CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

CALIFORNIA AIR RESOURCES BOARD

California Energy Commission

California Air Resources Board

Joint Agency Staff Report on Assembly Bill 126: 2024 Annual Assessment of the Hydrogen Refueling Network in California

June 2025|CEC-600-2025-025

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ACKNOWLEDGEMENTS

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ABSTRACT

The Joint Agency Staff Report on Assembly Bill 126: 2024 Annual Assessment of the Hydrogen Refueling Network in California is in accordance with Assembly Bill 126 (Reyes, Chapter 319, Statutes of 2023). This bill required the California Energy Commission (CEC) and California Air Resources Board to 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 CEC's Clean Transportation Program has allocated nearly $234 million in public hydrogen infrastructure primarily for light-duty vehicles. This allocation reflects Shell's cancelled agreement for 50 stations and one declined award. Through CEC's funding and private investments, California is expected to have 129 hydrogen refueling stations by 2030 with at least 8 stations capable of fueling medium- and heavy-duty vehicles. As of November 4, 2024, 42 stations were open to the public, and 20 additional stations had been offline for more than 30 days, many for more than a year, for various reasons. These 20 offline stations are expected to reopen in the future. Since reported last year, three additional stations have opened.

The stations open to the public have operated at an average of 62 percent of capacity, due to maintenance, equipment failures, supply chain constraints, and hydrogen supply disruptions. Under current conditions, the network could serve about 36,000 fuel cell electric vehicles (FCEVs), more than double the fueling needs of the 14,415 light-duty FCEVs estimated to be on the road as of the end of the third quarter of 2024.

The CEC estimates 129 fully operational stations will have the capacity to serve nearly 195,000 light-duty FCEVs, which is nearly 10 times more than fuel demand from the projected light-duty FCEVs population in 2030. Auto manufacturers have reduced their FCEV deployment projections significantly to 18,400 FCEVs by 2027 and 20,500 FCEVs by 2030. CEC and CARB staffs intend to continue evaluating the fueling needs for the light duty FCEV market as it evolves.

The CEC has allocated nearly $120 million for hydrogen stations for public, private, and transit medium- and heavy-duty vehicles. Combined with other public and private funding, California has 14 stations and an additional 35 stations planned for these vehicles.

Keywords: Assembly Bill 126, California Air Resources Board, California Energy Commission, Clean Transportation Program, fuel cell electric vehicle, hydrogen refueling station

Please use the following citation for this report:

Crowell, Miki and Acharya, Tri Dev. 2025. *Joint Agency Staff Report on Assembly Bill 126: 2024 Annual Assessment of the Hydrogen Refueling Network in California.* California Energy Commission and California Air Resources Board. Publication Number: CEC-600-2025-025.

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EXECUTIVE SUMMARY

The *Joint Agency Staff Report on Assembly Bill 126: 2024 Annual Assessment of the Hydrogen Refueling Network in California* (2024 AB 126 Joint Report) describes the investment, planning, development, and use of hydrogen refueling stations to support fuel cell electric vehicles (FCEVs) in California as directed by Assembly Bill (AB) 126 (Reyes, Chapter 319, Statutes of 2023). AB 126 further directed the California Energy Commission (CEC) to allocate no less than 15 percent of the amount of funds appropriated by the Legislature to fund hydrogen refueling stations until there is a sufficient network of stations, which includes all types available, in operation in California to support existing and expected hydrogen vehicles until July 1, 2030. AB 126 removed the previous requirement for a joint assessment of the time and cost needed to attain 100 hydrogen refueling stations. Instead, the CEC and California Air Resources Board (CARB) must jointly review and report annually on progress toward establishing a sufficient hydrogen-fueling network that provides the coverage and capacity to fuel vehicles requiring hydrogen fuel that are being placed into operation in the state.

Governor Gavin Newsom's Executive Order N-79-20 sets goals for all new passenger cars and trucks sold in California to be zero-emission by 2035, all medium- and heavy-duty trucks and buses operated in California to be zero-emission by 2045 everywhere feasible, and all drayage trucks to be zero-emission by 2035. The goals will influence the policies, requirements, and investments planned by numerous California agencies and municipalities, including the CEC and CARB.

The State of California, in partnership with industry stakeholders, applied to the U.S. Department of Energy (DOE) for federal funding for a hydrogen hub. On October 13, 2023, the U.S. DOE announced $7 billion to launch seven regional clean hydrogen hubs, including up to $1.2 billion for the California hydrogen hub called the Alliance for Renewable Clean Hydrogen Energy Systems or "ARCHES." This hydrogen hub plans to have more than 60 hydrogen refueling stations that will serve more than 5,000 Classes 6–8 trucks (vehicle weight rating more than 19,501 pounds)

KEY TAKEAWAYS

California has 42 open retail stations that are available to customers and an additional 20 open retail stations that are nonoperational for more than 30 days. Station reliability, hydrogen supply disruptions, and high hydrogen prices have affected the customer experience negatively. The CEC awarded grant funds to two station operators to improve the reliability of existing stations.

Cumulative sales or leases of light-duty FCEVs in California since 2010 have been 17,999, while 14,415 FCEVs are estimated to be on California's roads as of the end of the third quarter (July–September) of 2024.

Auto manufacturers have reduced their FCEV deployment projections significantly to 18,400 FCEVs by 2027 and 20,500 FCEVs by 2030.

Global inflation, labor and material shortages, and supply chain interruptions continue to affect station development.

The average daily hydrogen dispensing between the third quarter of 2023 and the second quarter of 2024 decreased.

Staff estimates that developing 71 more stations can cost about $213 million and take 14.2 years.

and 1,000 fuel cell electric buses. ARCHES also plans more than 10 production project sites with hundreds of metric tons per day of clean hydrogen produced with renewable electricity and biogenic sources and also plans to generate clean power at two major power plants and other stationary distributed locations throughout the state, including the Los Angeles Scattergood plant and Lodi Energy Center.

As of the end of the third quarter of 2024, the number of light duty FCEVs that are estimated to be on California's roads was 14,415 FCEVs, according to CEC analysis of California Department of Motor Vehicles data on the Zero Emission Vehicle (ZEV) Dashboard. CARB reported in the 2024 Annual Evaluation that the light-duty FCEV population in California could grow to 18,400 FCEVs by 2027 and 20,500 FCEVs by 2030. CARB bases these projections on the latest auto manufacturer survey responses. These projected numbers of vehicles are significantly smaller than what was reported in the 2023 Annual Evaluation (34,900 FCEVs by 2026 and 62,600 FCEVs by 2029).

Since last year's joint report, 3 hydrogen refueling stations for passenger vehicles have opened, bringing the total number of stations that are serving the public to 42 as of November 4, 2024. This number includes a new heavy-duty station at the Port of Oakland, which became open retail to light-duty fueling in July 2024. There are an additional 20 stations that are considered temporarily nonoperational. The temporarily nonoperational stations previously achieved open retail status but have been unavailable for customer fueling for more than 30 days for various reasons, including mechanical upgrades or repairs, hydrogen supply disruptions, station testing, and reviews by local officials. Many of these temporarily nonoperational stations have been unavailable for fueling for more than a year.

The number of temporarily nonoperational stations increased this year because 13 stations in Southern California have been affected by a hydrogen supply disruption and are not open to the public. These temporarily nonoperational stations are expected to become available for customer fueling again when the supply disruption resolves. The remaining 42 open retail stations are available for customer fueling with the exception of downtime events that can last for periods up to 30 consecutive days due to hydrogen supply issues, maintenance, equipment failures, and supply chain constraints.

The objective of the CEC's Clean Transportation Program solicitations has been for the fueling capacity of the station network to stay well ahead of hydrogen fuel demand so that consumers can have confidence in fuel availability if they choose to drive a FCEV. Through 2023, the Clean Transportation Program allocated funding sufficient to support 123 stations (including 16 stations fully funded by match share in a CEC agreement). With the private sector announcing an additional 7 privately funded stations, the state expected at least 130 stations to be open retail by 2027 as reported in *Joint Agency Staff Report on Assembly Bill 8: 2023 Annual Assessment of the Hydrogen Refueling Network in California* (2023 AB 8 Joint Report).

However, one grant applicant (Phillips 66 Company) that was proposed for an award to build four stations under the grant funding opportunity, GFO-22-607, declined, and one grant recipient (Equilon Enterprises LLC, doing business as Shell Oil Products US) announced the permanent closure of seven open-retail stations in February 2024. Further, Shell returned $41 million in CEC grant funding, which would have built 50 new stations to support light-duty FCEV.

An additional nine privately funded stations (eight stations by Chevron Products Company and one station by H2B2 USA, LLC) for passenger vehicles have been approved by CARB's Low Carbon Fuel Standard (LCFS) hydrogen refueling infrastructure (HRI) program to earn credits once they start operating. These HRI-approved stations already have addresses where the stations should be constructed. In addition, Sunline Transit Agency is building a station that includes a dispenser for public light-duty vehicles using match funding for a CEC agreement. With these changes, the new total expected number of stations for passenger vehicles is 129 by 2030.

The CEC will continue to explore ways to support current and future FCEV drivers so they have sufficient, convenient, and reliable refueling options. The CEC released a solicitation, GFO-24-601, offering $10 million for developing new stations in Sacramento and San Francisco Counties and $5 million to support capital expenditures and operation and maintenance for planned or temporarily nonoperational light-duty hydrogen refueling stations that have had open retail progress stall due to cost constraints. This solicitation reflects the new requirements under AB 126 such as the CEC releasing a competitive grant funding opportunity for annual hydrogen funding at least annually and 90 days after the start of the fiscal year, 50 percent of the hydrogen funds being spent to benefit or serve residents of disadvantaged communities or low-income communities directly, providing preference to applicants with the least carbon-intensive proposed fuel measured through the point of production, requiring the awardees to provide the source and carbon intensity of the hydrogen dispensed by stations, and collecting additional station operation data to monitor reliability and accessibility of the refueling infrastructure.

Although the average daily hydrogen dispensing across the network was increasing at a higher rate last year than what was before the COVID-19 pandemic, the average daily hydrogen dispensing between the third quarter of 2023 and the second quarter of 2024 decreased by 22 percent. The drop in hydrogen dispensing could be due to FCEVs being driven fewer miles, fewer FCEVs are on the road, or a combination. If fully operational, the network of 62 open retail stations has the capacity to support nearly 57,000 light-duty FCEVs, about four times the capacity needed for the existing FCEV population.

However, the actual fueling capacity of the network is lower due to station reliability challenges and hydrogen supply shortages. According to the data collected by the Hydrogen Fuel Cell Partnership's Station Operational Status System, obtained by CARB staff, the average availability of open retail stations, was around 62 percent from the third quarter of 2023 to the second quarter (April–June) of 2024 including temporarily nonoperational stations as 0 percent available. Reducing the network capacity of open retail stations using the 62 percent availability percentage shows that the network can support about 36,000 FCEVs, about 2.5 times the capacity needed for the existing FCEV population.

Improving station reliability and hydrogen availability are key to providing all stakeholders, most notably FCEV drivers and auto manufacturers, confidence in the FCEV market such that it can grow to the full potential. The CEC approved operations and maintenance grants totaling $9.4 million to two station operators to improve the reliability of 45 open retail stations at the May 2024 business meeting. These station operators are required to commit to achieving 95 percent uptime as a condition for receiving grants. The CEC has started collecting data on downtime related to maintenance, equipment failures, or hydrogen fuel supply issues to understand the reliability of the network from a customer experience.

The price of hydrogen remains high at $36 per kilogram in August 2024, which is comparable to paying about $14.40 for a gallon of gasoline (when accounting for the improved efficiency of a FCEV compared to a gasoline-powered vehicles). This price is more than a doubling of historical prices; the average price of hydrogen in the second quarter of 2022 was $14.95. Station operators attribute the high price of hydrogen to the low price of LCFS credits and inflation. The CEC awarded operations and maintenance grants to two station operators (supporting 45 existing open retail stations total) in May 2024, which may help lower the prices paid by FCEV drivers.

In addition, CARB held a public hearing to consider amendments to the LCFS on November 8, 2024, and the board approved the amendments. The amendments are expected to be in effect in early 2025 and help recover the LCFS credit price in the future. Finally, the CEC continues to collaborate with other agencies and industry stakeholders to continue identifying and working on new strategies to overcome these key barriers. State officials and industry stakeholders must work together to address these barriers.

The 2030 projected light-duty FCEV population of 20,500 is nearly 10 percent of the 195,000 light-duty FCEVs that the anticipated fueling network of 129 stations could support based on the nameplate capacity of the stations. This project FCEV population is nearly 13 percent assuming that stations would dispense no more than 80 percent of nameplate capacity and about 17 percent assuming the 62 percent average station availability from the third quarter of 2023 to the second quarter of 2024. With the significantly reduced projected number of FCEVs in the future, the capacity of the anticipated fueling network of 129 stations would be sufficient for the fuel demand from the anticipated on-road FCEVs in 2030. However, factors such as the locations of stations, station reliability, hydrogen availability, and the development speed of new stations are expected to continue to affect the availability of fuel to FCEV drivers.

As seen in the recent years, the pace of building out new hydrogen stations has continued to be slower than expected. The station development pace depends not only on the amount of funding available, but also on the number of station equipment vendors and the number of station developers available to deploy stations. Further, a positive financial business case can help accelerate deployment and encourage private investments. A material factor in achieving a solid business condition is sufficient FCEVs and station utilization.

Station development times were decreasing until the COVID-19 pandemic slowed many station development activities. The low LCFS credit price combined with global inflation made developing stations more expensive for station developers. Two developers have paused development of new stations while searching for more funders or waiting for the LCFS credit price to increase. Lack of station equipment options is also affecting a developer, who has delayed station development until it found a reliable equipment to install. CEC staff continues to learn about these issues from station developers and plans to incorporate ways to address these issues in future solicitations.

The CEC and CARB also evaluate fueling needs regionally to analyze if the specific areas where vehicles are being sold and leased are adequately served by stations. This analysis is particularly important during early market development, as having infrastructure in places where potential customers need it can influence the decision to adopt FCEV technology. The largest urban areas of the state will continue to have sufficient network capacity capable of supporting more than projected

FCEVs in those areas; however, station reliability and availability affect the actual capability of the refueling network to be able to support FCEVs.

Due to the closing of two of the three stations in the Sacramento Area, the remaining station is not able to support the number of FCEVs on the road in that area. A new, much-needed station is anticipated to open in 2025, followed by two additional stations in 2026 and 2028. The San Diego Area received much needed additional capacity because of the opening of one more station in May 2023 and will have sufficient capacity to support projected FCEVs when two more planned stations open.

About 71 percent of California's residents who live in disadvantaged communities are within a 15-minute drive of an open retail or planned hydrogen station. This percentage is similar to 65 percent of the general statewide population being in the same drive distance to a station. However, rural disadvantaged communities and disadvantaged communities with lower population density still tend to be farther than a 15-minute drive to any hydrogen refueling station. These numbers could increase as addresses for stations in future batches funded under GFO-19-602 are announced and with new stations that will be funded under GFO-24-601, which requires at least 50 percent of new stations be in disadvantaged communities.

The Clean Transportation Program has allocated about $234 million to light-duty hydrogen refueling station projects through Fiscal Year 2023–2024. This amount is lower than what was reported in the 2023 AB 8 Joint Report because it reflects the amount in the cancelled agreement (Shell elected to turn down $41 million in CEC grant funds, which would have built 50 stations.) and declined award. (Phillips 66 Company declined a proposed award under GFO-22-607.)

The private sector has contributed match funding to station development. Industry has made independent investments in hydrogen refueling stations and production plants that are outside CEC agreements. As of November 4, 2024, grant recipients have contributed nearly $100 million in match funding and will contribute another $59 million by the end term (in 2026) of the CEC grant agreements funded under GFO-19-602. These contributions will bring the total public and private investment in hydrogen refueling stations under the Clean Transportation Program to nearly $420 million.

The projected number of FCEVs has significantly reduced this year and the fueling capacity of the planned 129 stations are more than sufficient if just comparing the networkwide fuel demand and supply. The 2024 Annual Evaluation does not have quantitative analysis of a sufficient network, but future annual evaluations and AB 126 joint reports will likely include a quantitative and or geographical analysis of a sufficient network. Staff estimates that developing 71 more stations to reach 200 stations will cost about $213 million and take 13.2 years. (The network size of 200 stations may not be needed to support the number of current and projected light-duty FCEVs.)

An important factor in how best to support current and future FCEV drivers will be consumer uptake of FCEV, reduction of additional barriers such as fuel costs and fuel reliability, and the availability of FCEV makes and models. There are three vehicle models available. There should be an appropriate balance of hydrogen stations and hydrogen vehicles to ensure that there is sufficient station utilization, thereby strengthening the ability of the stations to become profitable.

Despite recent reductions in the number of stations, California continues to support the current and future FCEV population by providing funding for hydrogen refueling infrastructure that exceeds current and projected vehicle demand at least through 2030. To increase confidence in the FCEV market and foster the market growth to the full potential, increased reliability of the refueling network and accelerated deployment of refueling infrastructure and FCEVs are all equally critical. The CEC and CARB staffs' joint evaluation of the FCEV market will continue to guide future funding decisions, including assessing an appropriate funding amount per station given inflation, supply chain challenges, and uncertainty around the future fuel demand from light-duty FCEVs. The state will continue to monitor the hydrogen and vehicle market and provide appropriate support to meet California's zero-emission vehicle goals and support drivers of light-, medium-, and heavy-duty hydrogen FCEVs.

In addition to light-duty FCEVs, the state is working to support the demonstration and deployment of medium- and heavy-duty FCEVs. At least 8 of the 129 projected stations should be capable of fueling medium- and heavy-duty vehicles in addition to light-duty ones, thereby leveraging infrastructure to address multiple markets and accelerating the development of commercial fuel cell electric trucks. There are 7 private depot hydrogen stations for transit in operation, and an additional 10 stations are planned.

Through the CEC's block grant program, EnergIIZE Commercial Vehicles, the CEC has provided $59.2 million to support an additional 17 hydrogen stations with the ability to serve 768 hydrogen medium- and heavy-duty vehicles. California has four completed publicly available medium- and heavy-duty hydrogen refueling stations, and seven more are planned through the CEC funding and other agency funding. California also has three stations for private truck fleets in operation with one additional station planned.

The CEC published *2023 Final Staff Report on Senate Bill 643: Clean Hydrogen Fuel Production and Refueling Infrastructure to Support Medium-and Heavy-Duty Fuel Cell Electric Vehicles and Off-Road Applications* on January 24, 2024, which discusses medium- and heavy-duty FCEVs along with off-road, nontransportation vehicles that use hydrogen as fuel in more depth. This AB 126 Joint Report provides a brief summary of medium- and heavy-duty vehicles and infrastructure in Appendix C.

Along with California, other governments, specifically China, Germany, Japan, and South Korea, continue to invest in hydrogen refueling stations and vehicles. Together, California and these four countries have 766 open hydrogen refueling stations, including light-, medium-, and heavy-duty hydrogen refueling stations, and have deployed nearly 60,000 light-duty FCEVs and more than 10,000 buses, commercial vehicles, and medium- and heavy-duty FCEVs.

CHAPTER 1: Introduction

Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007) created the California Energy Commission's (CEC) Clean Transportation Program.[1] Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorized the Clean Transportation Program until January 1, 2024. AB 8 also directed the CEC to allocate $20 million annually, not to exceed 20 percent of the amount of funds appropriated by the Legislature, toward at least 100 publicly available hydrogen refueling stations.[2] In October 2023, Assembly Bill 126 (Reyes, Chapter 319, Statutes of 2023) reauthorized the Clean Transportation Program until July 1, 2035, and directed the CEC to allocate no less than 15 percent of the amount of funds appropriated by the Legislature to fund hydrogen refueling stations until July 1, 2030.[3] AB 126 removed the requirements that hydrogen refueling stations be publicly available and that there be at least 100 stations operating in the state.

The CEC and California Air Resources Board (CARB) must jointly review and report annually on progress toward establishing a sufficient network of hydrogen refueling stations, which includes all types available, in operation in the state to support existing and expected vehicles requiring hydrogen fuel. The *Joint Agency Staff Report on Assembly Bill 126: 2024 Annual Assessment of the Hydrogen Refueling Network in California* (2024 AB 126 Joint Report) is the tenth annual report (first report under AB 126). CARB published the *2024 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network* (2024 Annual Evaluation) on December 27, 2024, also required by AB 126.[4] Appendix D lists references for previous reports.

This report will review progress toward establishing a sufficient network of hydrogen refueling stations that provides the coverage and capacity to support light-duty fuel cell electric vehicles (FCEVs) requiring hydrogen fuel that are being placed into operation in the state. The report will also assess whether funding from the Clean Transportation Program remains necessary. This report is organized with five analytical chapters:

- Chapter 2: The Coverage, Capacity, and Public Accessibility of the Hydrogen Refueling Station Network
- Chapter 3: Fuel Cell Electric Vehicle Deployment
- Chapter 4: Time Required to Permit and Construct Hydrogen Refueling Stations

1 California Legislative Information. Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200720080AB118.

2 California Legislative Information. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB8.

3 California Legislative Information. Assembly Bill 126 (Reyes, Chapter 319, Statutes of 2023), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB126.

