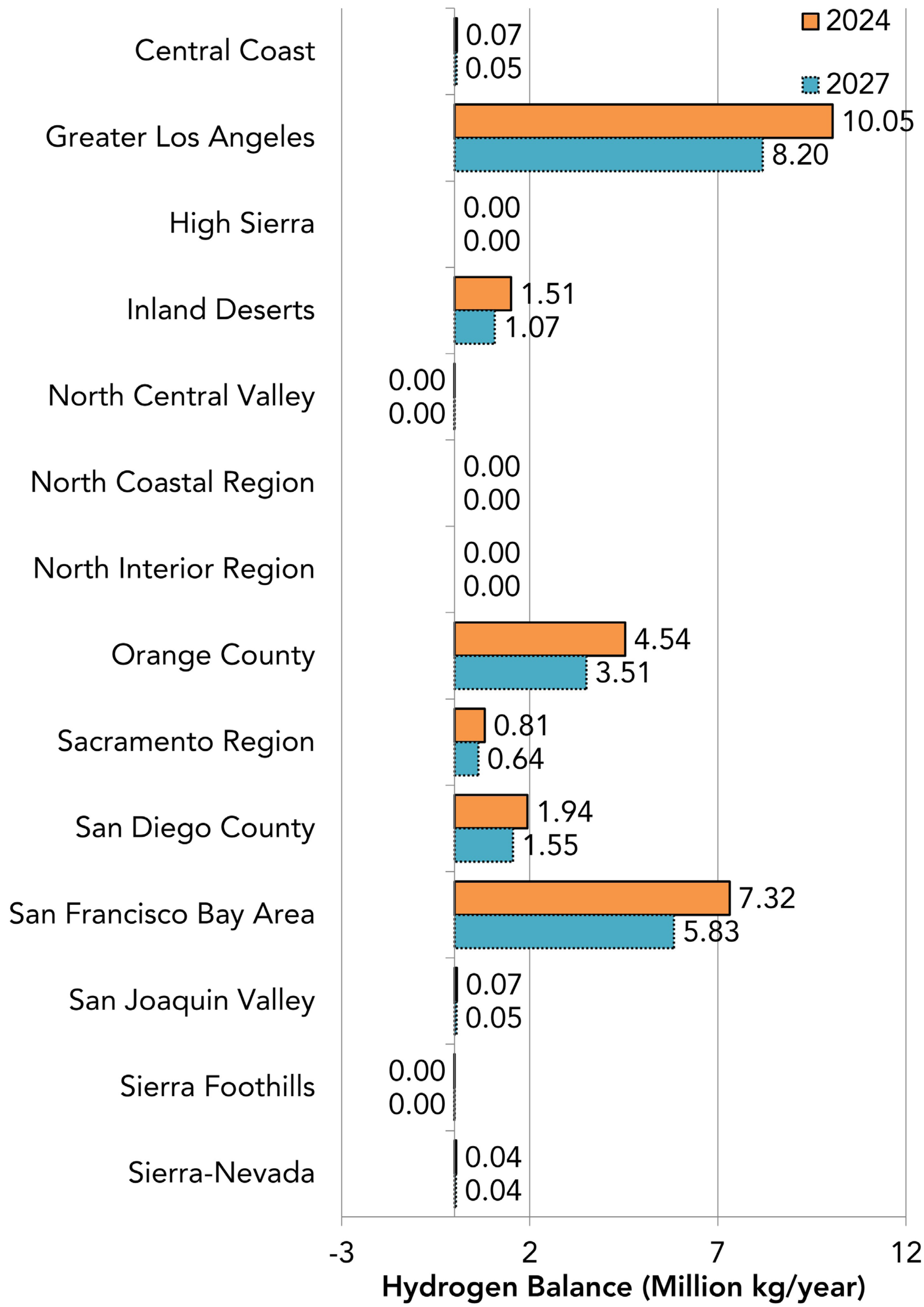
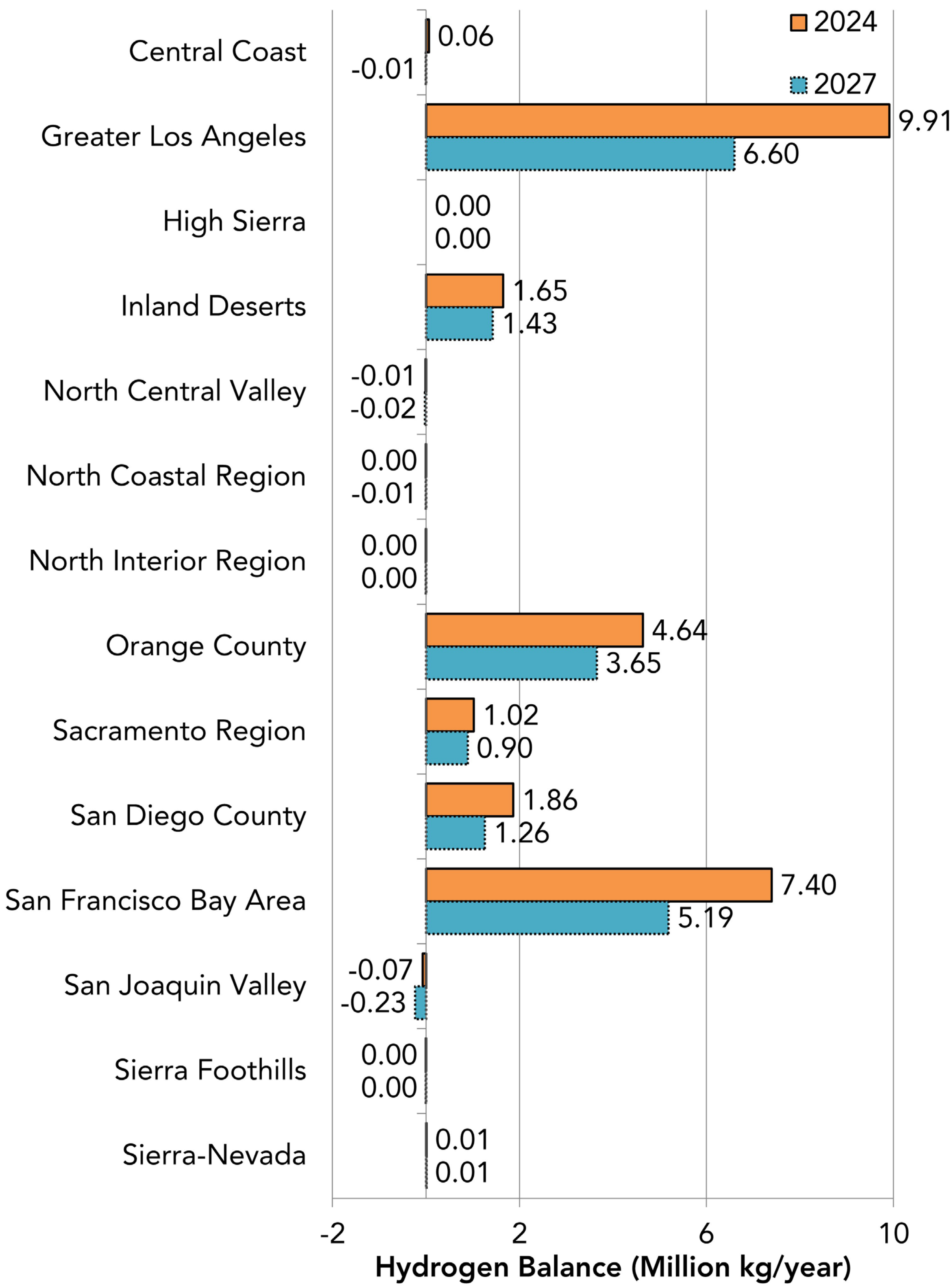


Figure 25: Projected Hydrogen Fueling Capacity Balance According to CHIT Market Estimates



The regional analysis of hydrogen capacity balance based on CHIT-determined market strength is shown in Figure 25. A positive balance indicates sufficient hydrogen fueling capacity for the projected number of FCEVs fueling in the region. A negative hydrogen balance indicates additional refueling capacity beyond current known plans is needed to meet the projected demand in the region. Regions with a smaller positive or larger negative hydrogen balance in Figure 25 than in Figure 24 indicate areas where potential market demand and capacity need is not sufficiently met by the planned hydrogen fueling network. There may be unmet market demand in these areas. Though the overall capacity need is typically small, it does appear that some regions have unmet potential for capacity growth in addition to the coverage needs shown in Figure 17. The Central Coast, San Diego, Sierra-Nevada, and especially the San Joaquin Valley regions appear to have the most unmet potential for capacity growth based on this analysis.

