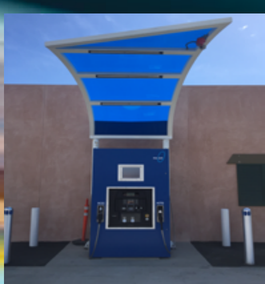


Zero-Emission Vehicles in California: **Hydrogen Station Permitting Guidebook**

Best practices for planning, permitting, and opening a hydrogen fueling station

California Governor's Office of Business and Economic Development

Hydrogen Station Permitting Guidebook

Best practices for planning, permitting and opening a hydrogen fueling station

Published November 2015

First Edition

Governor's Office of Business and Economic Development

Electronic version available: www.business.ca.gov

Lead Authors
Tyson Eckerle
Taylor Jones

Layout and Production
BKi

Acknowledgements

Several federal, state and local agencies, along with a host of ZEV experts, provided essential feedback for this Guidebook. The Governor's Office of Business and Economic Development would like to extend thanks to all individuals and organizations that contributed to this effort. The purpose of this Guidebook is to provide helpful information to local and regional governments, community leaders, businesses and residents in the process of opening a hydrogen fueling station and the compilation of information achieved would not have been nearly as robust without the open collaboration of stakeholders.

In addition, this Guidebook benefits from several helpful informational resources that preceded it. The publications listed below provided the basis for the information in this Guidebook. In many cases, the organizations, authors and contributors of these publications directly helped to shape the Guidebook.

California Fuel Cell Partnership

A California Roadmap: Bringing Fuel Cell Electric Vehicles to the Golden State

Air, Climate, Energy, Water and Security Well-to-Wheels Report

Clean Cities Coalition

H2 Readiness: Best Practices for Hydrogen Stations in Early Adopter Communities

Governor's Interagency Working Group on Zero-Emission Vehicles

2013 ZEV Action Plan

Governor's Office of Planning and Research

Zero Emission Vehicles in California: Community Readiness Guidebook

TABLE OF CONTENTS

HYDROGEN STATION PERMITTING CHECKLIST

Prior to beginning development of a hydrogen fueling station, station developers should consider key questions related to siting, as outlined in the series of questions below. Corresponding page numbers and section headings will lead you to a more in-depth discussion of these topics in the main body of the Hydrogen Station Permitting Guidebook.

Preliminary Checklist for Station Developers

1. Is the property owner committed to the project?
(Page 21: "Securing Site Control")
   - ❒ Yes
   - ❒ No—Get commitment from property owner.

2. Is the proposed site properly zones for hydrogen fueling?
(Page 22: "Zoning")
   - ❒ Yes
   - ❒ No—During pre-application meeting, ask city or county planning department if a zoning variance could be obtained or if the site could be re-zoned.

3. Can the fueling equipment fit on site and accommodate relevant set-back distances?
(Page 24: "Fire Department Approval," Appendices B and F)
   - ❒ Yes
   - ❒ No—Can mitigation measures reduce set-back distance required? If yes, establish a proposal, raise in pre-application meeting and review with local fire marshal. If not, find a new site.

4. Do any local ordinances impact the ability to add hydrogen to the property?
(Page 18: "Local Government Modifications")
   - ❒ No
   - ❒ Yes—During pre-application meeting, ask city or county planning department if a zoning variance could be obtained or if the site could be re-zoned.

5. Is there potential for California Environmental Quality Act-related concerns to develop?
(Page 23: "CEQA")
   - ❒ No—Most brownfield sites fall into the category.
   - ❒ Yes—Determine if similar projects have been completed in California. If so, share how the projects complied with CEQA during the pre-application meeting with the city or county planning department.

Once this initial assessment is complete, the station developer should secure a pre-applicaiton meeting with the city or county planning department to review the potential station installation. Ideally, the station developer will prepare a rough general arrangement drawing to facilitate feedback.

HYDROGEN STATION PERMITTING CHECKLIST

Pre-application meetings are highly recommended and provide an excellent opportunity for the station developer and local Authority Having Jurisdiction (AHJ) to have an early discussion about the proposed station and identify potential issues that may arise. Addressing the questions below during the pre-application meeting can often help save time and effort throughout the remainder of the process.

Pre-Application Meeting Questions (Station Developer)

- ✓ Are there any site issues we (the station developer) should be aware of?
  (Page 21: "Pre-application Outreach")
- ✓ How should a permit application be structured to make it as easy as possible for each department? What level of detail is expected?
  (Page 21: "Pre-application Outreach")
- ✓ Can (should) an application intake meeting be scheduled with relevant departments?
  (Page 21: "Pre-application Outreach")
- ✓ Are there any steps that can be taken to reduce the permitting timeline? What can we (the station developer) do to help streamline review efforts?
  (Page 21: "Pre-application Outreach")
- ✓ If a project will be heard by a political body (Planning Commission, City Council), can members be approached prior to the hearing?
  (Page 22: "Phase 1: Planning Review")
- ✓ Is the location in an aesthetically sensitive area? If not, the station developer should focus on the engineering package, but keep in mind visual appeal is often crucial to planning approval. If yes, the station developer should consider hiring a local architect to help ensure the project reflects the local view-shed.
  (Page 26: "Aesthetics")
- ✓ How does the construction inspection process work? Is there anything we (the station developer) can do to get ahead of typical issues that may arise during inspections?
  (Page 30: "Phase 4: Construction")

HYDROGEN STATION PERMITTING CHECKLIST

Authorities Having Jurisdiction (AHJs) are the local planning, building and fire experts. They know their processes, and what questions to ask, better than anyone else. Discussing the below questions early in the process can help avoid common permitting pitfalls.

Pre-Application Meeting Questions (AHJ)

- ✓ How will the station be supplied with hydrogen?
  (Page 13: "Delivery")
- ✓ How do you expect traffic to flow through the site?
  (Page 26: "Traffic Flow and Site Circulation")
- ✓ What codes and standards do you plan to design to?
  (Page 17: "State Code Requirements," Appendix A, H2Tools.org)
- ✓ How do you plan to meet relevant set-back distances?
  (Page 24: "Fire Department Approval," Appendices B and F)
- ✓ What do you expect the station to look like?
  (Page 23: "Architectural Review" and Page 26: "Aesthetics")
- ✓ Have you engaged the local utility?
  (Page 25: "Utility Power Considerations")

HYDROGEN STATION PERMITTING CHECKLIST

Submitting a complete, yet simple application is essential to help streamline the permitting process and ensures the AHJ has all information required for review. The checklist below identifies key components of a complete application.