4 California Air Resources Board. December 2024. *2024 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development,* https://ww2.arb.ca.gov/sites/default/files/2024-12/AB-126-Report-2024-Final.pdf

- Chapter 5: Amount and Timing of the Growth of the Hydrogen Refueling Network
- Chapter 6: Remaining Cost and Time Required to Establish a Sufficient Network of Refueling Stations

On September 23, 2020, Governor Gavin Newsom's Executive Order N-79-20 set goals that all new passenger cars and trucks sold in California be ZEVs by 2035, all medium- and heavy-duty trucks and buses operated in California be ZEVs by 2045 everywhere feasible, and all drayage trucks be ZEVs by 2035.[5] This imperative strengthens California's focus and activities for electric vehicle charging infrastructure, hydrogen refueling infrastructure, and ZEVs. CARB adopted the Advanced Clean Cars II regulations in 2022 that requires all new cars and light-duty trucks sold in California to be ZEVs by 2035, effective November 30, 2022.[6]

The CEC Fuels and Transportation Division and CARB program staffs collaborate with experts, market participants, and stakeholders to plan and encourage development of hydrogen refueling infrastructure and deployment of fuel cell electric vehicles, including:

- The Governor's Office of Business and Economic Development (GO-Biz) and the California Department of Food and Agriculture, Division of Measurement Standards (CDFA/DMS).
- The South Coast Air Quality Management District (SCAQMD), Bay Area Air Quality Management District (BAAQMD), and other air districts.
- Local agencies, including planning, building, and safety officials.
- The United States Department of Energy (U.S. DOE) and national laboratories, including the National Renewable Energy Laboratory (NREL) and Pacific Northwest National Laboratory (PNNL).
- Industry stakeholders, including the Center for Hydrogen Safety under the auspices of the American Institute of Chemical Engineers (AIChE), Hydrogen Fuel Cell Partnership, California Hydrogen Business Council, SAE International, and the CSA Group.

Staff also considers input from public comments received in workshops and submitted to the docket to develop grant solicitations and analyses. For example, the CEC held the Staff Workshop for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure Solicitation Concepts in July 2024 to solicit feedback on proposed solicitation concepts.

The CEC released seven solicitations to support the development of hydrogen refueling infrastructure:

- GFO-24-601 in 2024 (notice of proposed awards (NOPA) to be released in 2025)
- GFO-22-607 in 2022 (NOPA in April 2023)

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5 Office of Governor Gavin Newsom. September 23, 2020. Executive Order N-79-20, https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.

6 California Air Resources Board. "Advanced Clean Cars II Regulations: All New Passenger Vehicles Sold in California to be Zero Emissions by 2035," https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.

- GFO-19-602 in 2019 (first NOPA in September 2020)
- GFO-15-605 in 2016 (NOPA in 2017)
- Public opportunity notice (PON)-13-607 in 2013 (NOPA in 2014)
- PON-12-606 in 2012 (NOPA in 2013)
- PON-09-608 in 2010 (NOPA in 2010).

The CEC has a history of strong investments in hydrogen station infrastructure for well over a decade.

GFO-19-602 was also proceeded by the development of CARB's Low Carbon Fuel Standard (LCFS) hydrogen refueling infrastructure (HRI) program, which became effective January 1, 2019. LCFS HRI credits fund and support hydrogen stations, in particular for operations and maintenance. GFO-19-602 requires hydrogen station developers to develop stations in batches. The developers are working on their first and second batches and will be able to access the third batch of funding upon successful completion of the milestones specified in GFO-19-602. Appendix A shows a list of stations that are in development and corresponding grant funding opportunity that funded those stations.

The public is encouraged to visit the following web pages to become involved in CEC activities:

- Subscriptions: https://www.energy.ca.gov/subscriptions
- Events: https://www.energy.ca.gov/events
- Solicitations: https://www.energy.ca.gov/funding-opportunities/solicitations

The CEC and CARB staffs review the year's refueling trends and describe other hydrogen and fuel cell projects that are expanding the potential for FCEVs, including buses and trucks, to serve several functions in transitioning to a national and international zero-emission transportation system. The data this 2024 AB 126 Joint Report uses, unless otherwise noted, are:

- From the third quarter of 2023 through the second quarter of 2024 for hydrogen refueling station-related analyses.
- Through the end of the third quarter of 2024 for the latest number of FCEVs.
- As of November 4, 2024, for reporting new station openings.

CHAPTER 2:
The Coverage, Capacity, and Public Accessibility of the Hydrogen Refueling Station Network

This chapter discusses the progress toward establishing a hydrogen refueling network to provide the coverage (the placement of stations) and capacity (the number of FCEVs the stations and the network can support) needed to fuel FCEVs that are on the road in California. This chapter also identifies the public accessibility of the hydrogen refueling network. Further, the chapter discusses station statistics such as hydrogen dispensed, utilization, retail price of hydrogen, station reliability and accessibility, and hydrogen supply to analyze whether the current network of stations is sufficient to serve on-road FCEVs.

The coverage and capacity of the open retail hydrogen refueling station network has decreased in 2024. In addition to the Equilon Enterprises LLC, doing business as Shell Oil Products US, (Shell) canceling its $41 million grant agreement last year, which would have funded 50 new stations and one upgrade, Shell announced the permanent closure of seven open-retail stations in February 2024. One grant applicant (Phillips 66 Company) that was proposed for an award to build four stations under GFO-22-607 declined. A new heavy-duty station opened in May 2024 at the Port of Oakland that also offers light-duty fueling, which became open retail in July 2024.

Additionally, CARB's LCFS hydrogen refueling infrastructure (HRI) program has approved nine privately funded stations (eight stations by Chevron Products Company and one station by H2B2 USA, LLC) for passenger vehicles to earn credits once they start operating. These HRI-approved stations already have addresses where the stations should be constructed. In addition, Sunline Transit Agency is building a station that includes a dispenser for public light-duty vehicles using match funding for a CEC agreement. As a result of these changes, the expected total number of stations (open retail stations and planned stations combined) in California is now 129. Therefore, this AB 126 Joint Report uses the 129-station network for evaluating coverage and capacity. These 129 stations will be publicly accessible when they open.

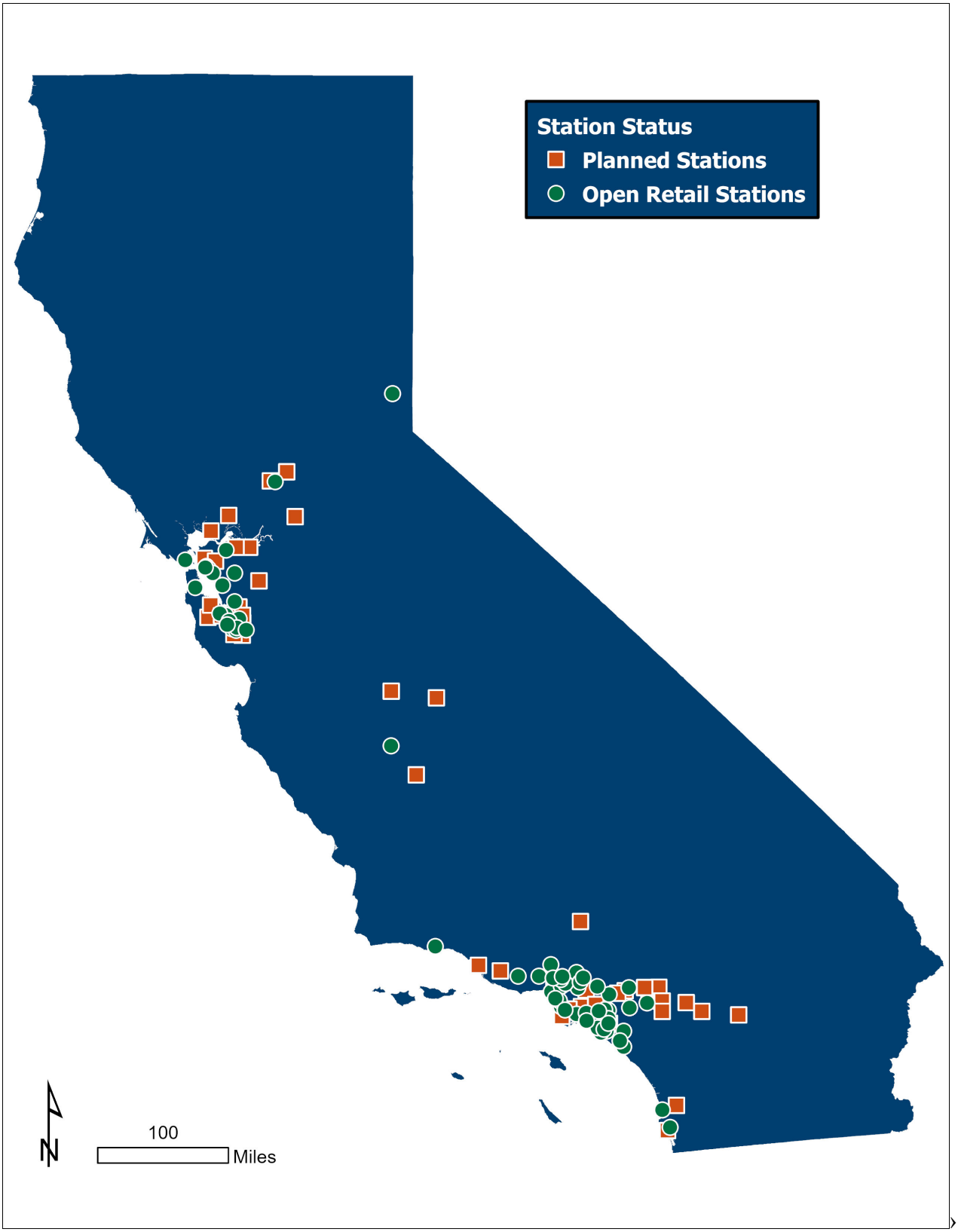
Figure 1 through Figure 3 show the locations of stations in the hydrogen refueling station network in California. Planned stations that do not have locations yet are not shown in these figures. The California network includes 62 open retail stations and 67 planned stations. Appendix A lists 109 stations with addresses. Appendix B lists the changes in the station network from 2017 to 2024.

The network of open retail stations includes 42 stations that are available for customer fueling with the exception of brief downtime events and an additional 20 stations that are considered temporarily nonoperational (TNO),[7] a total of 62 stations. The TNO stations have previously achieved open retail

7 A TNO station in Riverside is available for FCEV drivers to fuel by reservation. Stations located in Anaheim – E. La Palma, LAX, and Palo Alto are offline and awaiting station upgrades. The Emeryville, Ontario, and CSULA stations are offline and awaiting necessary repairs. The Anaheim – N. Euclid, Costa Mesa – Harbor, Del Mar, La Canada Flintridge, Lake Forest, Long Beach, Playa Del Rey, South Pasadena, Hawaiian Gardens, Seal Beach, and Santa Ana stations are experiencing supply outages.

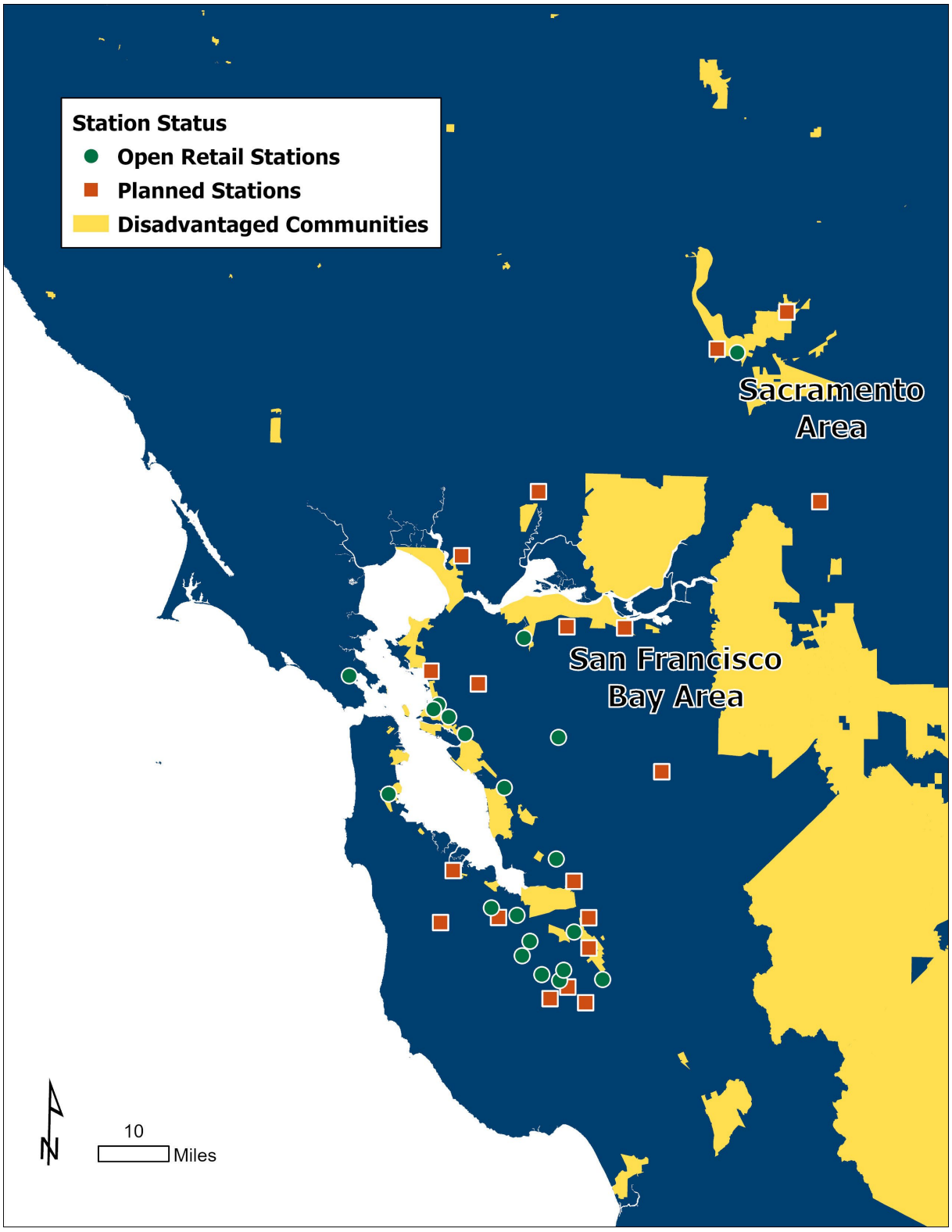
status but have been unavailable for customer fueling for a period greater than 30 days for various reasons. These TNO stations are expected to become available for customer fueling again in the future and are shown as open retail stations in Figure 1 through Figure 3. However, station operators do not have estimated time frame for when these TNO stations will reopen. The number of TNO stations increased this year because 13 stations in Southern California that have been affected by a supply disruption and are not open to the public. These stations are expected to become available for customer fueling again when the supply disruption resolves.

Figure 1: Hydrogen Refueling Station Locations in California



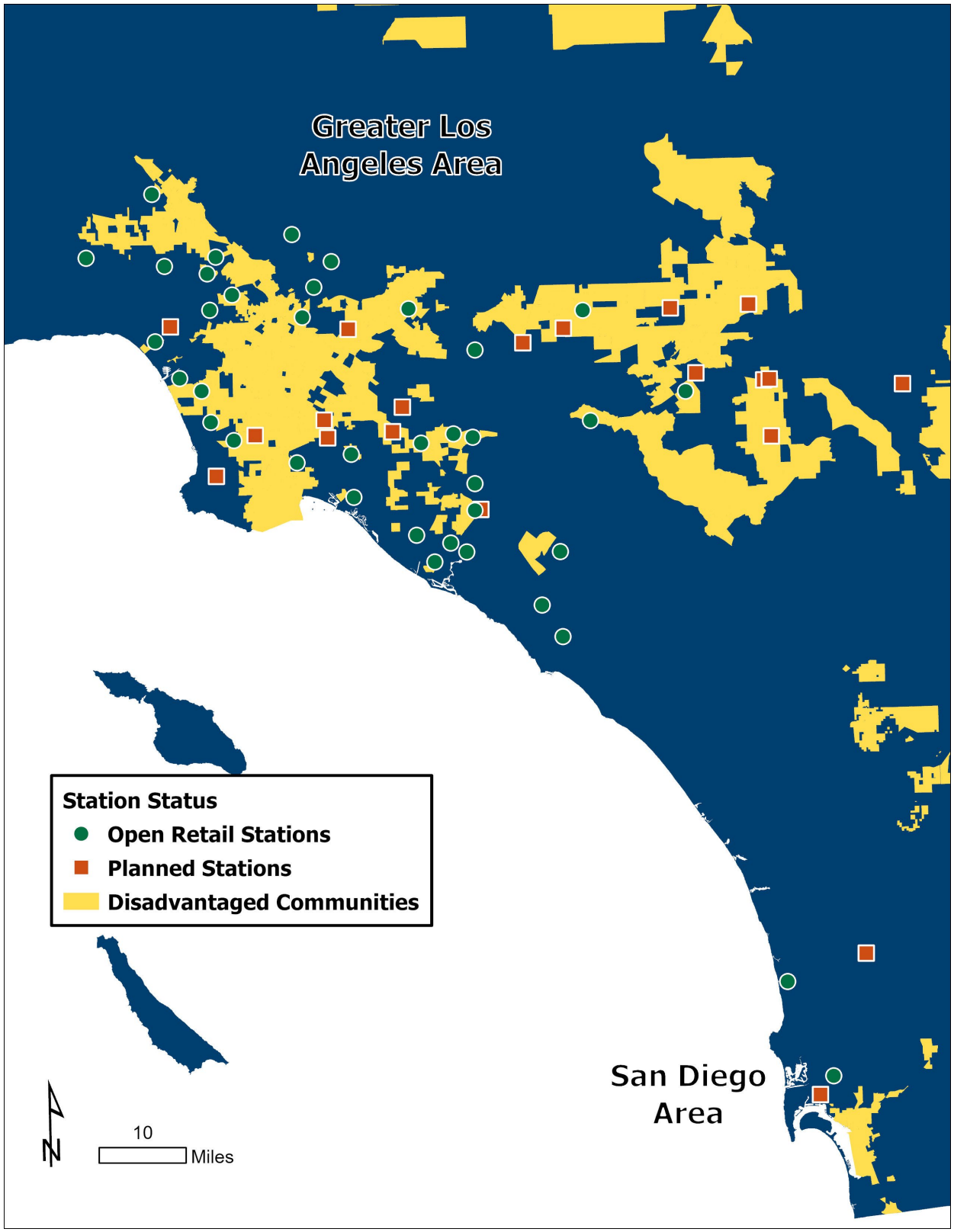
Source: CEC

Figure 2: Hydrogen Refueling Station Locations in Northern California With Disadvantaged Communities Highlighted



Source: CEC; Disadvantaged Communities data obtained from CalEnviroScreen 4.0

Figure 3: Hydrogen Refueling Station Locations in Southern California With Disadvantaged Communities Highlighted



Source: CEC; Disadvantaged Communities data obtained from CalEnviroScreen 4.0

The CEC continues to emphasize the importance of serving disadvantaged communities in its solicitations. The last solicitation, GFO-22-607, promoted disadvantaged communities with low access to a hydrogen refueling station as eligible areas to site new hydrogen refueling station projects. As a result, five of six stations are in disadvantaged communities. With all the stations with known addresses under GFO-19-602, new stations funded under GFO-22-607, and privately funded stations that are proposed for development, 30 stations will be in disadvantaged communities.[8] The proposed refueling network will provide coverage so that 71 percent of the disadvantaged community population and 65 percent of the general population of California will be within a 15-minute driving distance to a hydrogen refueling station.

These numbers could increase as addresses for stations in future batches funded under GFO-19-602 are announced and with new stations that will be funded under GFO-24-601, which requires at least 50 percent of new stations be in disadvantaged communities. However, as observed in the past, rural disadvantaged communities and disadvantaged communities with lower population density still tend to be farther than a 15-minute driving distance to any hydrogen refueling station. The CEC and CARB will continue to promote equity in their investments and explore options to expand hydrogen refueling network benefits to as many disadvantaged communities as possible.

Coverage Map Using California Hydrogen Infrastructure Tool

Figure 4 displays the coverage provided by all stations in the 129-station network with known addresses. As awarded station developers notify the CEC of addresses for additional locations, or possible station relocations and other changes, the evaluation of coverage is expected to change. The figure was produced by the CARB California Hydrogen Infrastructure Tool (CHIT).[9] Areas on the map without color are not within a 15-minute drive from any hydrogen refueling station. In the coverage map, the areas shown with the red shading have the highest degree of coverage. These areas often have several stations providing coverage to neighborhoods and communities in the nearby area. The blue areas have less fueling coverage; these areas typically have a small number of available stations or are farther away from the fueling station network.

The stations are generally concentrated in the San Francisco Bay Area, the Greater Los Angeles Area, the Sacramento Area, and the San Diego Area. There are a few connector stations in the Central Valley and a few destination stations. The highest degree of coverage is in the southwest side of the San Francisco Bay Area around San Jose, Cupertino, and other nearby cities with additional hot spots in San Francisco, Oakland, Emeryville, Orange County between Irvine and Costa Mesa, and in a few spots around Los Angeles County.

