CALIFORNIA
AIR RESOURCES BOARD

September 2022

2022 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)

Image 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

List of Acronyms

AB 8	Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013)
AB 128	Assembly Bill 128 (Ting, Chapter 21, Statutes of 2021)
ACC II	Advanced Clean Cars II
BEV	Battery-Electric Vehicle
CARB	California Air Resources Board
CHIT	California Hydrogen Infrastructure Tool
DAC	Disadvantaged Community
DMS	Division of Measurement Standards at the California Department of Food and Agriculture
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
HGV	Hydrogen Gas Vehicle
HRI	Hydrogen Refueling Infrastructure
HySCapE	Hydrogen Station Capacity Evaluation
HyStEP	Hydrogen Station Equipment Performance
IIJA	Infrastructure Investment and Jobs Act
LCFS	Low Carbon Fuel Standard
OEHHA	Office of Environmental Health Hazard Assessment
PHEV	Plug-In Hybrid Electric Vehicle
REC	Renewable Energy Credit, or equivalently Renewable Electricity Certificate
SB 1505	Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006)
SOSS	Station Operational Status System developed and operated by the California Fuel Cell Partnership
ZEV	Zero-Emission Vehicle

Courtesy of Shell.

Executive Summary

California is vigorously moving forward to enable a transition to zero-emission transportation across the state. This transition will include all transportation sectors: light-duty, medium-duty, heavy-duty, on-road, and off-road vehicles alike. On June 9, 2022, the California Air Resources Board (CARB) held the first public board meeting to hear and discuss staff's proposal for the Advanced Clean Cars II (ACC II) regulation. ACC II would achieve (among other goals) 100 percent zero-emission vehicle (ZEV) sales of new light-duty vehicles in California by 2035[1], as first outlined by Governor Newsom's Executive Order (EO) N-79-20 [1]. The Executive Order envisions a transformation of California's transportation sector by 2035 with individual target dates for various vehicle types and applications (such as passenger cars, drayage trucks that are used to move goods within ports and other shipping centers, etc.) [2]. Like the multiple regulations and support programs across California State agencies that aim to meet EO N-79-20's goals, ACC II will likely lead to an expansive deployment of ZEVs.

California's drivers have a wide variety of needs and expectations for their vehicles. CARB staff analysis anticipates that meeting the requirements of ACC II will require growth of hydrogen fueling and fuel cell electric vehicles (FCEVs) alongside battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), as auto manufacturers need to provide technology options for all vehicle segments, vehicle use patterns and behaviors, and individuals' access to ZEV fueling and charging infrastructure.

As FCEVs are still a relatively new technology and not familiar to much of the car-buying public, their introduction must overcome several initial hurdles, some of which have been common to other ZEV technologies. Consumers must become familiar with, and have confidence in, hydrogen fueling and fuel cell technology and feel assured that it can be safely used on a day-to-day basis. To support deployment, the customer-facing fueling infrastructure must continue to grow and the hydrogen fuel supply chain needs to mature and expand to ensure reliable, safe, and environmentally clean hydrogen production and delivery to hydrogen fueling stations.

Other continued developments across the FCEV and hydrogen fueling industry are also necessary for FCEVs to become a larger part of California's ZEV market. High initial costs for FCEVs and hydrogen fuel must decrease over time to make the vehicles a viable and affordable option for a wider consumer base. Development of codes, standards, streamlined permitting, and other policies require continual attention, improvement, and updating to promote growth of the hydrogen fueling market while protecting consumers and providing industry with predictable guidelines to participate in the market.

1 ZEVs in the proposed regulation include BEVs, FCEVs, and PHEVs, though the proposal admits a limited number of PHEVs.

California State agencies and their public and private partners have worked in varying degrees on each of these pieces with the goal of fostering the initiation and growth of a FCEV and hydrogen fueling market in the state. Each factor may require a different set of tools, support programs, and participants (public, private, or both) to ensure that FCEV use expands and becomes a viable ZEV option for an increasing number of Californians in the future.

California's Assembly Bill 8 (AB 8; Perea, Chapter 401, Statutes of 2013) most directly helps address the hurdle of fueling infrastructure. AB 8 provides the Energy Commission with up to $20 million annually through the end of 2023 to co-fund the development of hydrogen fueling stations in California [3]. The Energy Commission has used competitive grant solicitations to provide these funds to station developers since 2014. As required by AB 8, CARB has advised the Energy Commission on the use of these funds through a series of *Annual Evaluations*. AB 8 requires that these reports provide analysis of current and projected future FCEV deployment and hydrogen fueling station development, and identify needs for further hydrogen station network development[2]. These recommendations center around the location, daily fueling capacity, and technical requirements of stations to receive Energy Commission co-funding.

As outlined by AB 8, CARB staff annually perform an analysis to evaluate and report findings to the Energy Commission on "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." [3] CARB staff complete these assessments each year by evaluating data provided by auto manufacturers, station developers, and California State agencies like the Department of Motor Vehicles, Energy Commission, and Governor's Office of Business and Economic Development. CARB staff aggregate these data to report on the current status of FCEV use and hydrogen station network development, provide projections for future FCEV sales and fueling network growth, and perform geospatial analysis to identify localized gaps in coverage and daily fueling capacity to support expansion of the on-the-road FCEV fleet. This report provides these analyses with a focus on new developments and data that have become available since the publication of the 2021 *Annual Evaluation*.

The FCEV sales and hydrogen fueling markets have continued to progress in the year since the 2021 *Annual Evaluation*, and 2022 has the potential to be one of, if not the most, successful year for new retail station openings and FCEV sales in California. Acceleration in these markets has been projected for the early 2020s in prior analyses, though the timelines continue to be unpredictable, and delays are more common than advances in projected schedules. Regardless, the growth potential that has now been put in place by station funding under AB 8 is substantial and work needs to be done to ensure the benefits can be realized as quickly and as equitably as possible. Considering the recent changes in trends for current and future FCEV deployment and hydrogen fueling station network development, CARB staff have assembled the following key findings for the 2022 *Annual Evaluation*.

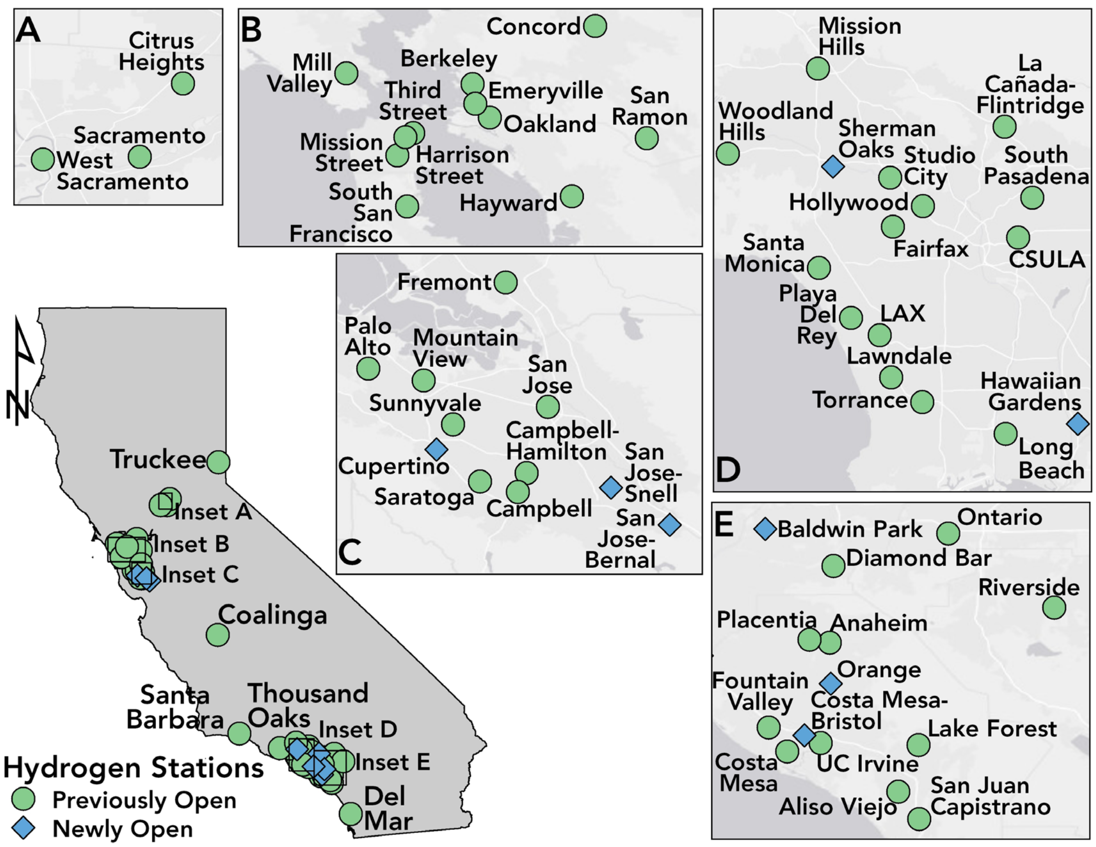
2 See *Appendix A* for an excerpt of the language of AB 8 relevant to this report.

Findings

Finding 1: California's hydrogen fueling network has grown to 60 stations, with 56 Open-Retail stations available for customer fueling as of June 30, 2022

California's hydrogen fueling network continued to expand during the year since the 2021 *Annual Evaluation*[3] was published. Eight new hydrogen fueling stations have achieved Open-Retail status and one station (Berkeley) has progressed from Temporarily Non-Operational to Open-Retail status[4]. New station openings since June of 2022 have been spread across the Greater Los Angeles, Orange County, and San Francisco Bay Area regions[5]. Figure ES 1 shows the locations of the newly opened stations: Baldwin Park, Costa Mesa-Bristol, Cupertino, Hawaiian Gardens, Orange, San Jose-Bernal, San Jose-Snell, and Sherman Oaks. These stations add a combined total of 10,209 kg/day of fueling capacity to California's network.

FIGURE ES 1: CURRENT OPEN HYDROGEN FUELING STATION NETWORK AS OF JUNE 30, 2022[6]



3 Prior *Annual Evaluations*

4 See *Appendix C* for station status definitions. In brief, Open-Retail hydrogen stations provide similar fueling service as standard gasoline stations. Temporarily Non-Operational stations were once Open-Retail but have been unavailable for an extended period of time. They are expected to return to Open-Retail status at an unknown future date. Four stations are currently in Temporarily Non-Operational status: Mountain View, Ontario, Riverside, and San Francisco- Harrison Street. The Riverside station offers fueling by appointment, though it does not fully meet the definition of Open-Retail. Appointments can be made by visiting the following link: *Riverside Station Appointment Site*

5 See *Figure 3* for definitions of these regions.

6 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 (SOSS) maintained by the California Fuel Cell Partnership and accessible at the website *m.cafcp.org*.

All new stations also offer multiple fueling positions capable of simultaneous fueling; five include four fueling positions each while the remaining three offer two fueling positions each. New and improved equipment technology that promises improved reliability and more consistent back-to-back fueling performance is also being installed at newer stations. These site designs with multiple fueling positions and large storage and dispensing capacity may provide customers with an improved fueling experience compared to older stations that have a single dispenser and lower daily fueling capacity. The larger onsite capacity helps stations be more resilient to disruptions in hydrogen supply and the multiple fueling positions enable on-site redundancy that improves overall station reliability and helps customers avoid long lines and wait times to fuel their FCEVs.

Finding 2: Station development will be slower in 2022 than previously projected, but station developer projections are relatively unchanged for 2023 and later years

While California's hydrogen fueling network has continued to grow over the past year, total progress was slower than previously projected at this same time in 2021. As shown by the dashed line in Figure ES 2, the 2021 *Annual Evaluation* projected 62 stations would be open by the end of 2021 [4]. However, as shown by the solid line in Figure ES 2, only 54 total stations were either Open-Retail or Temporarily Non-Operational by that time. In addition, previous projections indicated 97 total open stations by the end of 2022 but updated estimates by station developers indicate a total of 79 stations may be open by the end of this year. The pace of development in 2021 and 2022 will therefore be significantly slower than prior projections. Station developers report delays in equipment procurement, permit review and approval, host site owner schedules (sometimes due to other unrelated construction at the same site), and electric utility connections as common reasons for delays.

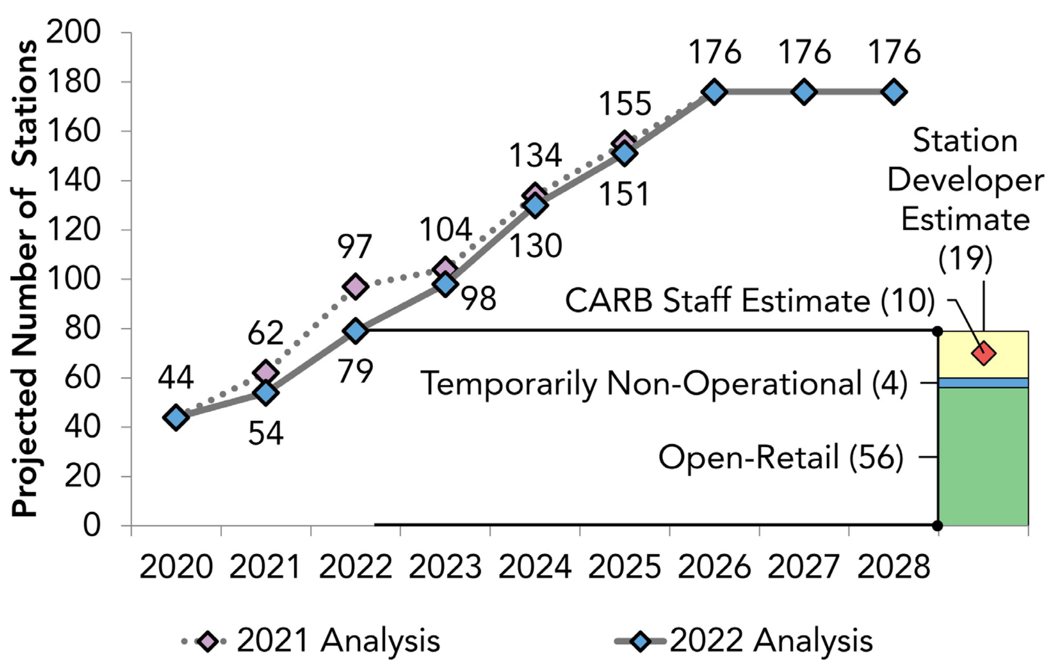
The bar chart to the right of Figure ES 2 provides a breakdown between currently open stations and estimated development (informed by station developers' schedules reported to CARB and other California State agencies earlier this year) to reach 79 open stations by the end of 2022. Reaching a total of 79 open stations by the end of 2022 will still represent a significant increase of up to 19 stations from today's open station count and, if achieved, will be the fastest pace of station openings in California history. Based on conversations related to scheduling of the Hydrogen Station Equipment Performance (HyStEP) device, CARB staff estimate that up to 10 of these 19 stations have a high likelihood of reaching Open-Retail status by the end of the year. Maintaining this projected pace will likely be a challenge given recent trends of extended station development timelines.

Even though station development pace has slowed for 2021 and 2022, station developers' current plans indicate that much of the previous projected pace can be recovered by 2023 as shown in Figure ES 2. Since most stations that were awarded grant funding in early Energy Commission solicitations are complete, schedules for future stations are primarily driven by stations awarded in grant funding opportunity (GFO) GFO-19-602. The projection made in the 2021 *Annual Evaluation* was based on station developer schedules that predominantly showed construction would complete on all stations in their first batch of stations funded under GFO-19-602 before beginning planning and construction of stations in batch two[7]. This corresponds to the slower pace of development between 2022 and 2023 in the projections made for the 2021 *Annual Evaluation*.

7 Applications to GFO-19-602 were required to define a total set of stations (termed a tranche) to be built over multiple years [13]. Each tranche was then divided into successive batches by the applicants, with each batch requiring approval by the Energy Commission. Each applicant proposed their own number of stations in each batch and their tranche in total, as well as a projected schedule of completion for each batch and the full tranche.

Since the 2021 *Annual Evaluation*, station developers have reported that they actually began planning and developing stations for future batches concurrent to batch one[8]. Concurrent development of some stations in future batches aligns with the more steady projected pace of stations reaching Open-Retail status in 2022 and 2023 in this year's *Annual Evaluation*. As a result, while station development pace for 2021-2022 is slower in this year's analysis, the overall network development projections are similar to the estimate made in 2021 for the years 2023-2026. Station developers also currently anticipate that by 2026 the network will grow to 176 Open-Retail stations, exactly matching prior projections. There is inherently more uncertainty about the timing of any station beyond the first 110, as those stations do not currently have a confirmed address and typically have a less well-defined project timeline than earlier stations.

Figure ES 2: Comparison of Statewide Funded Station Projections Between the 2021 and 2022 Annual Evaluations



8 Station developers must still obtain approval from the Energy Commission before they can be reimbursed for any eligible expenses incurred building stations in batches after the first batch. Submission of second batch (and later batch) stations cannot begin until all stations in earlier batches have received approval to build from the local authority having jurisdiction and the new proposed locations meet various critical milestones and requirements. Station developers who begin station development in any batch prior to approval have decided to absorb the risk that those stations may not be approved upon submittal to the Energy Commission.

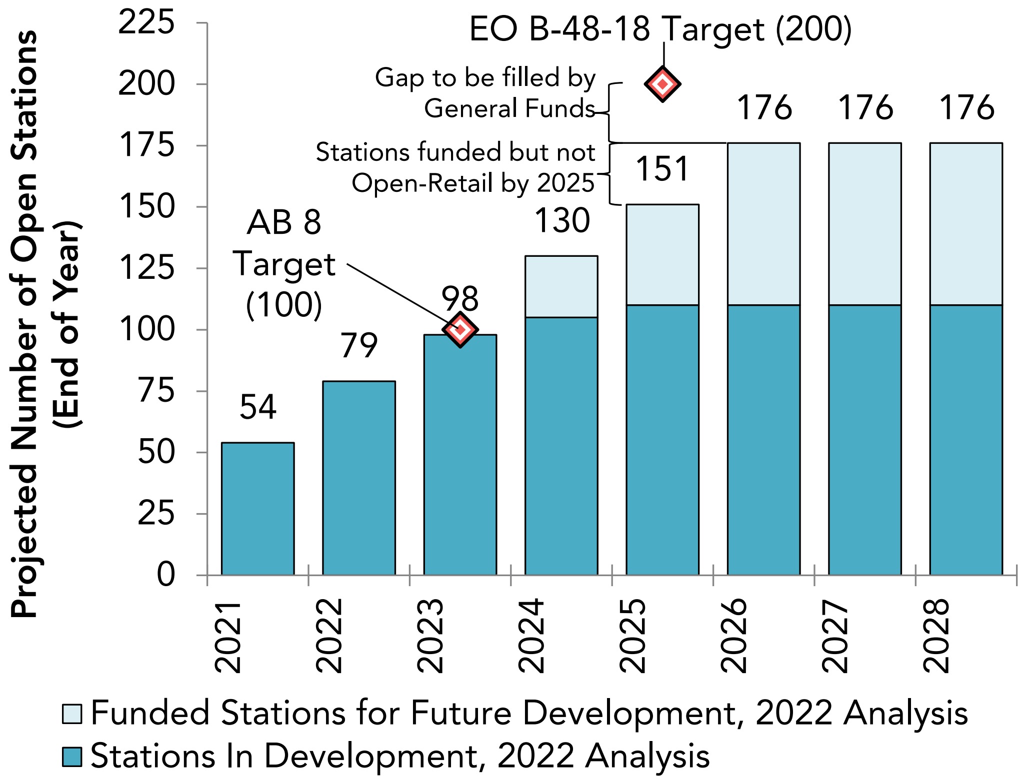
Finding 3: Extended station development timelines appear to have shifted projections for the 100th Open-Retail station to 2024

California's AB 8 requires the Energy Commission to co-fund the development of hydrogen fueling stations until there are at least 100 stations operating in the state, or CARB and the Energy Commission determine that public funds are no longer needed [3]. With the announcement of awards in GFO-19-602, the Energy Commission far surpassed this goal by committing funding as early as 2020 to more than 150 stations through the AB 8 program, with the milestone of 100 stations projected to be achieved by 2024. Subject to continued appropriation by the California State Legislature and approval by the Energy Commission, GFO-19-602 secured a funding plan three years earlier than AB 8's suggested timeline. In addition, the Energy Commission's 2021-2023 *Clean Transportation Program Investment Plan Update* indicates the addition of $27 million from California's General Fund is sufficient to close the gap to 200 hydrogen fueling stations required in EO B-48-18[9] [5], [6].

While the 2021 analysis noted that 100 Open-Retail stations could be achieved by the end of the AB 8 program in 2023, the latest station developer timelines indicate that is no longer the case. Figure ES 3 shows the latest projections of the total number of Open-Retail stations by the end of the year in 2023 through 2028. Reference points for the targets outlined by AB 8 and EO B-48-18 are also provided for comparison. As shown in Figure ES 3, if current projections can be maintained over the next year and a half, California's network will have 98 Open-Retail stations by the end of 2023 and the 100th Open-Retail station would begin operations in 2024. The 100th station is expected one year later than reported in the 2021 *Annual Evaluation* due to extended development timelines, station installations that have needed to relocate due to unforeseen challenges at their original proposed locations, and at least one station project that may be cancelled. In addition, some station developers have indicated that at least some stations intended for future development (e.g., batch two or later stations in GFO-19-602) will be delayed because stations currently under development have taken longer to complete than previously projected.

9 EO B-48-18 established direction for California government agencies to work toward specific ZEV deployment and infrastructure development goals. Among other items, EO B-48-18 established a target of 5 million ZEVs on the road by 2030, the construction and installation of 200 hydrogen fueling stations, and the construction and installation of 250,000 chargers, including 10,000 direct current fast chargers, by 2025. View the full text of *EO B-48-18*

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



Securing a plan and resources to co-fund the development of enough stations to meet the A`B 8 and EO B-48-18 goals is an important first step. Translating those goals and funding resource commitments to Open-Retail stations that are available to consumers is often a complex and time-consuming process. Each step in the process, including securing a host site, station design, permit application, parts and equipment procurement, approval to build, coordination with the local electric utility to connect electrical power, and commissioning, can present its own challenges. In general, the timeline to reach Open-Retail status has shortened over time but remains quite extensive. Station development timelines of two years or longer are not uncommon[10]. Developing solutions to shorten this timeline will likely be a key factor to ensuring that total network growth can accelerate as currently planned.

Finding 4: Updated coverage analyses continue to demonstrate that California's expanding hydrogen fueling network is conveniently located for some disadvantaged communities though gaps remain in many communities across the state

As the transition to ZEVs continues to advance in California, efforts to deploy ZEVs and develop supporting infrastructure place significant focus on meeting the needs of disadvantaged communities (DACs). Residents of these communities face disproportionate environmental and socio-economic burdens. It is important that public efforts to accelerate ZEV uptake and use ensure that residents of DACs receive the benefits of the ZEV transition alongside other communities and

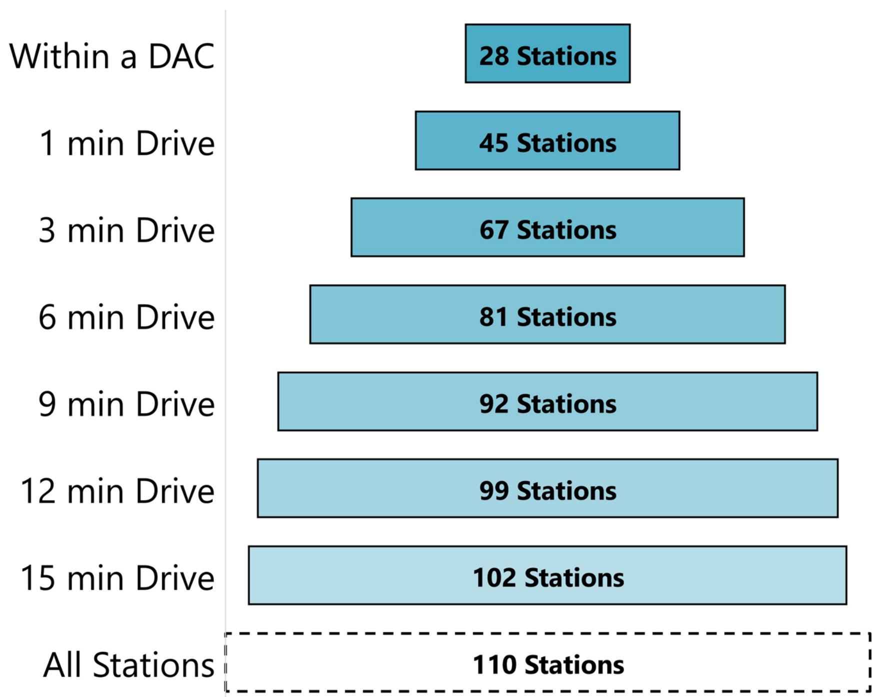
10 The 2021 *Joint Agency Staff Report* provided data demonstrating that stations funded in 2010 required approximately 1,200 to 2,000 days to open from the date of funding award, with a median of 1,415 days. The minimum, maximum, median, and mean days to open stations has generally decreased with successive solicitations. For example, stations funded in 2015 required approximately 500 to 1,500 days to open, with a median of 960 days. At the time of the 2021 *Joint Agency Staff Report*, only a few stations funded in 2020 had opened and required approximately 500 days to open.

work to eliminate disparities in communities' environmental hazards. This can be a complex task that requires spatial data and analysis related to the tens of thousands of communities in California.

To standardize identification of DACs and help public programs analyze their effectiveness at addressing these community needs, CalEPA's Office of Environmental Health Hazard Assessment (OEHHA) developed CalEnviroScreen. OEHHA launched CalEnviroScreen 4.0 in early 2022, which provided several updates to the identification of communities as DACs [7].

Analysis of open and planned hydrogen fueling stations according to the revised CalEnviroScreen 4.0 data indicates similar conclusions to prior *Annual Evaluations*. As shown in Figure ES 4, all but a few known station locations are within a 15-minute drive (considered the maximum extent of coverage) of a DAC. Figure ES 5 shows the number of stations within progressive longer driving distances of a DAC from top to bottom. Nearly 74 percent of stations are within a 6-minute drive of a DAC, which is considered to be equivalent to the convenience provided by today's gasoline fueling network [8]. The open and planned hydrogen fueling network is therefore well-positioned to meet the needs of DAC residents who may adopt FCEVs. A significant portion (62 percent) of the DAC population also lives within 15 minutes of a hydrogen station. This matches well with the portion of the general population (59 percent) living within the same distance of a hydrogen station.

Figure ES 4: Hydrogen station proximity to DACs



However, only one-quarter of the DAC and general populations live within the more standard convenience metric of a six-minute drive to a hydrogen station. Spatial analysis also indicates that most of the rural DACs and DACs with lower population density are outside of both the 6-minute and 15-minute drivetime metrics. Although hydrogen station development appears to similarly benefit some DACs alongside the general population, many DACs are not at all addressed by the open and planned hydrogen fueling network. More work must be done to ensure the hydrogen fueling network reaches all communities.

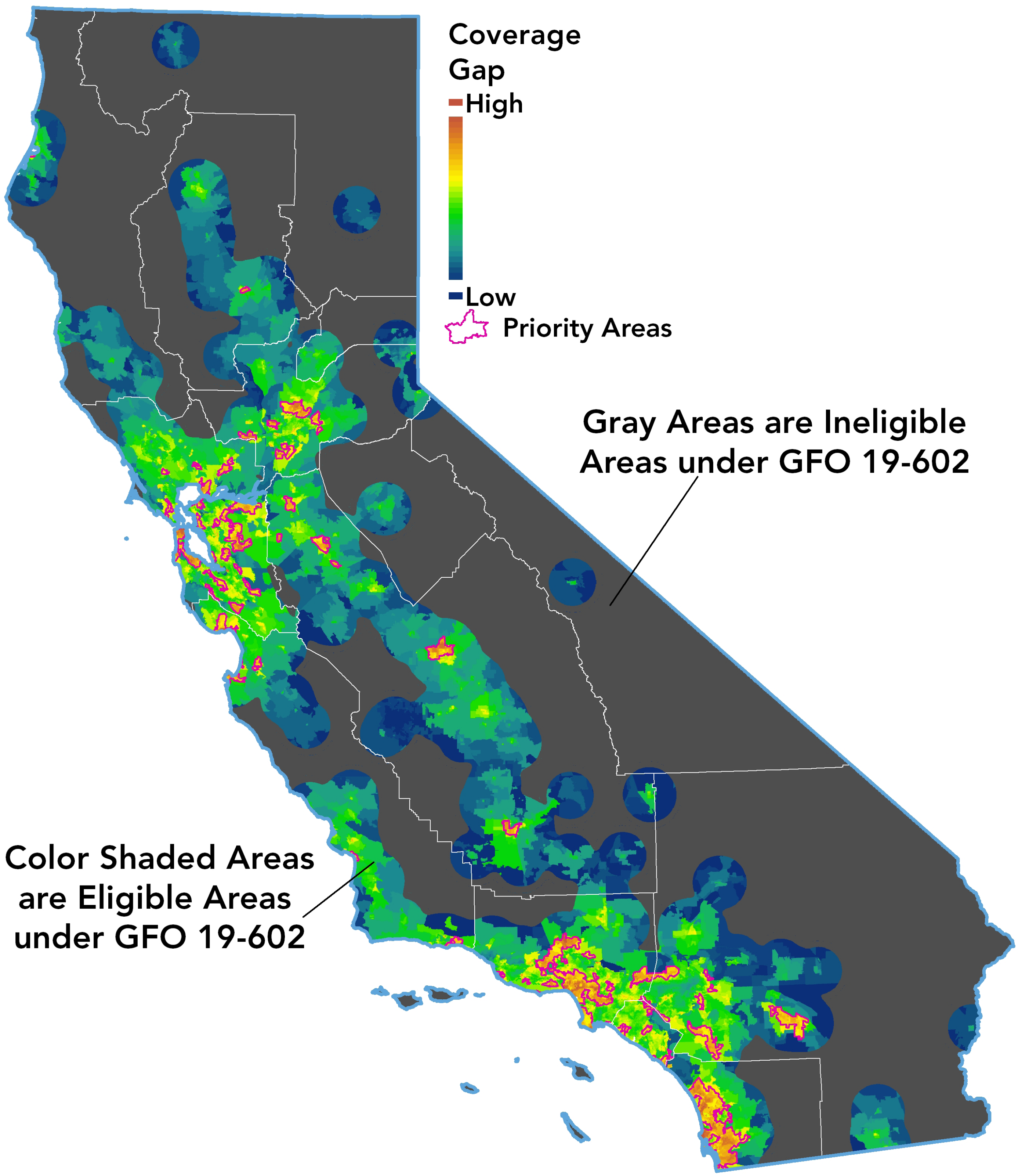
Finding 5: Analysis of hydrogen station network coverage gaps reveals opportunity for new station development remains strong in developed hydrogen fueling markets and untapped markets across the state

In the year since the 2021 *Annual Evaluation* was published, there have been some changes in the open and planned hydrogen fueling station network. Some station locations have moved, some planned projects are no longer included in the analysis because they are not anticipated to proceed, and in some cases completely new station locations have been added. Annual CARB staff analysis evaluates the locations of the known hydrogen fueling stations to quantify the degree of coverage provided to communities across the state. Coverage to a community is evaluated as being higher as the number of stations closer to the community increases. This evaluation of coverage is compared to a geospatial analysis of the potential hydrogen fueling demand across the state to identify locations where there is a gap between coverage and the potential hydrogen fueling market. Even with the changes in some station locations since the 2021 *Annual Evaluation*, the analysis of coverage gaps across the state remains largely unchanged.