Application Checklist

- ✓ Is the application appropriately tailored to each department?
  (Page 29: "Balancing Detail with Simplicity")
- ✓ Does the application clearly spell out the codes and standards it has been designed to meet?
  (Page 29: "Balancing Detail with Simplicity")
- ✓ Does the application address relevant ordinance and zoning constraints?
  (Pages 22: "Zoning")
- ✓ Have all pre-application meeting questions been answered?
- ✓ Has the station's safety plan been clearly articulated?
  (Page 33: "Safety Planning")

WHY IS HYDROGEN IMPORTANT?

Massive adoption of zero-emission vehicles (ZEVs) is essential for California to meet health-based air quality requirements and climate-driven greenhouse gas emissions targets in the coming decades. ZEVs, which include plug-in electric vehicles (PEVs) and hydrogen fuel cell electric vehicles (FCEVs), share two fundamental attributes: they are electric drive vehicles with zero tailpipe emissions.[1] PEVs store electricity on-board in batteries; FCEVs generate electricity on board using hydrogen and fuel cells. ZEV success depends on a robust fueling infrastructure, and hydrogen fueling stations are the lifeline of FCEVs. After more than a decade of demonstration cars on California roads, retail FCEVs are beginning to enter the market in commercial volumes—it is vital to build out the network of hydrogen fueling stations to enable this exciting new market.

Hydrogen as a vehicle fuel adds value to the overall ZEV portfolio and complements the growing PEV market. The benefits of FCEVs include: zero tailpipe emissions, fast refueling time (3-to-5 minutes), and a driving range of approximately 300 miles, depending on the tank's capacity. The overall experience is similar to gasoline and diesel fueling. The first commercial FCEVs are already on the road in California, with more on the way.[2] In a 2015 survey completed by automakers to the California Air Resources Board (ARB), an estimated 10,500 FCEVs will be on the road by the end of 2018 and 34,300 by the end of 2021 (nearly double estimates from 2014).[3,4]

The State of California is working closely with communities and the private sector to ensure a robust hydrogen fueling infrastructure is in place to support vehicle deployment.

Two guiding principles, coverage and capacity, underlie the process of determining the number and location of stations necessary to support commercial FCEV deployment. Coverage emphasizes installation of an adequate number hydrogen fueling stations in locations of high demand. Capacity describes the amount of fuel available in a station or group of stations which defines the maximum number of vehicles those stations can support.

By the end of 2015, approximately 25 hydrogen fueling stations for light-duty vehicles are anticipated to be operational statewide, including 12 fully open retail and 5 non-retail stations.[5] A total of approximately 50 stations are anticipated to be open by the end of 2016. These stations are planned around five early markets (listed below), providing enough fuel for approximately 7,725-13,520 vehicles. The initial network will allow FCEV owners to drive from San Diego to Lake Tahoe, with significant coverage in Los Angeles, Orange County, and the Bay Area, creating key connections throughout the state.

Early Markets

- Santa Monica/West Los Angeles, including Beverly Hills and West Hollywood
- Torrance and nearby coastal cities
- Irvine and southern coastal Orange County
- Berkeley, Hayward, Oakland
- San Francisco, the Peninsula, San Jose

1 PEVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). PHEVs have zero tailpipe emissions when operated in battery only mode.
2 Hyundai in 2014; Toyota in 2015, Honda in 2016; with Mercedes, Nissan and Ford expected in 2017.
3 2015 Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development (July 2015) www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_2015.pdf
4 Compare numbers to 2014 AB8 report. California Air Resources Board, Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development (Sacramento, CA: California Environmental Protection Agency, 2014), 3, www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_final_june2014.pdf

5 "Operational" stations are fully constructed and ready to fill vehicles, but have not yet completed final commissioning. Commissioning and confirmation typically takes 30-90 days and involves testing by automakers, inspection by the California Division of Measurement Standards, and a number of additional checks to ensure the station is properly functioning and ready for public use. "Open retail" stations are fully open to the public and enabled with credit/debit card readers so that anyone can visit the station and fuel. "Non-Retail" stations serve customers on an automaker by automaker basis. They do not offer credit card access.

Executive Order and Governor's Office Vision

In March 2012, Governor Edmund G. Brown Jr. issued Executive Order B-16-12 to "encourage the development and success of zero-emission vehicles." The Governor's Executive Order directs state government to meet a series of milestones toward a long-term target of 1.5 million ZEVs on California's roadways by 2025. Following this action, the Governor's Office launched the *ZEV Action Plan*, which details more than 100 specific actions state government will take in order to accelerate the deployment of ZEVs in California.[6]

The *ZEV Action Plan* is a living document that will be updated to reflect progress and market needs. In May 2015, the Governor's Office hosted a Summit on Zero-Emission Vehicles to provide an update on the items in the *ZEV Action Plan* and solicit feedback from a wide range of stakeholders. This event represents the on-going effort by the Governor's Office and relevant agencies to collect and incorporate stakeholder feedback.

California's Investment

The State of California is investing significantly in the hydrogen station infrastructure network to provide certainty during the early days of this growing market. Through the Alternative and Renewable Fuel and Vehicle Technology Program, the California Energy Commission (CEC) provides funding for the development of hydrogen stations across the state.[7] Assembly Bill 8 (statutes of 2013) authorizes CEC to co-fund at least 100 hydrogen stations with a commitment of up to $20 million per year through a competitive grant process. To date, grant recipients have included a diverse range of hydrogen station integrators, industrial gas companies, and designers and builders partnered with gas station owners and operators.

Purpose of this Guidebook

In fall of 2013, the Governor's Office of Planning and Research published the *Community Readiness Guidebook* to help communities across the state support their residents and businesses making the switch to ZEVs.[8] The *Community Readiness Guidebook* highlights many aspects of preparing communities for ZEVs, including identifying necessary infrastructure, planning and zoning, permitting guidelines, greening local fleets, and encouraging consumers to purchase ZEVs through incentives and outreach.