The current coverage decreased significantly in the Sacramento Area and in the city of San Francisco due to Shell closing stations permanently, leaving only one station in the Sacramento Area and no station within San Francisco. The CEC released a solicitation, GFO-24-601, in September 2024 to

8 *Disadvantaged communities* are identified using the California Office of Environmental Health Hazard Assessment's CalEnviroScreen 4.0. Information is available at OEHHA, CalEnviroScreen. https://oehha.ca.gov/calenviroscreen.

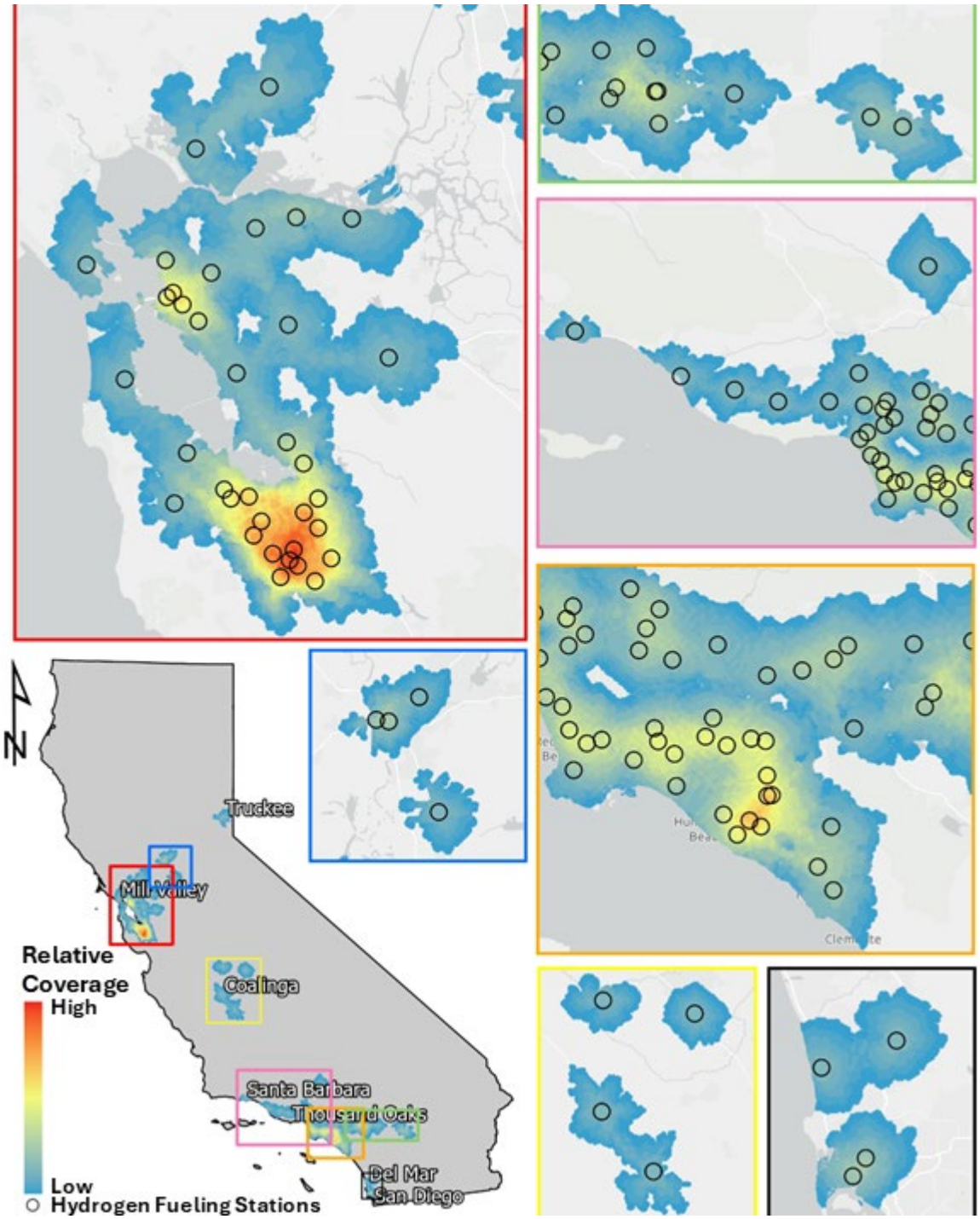
9 California Air Resources Board. "Hydrogen Refueling Infrastructure Assessments." https://ww2.arb.ca.gov/resources/documents/california-hydrogen-infrastructure-tool-chit.

address this issue. The solicitation focuses on these two areas. This solicitation reflects the new requirements under AB 126 such as:

- The CEC releasing a competitive grant funding opportunity for annual hydrogen funding at least annually and 90 days after the start of the fiscal year
- 50 percent of the hydrogen funds being spent to benefit or serve residents of disadvantaged communities or low-income communities directly
- Providing preference to applicants with the least carbon-intensive proposed fuel measured through the point of production
- Requiring the awardees to provide the source and carbon intensity of the hydrogen dispensed by stations
- Collecting additional station operation data to monitor reliability and accessibility of the refueling infrastructure.

Planned privately funded stations are also adding coverage in the future, specifically two in the Sacramento Area.

Figure 4: Coverage Map



Source: CARB

Quantity of FCEVs Supported by Hydrogen Refueling Station Network

Table 1 summarizes the coverage, capacity, and public accessibility of the hydrogen refueling station network in California by showing the station quantity, fueling capacity in terms of the quantity of FCEVs that the network can support when operating at capacity, and the station quantity that is accessible to the public. This network summary includes the Clean Transportation Program-funded

and privately funded stations. Including all known publicly and privately funded stations, the projected network will contain 129 stations.

CEC staff used the assumption of 0.7 kilogram per day of hydrogen consumed per FCEV to convert the station nameplate capacity into the estimated number of FCEVs supported (by dividing the fueling capacity by 0.7).[10] However, other factors can influence the quantity of FCEVs that can be supported. These factors include station availability and reliability, fuel availability, the interdependency of the actual FCEV geographical distribution relative to stations, driver habits, vehicle miles traveled, and routes traveled. The number of connector stations and destination stations can affect these factors.

These 129 known planned stations will have the capacity to support nearly 195,000 FCEVs when assuming operation at 100 percent availability, which is more than nine times the fueling needs of the projected FCEV population in 2030, according to the 2024 Annual Evaluation. Even when assuming 80 percent of nameplate capacity (more realistic and sustainable level of fueling),[11] these stations are capable of supporting nearly 156,000 FCEVs, which is more than seven times the fueling needs of the projected FCEV population in 2030.

However, FCEV drivers continue to suffer from lack of confidence in fuel availability because of stations being unavailable and unreliable. According to the data collected by the Hydrogen Fuel Cell Partnership's Station Operational Status System (SOSS), obtained by CARB staff, the average availability of open retail stations was around 62 percent from the third quarter of 2023 to the second quarter of 2024. This data includes TNO stations as 0 percent available. Station unavailability was due to maintenance, equipment failures, supply chain constraints, and hydrogen supply disruptions. Reliability and accessibility of the refueling infrastructure are discussed later in this chapter.

Overall, the current 62 open retail stations can support nearly 57,000 FCEVs when operating at capacity, which is nearly quadruple the estimated 14,415 FCEVs on the road as of the third quarter (July–September) of 2024. However, reducing the network capacity of open retail stations using this availability percentage shows that the network can support about 36,000 FCEVs. To help make the existing stations more reliable, in May 2024, the CEC awarded operation and maintenance grants to two station operators to improve the reliability of 45 open-retail stations. The CEC requires commitment to achieving 95 percent uptime as a condition for receiving these grants. The latest solicitation released in September 2024 should also help add more station locations to the network expanding the coverage and the accessibility of the refueling network.

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10 Pratt, Joseph, Danny Terlip, Chris Ainscough, Jennifer Kurtz, and Amgad Elgowainy. 2015. *H2FIRST Reference Station Design Task, Project Deliverable 2-2.* National Renewable Energy Laboratory and Sandia National Laboratories, https://www.osti.gov/biblio/1215215.

11 The 2023 AB 8 Joint Report and past AB 8 joint reports have used an assumption of 80 percent of nameplate capacity for some analyses as a more realistic and sustainable level of fueling. This assumption allows for neighboring stations to cover for stations that need to go offline temporarily because of mechanical issues or scheduled maintenance. If all stations were operating at 100 percent of nameplate capacity, neighboring stations would not be able to cover for other stations during outage or maintenance. In addition, accounting for variability of demand throughout the year is important. For example, if a station was operating at nameplate capacity daily, then the station would not be able to accommodate any increased demand during busy travel seasons.

Table 1: Hydrogen Refueling Station Network and Quantity of FCEVs Supported

Station Status	Station Quantity	FCEVs Stations Can Support at Nameplate	FCEVs Stations Can Support at 62 Percent Average Operating Capacity	Station Quantity Accessible to the Public
Open Retail Available	42	47,000	29,100	42
Open Retail TNO	20	10,000	6,200	20
Planned	67	138,000	85,600	67
Total Funded	***129***	***195,000***	**120,900**	***129***

Source: CEC

Hydrogen Dispensing and Station Utilization

Although the average daily hydrogen dispensing across the network was increasing at a higher rate last year than what was before the COVID-19 pandemic, the average daily hydrogen dispensing between the third quarter of 2023 and the second quarter of 2024 decreased by 22 percent. The drop in hydrogen dispensing could be due to FCEVs being driven fewer miles, fewer FCEVs are on the road, or a combination.

Factors affecting the number of kilograms dispensed across the network may include fluctuations in commuting and daily driving, extended time frames for planned and unscheduled maintenance at the stations, the availability of delivered hydrogen, and station closures. CARB's 2024 Annual Evaluation reported that FCEV registrations grew by 1,436 FCEVs between April 2023 and April 2024. This growth was less than 1,859 FCEVs registered between April 2022 to April 2023.

The existing network of hydrogen refueling stations in California has ample fueling capacity to support the on-road light-duty FCEVs because the average utilization[12] of the overall network is 17 percent. Many of the older legacy stations funded before 2014 are operating close to capacity because the nameplate capacity of those stations is small. The newer generation stations, which were funded after 2014, have been operating at a lower utilization rate because they are four times larger than the stations built before the end of 2014. Newer generation stations are used at about 25 percent of capacity, even on the most heavily trafficked days.

The CEC requires grant recipients to report hydrogen dispensing data during the term of their grant agreements. Once an agreement term ends, some station operators continue reporting data voluntarily. Figure 5 shows the average daily hydrogen dispensing in California based on the station operators' reports. For stations that do not report, staff estimated the average daily dispensing based on the daily regional dispensing (Greater Los Angeles Area, San Francisco Bay Area, San Diego Area, Sacramento Area, and connector area outside the four other areas) where each nonreporting station is located. Of 62 open retail hydrogen refueling stations, CEC staff received data from 45 stations and

12 The term "utilization" is used in this 2024 AB 126 Joint Report to align with the industry norm to describe the ratio of fuel throughput to the nameplate capacity of the station or the network of stations.

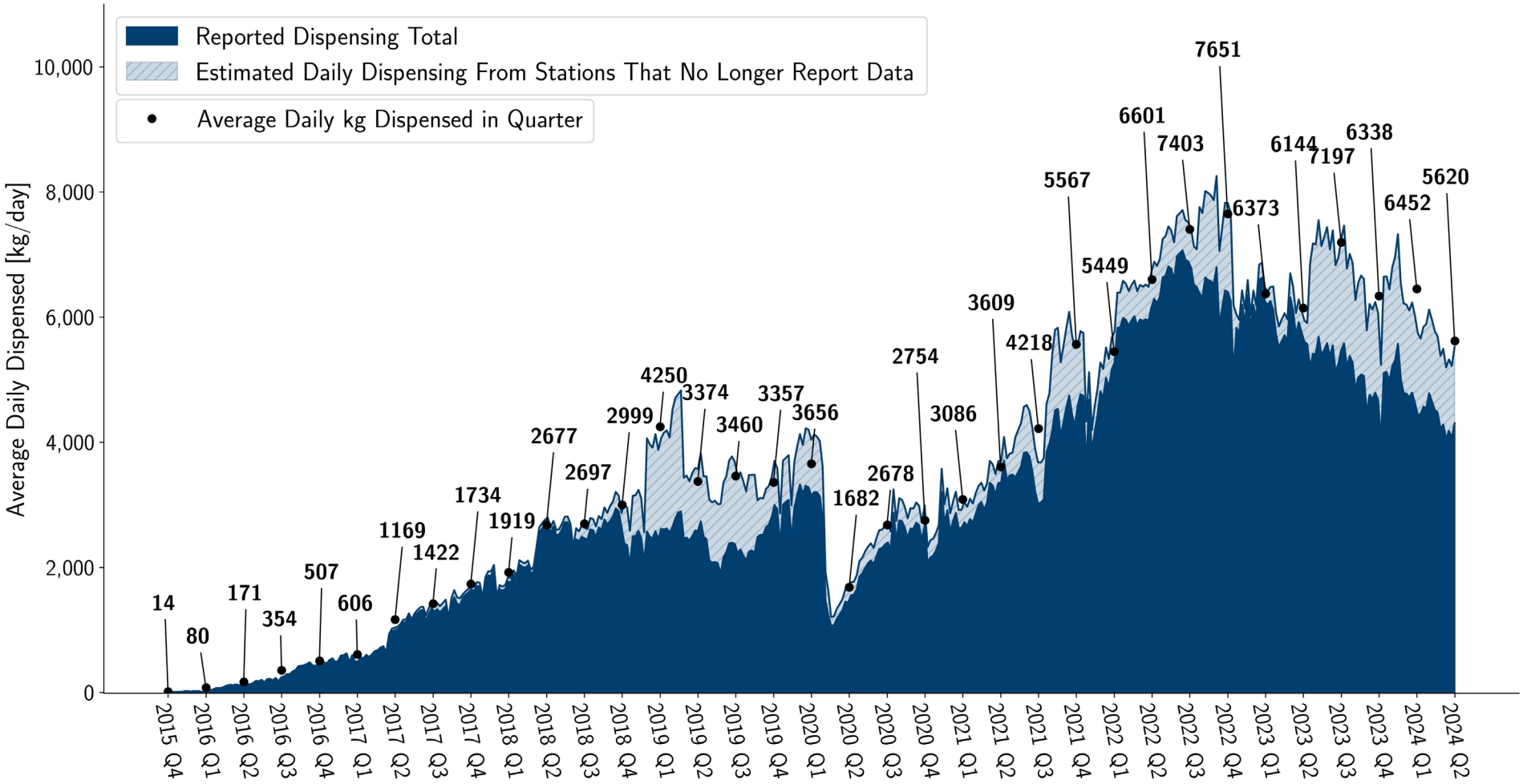
estimated dispensing for 8 stations in the second quarter of 2024. Staff assumes the TNO stations have dispensed zero kilograms of hydrogen for the quarter that they are categorized as TNO.

The solid color in Figure 5[13] shows the average weekly dispensed fuel reported by station operators. The patterned area shows the estimated dispensing for stations that do not report to the CEC.[14] The average daily dispensing is shown above each quarter. After the dip in the second quarter of 2020 due to the outbreak of COVID-19, the average daily dispensing recovered by the second quarter of 2021 and increased further at a higher rate than before the pandemic. The maximum average daily dispensing was reached during the third quarter of 2022, followed by a sharp decrease since the beginning of 2023, which can be explained by the closing of the Shell stations in the San Francisco Bay Area and Sacramento Area, leading to fewer FCEVs on the road. In the second quarter of 2024, the average daily dispensing decreased to about 5,140 kg/day. The sharp increase in the patterned area starting in the third quarter of 2023 can be explained by new stations that have come on-line being larger and increasing the average daily dispensing used to estimate for nonreporting stations.

13 Estimated dispensing fluctuates since reporting requirements vary according to CEC agreements.

14 In 2019, many agreements ended, and many of those stations discontinued reporting fueling data to the CEC; hence, the patterned line is larger in that year. However, starting in 2020, many station operators have agreed to provide the CEC with an abbreviated amount of fueling data for stations that are no longer part of CEC agreements to allow the CEC to do this reporting.

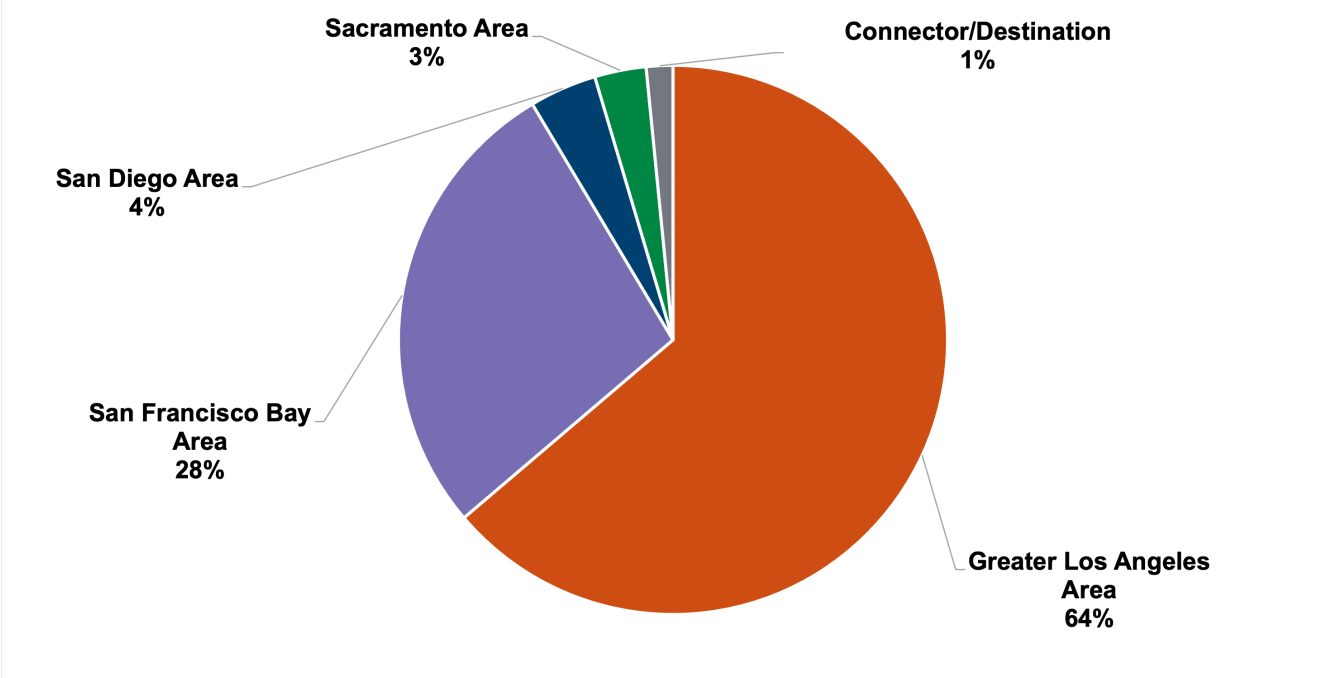
Figure 5: Average Daily Hydrogen Dispensing



Source: CEC

Figure 6 shows the percentage of hydrogen dispensed (actual and estimated) in each region from the beginning of the third quarter of 2023 to the end of the second quarter of 2024. About two-thirds of all hydrogen dispensed in California was in the Greater Los Angeles Area, which is consistent with the fact that around 60 percent of the open retail stations are located there.