The updated analysis of coverage gaps and priority areas[11] for future station development is shown in Figure ES 5. Coverage gap is displayed on a color scale from blue (indicating low coverage gap) to red (indicating high coverage gap). The map also includes a gray overlay of areas that are not eligible for application under GFO-19-602 to help inform station developers awarded in that solicitation for the remaining 66 locations that are yet to be submitted for Energy Commission approval. The ineligible areas also align with regions of extremely low hydrogen fueling need based on prior CARB analyses like the *Self-Sufficiency Analysis* [9]. Needs for new station coverage continue to be high in regions where station network development is currently planned (such as the Greater Los Angeles, Sacramento, San Diego, and San Francisco Bay Area regions). At the same time, there is an equally significant need identified in areas with no hydrogen stations currently open or planned. This includes locations in the Central Coast, Inland Deserts, and San Joaquin Valley regions as well as select cities in the northern third of California. Station developers should carefully consider the opportunity to reach these unmet potential market demands across the entire state when planning new station development.

11 A priority area is a location with a large imbalance between local hydrogen fueling coverage and the local potential market for hydrogen fueling. The evaluation is relative, comparing markets across the state to one another and emphasizing the gap between the potential FCEV fueling market and hydrogen fueling supply, rather than focusing solely on the magnitude of the potential hydrogen fueling market.

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



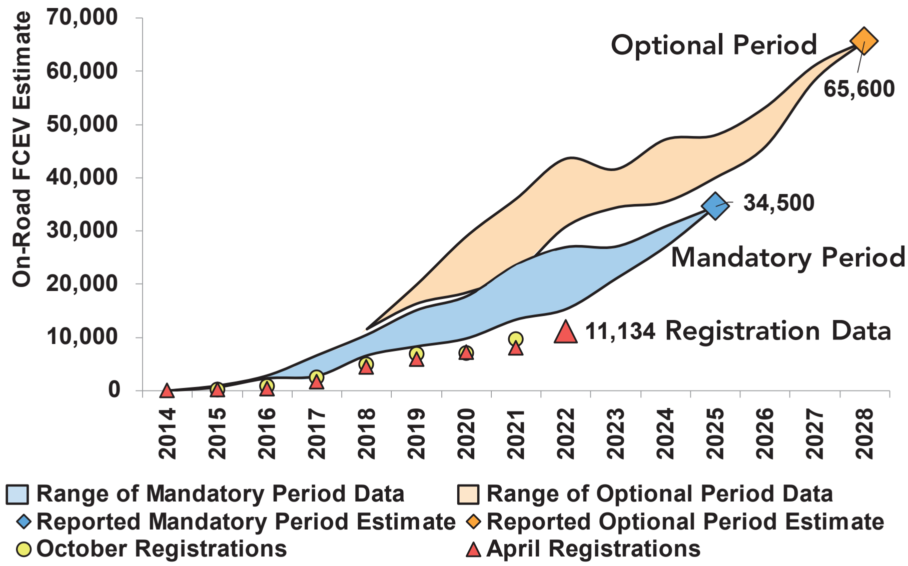
Finding 6: FCEV sales increased in 2021, and auto manufacturer projections for future FCEV deployment show incremental growth at rates similar to prior projections

Based on Department of Motor Vehicles (DMV) vehicle registration data from April 1, 2022, CARB estimates that 11,134 vehicles currently have a valid and active registration within the state of California. Sales in Q1 2022 were slightly more than 1,000 vehicles, based on comparison of registration data to the Energy Commission's reported 10,127 FCEVs on the road at the end of 2021 [10]. This sales rate matches well with industry-provided data published by the California Fuel Cell Partnership, which estimates 1,033 FCEVs sold nationwide in Q1 2022 [11]. The industry estimates also indicate a nationwide total of 13,316 cumulative FCEV sales through the end of Q1 2022 since tracking began in 2012[12]. Based on the industry data, the first quarter of both 2021 and 2022 had nearly identical FCEV sales and had the most quarterly sales to date. Annual sales in 2021 (3,352 FCEVs) were also the largest to date and approximately 40 percent higher than in 2018, which was previously the best-selling year. This is reflected in the registration data of Figure ES 6 (shown as red triangles); the increase in registrations between April 2021 and April 2022 is the largest annual growth in estimated on-road FCEVs since CARB began reporting in 2014.

Future on-road FCEV estimates account for the registered FCEVs currently on the road and projections of future sales provided by auto manufacturer responses to an annual survey. Responses to the 2022 annual survey indicate similar growth trajectories to the 2021 responses. This results in incremental increases in projected on-the-road FCEVs during both the mandatory survey reporting period (2022-2025) and the optional survey reporting period (2026-2028). Revised estimates of future on-the-road FCEVs are 34,500 in 2025 and 65,600 in 2028, demonstrated by the diamonds in Figure ES 6. The figure also displays the range of estimates from all prior surveys, shown by the shaded areas. As discussed in prior reports, the mandatory and optional periods are moving windows of time. Each year's mandatory reporting period includes the remainder of the current and following three vehicle model years. The optional period extends a further three model years. Individual manufacturer estimates for a given model year vary across surveys in different years, as does participation in the optional reporting period. Manufacturer estimates have historically exceeded the actual sales of FCEVs based on registration data.

12 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. Industry sales data may also include vehicles that owners register as Planned Non-Operation, which CARB does not include in its estimates of vehicles with active registration status. CARB has also confirmed that California Fuel Cell Partnership 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



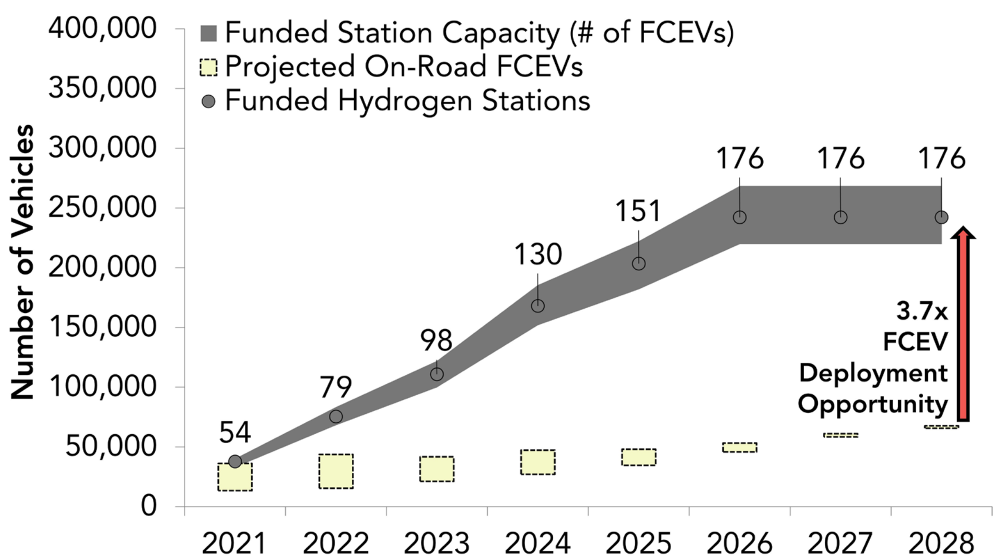
Several new auto manufacturers have recently made public announcements of intent to develop and sell ZEVs (both BEVs [e.g., Canoo, Faraday, Fisker, Lucid] and FCEVs [e.g., Hopium, Hyperion, Riversimple]). CARB staff reached out to several new auto manufacturers for voluntary participation in the annual survey process[13]. While some data were received, CARB has not yet included new manufacturers' responses in this year's analysis. The responses from new auto manufacturers indicated higher degrees of uncertainty than are typically conveyed from more established manufacturers. Reporting in future *Annual Evaluations* may include these new auto manufacturer responses as they demonstrate more certainty. The introduction of new FCEV models, whether by new or established auto manufacturers, may help generate increased driver interest in FCEVs by meeting more drivers' needs and desired features, resulting in accelerated future sales.

13 Auto manufacturers are not required to provide a survey response until they have received an Executive Order that certifies one or more of their vehicles for sale in the state of California. These new manufacturers had not yet met this criterion at the time the survey was distributed so they were considered voluntary respondents.

Finding 7: Auto manufacturer survey responses show network daily fueling capacity will lead FCEV sales by a significant margin through 2028

The recent growth in FCEV sales is a positive signal of consumer acceptance and auto manufacturer confidence in the growing hydrogen fueling network. Projections for future FCEV deployment based on the auto manufacturer survey responses also indicate that growth should continue through 2028. At the same time, the 2021 *Annual Evaluation* noted that the projected FCEV growth rate was significantly slower than the planned hydrogen network capacity growth rate. Given that responses in this year's annual survey show a similar FCEV growth rate, auto manufacturer FCEV deployment plans continue to significantly lag the planned growth in hydrogen network daily fueling capacity. The projected gap in 2028 is slightly smaller than the gap previously reported for 2027, due to the projected continued growth in on-the-road FCEVs through 2028 and reduction in the planned daily fueling capacity of some funded stations. The 2028 network fueling capacity is projected to be 3.7 times the projected FCEV fueling demand (assuming 100 percent availability and fueling station utilization), as shown in Figure ES 7. Using an industry standard approximation (based off gasoline station experience) that an optimal station operation dispenses 85 percent of its rated capacity, the projected network capacity is still 3.2 times the projected fueling demand[14].

Figure ES 7: Projected Hydrogen Demand and Fueling Capacity



The auto manufacturer projections for FCEV deployment appear to lag network capacity growth by more than five years. Although auto manufacturer FCEV projections show positive steady growth in the future, the pace of growth does not yet appear to be influenced by or align with the projected station network growth through 2026. As reported in the 2020 *Annual Evaluation*, auto manufacturers cite difficulties in predicting station development timelines and maintaining high reliability as factors limiting their projections of future FCEV sales. Over the past few years, multiple disruptions have caused the supply of hydrogen to be limited to half or more of the hydrogen fueling network for months at a time. In recent months, new production and distribution facilities have come online and network-wide station availability is improving to near historic highs. Assuming that the current planned hydrogen fueling network development schedule can be maintained and improvements in station reliability continue to be effective, auto manufacturers still have an opportunity to significantly accelerate their FCEV deployment plans for California.

14 The 85 percent optimum ensures that the station maintains high fuel sales while also avoiding long lines and wait times for customers. It is separate from any considerations regarding equipment reliability and the availability of hydrogen fuel delivered to the station.

Finding 8: Updated data and analysis continue to show that renewable assets contribute to hydrogen production at a higher rate than SB 1505 and incentive program requirements

Following the requirements of Senate Bill 1505 (SB 1505; Lowenthal, Chapter 877, Statutes of 2006), any hydrogen fueling station that receives co-funding from a California government agency must dispense hydrogen with at least 33.3 percent of its production resources provided by renewable energy [12]. This has been ensured by the funding eligibility requirements of the Energy Commission's hydrogen station co-funding grant solicitations and the Low Carbon Fuel Standard (LCFS) program's Hydrogen Refueling Infrastructure (HRI) provision. The HRI provision and the Energy Commission's most recent grant funding solicitation, GFO-19-602, adopt a higher standard of 40 percent renewable content for program eligibility[15] [13], [14].

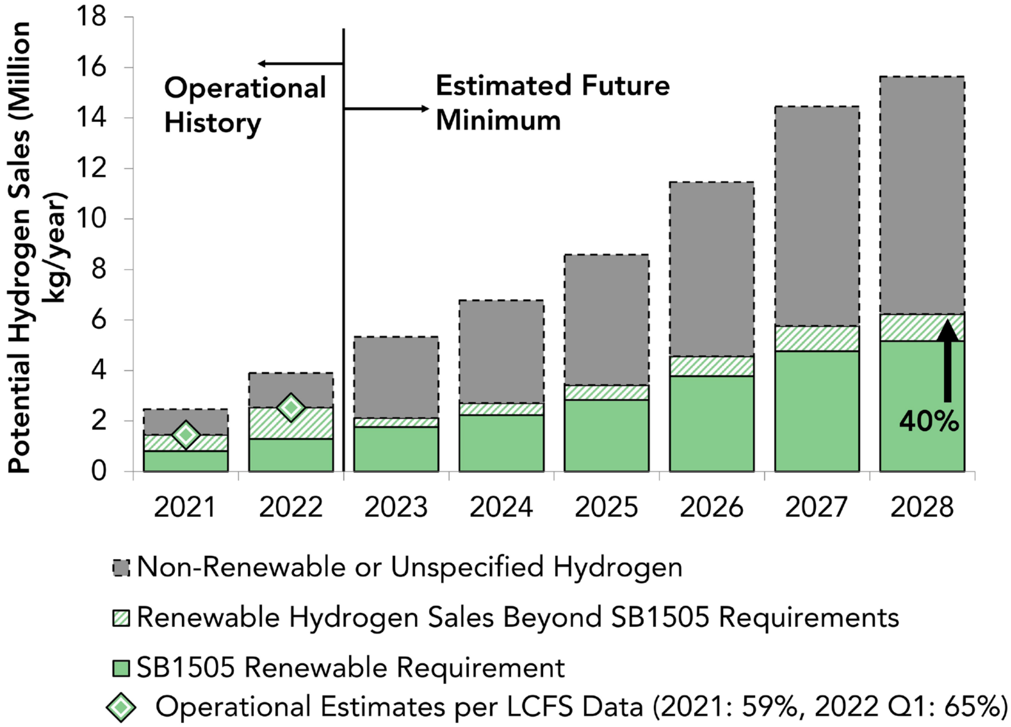
In recent years, station operators have indicated that California's network of hydrogen fueling stations incorporated significantly larger amounts of renewable resources than required. Evaluation of LCFS HRI program data reported in the 2021 *Annual Evaluation* confirmed station operators' claims. From 2020 through the first half of 2021, renewable implementation reported through the LCFS HRI program demonstrated at least 90 percent renewable content.

Since the 2021 *Annual Evaluation* was published, shifts have occurred in the resources used to produce and deliver hydrogen fuel in California. While program and statutory requirements continued to be exceeded in 2021 and 2022, recent operations have used less renewable hydrogen than the high renewable contents observed in 2020 and early 2021. As shown in Figure ES 8, renewable implementation in 2021 and the first quarter of 2022 continued to exceed SB 1505 and California government agency program requirements but are less than previous reports, now showing a renewable content of 59 to 65 percent[16]. The bottom green portion of each bar represents the amount of renewable hydrogen sales needed to meet the requirements of SB 1505. The striped green and white portion above that shows the amount of historical or projected renewable hydrogen sales in excess of the SB 1505 requirement. The top gray portion of each bar represents hydrogen that would not come from renewable resources. Bars for 2021 and 2022 (based on the first quarter) depict historical data from the LCFS program; bars for 2023 through 2028 represent estimated projections.

15 GFO-19-602 and the LCFS HRI program both consider the use of direct and indirect renewable attributes in project evaluation and reporting; more discussion is provided in the Finding and the body of this report. Data provided to the Energy Commission and CARB indicate that the majority of renewable hydrogen is indirect, involving the application of renewable attributes from a hydrogen supplier's portfolio of facilities to the production of hydrogen dispensed at fueling stations.

16 Renewable content in this analysis is based on the portfolio of individual station developers' networks. 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 content. 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".

Figure ES 8: Evaluation of Minimum Renewable Hydrogen Content in California's Fueling Network[17]



As reported in the 2021 *Joint Agency Staff Report*, a significant amount of the renewable content attributed to hydrogen fuel is derived from renewable energy attributes [15]. The Energy Commission reported many of these credits are sourced from the production, sale, and/or purchase of biomethane. These attributes are generated by other facilities and resources within the hydrogen producer's operations or business transactions but may not be directly incorporated into the process of generating the specific hydrogen molecules delivered to fueling stations in California. While much of the renewable content is therefore not directly supplied to the hydrogen generation process, the LCFS program has adopted rigorous limits and requirements to ensure that accounting for the renewable energy attributes is reasonable and credits are not counted multiple times across jurisdictions or programs.

Conclusions

California's programs to support the development and operations of hydrogen fueling infrastructure (primarily the Energy Commission's Clean Transportation Program and CARB's LCFS program) are firmly focused on achieving the 100-station goal of AB 8 and the 200-station goal of EO B-48-18. Funding has been secured to develop substantially more stations than the 100-station minimum called for in AB 8, and a plan is currently underway to close the gap to EO B-48-18's 200-station goal. Meeting these goals will bring significant growth to California's hydrogen fueling network and provides substantial opportunity for similar growth in FCEV sales.

17 Note that this analysis is statewide and does not consider the details of individual station utilization. In addition, the 59 percent renewable content reported for 2021 and 65 percent in the first quarter of 2022 is specific to light-duty vehicle fueling. Including medium- and heavy-duty vehicle fueling reported to the LCFS program, renewable resources contribute to 62 percent and 56 percent of the hydrogen sold as transportation fuel in California during 2021 and the first quarter of 2022, respectively. LCFS program data also indicate that light-duty hydrogen fueling stations participating in HRI provisions dispense a larger proportion of renewable hydrogen than the network-wide average. The renewable content for HRI stations in the first quarter of 2022 was 75 percent.

Approximately half of the 200 stations mentioned in EO B-48-18 currently have a known location in markets across the state. Most of these stations are in urbanized markets with high concentrations of potential FCEV first adopters. Most of these stations are also located within convenient driving distances of a small set of DACs. Because of the potential growth rate in FCEV sales in these areas, continued local network development remains necessary where stations are currently planned. At the same time, the concentration of stations in core areas with high first adopter markets is potentially leaving unmet demand in regions across the state.

Evaluation of coverage and capacity gaps across California reveals the needs for further network development. Network development in new markets, particularly in the San Joaquin Valley region, Inland Deserts region, and northern California, can help unlock new markets and enable the market to reach residents of more DACs than the planned network currently serves. Expanding California's hydrogen fueling network into these new markets may be a key step to further evolving the FCEV market and progressing from the earliest adopters to broader market acceptance.

As has historically been the case for hydrogen station development and FCEV sales, the timing of future growth remains one of the most significant and largest unknowns. Additional effort may be necessary from public and private stakeholders to accelerate the process from securing capital funds to Open-Retail status. Working to reduce station development times may provide reassurance that plans for future network expansion are achievable and encourage accelerated FCEV sales that are even faster than recent high sales rates.

Analyses by CARB have outlined the potential for FCEVs to meaningfully contribute to ZEV uptake and help reduce greenhouse gas and air pollutant emissions. The primary scenario evaluated in CARB's 2020 Mobile Source Strategy found potential for more than 20 percent of the new car market to be met by FCEVs by 2045, based on assumptions of market growth supported by infrastructure development and future ZEV policy [16]. CARB previously published the *Self-Sufficiency Analysis* that outlined viable paths to hydrogen station network financial self-sufficiency and include FCEV deployment rates similar to these projections [9]. Both of these scenarios demonstrate significantly greater opportunity for FCEV sales than currently projected by auto manufacturers. Additional efforts to expand hydrogen and fuel cell use in other transportation sectors, including CARB regulations like the Innovative Clean Transit and Advanced Clean Truck rules and the Energy Commission's recent commitments to invest in medium- and heavy-duty charging and hydrogen fueling infrastructure, can further advance technology and market conditions in ways that provide cross-over benefits for growth of the light-duty FCEV and hydrogen fueling markets in California.

The potential for FCEV market growth in California appears clear, and California government policies to support hydrogen infrastructure development are well-aligned to help initiate this market and support early growth. The steps outlined in this report to further support market development in the coming years may be essential pieces to ensuring FCEVs play a significant role in transforming the vehicle market, as they appear capable of fulfilling. Auto manufacturers must then respond with accelerated FCEV deployment plans equivalent to the network growth rate that California State agencies support programs help to establish. Projected growth rates well beyond the most recent data provided by auto manufacturers will help demonstrate that the private sector vision for FCEV market growth in California will take full advantage of the investments being made today and in the future to support hydrogen fueling infrastructure development.

Courtesy of California Fuel Cell Partnership.

Introduction

Interest in hydrogen fuel for a variety of use cases has significantly increased in California, the United States, and across the globe in the past year. The United States Department of Energy announced its Hydrogen Earth Shot program to demonstrate the ability to produce clean hydrogen for $1/kg by 2030 [17]. The Infrastructure Investment and Jobs Act included significant funding for hydrogen project development and research [18]. Several countries, especially European Union members, South Korea, Japan, and Australia have made significant announcements of intent, drafted roadmaps, and committed funding to develop the hydrogen industry [15], [9], [19], [20], [21]. Hydrogen fueling station operators in California and their fuel suppliers have developed and opened several new facilities that will help ensure robustness of hydrogen fuel availability along the full supply chain [22], [23], [24]. Legacy and new technology providers have also announced their intention to participate in the hydrogen-related market, including fueling infrastructure solutions, hydrogen production and delivery technologies, and vehicle and vessel technologies spanning light-, medium-, and heavy-duty over-the-road vehicles as well as marine vessels, aircraft, and even locomotives [25], [26], [27], [28], [29], [30], [31], [32].

The general momentum of these developments point to the potential for a growing role for hydrogen in global energy markets. As with any transportation fuel or use of energy resources, California State agencies continue to monitor market development, technology viability, performance, and environmental impact. As the hydrogen market continues to grow, it will be increasingly important to ensure that the expanding use of hydrogen as a transportation fuel provides benefits in terms of reduced greenhouse gas emissions, improved air quality, efficient, resilient and reliable energy resources, and improved environmental equity across all of California's communities.

California's AB 8 was signed into law in September 2013 and, among several other provisions, established what is now the Clean Transportation Program at the California Energy Commission. The Clean Transportation Program provides funds for a variety of efforts aimed at transforming California's vehicle population and fueling infrastructure to sustainable, low-emission options. In recent years, the focus of the program has concentrated on ZEV fueling infrastructure, including charging stations to support BEVs and hydrogen fueling stations to support FCEVs. AB 8 enables the Energy Commission to invest up to $20 million each year (subject to appropriation by the California State Legislature and approval by the Energy Commission) for the construction of hydrogen fueling stations.

In addition to providing a funding source to support hydrogen fueling station development, AB 8 requires annual reporting by CARB and the Energy Commission. By June 30 of each year, CARB must report to the Energy Commission with updates on the status o registered FCEVs operating on California roads and the development of the hydrogen fueling station network. CARB must also provide the Energy Commission with an analysis of "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." [3] These analyses are informed by data collected from station developers, the California DMV, auto manufacturers (primarily through an annual survey of projected future FCEV sales), and other public and private organizations collaborating to support the development of hydrogen fueling infrastructure in California.

This report provides these analyses based on the latest information available from these resources. Changes since the 2021 *Annual Evaluation* are highlighted throughout, especially in timing of station construction schedules and FCEV sales projections as these data are central to the analysis of coverage and capacity gaps in today's open and funded hydrogen fueling station network.

The introduction of this report provides an overview of the current station network status and highlights California state and United States federal programs that directly support the development of the hydrogen fueling and FCEV markets in California. Select observations from recent industry trends are also covered in the Introduction.

The introduction is followed by an evaluation and analysis of the FCEVs currently on the road in California and projected to be sold in the future by auto manufacturers. DMV data and the annual survey distributed to auto manufacturers form the basis of this analysis.

Analysis of FCEVs is followed by updates on the locations of known hydrogen fueling stations along with an analysis of the coverage provided by the currently open hydrogen fueling station network and the network of stations either open or currently under construction. Detailed analysis is also presented for the coverage provided by the hydrogen fueling network to residents of DACs. Geospatial analysis tools are used to compare coverage provided by the hydrogen fueling network to the potential hydrogen fueling market to identify localized haps in coverage across the state.

Capacity analysis follows the analysis of coverage. Daily fueling capacity is analyzed for gaps at multiple geographic resolutions, from a statewide analysis to highly localized evaluation.

The capacity analysis is followed by updates to hydrogen fueling station codes and standards that should be incorporated into future station support programs. This discussion also includes updates to ongoing and future station testing programs that help ensure stations meet performance and safety expectations and provide FCEV drivers with safe, reliable, and fast hydrogen fueling experiences.

Finally, this report closes with concluding observations and recommendations for future efforts to expand upon the progress made to date and currently underway in California to support the continued growth of an in-state hydrogen fueling network.

Station Network Progress

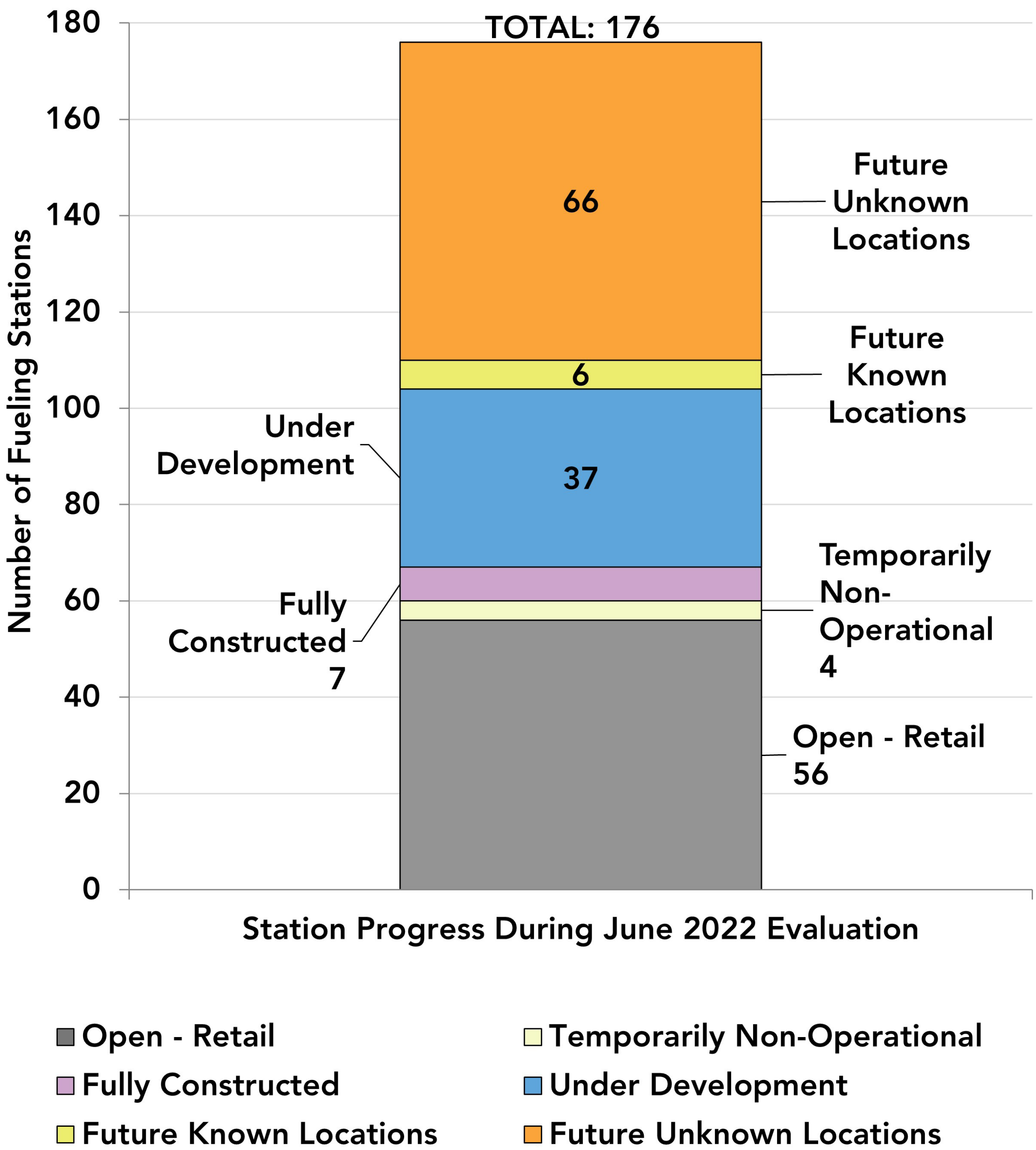
For the second year in a row, the rate of growth in California's hydrogen fueling network has returned to pre-pandemic levels and 2022 may close as one of the most successful years for the number of new Open-Retail stations. Between the 2019 and 2020 *Annual Evaluations*, station development came nearly to a standstill due largely to the COVID-19 pandemic. During that time, the hydrogen fueling network saw a net gain of only one new hydrogen fueling station. Between the 2020 and 2021 *Annual Evaluations*, station development pace had clearly rebounded as constraints introduced by the COVID-19 pandemic eased. Six new stations achieved Open-Retail status during that period. Since the 2021 *Annual Evaluation*, there have been a total of 8 new Open-Retail hydrogen fueling stations added to California's network (6 of which opened in 2022), and station developers report as many as 19 additional stations may achieve Open-Retail status by the end of the year. Based on conversations related to HyStEP scheduling, CARB staff estimate up to 10 of these 19 stations have a high likelihood of reaching Open-Retail status by the end of the year. Even if only these higher likelihood stations complete development on time, 2022 will prove to be one of the most successful years for station network growth in California.

While there has been significant progress in recent months, station developers continue to contend with lingering delays due to altered supply chains and commonly reported difficulties at individual stations. Typically, these delays include longer permitting times than expected, long waitlists for connection to the local electric utility grid infrastructure, and changes in site owners' commitments to host a hydrogen fueling station. As in previous years, even with significant growth in the network, the actual station development pace has been slower than previously projected.

The most recent status of development of the 176 currently known hydrogen fueling stations and development projects is shown in Figure 1. As of June 30, 2022, 56 stations are in Open-Retail operations. Four stations are Temporarily Non-Operational. One of those stations (Riverside) does offer fueling to customers on an appointment basis, so it is available to consumers but does not meet the definition of Open-Retail. Plans to bring the remaining Temporarily Non-Operational stations to Open-Retail status continue to be developed or implemented.

In addition to these completed stations, seven stations have been fully constructed and are in the process of testing and commissioning before they begin Open-Retail operations. There are an additional 37 stations currently under various stages of development. Most of these are batch one stations in GFO-19-602 or privately funded stations, but some of these also include batch two stations that the developers have indicated are already initiated. Finally, 72 more stations are expected for future development (in batches two or later of GFO-19-602), with 6 of these having known addresses.

Figure 1: Hydrogen Fueling Station Network Status as of June 30, 2022



Hydrogen Provisions in the Infrastructure Investment and Jobs Act

On November 15, 2021, President Joe Biden signed the Infrastructure Investment and Jobs Act (IIJA; also nicknamed the Bipartisan Infrastructure Bill) into law. The IIJA authorizes $1.2 trillion in a wide variety of infrastructure projects and research and development spending across several federal agencies [18]. The bill includes funding for transportation, broadband, water, highway, and other national infrastructure applications. The IIJA invests significantly into a widespread transformation of the country's transportation system to electrification. Investments will support the development of plug-in electric vehicle charging infrastructure as well as hydrogen production, distribution, and use across a variety of end-use sectors, including FCEVs.