The scenario analyzed in CARB's *Self-Sufficiency Analysis* and the CaFCP's *Revolution* document provides a useful perspective for long-term planning (through 2035) of capacity growth. The difference between planned network capacity and 2027 capacity in this reference scenario is shown by region in Figure 26 and by county in Figure 27. Values in both figures represent the additional fueling capacity beyond current known development plans that is required to match the reference scenario, in which the FCEV population reaches 1.4 million by 2035. A negative value indicates current plans are sufficient to match the reference scenario. This analysis points to significant opportunities for fueling capacity growth in nearly all regions across the state, if FCEV deployment were to match the Self-Sufficiency scenario. The largest needs would be in the San Francisco Bay Area and San Joaquin Valley regions, followed by the Central Coast, Greater Los Angeles, Inland Deserts, Sacramento, and San Diego County regions. Riverside, San Diego, and Ventura counties individually demonstrate the largest need for long-term hydrogen fueling capacity growth. Several other counties including Contra Costa, Kern, Los Angeles, Sacramento, San Joaquin, Solano, and Stanislaus also show mid-range capacity growth potential.

Localized near-term capacity growth needs based on the 61,100 FCEVs projected for 2027 are shown in Figure 28 and Figure 29. As expected from the regional hydrogen balances shown in Figure 24, there are relatively few localized areas with high need for additional fueling capacity. The largest localized need is only 1,300 kg/day, roughly equivalent to the capacity of just one of the largest stations currently Open-Retail or under development. Therefore, based only on the fueling demand of the currently projected 61,100 FCEVs, most of the need for hydrogen fueling network expansion is currently driven by coverage. Capacity growth needs would play a more significant role in a scenario where auto manufacturers accelerated their near-term FCEV deployment plans beyond those shared in the most recent auto manufacturer survey. Still, many of the relative observations of regional opportunity for capacity growth shown in Figure 25 are apparent in the localized needs analysis of Figure 28. Outside of the regions that will see the most development (as shown in Figure 23), mid-to-high capacity need is observed in San Diego County, in Fresno and Stockton, near San Bernardino, and in Santa Cruz.

Figure 26: Projected Hydrogen Fueling Capacity Need by Region to Match Referenece Self-Sufficiency Scenario

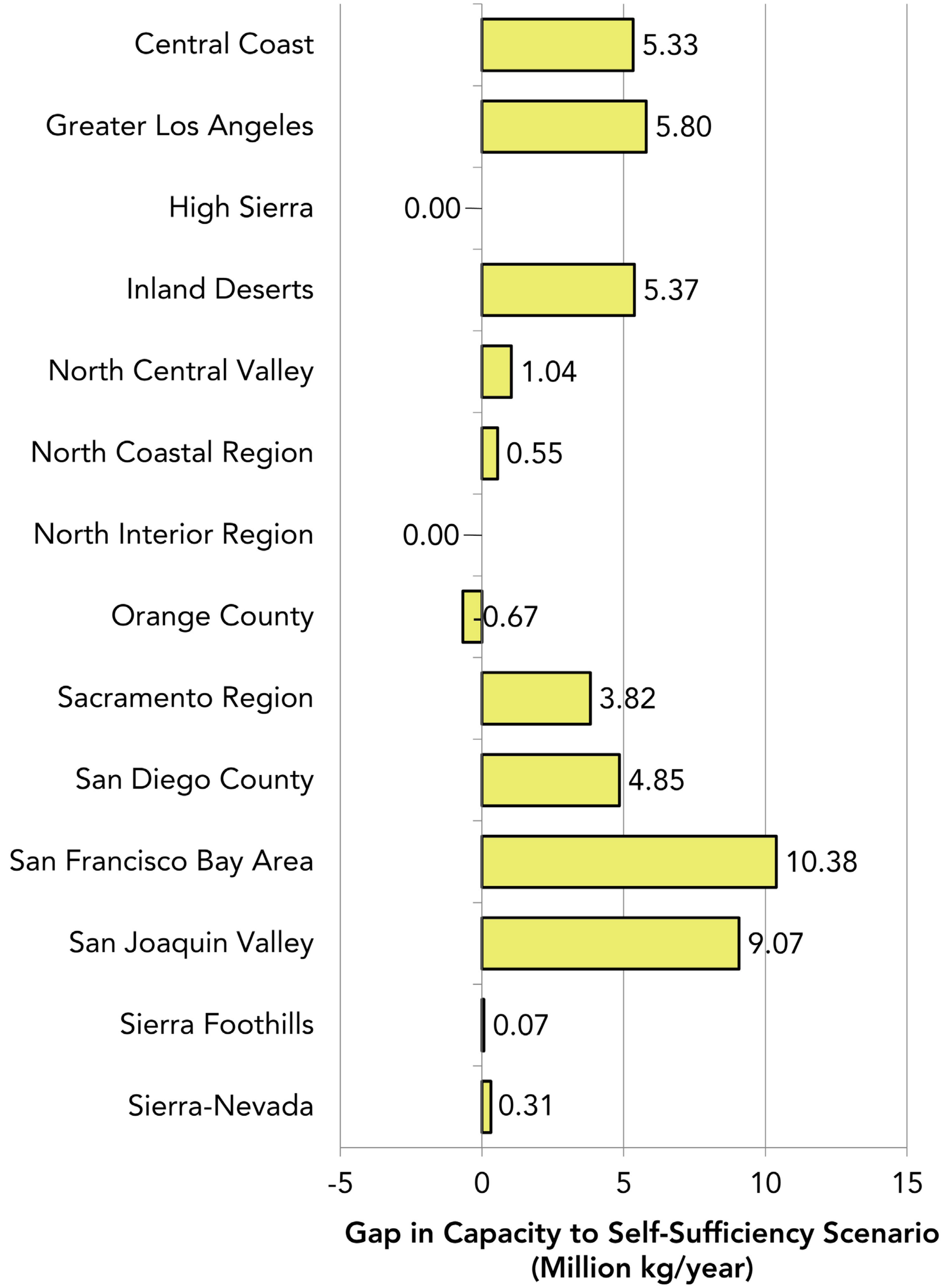


Figure 27: Projected Hydrogen Fueling Capacity Need Detail by County to Match Referenece Self-Sufficiency Scenario