Figure 6: Percentage of Hydrogen Dispensing by Region



Source: CEC

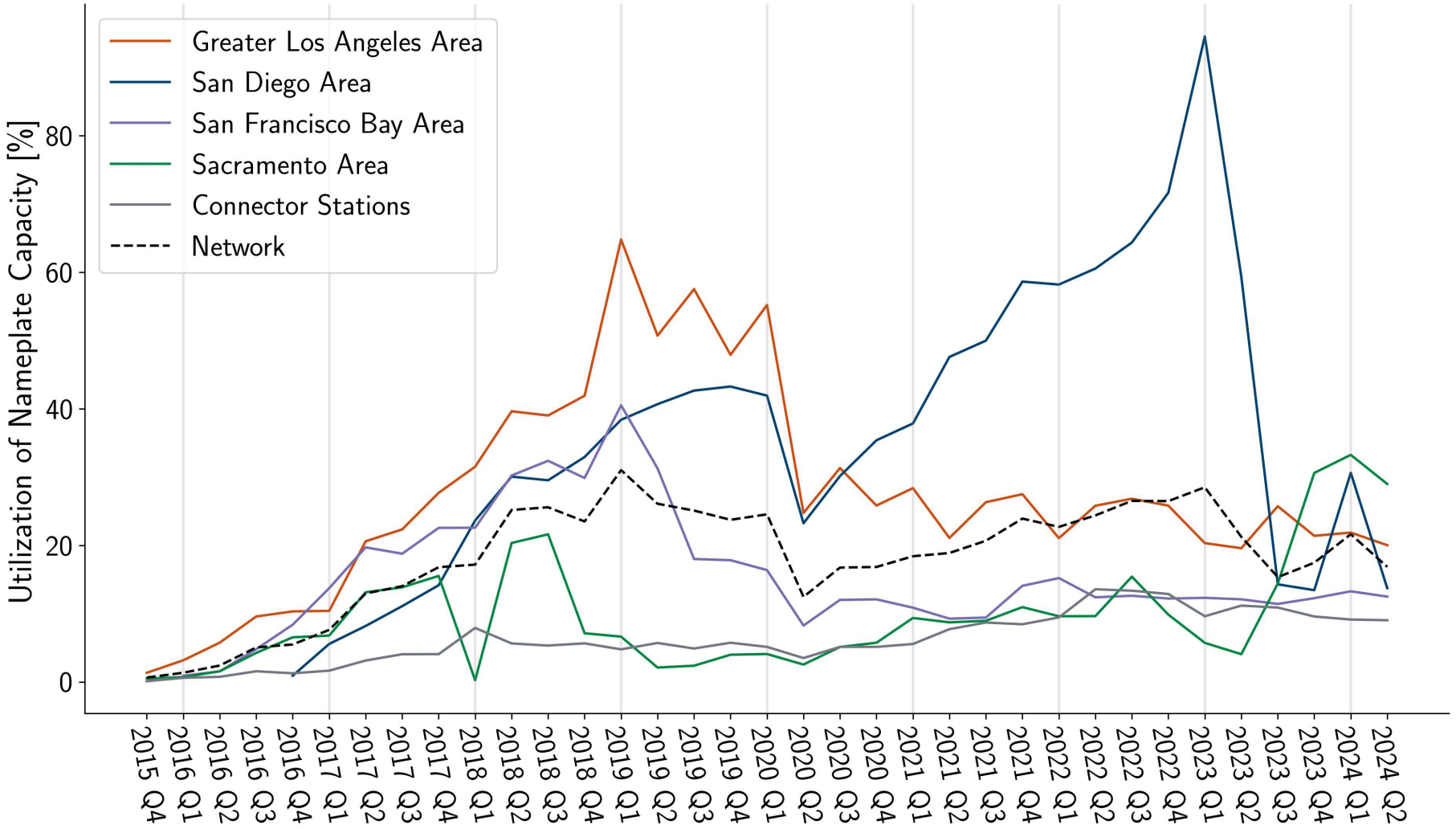
Figure 7 shows the quarterly hydrogen station utilization rates statewide. Staff calculated the utilization rate by dividing the total quarterly amount dispensed by the overall quarterly nameplate capacity of the open retail station network. If a station is designated as TNO or down for maintenance, the station is considered to have dispensed zero for the period that it is offline. The overall network utilization was 15.5 percent in the second quarter of 2024, showing a slight increase since Q3 2023 due to the closing of Shell stations in the Sacramento Area. The utilization percentage has been hovering around 20 percent consistently since the first quarter of 2020 because fueling capacity and fueling demand have grown at a similar rate.

The San Diego Area had the highest average utilization rate, more than 90 percent in the first quarter of 2023 because the area had only one station with the fueling capacity of 266 kg/day. In the second quarter of 2023, the San Diego-Mission Center station opened with more than 1,200 kg/day capacity, causing the overall utilization rate in that area to decline to around 14 percent in the third quarter of 2023. Since the start of 2024, San Diego is back to one operating station because the station in Del Mar has been TNO. However, the utilization rate in the San Diego Area did not appear to be affected much, probably because the overall fuel demand in the area is still small compared to the fueling capacity provided in the area.

In the first quarter of 2024, the Sacramento Area had the highest utilization percentage because of the closure of two Shell stations. At this time, Sacramento relies on one station in West Sacramento. Although Shell stations also closed in the San Francisco Bay Area, the utilization rate in that area has not increased as much, which can be explained by a decreased number of FCEVs on the road in that region.

These trends shown in Figure 6 and Figure 7 help inform stakeholders where future stations are needed.

Figure 7: Hydrogen Station Utilization by Quarter



Source: CEC

Retail Price of Hydrogen

Figure 8 shows the weighted average retail price of hydrogen and the total kilograms of hydrogen sold per quarter for hydrogen stations that report dispensing data to the CEC. The weighted average retail price of hydrogen is the quarterly revenue generated by hydrogen sales in the network divided by the total kilograms dispensed by the network in the quarter. This sample represents all stations that have agreements with the CEC and are required to report their fueling data and stations that voluntarily submit data to the CEC. The samples for the latest quarter account for about 70 percent of open retail stations in the state.

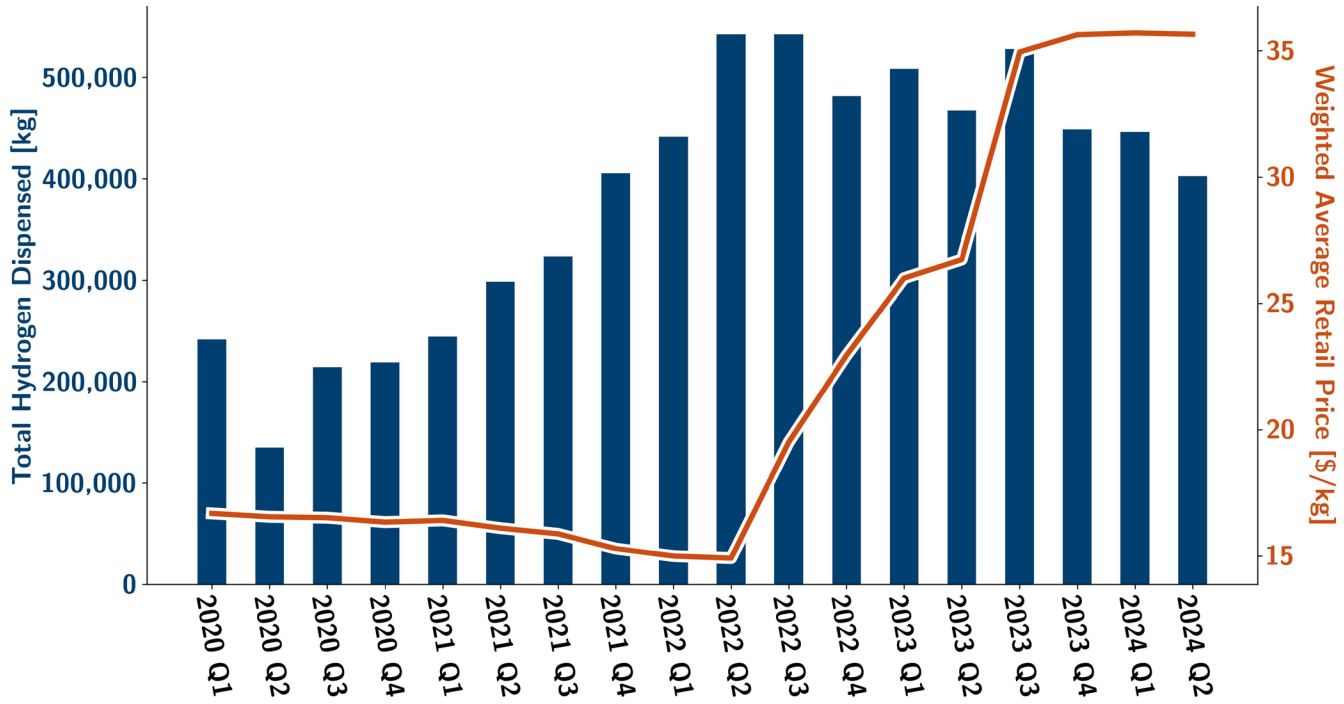
Figure 8 shows that the average price of dispensed hydrogen has remained the same since last year. FCEVs are about 2.5 times more efficient than gasoline-powered vehicles.[15] Therefore, in terms of driving range obtained from the fuel, $36 per kilogram of hydrogen is equivalent to paying about $14.40 for a gallon of gasoline. FCEV drivers could be paying up to $180 to fill an empty tank at $36 per kilogram. Station developers have cited that these price increases are due to increasing energy costs for natural gas, increasing labor and materials costs due to inflation, and lower value of CARB LCFS credits traded on the market, meaning station operators are earning fewer dollars per credit.

LCFS revenue can help offset the costs of operations and maintenance of stations, which has helped keep prices paid by FCEV drivers at the pump lower in the past. When GFO-19-602 was released, the LCFS credit price was around $200 per credit, which decreased to around $50 per credit as of July 2024. The low LCFS credit price can be attributed to the high supply of credits by biodiesel production. The total amount of hydrogen dispensed shown in Figure 8 has decreased between the third quarter of 2023 and the second quarter of 2024, likely reflecting the effects of the high hydrogen price, the lacking reliability of the stations, and station closures.

The CEC, CARB, GO-Biz, and station developers have been searching for ways to improve the current situation and reduce the prices paid by FCEV drivers. The CEC awarded operations and maintenance grants to two station operators (supporting 45 existing open retail stations total) in May 2024, which may help lower the prices paid by FCEV drivers. In addition, CARB held a public hearing to consider amendments to the LCFS on November 8, 2024 and the board approved the amendments. The amendments are expected to be in effect in early 2025. The amendments are expected to help recover the LCFS credit price in the future.

15 California Air Resources Board. July 2020. *Unofficial Electronic Version of the Low Carbon Fuel Standard Regulation,* https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf.

Figure 8: Weighted Average Price of Hydrogen and Total Kilograms Sold per Quarter



Source: CEC

Hydrogen Dispensed

Most of the hydrogen dispensed in the California station network has been produced using fossil gas steam methane reformation (SMR). This means that most of the hydrogen being produced relies on carbon-emitting fossil fuels such as natural gas to create the hydrogen.

The CARB LCFS Program allows program participants to meet the renewable requirements by using either direct renewable content or purchasing renewable attributes, or credits. The CARB LCFS Program uses the definition of renewable hydrogen as hydrogen derived from electrolysis of water or aqueous solutions using renewable electricity, catalytic cracking or steam methane reforming of biomethane, or thermochemical conversion of biomass, including the organic portion of municipal solid waste.[16]

The LCFS Program explains how indirect accounting may be used for renewable natural gas to produce hydrogen for transportation purposes by obtaining environmental attributes.[17] Renewable electricity, for renewable hydrogen production by electrolysis, means electricity derived from sources that qualify as eligible renewable energy resources as defined in California Public Utilities Code Sections 399.11–399.36.[16] These code sections define

16 California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 10, Article 4, Subarticle 7, §95481.

17 California Air Resources Board. July 2020. *Unofficial Electronic Version of the Low Carbon Fuel Standard Regulation,* https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf.

renewable electricity as electricity produced via many renewable pathways, including solar, wind, geothermal, biomass, landfill gas, municipal solid waste, tidal energy, and others.[18]

For several years, the CEC stopped receiving data on the kilograms of hydrogen dispensed at stations and the percentage of renewable hydrogen dispensed in attestations provided by station developers because many CEC agreements had ended. However, the new operations and maintenance agreements require data collection for 45 existing open retail stations. Data collected from these stations will be included in the next year's AB 126 joint report.

For stations reporting to the CARB LCFS Program under the HRI provision,[19] the CARB 2024 Annual Evaluation estimates 39 percent renewable content in 2023 and 37 percent renewable content in the first quarter of 2024 using data available through the LCFS program for all reporting hydrogen stations. Book and claim accounting[20] is likely used to reach those levels of renewable content. The CARB's analysis shows that the renewable content continued to decrease, to even below the HRI crediting requirement of 40 percent. The CARB 2024 Annual Evaluation suspected that Shell's exist, and the supply disruption in Southern California might be contributing to this decrease.

The CEC will continue to explore ways to help increase the renewable content of hydrogen directly produced in-state that is used in vehicles.

Reliability and Availability of the Refueling Infrastructure

Improving station reliability so that stations are available consistently is key to providing all stakeholders, most notably FCEV drivers and auto manufacturers, confidence in the FCEV market such that it can grow to the full potential. Although on paper, the network of 62 stations has more fueling capacity than the demand, actual network fueling capacity depends on the reliability of hydrogen supply and station uptime. According to the data collected by the Hydrogen Fuel Cell Partnership's SOSS, obtained by CARB staff, the average availability of open retail stations, was around 62 percent from the third quarter of 2023 to the second quarter of 2024 (including TNO stations as 0 percent available). Reducing the network capacity of open retail stations using the 62 percent availability percentage reported by CARB shows that the network can support about 36,000 FCEVs.

Recent station unavailability has been caused mostly by unexpected equipment failure, spare parts shortages, and hydrogen supply disruptions. For example, a supply service disruption has been affecting 13 stations in Southern California since September 2023, and most of these stations have remained closed. In addition, Shell announced the permanent closure of seven stations in February 2024. The closure of Shell stations has left the Sacramento Area with one open station, which is one of the oldest stations in the state and cannot handle the increased

18 California Public Utilities Code §§399.11–399.36 and California Public Resources Code §25741.

19 California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 10, Article 4, Subarticle 7, §95481.

20 CARB defines book and claim accounting as, "the chain-of-custody model in which decoupled environmental attributes, such as Renewable Energy Certificates, are used to represent the ownership and transfer of transportation fuel under the LCFS without regard to physical traceability" in the LCFS Guidance. https://ww2.arb.ca.gov/sites/default/files/2022-12/19-01_updated%20for%20WREGIS%20changes_ADA.pdf.

demand without requiring a mandatory 10-minute wait time between fills to avoid equipment failure. As a result, drivers could spend hours waiting for an opportunity to refuel. The closure also left San Francisco with no stations. Toyota has provided rental cars and reimbursement for fuel to affected drivers; however, these provisions mean many of these drivers could be driving cars with tailpipe emissions instead of ZEVs.

With fewer stations available, it is even more critical to have the existing stations operating reliably and be accessible to FCEV drivers. The CEC approved operations and maintenance grants totaling $9.4 million to two station operators to improve the reliability of 45 open retail stations at the May 2024 business meeting. These station operators will implement projects to improve these existing stations, including installation of new hardware components, development of new software tools, development of a customer-facing mobile app for SOSS, expansion of spare parts inventory, hiring additional staff, and point-of-sale interface improvements.

These station operators are required to commit to achieving 95 percent uptime as a condition for receiving grants. These station operators are also required to submit data on downtime related to maintenance, equipment failures, or hydrogen fuel supply issues through these grant agreements for the CEC to understand the reliability of the network from a customer experience. Specifically, the CEC collects, as required in AB 126, the availability of operational fueling nozzles, whether hydrogen is available for refueling at that station, the volume of hydrogen-dispensed basis, and the number of vehicles fueled by a station. Analyses of the reliability related data will be included in the next year's AB 126 joint report.

Expanding Options for Hydrogen Supply for California

Although various factors affect station uptime, ensuring the reliable and consistent supply of hydrogen fuel is essential to minimizing station downtime. In fact, a supply service disruption has been affecting 13 stations in Southern California since September 2023 with no estimated timeline for when the disruption will be resolved, and most of these stations have remained closed. Diversifying the supply of hydrogen for FCEVs will also be significant for increasing the reliability of refueling stations and decreasing the cost of hydrogen.

The State of California, in partnership with industry stakeholders, applied to the U.S. DOE for federal funding for a hydrogen hub. On October 13, 2023, the U.S. DOE announced $7 billion to launch seven regional clean hydrogen hubs, including up to $1.2 billion for the California hydrogen hub called the Alliance for Renewable Clean Hydrogen Energy Systems or "ARCHES."[21] In July 2024, U.S. DOE awarded $30 million to ARCHES for the first tranche of funding of up to $1.2 billion to begin the first phase, which can last up to 18 months and includes planning, design, and community and labor engagement.[22] This hydrogen hub plans

21 U.S. DOE. October 13, 2023. "Biden-Harris Administration Announces $7 Billion For America's First Clean Hydrogen Hubs, Driving Clean Manufacturing and Delivering New Economic Opportunities Nationwide," https://www.energy.gov/articles/biden-harris-administration-announces-7-billion-americas-first-clean-hydrogen-hubs-driving.

22 U.S. DOE. Office of Clean Energy Demonstrations. "California Hydrogen Hub (ARCHES)," https://www.energy.gov/oced/california-hydrogen-hub-arches?utm_medium=email&utm_source=govdelivery.

more than 10 production project sites with hundreds of metric tons per day of clean hydrogen produced with renewable electricity and biogenic sources, along with generating clean power at two major power plants and other stationary distributed locations throughout the state, including the Los Angeles Scattergood plant and Lodi Energy Center.

In addition, the Clean Transportation Program has funded three new renewable hydrogen production plants and two upgrade projects to existing plants, with a combined daily nameplate capacity of nearly 24,000 kg.[23] One of these plants started production in June 2023.[24] Most of the plants are still in early stages of development. Four of these projects use electrolyzers to produce hydrogen, and one in Southern California is anticipated to begin production in the first quarter of 2025.

The CEC's Energy Research and Development Division (ERDD) also has a program called the Clean Hydrogen Program,[25] which was established by Assembly Bill 209 (The Energy and Climate Change budget bill, Chapter 251, Section 12, Chapter 7.6, Article 4, enacted in September 2022). The Clean Hydrogen Program intends to provide financial incentives to eligible in-state projects to demonstrate or scale-up hydrogen projects that produce, process, deliver, store, or use clean hydrogen. However, the program funding was reduced to $40 million from the initial $100 million and has been delayed to Fiscal Year 2025–2026.

Other hydrogen production updates since the *Joint Agency Staff Report on Assembly Bill 8: 2023 Annual Assessment of the Hydrogen Refueling Network in California* (2023 AB 8 Joint Report),[26] including projects that will serve transportation uses and those that will not, are summarized in the following list.

- SGH2 Energy received permits from the City of Lancaster. (Its CEC-funded project was approved at the CEC's business meeting on May 31, 2023.) The project is expected to start producing roughly 3,800 metric tons[27] of renewable hydrogen annually using waste in 2025 to support FCEVs.
- The City of Lancaster released an update about Element Resources planning to build a renewable hydrogen production plant in the city that will use hydrocarbon feedstock from

23 Two production plants were funded by GFO-17-602, Renewable Hydrogen Transportation Fuel Production Facilities and Systems, released December 2017. Two additional plants and a plant upgrade were funded by GFO-20-609, Renewable Hydrogen Transportation Fuel Production, released April 9, 2021.

24 H2B2. June 15, 2023. "H2B2's SoHyCal Project in California Has Started Hydrogen Production," https://www.h2b2.es/h2b2s-sohycal-project-in-california-has-started-hydrogen-production/.

25 California Energy Commission. "Clean Hydrogen Program," https://www.energy.ca.gov/programs-and-topics/programs/clean-hydrogen-program.

26 Crowell, Miki and Martinez, Andrew. 2023. *Joint Agency Staff Report on Assembly Bill 8: 2023 Annual Assessment of the Hydrogen Refueling Network in California.* California Energy Commission and California Air Resources Board. Publication Number: CEC-600-2023-069. https://www.energy.ca.gov/sites/default/files/2023-12/CEC-600-2023-069.pdf

27 The metric ton is a unit of mass and defined as 1,000 kilograms.

recycled mixed paper waste to produce 3.85 million kilograms of hydrogen per year dedicated for use in transportation.[28]

- Raven SR Inc., Chevron New Energies, and Hyzon Motors Inc., announced January 9, 2023, that they are collaborating for a green waste-to-hydrogen production plant in Richmond (Contra Costa County) to supply transportation markets in Northern California. The production plant is expected to divert up to 99 wet tons of green and food waste a day and to produce up to 2,400 metric tons of renewable hydrogen annually.[29] As of July 2024, the project was engaged in the permitting process. The project received CEQA approval in May 2023.[30]
- Yosemite Clean Energy LLC announced that its project has been awarded funding from the CEC to build a hydrogen production plant in Oroville (Butte County) by converting forest biomass into green hydrogen. Using wood waste will also help reduce the risk of wildfire. The project is expected to be completed in the first quarter of 2026 and produce 7,000 metric tons of hydrogen annually.[31]
- Chevron New Energies, a division of Chevron U.S.A. Inc., announced that it is developing a 5 MW hydrogen production project in the Central Valley, using electrolysis. The project is expected to produce 2 tons of hydrogen each day, for the transportation market.[32]

The total fueling capacity of the 129-station network is nearly 137,000 kg/day (137 metric tons/day), or enough hydrogen fuel for nearly 195,000 light-duty FCEVs. The combined daily production capacity of existing and new production plants that will supply hydrogen to the transportation sector is about 108,000 kg/day, most of which can be available to use in California. This amount is about 55 percent of the capacity of the future light-duty fueling network (though more than five times the anticipated demand of 14,350 kg/day from the latest light-duty FCEV projection by auto manufacturers of 20,500 FCEVs on the road by 2030). However, all this production capacity is not necessarily dedicated to light-duty vehicles,

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28 The City of Lancaster. January 24, 2023. "Element Resources to Build One of California's Largest Renewable Hydrogen Production Facilities in the City of Lancaster, CA," https://www.cityoflancasterca.org/Home/Components/News/News/9889/.

29 Chevron Corporation. January 9, 2023. News release. "Raven SR, Chevron and Hyzon Motors Collaborate to Produce Hydrogen From Green Waste in Northern California," https://www.chevron.com/newsroom/2023/q1/raven-sr-chevron-hyzon-motors-collaborate-to-produce-hydrogen-from-green-waste.

30 Raven. May 24, 2023. Media release. "Raven SR Bioenergy Project Receives Environmental Approval From City of Richmond, Calif.," https://ravensr.com/richmmond-bioenergy-project-approved/.