This *Hydrogen Station Permitting Guidebook* is an extension of the *Community Readiness Guidebook*. It provides a detailed discussion of the hydrogen station permitting process and suggested best practices for local and regional governments and station developers seeking to open (or in the process of opening) a hydrogen fueling station.

Increasing the number of hydrogen fueling stations in the coming years will be crucial to support the ongoing launch of the FCEV market and provide adequate fueling opportunities. The insight and tools provided in this guidebook are designed to serve as a starting point to facilitate discussions and aid in the timely completion of hydrogen fueling stations. In addition, the guidebook includes connections to a number of experts who are ready and willing to help throughout the process.

---

6 Governor's Interagency Working Group on Zero-Emission Vehicles, 2013 ZEV Action Plan: A roadmap towards 1.5 million zero-emission vehicles on California roadways by 2025 (Sacramento, CA: Office of Governor Edmund G. Brown Jr., 2013) www.opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf

7 "Alternative and Renewable Fuel and Vehicle Technology Proceedings," California Energy Commission, last modified 2015, www.energy.ca.gov/altfuels

8 Office of Planning and Research, Zero-Emission Vehicles in California: Community Readiness Guidebook (Sacramento, CA: Office of Governor Edmund G. Brown Jr., 2013), opr.ca.gov/docs/ZEV_Guidebook.pdf

HYDROGEN AS FUEL

Hydrogen is a carbon-free, non-toxic fuel that is domestically produced from local resources.[9] Most hydrogen is made from natural gas, but increasingly it is made from water, biogas and biomass. For more than 75 years, hydrogen has been safely handled, distributed and dispensed. Building codes and technical standards have been created to address hydrogen's specific properties: a small, lighter-than-air molecule with quick diffusion in its gaseous state.

Hydrogen is a recognized fuel for transportation and has been classified as such by the State of California.[10] In addition to transportation, hydrogen is commonly used in large quantities in the petroleum refinery process, in several industrial applications, and as fuel for space exploration. These uses resulted in reliable standards used to safely produce, store, and transport hydrogen.

The application of appropriate codes and standards make hydrogen fuel just as safe as—or safer than—gasoline or other commonly used fuels, such as compressed natural gas (CNG). Retail hydrogen stations are designed to safely accommodate new hydrogen users with minimal training. However, a general understanding of the physical properties of hydrogen is helpful.

To date, widespread commercial and government fleet CNG stations have provided valuable experience as equipment for hydrogen fueling becomes more readily available. CNG stations have a safe operating record and, similarly, hydrogen stations have not exhibited safety concerns when applying appropriate codes and standards during the development process. In fact, hydrogen's properties generally provide safety benefits when compared to gasoline or other fuels.[11]

Properties of Hydrogen

Hydrogen is lighter and smaller than other fuels: Diatomic hydrogen is the lightest molecule in the universe and diffuses rapidly in its gaseous state, elevating at approximately 65 feet per second. This property is known as high buoyancy. High buoyancy makes it unlikely to accidentally form a flammable mixture with hydrogen. Codes and standards take into account the buoyancy and diffusivity of hydrogen when designing structures to store, transport, and use hydrogen safely.

Hydrogen is odorless, colorless and tasteless: Hydrogen sensors are used to detect leaks and have been used to meet safety standards for decades. By comparison, natural gas is also odorless, colorless, and tasteless. In this case, a sulfur-containing odorant, called mercaptan, is typically added to make natural gas detectable by smell. Hydrogen fuel would not work well with odorants because they interfere with the fuel cell systems, so other safety measures, like sensors, are used.

Hydrogen flames have low radiant heat: When a pure hydrogen flame ignites, it burns with an invisible or near-invisible flame, and produces heat and water vapor. A hydrogen fire radiates significantly less heat compared to a typical hydrocarbon fire; the flame is more easily contained and the risk of secondary fires is lower than with other fuels.

Hydrogen has a wide flammability range: The energy required to ignite hydrogen (0.02 megajoule) is low compared to gasoline (0.24 megajoule) and natural gas (0.34 megajoule), meaning that hydrogen can ignite more readily than other fuels. Offsetting this characteristic, hydrogen is lighter than air and disperses rapidly. Compared to other fuels, it is more difficult for hydrogen to reach a combustible state.

9 The carbon associated with the lifecycle emissions of hydrogen occur during the production processes.
10 Senate Bill 76–Committee on Budget and Fiscal Review, Energy, S. 76, 2005 Leg. § Chapter 91 (Cal. 2005) leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060SB76
11 All vehicle fuels contain significant amounts of energy and must be handled responsibly. Like gasoline and other fuels, hydrogen can behave dangerously under specific conditions and is safely handled by understanding its behavior.

Hydrogen is non-toxic and non-poisonous: Hydrogen cannot contaminate groundwater. It is a gas under normal atmospheric conditions and must be at -423°F to reach liquid state. As such, liquid hydrogen will vaporize very quickly and gaseous hydrogen does not contribute to atmospheric pollution. Hydrogen does not create harmful fumes when burned, and cannot cause drips, spills, or soil contamination associated with liquid fuels.

Hydrogen has a low risk of asphyxiation: Any non-oxygen gas can cause asphyxiation. Hydrogen's buoyancy and diffusivity make hydrogen difficult to be confined in a space where asphyxiation might occur. Hydrogen station fueling occurs in well ventilated outdoor and indoor areas, just like gasoline fueling.

How it's Made

Most hydrogen today is made from steam methane reformation at a central production plant, often at or near an oil refinery, food processing plant, fertilizer plant or other industrial chemical process plant.[12] This process typically collects hydrogen from natural gas and water, but can also utilize biogas as the primary feedstock. If produced off site, hydrogen is transported to the fueling station by tanker truck. It is also possible to have a small steam reformer at a fueling station to produce hydrogen on site.