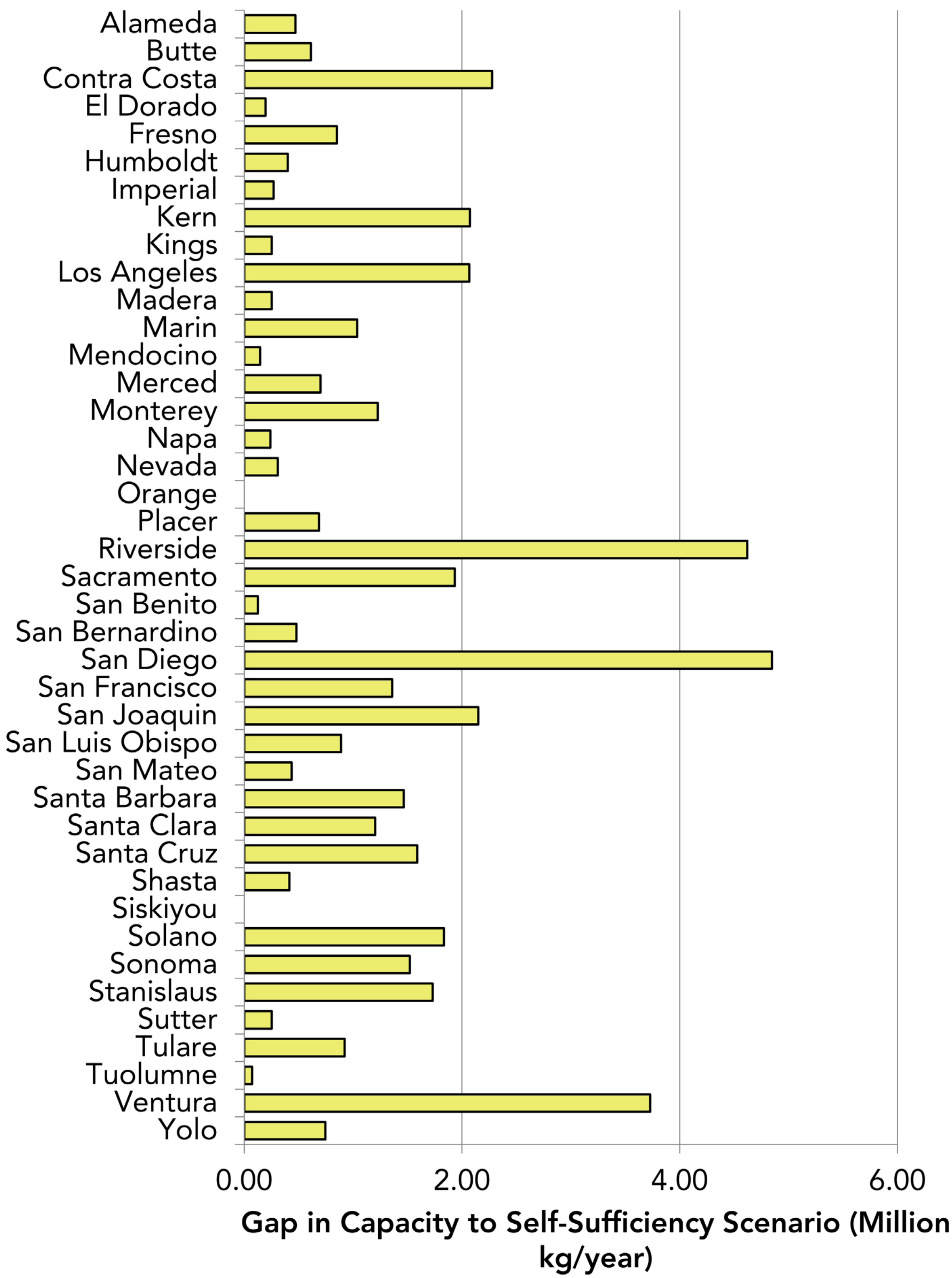


Figure 28: Current Capacity Gap Evaluation for Estimated 2027 FCEV Population

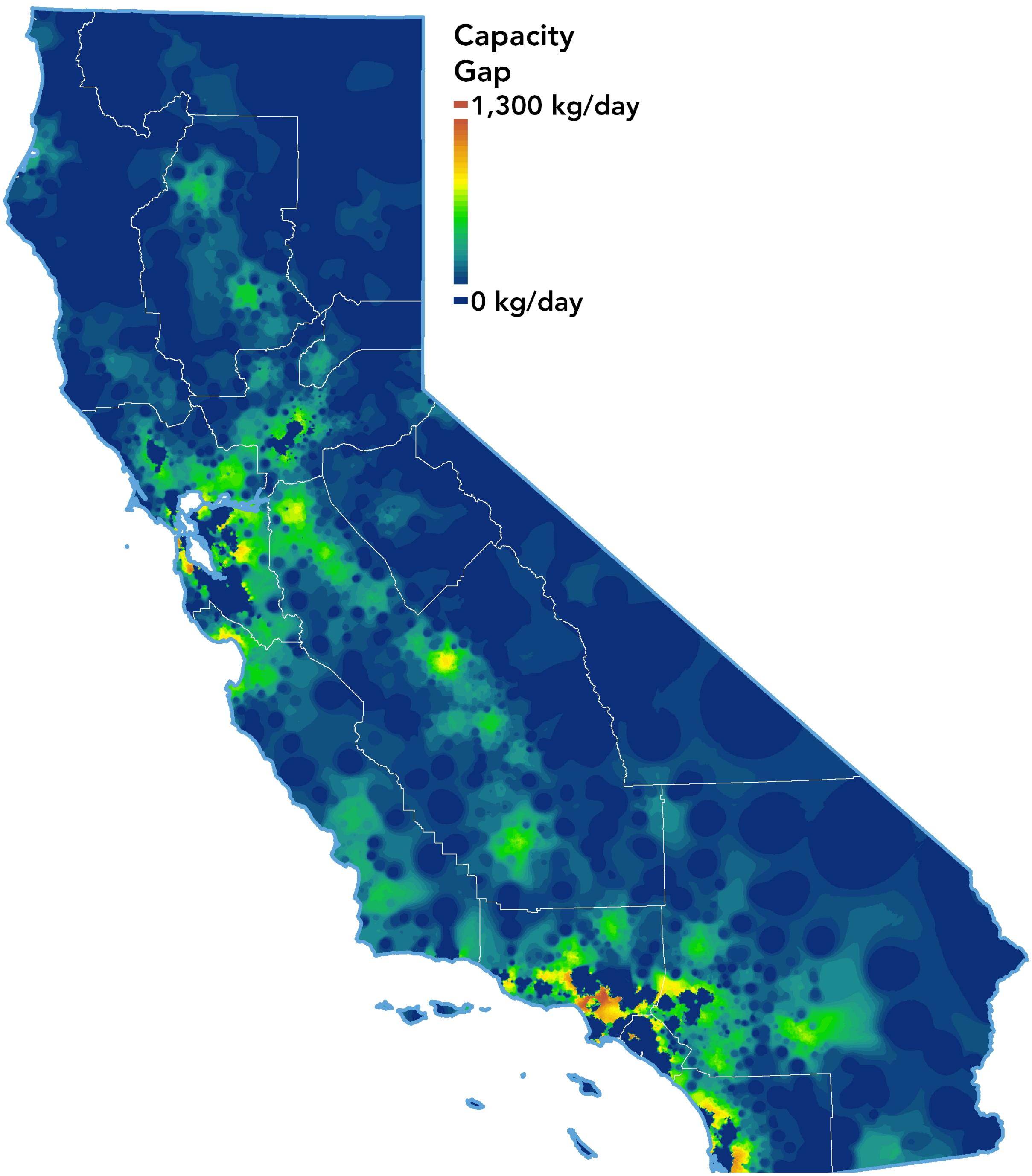
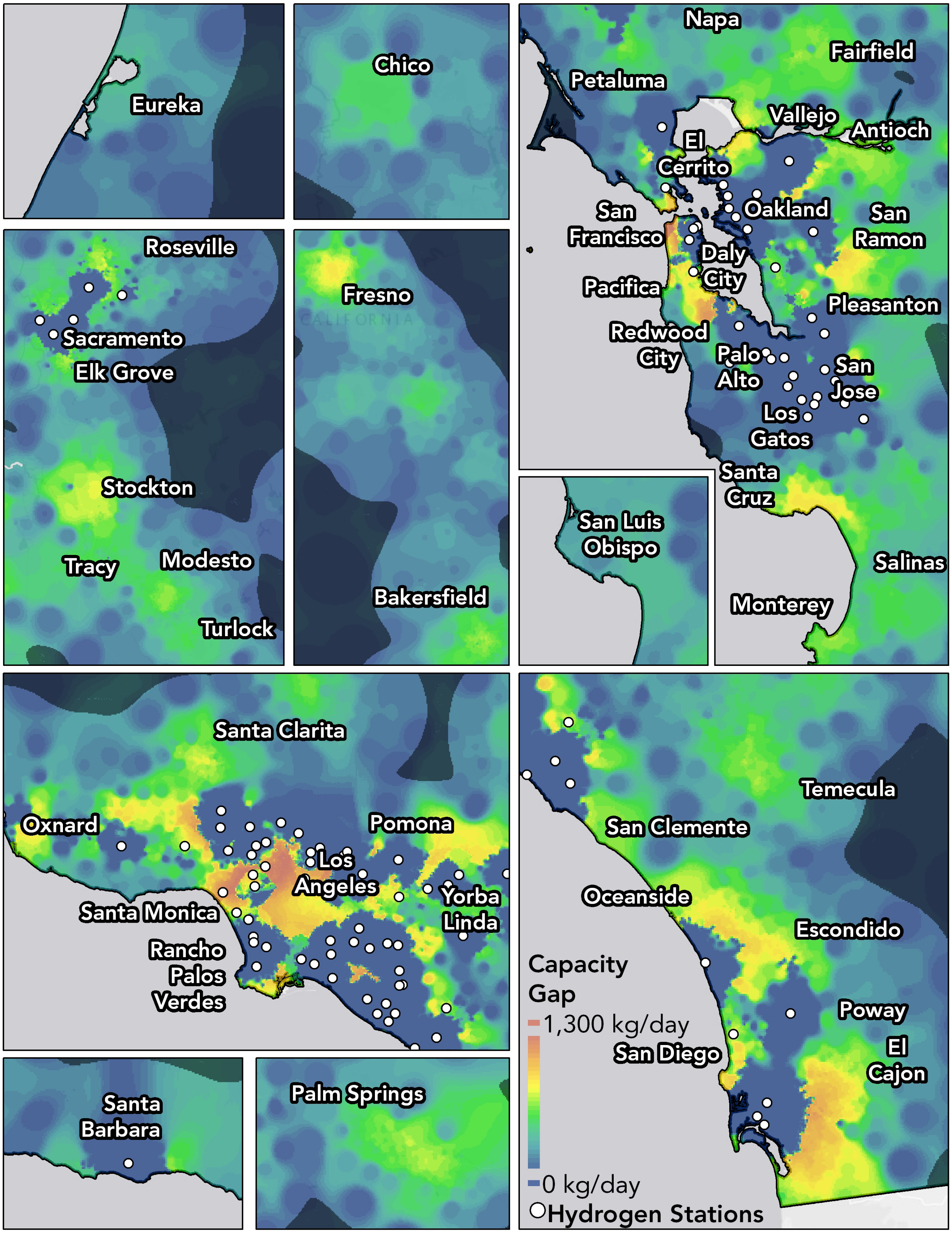
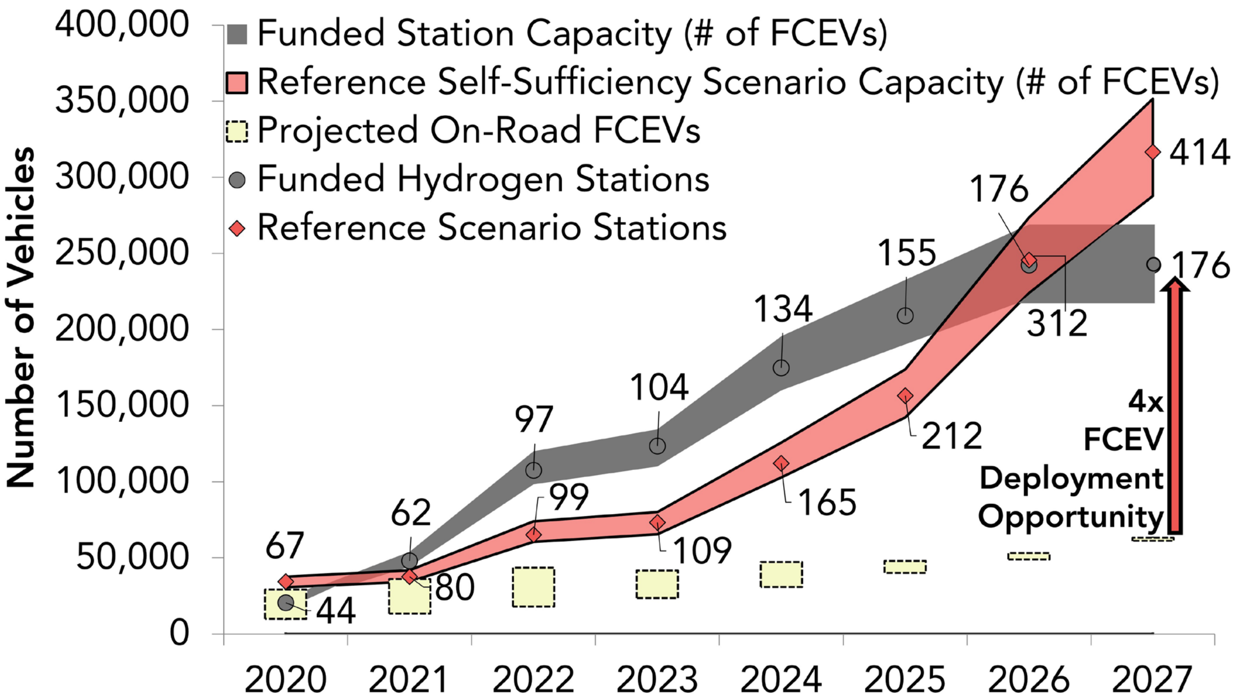