The IIJA established several significant efforts related to hydrogen, most to be completed or administered by the US Department of Energy over the next five years. Federal agencies are currently working to develop related analyses, reports, and funding programs so many of the details are not yet known. But these efforts have the potential to accelerate the widespread use of hydrogen fuel and fuel cells, including in FCEVs. Programs within the IIJA may expand the hydrogen fueling network in California and other states (along with infrastructure to support the use of hydrogen in industrial, energy storage, chemical processing, and other applications), drive innovation in the technology for hydrogen production, transportation, delivery, and use to sustainable and low-cost options, and contribute to the advancement of hydrogen production technologies with low or zero emissions of greenhouse gases and criteria pollutants. The provisions of the IIJA that may help advance the use of hydrogen as a clean fuel source in California include:

- **Funding for Regional Clean Hydrogen Hubs:** The IIJA authorized $8 billion in funds to be administered by the US Department of Energy to establish at least four Regional Clean Hydrogen Hubs across the United States. The hubs are defined as "a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity". In addition, the hubs are to be regionally diverse, demonstrate hydrogen use in a variety of end-uses, and demonstrate hydrogen production processes from various resources, including renewable energy, nuclear energy, and fossil fuels with carbon capture and sequestration. No individual hub must include all production methods and end-uses, but the aggregate network of hubs must include all of them. In addition, all hubs must demonstrate the ability to develop over time into a national network of hydrogen hubs and associated applications. A notice of intent for a coming funding opportunity announcement was released on June 6, 2022. The notice outlined key concepts that will be incorporated into the final funding opportunity announcement, which may be released later this year.
- **Funding for Corridor and Community Infrastructure Development:** Over the past several years, the Federal Highway Administration has administered a program designating portions of the National Highway System as Alternative Fuel Corridors. Corridors are nominated by state and local governments based on the existing and planned alternative fuel and charging infrastructure along them. The IIJA authorizes $2.5 billion to be spent over 5 years for further development of charging and fueling infrastructure along these alternative fuel corridors and in rural communities, low- and moderate-income communities, and communities with low parking-to-household ratios or high ratios of multifamily housing to single-family housing. Eligible projects include plug-in electric vehicle charging, hydrogen fueling, natural gas fueling, and propane fueling. A separate provision requires the US Department of Transportation to publish a report in late 2022 that identifies the infrastructure development needs for alternative fuels for the next five years and identifies the locations where the vehicle markets are likely to be concentrated.

- **Funding for Hydrogen Manufacturing and Advanced Recycling:** Over the next five years, this program will devote $500 million to advanced research and development of clean hydrogen production technology and recovery of raw materials in key hydrogen-enabling technologies (such as electrolyzers). The program is focused on projects that increase hydrogen production efficiency and cost effectiveness, support domestic supply chains, incorporate nonhazardous options, operate in partnership with tribes, and are located in economically distressed major natural gas-producing regions.
- **Funding for Clean Hydrogen Electrolysis Program:** This program allocates $1 billion over five years for research, development, and demonstration of electrolyzer technology. The program's goal is to demonstrate the production of clean hydrogen via electrolyzers at a cost of less than $2/kg by 2026. Further goals, with lower costs per kilogram of hydrogen, may be determined by the Secretary of the US Department of Energy. Notably, the agency launched its Hydrogen Shot initiative in June 2021, which has a goal to demonstrate a cost of $1/kg of clean hydrogen by 2030.
- **National Clean Hydrogen Strategy and Roadmap:** By May 2022 (and updated annually), the US Department of Energy must deliver a report to Congress that describes an economically and technologically feasible roadmap and strategy for the widescale production and use of clean hydrogen. The report must prioritize existing US Department of Energy models and analyses and address opportunities and challenges in production, distribution, and use of clean hydrogen. End uses considered in the roadmap may include the multiple transportation sectors and others, such as industrial, build`ing heating, and chemical processes. The strategy must also address regional diversity in its analysis.
- **Clean Hydrogen Production Qualifications:** Several of the programs authorized by the IIJA reference the use of "Clean Hydrogen" in end-use applications. To ensure that hydrogen use contributes to reduction in greenhouse gas emissions, the IIJA charges the US Department of Energy and US Environmental Protection Agency with developing a standard qualification for Clean Hydrogen. The requirements in this definition must be based on the carbon intensity of hydrogen production pathways and should be no greater than two kilograms CO_2eq per kilogram of hydrogen produced[18]. This metric is to be evaluated at the site of production of the hydrogen fuel. The agencies are to periodically revisit this definition in the future and consider more stringent definitions that will reduce the carbon intensity of hydrogen fuel over time.
- **Other Funding Provisions with Hydrogen as an Eligible Technology:** Several provisions of the IIJA focus on the development of clean transportation infrastructure across the United States. Specific end-uses (such as school buses and ferries) receive individual funding programs within the IIJA. Many of these programs are structured to support a variety of alternative fuels, including hydrogen.

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18 The federal Clean Hydrogen standard of 2 kilograms CO_2eq per kilogram of hydrogen is equivalent to an LCFS program carbon intensity metric of 20 gCO_2/MJ. However, it is important to recognize that the federal Clean Hydrogen standard is evaluated only at the point of production, whereas the LCFS program evaluates carbon intensity on a fuel's full lifecycle. The total lifecycle carbon intensity of hydrogen fuel that meets the federal Clean Hydrogen standard would therefore be more than 20 gCO_2/MJ and would depend on the details of the full lifecycle. As an example, for a pathway that produces hydrogen from steam methane reformation of fossil natural gas, the additional upstream emissions would add an estimated 15 gCO_2/MJ (1.5 $kgCO_2$eq/kg H_2) and downstream emissions for delivery would add up to an additional estimated 20 gCO_2/MJ (2 $kgCO_2$eq/kg H_2). For this example, the estimated full lifecycle equivalent of federal Clean Hydrogen may be up to approximately 55 gCO_2/MJ (5.5 $kgCO_2$eq/kg H_2).

Renewable Hydrogen Production Facilities Awarded in GFO-20-609

On February 3, 2022, the Energy Commission announced proposed awards under its Renewable Hydrogen Transportation Fuel Production solicitation GFO-20-609 [33]. The competitive solicitation was designed to help co-fund the design, engineering, construction, installation, testing, operation, and maintenance of hydrogen production facilities located in California that produce 100 percent renewable hydrogen from in-state renewable resources. Hydrogen produced by awarded facilities is intended to serve the in-state on-road transportation market. This was the second such solicitation administered by the Energy Commission, following on from GFO-17-602. As these projects develop, they will contribute to the expanding diversity of hydrogen fuel sources serving California's hydrogen fueling stations. This can help enhance network reliability and resilience to hydrogen supply outages at individual facilities while increasing the availability of low-carbon and renewable hydrogen fuel in the state.

Three projects were recommended by Energy Commission staff for award under GFO-20-609. These projects will be presented for approval by the Commission in a future public Business Meeting. The three proposed awards include:

- **Linde, Inc:** $3 million award proposed for 1,728 kg/day of hydrogen production capacity to an existing 25,000 kg/day facility in Ontario. The existing facility produces hydrogen through steam methane reformation, but the funded addition will produce hydrogen through electrolysis powered by renewable electricity. The renewable aspects will be provided via purchase of renewable energy credits (RECs) from Southern California Edison[19]. The anticipated carbon intensity is 10.51g CO_2eq/MJ (or 1.26kg CO_2eq per kg of hydrogen).
- **SG H2 Lancaster Holding Company LLC:** $3 million award proposed for 11,000 kg/day of hydrogen production through gasification of rejected recycled mixed paper waste. The anticipated carbon intensity is a net negative carbon intensity of -188 gCO_2eq/MJ (or -22.56 kg CO_2eq per kg of hydrogen). This means that the hydrogen production process has a net effect of avoiding or sequestering these carbon emissions.
- **Stratosfuel, Inc:** This project was previously funded under GFO-17-602. With this new $3 million award, the facility will double its hydrogen production capacity by adding an additional 5,000 kg/day. Hydrogen will be produced via electrolysis powered by solar and wind renewable electricity via RECs. The anticipated carbon intensity is between 0 and 10g CO_2eq/MJ (or between 0 and 1.2kg CO_2eq per kg of hydrogen).

19 GFO-20-609 included the following requirements for RECs: Renewable electricity may be an eligible feedstock, if the renewable electricity either goes directly to the hydrogen production system or is connected via the grid from an in-state generation facility that has its first point of interconnection within the metered boundaries of a California balancing authority area. Renewable electricity certificates (RECs) must be retired in the Western Renewable Energy Generation Information System for the production of hydrogen in the proposed system [41].

Upcoming General Funds Solicitation

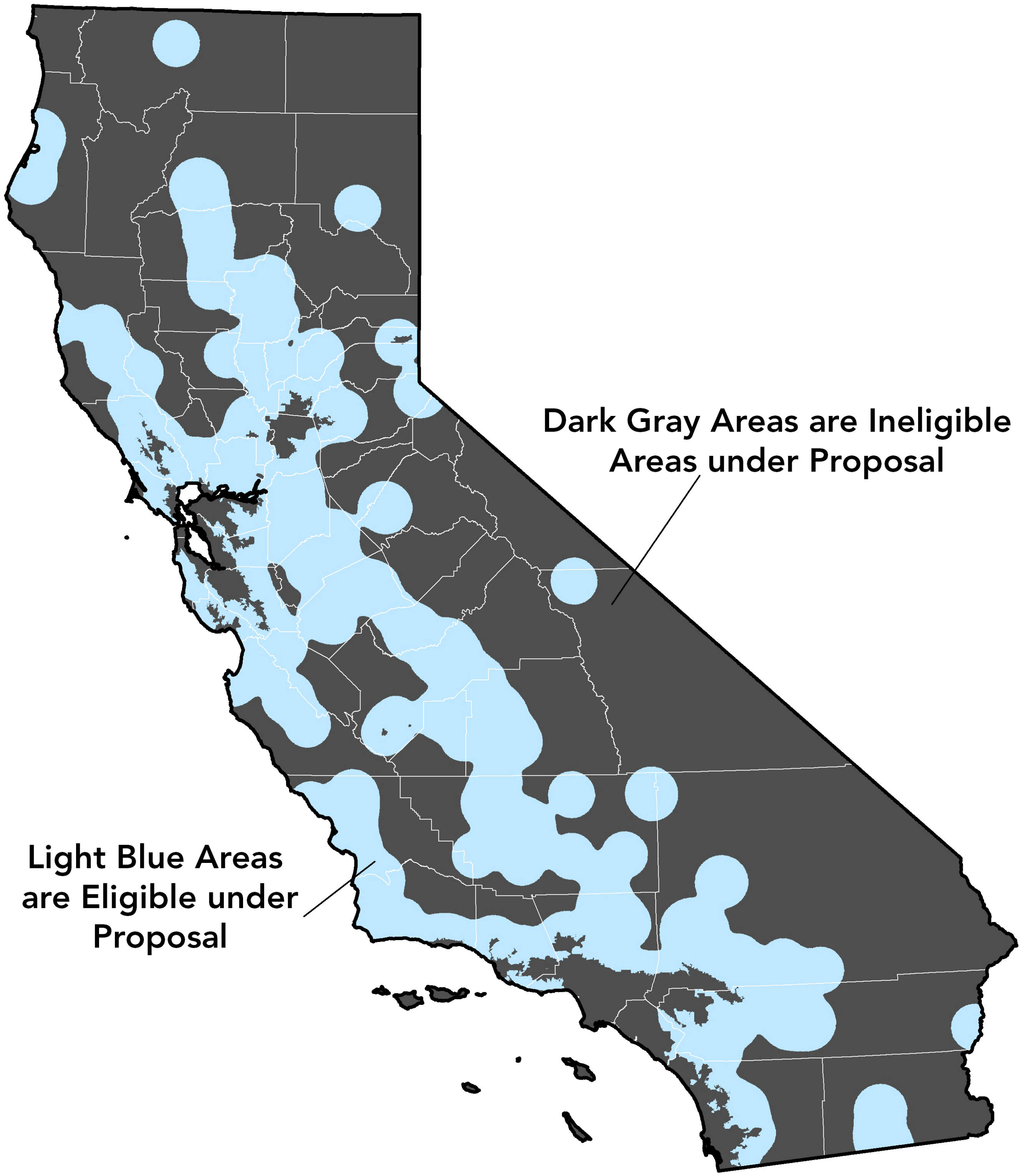
In the 2021-2023 *Clean Transportation Program Investment Plan Update*, the Energy Commission directed new funds of $27 million to the development of hydrogen fueling infrastructure to help close the gap to the goal of 200 stations established by Executive Order B-48-18 [5]. These funds are in addition to those outlined in AB 8 and are sourced from the General Fund, through the California Budget Act of 2021 (AB 128; Ting, Chapter 21, Statutes of 2021) [34]. The Energy Commission then held a public workshop on February 28, 2022 to discuss concepts for future solicitations in the Clean Transportation Program, including the $27 million new allocation for hydrogen fueling stations.

The concept presented by Energy Commission staff focused on growing the hydrogen fueling network to locations and market segments that have not typically been targeted by station development in prior solicitations [35]. Two broad categories for funding eligibility were proposed. One focused on supporting light-duty FCEV deployment in new markets, while the other focused on supporting medium- and heavy-duty FCEV market development. For both concepts, each hydrogen station would be required to be publicly available to light-duty FCEVs and include at least two fueling positions. The stations could include a public or private fueling component for medium- and heavy-duty vehicles.

The light-duty concept would seek new station development in areas outside the main urban centers where most of today's open and planned hydrogen fueling stations are located. CARB and Energy Commission staff currently anticipate that station developers funded under GFO-19-602 (the Energy Commission's most recent station grant funding solicitation, which selected more than 100 stations for award) will continue to focus their development in these urban areas for future batches (which includes a total 66 station locations that have not yet been announced). Therefore, the new solicitation would aim to bring hydrogen fueling to new markets in the San Joaquin Valley, along the Central Coast, in northern California, and inland southern California counties. A map of eligible locations was developed by CARB, as shown in Figure 2. The eligible areas are similar to those shown in Figure ES 5, with the omission of urban areas where hydrogen station network development has already occurred or is currently planned. The map in Figure 2 also simply relates eligibility and does not assess degree of need, as shown in Figure ES 5.

The medium- and heavy-duty concept would seek to help accelerate deployment of medium- and heavy-duty hydrogen-powered ZEV fleets by promoting co-location of light-duty fueling with fleet fueling. Instead of requiring stations to be located in the eligible areas shown in Figure 2, projects in this category could be located anywhere in the state that is on or adjacent to property where a medium- or heavy-duty vehicle fleet is serviced.

Figure 2: Proposed Concept for Eligibile Light-Duty Hydrogen Fueling Stations in Upcoming General Funds Solicitation



The Energy Commission is currently reviewing comments submitted by stakeholders and the public in response to the proposal. A finalized solicitation may be released in late 2022. The Energy Commission encourages participation in the public process. Comments may be submitted by visiting the *Energy Commission's comment submission page* for Docket 19-TRAN-02.

LCFS HRI Program Update

Participation in the HRI provision of the LCFS program continues to grow. There are now a total of 63 stations approved for credit generation under the HRI provision, representing a total fueling capacity of 41,972 kg/day. As with prior years, new stations have been added to the program while other stations that were previously approved but will no longer be developed have been removed from the program. Table 1 lists the stations that are currently approved under the HRI provision, including their address, approved daily fueling capacity for crediting, and the dates in which the stations may generate credits under the HRI provision.

Table 1: Stations Approved for LCFS HRI Credit as of May 12, 2022[20]

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

20 Note that capacity in this table refers to the approved capacity for generating credits in the LCFS program through the HRI pathway. The HRI pathway has a cap of 1,200 kg/day credit generating potential for each station. Some stations listed in this table as 1,200 kg/day capacity may therefore have an actual dispensing capacity higher than the approved capacity shown. Refer to Appendix B for actual capacities of all stations.

Applicant	Address	City	Capacity (kg/day)	Effective Date Range
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.	6141 Greenback Lane	Citrus Heights	513	04/01/2019 - 03/31/2034
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
Air Liquide Hydrogen Energy US LLC	10400 Aviation Boulevard	Los Angeles	200	04/01/2019 - 03/31/2034
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	1200	10/01/2019 - 09/30/2034
First Element Inc.	337 East Hamilton Avenue	Campbell	1200	10/01/2019 - 09/30/2034
First Element Inc.	18480 Brookhurst Street	Fountain Valley	1200	10/01/2019 - 09/30/2034
First Element Inc.	15544 San Fernando Mission Blvd	Mission Hills	1200	10/01/2019 - 09/30/2034
First Element Inc.	503 Whipple Ave	Redwood City	1200	01/01/2020 - 12/31/2034
First Element Inc.	605 Contra Costa Blvd	Concord	1200	01/01/2020 - 12/31/2034
First Element Inc.	26813 La Paz Road	Aliso Viejo	1200	01/01/2020 - 12/31/2034
First Element Inc.	14477 Merced Ave	Baldwin Park	1200	01/01/2020 - 12/31/2034
First Element Inc.	2995 Bristol Street	Costa Mesa	1200	01/01/2020 - 12/31/2034
First Element Inc.	21530 Stevens Creek Blvd	Cupertino	1200	01/01/2020 - 12/31/2034
First Element Inc.	615 S Tustin Street	Orange	1200	01/01/2020 - 12/31/2034
First Element Inc.	313 W. Orangethorpe Ave	Placentia	1200	01/01/2020 - 12/31/2034

Applicant	Address	City	Capacity (kg/day)	Effective Date Range
First Element Inc.	3939 Snell Ave	San Jose	1200	01/01/2020 - 12/31/2034
First Element Inc.	1832 W. Washington St	San Diego	1200	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	1200	04/01/2021 - 03/31/2036
Iwatani Corporation of America	2120 E McFadden Ave	Santa Ana	808	04/01/2021 - 03/31/2036
Iwatani Corporation of America	8095 Lincoln Ave	Riverside	808	07/01/2021 - 06/30/2036
Iwatani Corporation of America	13980 Seal Beach Blvd	Seal Beach	808	07/01/2021 - 06/30/2036
Iwatani Corporation of America	3260 Chino Ave	Chino Hills	808	10/01/2021 - 09/30/2036
First Element Inc.	14478 Ventura Boulevard	Sherman Oaks	808	01/01/2022 - 12/31/2031
Iwatani Corporation of America	4475 Norris Canyon Rd	San Ramon	1200	04/01/2022 - 03/31/2037
Iwatani Corporation of America	466 W Broadway	Glendale	1200	04/01/2022 - 03/31/2037
Iwatani Corporation of America	601 W Willow St	Long Beach	1200	04/01/2022 - 03/31/2037
Iwatani Corporation of America	19260 Nordhoff St	Northridge	1200	04/01/2022 - 03/31/2037

New Market Developments

Prior reports published by CARB and the Energy Commission related to AB 8 have focused primarily on the network of hydrogen fueling stations with co-funding from California State agencies and FCEV deployment from legacy auto manufacturers with established interest in FCEV deployment (via CARB's annual survey process). This focus was informed by the known activity in each industry. That is, all known station development in prior years included some form of support from California state government and no new auto manufacturers had expressed interest or plans for bringing FCEVs to California.

Several announcements and developments in the past year have changed the landscape of potential FCEV deployment and hydrogen station network development. Private stakeholders are increasingly announcing interest and intent to develop stations without seeking government co-funding support. Additionally, new auto manufacturers are proposing to bring FCEV products to market, similar to the recent introduction of new BEV-focused auto manufacturers.

CARB and other California State agencies are tracking these developments with interest, especially to understand the implications for growth of the hydrogen fueling and FCEV industries in California and to understand the pace of evolving market maturity. At the same time, these new developments often present information with additional uncertainties or limitations that must be accounted for in analysis and reporting. For example, public announcements of intent for future developments are often subject to business decisions that have not yet been finalized or include uncertain timelines. Other times, CARB or another California government agency may receive more detailed or assured information, but it is considered business confidential and cannot be presented in a manner that adequately preserves confidentiality.

This year's report therefore does not account for these newer announcements in analysis and projections of future station development or FCEV deployment, though CARB notes that they may impact future analysis as more information becomes available in a form that can be shared publicly. This includes several prominent recent announcements:

- Iwatani and Chevron announced a partnership to develop and operate 30 hydrogen fueling stations at Chevron locations throughout California [36]. The agreement intends to develop all 30 locations by 2026. Details about each station (location, daily fueling capacity, etc.) are currently unavailable. However, CARB staff have confirmed with Chevron and Iwatani representatives that these 30 stations will be in addition to the stations that Iwatani develops under its agreement with the Energy Commission for GFO-19-602. Therefore, under the companies' current plans, station counts could be larger than reported here by as many as 30 stations by 2026.
- Additional new hydrogen station equipment and development companies have recently made announcements of their intent to develop hydrogen fueling stations in California. However, the details of these intentions are often not available from public announcements. CARB and the Energy Commission will continue to monitor developments from these companies as they may happen in the future.
- Riversimple is a new auto manufacturer from the United Kingdom that has developed a high-efficiency fuel cell-based "Eco Car" with room for two people (including the driver). Vehicle designs to date have targeted a 300-mile range with a fuel efficiency equivalent to 250 miles per gallon. The company intends to offer vehicles through a subscription model rather than traditional vehicle ownership. Riversimple recently announced membership in the California Mobility Center, a non-profit public-private organization aimed at helping innovative mobility companies and start-ups reach commercialization [37]. The partnership may help Riversimple reach commercialization and deployment of FCEVs in California, though timing and volume of vehicles remains uncertain.

Location and Number of Fuel Cell Electric Vehicles

AB 8 Requirements: Estimates of FCEV fleet size and basis 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 network coverage.

Information Sources for FCEV Projections

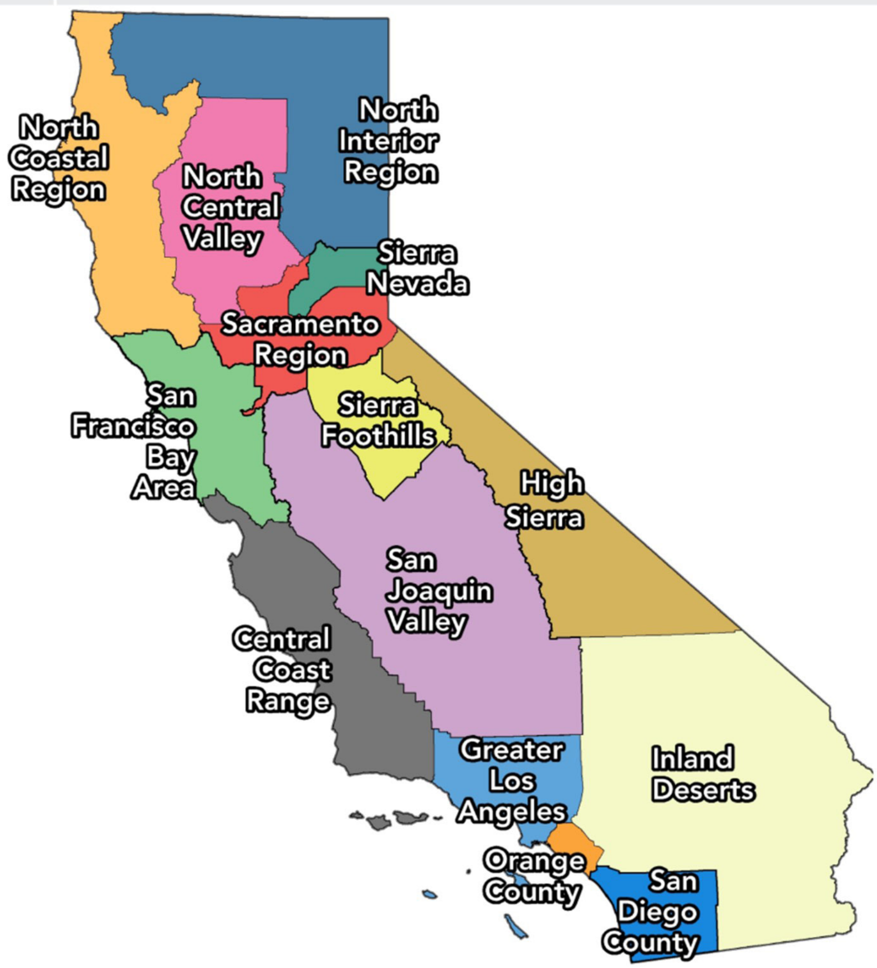
Each year, CARB relies on two main sources identified by AB 8 to evaluate the number and location of FCEVs currently on the road and projected for future sales in California. The first resource is vehicle registration data, obtained in early April and provided by the DMV. This resource indicates the number, location (to the resolution of ZIP code), and registration status of FCEVs in California. CARB staff analyze these data to develop counts of valid active FCEV registrations at the ZIP code, county, regional (as defined in Figure 3), and statewide resolution.

The second resource that CARB relies on is an annual survey sent to auto manufacturers. Responses are required of all auto manufacturers with vehicles certified for sale in California. The survey asks each auto manufacturer for projections of the number of BEVs, PHEVs, and FCEVs projected to be sold in California for the remainder of the current model year and the following three model years. Auto manufacturers must provide this information for each applicable model in the time period and are also asked to provide various technical specifications of each model, like estimated range, fuel economy, battery size, fuel cell power, etc.

In addition to the mandatory responses, each survey also asks auto manufacturers to provide data on projected FCEVs for an additional three model years into the future. This period is considered the optional period. For the 2022 survey, the mandatory response period included model years 2022-2025 and the optional response period included model years 2026-2028. In 2022, CARB also sent surveys to new auto manufacturers that have publicly announced intent to sell ZEVs in California in the near future. Since these auto manufacturers did not yet have vehicles certified for sale, their responses were considered voluntary.

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 Bernardino
North Central Valley	Butte, Colusa, Glenn, Shasta, Tehama
North Coastal Region	Del Norte, Humboldt, Lake, Mendocino, Trinity
North Interior Region	Lassen, Modoc, Plumas, Siskiyou
Orange Country	Orange
Sacramento Region	El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba
San Diego County	San Diego
San Francisco Bay Area	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
San Joaquin Valley	Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare
Sierra Foothills	Amador, Calaveras, Mariposa, Tuolumne
Sierra Nevada	Nevada, Sierra

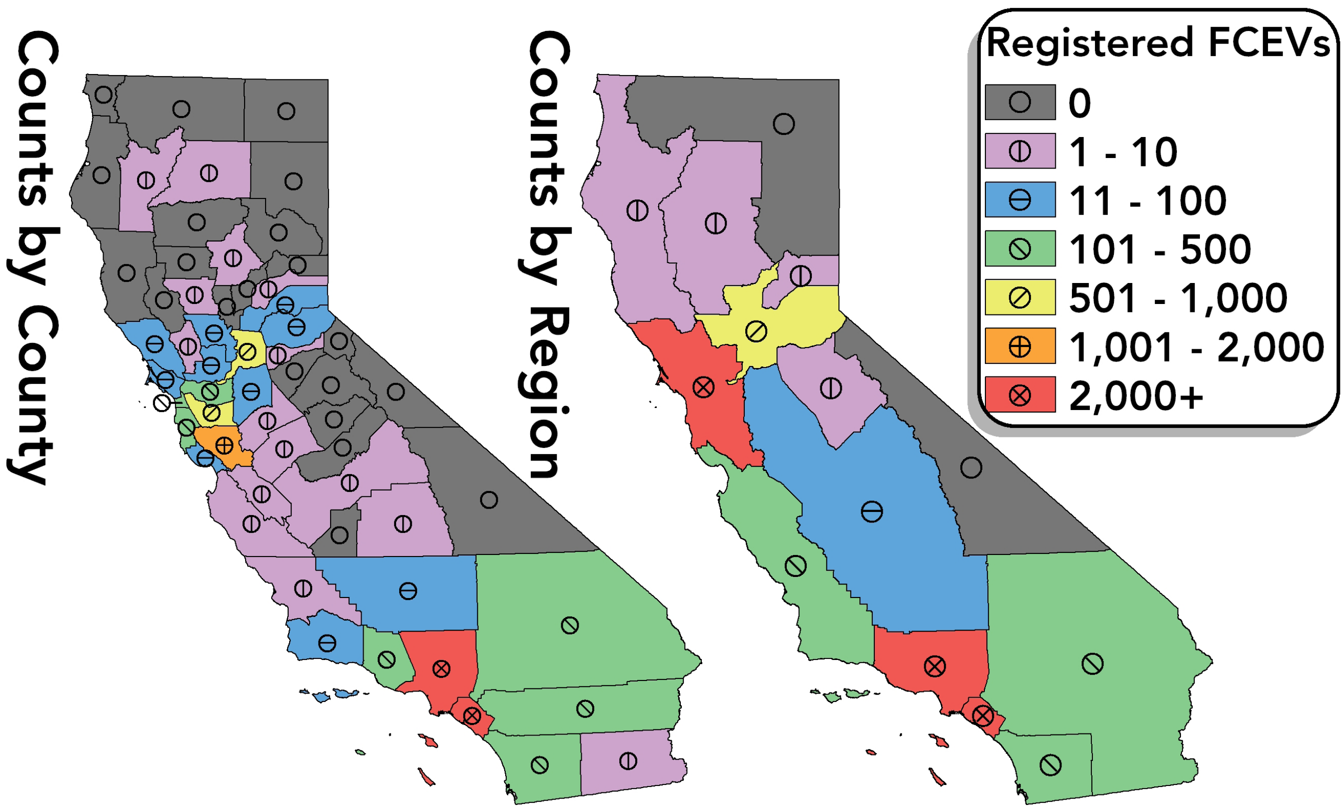


Analysis of Current On-The-Road FCEVs

CARB staff analysis of DMV registration data eliminates vehicles registered out of state and vehicles that do not have valid active registration status. This process removes any vehicles that the registered owner themselves indicates will not be driven in California (called Planned Non-Operation) and vehicles that have a lapsed registration or other status code indicating uncertainty that they are currently in use in California. Individual vehicles may have multiple registration status entries in DMV data and CARB staff analysis resolves these duplications by assuming the most recent status is correct. Registration data are then aggregated at various geographic resolutions. ZIP code-level data are also integrated into each year's hydrogen fueling market evaluation completed with CARB's California Hydrogen Infrastructure Tool (CHIT). Current registered vehicles are also included in projections of end-of-year FCEV populations for the current year and following six years.

As of April 1, 2022, there are an estimated 11,134 active FCEV registrations in California. Currently active FCEV registration counts by county and region are shown in Figure 4. Similar to prior years, registered FCEVs are concentrated in the Greater Los Angeles, Orange County, and San Francisco Bay Area regions. Los Angeles and Orange counties have the most active registrations, followed by Santa Clara County, then Alameda and Sacramento counties. These also tend to be the counties with the most growth in FCEV registrations since the 2021 *Annual Evaluation*. The distribution of registered FCEVs also correlates well with the location of Open-Retail stations.

Figure 4: Distribution of Current FCEV Registrations as of April 1, 2022



At the same time, there are vehicles in regions and counties that are a significant distance from the developing hydrogen fueling network. There are typically only a few vehicles in these counties (less than 10), though more FCEVs appear to be registered in counties with a single hydrogen fueling station or counties adjacent to a local concentration of stations. Figure 5 provides additional clarity and detail of the geographical dispersion of the registered FCEVs in California. As noted in the previous *Annual Evaluation*, there are some FCEVs registered in ZIP codes that are a very long distance from the Open-Retail and planned hydrogen fueling network. Drivers that are further from the developing hydrogen fueling network must either make special, long-distance drives to fuel, have alternative local fueling arrangements (such as a potential private fueling station), or may have registered vehicles to an address other than their primary home address. Although the exact ZIP codes with at least one registered FCEV have shifted a little since the last report (FCEVs are no longer registered in some ZIP codes while the first registrations have recently appeared in other ZIP codes), approximately 49 percent of counties still have at least one registered FCEV.

The statewide distribution of registered FCEVs underscores the importance of periodic analysis and evaluation of the hydrogen fueling network and FCEV deployment. Table 2 provides a breakdown of registered FCEVs, number of Open-Retail and planned stations, and capacity of Open-Retail and planned stations according to the cluster definition developed for the California Fuel Cell Partnership's 2013 Roadmap document [38]. At the time the Roadmap was developed, five clusters were envisioned as the areas with the greatest FCEV sales potential and need for hydrogen fueling station development. Over time, the actual FCEV sales and infrastructure development have occurred within and outside of the clusters, generating a need for continually updated analysis of new needs for further station development.