31 Yosemite Clean Energy LLC. July 12, 2023. "Yosemite Clean Energy Receives $5 Million Grant." *Biomass Magazine,* https://biomassmagazine.com/articles/20207/yosemite-clean-energy-receives-5-million-grant.

32 Chevron Corporation. February 29, 2024. News release. "chevron Announces Its First Solar-to-Hydrogen Production Project in California's Central Valley." https://www.chevron.com/newsroom/2024/q1/chevron-announces-its-first-solar-to-hydrogen-production-project-in-californias-central-valley#:~:text=alternative%20fuels-,chevron%20announces%20its%20first%20solar-to-hydrogen%20production%20project%20in,project%20in%20California's%20Central%20Valley.

and continuing to focus on increasing hydrogen production for the California mobility market, with a focus on clean hydrogen and low-carbon intensities, should remain a priority.

In addition, more hydrogen production projects, even the ones that will not supply the transportation sector, will help advance technologies and reduce the costs of hydrogen.

CHAPTER 3:
Fuel Cell Electric Vehicle Deployment

This chapter discusses the estimated number of FCEVs currently in the state and the projected FCEV population, along with barriers to widespread FCEV adoption.

CARB's 2024 Annual Evaluation found that only 1,436 additional FCEVs were registered between April 2023 and April 2024, compared to 1,859 additional FCEVs registered between April 2022 and April 2023. This recent slower growth most likely reflects the permanent closure of seven Shell hydrogen stations in Northern California, station development pace, the reliability issues of stations, fuel supply disruptions, high fuel costs, and a lack of vehicle make/model options.

The current network nameplate fueling capacity could support more deployment of FCEVs. However, actual network fueling capacity depends on the availability of hydrogen supply and the availability of the stations themselves. As noted in Chapter 2, concerns with reliability and TNO stations reduce the availability of the stations. The new operations and maintenance agreements should help improve the reliability and availability of 45 existing open-retail stations to support FCEVs.

Both the CEC and CARB publish FCEV deployment numbers. The CEC Energy Assessments Division collects and analyzes California Department of Motor Vehicles (DMV) data about the trends in ZEV sales and population. CARB also collects and reports the estimated number of FCEVs on the road in April and October each year based on the analysis of DMV data, including removing vehicles that appear to be no longer registered in the state.

The CEC publishes "Zero Emission Vehicle and Infrastructure Statistics,"[33] which offer a collection of dashboards for ZEV sales, ZEV population, school buses, and corresponding infrastructure information. The New ZEV Sales in California dashboard reports that the on-road population of FCEVs was 13,988 at the end of 2023, and the dashboard reports the new FCEV sales for 2024, through the end of the third quarter, as 427 FCEVs. With this information, staff estimates the total on-road FCEV population to be 14,415, the summation of 13,988 and 427.[34]

The dashboard shows cumulative light-duty ZEV sales, including FCEV, BEV, and plug-in hybrid electric vehicles, as 2,113,135 in California as of the third quarter of 2024. The dashboard also shows 173 fuel cell electric buses and 30 fuel cell trucks at the end of 2023. The *2023 Final Staff Report on Senate Bill 643: Clean Hydrogen Fuel Production and Refueling Infrastructure*

33 California Energy Commission. "Zero Emission Vehicle and Infrastructure Statistics," https://www.energy.ca.gov/zevstats.

34 According to the CEC ZEV Dashboard, cumulative sales or leases of FCEVs in California were 17,999 in the third quarter of 2024; however, the cumulative sales number of FCEVs does not account for those FCEVs no longer in use due to replacement or attrition.

to Support Medium-and Heavy-Duty Fuel Cell Electric Vehicles and Off-Road Applications[35] discusses medium- and heavy- duty vehicles in more detail, and Appendix C of this report provides updates on medium- and heavy- duty vehicles and stations.

CARB's analysis of DMV data found the population of FCEVs was 14,429, as of April 2024. Per the provision set forth by AB 126, CARB is to aggregate and make available to the public, no later than June 30, 2014, and every year thereafter, "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" and "the total number of hydrogen-fueled vehicles registered with the Department of Motor Vehicles through April 30."[36] AB 126 also requires the CEC and CARB to consider "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, …" and other factors.

Figure 9, reprinted from CARB's 2024 Annual Evaluation, shows data as provided by auto manufacturers for estimates of vehicles on the road and projected for future deployment from all years of reporting in CARB's Annual Evaluations. CEC staff notes that the material in Figure 9 are projections, per AB 126. Estimated numbers of vehicles on the road per CARB's annual analysis of April 2024 DMV registration data are shown by the red triangles, growing to an estimate of 14,429 vehicles.

In Figure 9, yellow circles show estimated numbers of vehicles on the road based on October DMV data. Two shaded areas in the figure represent projections made by auto manufacturers for future FCEV deployment in all annual evaluations to date. For each annual evaluation, auto manufacturers submit projections to CARB of future FCEV deployment, split into two periods. All auto manufacturers who seek to certify vehicles for sale in California must provide estimates for the mandatory period, which always covers the current model year and the next three model years. Auto manufacturers may also provide responses for the optional reporting period, which extends three further model years. For example, in the 2024 survey, the mandatory survey reporting period covers the Model Years 2024 through 2027, and the optional survey reporting period covers Model Years 2028 through 2030.

In Figure 9, the lower, blue-shaded area displays results for mandatory periods in all past surveys, while the upper, orange-shaded area displays results for optional periods in all past surveys. The information provided on the survey, by auto manufacturers, represents projected FCEV sales or leases in terms of model years. CARB's analysis translates model year into calendar year by assuming that one-third of all vehicles of a given model year are sold or leased in the prior calendar year based on the historical DMV registration data from 2007 to 2012.

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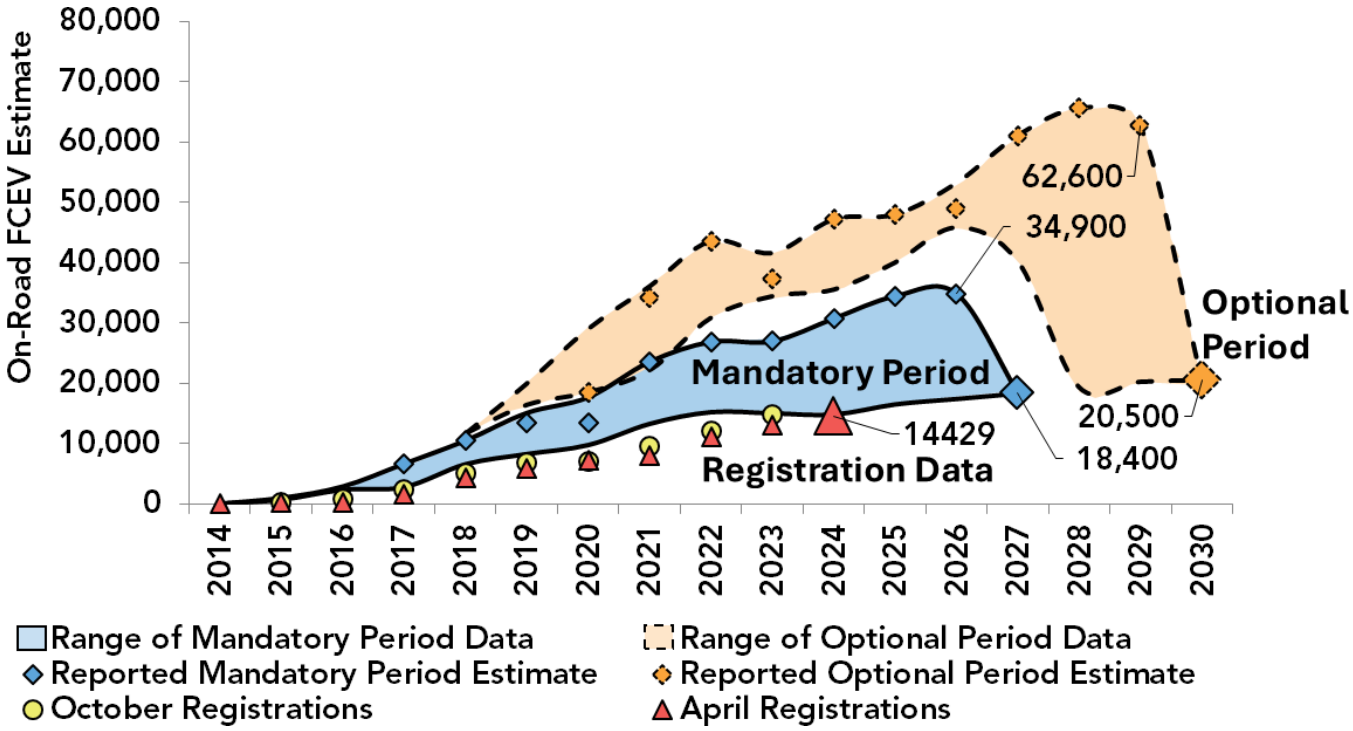
35 Villareal, Kristi. 2023. *2023 Final Staff Report on Senate Bill 643: Clean Hydrogen Fuel Production and Refueling Infrastructure to Support Medium-and Heavy-Duty Fuel Cell Electric Vehicles and Off-Road Applications.* California Energy Commission. Publication Number: CEC-600-2023-053-SF, https://www.energy.ca.gov/publications/2023/senate-bill-643-clean-hydrogen-fuel-production-and-refueling-infrastructure.

36 California Legislative Information. Assembly Bill 126 (Reyes, Chapter 319, Statutes of 2023), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240AB126.

For example, if an auto manufacturer responds with a projection of 900 FCEVs to be sold in Model Year 2024, CARB's analysis assumes 300 FCEVs will be sold in Calendar Year 2023 and the remaining 600 FCEVs in Calendar Year 2024. CARB's analysis also assumes a standard rate at which FCEVs fall out of the fleet, such as vehicles being moved to another state, accidents, and other causes to estimate the on-road population. This rate is based on similar assumptions in CARB's vehicle fleet modeling tool EMFAC.[37]

Auto manufacturers' deployment plans in the 2024 annual survey would result in 18,400 FCEVs on the road in California in 2027 and 20,500 on the road in 2030. These projected numbers of vehicles are smaller than what was reported in the 2023 Annual Evaluation (34,900 FCEVs by 2026 and 62,600 FCEVs by 2029).

Figure 9: FCEV Projections Based on CARB Analysis of Responses to the Annual Auto Manufacturer Survey



Source: CARB

There are many factors affecting FCEV projections. The recent changes in the projected size of the hydrogen refueling network and the number of open-retail stations due to Shell's exit, ongoing station and fuel supply reliability issues and high price of hydrogen at the pump, and lack of robust FCEV make and model offerings by auto manufacturers and robust sales in California and globally may have affected the auto manufacturers' FCEV sales projections.

As discussed in Chapter 2, the CEC approved operations and maintenance grants totaling $9.4 million to two station operators to improve the reliability of 45 open retail stations at the May 2024 business meeting. In addition, the contract with University of California, Davis (UC

37 CARB's EMissions FACtor model used to assess emissions from on-road vehicles.

Davis), to gain a better understanding of customer experiences with light-duty hydrogen refueling and hydrogen refueling market potential, will help the CEC plan future efforts.

The CEC also continues to explore options to enhance the hydrogen station network reliability, resiliency, and availability by working with the industry and setting uptime requirements in future solicitations. The CEC will use data on downtime related to maintenance, equipment failures, or hydrogen fuel supply issues collected through the operations and maintenance agreements to understand the reliability of the network from a customer experience.

CHAPTER 4:
Time Required to Permit and Construct Hydrogen Refueling Stations

Chapter 4 covers the station development time, shows how the development time has changed over the years, and discusses efforts to help reduce station development time.

Overall station development has slowed considerably in the last few years. One developer has paused their station development until they secure more private funding to cover increased costs due to global inflation. Another developer had been reviewing equipment options when the equipment they chose did not work out although they selected an equipment supplier for the rest of their future stations funded by CEC. Two developers mentioned that they are waiting for the LCFS amendments in hopes of the LCFS credit price recovering. Therefore, time required to permit and construct hydrogen refueling stations observed since 2020 may not be an accurate representation of how long station development takes under normal conditions.

This report breaks down station development time into four phases to analyze the trend. Table 2 lists the phases of station development.

Table 2: Station Development Phases

Phases	Description	Responsible Entity(ies)
Phase One: From start of CEC grant-funded project to initial permit application filing	Begins when the grant-funded project agreement is executed and includes site selection and site control, station planning, participation in prepermitting meetings for confirmation of station design consistency with local zoning and building codes and filing the initial permit application with the authority having jurisdiction (AHJ). Equipment ordering could occur during this phase.	Grant recipient and AHJ
Phase Two: From initial permit application filing to receipt of approval to build	Consists of AHJ review of the application and potential site reengineering/redesign based on AHJ feedback. Minor construction work sometimes begins.	Grant recipient and AHJ
Phase Three: From approval to build to station becoming operational	Includes station construction and meeting operational requirements: fuel supply, hydrogen quality testing, dispensing per standard, successful refueling of one FCEV, and receipt of an occupancy permit from the AHJ.	Grant recipient and AHJ

Phases	Description	Responsible Entity(ies)
Phase Four: From station becoming operational to becoming open retail	The station undergoes accuracy testing with the California Department of Food and Agriculture/Division of Measurement Standards (DMS) and protocol testing with auto manufacturers and the Hydrogen Station Equipment Performance (HyStEP) device. Once the station has been confirmed to meet the refueling protocol, the station is categorized as open retail.	Grant recipient, DMS, CARB (HyStEP), and auto manufacturers

Source: CEC

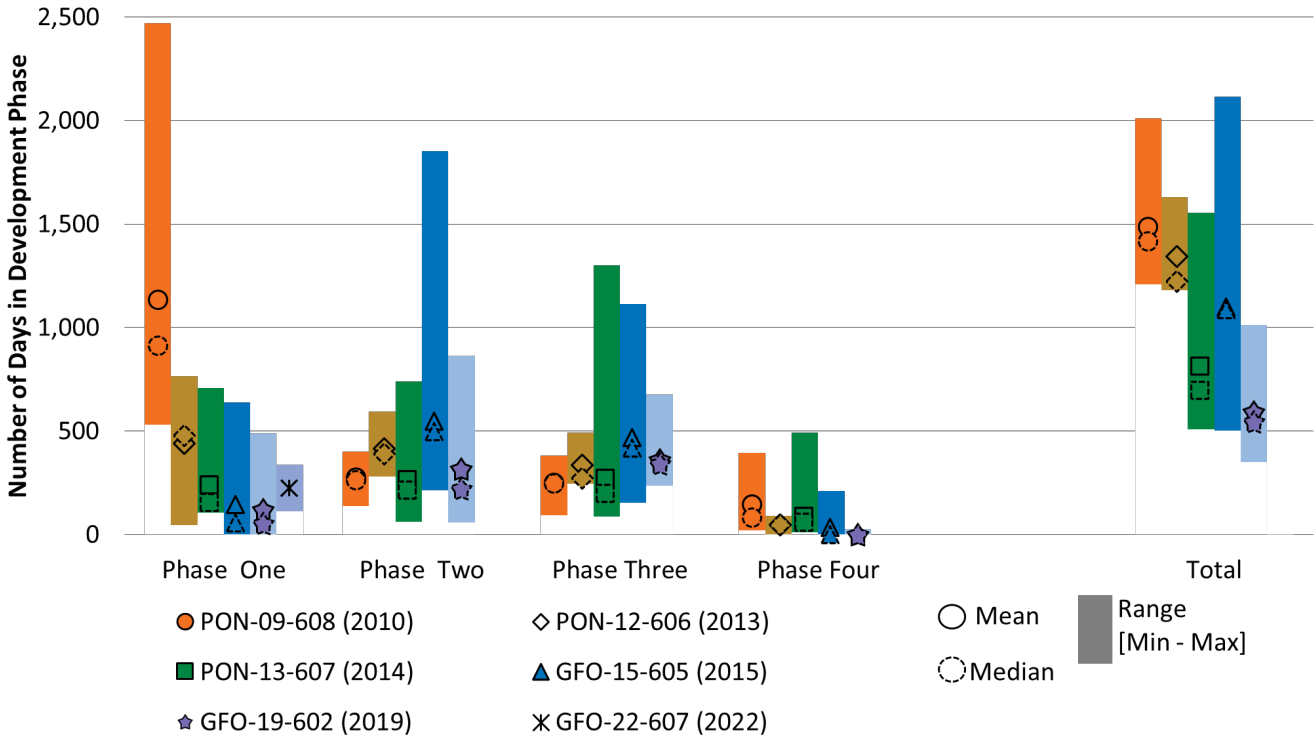
Figure 10 presents station development time, showing mean, median, minimum, and maximum number of days for each phase with one bar representing all the stations that completed that phase per solicitation. A *mean number of days* represents the average number of days for all stations that completed each phase. Mean numbers can be affected by unusual circumstances some stations experience that lead to atypical station development time. A *median number of days* represents the middle value of the reported number of days for all stations that completed each phase. Median numbers represent more typical station development time.

Minimum and maximum numbers of days represent the minimum and maximum time spent in each phase for all stations that completed each phase. The figure includes data from stations that are not yet open for retail fuel sales but includes only data for those stations for the completed phases. The bars on the far right in the figure show mean, median, minimum, and maximum numbers of days for the *total* station development time for each solicitation and include *only stations that have completed all phases*.

Figure 10 shows, per solicitation, the actual time station projects spent in each phase; therefore, the time spent in development phases includes data of stations that were canceled without completing or stations that have closed. For example, nine projects were either canceled or closed without completing during 2023, but these stations had completed Phase One (and one station project completed Phase Two), and the associated data are included in the corresponding solicitation bars for these phases. The Phase One and Two development times from these stations are *not* represented in the Total Development Time bars because the stations did not complete all phases.

The three stations that opened during 2024 were all privately funded stations; therefore, the CEC does not have information on the station development time. And because most of the station development has been on pause, there was little update to this year's analysis — GFO-22-607 stations completing the Phase One. Figure 10 shows no updates other than two stations under GFO-22-607 completing the Phase One.

Figure 10: Mean, Median, Minimum, and Maximum Days of Each Station Development Phase by Solicitation



Overall, the time spent in Phase One decreased after 2010 for newer solicitations. The mean, median, and maximum of station development time for solicitations with active agreements continue to increase as more stations are completed. The median total station development time was decreasing from about four years to two years for stations that opened before the pandemic. The median total station development time increased to about three years for those stations that completed during the pandemic (GFO-15-605). The median total station development time for GFO-19-602 is lower than the other solicitations, but only 10 stations have completed all phases. The development time for GFO-19-602 is expected to increase because many of the stations are still in development and affected by global inflation and supply chain issues. Only two stations are funded under GFO-22-607, and they only completed the Phase One.

Sources: CEC and CARB

Station developers shared how supply chain issues and global inflation are affecting their station development. One developer reported that securing funding commitments is more difficult due to inflation increasing the costs to develop stations along with the lower LCFS HRI credit value. They also spend more time trying to negotiate a better construction contract, which sometimes affect Phase Three. Another developer reported that finding equipment that ensures station uptime has been difficult; the equipment installed at existing stations either cannot maintain sufficient uptime or require station operators to develop their own parts to improve. This developer is carefully selecting equipment for the rest of the stations they develop to meet the customer expectations. Another developer also pointed to construction cost escalation, supply chain, and global inflation. Until global inflation, labor and material shortages, supply chain interruptions, and the lower LCFS HRI credit value are resolved, staff expects overall station development time for remaining stations to continue to increase.

Efforts to Help Reduce Station Development Time

CEC staff continues to work with station developers to explore ways to overcome the hurdles they are experiencing and expedite station development, including assessing an appropriate funding amount per station given inflation, supply chain challenges, and the uncertainty around the future fuel demand from light-duty FCEVs.

The CEC held the Staff Workshop for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure Solicitation Concepts in July 2024 and solicited feedback on the appropriate funding amounts per station for capital expenses and operations and maintenance grants. As a result, the CEC released a solicitation, GFO-24-601, offering $10 million for developing new stations in Sacramento and San Francisco Counties and $5 million to support capital expenditures and operations and maintenance for planned or TNO light-duty hydrogen refueling stations that have had open retail progress stall due to cost constraints. Reducing station development time will give current and future FCEV drivers more confidence in their refueling options.

In the time between PON-13-607 and GFO-15-605, CARB, the CEC, GO-Biz, and DMS collaborated with public and private stakeholders to develop the HyStEP device and program. Stations are tested using the HyStEP device before becoming open for retail hydrogen sale. The HyStEP tests the ability of hydrogen refueling stations to adhere to the fueling protocols of the industry-adopted SAE J2601 standard. This standard protocol helps ensure fast, safe, and reliable fueling experiences for customers. The HyStEP device verifies conformance to the protocol in one to two weeks. Prior efforts that relied on testing via multiple auto manufacturers using test vehicles could require months of scheduling, testing, adjusting, and retesting.

However, there is only one HyStEP device in the state, which could slow station opening if the station development pace improves or if multiple stations are ready for testing simultaneously. Furthermore, the current HyStEP device can only test stations that fuel light-duty vehicles. In the future, a new device will be needed to test medium- and heavy-duty hydrogen stations. The HyStEP program is operated by CARB, with collaborative review of HyStEP testing results among state agencies, the station developer, and auto manufacturers.