Figure 29: Capacity Gap Evaluation Detail



The analysis presented in Figure 24 highlights that regional fueling network capacity growth should be sufficient for projected FCEV hydrogen demand through 2027. The full scale of statewide network capacity growth is further emphasized by the comparisons made in Figure 30. From 2021 onward, if current station development schedules are maintained, California's hydrogen fueling network should have more fueling capacity than the demand generated by projected FCEV deployment. Over time, the net difference between network capacity and projected hydrogen demand will grow substantially. By 2027, CARB estimates that California's hydrogen fueling network will provide an opportunity to deploy four times the amount of FCEVs as the latest auto manufacturer survey indicates. This is an unprecedented situation in California's history of hydrogen fueling network development and presents an opportunity for FCEV deployment that auto manufacturers have not previously encountered. Auto manufacturers should capitalize on the opportunity that California's network development efforts have generated and begin to plan for significantly more future FCEV deployment than has thus far been reported.

Figure 30: Comparison of Projected Vehicle Deployment and Network Nameplate Capacity



The analysis shown in Figure 30 also demonstrates that California's planned hydrogen fueling network compares favorably to the reference scenario presented in CARB's *Self-Sufficiency Analysis* and the CaFCP's *Revolution* document. Development of the 176 known stations is expected to be completed in 2026. Between 2021 and 2026, the planned hydrogen fueling network capacity is expected to be equal to or greater than the capacity of the network in the reference self-sufficiency scenario. This is another positive indicator that the results of GFO-19-602 and private station funding have positioned California's planned network development such that eventual self-sufficiency may be achieved. However, significant work remains to ensure that development continues the momentum established so far.

In addition, self-sufficiency is dependent on vehicle deployment and station utilization. As shown in Figure 21, projected FCEV deployment based on analysis of annual auto manufacturer surveys also matches well with the self-sufficiency reference scenario through 2026. However, the self-sufficiency scenario reference also assumes approximately twice as many FCEVs in 2027 as current projections and further acceleration in later years. Based on these observations, FCEV deployment beyond current projections is also required to maintain a path to self-sufficiency by 2030.

While the statewide capacity of the planned hydrogen network compares favorably well to the reference self-sufficiency scenario, there are important differences to consider in future planning. Figure 30 makes it apparent that while the capacity of the planned and reference networks eventually reach the same point in 2026, the planned network does so with far fewer stations. In one sense, this may be a positive indication of the potential to reach self-sufficiency. By reaching the same capacity with fewer stations, the planned network is composed of stations that individually have larger capacity than the stations in the reference self-sufficiency scenario. CARB's *Self-Sufficiency Analysis* highlighted that larger stations typically have more favorable economic performance and may be more amenable to achieving self-sufficiency. In some sense, the planned network may be closer to the alternative scenario focused on early deployment of high-capacity stations (termed the "CAFCR-Large" scenario in the *Self-Sufficiency Analysis*) than the scenario shown in Figure 30.

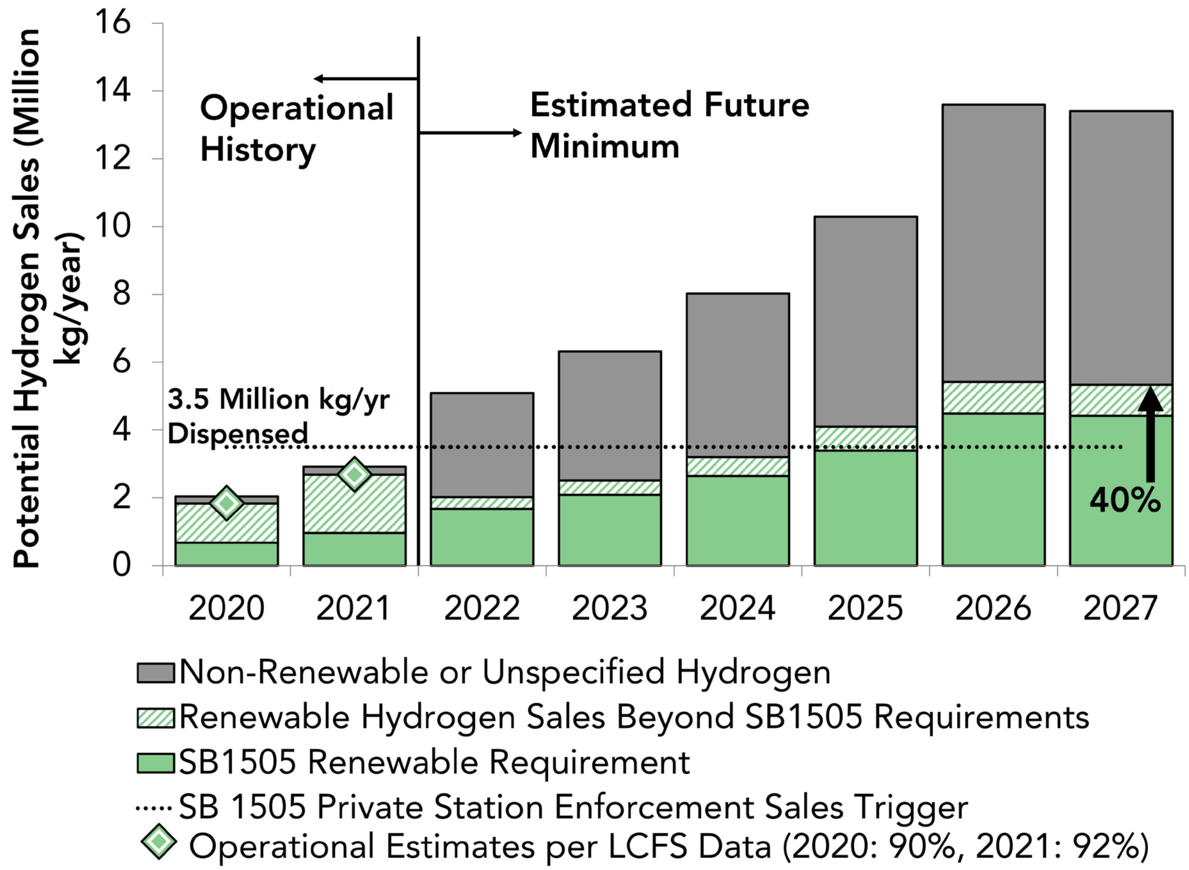
On the other hand, this also may imply a risk that the planned network will achieve less extensive coverage than the reference scenario outlines. Fewer stations may result in fewer opportunities to extend the total reach of coverage and result in some local communities waiting longer for development of nearby hydrogen fueling stations than outlined in the reference self-sufficiency scenario. This is indeed the case based on the 110 stations that currently have a location specified. The planned network is less regionally diverse and more concentrated in the Greater Los Angeles, Orange County, and San Francisco Bay Area regions than the network in the reference self-sufficiency study. This is made apparent in the analysis presented in Figure 26 and Figure 27. Careful analysis of needs in established and not-yet-activated fueling markets should be considered by all station developers going forward.