Hydrogen can also be produced from renewable sources. California Senate Bill 1505 currently requires 33% of hydrogen used for vehicle fuel in California, in aggregate, to be produced from renewable energy sources.[13] Two common methods for renewable hydrogen production include electrolyzing (splitting) water with renewable electricity and using renewable biogas as the primary feedstock for steam methane reformation or stationary fuel cell hydrogen generation.[14] Biogas can be collected from a variety of sources of biomass and waste. Today, most renewable hydrogen for fueling stations is produced from the steam methane reformation of biogas, but small- and medium-scale electrolyzers powered with renewable electricity are making an increasing contribution. Electrolyzers have tremendous potential to provide load-balancing services to the grid, perhaps increasing the potential for renewable electricity production more broadly.

The abundance of hydrogen as a naturally occurring resource opens up the potential for a number of novel, lab-proven renewable production methods, such as enzymatic bio-hydrogen and photo electrochemical production. The establishment of a robust hydrogen transportation market is expected to spur investments required to scale up these creative production techniques.

As the FCEV market continues to grow, widespread availability of renewable hydrogen is expected to rise. For more information on research involving renewable hydrogen projects, visit the National Renewable Energy Laboratory (NREL) website.[15]

12 During steam-reformation, water (as steam) reacts with natural gas (mostly methane) to ultimately produce carbon dioxide and hydrogen. Hydrogen is frequently used in the oil refining process to remove sulfur and nitrogen compounds from crude oil feedstocks.
13 Senate Bill 1505–Fuel: Hydrogen Alternative Fuel, S. 1505, 2006 Leg. § Chapter 877 (Cal. 2006) www.leginfo.ca.gov/pub/05-06/bill/sen/sb_1501-1550/sb_1505_bill_20060930_chaptered.html
14 National Renewable Energy Laboratory, Hydrogen Production and Delivery, Hydrogen & Fuel Cell Research, last modified December 2, 2014 nrel.gov/hydrogen/proj_production_delivery.html
15 National Renewable Energy Laboratory,Hydrogen and Fuel Cell Research, last modified October 30, 2014 www.nrel.gov/hydrogen

FUEL CELL ELECTRIC VEHICLES

Fuel cell electric vehicles (FCEVs) are an important part of California's long-term strategy to reach climate goals, improve air quality, and diversify the transportation sector. FCEVs provide vehicle operators with the range, refill time, performance, and comfort comparable to today's gasoline vehicles, along with zero tailpipe emissions. FCEVs are quiet and smooth, and low maintenance.

FCEVs are powered by electricity generated through an on-board fuel cell that chemically combines hydrogen (from the tank) and oxygen (from the air), resulting in water vapor as the tailpipe "emission." Hydrogen is stored on-board the vehicle as a compressed gas, similar to compressed natural gas, but at a higher pressure. FCEVs take 3-to-5 minutes to fill at a hydrogen station and have a range similar to gasoline vehicles (approximately 300 miles). In addition to zero tailpipe emissions, a hydrogen-powered FCEV is 2-to-3 times more efficient in producing usable energy, compared to gasoline in a conventional internal combustion engine vehicle.

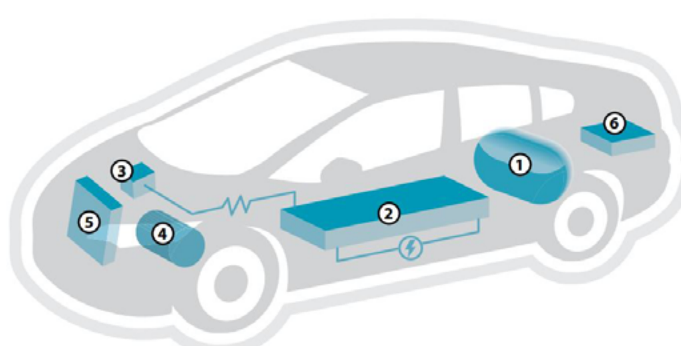
FCEVs are as safe as or safer than other vehicles on the road and meet all Federal Motor Vehicle Safety Standards. FCEVs incorporate a number of additional unique safety features, including on-board hydrogen sensors that are designed to detect unlikely hydrogen leaks and respond by automatically sealing the hydrogen in the storage tank. Hydrogen tanks themselves—constructed from carbon-fiber-reinforced polymer material—have undergone rigorous testing to ensure their durability during the full spectrum of crash scenarios. These tests include crashing, dragging, dropping, shooting, and placing the tank in a bonfire.[16,17]

Should a FCEV be subject to extreme, high temperatures, such as from a gasoline fire from another vehicle, the tank system is designed to safely discharge energy. In this case, a frangible fuse, which is common in all industrial gas bottles, melts open to rapidly, loudly, and safely release hydrogen into the atmosphere (discharging a full tank takes approximately three minutes).[18] The rapid release of hydrogen aids the removal of the hydrogen from the crash site because hydrogen is lighter than the surrounding air, compared to the gasoline vapor that pours out and continues to burn under and around the leaked fuel.

Well-to-Wheel Emissions

1. Compressed Hydrogen Storage System (CHSS) stores and supplies hydrogen to the fuel cell stack.
2. Fuel cell stack generates electricity that flows to the power module.
3. Power module distributes the electricity throughout the vehicle including the motor.
4. Electric motor turns the wheels.
5. Radiator dissipates the heat.
6. High-voltage Battery stores energy from the fuel cell and regenerative braking. Similar to electric and hybrid vehicles, the high-voltage battery on a FCEV supports propulsion as well as improve overall system efficiency.

How a FCEV Works



16 Tanks are tested to American National Standards Institute (ANSI) NGV 2 Standards
17 Ben C. Odegard, Jr and George J. Thomas, *Testing of High Pressure Hydrogen Composite Tanks* (Livermore, CA: Sandia National Laboratories, n.d.)
18 California Fuel Cell Partnership, Fuel Cell Electric Vehicle Safety Systems (West Sacramento, CA: n.p., 2014), cafcp.org/sites/files/FCEVSafetySystems.pdf

As mentioned before, FCEVs have zero tailpipe emissions and provide significant air quality and climate benefits. As with any fuel generated from a variety of sources, some pollution and emissions are associated with the upstream fuel production and distribution. When these are added to vehicular emissions (e.g., from tailpipe) to obtain total emissions, this total reflects "well-to-wheel" impacts. The impact of FCEVs is comparable to BEVs, depending the source of electricity. All in all, the well-to-wheel emissions and air pollutants associated with zero-emission vehicles (ZEVs) are very low compared to internal combustion engine vehicles. BEVs and FCEVs both have the potential to reach zero emissions on a well-to-wheel basis.