CARB released a request for proposal October 18, 2023, with $1.05 million available to design, engineer, build, test, and validate the next generation HyStEP 2.0. When compared to the original HyStEP device, the HyStEP 2.0 device will include new hardware and capabilities, which lead to reduced testing time. These capabilities include simultaneous testing and venting, accommodating back-to-back fueling, and ability to test a larger variety of vehicle tank sizes (up to 25 kg). The contract to build HyStEP 2.0 was executed in July 2024, and the device is expected to begin testing hydrogen stations in California by mid-2026.

Senate Bill (SB) 1291 (Archuleta, Chapter 373, Statutes of 2022)[38] has also been helpful in improving station development timeline by streamlining hydrogen station permitting. SB 1291 requires every city and county to approve administratively an application to install hydrogen

38 California Legislative Information. Senate Bill 1291 (Archuleta, Chapter 373, Statutes of 2022), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB1291.

refueling stations unless there are documentable health and safety concerns. GO-Biz is the lead agency for ensuring jurisdictions are in compliance and uses Hydrogen Fueling Station Readiness[39] to help station developers and jurisdictions. Senate Bill 1418 (Archuleta, Chapter 607, Statues of 2024)[40] requires every city and county to adopt a permit streamlining ordinance and a checklist that outlines all the requirements for permitting application.

Reducing the station development time is critical in ensuring that FCEV drivers and auto manufacturers feel confident about the refueling infrastructure. However, this effort requires state and industry stakeholders to collaborate as station development depends on several factors, including permit timing, public and private funding, the number of station equipment vendors and supply chain, and the number of station developers participating in the market available to deploy stations.

39 Governor's Office for Business and Economic Development. "Hydrogen Fueling Station Readiness," https://business.ca.gov/industries/zero-emission-vehicles/hydrogen-readiness/.

40 California Legislative Information. Senate Bill 1418 (Archuleta, Chapter 607, Statutes of 2024). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240SB1418.

CHAPTER 5:
Amount and Timing of the Growth of the Hydrogen Refueling Network

This chapter analyzes the amount and timing of the growth of the hydrogen refueling network by comparing the anticipated schedule of hydrogen refueling station openings over the next six years to the estimated schedule of FCEV deployment in California. The objective of the Clean Transportation Program solicitations is for the fueling capacity of the station network to stay well ahead of hydrogen fuel demand so that consumers can have confidence in fuel availability if they choose to drive a FCEV. This chapter also discusses contextual information about station and FCEV deployment in other parts of the world.

This report uses the nameplate capacity of stations to analyze the amount and timing of the growth of the hydrogen refueling network in California, discusses the statewide network of stations, and then evaluates the anticipated growth in greater detail at a regional level. This analysis assumes that stations within the network are operating regularly at the respective nameplate capacities without significant downtime.

The validity of this analysis depends on the degree to which stations are actually functioning this way in the real world — they have hydrogen supply available to dispense and are up and running. If stations are down due to broken equipment or because they have run out of hydrogen fuel, the station network cannot support the number of FCEVs that they should on paper. The analysis does not include closed or TNO stations. Chapter 2 already discussed challenges with hydrogen supply and other factors that have at times significantly affected station network performance.

As of November 4, 2024, California has built about four times more dispensing capacity than the demand needed to fuel its population of FCEVs. The station opening timelines provided to the CEC by hydrogen station developers suggest that by 2030, the network of 129 projected stations will have the capacity to serve nearly 195,000 FCEVs, assuming all 129 stations are operational. This number is more than nine times the amount of fuel needed to supply the projected 20,500 FCEVs by 2030 reported in CARB's 2024 Annual Evaluation, based on the latest auto manufacturer survey responses.

Even though the overall network nameplate capacity should still exceed fuel demand, there have been setbacks, such as proposed stations being canceled and existing stations experiencing reliability and availability issues.

Regional Analysis of Network Growth and FCEV Deployment

This section evaluates four major regions of the state: the Greater Los Angeles Area, the San Francisco Bay Area, the Sacramento Area, and the San Diego Area. The regions are defined in the glossary. This section also evaluates the rest of the state, composed of the North Region, Central Coast, Central Valley, Eastern Sierra, and Imperial County.

Table 3 presents the estimate of FCEV registrations per region as of April 2024, the number of FCEVs that the regional capacity of open retail stations with TNO stations removed can support, and the additional number of FCEVs the regional capacity can support. The Greater Los Angeles Area and the San Francisco Bay Area have more than sufficient nameplate fueling capacity for the number of FCEVs registered in the area, although station downtime can mean there are still times when fuel is unavailable. The San Diego Area has more capacity compared to the number of FCEVs than it has in past years because of the opening of one more station in 2023.

The region with the most urgent need of additional fueling capacity is the Sacramento Area, because two of the three stations closed permanently. Additional three stations are anticipated to open in the area in 2025, 2026 and 2028, adding a total of 4,848 kg/day in nameplate capacities that can support close to 7,000 FCEVs.

Table 3: Regional FCEVs and Open Retail Minus TNO Station Capacity

Region	# of FCEV Registrations[41]	Estimated # of FCEVs Open Retail Stations Can Support[42]	Additional # of FCEVs That Open Retail Stations Can Support
Greater Los Angeles Area	9,383	20,300	10,917
San Francisco Bay Area	3,369	14,600	11,231
Sacramento Area	1,035	560	(475)
San Diego Area	539	1700	1,161
Rest of State	912	1,100	188
Total	14,529	38,260	23,497

Source: CEC

Table 4 presents projections of vehicle and station rollout in 2030 using only 109 open and planned stations with known locations. These 109 stations alone are expected to have sufficient nameplate capacity to serve the number of FCEVs projected to be sold by that year as reported in CARB's 2024 Annual Evaluation based on the latest auto manufacturer survey responses.

In past years, this report has highlighted limited opportunity for FCEV deployment in the rest of the state outside the four main urban regions. The results of GFO-22-607 and GFO-19-602 will add new stations in Kettleman City and Fresno. When these newly funded stations open in

41 Numbers of FCEVs determined by DMV registration data, April 2023.

42 The estimated numbers of FCEVs supported are displayed with rounding to the nearest hundred in this table to better show regional differences. Elsewhere in this report, the statewide estimates are rounded to the nearest thousand.

2025, Central Valley communities will have the fueling access needed to support FCEV adoption.

Table 4: Regional Projection of FCEVs and Station Network Capacity in 2030

Region	Projected # of FCEVs in 2030[43]	Estimated # of FCEVs Stations Could Support in 2030	Additional # of FCEVs That Stations Could Support in 2030
Greater Los Angeles Area	16,400	71,700	55,300
San Francisco Bay Area	2600	44,100	41,500
Sacramento Area	700	7,400	6,700
San Diego Area	400	6,300	5,900
Rest of State	300	11,500	11,200
Total	20,400	141,000	120,600

Source: CEC

The regional analysis in this chapter evaluates all open retail stations, the planned stations under CEC solicitations with confirmed addresses, and planned stations that are privately funded with confirmed addresses. There are 20 stations without addresses with about 31,000 kg/day of capacities total, which could support about 44,000 FCEVs.

To confirm station addresses under GFO-19-602, in which station developers build stations in batches, developers must meet various milestones to prove location viability. There are 41 stations with addresses out of the 61 stations that the CEC expects to result from GFO-19-602, once fully funded. Those stations without confirmed addresses under GFO-19-602 are not part of this analysis.

To calculate the projections presented in Table 3 and Table 4, as well as Figures 11 through 13, staff used the daily station capacity as determined by the Hydrogen Station Capacity Evaluation (HySCapE) tool (or the stated nameplate capacity, if HySCapE results are not available). Then, staff used the assumption of 0.7 kilogram per day of hydrogen consumed per FCEV to convert the station nameplate capacity into the estimated number of FCEVs supported.

Figures 11 through 13 compare the estimated FCEV rollout to the estimated regional station deployment based solely on the network of 109 stations with known locations. The orange areas in Figures 11 through 13 show the range of FCEVs projected from auto manufacturer surveys, which include results from this year's survey and previous years' surveys. The upper part of the orange area mostly reflects previously projected number of FCEVs and may not

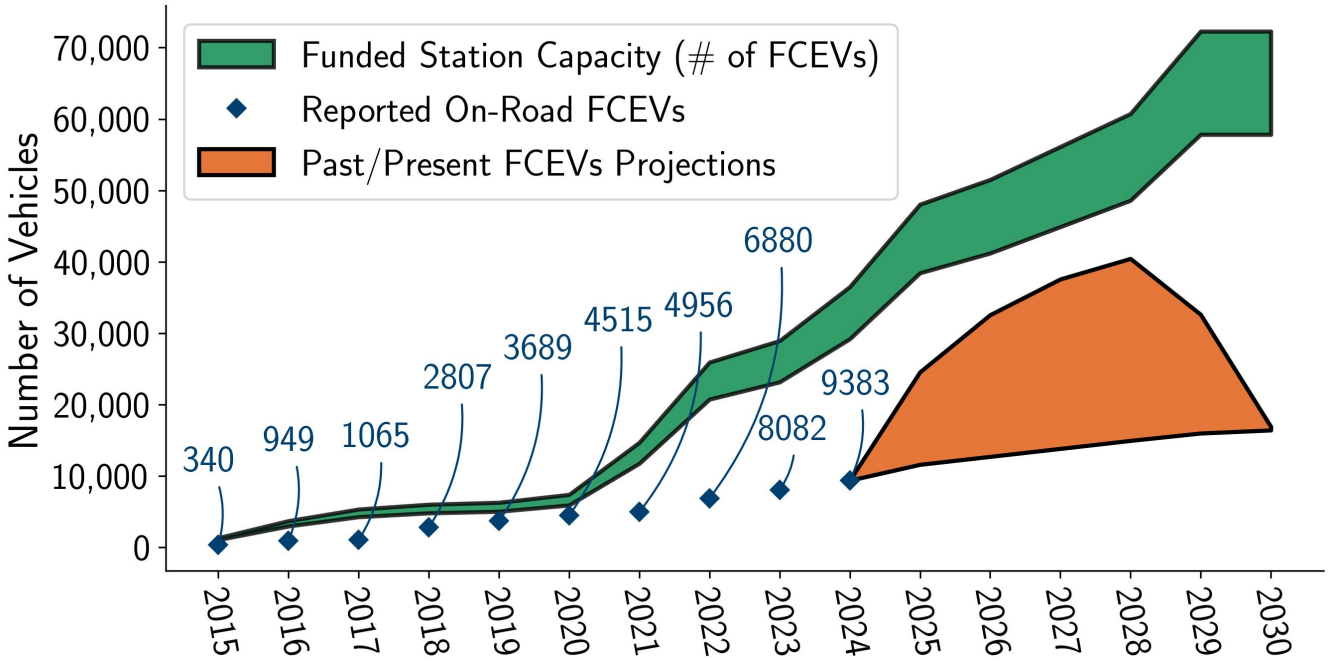
43 CARB assigned the proportion of projected vehicles (based on the auto manufacturers survey responses) to each county based on the proportion of network capacity among stations located within the county. This method assumed the regional distribution of FCEV deployment will closely follow the regional distribution of the fueling network.

represent the most recent auto manufacturers' reduced projected numbers of FCEVs. The green areas in the figures indicate the estimated number of FCEVs that could be supported by stations in each region.

The figures assume that stations will open according to station developers' timelines. The height of the green area represents the difference between using 100 percent of the station nameplate capacity to determine the number of FCEVs supported (the upper bound) and using 80 percent (the lower bound, representing a more sustainable level of fueling). The figures only include open retail stations and planned stations and do not count TNO stations or stations that are closed permanently. The regional nameplate capacity of each year was determined using the average nameplate capacity over the four quarters.

Figure 11 shows that the FCEV population in the Greater Los Angeles Area has largely followed capacity growth, increasing over time at a similar rate up until 2020. Subsequently, deploying additional stations has not resulted in an increased rate of FCEV adoption. The expected station capacity in the region has the potential to sustain projected FCEV deployment, with the ability to support 71,700 FCEVs by 2030.

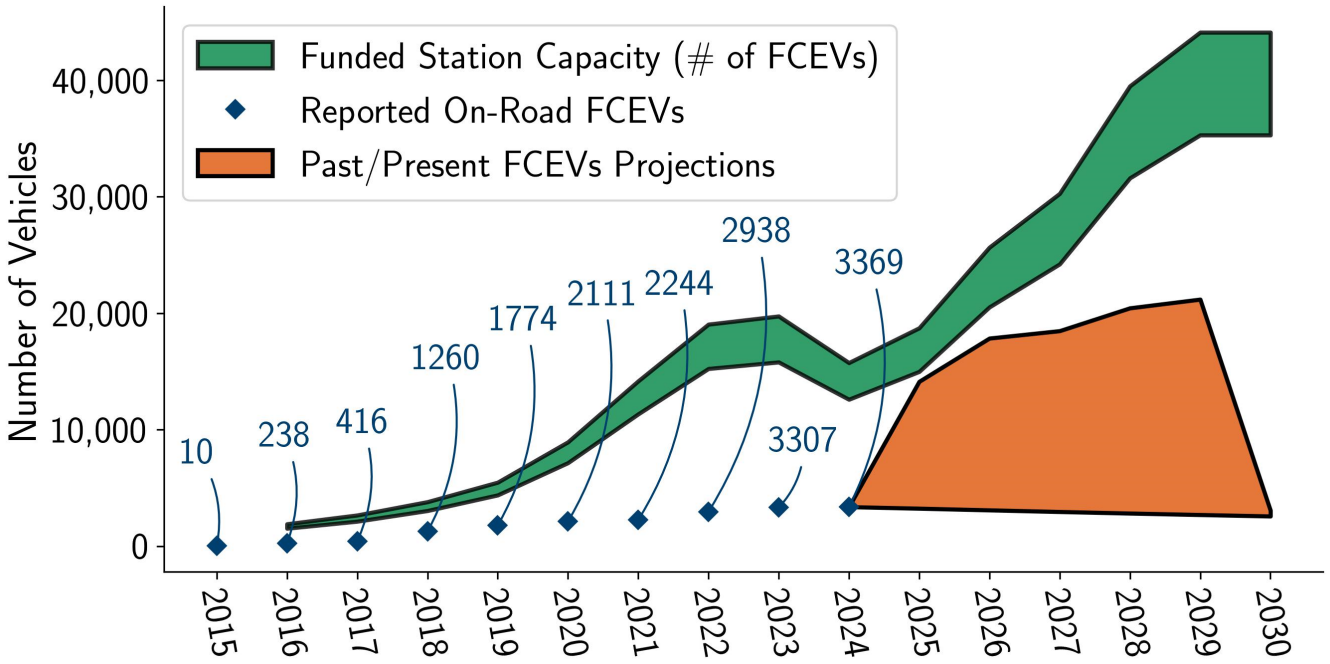
Figure 11: Greater Los Angeles Area Station Capacity and Number of Vehicles



Source: CEC

Figure 12 shows that the network capacity in the San Francisco Bay Area is maintaining an excess capacity to serve FCEVs, despite the permanent closing of three Shell stations in the area causing the dip in 2024, likely due to larger stations opening in the area. FCEV drivers in San Francisco continue to have to drive outside the city for fuel. A new station is anticipated to open in 2024 with a capacity of 808 kg/day to serve more than 1,100 FCEVs. The Bay Area should have capacity to serve at least 44,100 FCEVs by 2030. This number of FCEVs supported by the expected capacity is more than thirteenfold increase from today's 3,369 FCEVs on the road in the Bay Area.

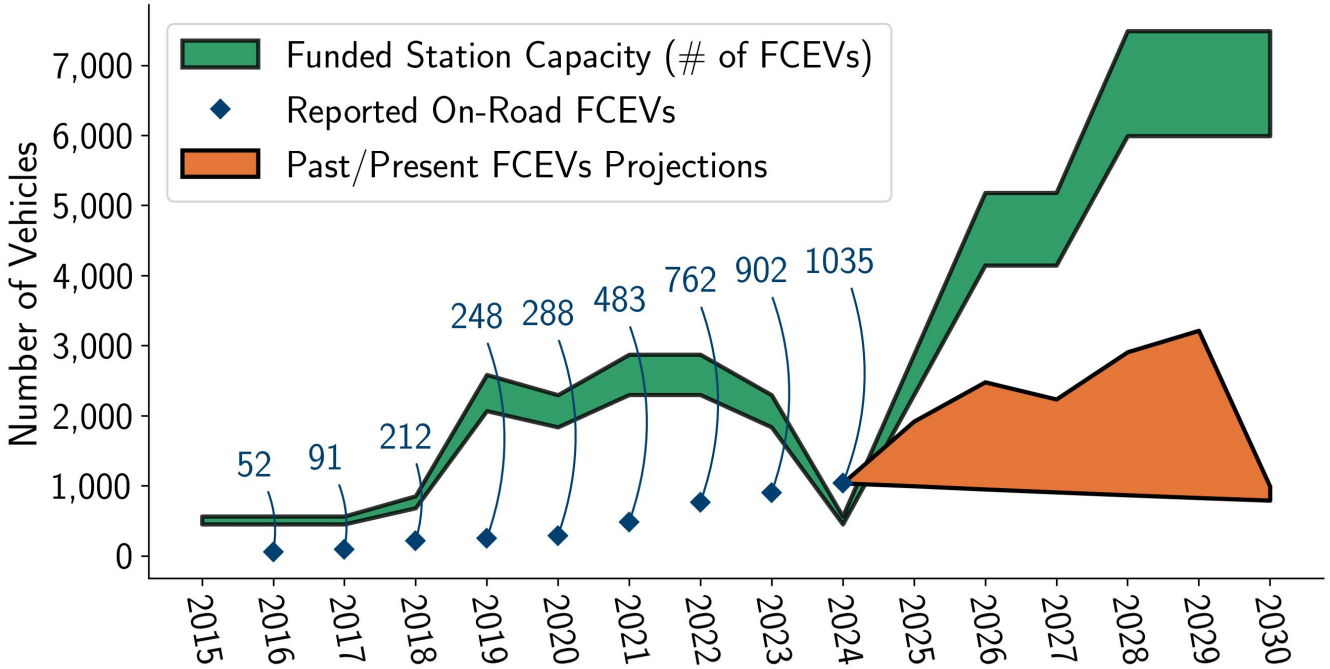
Figure 12: San Francisco Bay Area Station Capacity and Number of Vehicles



Source: CEC

As shown in Figure 13 and previously in Table 3, the current network capacity of the Sacramento Area is not enough to support existing FCEVs after the two Shell stations closed permanently in February 2024. Three new stations planned in the area are not expected until 2025, 2026, and 2028.

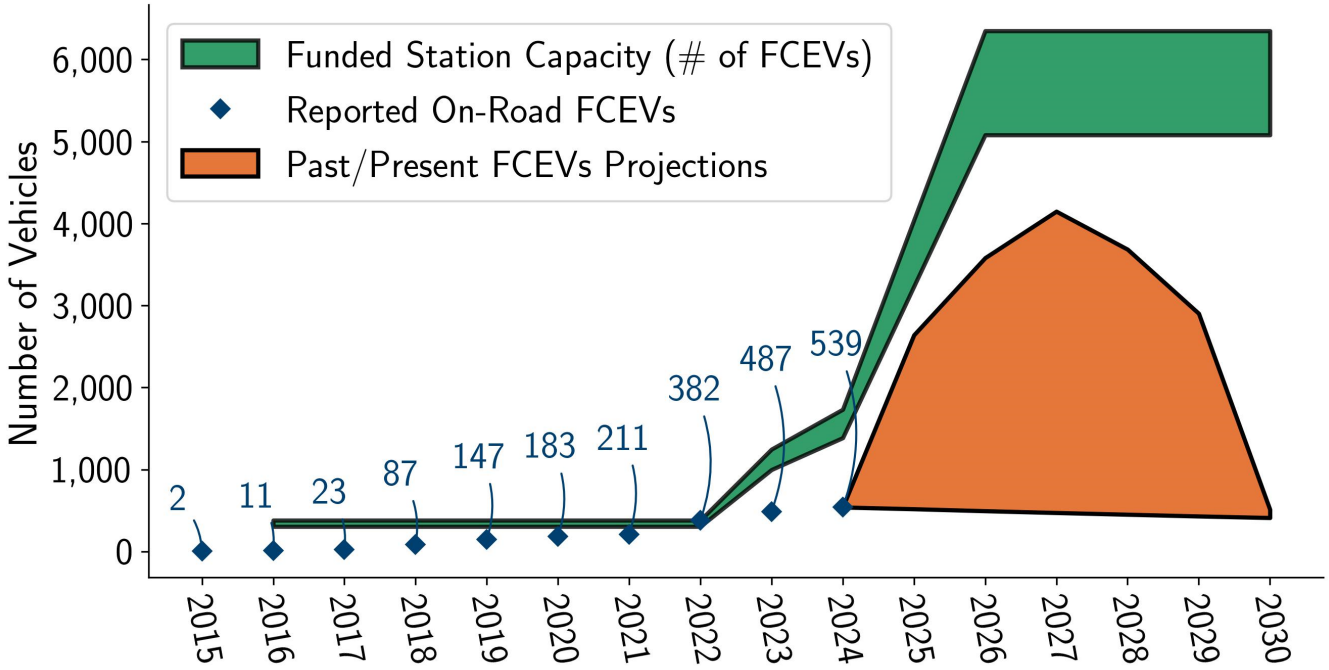
Figure 13: Sacramento Area Station Capacity and Number of Vehicles



Source: CEC

Figure 14 shows San Diego's network having sufficient capacity to serve existing FCEVs with a second station with 1,212 kg/day capacity that opened in May 2023. Two more stations are planned for the region in 2025 and 2026, adding a total of 3,232 kg/day in nameplate capacities that can support about 4,600 FCEVs in the area.