Courtesy of Air Products and Chemicals, Inc.

Renewable Content of California's Hydrogen Fueling Network

California's hydrogen fueling stations are subject to requirements of minimum renewable sourcing for hydrogen fuel sold at their stations. SB 1505 first established a minimum requirement that all stations receiving State funding must dispense hydrogen of at least 33.3 percent renewable content. State-run support programs have ensured this by adopting minimum renewable requirements that meet or exceed this benchmark. Grant solicitations administered by the CEC through GFO-15-605 required stations to operate at least at the 33.3 percent minimum and also awarded some stations with a requirement for 100 percent renewable fuel dispensing. When the LCFS program developed the HRI provision, the regulation included a minimum 40 percent renewable requirement for stations participating in the program. The CEC's latest solicitation, GFO-19-602, also adopted the 40 percent minimum requirement.

Figure 31: Evaluation of Minimum Renewable Hydrogen Content in California's Fueling Network



All of the stations funded through GFO-19-602 are subject to a minimum 40 percent renewable content requirement. All of the privately funded stations either were already included in the HRI provision of the LCFS program or have since enrolled in the HRI provision of the LCFS program. Therefore, all hydrogen fueling stations evaluated in this report are subject either to an earlier 33.3 percent minimum renewable hydrogen requirement, an earlier 100 percent renewable requirement, or a more recent 40 percent renewable requirement. In most of these cases, the renewable requirement is evaluated as an average across a developer's portfolio of stations. Therefore, some stations may dispense less renewable hydrogen while others dispense more renewable hydrogen in order to meet their requirements.

The resulting estimated renewable and non-renewable hydrogen fuel sales between 2020 and 2027 are shown in Figure 31. As in previous years, CARB has based this analysis of hydrogen fuel sales on estimates of statewide hydrogen demand and hydrogen capacity. The analysis does not consider more localized distribution of demand and capacity at finer resolutions of region, county, or smaller areas. Fuel sales are estimated to be equal to the lesser of demand and capacity. As shown in Figure 30, demand is expected to be the limiting factor in sales for all years in this analysis.

Attribution of fuel sales to currently funded stations (the 110 stations with known addresses, shown in Figure 11) and future stations (the 66 stations expected from GFO-19-602 that do not yet have an address) was based on the proportion of total statewide capacity of stations within each group. This is a slightly different method than in prior years, when demand was attributed first to funded stations until their capacity was all accounted for and then to future stations. The analysis method in this year's report has shifted given the greater certainty of future station development provided by GFO-19-602.

As Figure 31 shows, California's hydrogen fueling network is expected to achieve and maintain at least 40 percent renewable hydrogen sales through 2027. The size and number of stations funded under GFO-19-602 and participating in the HRI program is the primary driver for ensuring that hydrogen fuel sold in California will at least meet the 40 percent renewable estimate. This exceeds the minimum statutory requirement of 33.3 percent per SB 1505. This minimum requirement currently applies only to hydrogen fueling stations that receive State support. SB 1505 also stipulates that once annual hydrogen sales exceed 3.5 million kilograms in a given year, all stations in the state (whether they receive State support or not) must meet the minimum 33.3 percent renewable requirement. Figure 31 shows that this minimum sales trigger is likely to be crossed before the end of 2022. So far, all known privately funded stations participate in the HRI program and therefore meet SB 1505 requirements.

CARB considers the 40 percent renewable estimate to be a minimum expectation of future network performance, based on minimum requirements in State support programs. In the past two years, CARB has received reports that station operators are far exceeding these minimum requirements. Station data available to the LCFS program so far appears to support these claims. As reported in the 2020 *Annual Evaluation*, some operators in 2020 were able to dispense hydrogen at or very near 100 percent renewable content across their entire network of stations. Because of these operators, the network average renewable content was estimated to be 90 percent (based on data available from operators participating in the LCFS program and minimum requirements for hydrogen sold at all other stations) for at least some portion of 2020. This appears to have continued into 2021 as data from participating entities in the HRI program indicates that they are dispensing hydrogen with at least 92 percent renewable content. Similar to reporting in 2020, this has occurred because one or more station operators have reported sustaining the renewable content of fuel sold at or near 100 percent. The conditions that allowed these high-renewable hydrogen sales are not yet guaranteed to continue into the future, so CARB only considers these for historical reference points and does not project the same for the future network. Even so, these data offer a positive indication of the potential to continue expanding renewable hydrogen implementation in California's fueling network.

Hydrogen Fueling Station Performance Standards and Technology

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.

Open-Retail stations in California's hydrogen fueling network are expected to be built and operated in accordance with the latest available industry-accepted standards and test methods. Standards for hydrogen fueling stations ensure that customers receive a safe, fast, full, and reliable fill at California's hydrogen fueling stations. Standards and testing programs also ensure that drivers receive fuel that is free of contaminants that could degrade fuel cell performance or potentially cause permanent harm to their vehicle's fuel cell stack. State efforts also ensure that measurements of the amount of fuel sold in each transaction are accurate, providing the customer reassurance that they receive the amount of fuel they pay for and providing the station operator assurance that they have received the correct payment for the fuel they have sold.

The relevant codes, standards, and test procedures related to hydrogen fueling stations continuously evolve as the industry introduces new technology or innovations, and as needs for improvement are identified. As these reference documents change, so do State programs designed to ensure their consistent implementation across the hydrogen fueling network. Much of the development over the past year has been focused on the testing and verification of hydrogen stations' ability to follow the industry-accepted standard fueling protocol.

SAE J2601 is the standard that provides guidance on the expected filling process and rate of transfer of hydrogen fuel from the station's storage to the vehicle's onboard tank. The protocol is critical to ensuring that fuel is transferred quickly and safely, providing fueling customers with a complete fill in five minutes or less. The standard is able to be applied dynamically and specify fueling rates specific to ambient conditions and the initial state of the consumer's hydrogen tank and the station equipment. The 2020 *Annual Evaluation* highlighted the publication of the latest version in May 2020.

California's Hydrogen Station Equipment Performance (HyStEP) device and program has been a vital tool to ensure that stations perform fills as described by SAE J2601. Prior reports have also outlined how the HyStEP program has enabled streamlined and faster testing of station fill protocols. Prior to the development of the HyStEP device, station developers would need to coordinate with individual auto manufacturers to schedule testing of the station with their own vehicles or devices. Often times, multiple tests were required and scheduling could span months. The HyStEP device provides a single and comprehensive point of reference for station testing and is better able to provide support for on-site station tuning in order to demonstrate conformance with SAE J2601 protocols.

Several important developments related to the HyStEP program and device have occurred over the past year.

Updates to Standards and Test Protocols

In the 2020 *Annual Evaluation*, CARB reported on the adoption of the 2020 version of the fueling protocol SAE J2601. The HyStEP device checks a station's ability to follow this protocol through a standard test procedure outlined in CSA/ANSI HGV 4.3, which establishes the test method, criteria, and device to confirm a station's dispensing system complies with SAE J2601 and SAE J2799 (the industry-adopted standard protocol for communication between the station and the vehicle). Given the updates in SAE J2601, correlating updates were necessary for CSA/ANSI HGV 4.3. The updates include a new hydrogen storage system category (more than 10 kg of storage at 70 MPa), expanded pressure tolerances criteria, and various clarifications. As of the time of writing this report, the 2021 version of CSA/ANSI HGV 4.3 has not yet been published, but it is expected to be released later this year. Future station development will need to account for this updated station testing procedure. SAE J2600, which addresses design and testing of hydrogen fueling connectors, nozzles, and receptacles is also currently under revision.

In addition, the National Fire Protection Association (NFPA) published an update to its Hydrogen Technologies Code early in 2020. This code outlines several provisions that ensure the safe installation and operation of compressed gas and liquid hydrogen equipment, including hydrogen fueling station equipment. Since the publication of this national document, the California Office of the State Fire Marshal has adopted NFPA 2 and its provisions will become enforceable in California on July 1, 2021. Station developers and operators must ensure that their future development plans are in accordance with the guidance outlined in the revised 2020 version of NFPA 2.

Heavy-Duty Stations Field Tested with HyStEP

Over the past few years, public and private stakeholders have demonstrated growing interest in the development of zero-emission options for medium- and heavy-duty vehicles. Efforts have been directed at developing both BEVs and FCEVs in these larger and commercial vehicle classes along with solutions for their charging and fueling infrastructure needs. Several recent actions in California reinforce a transition to these zero-emission options. CARB recently adopted the Advance Clean Truck (which establishes a ZEV sales requirement for manufacturers) and Innovative Clean Transit (which requires transit agencies to establish a transition path to 100 percent ZEVs) regulations. CARB is also currently developing the Advanced Clean Fleet rule to establish zero-emission truck and bus procurement requirements for fleet operators. These efforts encourage ZEV market development towards the goals outlined in EO N-79-20.