As Table 2 demonstrates, nearly two-thirds of network development and FCEV deployment has occurred outside of the areas that were originally identified as high-deployment clusters. Much of the development in this "Expanded Network" has occurred in close to mid-range proximity of the original clusters, but the deviation from the original plan remains noteworthy. As station developers have encountered limitations in viable station locations, station technology has evolved, and information about the FCEV market has been refined over the past decade, the network development has appropriately shifted in response to the needs of FCEV drivers, as demonstrated by the close match in the last three columns of Table 2 in all clusters. Periodic network evaluation helps ensure that future development continues to respond to these market shifts.

Figure 5: ZIP Codes with Active FCEV Registrations

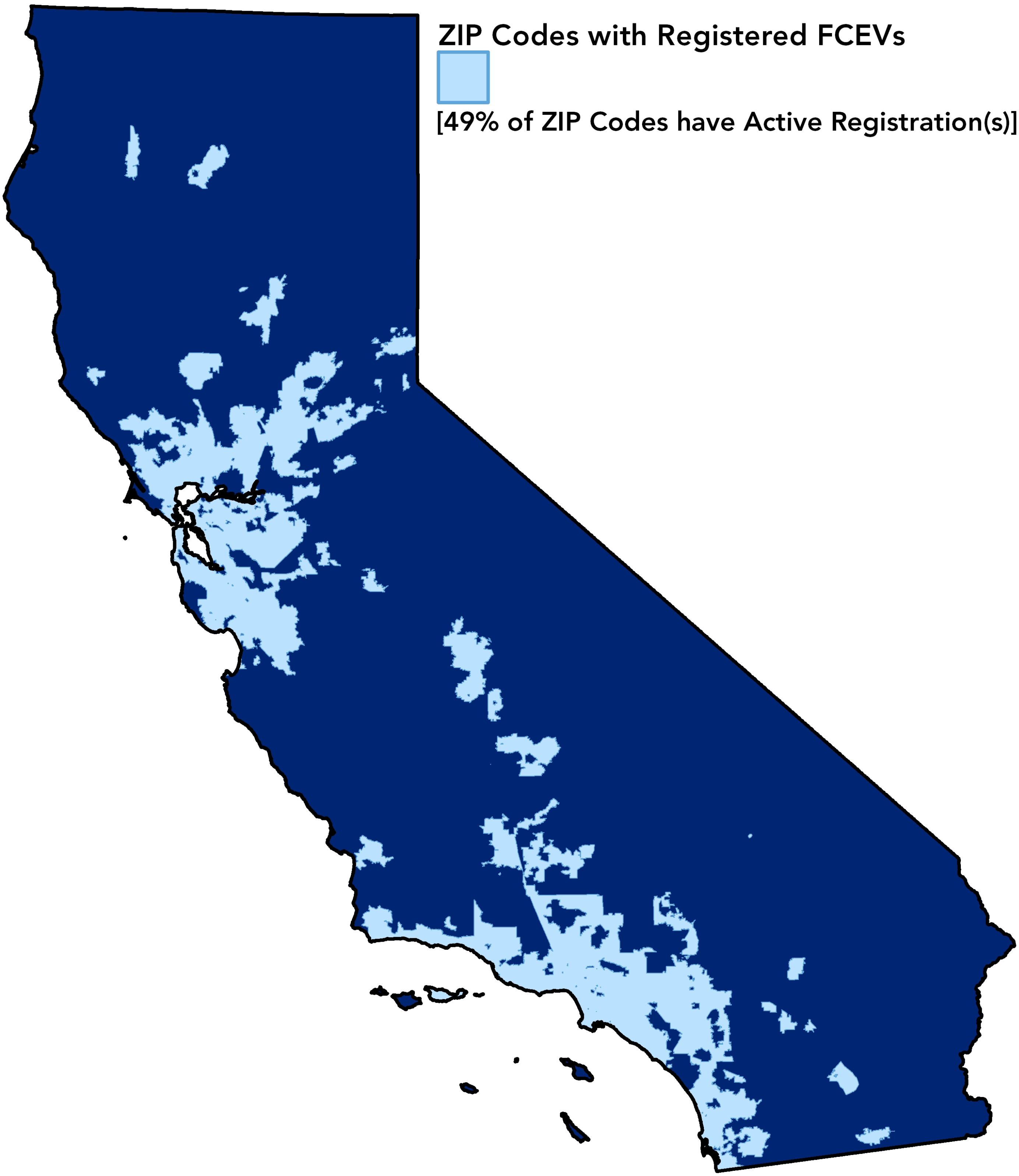


Table 2: Station Network and Registered FCEVs with Respect to Cluster Defintions

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	68	56,754	62%	64%	60%
South San Francisco/ Bay Area	14	10,299	13%	12%	11%
Coastal/South Orange County	12	12,850	11%	15%	17%
Torrance	6	2,066	5%	2%	5%
Berkeley	6	4,903	5%	6%	2%
West Los Angeles/ Santa Monica	4	1,396	4%	2%	5%

Analysis of Future On-The-Road FCEVs

Projections of future on-the-road FCEVs incorporate both the DMV registration data and auto manufacturer responses to the annual survey issued by CARB. CARB staff adjust submitted survey responses in three ways. First, CARB staff translate the responses provided in terms of model year into calendar year. As in all prior *Annual Evaluations*, one-third of the vehicles in a given model year are assumed to be sold in the prior calendar year while the remaining two-thirds are assumed to be sold in the calendar year that matches the model year. This is applied to responses for all future model years but is not applied to responses for the remainder of the current model year.

Next, all statewide sales projections for each model year are distributed across all California counties. As in the 2021 *Annual Evaluation*, the proportion of FCEVs distributed to each county in each year was determined by the proportion of projected fueling capacity in that county in the same year. This assumption was made because the capacity of the stations currently under development and planned for future development is quite large compared to historical network capacity and will likely drive the location of FCEV sales in the near future. Although the same method was used, the data in Table 3 are slightly different from similar data in the previous *Annual Evaluation* because of changes to plans for future hydrogen fueling station development.

Finally, all FCEVs included in projections are assumed to be subject to an average attrition rate. This attrition adjustment represents the typical annual rate at which vehicles may be removed from the on-the-road fleet due to a number of issues, such as vehicle crashes and owners moving their vehicles out of state. This analysis utilizes the same method as CARB's EMissions FACtor (EMFAC) model, which assumes vehicle attrition follows a power law curve with a vehicle half-life of 15 years. For example, under this model, a fleet of 100 initial vehicles will slowly be reduced each year for 15 years until there are 50 vehicles left in the fleet. The fleet would continue to slowly reduce in number over the next 15 years until 25 remain, and so on.

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

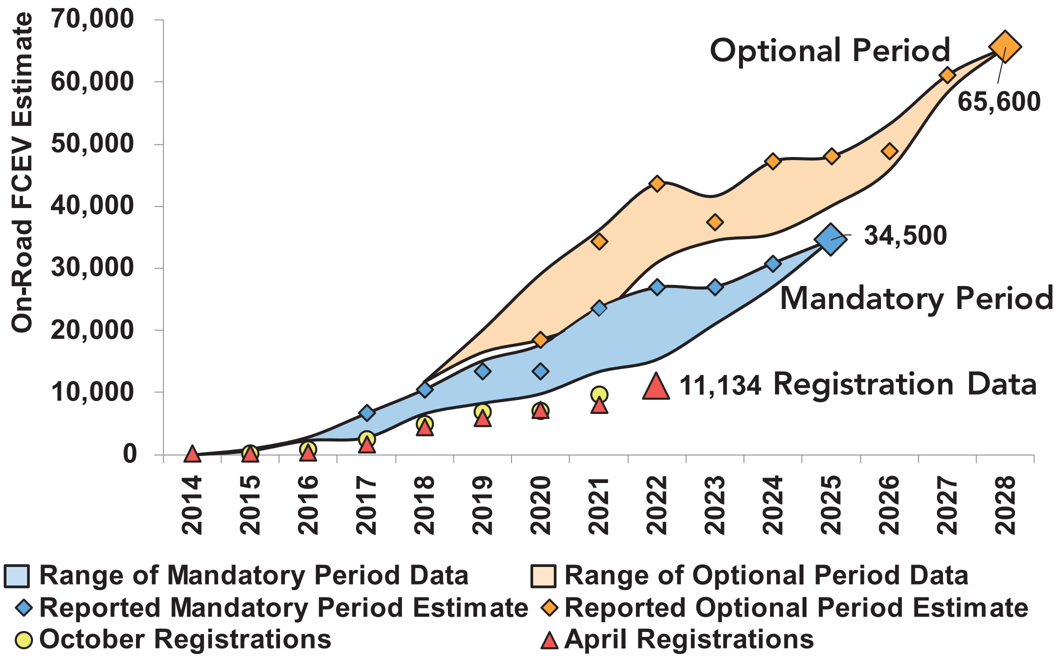
County	2022	2023	2024	2025+
Alameda	7.28%	7.07%	6.27%	5.74%
Contra Costa	3.06%	4.19%	4.64%	5.96%
Fresno	0.51%	0.35%	0.31%	0.28%
Los Angeles	24.02%	25.15%	29.17%	28.42%
Marin	0.51%	0.29%	1.19%	1.09%
Nevada	0.51%	0.35%	0.31%	0.28%
Orange	24.79%	21.17%	20.61%	18.87%
Riverside	4.81%	3.29%	3.73%	3.41%
Sacramento	3.42%	3.34%	2.96%	2.71%
San Bernardino	3.46%	5.52%	4.89%	6.18%
San Diego	5.90%	7.13%	6.32%	5.78%
San Francisco	2.93%	2.00%	1.77%	1.62%
San Mateo	2.95%	2.01%	1.78%	1.63%
Santa Barbara	0.51%	0.35%	0.31%	0.28%
Santa Clara	14.08%	13.82%	12.24%	12.91%
Sonoma	0.00%	1.00%	0.89%	0.81%
Ventura	0.51%	2.45%	2.17%	3.59%
Yolo	0.75%	0.51%	0.45%	0.42%
ALL OTHERS	0.00%	0.00%	0.00%	0.00%

Combining the DMV and auto manufacturer survey response data sources and the various analysis steps implemented by CARB staff provides an estimate of the projected number of FCEVs on-the-road for the current year and next six years. Each *Annual Evaluation* only reports the modeled estimate at the end of the survey's Mandatory Period (2025 for this yeawr's survey) and the end of the survey's Optional Period (2028 for this year's survey). Estimates of current and future on-the-road FCEVs are presented in Figure 6.

Figure 6 displays the progression of statewide registered vehicle counts according to April and October DMV registration data as red triangles and yellow circles, respectively. The growth in registered FCEVs from 7,993 reported in April 2021 to 11,134 in April 2022 is the largest annual growth in estimated on-road FCEVs since CARB began reporting in 2014. This high growth rate aligns well with the Energy Commission's ZEV dashboard data and industry-provided national FCEV sales data. The Energy Commission reports 7,129 and 10,127 FCEVs on-the-road at the end of 2020 and 2021, respectively [10]. The California Fuel Cell Partnership reports monthly aggregated sales estimates provided by industry members. The reported industry data shows that the calendar year 2021 was the best-selling year since data tracking began, with an estimated 3,359 FCEVs sold[21] [11]. This represents a 42 percent increase in sales over the previous highest-selling year 2018, with 2,368 FCEV sales. The first quarter of 2022 has also been essentially tied with Q1 2021 as the best-selling quarter to date, with 1,033 FCEV sales. If station development continues to build network capacity throughout the year as planned, 2022 could again prove to be a record-setting year for FCEV sales.

21 The vast majority of these sales are in California and may differ from DMV registrations due to differences in the nature and timing of the data. CARB has also confirmed that California Fuel Cell Partnership data likely do not adjust fully for vehicle attrition.

Figure 6: Comparison of On-the-Road Vehicle Counts in 2014-2022 Annual Evaluations

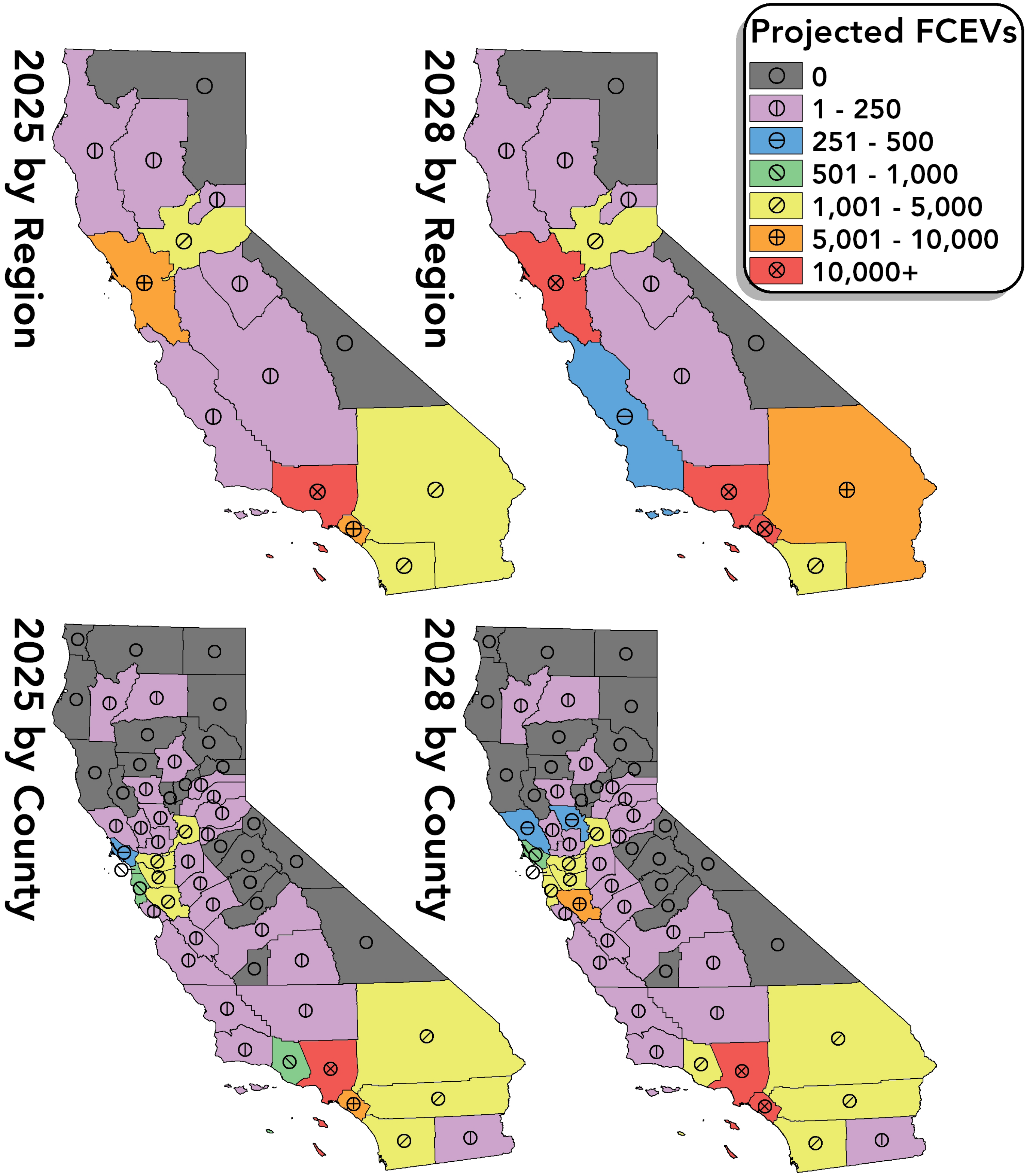


This year's projections for future on-the-road FCEVs are represented in Figure 6 by the large diamonds. The latest projections estimate that in 2025 there will be 34,500 FCEVs on California roads, and in 2028 there will be 65,600 FCEVs on California roads. Figure 6 also provides the previously reported end-of-period Mandatory and Optional Period estimates from all prior analyses of survey responses since 2014. These are indicated by the small diamond symbols. The range of estimates for all years provided by all surveys to date is represented by the shaded areas. As shown, the reported end-of-period estimates tend to be near or at the maximum of all estimates developed for a given year. This typically indicates that auto manufacturers express less certainty in near-term station network development and anticipate fewer FCEV sales than for dates that are further in the future.

As previous *Annual Evaluations* have noted, this reduction in vehicle sales projections over time has been highly correlated to the evolving projections for station network development over time and the tendency for station development timelines to extend beyond original or even revised projections. The FCEV registration data in Figure 6 shows that actual FCEV deployments also tend to lag projections. Similar to shifting future vehicle sales projections, this lag has been shown to have a correlation with shifting station development timelines.

Finally, Figure 7 displays the projected distribution by county and region of the 34,500 and 65,600 FCEVs in 2025 and 2028, respectively. The relative estimated distribution of vehicles is similar to the 2021 *Annual Evaluation* since much of the open and known planned network capacity distribution is the same. In addition, the counties and regions where future FCEVs are projected to be most concentrated are similar to the counties and regions where FCEV registrations are currently the highest (by comparison to Figure 4). FCEVs are anticipated to be concentrated most in the Greater Los Angeles, Orange County, and San Francisco Bay Area regions. The Sacramento, San Diego, and Inland Desert regions show the next-highest rates of FCEV deployment. At the county level, growth within the Greater Los Angeles region will be more concentrated in Los Angeles County than Ventura County. Most of the growth in the Sacramento region will occur in Sacramento County itself. FCEV fleet growth will be spread across the San Francisco Bay Area, but is estimated to be slower in Solano, Napa, and Marin counties.

Figure 7: Estimated Geographic Distribution of Future 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 early target markets. Assess how well this matches projections of regional distribution of FCEVs in these markets. Develop recommendations for locations of future stations to ensure hydrogen fueling network coverage continues to match vehicle deployment.

Current Open and Funded Stations

Station network development in the past year has progressed with relatively little change in the total number and location of previously known Open-Retail and planned hydrogen fueling stations. Station developers continue to make progress on their stations currently under construction or in earlier phases of development, and it is possible that one or more will provide new addresses for development of batch two stations under GFO-19-602 before the end of 2022. The changes that have occurred so far and are reflected in the analysis presented in this *Annual Evaluation* include the following:

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

- Eight new stations have achieved Open-Retail status. The new stations are Hawaiian Gardens and Sherman Oaks in the Greater Los Angeles Region, Baldwin Park, Costa Mesa-Bristol, and Orange in the Orange County Region, and Cupertino, San Jose-Bernal and San Jose-Snell in the San Francisco Bay Are Region.
- The Berkeley station has progressed from Temporarily Non-Operational status to Open-Retail operations.
- The Mountain View station has changed from Open-Retail operations to Temporarily Non-Operational status.
- The Riverside station remains in Temporarily Non-Operational status, but now accepts fueling by appointment[22].

Changes in Planned Stations:

- Station developer Iwatani has adjusted the fueling capacity of many of the stations that are currently under development through private funds and stations co-funded under GFO-19-602. These adjustments have been a mix of capacity increases and reductions.
- All station developers have indicated extended station development timelines for one or more stations currently under development.
- Station developer Iwatani has also indicated that the development schedules of future batches in GFO-19-602 have been pushed back one year.
- The Riverside station has now been identified for a future upgrade that will increase its daily fueling capacity.
- See Appendix B for all individual station details.

22 Appointments can be made by visiting the *Riverside Station Appointment Site*

The projected growth of the hydrogen fueling network by county between 2021 and 2028 is shown in Table 4. All currently known station locations are expected to achieve Open-Retail status by 2025. Of these 110 known station locations, the majority will be located in Los Angeles County (35), Orange County (17), and Santa Clara County (13). All other California counties have between one and seven known hydrogen stations projects, each. Stations in batches two and later in GFO-19-602 that do not currently have a known address are projected to be built in 2024 (25 additional stations), 2025 (41 cumulative additional stations), and 2026 (66 cumulative additional stations). The geographic distribution of stations by region (for all known locations) and the total number of unknown locations is shown by year in Figure 8. Individual station details (including current development or operating status and projected year of achieving Open-Retail status) are shown in Figure 9[23],[24].

Table 4: Historical and Projected Counts of Open-Retail Stations by County as of June 30, 2022

County	2021	2022	2023	2024	2025	2026 -2028
Alameda	5	6	7	7	7	7
Contra Costa	2	2	3	3	4	4
Fresno	1	1	1	1	1	1
Los Angeles	16	23	29	34	35	35
Marin	1	1	1	2	2	2
Nevada	1	1	1	1	1	1
Orange	9	14	16	17	17	17
Riverside	1	3	3	3	3	3
Sacramento	2	3	4	4	4	4
San Bernardino	1	3	5	5	6	6
San Diego	1	3	5	5	5	5
San Francisco	3	3	3	3	3	3
San Mateo	1	3	3	3	3	3
Santa Barbara	1	1	1	1	1	1
Santa Clara	7	10	12	12	13	13
Sonoma	0	0	1	1	1	1
Ventura	1	1	2	2	3	3
Yolo	1	1	1	1	1	1
TOTAL with Known Location	54	79	98	105	110	110
Future Stations (Location TBD)	0	0	0	25	41	66
TOTAL for All Stations	54	79	98	130	151	176

23 Based on station developer feedback, there are now multiple stations that are expected to receive an upgrade or be replaced with a nearby station. Stations with a planned upgrade that affects their nameplate capacity include Riverside, San Ramon, and Torrance. The UC Irvine station currently has a plan to move to a new location a short distance from the current Open-Retail station. In these cases, the station count and capacity data reflect these changes over time and at no time is the current and upgraded data included together. For example, all figures of current station network status include the UC Irvine station at its current Open-Retail location and capacity, while all figures of future network status include it at the new location and capacity since the station operator has indicated the current station will close at the end of 2022.

24 See *Appendix C* for similar individual station data in tabular form

Figure 8: End of Year Station Counts by Region as of June 30, 2022

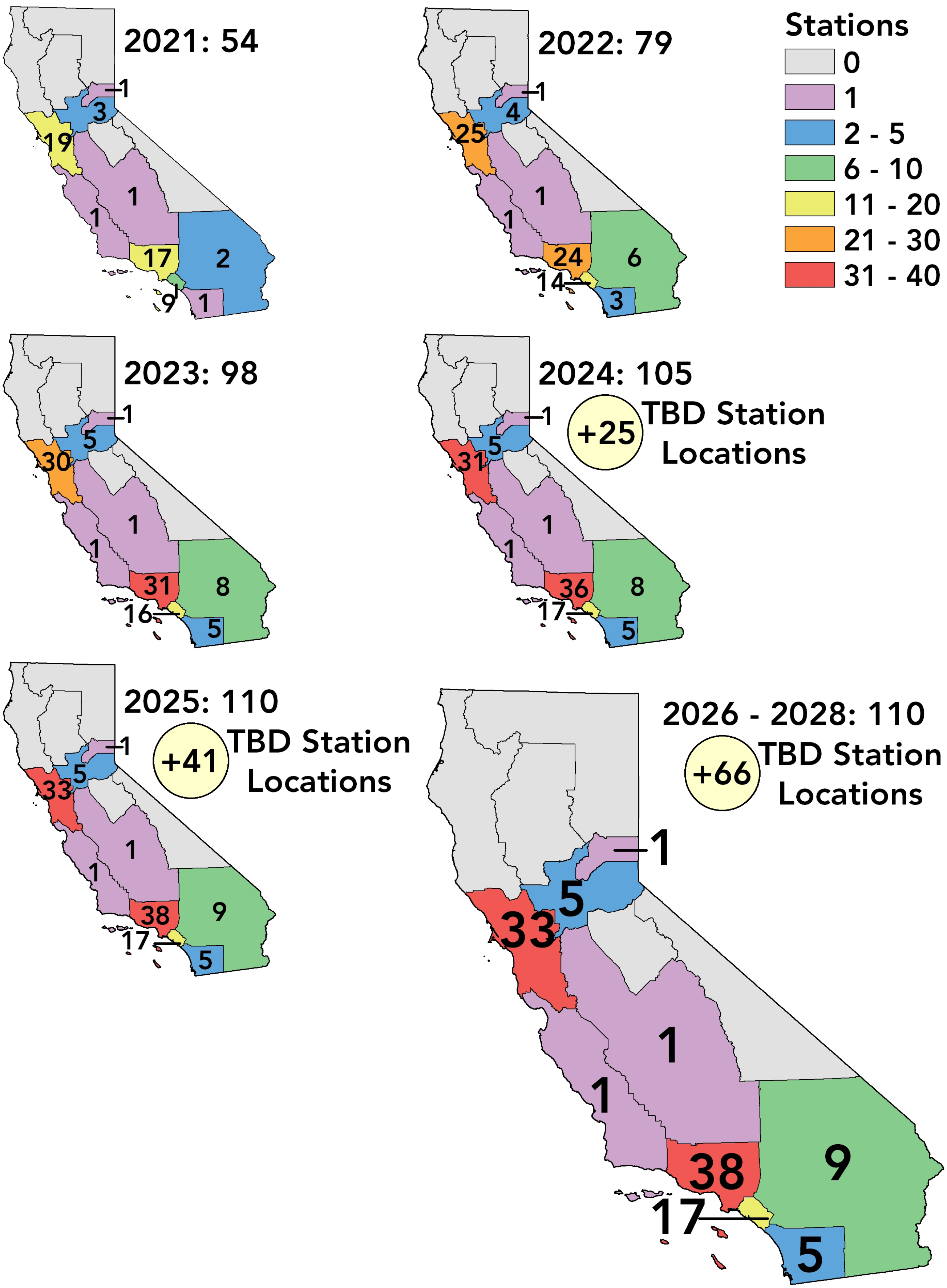
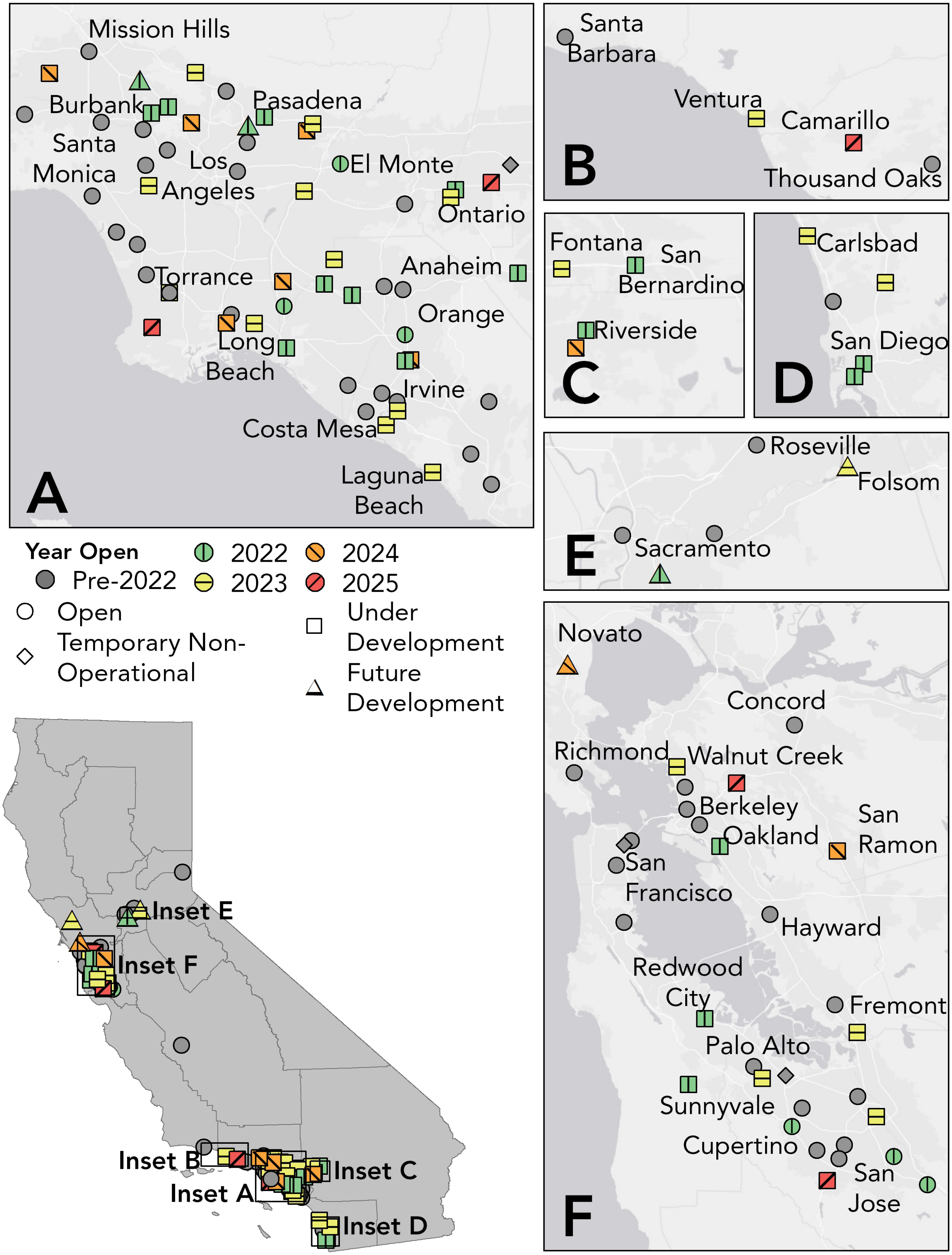


Figure 9: Map of Known Hydrogen Station Locations with Site-Specific Open Date and Development Status as of June 30, 2022



The currently Open-Retail and planned hydrogen fueling network provides varying degrees of coverage to communities across California. CARB staff utilize the CHIT tool to evaluate the relative degree of coverage provided by hydrogen fueling stations across the state [39]. Prior work has demonstrated that a 6-minute drive matches the convenience provided by the conventional gasoline fueling network. CARB staff evaluation of the hydrogen fueling network's coverage evaluates coverage at multiple drive distances out to a further limit of a 15-minute drive, due to the relative sparseness of the Open-Retail and planned hydrogen fueling network.

In CARB's evaluation, the relative degree of coverage provided to a community increases as more hydrogen fueling stations are located closer to the community. Overlapping coverage provided by multiple nearby stations indicates high coverage. Few stations located far from a community indicates low coverage. Any area outside of a 15-minute drive of any station in the network is considered to have no coverage. Evaluation of the time to drive to a station from any location across the state incorporates a highly detailed roadway dataset developed by CARB staff that utilizes US Census geographic information system (GIS) data for the structure of the roadway system in California. The roadway dataset combines this high-resolution roadway geography with CARB's Integrated Transportation Network model data to attribute afternoon peak traffic speeds at high local resolution. The Integrated Transportation Network model incorporates modeled and observed traffic data provided by California's metropolitan planning organizations.

With 56 Open-Retail stations concentrated in Los Angeles and Orange Counties and around the San Francisco Bay Area region, coverage is similarly highest in these areas. The highest degree of coverage is provided in two areas. The highest relative coverage is currently located in the southeastern portion of the San Francisco Bay Area region, where there are five stations – Campbell, Campbell-Hamilton, Cupertino, Saratoga, and Sunnyvale – that provide overlapping coverage to communities near these stations. Four stations in Orange County – Costa Mesa, Costa Mesa-Bristol, Fountain Valley, and UC Irvine – provide the next-highest degree of overlapping coverage to communities near these stations. All other communities around the state either have no coverage or have coverage provided by one or two overlapping stations.