Figure 14: San Diego Area Station Capacity and Number of Vehicles



Source: CEC

FCEVs and Stations in Other Countries

For FCEVs and hydrogen infrastructure to scale and reduce costs, investments must be made globally. CEC staff asked representatives of national governments and organizations[44] about the investments from their governments in hydrogen refueling infrastructure, station development numbers, and FCEV population. This section presents the findings of the countries making the largest investments: China, Germany, Japan, and the Republic of Korea (South Korea).

Table 5 summarizes the registered passenger vehicles and other nonpassenger vehicles (including buses, commercial vehicles, and trucks) in China, Germany, Japan, and South Korea in comparison with California. Table 6 summarizes the number of open hydrogen refueling stations (light-, medium-, and heavy-duty combined) in these countries. Although the vehicle population in these countries increased since last reported in the 2023 AB 8 Joint Report (with the exception of China), the number of open stations has decreased in all of the countries. South Korea has a significant lead on the number of passenger FCEVs (34,973), while China has the largest nonpassenger FCEV fleet.

44 CEC staff communicated via email in July, August, and September 2024 with representatives of national government agencies and organizations in China, Germany, Japan, and South Korea.

Table 5: Registered FCEVs in California and Other Countries

Country	Passenger FCEV	Nonpassenger FCEV (buses, commercial vehicles, and trucks)	Total
California	14,529	203	14,732
China	509	9,289	9,798
Germany	2,212	231	2,443
Japan	8,230	129	8,359
South Korea	34,973	1,014	35,987

Source: CEC

Table 6: Open Hydrogen Stations in California and Other Countries

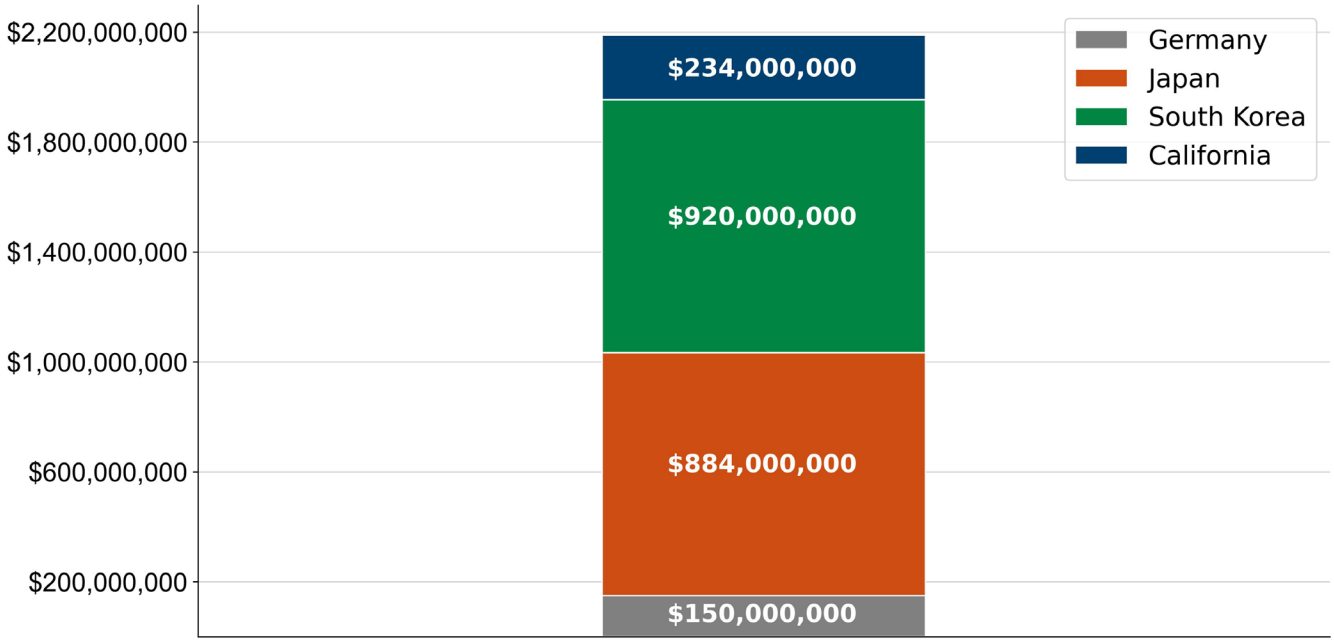
Country	Hydrogen Stations
California	62
China	274
Germany	86
Japan	151
South Korea	192

Source: CEC

Based on responses CEC staff received about government funding for hydrogen refueling infrastructure, the cumulative investment made by Germany, Japan, South Korea and California through 2023 is around $2.19 billion. This total includes about $150 million for Germany, about $884 million for Japan, and about $920 million for South Korea.[45] The responses did not include any information on funding in China. The breakdown per country is shown in Figure 15. Figure 16 shows the cumulative investments per capita through 2023 made by these countries. On a per capita basis, California ranks third after South Korea and Japan in terms of government funding for public hydrogen stations.

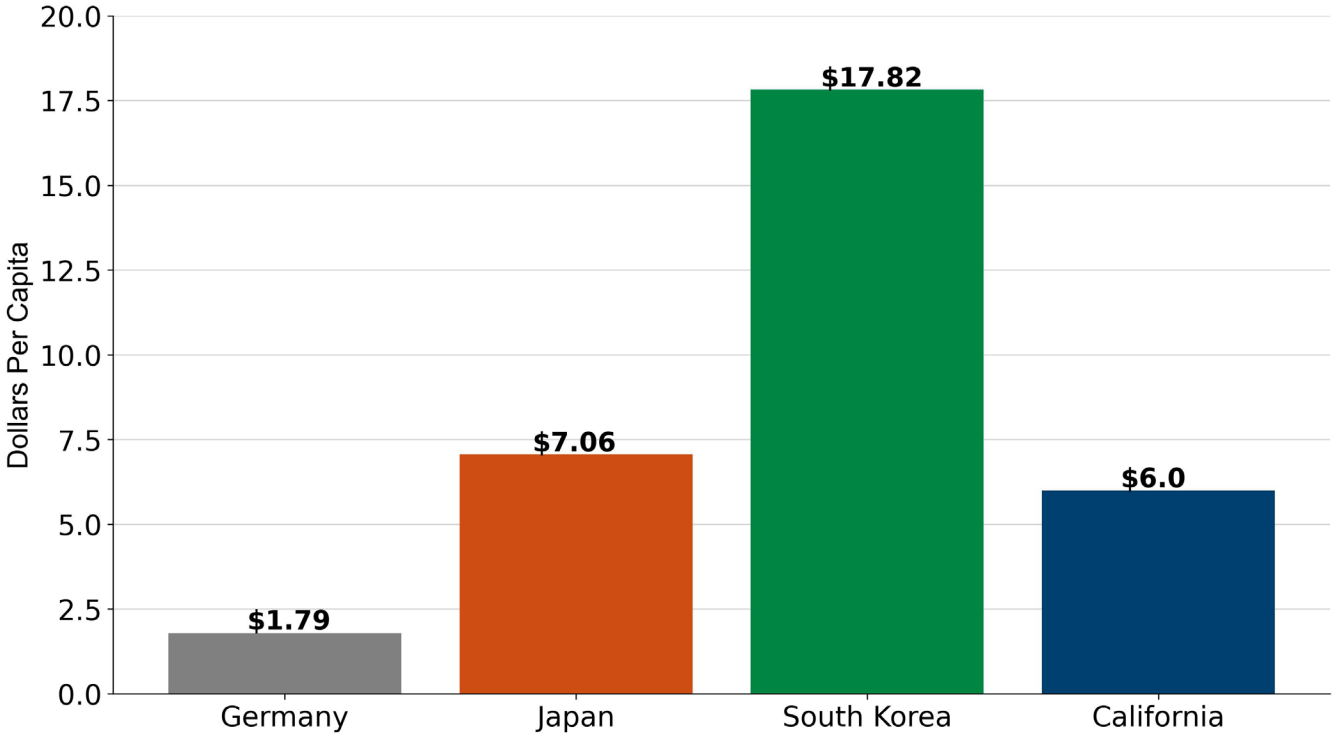
45 The funding amounts were converted in the U.S. dollar using currency conversion rates in September 2024. The conversion rates fluctuate over time and can affect the numbers significantly year to year.

Figure 15: Cumulative Hydrogen Refueling Infrastructure Investments Through 2023 by Germany, Japan, South Korea and California



Source: CEC

Figure 16: Cumulative Investments per Capita Through 2023 by Germany, Japan, South Korea, and California



Source: CEC

Continued global efforts in vehicle and station deployment will help bring down the costs of technologies and build robust supply chains.

CHAPTER 6:
Remaining Cost and Time Required to Establish a Sufficient Network of Hydrogen Refueling Stations

This chapter focuses on the remaining cost and time required to establish a sufficient network of hydrogen refueling stations.

Overall, the CEC's Clean Transportation Program has allocated nearly $234 million through Fiscal Year 2023–2024. This amount is lower than what was reported in the 2023 AB 8 Joint Report because it reflects the amount in the cancelled agreement and declined award.

Of the $234 million, the CEC has awarded about $211 million so far to support 90 stations funded by solicitations. The $211 million includes two awards made in May 2024 for operations and maintenance of existing hydrogen stations.

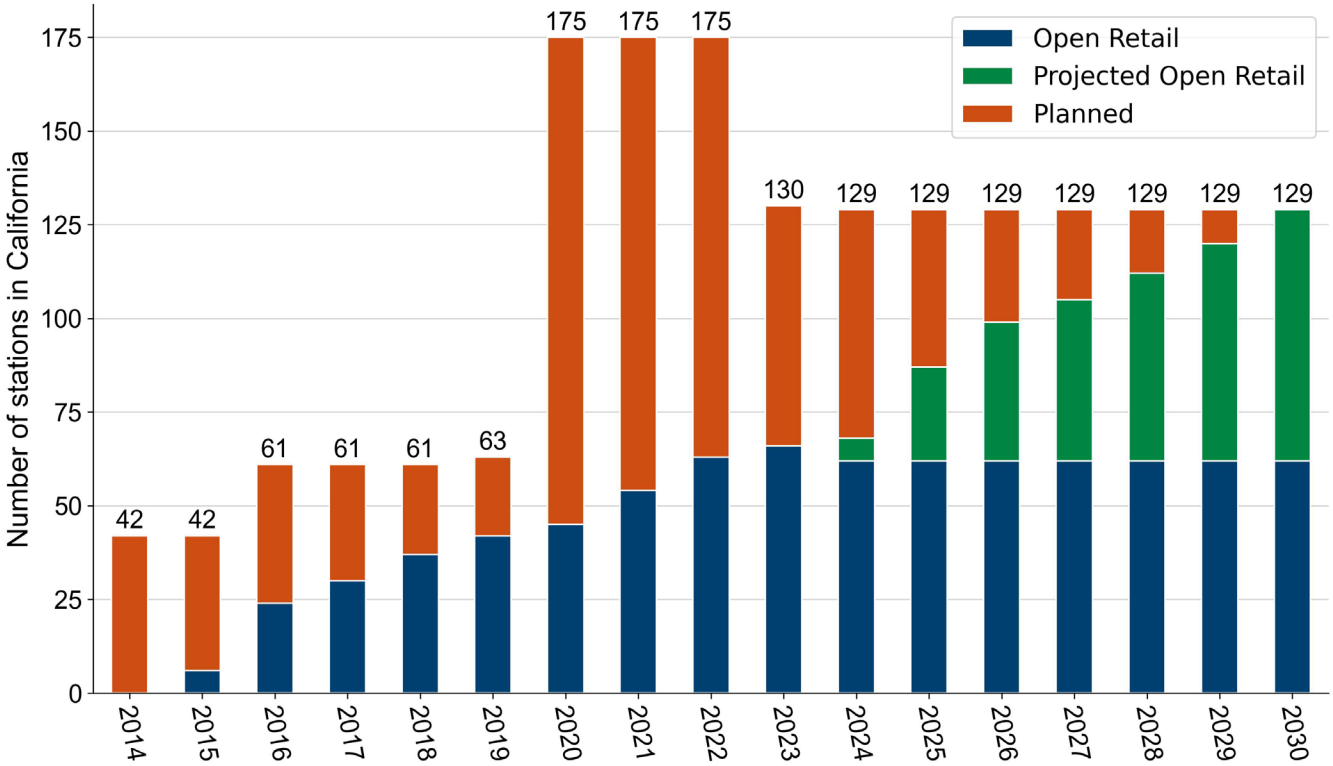
Private investment has included nearly $135 million committed to match public-sector funding to date, and grant recipients will have committed more than $30 million in additional match funding for the remaining stations funded under GFO-19-602, making the total private investment about $165 million. The total reported public and private investment in hydrogen refueling stations is nearly $420 million. This figure is lower than the actual investment because the private investment in privately funded stations is not included.

With the 129 stations funded by the combined spent and committed funds, the state has allocated sufficient funds to meet and exceed the former 100-station goal set by AB 8. However, the 100-station goal was removed in AB 126.

Figure 17 shows the total estimated stations resulting from the Clean Transportation Program (including $5 million from the Volkswagen Mitigation Trust Fund[46] allocated to GFO-19-602) and private investments. The total estimated stations include 16 stations included in a CEC agreement with FirstElement Fuel funded fully by match share, 7 privately funded stations by Iwatani Corporation of America, 1 station at the Sunline Transit Agency station that offers light-duty fueling, and 1 station at the Port of Oakland that offers light-duty fueling. Based on the most recent station development schedules shared by station developers, all 129 stations are estimated to be open retail by 2030.

46 Funding from the Volkswagen Environmental Mitigation Trust is the result of a settlement agreement among Volkswagen Group of America, Inc., the United States Environmental Protection Agency, and CARB following VW's admission that they used illegal software "defeat devices" in certain 2.0-liter and 3.0-liter diesel passenger vehicles sold in the United States and California. https://ww2.arb.ca.gov/our-work/programs/volkswagen-environmental-mitigation-trust-california.

Figure 17 18: Open Retail, Projected Open Retail, and Planned Hydrogen Refueling Stations by Year



Source: CEC

The projected number of FCEVs has significantly reduced this year, and the fueling capacity of the planned 129-station network is more than sufficient if just comparing the networkwide fuel demand and supply. The 2024 Annual Evaluation does not have quantitative analysis of a sufficient network, but future annual evaluations and AB 126 joint reports will likely include a quantitative and or geographical analysis of a sufficient network.

The industry has been leaning toward having multiuse stations that can fuel light-duty, medium-duty, and heavy-duty vehicles instead of having just light-duty-only stations. Based on market conditions and light-duty FCEV uptake, it may be prudent to focus state funds on multiuse stations that can support light-duty FCEVs as well as heavier vehicles or a more concerted effort toward the medium- and heavy-duty segment. This focus of state funds on multiuse stations would allow time for the funded light-duty stations under GFO-19-602, GFO-22-607, and new stations that will be funded under GFO-24-601 to advance.

Based on the funding amounts for recently funded multiuse stations under GFO-22-607, staff assumed that the cost to the state to build one multiuse station is $3 million. Also based on the schedules that these CEC-funded multiuse stations are following, staff assumed that the time required to build a multiuse station is two years. AB 126 requires that the CEC allocates no less than 15 percent of the funding appropriated by the Legislature from the Alternative and Renewable Fuel and Vehicle Technology Fund annually to support hydrogen vehicles. Assuming that the CEC receives $100 million annually and the entire 15 percent earmark is allocated to fund multiuse stations, the CEC would be able to fund five stations per year. This analysis also assumes that the CEC will continue to have $15 million available annually and

that 200 stations is the appropriate goal. The analysis further assumes no changes in the amount of funding that the industry needs from the state to develop stations.

Using all these assumptions, staff estimates that developing 71 more stations will cost about $213 million and take 14.2 years.

Table 7: Remaining Cost and Time Required to Develop 200 Hydrogen Refueling Stations to Support Light-Duty FCEV

Number of Stations Needed*	Cost Required	Time Required
71	$213 million	14.2 years

Source: CEC

*** The network size of 200 stations may not be needed to support the number of current and projected light-duty FCEVs.**

As noted earlier 62 stations have achieved open retail status and an additional 67 stations under development. Further details on the 67 stations that are in various stages of development are as follows:

- GFO-19-602 stations:
    - One station is under development.
    - Eleven stations are paused.
    - Thirty-nine stations are pending for future batches.
- GFO-22-607 stations:
    - Two stations are under development.
- Iwatani private stations:
    - Two stations are under development.
- Stations funded before GFO-19-602:
    - Two stations are under development.
- Other privately funded stations:
    - Nine stations are approved with addresses by the LCFS HRI program.
    - One station is under development by Sunline Transit Agency using match funding for a CEC agreement.

Given inflation, supply chain challenges, and uncertainty around future fuel demand from light-duty FCEVs, supportive policies beyond CEC funding is important to support the hydrogen

refueling station network, including the CARB LCFS HRI. Seventy-one stations have been approved to generate LCFS credits through the HRI provision.[47]

47 California Air Resources Board. "LCFS ZEV Infrastructure Crediting — Approved HRI and FCI Applications." Accessed November 4, 2024, https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting.

CHAPTER 7: Conclusions

California has allocated nearly $234 million to hydrogen infrastructure with 129 hydrogen refueling stations expected by 2030. The allocation and the number of stations expected are different from what were reported last year. The changes reflect one grant applicant declining a proposed award and Shell's permanent closure of seven open-retail stations and cancellation of a $41 million grant agreement, and the addition of several privately funded stations.

California has 42 stations that are serving the public, with an additional 20 stations that are considered TNO, a total of 62 stations, as of November 4, 2024. These stations, when operating at capacity, have excess fueling capacity that is nearly quadruple today's demand needed by the 14,415 FCEVs in California. The hydrogen station network nameplate fueling capacity of today would also be sufficient to meet the 2027 projected fuel demand of 18,400 FCEVs and the 2030 projected fuel demand of 20,500 FCEVs as reported in CARB's 2024 Annual Evaluation. However, the reliability and availability of the hydrogen refueling network is an issue; 20 of the 62 open retail stations are TNO and have not been operating for more than 30 days, many for more than a year.

Other stations have downtime periodically because of maintenance, equipment failures, and hydrogen supply issues. According to CARB staff, the network of open retail stations has operated at around 62 percent of capacity on average from the third quarter of 2023 to the second quarter of 2024 (including TNO stations as 0 percent). When considering this availability percentage, the network of open retail stations can support about 36,000 FCEVs. Thus, these excess capacities appear exaggerated when many stations are unreliable and unavailable in reality.

The current coverage decreased significantly in the Sacramento Area and in San Francisco due to Shell closing stations permanently, leaving only one station in the Sacramento Area and no station within San Francisco. The fueling capacity in the Sacramento Area is not sufficient to support existing FCEVs in the area. Investments made by the private sector and GFO-24-601 should increase the locations of hydrogen refueling stations across California and continue to expand the coverage needed by FCEVs drivers.

The CEC and CARB have reported about barriers that are affecting the customer experience in the past few years, and these barriers continue to exist. These barriers include high hydrogen prices and station downtime due to equipment failures, supply chain constraints, and hydrogen fuel supply issues. Addressing these barriers and improving station reliability and availability are critical to helping support existing FCEV drivers.

This year, the projected number of FCEVs has reduced significantly. The projected FCEV population of 20,500 by 2030 (compared to the previous projected 62,600 FCEVs by 2029) is not much more than the current estimated on-road population of 14,415. There are many factors affecting FCEV projections.

At the May 2024 business meeting, the CEC approved operations and maintenance grants totaling $9.4 million to two station operators to improve the reliability of 45 open retail stations. More CEC-funded renewable hydrogen production plants are expected to come on-line in the next few years. Also, ARCHES plans more than 10 production project sites with hundreds of metric tons per day of clean hydrogen produced with renewable electricity and biogenic sources. These new efforts should help ease fuel supply disruption issues and potentially reduce the price of hydrogen in the transportation sector.

About 71 percent of California's residents who live in disadvantaged communities are within a 15-minute drive time of an open retail or planned hydrogen station. This percentage is similar to 65 percent of the general statewide population being in the same drive distance to a station. However, the CEC and CARB will continue to explore options to expand hydrogen refueling network benefits to as many disadvantaged communities as possible because rural disadvantaged communities and disadvantaged communities with lower population density tend to be farther than a 15-minute driving distance to any hydrogen refueling station. These numbers could increase as addresses for stations in future batches funded under GFO-19-602 are announced and with new stations that will be funded under GFO-24-601, which requires at least 50 percent of new stations be in disadvantaged communities.