Four major air pollutants (commonly called "criteria pollutants") in California are volatile organic compounds, carbon monoxide, oxides of nitrogen, and particulate matter. Because most criteria pollutants from vehicles are related to on-board combustion, FCEVs have almost zero air pollutants from well to wheels (Figure 1). The small amount of criteria pollution that does exist is mainly related to electricity used to compress and dispense hydrogen fuel at the station.

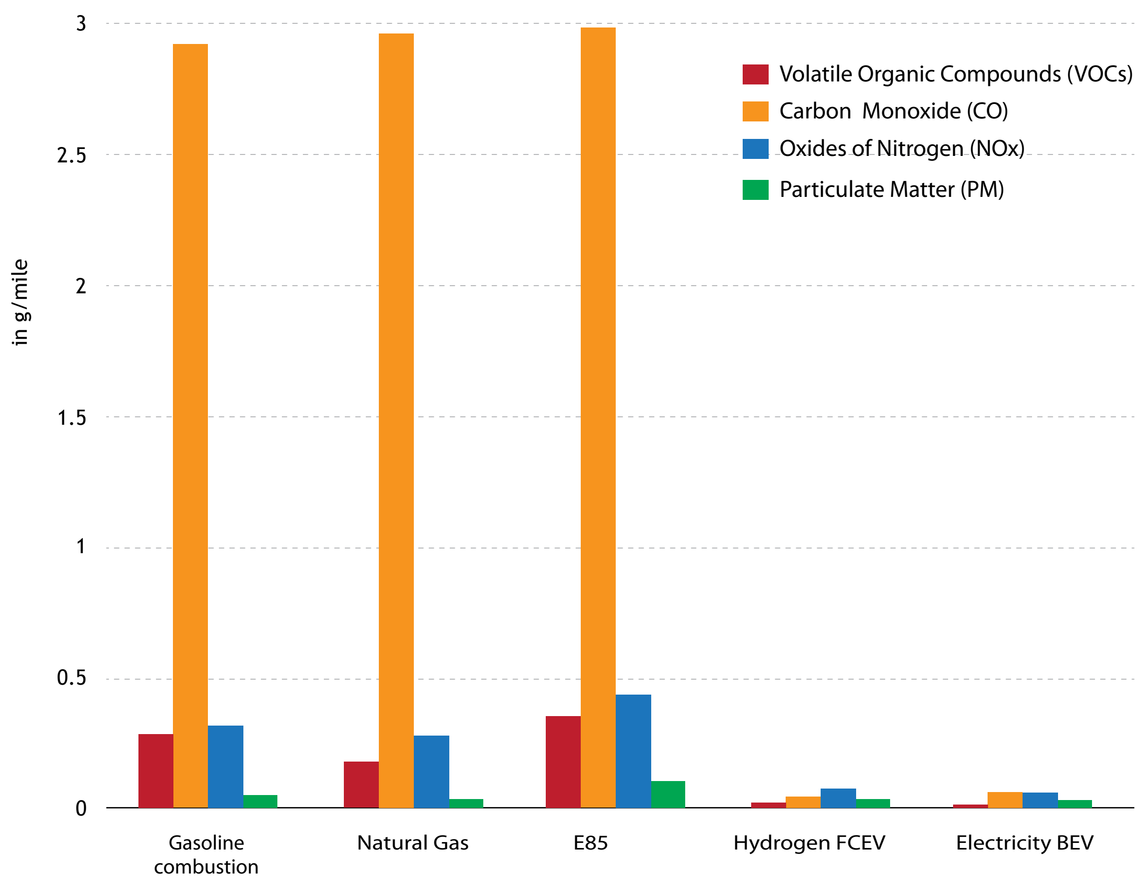


FIGURE 1: Criteria pollution associated with California mix of fuels in grams per mile.[20]

In addition to reductions in criteria pollutants, ZEVs provide significant well-to-wheel reductions in greenhouse gas emissions (GHGs). In 2013, California emitted 386.6 million metric tons of carbon dioxide equivalent, second highest in the United States and 20th worldwide.[19] Transportation is the largest source of emissions in California, accounting for 37 percent. On average, FCEVs provide a 62.5 percent well-to-wheel GHG reduction compared to gasoline-powered vehicles (Figure 2).

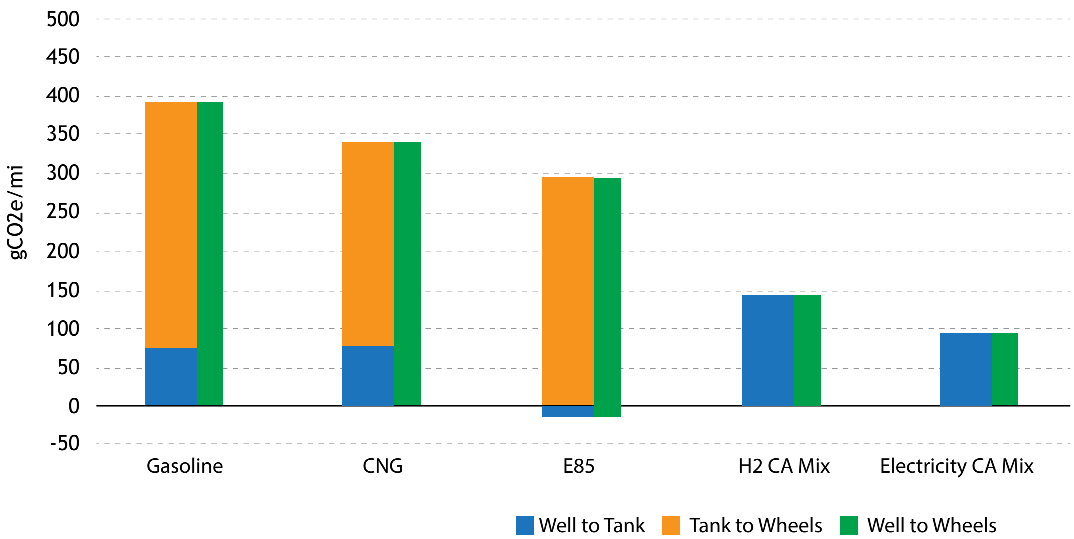


FIGURE 2: Greenhouse gas emissions associated with California mix of fuels in grams per mile.[20]