As with the deployment of light-duty ZEVs, charging and fueling infrastructure development for these fleets is a primary challenge for market initiation and growth. Both CARB and the CEC have co-funded some of the first medium- and heavy-duty hydrogen fueling infrastructure developments in California. Recently, the HyStEP device was utilized to perform preliminary testing of two of these stations, located in Ontario and the Port of Los Angeles. These stations are designed and operated by Shell and hydrogen station equipment provider Nel. Both are intended to support the operation of class 8 FCEV drayage trucks designed by Toyota and Kenworth.

The HyStEP device was originally designed to test light-duty hydrogen fueling stations and there are usually important differences in design between stations meant to fuel light-duty and heavy-duty vehicles. However, the design of the on-board hydrogen storage system for the drayage trucks and the station dispensing equipment does allow for testing using the HyStEP device. The stations are designed to fuel vehicles according to the Japanese industry standard JPEC-S 0003 (2016). The JPEC-S standard is derived from SAE J2601, though it also specifies protocols to fill larger tanks at slower pressure ramp rates than included in SAE J2601. Since HyStEP is designed for confirmation of the SAE J2601 protocol, it is not capable of evaluating the full range of protocols within JPEC-S 0003 but can provide preliminary guidance on station performance.

The HyStEP device was used to complete all general fault tests, all communications tests, and some large (up to 9 kg) fill events at each of the two dispensers at each facility (a total of four dispensers tested). Testing was successful and no safety issues were identified at either location. Data provided by the HyStEP evaluation also helped the station developers identify opportunities to improve performance, especially to enhance reliability in providing full fills for consecutive fueling events. The project partners for each station continue to collaborate on improving station performance through the commissioning and testing process.

Updates to the Development of a Hydrogen Station Testing Regulation

Today, nearly all stations that are either Open-Retail or under development have received co-funding through the CEC. The co-funding agreements require station operators to certify their stations have been tested for their ability to meet the requirements of SAE J2601, which is typically accomplished through the HyStEP program. Stations that are completely privately funded currently do not face similar requirements. Over the past few years, CARB has explored ways to ensure that privately funded stations perform this vital step in station testing and validation. Additionally, with the large number of new stations projected to be built over the next few years and limited testing capacity, CARB is looking for ways to ensure that all stations have the ability to undergo testing in a timely manner.

Originally, CARB considered promulgating a regulation that would achieve these objectives. After reviewing input from a number of internal and external stakeholders, CARB is now exploring other pathways to achieve the same goals in a more efficient manner. Specifically, CARB is looking to partner with other State departments or agencies to implement a more formal testing program that will apply to all stations, regardless of funding source, and allow qualified third parties to conduct station testing. Additionally, this partnership may enable fees to be collected, thereby ensuring long term financial stability for the station testing program. If this partnership is successful, it would provide a pathway to establish a well regulated, private market for station and dispenser testing and greatly expand the current capacity and ability to test stations.

Development of a new HyStEP Station Testing Device

CARB and the CEC have been collaborating to secure funding for a second, updated HyStEP device. As Figure ES 2 demonstrates, the pace of station development is expected to significantly accelerate in the coming years. As many as 30 new stations may become Open-Retail in some years; all of these stations will require some form of station testing and verification. As an addition to the current HyStEP testing device, a new and updated device will help CARB ensure availability of test equipment to meet the demanding schedule of testing currently projected through 2026. CARB would also support the establishment of independent, private testing companies to provide services in California once the hydrogen station testing regulation is in place. If station network development continues to expand beyond the current projections, the needs for additional station testing capacity will only become greater. There is a clear need for the State to have additional resources available to ensure that station testing does not become a bottleneck in development schedules, both to complement private testing services and to audit station performance as needed.

The new HyStEP device will be more capable than the original version. The new device will be able to perform tests in accordance with the latest 2020 version of the SAE J2601 protocol and perform fill tests for larger vehicle tank sizes. The ability to test larger tank sizes will allow the device to more effectively test stations designed to serve the medium- and heavy-duty sector. The new device may also have improved capability to test the back-to-back fueling performance of hydrogen stations, evaluating the station's ability to maintain performance for multiple vehicle fueling events in a row. Back-to-back fueling capability is not a requirement addressed by SAE J2601, but it is a highly desirable performance feature and minimum requirements are outlined in CEC co-funding agreements. Back-to-back performance also has implications for daily station fueling capacity, which is a critical factor in credit generation through the LCFS HRI provision. These more rigorous tests will provide station developers and other stakeholders with critical information on opportunities to improved station equipment design and performance.

The CEC has developed a contract with the National Renewable Energy Laboratory (NREL) to develop a design for the new HyStEP device. NREL also designed the first HyStEP device. The design process is expected to begin soon and will incorporate feedback provided by the public and stakeholders through a workshop process. Once the design is complete, CARB is expected to administer a solicitation to identify a qualified organization to build the new HyStEP device. Funds for the device construction will be provided by the CEC and staff from both agencies have developed an interagency agreement to finalize this transfer of funds. The CEC approved the interagency agreement at the June, 2021, CEC Business Meeting. The projected schedule for project completion is currently in development, though current estimates anticipate the device could be built and delivered to California in 2024.

Conclusions and Recommendations

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.

The outlook for hydrogen fueling network development in California is stronger than it has ever been. The assurance and ability to implement long-term planning provided by the structure of GFO-19-602 has fundamentally altered the projected network development in California. The Clean Transportation Program will co-fund and enable development of far more than the minimum 100 stations referenced in AB 8 and bring the state very near to the additional 2025 goal for 200 stations as set by EO B-48-18. Simultaneous advances in station cost and size demonstrate that CEC's implementation of GFO-19-602 was also successful in catalyzing important steps in developing economies of scale. Comparisons to prior scenario analysis also demonstrate the potential to set in-state network development on a path of financial self-sufficiency.

These new developments in projected hydrogen fueling network development create unprecedented potential for FCEV deployment, and auto manufacturers have begun to positively respond to this new opportunity. For the first time since reporting began in 2014, CARB projects that the development of the hydrogen fueling network will significantly outpace projected FCEV deployment. This provides auto manufacturers with critical assurance that an extensive network of hydrogen fueling stations will be available for customers who choose to adopt this zero-emission technology. While auto manufacturers appear to have begun acknowledging this potential, CARB estimates that auto manufactures could deploy as many as four times the amount of FCEVs as currently projected through 2026.

The greatest challenge facing public and private stakeholders alike is now ensuring that potential is delivered. To continue maximizing the opportunities presented by the current plans for network development, CARB draws the following conclusions and recommendations for public and private entities alike in continuing collaboration:

- **Ensure that future hydrogen fueling network development continues as close as possible to the pace of current projections.** With the awards made through GFO-19-602, the CEC has provided substantial assurance for future co-funding of hydrogen fueling stations in California. The resulting awards anticipate accelerated network development that can usher in a new phase of FCEV market growth beyond the very first adopters. Significant promise is represented by the 94 new and four upgraded station projects under the solicitation. Delivering on the promise presented by these stations should be a primary effort of participating public and private stakeholders. The ability to identify, design, build, test, and open stations on time will be critical to building momentum for further FCEV deployment. The current schedule of network capacity growth and FCEV deployment potential matches well with prior studies of approaches to hydrogen fueling network financial self-sufficiency. All parties involved should work to ensure that the actual development stays as close as possible to this plan in order to provide the best chance at achieving self-sufficiency within the decade.