Along with California, other governments, specifically China, Germany, Japan, and South Korea, are making investments in hydrogen refueling stations and vehicles. Together, California and these four countries have more than 600 open hydrogen refueling stations, including light-, medium-, and heavy-duty hydrogen refueling stations, and have deployed nearly 60,000 light-duty FCEVs and more than 10,000 buses, commercial vehicles, and medium- and heavy-duty FCEVs.

Station development time continued to suffer this year. Many stations in development are on pause until station developers secure more private funding to cover increased costs due to global inflation and until the LCFS program is amended in hopes of the LCFS credit price recovering. CARB approved the LCFS amendments November 8, 2024, and they are expected to be in effect in early 2025.

To overcome the recent hurdles that the hydrogen refueling infrastructure network faced, California continues to provide support for hydrogen refueling infrastructure by providing the reliable coverage and the capacity to support light-, medium-, and heavy-duty FCEVs. CEC and CARB staffs' joint evaluation of the FCEV market will continue to guide future funding decisions, including assessing an appropriate funding amount per station given inflation and uncertainty around the future fuel demand from light-duty FCEVs.

GLOSSARY

Term	Definition
American Institute of Chemical Engineers (AIChE)	A global organization of chemical engineers
Authority having jurisdiction (AHJ)	An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.
California Hydrogen Infrastructure Tool (CHIT)	A geographical information system-based tool developed using ArcGIS software to assess the spatial distribution of the gaps between the coverage and capacity provided by existing and planned stations and the potential first adopter market for fuel cell electric vehicles.
Disadvantaged community	Defined by Health and Safety Code 39711 as the most burdened census tracts in California. Burden scoring is determined by 20 pollution/health and socioeconomic factors.
Electrolyzer	A system or device that uses an electrochemical process that splits water into hydrogen and oxygen.
Energy Research and Development Division (ERDD)	A division within the California Energy Commission. ERDD helps California meet its energy and greenhouse gas reduction goals by investing in cutting-edge research.
Fuel cell electric vehicle	A zero-emission vehicle that runs on compressed hydrogen fed into a fuel cell "stack" that produces electricity to power the vehicle.
Greater Los Angeles Area	The counties of Los Angeles, Orange, Riverside, San Bernardino, and Ventura.
Hydrogen Refueling Infrastructure (HRI) credits	Low Carbon Fuel Standard (LCFS) credits that allow eligible hydrogen stations to generate infrastructure credits based on the capacity of the station minus the quantity of dispensed fuel.

Hydrogen Station Capacity Evaluation model (HySCapE)	A tool for verifying the dispensing capacity of a hydrogen refueling station, based on the Chevron profile. CARB uses HySCapE to verify station capacity for the LCFS HRI program, and the CEC used it to verify station capacity under GFO-19-602.
Hydrogen Station Equipment Performance (HyStEP)	A device that tests the ability of hydrogen refueling stations to adhere to the fueling protocols of the industry-adopted SAE J2601 standard.
Low Carbon Fuel Standard (LCFS)	Standard developed by CARB to reduce the carbon intensity of transportation fuel used in California.
Metric ton (MT)	A unit of mass and defined as 1,000 kilograms.
Nameplate capacity	Rated capacity, nominal capacity, installed capacity, or maximum effect, is the intended full-load sustained output of a hydrogen refueling station.
Sacramento Area	The counties of El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba.
San Diego Area	The area of San Diego County.
San Francisco Bay Area	The counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma.
Station Operational Status System (SOSS)	A customer-facing mobile app to report hydrogen station operational status information consistently and reliably to FCEV customers.
Steam methane reformation (SMR)	A process in which methane molecules are split to extract the hydrogen and carbon dioxide is released into the atmosphere.
Temporarily nonoperational (TNO)	A hydrogen refueling station that has previously achieved open retail status but has been unavailable for customer fueling for a period greater than 30 days for various reasons. A TNO station is expected to become available for customer fueling again in the future.

Utilization	The ratio of fuel throughput to the nameplate capacity of the station or the network of stations.
Zero-emission vehicle (ZEV)	A vehicle that emits no exhaust gas from the onboard source of power.

APPENDIX A:
Hydrogen Refueling Stations in California

Table A-1 lists the 62 open retail hydrogen refueling stations (42 stations available for customer fueling and 20 TNO stations) with street addresses and open retail dates. Table A-2 lists the stations in the process of becoming open retail. These lists include Clean Transportation Program-funded and privately funded stations. Real-time status is available to drivers via the Station Operational Status System, maintained by the Hydrogen Fuel Cell Partnership.[48]

Table A-1: Open Retail and Temporarily Nonoperational Stations

Station Address (A to Z by city)	Open Retail Date
2618 La Paz Road, Aliso Viejo, CA 92656	6/22/2021
3731 East La Palma Avenue, Anaheim, CA 92806	11/29/2016
1100 North Euclid Street, Anaheim, CA 92801	4/24/2023
14477 Merced Avenue, Baldwin Park, CA 91706	2/7/2022
800 North Hollywood Way, Burbank, CA 91505	8/20/2022
337 E. Hamilton Avenue, Campbell, CA 95008	5/24/2021
2855 Winchester Boulevard, Campbell, CA 95008	6/9/2016
24505 West Dorris Avenue, Coalinga, CA 93210	12/11/2015
605 Contra Costa Boulevard, Concord, CA 94523	5/28/2021
616 Paseo Grande, Corona, CA 92882	1/19/2024
2995 Bristol Street, Costa Mesa, CA 92626	12/29/2021
2050 Harbor Boulevard, Costa Mesa, CA 92627	1/21/2016
21530 Stevens Creek Boulevard, Cupertino, CA 95014	4/6/2022
21865 East Copley Drive, Diamond Bar, CA 91765	8/18/2015
1172 45th Street, Emeryville, CA 94608	11/19/2018
18480 Brookhurst Street, Fountain Valley, CA 92708	7/6/2020
41700 Grimmer Boulevard, Fremont, CA 94538	9/7/2017
391 West A Street, Hayward, CA 94541	4/27/2016
11807 East Carson Street, Hawaiian Gardens, CA 90716	3/21/2022
19172 Jamboree Road, Irvine, CA 92612	11/12/2015
550 Foothill Boulevard, La Cañada Flintridge, CA 91011	1/25/2016
20731 Lake Forest Drive, Lake Forest, CA 92630	3/18/2016
15606 Inglewood Avenue, Lawndale, CA 90260	6/22/2017
3401 Long Beach Boulevard, Long Beach, CA 90807	2/22/2016
10400 Aviation Boulevard, Los Angeles, CA 90045	12/21/2018

48 Hydrogen Fuel Cell Partnership. Station Operational Status System, https://m.h2fcp.org.

Station Address (A to Z by city)	Open Retail Date
5151 State University Drive, Los Angeles, CA 90032	11/20/2019
5700 Hollywood Boulevard, Los Angeles, CA 90028	11/10/2016
7751 Beverly Boulevard, Los Angeles, CA 90036	5/2/2016
8126 Lincoln Boulevard, Los Angeles, CA 90045	8/18/2016
570 Redwood Highway, Mill Valley, CA 94941	6/16/2016
15544 San Fernando Mission Boulevard, Mission Hills, CA 91345	10/26/2020
830 Leong Drive, Mountain View, CA 94043	2/28/2018
2450 Engineer Road, Oakland, CA 94607	7/3/2024
4280 Foothill Boulevard, Oakland, CA 94601	10/18/2023
350 Grand Avenue, Oakland, CA 94610	9/20/2019
1850 E. Holt Boulevard, Ontario, CA 91761	4/24/2018
615 South Tustin Street, Orange, CA 92866	3/23/2022
3601 El Camino Real, Palo Alto, CA 94306	12/20/2018
475 North Allen Avenue, Pasadena, CA 91106	12/16/2022
313 West Orangethorpe Avenue, Placentia, CA 92870	5/7/2021
8095 Lincoln Avenue, Riverside, CA 92504	3/8/2017
3060 Carmel Valley Road, San Diego, CA 92130	12/2/2016
5494 Mission Center Road, San Diego, CA 92108	5/9/2023
2101 North First Street, San Jose, CA 95131	1/15/2016
3939 Snell Avenue, San Jose, CA 95136	5/27/2022
26572 Junipero Serra Road, San Juan Capistrano, CA 92675	12/23/2015
4475 Norris Canyon Road, San Ramon, CA 94583	7/26/2017
2120 East McFadden Avenue, Santa Ana, CA 92705	1/19/2024
150 South La Cumbre Road, Santa Barbara, CA 93105	4/9/2016
1819 Cloverfield Boulevard, Santa Monica, CA 90404	2/1/2016
12600 Saratoga Avenue, Saratoga, CA 95070	3/14/2016
13980 Seal Beach Boulevard, Seal Beach, CA 90740	10/3/2022
14478 Ventura Boulevard, Sherman Oaks, CA 91423	12/2/2021
1200 Fair Oaks Avenue, South Pasadena, CA 91030	4/10/2017
248 South Airport Boulevard, South San Francisco, CA 94080	2/12/2016
3780 Cahuenga Boulevard, Studio City, CA 91604	4/26/2021
1296 Sunnyvale Saratoga Road, Sunnyvale, CA 94087	2/11/2021
3102 Thousand Oaks Boulevard, Thousand Oaks, CA 91362	3/30/2018
2051 West 190th Street, Torrance, CA 90501	8/18/2017
12105 Donner Pass Road, Truckee, CA 96161	6/17/2016
1515 South River Road, West Sacramento, CA 95691	7/7/2015
5314 Topanga Canyon Road, Woodland Hills, CA 91364	10/5/2016

Source: CEC

Table A-2 lists the locations of stations that are under development. The stations are listed in alphabetical order by city. If the station received Clean Transportation Program funding, the CEC solicitation or contract under which the station received funding is provided.

Table A-2: Stations Under Development

Station Address (A to Z by city)	Solicitation or Contract
2413 A Street, Antioch, CA 94509	Privately Funded
325 Luis Estrada Road, Beaumont, CA 92223	Privately Funded
9409 Alondra Boulevard, Bellflower, CA 90706	GFO-19-602
6392 Beach Boulevard, Buena Park, CA 90621	GFO-19-602
2911 Petit Street, Camarillo, CA 93012	GFO-19-602
111 East Victoria Street, Carson, CA 90746	Privately Funded
3260 Chino Avenue, Chino Hills, CA 91709	Privately Funded
3160 Carlson Boulevard, El Cerrito, CA 94530	GFO-19-602
2595 North Texas Street, Fairfield, CA 94533	GFO-19-602
16880 Slover Avenue, Fontana, CA 92337	GFO-19-602
47700 Warm Springs Boulevard, Fremont, CA 94539	GFO-19-602
4163 South Chestnut Avenue, Fresno, CA 93725	GFO-19-602
Northwest Corner of Carol Drive and Amador Avenue, Galt, CA 95632	GFO-22-607
24209 West Whitesbridge Avenue, Kerman, CA 93630	Privately Funded
33252 Hubert Way, Kettleman City, CA 93239	GFO-22-607
5500 South Street, Lakewood, CA 90713	GFO-19-602
13550 South Beach Boulevard, La Mirada, CA 90638	Privately Funded
43144 10th Street West, Lancaster, CA 93534	Privately Funded
7810 National Drive, Livermore, CA 94550	GFO-19-602
988 North San Antonio Road, Los Altos, CA 94022	GFO-19-602
10867 Santa Monica Boulevard, Los Angeles, CA 90025	GFO-19-602
666 North Santa Cruz Avenue, Los Gatos, CA 95030	GFO-19-602
4785 Bailey Loop, McClellan Park, CA 95652	GFO-19-602
12520 Graham Street, Moreno Valley, CA 92553	GFO-19-602
12431 Heacock Street, Moreno Valley, CA 92553	Privately Funded
2160 South Euclid Avenue, Ontario, CA 91762	GFO-19-602
67 Moraga Way, Orinda, CA 94563	GFO-19-602
East Vista Chino & North Gene Autry Trail, Palm Springs, CA 92262	GFO-19-602
796 Ramona Expressway, Perris, CA 92571	Privately Funded
503 Whipple Avenue, Redwood City, CA 94063	GFO-15-605
3505 Central Avenue, Riverside, CA 92506	GFO-19-602
939 San Gabriel Boulevard, Rosemead, CA 91770	GFO-19-602
1930 South Waterman Avenue, San Bernardino, CA 92408	GFO-19-602

Station Address (A to Z by city)	Solicitation or Contract
11030 Rancho Carmel Drive, San Diego, CA 92128	GFO-19-602
1832 West Washington Street, San Diego, CA 92103	GFO-19-602
510 East Santa Clara Street, San Jose, CA 95112	GFO-19-602
1898 North Capitol Avenue, San Jose, CA 95132	GFO-19-602
1331 Redmond Avenue, San Jose, CA 95120	GFO-19-602
3707 Union Avenue, San Jose, CA 95124	GFO-19-602
32505 Harry Oliver Trail, Thousand Palms, CA 92276	Privately Funded
24505 Hawthorne Boulevard, Torrance, CA 90505	GFO-19-602
14244 Newport Avenue, Tustin, CA 92780	GFO-19-602
299 Orange Drive, Vacaville, CA 95687	Privately Funded
10 Sage Street, Vallejo, CA 94589	GFO-19-602
2121 Harbor Boulevard, Ventura, CA 93001	GFO-19-602
4900 West Capitol Avenue, West Sacramento, CA 95691	Privately Funded
17287 Skyline Boulevard, Woodside, CA 94062	PON-13-607

Source: CEC

APPENDIX B:
Changes in the Planned Network

Since 2017, the planned network changed because of new funding solicitations, station replacements, stations that did not reach completion, and station closures. Table B-1 shows the changes in the planned network resulting from CEC agreements funded by the Clean Transportation Program and the associated number of FCEVs that could be supported. The 50 stations shown in the first row for 2017 were funded under solicitations and contracts before GFO-15-605, GFO-19-602, and GFO-22-607.

Table B-1: Changes in the Planned Station Network Since 2017

Year	Reasons for Changes	Number of Planned Stations	Number of FCEVs That Could Be Supported
2017	Clean Transportation Program provided Operations and Maintenance funds to CARB-funded CSULA station (60 kg/day), so the station was added to the collection of Clean Transportation Program-funded stations.	50	13,000
2017	The stations planned for Encinitas (180 kg/day), Foster City (350 kg/day), and Los Altos (350 kg/day) were canceled because of lack of clear path to completion, and they were removed from the list of Clean Transportation Program-funded stations.	47	12,000
2017	Sixteen new stations were approved under GFO-15-605 (5,180 kg/day) and added to the list of Clean Transportation Program-funded stations.	63	20,000
2017	Three HyGen Industries stations (130 kg/day each) were addressed at the October 2017 CEC Business Meeting and removed from the list of Clean Transportation Program-funded stations.	60	19,000
2017	Five additional stations (1,600 kg/day) were proposed for funding under GFO-15-605 and added to the list of Clean Transportation Program-funded stations.	65	21,000

Year	Reasons for Changes	Number of Planned Stations	Number of FCEVs That Could Be Supported
2018	FirstElement upgraded 12 stations from 310 kg/day to 500 kg/day liquid technology (+2,280 kg), and the Air Liquide Anaheim station capacity was adjusted in reporting from 100 kg to 180 kg to reflect more realistic operations.	65	25,000
2018	One of the five additional stations proposed for funding under GFO-15-605 did not move forward (360 kg/day) and was removed from the list of Clean Transportation Program-funded stations.	64	24,000
2019	Mobile refueler project (45 kg/day) and Santa Nella (180 kg/day) station ended without completion and were removed from the list of Clean Transportation Program-funded stations.	62	24,000
2019	Station capacities were updated with the numbers reported to the CARB LCFS HRI credit program.	62	35,000
2020	Two more stations (Concord and Redwood City) were approved for HRI credits and station capacities were updated, each using the numbers reported to the HRI credit program. (+1,400 kg/day)	62	37,000
2020	West Los Angeles station (180 kg/day) closed. The station operator lost lease because of redevelopment plans for the site.	61	36,000
2020	Thirty new stations were approved at the CEC business meeting in December. One of these stations is an upgrade to the station in Torrance.	90	98,000
2021	The station capacities were adjusted using the latest LCFS HRI approved capacities.	90	101,000
2022	Rancho Palos Verdes (180 kg/day) and Santa Clarita (180 kg/day) stations were canceled because the sites became unviable.	88	100,000
2022	Culver City (1,616 kg/day) station was canceled because of issues in obtaining site control.	87	98,000

Year	Reasons for Changes	Number of Planned Stations	Number of FCEVs That Could Be Supported
2022	Seven GFO-15-605 station capacities were adjusted from 1,616 kg per day to 1,212 kg/day because of an error in last year's reporting of the number of fueling positions each station contained.	87	94,000
2022	Seven privately funded Iwatani stations that are outside a CEC agreement were added to the total planned station count.	94	102,000
2022	Laguna Beach (808 kg/day) station was canceled because of issues in permitting.	93	101,000
2022	Six GFO-19-602 Iwatani Batch 2 stations were approved. (Locations to be determined, but two of six are planned to be upgrades of existing stations.)	97	110,000
2023	Fourteen GFO-19-602 FirstElement Fuel Batch 2 stations were approved.	111	142,000
2023	Two new stations were approved under GFO-22-607 at the CEC Business Meeting in August 2023.	113	147,000
2023	Seven Shell stations and an upgrade to the Torrance station through GFO-19-602 were cancelled. All future batch stations proposed under the agreement were also cancelled.	106	139,000
2023	Chino (100 kg/day) station agreement expired. The station will not be completed.	105	139,000
2023	Twenty-five stations (21 GFO-19-602 future batch stations and 4 GFO-22-607 stations) are pending and not in CEC agreements yet.	130	188,000
2024	Seven existing Shell stations funded under GFO-15-605 closed.	123	183,000
2024	Burbank (100 kg/day) station agreement expired. The station will not be completed.	122	183,000
2024	One grant applicant that was proposed for an award to build four stations under GFO-22-607 declined.	118	180,000

Year	Reasons for Changes	Number of Planned Stations	Number of FCEVs That Could Be Supported
2024	One station located at the Port of Oakland was privately funded.	119	182,000
2024	Eight privately funded Chevron stations that are outside CEC agreement were added to the total planned station count.	127	194,000
2024	One privately funded H2B2 USA station that is outside CEC agreement was added to the total planned station count.	128	195,000
2024	One SunLine Transit station that is using match funding for a CEC agreement was added to the total planned station count.	129	195,000

Source: CEC

APPENDIX C:
Brief Updates on Medium- and Heavy-Duty Fuel Cell Electric Vehicle Deployment and Refueling Infrastructure

SB 643 staff reports are published every three years.[49] The first report was published in January 2024,[50] and the next report will be published in 2026. Meanwhile, the AB 126 joint reports will include brief updates on medium- and heavy-duty fuel cell electric vehicle deployment and refueling infrastructure.

With ARCHES being awarded by the U.S. DOE, California expects to have more than 60 hydrogen fueling stations that will serve more than 5,000 Class 6-8 trucks and 1,000 fuel cell electric buses as a result of ARCHES' project. More than 13 regional transit agencies have partnered with ARCHES.[51] While the partnering transit agencies have not been publicly disclosed yet, there are transit agencies that have refueling infrastructure on-site, including Orange County Transit, Sunline Transit, AC Transit, Golden Empire Transit, and others that have been awarded funding for infrastructure. According to a voluntary survey issued by CEC staff in July 2024, an additional 10 transit agencies plan to install refueling infrastructure for new fuel cell electric buses, some of which have already been ordered. Funding sources for this infrastructure include the CEC, the Federal Transit Administration, and other agencies.

Vehicle Deployment

At the end of the third quarter of 2024, 113 fuel cell electric buses and 140 fuel cell electric trucks were registered in California, according to CEC staff. Additional fuel cell electric trucks may be operating under a special permit from CARB.

Refueling Infrastructure

California has 4 completed publicly available medium- and heavy-duty hydrogen refueling stations intended for refueling trucks, with 24 additional stations in various stages of development as of the end of the third quarter of 2024. In addition, 7 transit bus stations are in operation with an additional 10 stations planned. California also has three stations for

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49 California Legislative Information. Senate Bill 643 (Archuleta, Chapter 646, Statutes of 2021), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB643.

50 Villareal, Kristi. 2023. *2023 Final Staff Report on Senate Bill 643: Clean Hydrogen Fuel Production and Refueling Infrastructure to Support Medium-and Heavy-Duty Fuel Cell Electric Vehicles and Off-Road Applications.* California Energy Commission. Publication Number: CEC-600-2023-053-SF, https://www.energy.ca.gov/publications/2023/senate-bill-643-clean-hydrogen-fuel-production-and-refueling-infrastructure.

51 U.S. DOE. Office of Clean Energy Demonstrations. "California Hydrogen Hub (ARCHES)" https://www.energy.gov/oced/california-hydrogen-hub-arches?utm_medium=email&utm_source=govdelivery.

private truck fleets in operation with one additional station planned. More stations are planned under ARCHES.

The CEC has developed an interactive dashboard displaying medium- and heavy-duty ZEV hydrogen refueling and charging infrastructure development in California.[52]

California Energy Commission Investments

The CEC has allocated $120 million to fund medium- and heavy-duty hydrogen refueling infrastructure as of November 2024.

52 California Energy Commission. "MDHD ZEV Station Development in California – Beta Version," https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics-collection/mdhd-zev.

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