For additional information about the well-to-wheel impacts of FCEVs, including efficiency, water, and energy security statistics, please see the California Fuel Cell Partnership's report.[21]

19 California Air Resources Board, California Greenhouse Gas Emission Inventory: 2000-2013 (Sacramento, CA: California Environmental Protection Agency, 2014), i,

20 Figures 1 and 2 are courtesy of the California Fuel Cell Partnership, modified for color. Data sourced from the Argonne National Lab GREET V1_2013 model. The figure assumes a 2020 model year mid-sized sedan, California mix of electricity in all pathways, and California blend of gasoline. California's near-term mix of hydrogen and electricity provides significant criteria pollutant and greenhouse gas emission reduction benefits when used for transportation. Increasing renewable electricity generation and utilization will improve the greenhouse gas profile of both FCEVs and battery electric vehicles (BEVs). Increasing renewable feedstock will further improve the hydrogen profile as well.

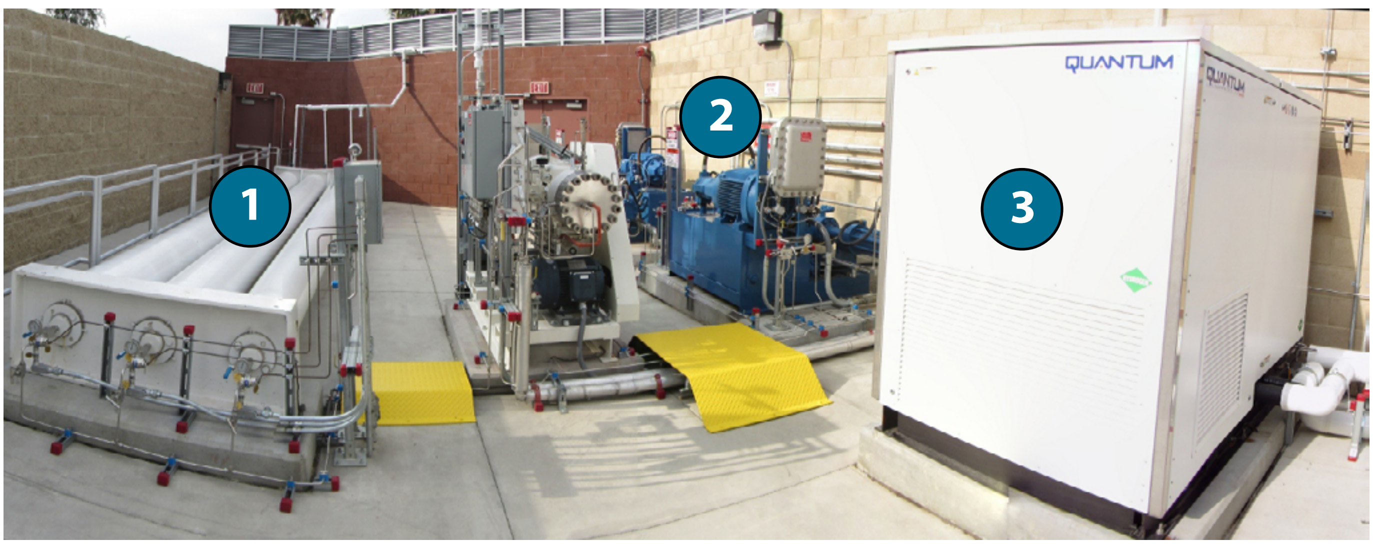
21 California Fuel Cell Partnership, Air Climate Energy Water Security: A guide to understanding the well-to-wheels impact of fuel cell electric vehicles (West Sacramento, CA: 2014), cafcp.org/sites/files/W2W-2014_Final.pdf

HYDROGEN STATIONS

Typical Station Components

Hydrogen stations will have different designs depending on how the hydrogen is produced, delivered, and where the station is located.[22] Hydrogen stations may be integrated into an existing fueling station, such as a gasoline or compressed natural gas station, or constructed as a stand-alone project. Every hydrogen station includes, at minimum:

1. **Hydrogen storage tank(s)**
   At a fueling station, hydrogen is stored on site in a storage tank. Different tanks exist to accommodate cryogenic (very low temperature) liquid hydrogen, and low- and high-pressure compressed gaseous hydrogen. Storage tanks are constructed from hydrogen-safe materials and contain several pressure relief and safe-venting mechanisms.
2. **Compressor**
   Hydrogen flows from the storage tank to the compressor, which reduces the volume and increases the pressure, preparing the hydrogen for fueling. Compressors also contain real-time monitoring controls and pressure relief systems.
3. **Chiller**
   After leaving the compressor, hydrogen typically enters a closed-loop cooling system to chill the molecules prior to dispensing. The chiller enables high-pressure, fast fills.



4. **Dispenser**
   Hydrogen dispensers are very similar to typical gasoline or diesel dispensers. Dispensing equipment can sometimes be placed under the canopy at an existing fueling station, but some station agreements do not allow alternative fuels to be co-located under the branded canopy. Some stations have hydrogen dispensers on the same island as other dispensers; other stations have hydrogen dispensers on their own island under the fueling canopy, just outside of canopy or on a separate section of property.

22 Please refer to "H2FIRST Reference Station Design Task, Project Deliverable 2-2" (April 2015) for a detailed explanation of common hydrogen station designs, components, and layouts: www.nrel.gov/docs/fy15osti/64107.pdf

Hydrogen dispensing nozzles look similar to gasoline nozzles (as shown in the photo) and the fueling experience is analogous to filling a gasoline car when using the locking lever. To fuel, a driver places the dispenser onto the FCEV tank receptacle, squeezes the trigger, and locks the lever in the "fill" position. The dispenser manages the fill once the hose is properly connected. After filling, the driver removes the nozzle, places it back onto the dispenser, closes the fuel tank cap, and drives away.