Figure 10: Assesment of Coverage Provided by Network of 56 Currently Open-Retail Stations as ofJune 30, 2022

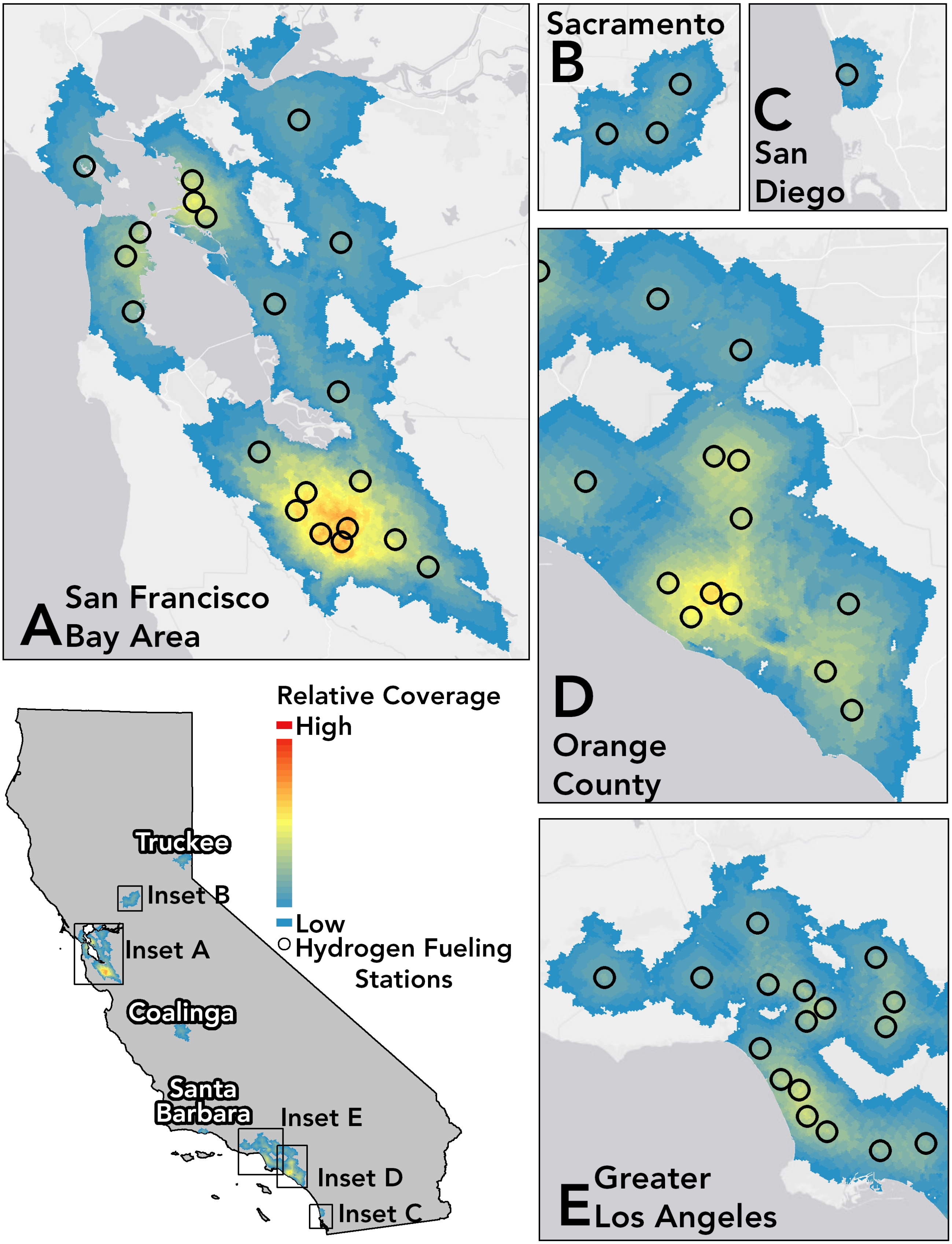
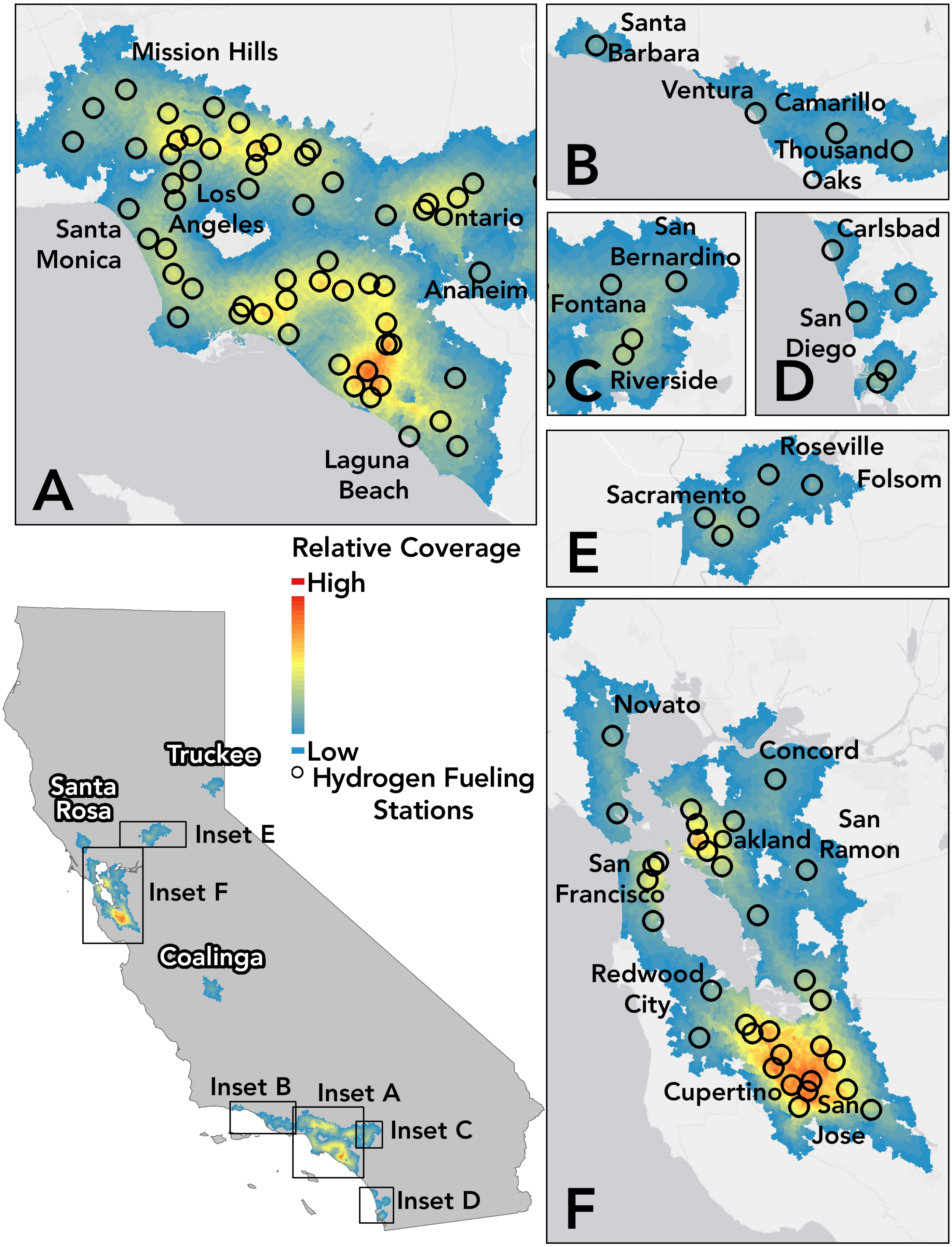


Figure 11: Assessment of Coverage Provided by Open and Funded Hydrogen Station Network as of June 30, 2022



As the network continues to add stations, coverage will expand in many areas across the state. Of the 176 total known hydrogen fueling station projects, 110 currently have a known address. The coverage provided by these 110 known addresses is shown in Figure 11. The highest degrees of coverage will be in the same general locations in the southeast portion of the San Francisco Bay Area Region and in Orange County, near Costa Mesa and Irvine. More stations will be built in these areas over the coming years. In addition, new stations will be built in a wider geography than the currently Open-Retail stations, but will remain concentrated in the Greater Los Angeles, Orange County, and San Francisco Bay Area regions. Neighborhoods near Oakland and Berkeley will have noticeably high degrees of overlapping coverage as well. Other markets across the state, like Sacramento, in Riverside and San Bernardino Counties, and near San Diego will see new station development as well, but they will be relatively dispersed and provide limited degrees of overlapping coverage.

Equity is a major focus of California's efforts to transition to clean zero-emission transportation options. It is important to ensure that all communities benefit from and are enabled to participate in this transition. Meaningful methods to evaluate equity with respect to zero-emission fueling and charging infrastructure are being explored and developed by California's government agencies. At a fundamental level, communities that have disproportionately faced environmental health hazards or other barriers to improved air quality require focused attention and investment for zero-emission vehicle and infrastructure deployment in order to reduce or eliminate those disparities.

At a minimum, a community will require zero-emission infrastructure located within their neighborhoods or nearby in order to support local residents' choice to lease or purchase ZEVs[25]. Figure 12 displays the proximity of the 110 known hydrogen fueling station locations to disadvantaged communities as identified by the CalEnviroScreen 4.0 tool [7]. CalEnviroScreen provides an analysis of communities across California at the census tract geographical resolution. Each community is evaluated according to many factors, divided into two categories: local environmental and health hazards affecting the community and socio-economic factors that may make them more sensitive to these local pollution burdens. Prior *Annual Evaluations* reported similar data using CalEnviroScreen 3.0. In late 2021, the Office of Environmental Health Hazard Assessment updated the CalEnviroScreen tool to version 4.0. The update includes new revised data and adds new factors into the identification of disadvantaged communities, though the methodology remains unchanged. CalEnviroscreen 4.0 also ensures that communities previously identified as a disadvantaged community in CalEnviroscreen 3.0 retain that designation.

With the updated data, the vast majority (102) of the 110 stations are located within a 15-minute drive (the maximum extent of coverage in CHIT analysis) of a disadvantaged community. Nearly three quarters (81) of the 110 stations are located within a six-minute drive of a disadvantaged community, potentially providing similar convenient access as today's network of gasoline stations to residents of those neighborhoods. Table 5 shows that the access to hydrogen fueling stations is similar across DACs and the general statewide population at all evaluated drive times within the limits of coverage.

25 Location of supporting infrastructure is likely only one aspect of these equity considerations. Enabling ZEV uptake and use in these communities, by the community members, is also an important aspect. Other secondary effects, like traffic and congestion, that may be impacted by the development of local zero-emission infrastructure may also play a role. Data and methods to evaluate these additional considerations are not yet available or standard practice, though California government agencies are working to develop these capabilities.

Figure 12: Hydrogen Station Locations at Various Proximities to a Disadvantaged Community

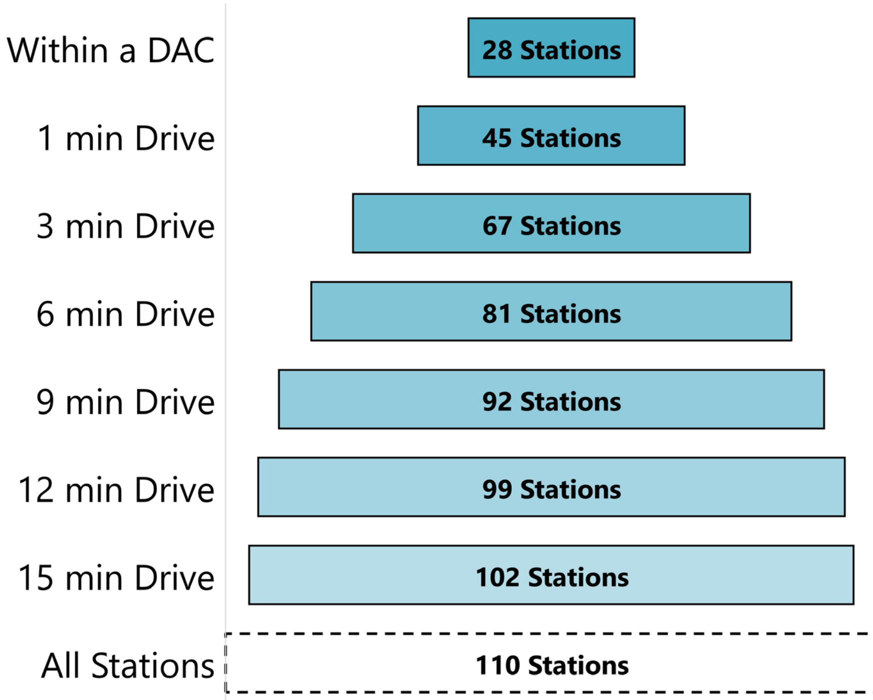


Table 5: Analysis of Population Proximity to Hydrogen Stations

Station Proximity to a DAC	Count of Stations	Percent of Known Locations	Percent of DAC Population[26]	Percent of Statewide General Population in Same Drive Distance
Within a DAC	28	25%	N/A	N/A
1 min Drive	45	41%	1%	1%
3 min Drive	67	61%	7%	8%
6 min Drive	81	74%	25%	26%
9 min Drive	92	84%	42%	43%
12 min Drive	99	90%	55%	53%
15 min Drive	102	93%	62%	59%

26 The calculation of the Percent of DAC and Statewide General Population is based on block-level resolution population data from the federal census. This is the finest resolution available and enables a highly accurate estimate of the percent of each population within each driving distance of the hydrogen fueling network without requiring assumptions of the distribution of populations within a census tract. In this analysis, block populations are attributed to their geographic center.

The analysis of Table 5 and Figure 12 shows that, for the areas where hydrogen fueling stations are currently planned, significant investment is being placed in or near some disadvantaged communities. The location of these hydrogen fueling stations will be equally as accessible to residents of these disadvantaged communities as to the general statewide population of California. However, this analysis does not provide information about whether all disadvantaged communities may have convenient access to a hydrogen fueling station (or what proportion of disadvantaged communities have convenient access).

Figure 13 and Figure 14 provide an analysis to identify which disadvantaged communities are (and are not yet) addressed by the planned hydrogen fueling network within the metrics of a convenient 6-minute drive and the 15-minute extent of coverage. In both figures, all disadvantaged communities are as low coverage (solid red fill), midrange coverage (striped red fill) and high coverage (no fill). Disadvantaged communities with high coverage have a high percent of their population within the indicated driving distance of a hydrogen fueling station, while disadvantaged communities with low coverage have a low percent of their population within the indicated driving distance of a hydrogen fueling station. These data were developed by overlaying station coverage at each driving distance with census block level population data, which provides a high resolution for population location.

The analysis of Figure 13 and Figure 14 shows that at both drive distances, the coverage provided by the planned hydrogen fueling network is restricted to relatively few disadvantaged communities located primarily in Los Angeles and Orange Counties and in the San Francisco Bay Area. The 102 stations that are within a 15-minute drive of a DAC are mostly located in these regions. The vast majority of disadvantaged communities, located in the San Joaquin Valley and Inland Deserts regions, have little to no coverage at either a 6-minute or 15-minute drive distance. Even in large parts of the Greater Los Angeles Region and San Bernardino and Riverside Counties, coverage to disadvantaged communities is limited to the less convenient 15-minute driving distance. The 81 stations within a 6-minute drive of a DAC are therefore clustered around a limited set of DACs even within these regions. This analysis highlights that many disadvantaged communities' potential needs are currently not addressed by the planned hydrogen fueling station network. Additional effort may be needed to drive investment and development into these communities via the locations of the remaining 66 un-located stations currently planned to receive California government co-funding, the stations to be funded under the upcoming General Funds solicitation, and privately funded stations.

Figure 13: Analysis of DAC Population Access to Hydrogen Stations at 6-Minute Driving Distance

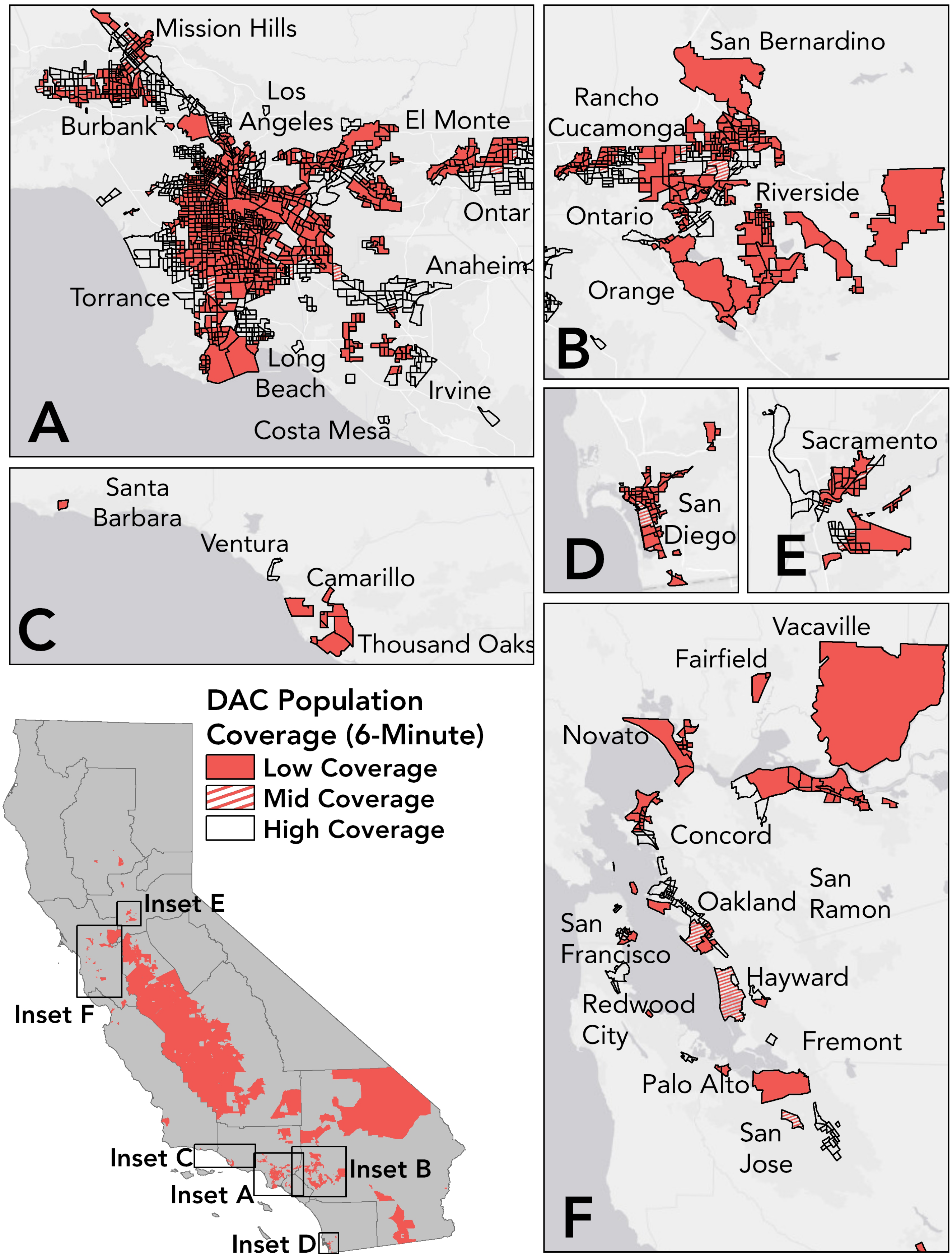
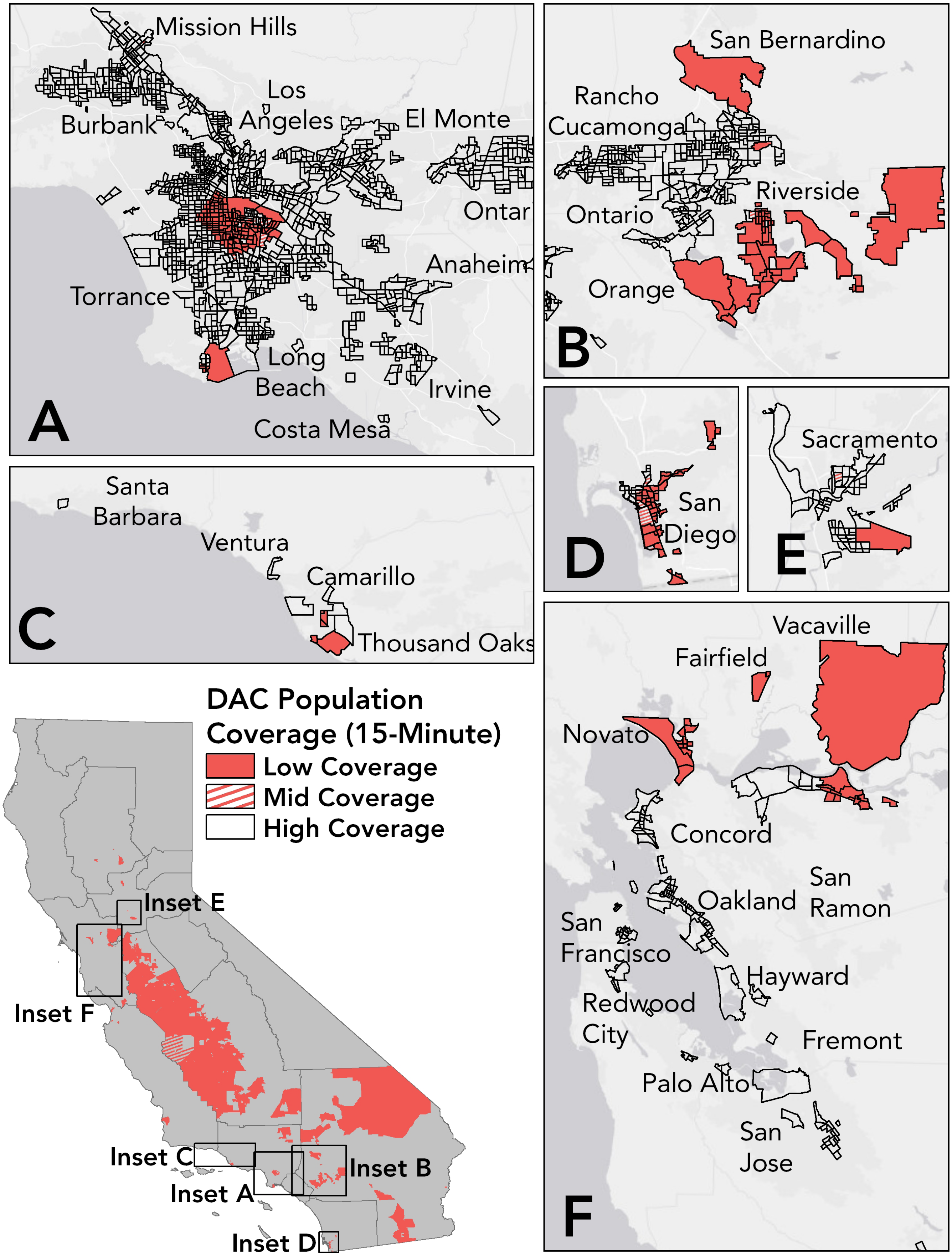


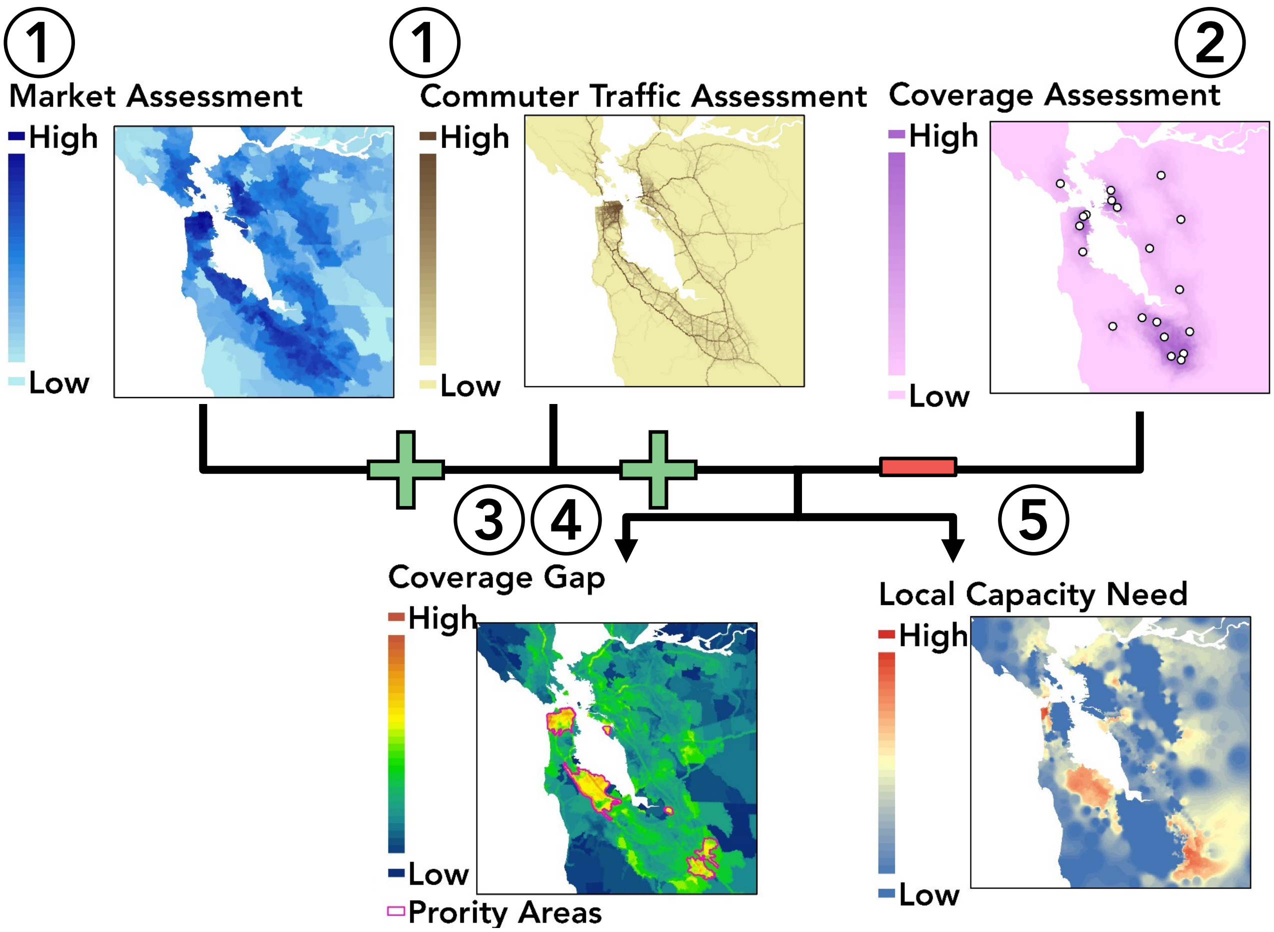
Figure 14: Analysis of DAC Population Access to Hydrogen Stations at 15-Minute Driving Distance



Evaluation of Network Coverage Gaps

Evaluating coverage provided by the network of open and planned hydrogen fueling stations is only one of the capabilities provided by the CHIT tool. CHIT is also capable of evaluating the potential market for FCEV adoption and hydrogen fuel demand across all communities in California. As shown in Figure 15, CHIT is used to evaluate the local market potential for hydrogen demand by evaluating both potential FCEV adoption rates and commuter traffic patterns (shown as step 1 in Figure 15). CHIT assumes that total hydrogen demand is driven primarily by local residents who own an FCEV and commuters passing near a hydrogen fueling station[27]. The potential local FCEV adoption rates are informed by several factors, including previous alternative fuel vehicle adoption and several socio-economic data available from the US Census.

Figure 15: CHIT Evaluation Processes



27 CARB evaluations in CHIT assume the resident-based demand is a stronger factor than the commuter-based demand.

Market demand and coverage provided by the open and planned hydrogen fueling network (step 2 in Figure 15) are compared to develop an assessment of coverage gaps across the state (shown as step 3 in Figure 15). This coverage gap assessment is performed on a relative basis. A local area that has a high potential for hydrogen demand may be evaluated as having a low coverage gap if a corresponding high degree of coverage is provided by the open and planned hydrogen fueling station network. At the same time, an area with lower estimated hydrogen demand may be identified as having a higher coverage gap if it lacks any planned coverage. This methodology enables identification of needs in smaller or emerging markets as larger markets' local needs are addressed.

The coverage gap assessment is then analyzed to identify areas where it is the highest and has statistical significance for being a high-gap area compared to surrounding areas. These areas are called Priority Areas in CHIT evaluations (shown as step 4 in Figure 15). These Priority Areas form the basis of CARB recommendation for locations where new hydrogen fueling stations are needed to continue to expand the network and meet the coverage needs of communities across California.

Finally, CHIT also provides a method to evaluate the need for new hydrogen fueling station capacity across California in a similar method to the evaluation of coverage gaps (shown as step 5 in Figure 15). Some of the details of the methodology differ for the capacity gap identification, but the intended interpretation of results is similar (to identify areas of high need for new hydrogen fueling capacity beyond the currently planned network). In particular, the evaluation of capacity gap requires additional information about the expected number of FCEVs that will be in California. CARB primarily analyzes capacity gaps based on the number of vehicles provided by auto manufacturers in annual surveys, though additional evaluations are also sometimes performed.

Suggestions for Future Co-Funding

An updated evaluation of coverage gap, informed by the latest data on Open-Retail and proposed station locations, current FCEV registrations, and census data reported in previous *Annual Evaluations*, is shown in Figure 16. Detail maps for specific areas are provided in Figure 17. Both maps show the evaluation of coverage gap on a blue-to-red color scale. Dark blue and green colors indicate low coverage gap and little need for a new station at this time. Lighter green and yellow colors indicate medium coverage gap. Orange and red indicate high coverage gap and significant need for additional coverage provided by new station planning. Both figures also show the identification of Priority Areas, indicated by magenta outlines.

Since there were few changes in the planned station network over the past year, the evaluation of coverage gaps and Priority Areas is similar to that reported in the previous Annual Evaluation. Locations with high coverage gap (and Priority Areas) are spread across much of the state. This includes locations in regions like Greater Los Angeles the San Francisco Bay Area, where much of the planned development is currently located, as well as opportunities in new regions like the San Joaquin Valley, Inland Deserts, Central Coast, and the northern California regions. Many of these locations where there is no planned station development yet known also offer opportunities to fill in coverage gaps for disadvantaged communities highlighted in Figure 13 and Figure 14.