- **Projected network development provides substantial opportunity for FCEV deployment beyond current projections.** The announcement of station development awards through GFO-19-602 appears to have had a positive effect on auto manufacturers' future FCEV deployment plans in California. Projections for FCEV deployments in the most recent annual survey are the first in the last three years to show growth in expected vehicle deployment in both the near-term and the long-term. This indicates improvement in auto manufacturers' sentiment on deployment potential, but that improvement is noticeably short of the potential provided by the planned network. With the current estimated station development schedule, auto manufacturers could deploy several times the amount of FCEVs by 2026 as has been communicated to CARB. As highlighted in CARB's *Self-Sufficiency Analysis*, the pace of network development is a key factor to achieving self-sufficiency by 2030 and a commensurate pace of FCEV deployment is equally as important. Collaborative efforts between public and private stakeholders should place emphasis on further accelerating future FCEV deployment.
- **The budget outlined in SB 129 offers an opportunity for California to narrow the gap to the EO B-48-18 goal of 200 stations.** The stations awarded co-funding under GFO-19-602 and the announcement of 23 additional privately funded stations may result in 100 hydrogen fueling stations reaching Open-Retail status by the start of 2024. The 100-station goal of AB 8 can therefore be met by 2023 if station development timelines remain close to current projections. This is a major milestone in the process of establishing an in-state hydrogen fueling and FCEV market and on the path towards ultimately achieving self-sufficiency. The next step is to meet the goal of EO B-48-18 and achieve at least 200 Open-Retail stations by the end of 2025. As discussed in prior reports, this follow-up milestone is well-matched to a path towards self-sufficiency. Reaching both the 100 and 200 station goals on-time is therefore critical to eventual market success. Prior to SB 129, known network development plans would fall short of the goal of 200 stations by 2025. The funding in SB 129 offers an opportunity for public funding to help close this gap with coinciding private funding and crediting under the LCFS HRI program. It will be important for policymakers to review many factors, including ongoing vehicle deployments, as they make further funding choices.
- **Encourage further hydrogen station network development in both established and new markets.** Most of the Open-Retail and planned hydrogen fueling station network is located in the Greater Los Angeles, Orange County, Sacramento, San Diego County, and San Francisco Bay Area regions. Awards made under GFO-19-602 that currently have a known address will significantly enhance and extend the coverage of the fueling network within these regions and in some new markets, especially in Riverside and San Bernardino counties. As these stations are developed, some of these regions will continue to have a need for increased coverage and capacity growth, though the need in established markets with the most development will be significantly reduced. At the same time, many potential markets for future development across the state do not yet have any network development planned. The relative importance of initiating coverage and capacity in these new markets will be at least as high as reinforcing the coverage and capacity in many of the established markets. Initiating network development will be important in several cities in the San Joaquin Valley along the California-99 highway, along the Central Coast, near Palm Springs, and near the northern California cities of Eureka and Chico. All of these areas should be considered seriously by station developers who should be encouraged to look for opportunities for market development in these new areas in addition to more established markets.

- **Ensure that hydrogen supply, especially renewable hydrogen, does not become a bottleneck to successful hydrogen station network development and operation.** Among the challenges to launch a viable in-state FCEV market, establishing a network of hydrogen fueling stations has received most of the State support so far. Vehicle deployment is inherently tied to network development so an early start to building hydrogen stations was necessary to create opportunities for customers to adopt FCEVs. Awards made through GFO-19-602 have helped California take a significant leap toward establishing a complete hydrogen fueling network that provides similar convenience as today's gasoline station network. Many more stations will be necessary to fully achieve gasoline network convenience, but the solicitation awards provide strong assurance of future growth. As statewide fueling capacity grows, the ability to maintain hydrogen supply will become increasingly important and maintaining a consistent supply of renewably sourced hydrogen will present additional challenges.

  The CEC has begun to address renewable hydrogen fuel production cvapacity through two solicitations for facilities that generate one hundred percent renewable hydrogen (one that was previously awarded in 2018 and another for which applications are currently under review). Industry members are also taking significant steps to increase hydrogen fuel production and delivery capacity. These are all positive actions that will be necessary to keep hydrogen supply from becoming a limiting a factor in future FCEV deployment, but both public and private stakeholders should continue to anticipate a need for significantly larger growth in the future. Even the largest known facility in development – a 30,000 kg/day hydrogen production facility under development in Nevada by Air Liquide – represents less than twenty percent of the projected network fueling capacity by 2027 and is approximately seventy percent of the estimated fuel demand of the 61,100 FCEVs projected on the road in 2027. Hydrogen production capacity, especially renewable hydrogen, will continue to grow in importance as network development progresses.

Courtesy of First Element, Inc.

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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

Table 6: List of Hydrogen Fueling Station Data as of May 6, 2021

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%
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 Street	Hayward	266	2016	Alameda	40%
Hollywood	5700 Hollywood Blvd	Los Angeles	266	2016	Los Angeles	40%
La Cañada-Flintridge	550 Foothill Blvd	La Cañada 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 Highway	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 Avenue	Lawndale	180	2017	Los Angeles	33%
Riverside	8095 Lincoln Avenue	Riverside	100	2017	Riverside	33%
San Ramon	2451 Bishop Drive	San Ramon	350	2017	Contra Costa	33%
South Pasadena	1200 Fair Oaks Ave	South Pasadena	206	2017	Los Angeles	40%
Citrus Heights	6141 Greenback Lane	Citrus Heights	513	2018	Sacramento	40%
Emeryville	1152 45th St	Emeryville	350	2018	Alameda	100%
LAX	10400 Aviation Drive	Los Angeles	200	2018	Los Angeles	40%