Delivery

Hydrogen fuel delivery methods depend on the physical state of the hydrogen and station infrastructure. If fuel is delivered (as opposed to created on site), a hydrogen provider and station operator negotiate a contract and arrange a delivery schedule.

Gaseous hydrogen is typically delivered using one of two approaches:

1. High-pressure delivery is similar to today's gasoline delivery in that hydrogen is off loaded from a delivery trailer into on-site storage vessels. This process takes approximately 30 minutes, depending on site logistics and quantity of hydrogen exchanged. Depending on volumes, a high-pressure delivery truck can fill or top-off multiple stations.
2. Trailer swapping involves swapping out trailers when the hydrogen is depleted. For this type of system, storage tubes are permanently mounted on a trailer. The driver opens the gate at the storage area, disconnects and removes the empty trailer, and then backs in a full trailer and connects it to the station system. The empty trailer is taken away and refilled at a central facility. Swapping trailers can take between 10 minutes and an hour, depending on site logistics.

The dispensable capacity of today's gaseous delivered stations is typically just under 200 kilograms (kg) per day, which is enough to fill approximately 50 light-duty vehicles per day.[23]

Liquid hydrogen is delivered by tanker trucks. The driver connects the hose from the truck to a valve on the storage tank and off loads liquid hydrogen. Because liquid hydrogen is at a cryogenic temperature, a vapor cloud forms around the transfer point. Filling the storage tank can take between 10 minutes and an hour, depending on the size of the tank. Today's liquid hydrogen stations typically have the ability to dispense around 350 kg per day (about 90 light-duty vehicles per day).

Pipeline hydrogen is available in unique situations. If available, a station can draw from a nearby hydrogen pipeline, and then purify, compress, and dispense the hydrogen on site.[24] The Torrance Pipeline Station (2051 West 190th Street, Torrance, CA 90504) connects to a hydrogen pipeline used primarily to carry hydrogen from the production plant to oil refineries for use in the refining process. Pipeline stations are expected to be economically attractive at high-throughput levels.

Multiple technologies can produce hydrogen on site. If fuel is created on site, all of the necessary production equipment is located on the same grounds or nearby. Some of the technologies for on site hydrogen production include:

23 Assuming approximately 3-4 kg per filling.

24 Hydrogen purity is crucial, as fuel cells are generally sensitive to contamination. Most pipeline hydrogen is used for oil refining, which does not require the same purity as automotive fuel cells.

On-site reformers produce hydrogen from natural gas or biogas. The reformer may be housed in a small building (or shipping container) or may not have to be enclosed at all, depending on the layout of the station. Additional equipment to compress and store the hydrogen is nearby.

Electrolyzers produce hydrogen from water and electricity by splitting water molecules into their component elements: hydrogen and oxygen.[25] Electrolyzers are attached to a water line and can be powered by a number of electricity supply arrangements: direct connection to the electrical grid, often leveraging renewable power purchase agreements, and/or direct connection to adjacent solar panels or wind generators.

Co-generation uses high-temperature fuel cell systems to generate heat and hydrogen from natural gas or biogas. Tri-generation systems add electricity as a production product.[26,27] These systems can generate the electricity to power the station or adjacent building, heat to support any number of industrial processes, and hydrogen for fueling.

Hydrogen ready for fueling, in its compressed gas form, is currently stored above ground in approved steel or composite pressure vessels, manufactured in accordance with American Society of Mechanical Engineers (ASME) standards.[28,29] In the future, underground storage of hydrogen may become an economically viable option.

How to Fuel

Hydrogen dispensers are designed for self-serve operation. Vehicle operators (or vehicle owners) receive fueling training one time and then are ready to fill at a hydrogen station. Training methods vary. The vehicle operator might receive training from the station developer, a FCEV salesperson, or a video screen on the dispenser. Filling with hydrogen is fast, easy, and safe. Throughout the fueling cycle, the system performs pressure checks to ensure appropriate levels of hydrogen. A full tank of hydrogen (3-to-6 kilograms) fills in 3-to-5 minutes.

A hydrogen station has several different safety systems (similar to a gasoline station) that work together to keep vehicle operators safe while fueling. If flame detectors or gas sensors detect a fire or leak, then safety devices automatically turn on, sealing storage tanks, stopping hydrogen flow or, in the case of a fire when the pressure exceeds limits, safely venting the hydrogen. Strategically placed emergency stops are designed to shut down hydrogen equipment and isolate the gas supply, if activated. Retaining walls, equipment setbacks are designed into the site plan to maximize safety. In addition to physical safety systems, hydrogen stations also have logic systems that use sensors to detect illogical patterns or flows. If a sensor detects something illogical, the system will shut down, if necessary.

Hydrogen is dispensed as a gaseous fuel to fill at either H35 (35 MPa, 5,000psi) or H70 (70 MPa, 10,000psi) pressures.[30] A hydrogen dispenser looks similar to other retail gasoline dispensers and usually has one hose and nozzle for each pressure. Vehicle operators cannot attach the high-pressure nozzle to a lower-pressure vehicle receptacle, similar to a diesel nozzle not fitting into a gasoline receptacle.

25 Small electrolyzers use approximately 2.4 gallons of water per hour and have a net hydrogen production rate of 21.6 kg per day. (Proton, "C Series Hydrogen Generation Systems," protononsite.com/resources/technical%20brochures/c_series_spec_rev_b.pdf). For comparison, it takes approximately 3-7 gallons of water to produce one gallon of gasoline (M. Wu et al., Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline (Chicago, IL: Energy Systems Division, rgonne National Laboratory, 2009), www.transportation.anl.gov/pdfs/AF/557.pd

26 University of California Irvine, "Tri-Generation from Biogas," Advanced Power and Energy Program, www.apep.uci.edu/3/research/partnership_TRI-GEN.aspx

27 The world's first tri-generation unit was demonstrated at the Orange County Sanitation District in Fountain Valley and next-generation plans are underway.