Figure 16: Coverage Gap Analysis, as of June 30, 2022

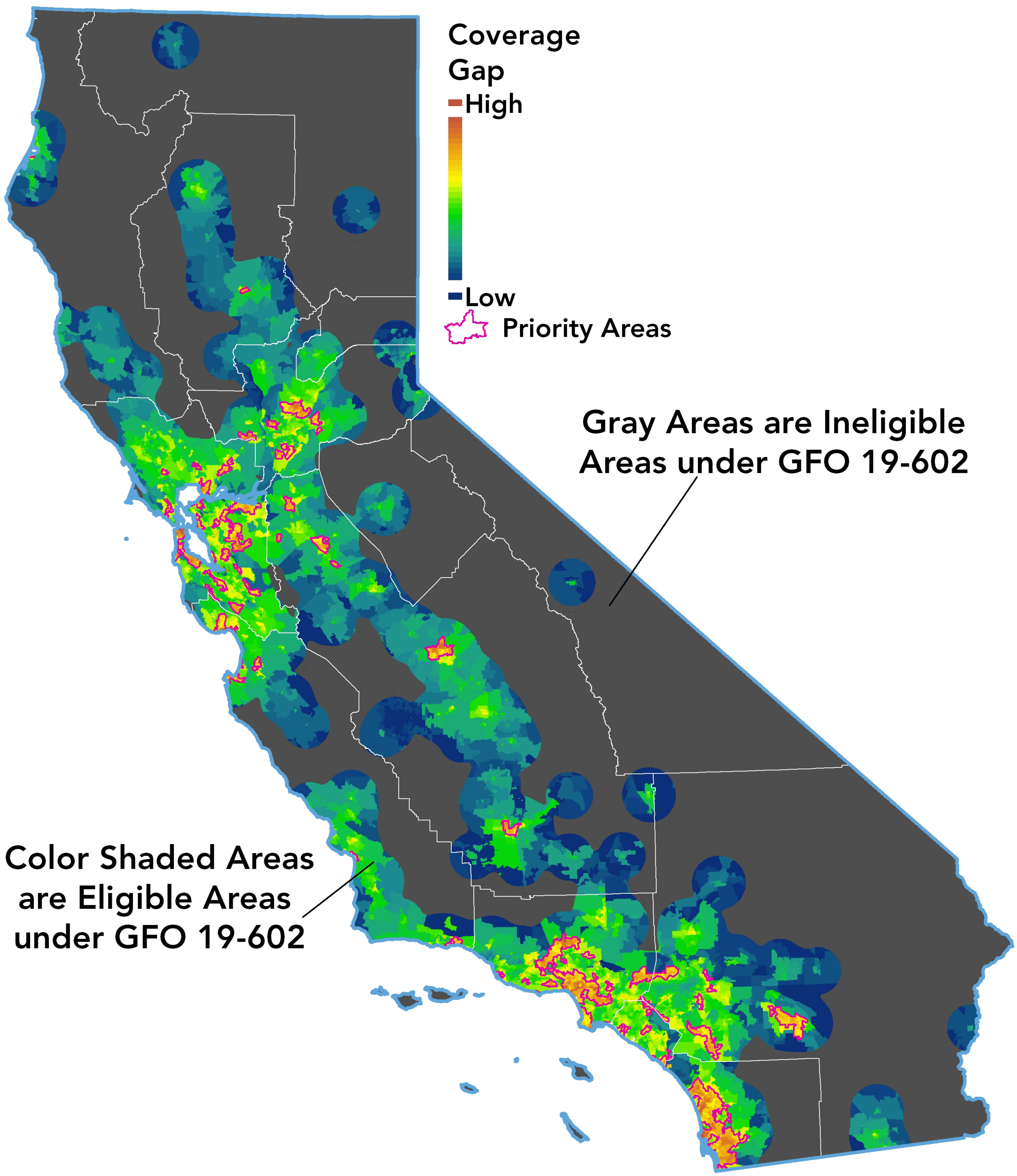
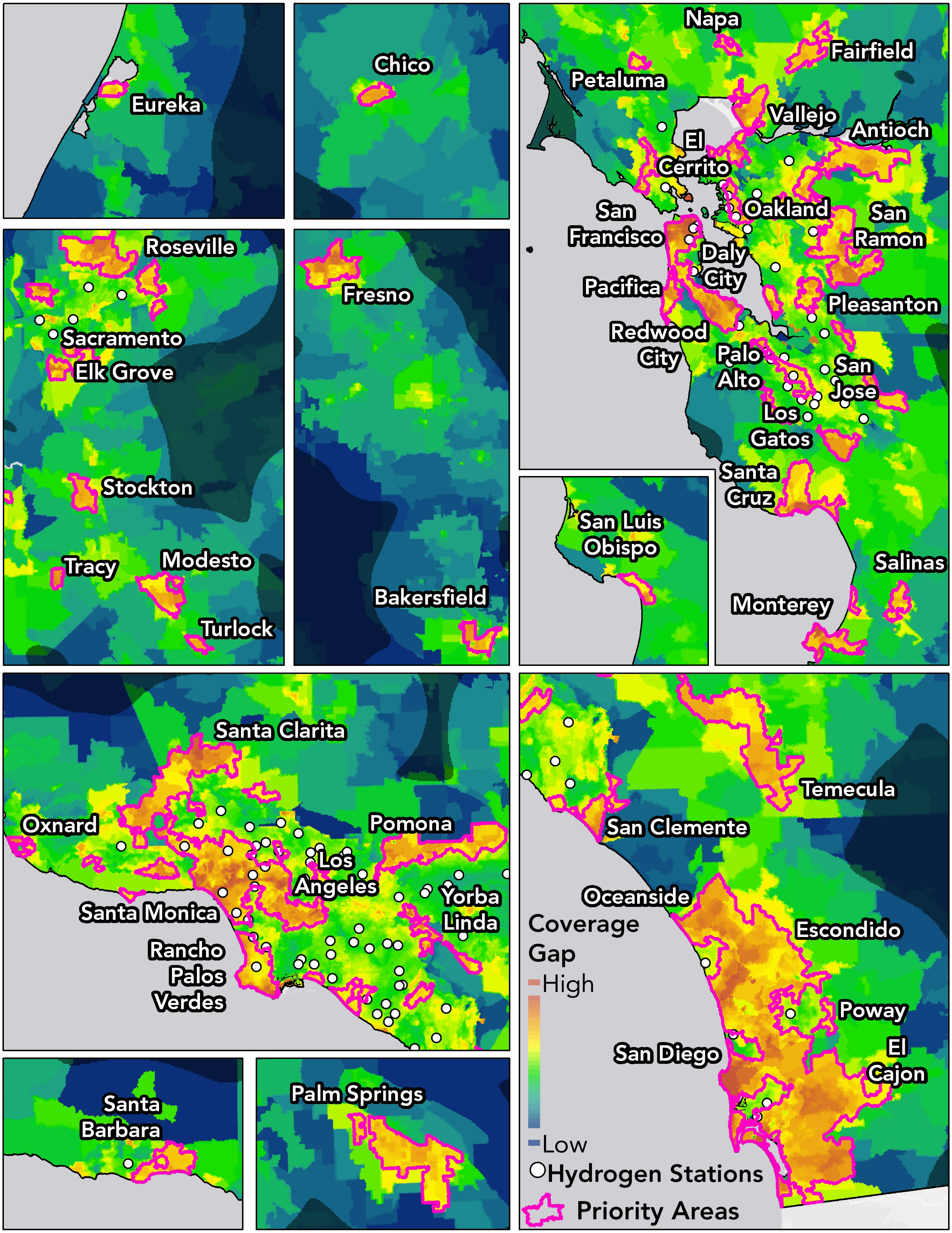


Figure 17: Priority Areas Detail for Future Station Development

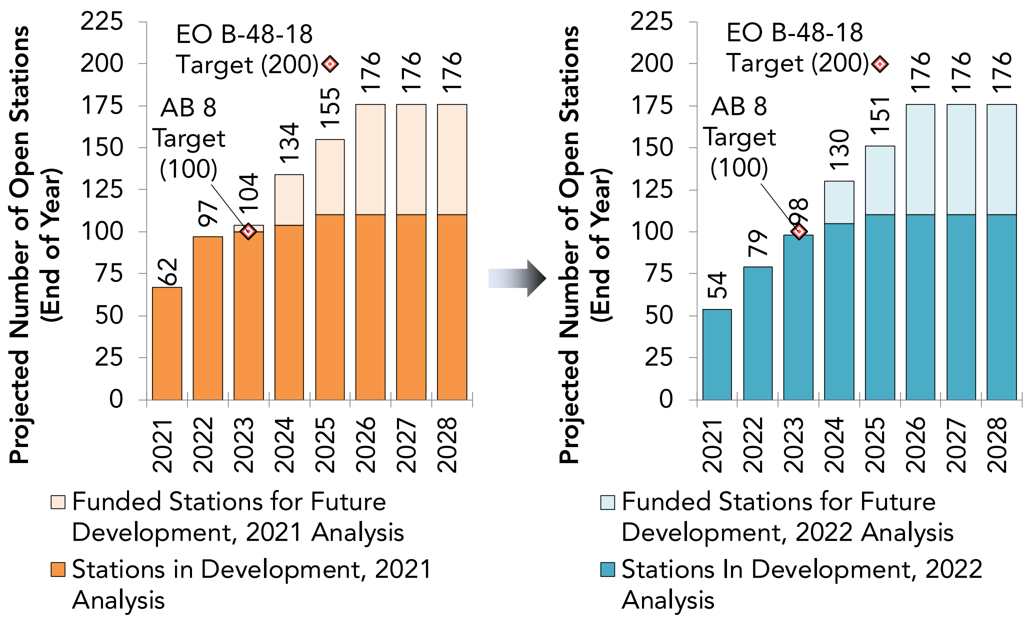


Trends of Station Deployment Rates

While there have been relatively few changes to the known plans for future station network development, some changes have made an impact with respect to achieving milestones established by California state government. AB 8 asks the Energy Commission to co-fund the development of at least 100 hydrogen fueling stations through the Clean Transportation Program (or until both CARB and the Energy Commission determine there is no longer a need to co-fund stations) [3]. AB 8 is also in effect through January 1, 2024, implying a milestone to achieve 100 stations co-funded by this time. With the award of GFO-19-602, the Energy Commission far surpassed this target with the total number of hydrogen stations planned to receive co-funding.

In the 2021 *Annual Evaluation*, CARB also reported that the most recent projections provided by station developers indicated that more than 100 stations would be Open-Retail by the end of 2023. With updated build schedules provided by station developers and some planned stations no longer expected to be built, revised estimates indicate 98 stations may be Open-Retail by the end of 2023 (as shown in Figure 18). Fulfilling this estimated growth projection depends on current estimated schedules for stations currently under development to face little to no further delays over the next 18 months.

Figure 18: Comparison of Statewide Station Projections between 2020 and 2021 Annual Evaluations



In addition, Governor Brown's Executive Order B-48-18 asked that all California government entities work with the private sector to ensure the development of 200 hydrogen fueling stations in California by 2025 [6]. To date, 176 station projects are known, including all stations co-funded by the Energy Commission, initiated planning through the LCFS HRI program, and confirmed through private funding. Of the 176 known station projects, 151 are expected to be Open-Retail by the end of 2025. The Budget Act of 2021 provided additional funds from California's General Fund to the Energy Commission for zero-emission fueling and charging infrastructure to the Clean Transportation Program [34]. The Energy Commission's 2021-2023 *Clean Transportation Program Investment Plan Update* identifies $27 million from these General Funds to dedicate to closing the gap to 200 hydrogen fueling stations [5]. The Energy Commission has held one workshop that included concepts for a potential upcoming solicitation for these funds. With the new solicitation, at least 200 stations will be funded by the end of 2025, though the timing to achieve Open-Retail status for all stations will depend on future build schedules.

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

As some station locations and expected performance details have shifted over the past year, there have also been some small shifts in the future projections for the pace of growth in daily hydrogen fueling capacity across the state. The total capacity of all known open and planned stations (including stations without an address) is 169,145 kg/day. With the most recent station build schedules, all of this capacity will be added to California's hydrogen fueling network between 2024 and 2026. All stations with a currently known address are projected to be complete by 2025 and will provide a total of 94,732 kg/day of hydrogen fueling capacity.

The breakdown of projected fueling capacity growth by region is shown in Figure 19 for 2021-2023 and in Figure 20 for 2024-2027[28]. Until further information becomes available either through the upcoming Energy Commission solicitation (that will leverage General Funds) or privately funded station development announcements, the total number of stations (and their fueling capacity) is projected to be the same for all years 2026-2028. The largest growth in station capacity is expected in the Greater Los Angeles and San Francisco Bay Area regions, followed by the Orange County region, and then the Inland Deserts and San Diego regions. The only other region that will have more than one station (with a total of nearly 3,000 kg/day fueling capacity) is the Sacramento region. The Central Coast Range, San Joaquin Valley, and Sierra-Nevada regions are currently expected to remain limited to the one station they each currently have, at 266 kg/day fueling capacity.

28 Note that similar figures in the 2021 *Annual Evaluation* contained an error where data for the Sierra-Nevada region was mapped onto the Sierra Foothills region.

Figure 19: Projected Fueling Capacity By Region, 2021-2023

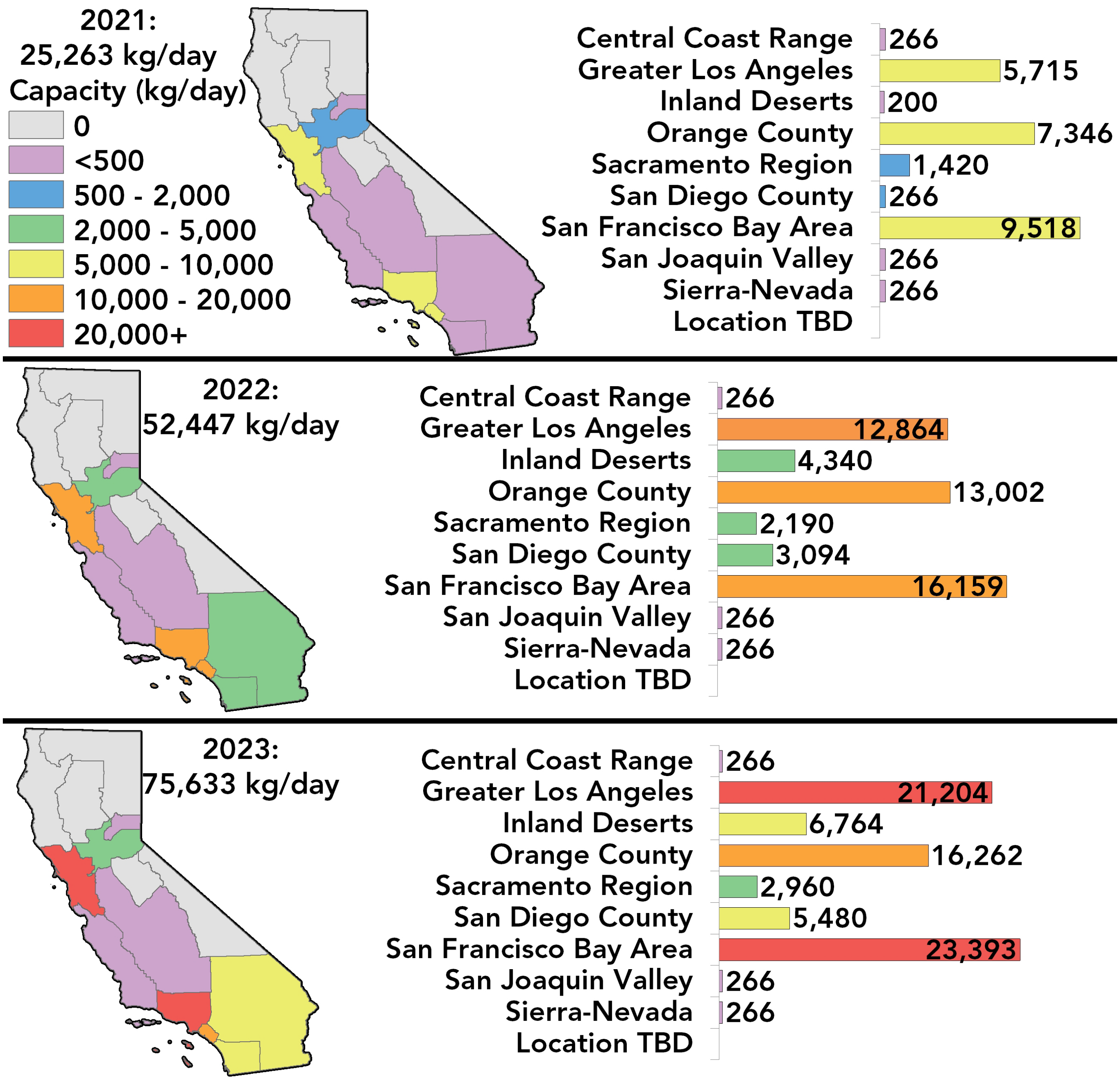
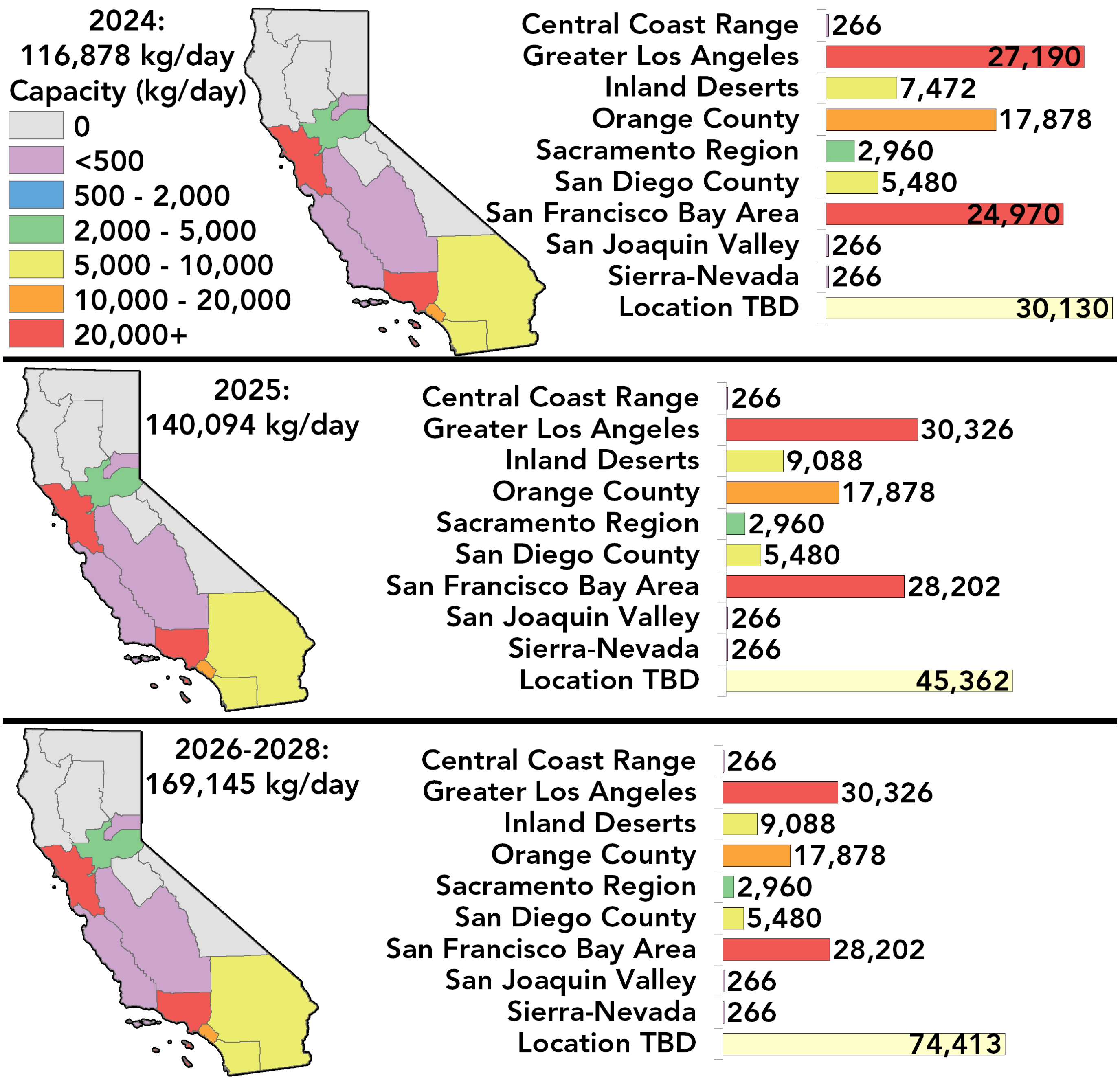


Figure 20: Projected Fueling Capacity By Region, 2024-2028



As the hydrogen fueling network is built out, it will be important to ensure that sufficient hydrogen fueling capacity is available in all regions, counties, and communities to support projected growth in the FCEV market. Multiple methods of evaluating this balance between projected fueling capacity and hydrogen fuel demand provide various insights into the locations where further capacity growth may be needed in 2025 and 2028.

At the most general level, projected statewide demand for hydrogen can be compared to the planned growth in hydrogen fueling capacity across California. This comparison is shown in Figure 21, with the capacity of the hydrogen fueling network translated into an equivalent number of FCEVs that could be served[29]. The statewide capacity of the hydrogen fueling network at the end of 2021 matches well with auto manufacturers' prior projections for cumulative FCEV sales by the same time. As the station network continues to be built out into the future, the statewide fueling capacity is projected to grow at a faster rate than the on-road FCEV population. By 2028, the statewide fueling capacity may be as much as 3.7 times larger than the demand from the projected FCEVs on the road. This represents a significant opportunity for auto manufacturers to accelerate FCEV deployment beyond their current projections, assuming projected hydrogen station build schedules are maintained. Using an industry standard approximation (based off gasoline station experience) that an optimal station operation dispenses 85 percent of its rated capacity, the projected network capacity is still 3.2 times the projected fueling demand[30].

The statewide network capacity at the end of 2021 was approximately 3.6 times as large as the number of FCEVs actually on the road at the time (which was less than prior projections) and may provide insight into auto manufacturers' approach to responding to the annual survey. The network capacity shown in Figure 21 is based on all stations' rated capacity per the Hydrogen Station Capacity Evaluation (HySCapE) tool or the operators' proprietary engineering calculations [40]. This method does not account for downtime due to equipment durability or limitations in hydrogen supply. These have been significant factors reducing station availability and uptime over the past few years. As previously reported, multiple events (like the closure of a major hydrogen distribution center in northern California, repairs to several hydrogen delivery trucks, and even major weather events) have caused hydrogen supply constraints or equipment performance challenges for California's network of hydrogen fueling stations. Although there has been recent improvement in the reliability of hydrogen supply and equipment performance, auto manufacturer responses to the annual survey may assume low station availability, near 50 percent or less.

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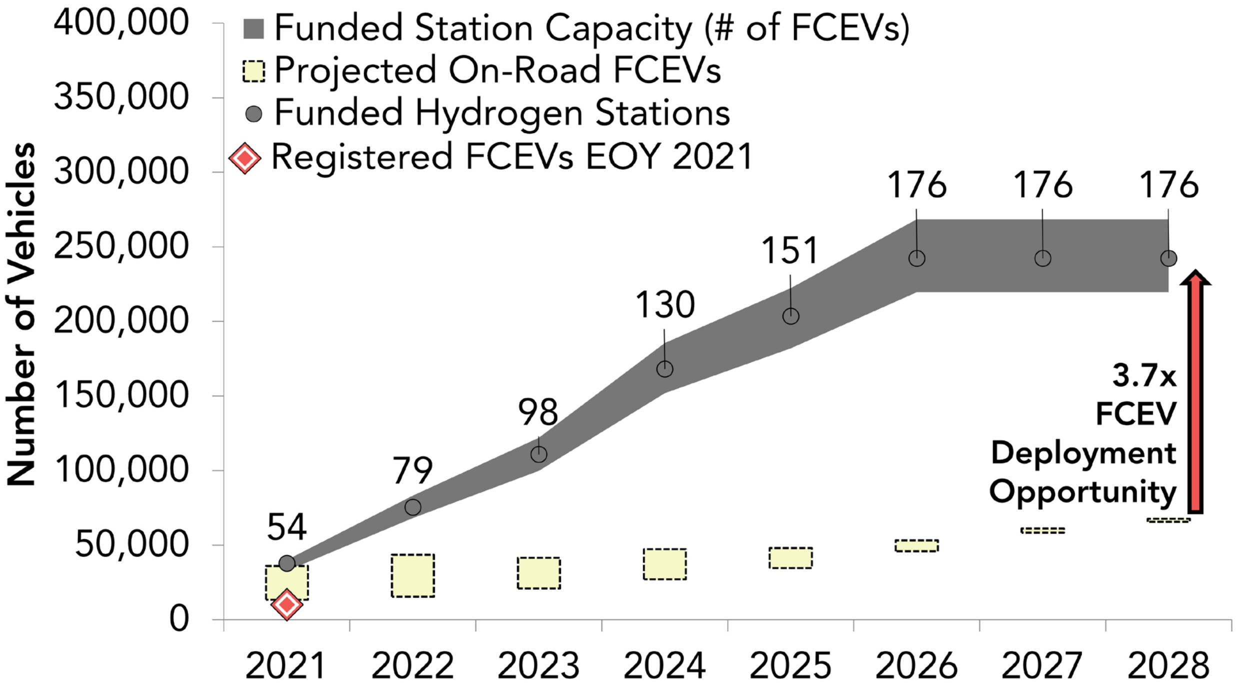
29 This conversion employs an industry-adopted standard assumption (established by researchers at the National Renewable Energy Laboratory) that each FCEV will consume approximately 0.7 kg/day. This assumes FCEV drivers use their vehicles in similar ways to gasoline drivers and captures the differences in energy content of gasoline and hydrogen and the efficiency of FCEVs versus conventional gasoline vehicles.

30 The 85 percent optimum ensures that the station maintains high fuel sales while also avoiding long lines and wait times for customers. It is separate from any considerations regarding equipment reliability and the availability of hydrogen fuel delivered to the station.

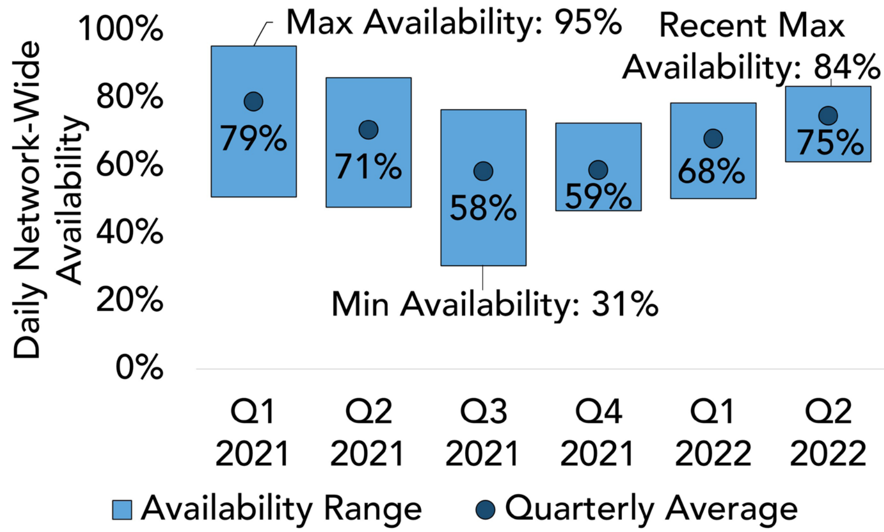
Figure 21: Comparison of Projected Vehicle Deployment and Network Nameplate Capacity



Recent actions by hydrogen providers and station operators have resulted in improved station availability and uptime over the past six months. This includes diversification of hydrogen supply, investment in new hydrogen production and distribution facilities and delivery trucks, growth in the station maintenance and repair workforce, and improvements to station equipment. Prior to these actions, data provided by the California Fuel Cell Partnership's SOSS[31] program indicates the average daily station uptime fell to as low as 31 percent in Q3 2021. Station availability was so low during Q3 2021 due to a combination of hydrogen fuel supply disruptions and equipment difficulties related to operations in extremely hot weather reported at some stations. Since that time, new supply arrangements and equipment improvements made by station operators and their suppliers have resulted in increased network-wide availablity. As shown in Figure 22, historical SOSS data indicate the highest daily average was 95 percent and the peak quarterly average was 79 percent in Q1 2021. Station availability has now significantly improved over the past year and is near historical highs. So far in Q2 2022, the peak daily availability has recovered to 84 percent and the quarterly average has been 75 percent.

31 SOSS is a program developed by the California Fuel Cell Partnership to monitor real-time status of hydrogen fueling stations and share that information with fuel cell drivers. This allows drivers an opportunity to verify station availability before they drive to a station to refuel. The system is largely automated and provides a status (Online, Offline, Limited, or Unknown) and an estimate of available hydrogen fuel at the station. The Limited status indicates that the station may be experiencing difficulty providing back-to-back fueling without interruption, which is more common during periods of high demand. Unknown typically denotes a temporary communication failure with the station.

Figure 22: SOSS Station Availability Data



Regardless of the assumed overall availability of stations, it does appear that auto manufacturer survey responses have had little reaction to the additional station development plans announced since awards were made for GFO-19-602. Prior to awards in GFO-19-602, the open and planned network contained 71 stations with a total capacity to support deployment of approximately 53,000 FCEVs[32]. Today, there are plans for more than double this amount of stations that can support more than four times the number of FCEVs on the road. Auto manufacturer projections for future FCEV sales have increased in the past two years, but at a more incremental pace than the additional station development plans. Auto manufacturers have previously shared that they rely more on historical data than planned development when responding to the annual survey, which seems to persist in the latest responses. This creates a delay between planned station development and FCEV deployment; based on the data of Figure 21, auto manufacturer plans for FCEV sales appear to lag planned network development by five or more years.

Statewide evaluation as shown in Figure 21 provides a sense of scale for whether there is sufficient hydrogen fueling capacity planned to support future FCEV deployment plans. However, not all FCEV drivers will be able to use all stations. The geographic distribution of FCEVs in relation to the locations of the network's hydrogen fueling stations is an important aspect to understanding whether there are more localized gaps in fueling capacity. These location-specific gaps may be masked at the statewide, or even county or regional, level of geographic resolution. CARB analysis leverages multiple methods to identify and quantify more targeted and localized capacity gaps.

The first method utilized by CARB evaluates the potential hydrogen fueling demand by assuming future FCEV sales will be distributed by county according to the data shown in Table 3. The available fueling capacity to drivers in a given county was calculated to account for the likelihood that vehicles may not fuel only in their home county, but also at stations in adjacent counties. This adjustment is made by dividing each station's capacity among all counties within a 15-minute drive distance of the station, proportional to the estimated number of FCEVs in each county in 2025 and 2028. The available fueling capacity to drivers in each county was then assumed to be the sum of all partial capacities from all stations that are located within a 15-minute drive distance of that county. The hydrogen fueling capacity balance (whether a surplus or deficit of fueling capacity relative to demand) in each county was then calculated by subtracting each county's hydrogen fuel demand from the available fueling capacity. The aggregated balances by Region in 2025 and 2028 are shown in Figure 23.

32 The count of 71 stations included stations that had been awarded in Energy Commission grant funding opportunities prior to GFO-19-602 and some stations that had at the time only been submitted to the LCFS HRI program.

All regions are shown to have either a zero or positive balance in both years in Figure 23, indicating planned capacity growth is sufficient to meet hydrogen fueling demand. In particular, the Greater Los Angeles, Orange County, and San Francisco Bay Area regions are projected to have significantly more hydrogen fueling capacity available to their residents than the projected demand. This is a positive sign that planned station capacity should be sufficient to enable further acceleration of FCEV sales, if current station build schedules can be maintained.

The balances shown in Figure 23 are in some sense logical. The analysis method inherently assumes that for the most part, FCEV sales will occur where the hydrogen fueling station network has been developed. This is because the data of Table 3 that formed the basis of the hydrogen demand calculation is based on the projected growth in fueling capacity by county. As a result, this analysis does not consider the possibility of potential FCEV and hydrogen fuel demand that is not addressed by the planned hydrogen fueling network. That is, there may be areas of the state where hydrogen demand (located in areas where no hydrogen stations are currently planned) would exist in the future that are not accounted for by this method.

CHIT was utilized to develop county and regional estimates of the hydrogen fueling capacity balance accounting for unmet demand. In this second calculation method, future FCEV sales were distributed across the state according to CHIT's FCEV market estimation data. With this method, FCEV sales were assumed to potentially occur anywhere in the state regardless of whether or not there are current plans for stations that would meet their needs. This helps provide a broader market view of the potential gap for new hydrogen fueling capacity. Attribution of station capacity to nearby counties was also assumed in this method. Results aggregated to the regional level are shown in Figure 24 and imply mostly the same conclusions as Figure 23. However, there are some regions, especially the San Joaquin Valley, where there is a notable opportunity for new market development that is not yet met by the planned network of hydrogen fueling stations.