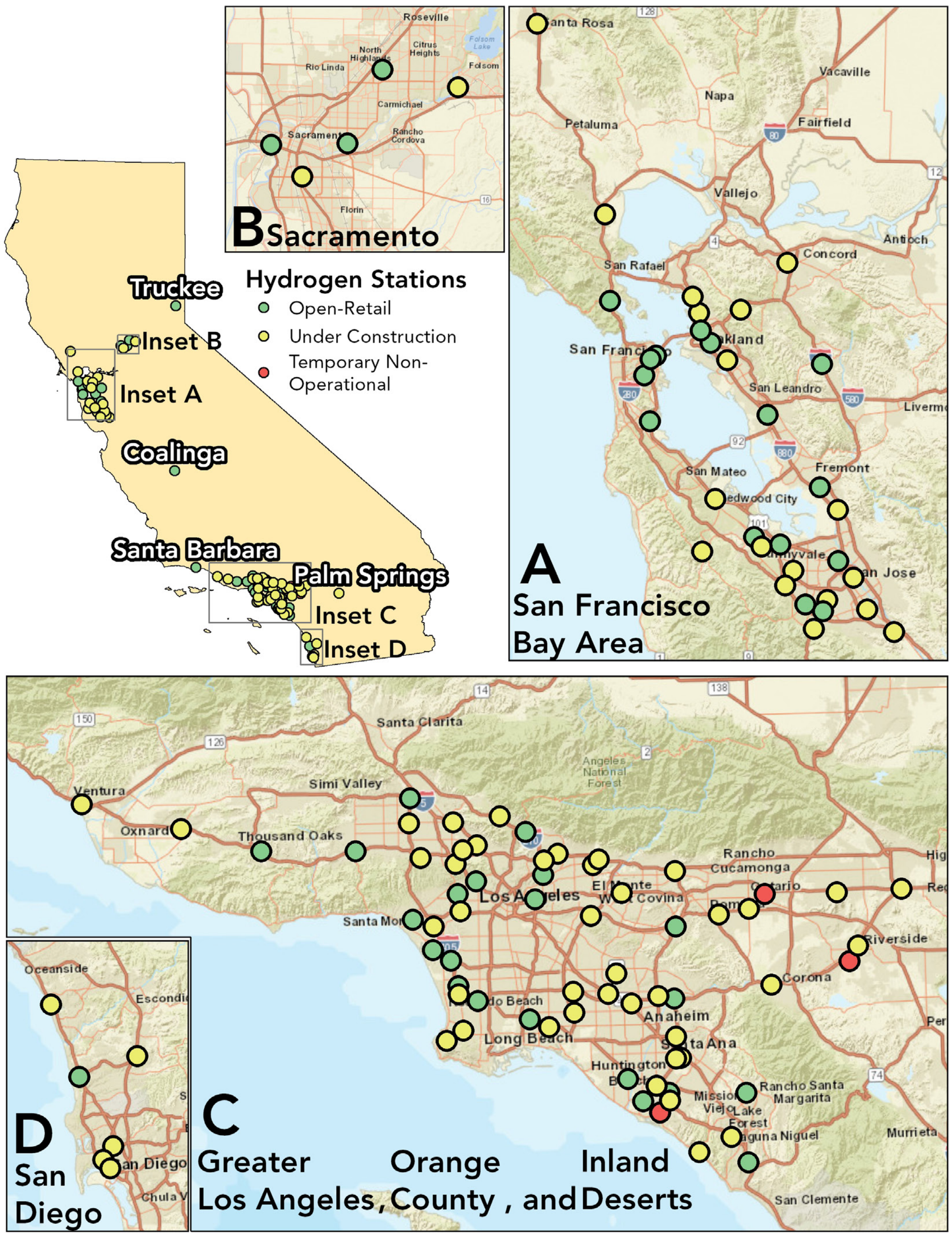
Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Mountain View	830 Leong Drive	Mountain View	350	2018	Santa Clara	33%
Ontario	1850 Holt Blvd	Ontario	100	2018	San Bernardino	100%
Palo Alto	3601 El Camino Real	Palo Alto	136	2018	Santa Clara	40%
Thousand Oaks	3102 Thousand Oaks Blvd	Thousand Oaks	266	2018	Ventura	40%
CSULA	5151 State University Dr	Los Angeles	60	2019	Los Angeles	100%
Oakland	350 Grand Ave	Oakland	808	2019	Alameda	40%
Sacramento	3510 Fair Oaks Blvd	Sacramento	513	2019	Sacramento	40%
San Francisco-Harrison Street	1201 Harrison Street	San Francisco	513	2019	San Francisco	40%
San Francisco-Third Street	551 Third Street	San Francisco	513	2019	San Francisco	40%
Fountain Valley	18480 Brookhurst St	Fountain Valley	1200	2020	Orange	40%
Mission Hills	15544 San Fernando Mission Road	Mission Hills	1200	2020	Los Angeles	40%
San Francisco-Mission Street	3550 Mission Street	San Francisco	513	2020	San Francisco	40%
Aliso Viejo	26813 La Paz Road	Aliso Viejo	1200	2021	Orange	40%
Baldwin Park	14477 Merced Ave	Baldwin Park	1200	2021	Los Angeles	40%
Berkeley	1250 University Ave	Berkeley	513	2021	Alameda	40%
Campbell-Hamilton	337 E Hamilton Ave	Campbell	1200	2021	Santa Clara	40%
Concord	605 Contra Costa Boulevard	Concord	1200	2021	Contra Costa	40%
Costa Mesa-Bristol	2995 Bristol St	Costa Mesa	1200	2021	Orange	40%
Cupertino	21530 Stevens Creek Blvd	Cupertino	1200	2021	Santa Clara	40%
Hawaiian Gardens	11807 Carson Street	Hawaiian Gardens	1436	2021	Los Angeles	40%
Orange	615 South Tustin St	Orange	1200	2021	Orange	40%
Placentia	313 West Orangethorpe Ave	Placentia	1200	2021	Orange	40%
Redwood City	503 Whipple Ave	Redwood City	1200	2021	San Mateo	40%
San Diego	5494 Mission Center Road	San Diego	1200	2021	San Diego	40%
San Jose-Bernal	101 Bernal Rd	San Jose	513	2021	Santa Clara	40%
Santa Ana	2120 East McFadden Avenue	Santa Ana	1436	2021	Orange	40%
Sherman Oaks	14478 Ventura Blvd	Sherman Oaks	808	2021	Los Angeles	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Studio City	3780 Cahuenga Blvd	North Hollywood	808	2021	Los Angeles	40%
Sunnyvale	1296 Sunnyvale Saratoga	Sunnyvale	1200	2021	Santa Clara	40%
UC Irvine (New Planned 2021)	100 Academy Way	Irvine	1212	2021	Orange	40%
Anaheim-Euclid	1100 North Euclid Street	Anaheim	956	2022	Orange	40%
Artesia	17325 Pioneer Blvd.	Artesia	770	2022	Los Angeles	40%
Buena Park	6392 Beach Boulevard	Buena Park	1616	2022	Orange	40%
Burbank	145 W Verdugo Rd	Burbank	100	2022	Los Angeles	33%
Burbank-Hollywood	800 N. Hollywood Way	Burbank	1616	2022	Los Angeles	40%
Carlsbad	7170 Avenida Encinas	Carlsbad	770	2022	San Diego	40%
Chino	12610 East End Ave	Chino	100	2022	San Bernardino	100%
City of Industry	2600 Pellissier Pl	City Of Industry	770	2022	Los Angeles	40%
Corona	616 Paseo Grande	Corona	956	2022	Riverside	40%
El Cerrito	3160 Carlson Blvd	El Cerrito	1616	2022	Contra Costa	40%
Fontana	16880 Slover Ave	Fontana	1436	2022	San Bernardino	40%
Fremont-Warm Springs	47700 Warm Springs Boulevard	Fremont	1616	2022	Alameda	40%
Glendale	3402 Foothill Blvd	La Crescenta	1616	2022	Los Angeles	40%
La Mirada	13550 South Beach Boulevard	La Mirada	956	2022	Los Angeles	40%
Laguna Beach	104 North Coast Highway	Laguna Beach	1200	2022	Orange	33%
Long Beach-Lakewood	2589 N Lakewood Blvd	Long Beach	770	2022	Los Angeles	40%
Los Altos	988 N. San Antonio Rd	Los Altos	1616	2022	Santa Clara	40%
Los Angeles-Washington	5164 W Washington Blvd	Los Angeles	770	2022	Los Angeles	40%
Los Gatos	666 N. Santa Cruz Avenue	Los Gatos	1616	2022	Santa Clara	40%
Monrovia	705 West Huntington Dr	Monrovia	770	2022	Los Angeles	40%
Newport Beach	1600 Jamboree Road	Newport Beach	1540	2022	Orange	33%
Ontario-Euclid	2160 S. Euclid Avenue	Ontario	1616	2022	San Bernardino	40%
Pasadena-Arroyo	290 S. Arroyo Pkwy	Pasadena	770	2022	Los Angeles	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Redondo Beach	2714 Artesia Boulevard	Redondo Beach	1436	2022	Los Angeles	40%
Sacramento-Martin Luther King	5551 Martin Luther King Jr. Blvd	Sacramento	770	2022	Sacramento	40%
San Bernardino	1930 South Waterman Avenue	San Bernardino	1616	2022	San Bernardino	40%
San Diego-First	1666 1st Avenue	San Diego	1616	2022	San Diego	40%
San Diego-Rancho Carmel	11030 Rancho Carmel Drive	San Diego	1616	2022	San Diego	40%
San Diego-Washington	1832 West Washington Street	San Diego	1200	2022	San Diego	40%
San Jose-Santa Clara	510 E. Santa Clara Street	San Jose	1616	2022	Santa Clara	40%
San Jose-Snell	3939 Snell Ave	San Jose	1200	2022	Santa Clara	40%
Seal Beach	13980 Seal Beach Blvd	Seal Beach	808	2022	Orange	40%
Sun Valley	10908 Roscoe Blvd	Sun Valley	770	2022	Los Angeles	40%
Torrance	2051 W 190th St	Torrance	1616	2022	Los Angeles	33%
Torrance-Hawthorne	24505 Hawthorne Boulevard	Torrance	1616	2022	Los Angeles	40%
Woodside	17287 Skyline Blvd	Woodside	140	2022	San Mateo	33%
Folsom	13397 Folsom Blvd	Folsom	770	2023	Sacramento	40%
Novato	5821 Nave Dr	Novato	770	2023	Marin	40%
Santa Rosa	266 College Ave	Santa Rosa	770	2023	Sonoma	40%
Arcadia	102 E Duarte Road	Arcadia	1616	2024	Los Angeles	40%
Oakland-Foothill	4280 Foothill Boulevard	Oakland	1616	2024	Alameda	40%
San Dimas	1110 W. Gladstone Street	San Dimas	1616	2024	Los Angeles	40%
Tustin	14244 Newport Avenue	Tustin	1616	2024	Orange	40%
Camarillo	2911 Petit Street	Camarillo	1616	2025	Ventura	40%
Orinda	67 Moraga Way	Orinda	1616	2025	Contra Costa	40%
Pasadena-Allen	475 N. Allen Avenue	Pasadena	1616	2025	Los Angeles	40%
Riverside-Central	3505 Central Avenue	Riverside	1616	2025	Riverside	40%
Van Nuys	15710 Roscoe Boulevard	Van Nuys	1616	2025	Los Angeles	40%
Ventura	2121 Harbor Boulevard	Ventura	1616	2025	Ventura	40%

Appendix C: Auto Manufacturer Survey Material

Figure 32: Statewide Station Map for 2021 Survey



Appendix D: Station Status Definition Details

The new awards for station development made by the CEC through GFO-19-602 have significantly expanded the future outlook of hydrogen fueling network development in California. This *Annual Evaluation* adopts a set of station status definitions designed to reflect the current state of the operating and planned hydrogen fueling network. Definitions remain aligned with those adopted by GO-Biz and other stakeholders, though this report has re-grouped some of these definitions into new categories in order to streamline reporting.

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:

Temporarily Non-Operational: These stations have previously achieved Open-Retail status in California's hydrogen fueling network, but have not been available to customers for fueling for an extended period of time. The reasons for the change in operating status vary for each station in this group. These stations are currently expected to return to Open-Retail status in the future, but the timeline is unknown.

Fully Constructed: Construction is complete at these stations and the station developer has notified the appropriate Authority Having Jurisdiction (AHJ).

Continuing Development: These stations initiated development as a result of efforts prior to awards made through GFO-19-602. These stations were initiated through prior grant funding administered by the CEC or began development as they received approval to participate in the LCFS HRI program.

Newly Under Development: Most of the stations in this group are part of Batch one in awardees' planned networks of stations through grant awards made in GFO-19-602. This group also includes stations that developers are currently building without funding through GFO-19-602.

Future Known Locations: These stations are part of Batch two in awardees' planned networks of stations through grant awards made in GFO-19-602. Per the requirements of GFO-19-602, station developers must first complete Batch one stations before being eligible for reimbursement on development of Batch two stations. Even though these locations are known via applications to GFO-19-602, construction is not expected to begin until a future date.

Future Unknown Locations: These stations are all part of awards made through GFO-19-602. These stations are included in Batch 2 or later of awardees' station development plans. Awardees were not required to provide addresses for these stations at the time of application, but will determine and share the specific locations with the Energy Commission as they complete each sequential Batch in their station construction plans.

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