Courtesy of Shell.

Figure 23: Hydrogen Fueling Capacity Balance by Region According to Current Known Stations

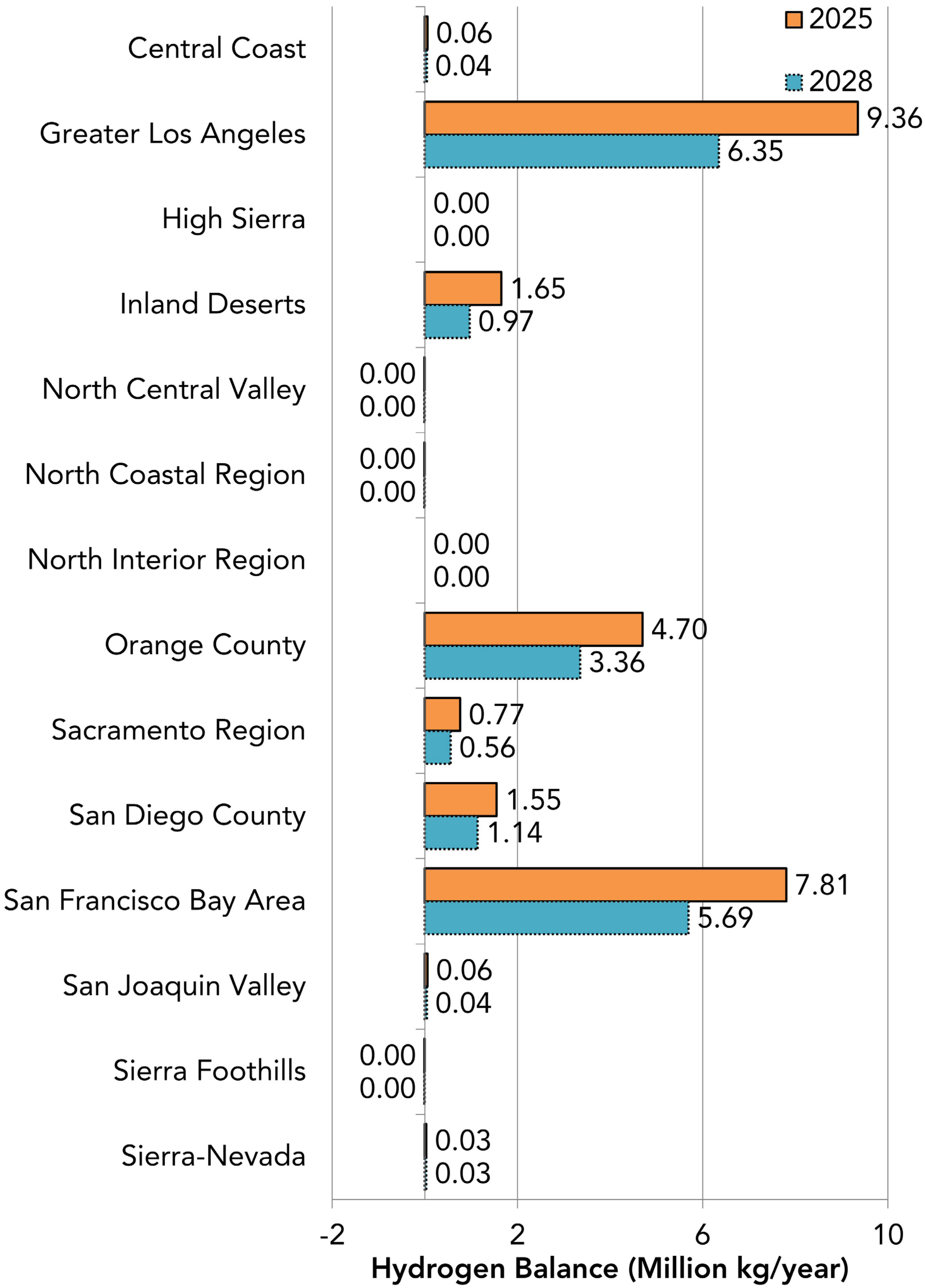
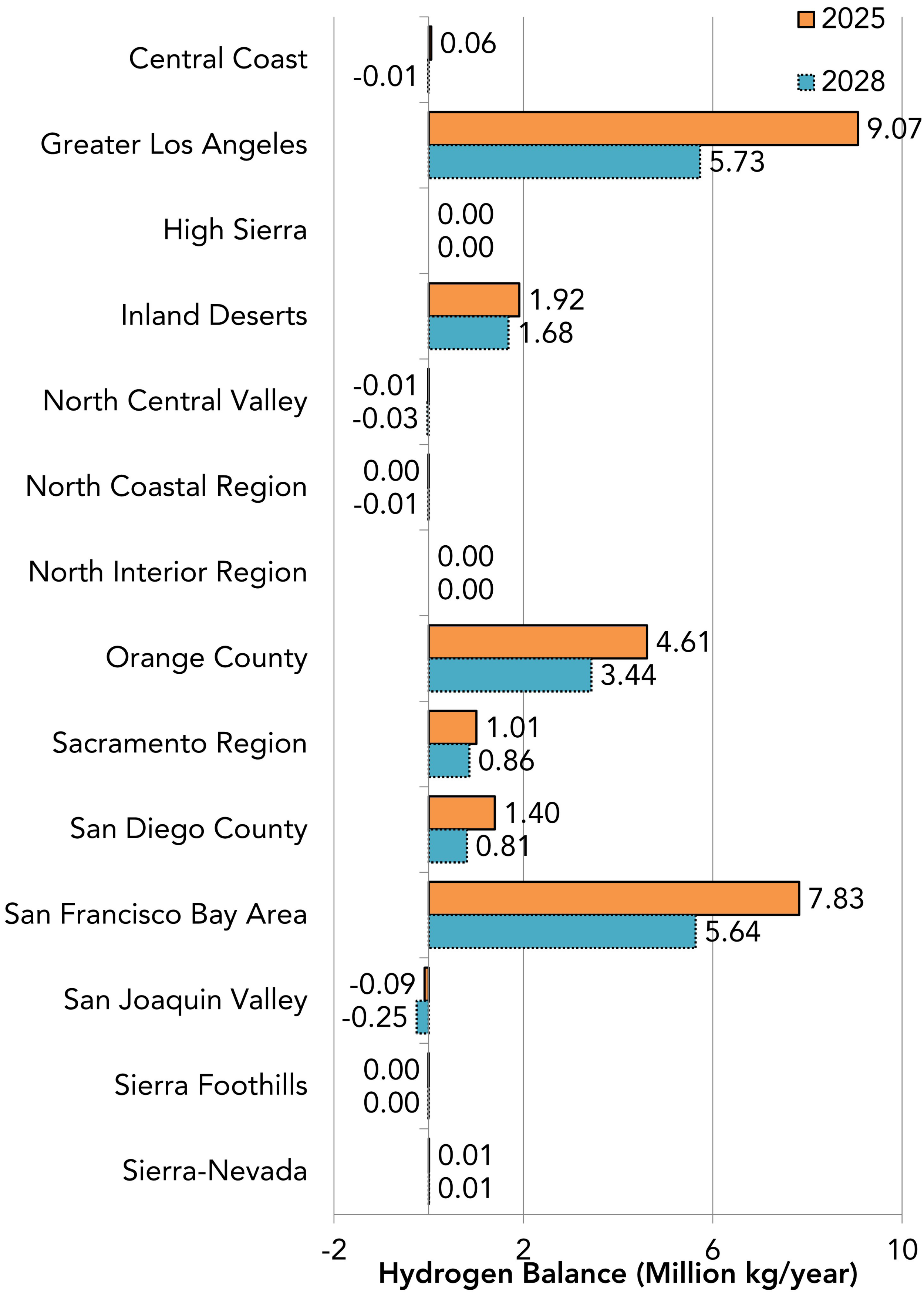


Figure 24: Projected Hydrogen Fueling Capacity Balance According to CHIT Market Estimates



A third method used by CARB to identify needed capacity in each county and region compares planned station development to the scenario presented in the *Self-Sufficiency Analysis*. This enables an assessment of capacity needs for useful reference scenarios where hydrogen station network development closely follows the CHIT-evaluated hydrogen fueling market and future FCEV sales are stronger than the auto manufacturers' latest projections. The network described in that report is approximately ten times as large by 2030 as the 110 known station locations. Because of the much larger size of the network, this analysis can also provide a useful reference point for the scale of capacity growth that is needed in the future to achieve a statewide and financially self-sufficient network of hydrogen fueling stations. Figure 25 shows the additional capacity needed by region to match the development status of the reference *Self-Sufficiency Analysis* network in 2028. Nearly all regions require additional capacity growth, with the most required in the San Francisco Bay Area region (approximately 82,000 kg/day), followed by the Greater Los Angeles region (approximately 49,000 kg/day), and then the Inland Deserts, San Joaquin Valley, and San Diego regions (between 23,000 and 33,00 kg/day).

Individual counties that require the most additional station capacity in this scenario are shown in Figure 26. Los Angeles and San Diego counties require the most additional fueling capacity. Alameda, Contra Costa, Orange, Riverside, Santa Clara, San Mateo, and Ventura counties each have a medium-sized need for additional capacity in this scenario. Most other counties require small amounts of additional fueling capacity, on the scale of one to a few stations with today's typical daily fueling capacity.

Figure 25: Projected Hydrogen Fueling Capacity Need by Region to Match Referenece Self-Sufficiency Scenario in 2028

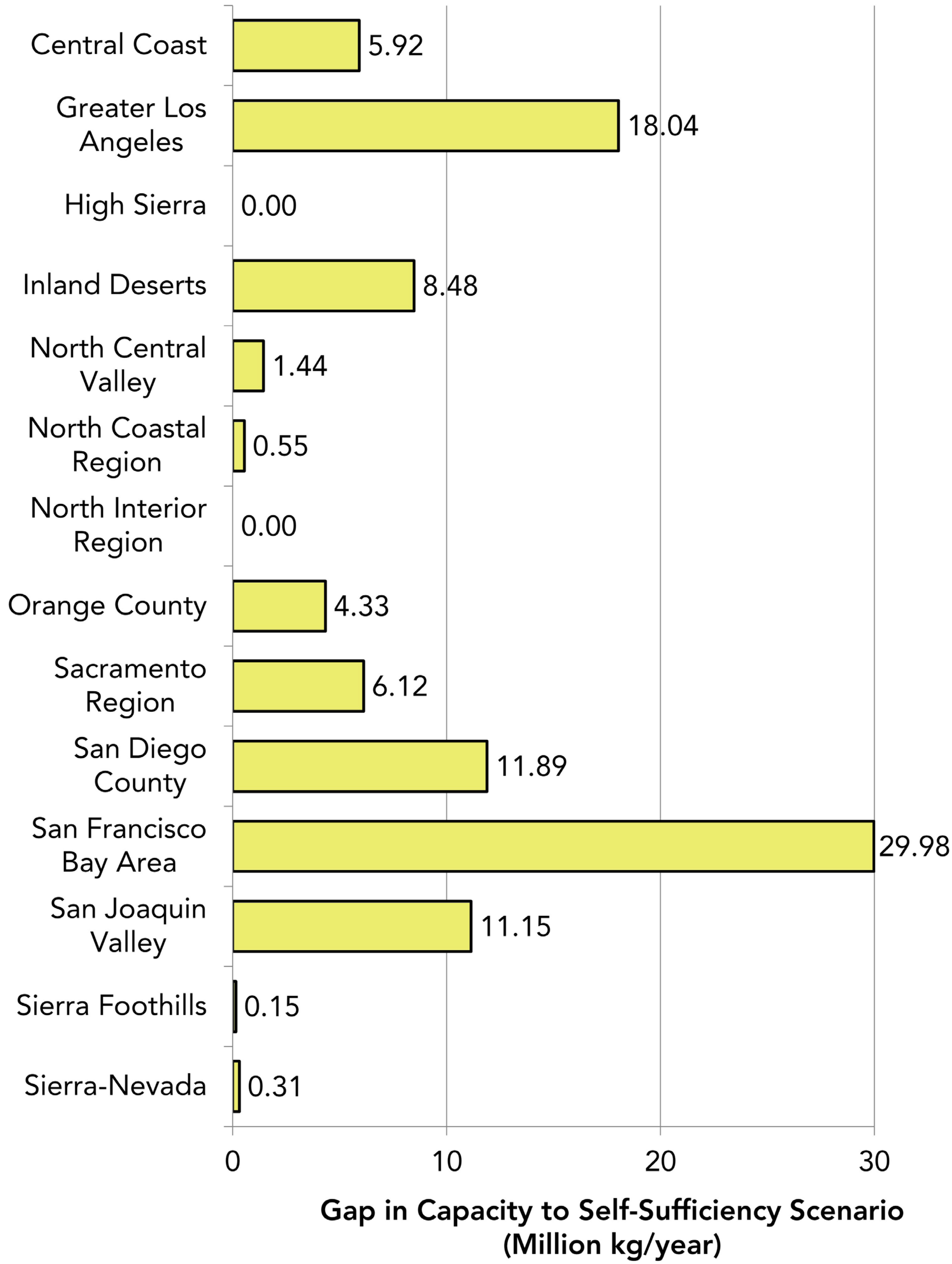
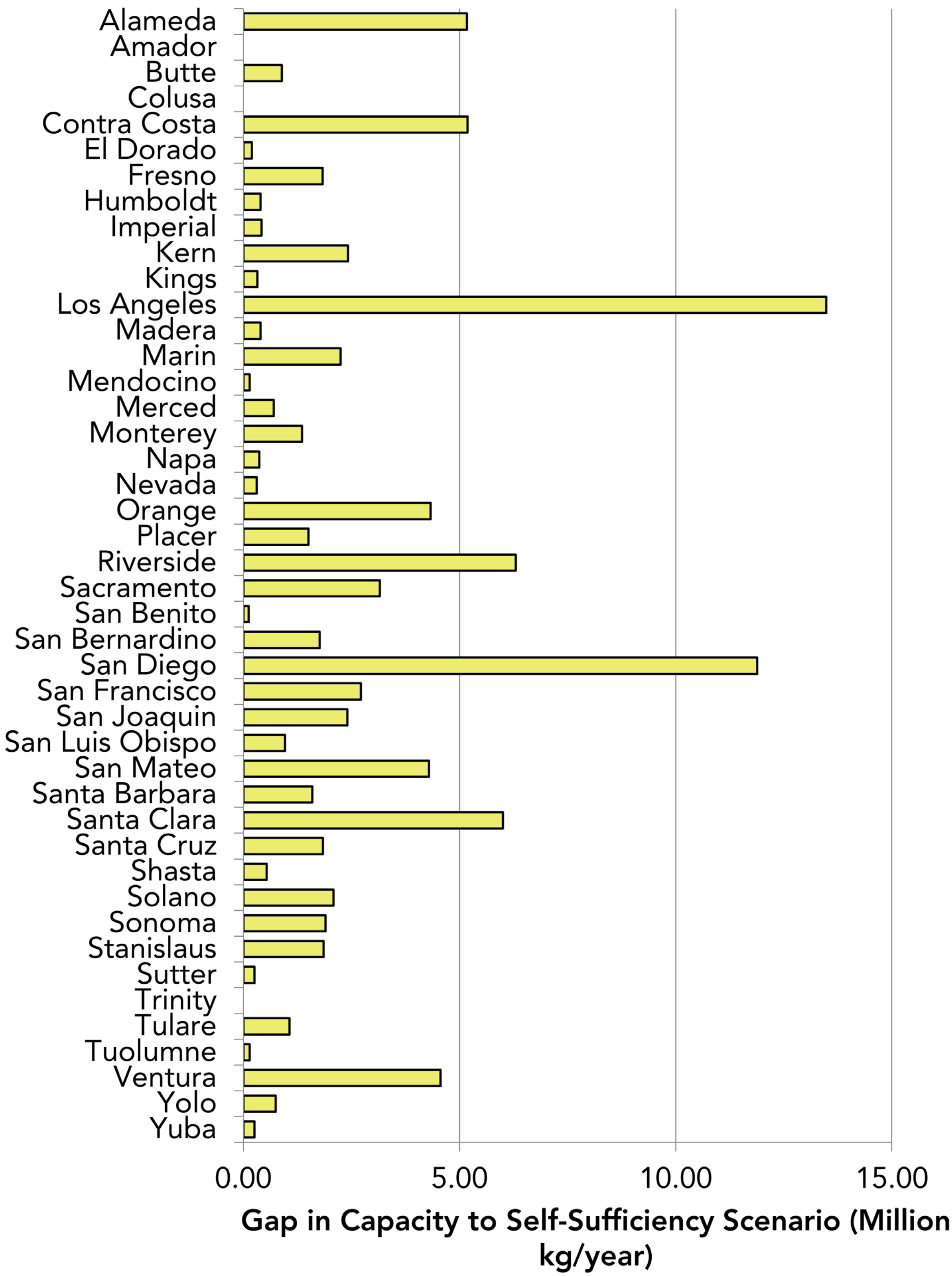


Figure 26: Projected Hydrogen Fueling Capacity Need Detail by County to Match Referenece Self-Sufficiency Scenario in 2028



Finally, the CHIT tool is utilized to evaluate potential capacity gaps, for the auto manufacturers' latest projections of future sales, at a high-resolution local level. This provides a highly detailed view of how the currently planned hydrogen fueling station network meets the needs of estimated FCEV market. This method assumes that future FCEV sales are distributed geographically according to the CHIT-based analysis for local FCEV market adoption strength, as in the analysis shown in Figure 24. This process attributes vehicles (and thus hydrogen fuel demand) at the census blockgroup resolution and interpolates between these data points. Gaps are then identified by subtracting the capacity of all stations within a 15-minute drive from the local demand calculation. Although this method and the analysis shown in Figure 24 both leverage the market evaluation capabilities of CHIT, this method provides a more detailed assessment of capacity gaps by attributing demand to the blockgroup resolution rather than aggregating to the county level. Analysis of gaps in this method remains highly localized, fully leveraging the detail analysis capabilities of CHIT. The projected localized capacity gap (to serve 65,600 on-road FCEVs in 2028) across the entire state is shown in Figure 27 with details of specific areas shown in Figure 28.

This highly localized evaluation reveals that even though there is sufficient hydrogen fueling capacity planned in most areas at the county, region, and state levels, there are gaps at a finer resolution. The highest localized capacity gap is 1,100 kg/day, which may be required in parts of San Francisco, near Redwood City, across much of the Greater Los Angeles region, near Pomona, and in communities within and around San Diego. There are also needs for smaller stations (up to approximately 500 kg/day) in these locations and others, including: around the San Francisco Bay Area (near El Cerrito, Pleasanton, San Jose, San Ramon, Santa Cruz, and others), in the San Joaquin Valley region (including Fresno and Stockton), cities surrounding San Diego and in southern Orange County, and in Palm Springs.

Figure 27: Current Capacity Gap Evaluation for Estimated 2028 FCEV Population

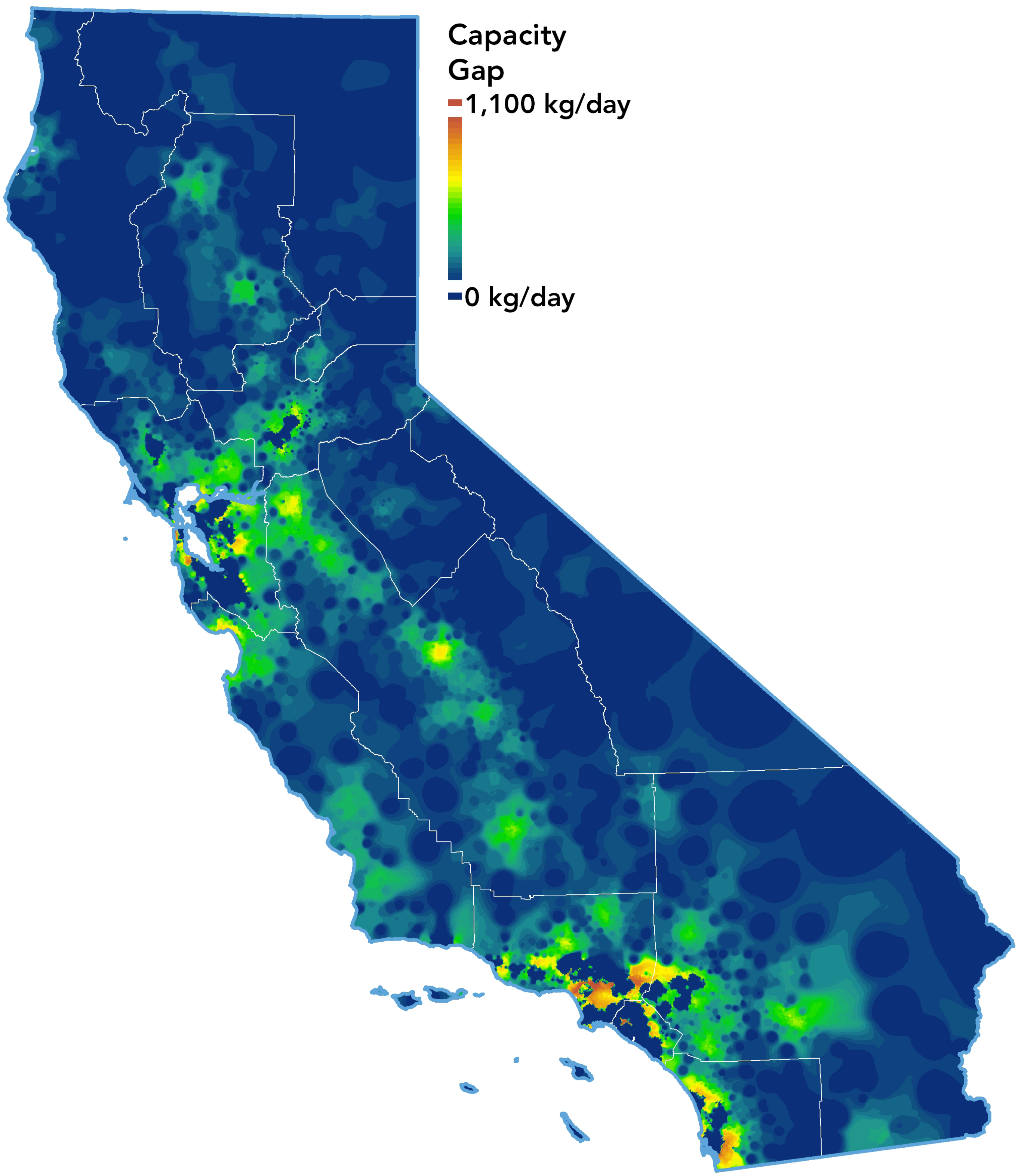
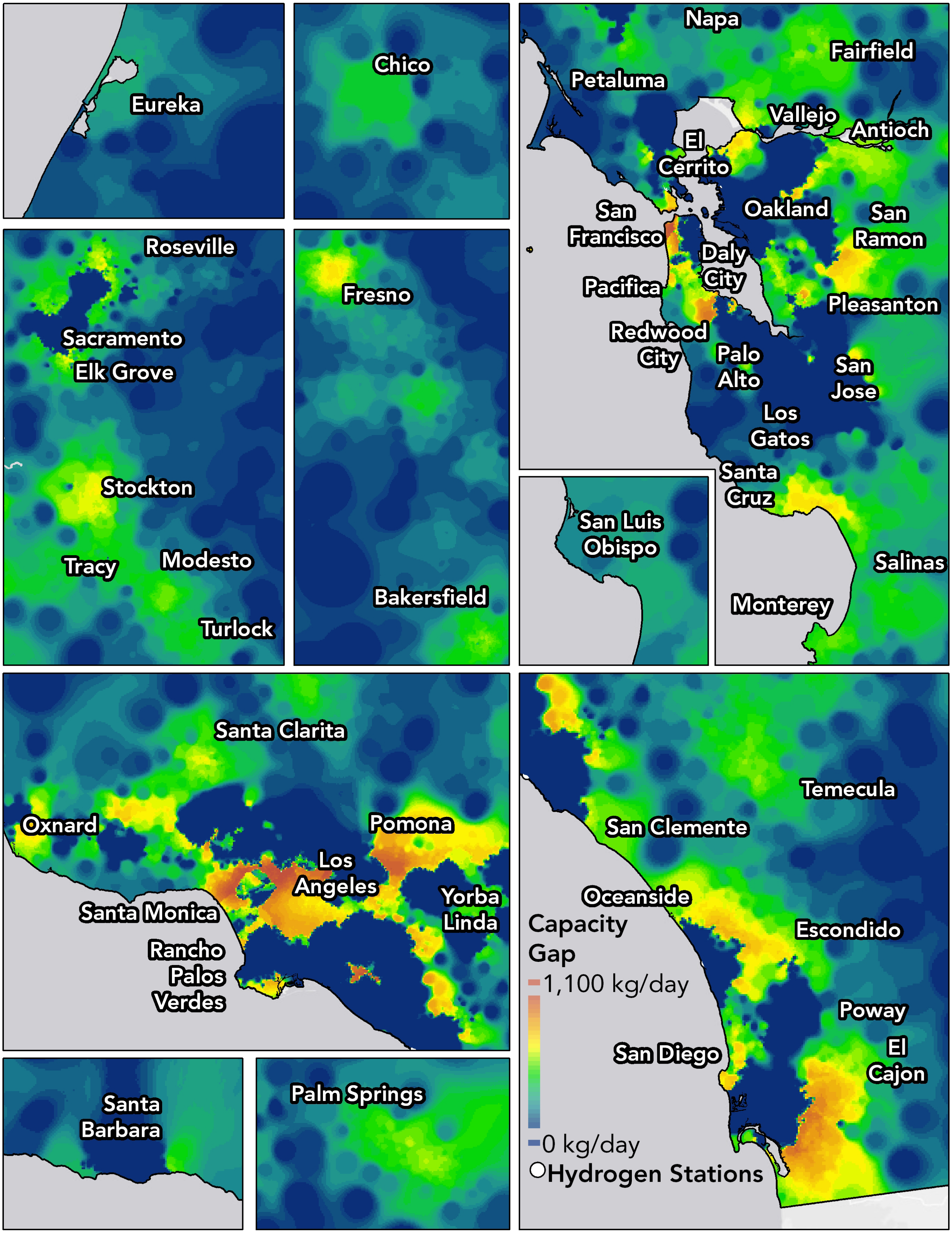


Figure 28: Capacity Gap Evaluation Detail



Capacity Requirements for GFO-19-602

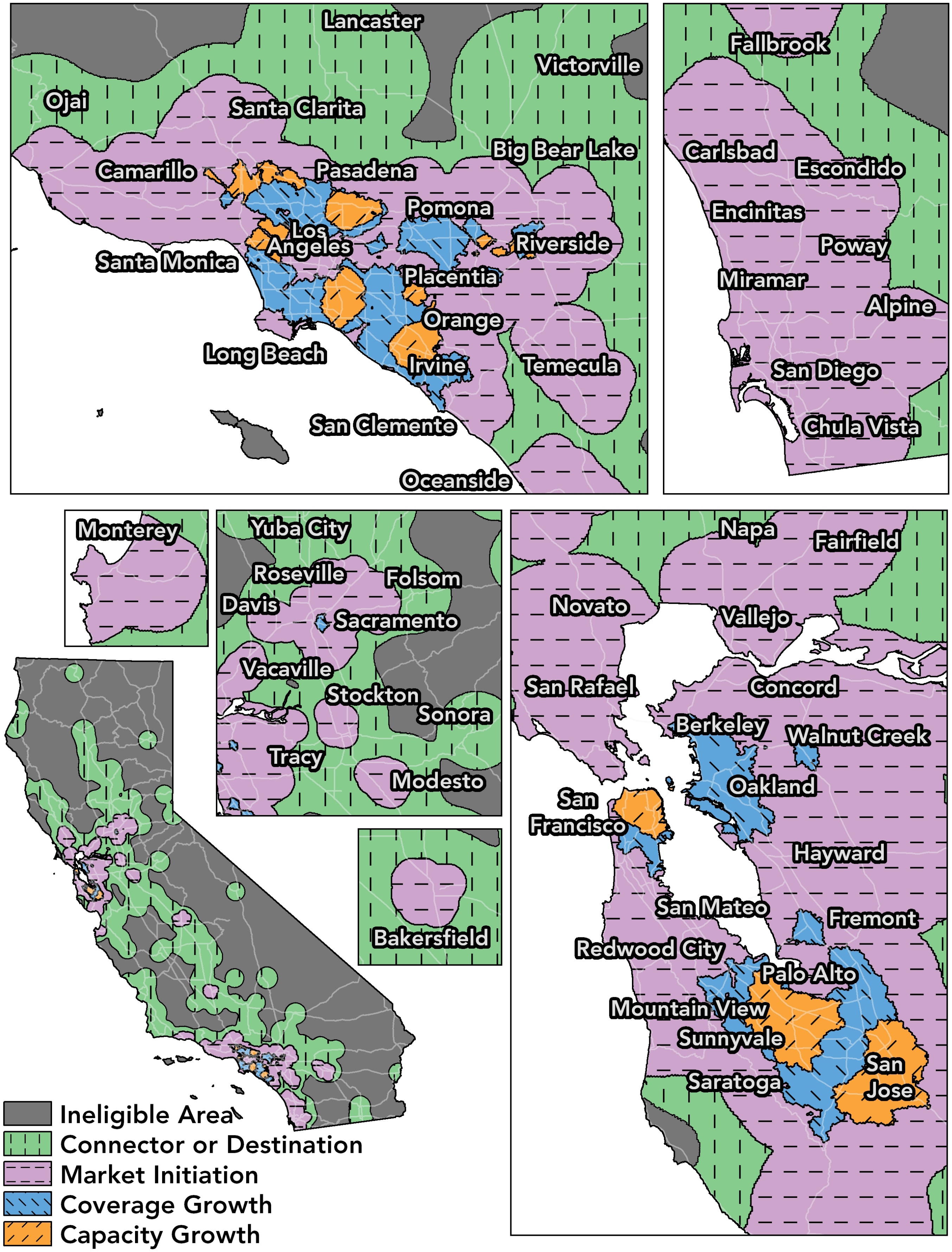
As station developers funded under GFO-19-602 continue to plan for locations to propose in future batches, they should be encouraged to seriously consider the coverage needs highlighted in Figure 16 and Figure 17, the disadvantaged communities highlighted in Figure 13 and Figure 14, and the capacity gap needs shown in Figure 27 and Figure 28. Station developers funded under GFO-19-602 are also required to meet minimum daily fueling capacities based on location.

GFO-19-602 introduced the concept of an Area Classification system to determine the minimum required daily fueling capacity for any proposed station based on its location. In general, higher daily fueling capacities are required in areas where there are more open and planned hydrogen fueling stations. A larger number of stations indicates greater local market maturity and a greater likelihood that capacity growth will be a more significant concern for local network expansion than coverage growth. The eligibility criteria also take into account the modeled need for network expansion as presented in the California Fuel Cell Partnership's Revolution document and analyzed in the *Self-Sufficiency Analysis*.

The Area Classification system defines five classes to determine minimum required daily fueling capacity. "Ineligible Areas" are far removed from the expected hydrogen fueling market. "Connector or Destination" areas have smaller projected hydrogen fueling markets but will be a vital part of a statewide network; these areas have the lowest daily fueling capacity requirements. Areas identified as "Market Initiation" are among the largest modeled hydrogen fueling markets but have only one or two open or planned stations with overlapping coverage. Building coverage remains a priority and stations with high daily fueling capacity are not emphasized. "Coverage Growth" areas are also areas with large market potential but additionally have a few stations with overlapping coverage. Station developers should consider stations with high daily fueling capacity in these areas. Finally, Capacity Growth areas meet the conditions of Coverage Growth but additionally have the largest fueling capacity needs based on prior modeling. Station developers are highly encouraged to consider high-capacity stations in Capacity Growth areas. Figure 29 shows the updated area classifications for GFO-19-602, using the latest information about the planned hydrogen fueling network[33].

33 The data shown should be considered temporary and should not be used to finalize any decisions that awardees in GFO-19-602 make for location and capacity of any station that will be submitted to the Energy Commission for approval. The solicitation manual for GFO-19-602 outlines the timing for re-evaluation of the Area Classifications with respect to applicants' completion of stations in each batch. CARB will work with the Energy Commission to provide an updated evaluation at the appropriate time per the GFO-19-602 guidelines. The information in Figure 28 is provided only as a reference point for the evaluation at the time this report was drafted.

Figure 29: Temporary Updated GFO-19-602 Area Classifications



Renewable Content of California's Hydrogen Fueling Network

To ensure that FCEVs meaningfully contribute to achieving California's climate goals, the full lifecycle of hydrogen fuel production, distribution, and use must be low- to zero-carbon. The use of hydrogen in a FCEV emits no greenhouse gases or criteria air pollutants (the only tailpipe emission is water). The production and distribution stages are therefore the key pieces of the hydrogen fuel lifecycle to evaluate greenhouse gas emissions, air pollutant emissions, and the implementation of clean and renewable energy resources.

California statute (SB 1505; Lowenthal, Chapter 877, Statutes of 2006) currently requires that one-third of the energy used to produce hydrogen for transportation fuel be sourced from renewable energy resources [12]. This requirement applies to all hydrogen fuel sold at stations that receive co-funding from California State agencies. Once the total amount of hydrogen fuel sold in a 12-month period reaches 3.5 million kilograms, the renewable requirement will apply to all stations, regardless of funding source. This renewable implementation requirement has been incorporated into multiple California State agencies' hydrogen fueling station support programs. Prior to GFO-19-602, the Energy Commission's co-funding solicitations typically implemented a one-third renewable energy requirement. Some stations funded in early Energy Commission solicitations were awarded with a requirement for 100 percent renewable implementation. Prior to GFO-19-602, the LCFS HRI program introduced a 40 percent renewable implementation requirement for eligibility. This 40 percent renewable requirement was then encouraged in GFO-19-602.

For all stations, the determination of which resources count as renewable in the production of hydrogen is guided by California Public Utilities Code, Sections 399.11-399.36[34]. The adopted definition of renewable energy resources identifies several options, including electricity from wind and solar power, but also geothermal, biomass, landfill gas, municipal solid waste, tidal energy, and other resources deemed renewable. In addition, accounting for renewable attributes for all alternative fuels under the LCFS program (and as evaluated for stations co-funded by the Energy Commission) allows the application of renewable energy attributes to be fungible across a company's projects. That is, a company that produces hydrogen sold at a hydrogen fueling station may achieve the 40 percent minimum renewable content by attributing renewable energy used at another of their facilities to the production of hydrogen dispensed at fueling stations. This renewable energy crediting must meet certain restrictions and the same renewable energy asset cannot be credited to multiple projects or facilities. CARB's LCFS program has rigorous requirements and auditing capabilities to ensure renewable energy assets used as credits are properly accounted. Data and discussions with station operators indicate that the vast majority of renewable hydrogen sold at California's fueling stations is based on the application of renewable energy attributes from other facilities (sometimes called "indirect" renewable hydrogen).

Renewable energy implementation and carbon intensity are often correlated; typically, the more renewable energy used, the lower the carbon intensity of a fuel's lifecycle. However, every hydrogen production and distribution pathway has its own lifecycle greenhouse gas emissions, even renewable pathways. Some pathways may emit significant amounts of greenhouse gases throughout their lifecycle, others may have zero or very low greenhouse gas emissions (like electrolysis powered by solar and wind), and yet others may have negative lifecycle emissions. CARB's LCFS program data show that due to the higher efficiency of a FCEV compared to a conventional gasoline vehicle, hydrogen pathways tend to lead to a lifecycle reduction in greenhouse gas emissions compared to conventional gasoline. Even hydrogen produced by the most common conventional method of steam methane reforming of fossil natural gas, while not renewable, offers approximately a 40 percent reduction in lifecycle greenhouse gas emissions over a conventional gasoline vehicle. The latest LCFS program data show that the average carbon intensity of hydrogen sold as transportation fuel in

34 California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 10, Article 4, Subarticle 7, §95481 (a)(131)

California has decreased substantially, from over 120 gCO_2eq/MJ in 2017 to under 35 gCO_2eq/MJ in 2022[35].

Participation in the LCFS HRI program requires station operators to report hydrogen fuel sales and pathway data to the LCFS program. The LCFS HRI program evaluates renewable content based on the average of each operator's network-wide data. Because of this requirement and the high rate of participation in the LCFS program, LCFS program staff are able to provide an estimate of renewable implementation that includes data for all, or nearly all, stations in California's Open-Retail network.

The operational estimates for 2021 and the first quarter of 2022 are 59 and 65 percent, respectively, renewable content across California's network[36]. This rate of renewable implementation is significantly higher than the SB 1505 requirement and CARB's and the Energy Commission's program requirements. However, it is also significantly less than was reported for 2020 and estimated for the first half of 2021 (previously reported at 90 percent or above). There have been no changes in methodology for calculating these numbers, so it appears that station operators have shifted their hydrogen supply over the last year to options with less renewable content. Indeed, some station operators have reported that they have diversified their hydrogen supply options in response to the supply constraints experienced in prior years. This may have had the secondary effect of reducing their network-wide renewable implementation.

Looking forward, CARB evaluates the minimum amount of renewable content that may be expected for future hydrogen fuel sales. The operational estimates for 2021 and 2022, along with future estimates for 2023-2028, are shown in Figure 30. Because all support programs currently require a minimum 40 percent renewable content, and CARB expects nearly all future stations to participate in the LCFS HRI program (regardless of whether or not they receive separate co-funding from a California government agency), the minimum renewable content in 2023-2028 is assumed to be 40 percent. The total throughput of hydrogen fuel in future years is informed by the projected network fueling capacity and demand from FCEVs on the road. The smaller of these two metrics in any year is assumed to determine the hydrogen throughput. Since there is more fueling capacity than demand projected for all years 2022-2028, the estimated fueling demand of FCEVs on the road determines the potential sales in Figure 30. Based on the most recent FCEV sales projections, the 3.5 million kilogram per year sales threshold may be reached by the end of this year. Any station selling hydrogen fuel in 2023 or later may then be required to adhere to the renewable implementation rate of at least one-third, whether or not the operator receives co-funding from a California government agency.

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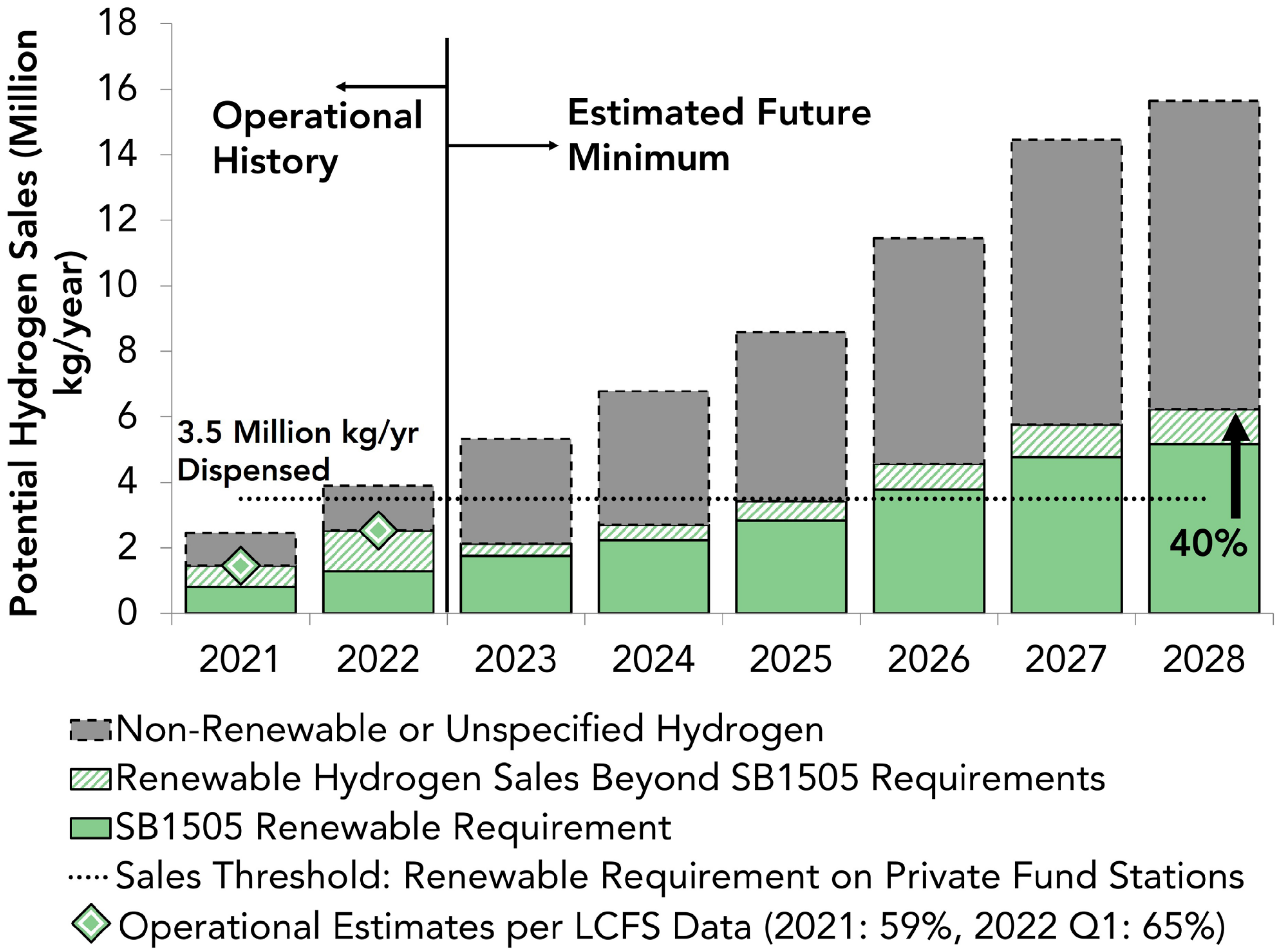
35 Similar to reporting of renewable percentage, the calculation of carbon intensity accounts for the application of fungible renewable attributes from facilities within the hydrogen producer's operations that may not be directly involved in the production of hydrogen gas dispensed in California's fueling network.

36 This renewable percentage represents only hydrogen sold at light-duty fueling stations. There are also a few stations across the state that are used to fuel busses. The LCFS program also has data related to these stations. For light-duty and bus stations combined, the renewable implementation has been 62 percent in 2021 and 56 percent in the first quarter of 2022. LCFS program data also indicate that light-duty hydrogen fueling stations participating in HRI provisions have a higher renewable content than the network-wide average, at 75 percent in the first quarter of 2022.

Figure 30: Evaluation of Minimum Renewable Hydrogen Content 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.

Hydrogen fueling stations in California provide fueling service to FCEV drivers that follow the requirements of several industry-adopted and regulatory standards. These standards help ensure that each time an FCEV driver fills their vehicle with hydrogen, the process will be fast, safe, and reliable. These standards and regulations also help ensure that FCEV drivers receive the high-purity hydrogen fuel product they expect and that their vehicles require to operate smoothly and maintain the onboard fuel cell and hydrogen storage system lifetimes. These standards are typically developed by collaborative efforts with members from industry, academia, government, and research organizations and published by well-known standards organizations like ISO and SAE or in code documents like the National Fire Protection Association code. In addition, some of these organizations publish test procedures that provide recommended methods to ensure the station equipment performance meets the requirements of the standards.

California's hydrogen fueling stations are typically held to these standards either by regulation (such as the Department of Food and Agriculture's Division of Measurement Standard's (DMS) regulations on accurate metering of hydrogen mass dispensed in each sale) or through incentive eligibility requirements (such as the minimum technical requirements in Energy Commission hydrogen station co-funding solicitations). In addition, California agencies administer support programs to help station developers ensure their stations meet these expectations prior to opening for retail hydrogen fuel sales and maintain these standards as they operate over the course of several years. Over time, codes, standards, test procedures, regulations, and support programs may adjust as new needs are identified or gaps in prior iterations are addressed with new knowledge and additional development time.

Updates to Standards and Test Protocols

Hydrogen fueling stations in California adhere to the SAE J2601 fueling protocol. This protocol outlines the allowable ramp rates of temperature and pressure during a hydrogen fueling event. The allowable rates ensure safe operation and minimal impact on the vehicles' hydrogen storage tank lifetime while providing drivers with a fast fill. The protocol also accounts for several variables that may change with each fill, including capacity of the vehicle's onboard hydrogen storage system, the initial amount of hydrogen in the system at the beginning of the fill, ambient temperature, the temperature of the pre-chilled hydrogen, the maximum pressure capability of the hydrogen storage system, and others.

Testing a station to ensure that it follows the protocol outlined by SAE J2601 requires a known and accepted test procedure. The industry-adopted test procedure for this process is CSA/ANSI HGV 4.3 (HGV stands for hydrogen gas vehicle). A new version of CSA/ANSI HGV 4.3 was published in February 2022. The new version of the test procedure includes a new compressed hydrogen storage system category D (more than 10 kg of storage at 70 MPa), identified the required factory acceptance testing and the minimum site acceptance testing, expanded pressure tolerances criteria, and provided various clarifications to prior language. Future station development and testing will need to account for this updated station testing procedure.

Heavy-Duty Stations Field Tested with HyStEP

Medium- and heavy-duty applications for hydrogen continue to attract significant interest, especially for their potential to reduce emissions in and near disadvantaged communities that are often located near sites of heavy commercial activity. This heavy commercial activity, especially the movement of freight, tends to be a major source of greenhouse gas and air pollutant emissions. Reducing or eliminating the tailpipe emissions of vehicles in this transportation sector can have significant benefit to residents in the nearby communities. As with the light-duty sector, CARB sees opportunity for FCEVs and BEVs to complement each other in different use cases in the medium- and heavy-duty vehicle sector.

Demonstration projects are already underway to evaluate and gain insights on FCEV heavy-duty truck use and hydrogen fueling. As reported in the 2021 *Annual Evaluation*, the HyStEP device has been used to perform preliminary testing at two heavy-duty hydrogen fueling stations in Ontario and the Port of Long Beach. Since last year, HyStEP has also been used to perform preliminary testing at a third heavy-duty fueling station in Wilmington.

While the HyStEP device is designed to test station performance according to the light-duty SAE J2601 protocol (categories A-C, which do not include the large tank sizes greater than 10 kg that are common in medium- and heavy-duty FCEV design), it has proven useful for initial testing and insights of these heavy-duty stations. These stations were designed to meet the Japanese industry standard JPEC-S 0003 (which is itself derived from SAE J2601 but includes lager tank sizes and slower fill rates). Although the stations use a slightly different protocol, HyStEP was able to provide preliminary guidance on station safety and performance. The HyStEP device was able to complete all general fault tests, all communication tests, and some large fill events (up to 9kg) at each station for a total of six dispensers tested. While no safety issues were identified through these tests, HyStEP provided some direction for issues and deficiencies that needed to be addressed prior to opening the stations for hydrogen fuel sales. Data provided by the HyStEP evaluation helped the station developers identify opportunities to improve performance, especially to enhance reliability in providing full fills for consecutive fueling events.

Updates to the Development of a Hydrogen Station Testing Regulation

The HyStEP testing program helps ensure that hydrogen fueling stations operating in California dispense fuel according to established protocols that enable fast, safe, and reliable hydrogen fueling to FCEV drivers. As the hydrogen fueling network expands and potentially accelerates in the coming years, this testing capability may need to be adjusted to efficiently and effectively ensure stations continue to meet expectations. Hydrogen station testing may be incorporated into new rules, regulations, support programs, or other mechanisms. One key aspect will be ensuring that these testing efforts and performance expectations are applied to all stations, whether they receive public funds or are built and operated completely with private capital.

CARB has been exploring pathways to ensure a future hydrogen station testing program will provide these assurances and be resilient to rapidly growing demand. With CARB's limited testing capacity and the large number of stations projected to open in the next few years, CARB is working to develop a solution to ensure that all stations can undergo testing in a timely manner. CARB also intends to develop a process that provides a level playing field of consistent expectations across all station developers and operators.

Over the past year, CARB has entered into a partnership with DMS at the California Department of Food and Agriculture. This partnership aims to promulgate a regulation that will codify station testing requirements in the California Code of Regulations. The rulemaking process will be carried out by DMS with assistance from CARB. Current DMS/CARB concepts also include periodic testing requirements. This is a first for stations and the periodic testing will help ensure that stations that both new stations and stations opened before the regulation becomes effective continue to dispense hydrogen safely and in compliance with industry standards.

Finally, the proposed regulation will help facilitate the development of a third-party testing industry through registered service agents. These registered service agents should help alleviate the workload requested of CARB staff and allow new stations to test and open more quickly. The draft CARB/DMS regulation is scheduled to have its first public workshop in August 2022 and, at the earliest, become effective in 2023.

Development of a new HyStEP Station Testing Device

As previously reported, CARB and the Energy Commission have begun an effort to procure a second, next-generation HyStEP station testing device (referred to as "HyStEP 2.0"). On July 21, 2021, CARB and the Energy Commission formally entered into an agreement in which the Energy Commission will provide funds to CARB for the procurement of HyStEP 2.0. CARB is to administer a competitive bid process for the design, construction, testing, validation, and delivery of the new device. Under a separate agreement with the Energy Commission, the National Renewable Energy Laboratory is developing the initial design specifications that the winning bidder would need to adhere to in their final device design. CARB is currently in the process of developing the solicitation documents and may announce the open solicitation later this year.

The HyStEP 2.0 device will provide improved performance compared to the original device. The new device will have higher hydrogen storage capacity that enables it to test the performance of fill events for vehicles with larger onboard tanks than the approximately five kilograms common in today's FCEV designs. These larger tanks may be important in designs of FCEV pickup trucks, vans, sport utility vehicles, and medium-duty or commercial vehicles that would fuel at stations designed for light-duty service. HyStEP 2.0 will also have the capability to simultaneously fill (to perform a test) and venting hydrogen (to re-set after a test), which may reduce total testing time at each station. This feature can also help HyStEP 2.0 be able to better test the back-to-back fill performance of hydrogen fueling stations. This can help give a better sense of station performance during high-stress peak demand periods of the day. Depending on the available standards and proposed designs, HyStEP 2.0 may even be capable of some amount of medium- and/or heavy-duty hydrogen fueling station testing. While HyStEP 2.0 will represent an advancement in station testing capability over the original HyStEP device, it is currently CARB's intent to maintain the use of both devices in future testing programs to help meet the anticipated demand for tests.

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.

Progress in station development and FCEV deployment have continued over the past year, and 2022 has the potential to prove to be a record year for growth in both areas. It will be important over the next few years to take advantage of these recent positive trends and take steps to ensure continued growth and even acceleration beyond recent market developments. The Energy Commission's secured and planned investments for hydrogen fueling stations through the Clean Transportation Program, combined with the LCFS HRI program and growing private investment, clearly chart a course toward 200 or more Open-Retail stations becoming a reality in California in the next four to five years. Auto manufacturers continue to plan for increasing FCEVs on the road, though projections for future sales FCEV sales are significantly slower than the projected growth in network fueling capacity. Planned station development is beginning to rapidly outpace planned FCEV deployment and a more significant "bend in the curve" of projected FCEV sales would demonstrate better alignment of auto manufacturer vision with planned station deployment and California's strategy for FCEVs and hydrogen fueling.

The development and operation of the state's hydrogen fueling network continues to face significant uncertainty but is proving resilient. Station development timelines remain one of the most significant unknowns in the industry, but overall development time has improved since the first retail station opened in California. Hydrogen station equipment reliability and fuel availability have at times severely hampered the operation of large parts of California's hydrogen fueling network. Station operators and fuel providers have worked diligently and made substantial investments to improve the supply chain, build new facilities, fix equipment issues, and hire an expanding workforce to address these reliability issues. Today, station availability has recovered and is near historic highs. Ensuring the continued reliability of stations will be a major factor in expanding consumer acceptance of FCEVs.

Station developers' plans for network growth may enable FCEV deployment, and local emissions reductions, in many communities across California. Some of these communities are also the most vulnerable, identified as disadvantaged communities. However, the planned network currently remains highly concentrated in a few key regions and leaves many communities, especially disadvantaged communities in the San Joaquin Valley and Inland Deserts regions, without planned network development. These new markets should continually be evaluated for their FCEV deployment potential and prioritized for future development. This may help ensure FCEVs enjoy broad market uptake in the future.

Broadly, considerable success has been made since the AB 8 program began and in the past year in particular. But there is still significant work that remains to be done. CARB staff make the following recommendations for ongoing development of the hydrogen fueling network in California:

- **Work to accelerate station development timelines.** Although the time to build a station has generally improved, it is still common for hydrogen fueling stations to take significantly longer to build than originally planned. Each station has proven to face its own challenges and often times the location of the proposed station can have a significant impact on its viability or the pace at which it can be built. Permitting schedules, equipment delivery, local electric utility connection, and other steps remain too unpredictable to develop reliable projections of individual or aggregate station growth rates. New and creative solutions may be necessary, including participation from public and private entities alike, to accelerate the process for planning and developing a hydrogen fueling station in California. Public-private consortia, focused workgroups, new government policies to accelerate station permitting timelines, improved industry sharing of best practices, and other efforts may help improve development timelines.
- **Emphasize development of hydrogen fueling stations in new markets.** There is no doubt that continued station network development is necessary in markets where FCEV first adopter potential is high and the first stations in the network have been concentrated. However, there is significant market opportunity that now exists with a similar degree of need in areas that California's hydrogen fueling network does not yet reach. In particular, the San Joaquin Valley, Central Coast, Inland Deserts, and regions in northern California have no known plans for station development. These areas currently show potential for new market development, but FCEV deployment cannot be supported until stations are built in these areas. Building from the lessons of the early hydrogen fueling network, multiple stations should be planned for areas in these regions with good FCEV market potential and hydrogen fueling potential.
- **Ensure new market development also addresses disadvantaged communities.** The Open-Retail and planned hydrogen fueling network so far provides a good degree of coverage and access to some disadvantaged communities. However, because this network is concentrated in a few areas across the state, many communities are currently left out of the network planning. This includes most of the disadvantaged communities across the state, especially in the San Joaquin Valley and the Inland Deserts regions. Some of these communities align with the identified new markets for development of hydrogen fueling stations. Station developers should be encouraged to address the potential hydrogen fueling market needs in these unserved disadvantaged communities as part of their plans for the remainder of GFO-19-602 or through the upcoming General Funds solicitation.
- **Encourage auto manufacturers to embrace a more expansive vision of FCEVs in California.** California's analyses of pathways to improved air quality, reduced greenhouse gas emissions, transformation of transportation to zero emissions, and economically viable hydrogen business cases all envision a significant role for FCEVs in California's future. These analyses point to the potential for FCEVs to be an important piece of the state's future on-the-road ZEV fleet. State investments in hydrogen fueling infrastructure are in place today or planned to get the network on an initial trajectory that enables this significant role for FCEVs in California's future. Auto manufacturers have yet to communicate such a vision through the annual survey process and appear more focused on uncertainty of station development than on the potential of the investment commitments made by California State agencies. Ongoing and potentially increased collaboration and open dialogue about how auto manufacturers plan to grow their future FCEV sales, especially to maintain them as a key component to meeting ZEV sales requirements in the Advanced Clean Cars II regulation, may be necessary to align the visions of auto manufacturers and California state government for future FCEV market growth.

- **Continue to emphasize clean hydrogen production and distribution.** California's hydrogen fueling network has historically exceeded the minimum requirements for the use of renewable energy in the production of hydrogen sold at fueling stations. In recent years, the network went far beyond minimum requirements and dispensed more than 90 percent renewable hydrogen. But more recent data reveals that these peaks of renewable implementation may not be guaranteed. The network still well exceeds minimum requirements, dispensing up to 65 percent renewable hydrogen, but the annual shifts up and down in the market highlight that this remains a highly dynamic aspect of the growing hydrogen fueling network. California State agencies should continue to encourage industry focus on high rates of renewable hydrogen use and develop ways to ensure that hydrogen stays on a trajectory that continually increases the use of renewable and clean, low-carbon, low-pollutant production processes.

Courtesy of California Fuel Cell Partnership.

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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 June 30, 2022

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	394	2015	Orange	33%
UC Irvine	19172 Jamboree Road	Irvine	180	2015	Orange	33%
West Sacramento	1515 S River Rd	West Sacramento	394	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 Canada Flintridge	266	2016	Los Angeles	40%
Lake Forest	20731 Lake Forest Dr	Lake Forest	266	2016	Orange	40%
Long Beach	3401 Long Beach Blvd	Long Beach	266	2016	Los Angeles	40%
Mill Valley	570 Redwood 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%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
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	393	2017	Contra Costa	33%
South Pasadena	1200 Fair Oaks Ave	South Pasadena	206	2017	Los Angeles	40%
Torrance	2051 W 190th St	Torrance	200	2017	Los Angeles	33%
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%
Mountain View	830 Leong Drive	Mountain View	349	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	51	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	1212	2020	Orange	40%
Mission Hills	15544 San Fernando Mission Road	Mission Hills	1212	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	1616	2021	Orange	40%
Berkeley	1250 University Ave	Berkeley	513	2021	Alameda	40%
Campbell-Hamilton	337 E Hamilton Ave	Campbell	1212	2021	Santa Clara	40%
Concord	605 Contra Costa Boulevard	Concord	1212	2021	Contra Costa	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Costa Mesa-Bristol	2995 Bristol St	Costa Mesa	1616	2021	Orange	40%
Placentia	313 West Orangethorpe Ave	Placentia	1616	2021	Orange	40%
Sherman Oaks	14478 Ventura Blvd	Sherman Oaks	808	2021	Los Angeles	40%
Studio City	3780 Cahuenga Blvd	North Hollywood	808	2021	Los Angeles	40%
Sunnyvale	1296 Sunnyvale Saratoga	Sunnyvale	1212	2021	Santa Clara	40%
Anaheim-Euclid	1100 North Euclid Street	Anaheim	808	2022	Orange	40%
Baldwin Park	14477 Merced Ave	Baldwin Park	1616	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%
Chino	12610 East End Ave	Chino	100	2022	San Bernardino	100%
Corona	616 Paseo Grande	Corona	808	2022	Riverside	40%
Cupertino	21530 Stevens Creek Blvd	Cupertino	1616	2022	Santa Clara	40%
Hawaiian Gardens	11807 Carson Street	Hawaiian Gardens	808	2022	Los Angeles	40%
Oakland-Foothill	4280 Foothill Boulevard	Oakland	1616	2022	Alameda	40%
Orange	615 South Tustin St	Orange	1616	2022	Orange	40%
Pasadena-Allen	475 N. Allen Avenue	Pasadena	1469	2022	Los Angeles	40%
Pasadena-Arroyo	290 S. Arroyo Pkwy	Pasadena	770	2022	Los Angeles	40%
Redwood City	503 Whipple Ave	Redwood City	1212	2022	San Mateo	40%
Riverside-Central	3505 Central Avenue	Riverside	1616	2022	Riverside	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	5494 Mission Center Road	San Diego	1212	2022	San Diego	40%
San Diego-Washington	1832 West Washington Street	San Diego	1616	2022	San Diego	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
San Jose- Bernal	101 Bernal Rd	San Jose	513	2022	Santa Clara	40%
San Jose- Snell	3939 Snell Ave	San Jose	1616	2022	Santa Clara	40%
Santa Ana	2120 East McFadden Avenue	Santa Ana	808	2022	Orange	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%
Woodside	17287 Skyline Blvd	Woodside	68	2022	San Mateo	33%
Carlsbad	7170 Avenida Encinas	Carlsbad	770	2023	San Diego	40%
Chino Hills	3260 Chino Ave	Chino Hills	808	2023	San Bernardino	40%
City of Industry	2600 Pellissier Pl	City Of Industry	770	2023	Los Angeles	40%
El Cerrito	3160 Carlson Blvd	El Cerrito	1616	2023	Contra Costa	40%
Folsom	13397 Folsom Blvd	Folsom	770	2023	Sacramento	40%
Fontana	16880 Slover Ave	Fontana	1616	2023	San Bernardino	40%
Fremont- Warm Springs	47700 Warm Springs Boulevard	Fremont	1616	2023	Alameda	40%
Glendale	3402 Foothill Blvd	La Crescenta	1616	2023	Los Angeles	40%
La Mirada	13550 South Beach Boulevard	La Mirada	808	2023	Los Angeles	40%
Laguna Beach	104 North Coast Highway	Laguna Beach	808	2023	Orange	33%
Long Beach- Lakewood	2589 N Lakewood Blvd	Long Beach	770	2023	Los Angeles	40%
Los Altos	988 N. San Antonio Rd	Los Altos	1616	2023	Santa Clara	40%
Los Angeles- Washington	5164 W Washington Blvd	Los Angeles	770	2023	Los Angeles	40%
Monrovia	705 West Huntington Dr	Monrovia	770	2023	Los Angeles	40%
Newport Beach	1600 Jamboree Road	Newport Beach	1420	2023	Orange	33%
San Diego- Rancho Carmel	11030 Rancho Carmel Drive	Rancho Bernardo	1616	2023	San Diego	40%
San Jose- Santa Clara	510 E. Santa Clara Street	San Jose	1616	2023	Santa Clara	40%
Santa Rosa	266 College Ave	Santa Rosa	770	2023	Sonoma	40%
Torrance Upgrade	2051 W 190th St	Torrance	1220 add'l	2023	Los Angeles	33%
UC Irvine Upgrade	100 Academy Way	Irvine	1032 add'l	2023	Orange	40%

Name	Address	City	Capacity (kg/day)	Retail Open	County	Renewable %
Ventura	2121 Harbor Boulevard	Ventura	1616	2023	Ventura	40%
Arcadia	102 E Duarte Road	Arcadia	1616	2024	Los Angeles	40%
Artesia	17325 Pioneer Blvd.	Artesia	770	2024	Los Angeles	40%
Glendale-Broadway	466 W Broadway	Glendale	1200	2024	Los Angeles	40%
Long Beach-Willow	601 W Willow St	Long Beach	1200	2024	Los Angeles	40%
Northridge	19260 Nordhoff St	Northridge	1200	2024	Los Angeles	40%
Novato	5821 Nave Dr	Novato	770	2024	Marin	40%
Riverside Upgrade	8095 Lincoln Ave	Riverside	708 add'l	2024	Riverside	40%
San Ramon Upgrade	2451 Bishop Drive	San Ramon	807 add'l	2024	Contra Costa	40%
Tustin	14244 Newport Avenue	Tustin	1616	2024	Orange	40%
Camarillo	2911 Petit Street	Camarillo	1520	2025	Ventura	40%

Appendix C: Station Status Definition Details

The new awards for station development made by the Energy Commission 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 the Governor's Office of Business and Economic Development 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 California Code of Regulations 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.
- **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 Energy Commission 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 two 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.

California Air Resources Board
1001 I Street
P.O. Box 2815
Sacramento, CA 95812
(916) 323-2514
arb.ca.gov

Sustainable Transportation and Communities Division
arb.ca.gov/our-work/programs/hydrogen-fueling-infrastructure
cleancars@arb.ca.gov