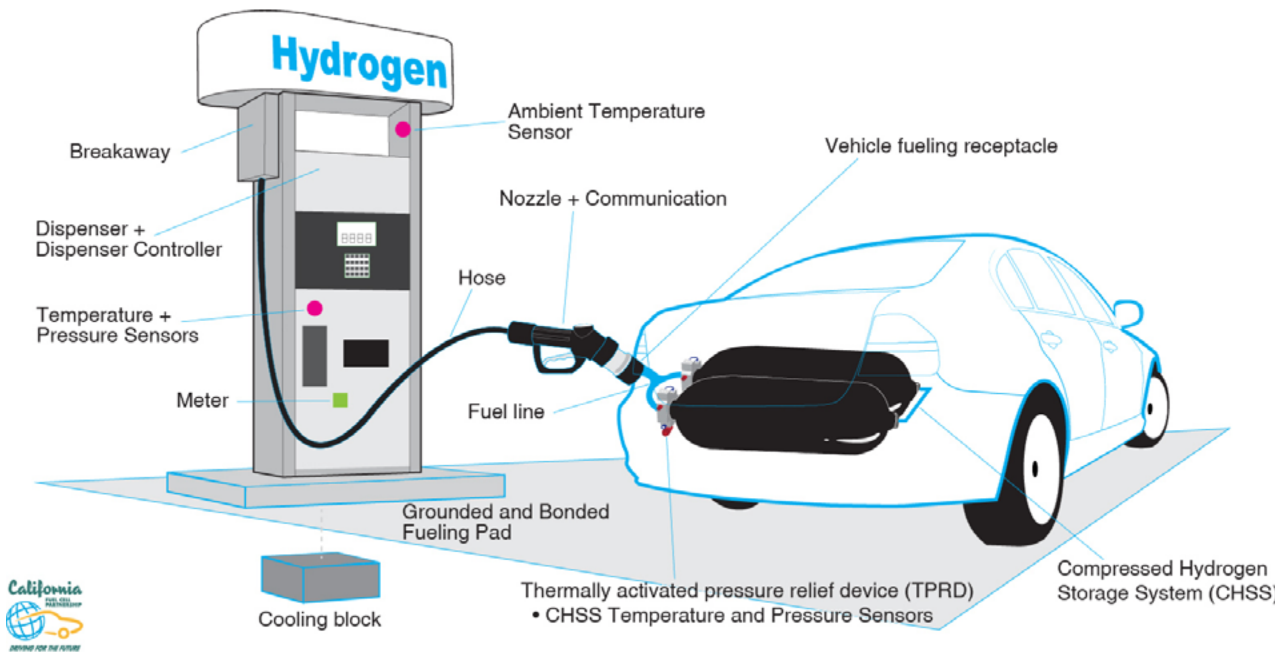
28 American Society of Mechanical Engineers, "Pressure Vessels," last modified 2013, www.asme.org/shop/standards/new-releases/boiler-pressure-vessel-code-2013/pressure-vessel

29 One fueling station in Berlin, Germany incorporates an underground storage tank. (www.the-linde-group.com/en/clean_technology/clean_technology_portfolio/hydrogen_as_fuel/building_hydrogen_refueling_infrastructure/index.html) Underground storage could be proposed and approved in California, neither of which has occurred at the time of publication.

30 5,000 psi=35 MPa=350 bar, 10,000 psi=70 MPa=700 bar

Like a gasoline dispenser, a hydrogen dispenser typically has two sides, each with a similar user interface. The dispensers are designed to accept credit cards and display sale information in accordance with state weights and measures requirements.[31] The quantity of fuel dispensed (units of measurement) is displayed in kilograms (kg).[32]

When a vehicle operator activates the dispenser, hydrogen flows from the storage tanks to the dispenser and through the nozzle into the vehicle in a closed-loop system. If filling with H70 (10,000 psi), the hydrogen either passes through a booster compressor or is dispensed from high-pressure storage tanks and then a chiller before entering the dispenser. If initial safety checks fail, for example if the nozzle is not correctly attached, fueling will not begin.



During the fill, at intervals of approximately 3,000 psi, the dispenser conducts integrity checks where it momentarily stops the flow of hydrogen.[33] These pauses generally last from 10-to-15 seconds, after which the fill resumes. Most vehicles have an infrared wireless communication system that sends various storage tank parameters to the dispenser, which then utilizes this information to calculate the appropriate pressure at which to end the fill.[34]

Refueling times are dependent on the temperature of the chiller system employed. The latest dispensers chill the hydrogen to nearly -40 °C, resulting in refueling times of approximately 3-to-5 minutes under most ambient temperature conditions.[35]

31 Cal. Code Regs, Title 4. Business Regulations, Division 9. Chapter 1. Article 1 Sections 4001. Exceptions and 4002. Additional Requirements, Subsection 4002.9. www.cdfa.ca.gov/dms/regulations.html
32 A kilogram of hydrogen carries approximately the same energy content as a gallon of gasoline.
33 NFPA 2: Hydrogen Technologies Code, Edition 2011
34 SAE J2799: Hydrogen Surface Vehicle to Station Communications Hardware and Software, Edition 2014-09
35 SAE J2601: Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles, Edition 2014-07

Selling Hydrogen in California

California has taken important steps to enable the retail sale of hydrogen. The California Department of Food and Agriculture's Division of Measurement Standards (DMS) adopted market enabling hydrogen gas measuring devices regulations on June 16, 2014.[36] These regulations established realistic near-, mid- and long-term targets for measuring hydrogen given the current and expected status of hydrogen measurement technology. Once a dispenser passes DMS inspection and is "type certified," hydrogen can be legally sold through that dispenser (and dispensers that are the same model) to retail consumers.

Hydrogen prices will be determined by the businesses retailing the fuel. During market launch, most industry experts expect costs to the consumer to be competitive with gasoline on a per mile basis. As with all fuels, hydrogen prices are associated with the quantity of fuel sold. Over time, as demand for hydrogen fuel increases, the price of hydrogen is expected to decline.[37]

There will be two notable changes in the way hydrogen fuel is sold to the public. First, all hydrogen dispensers will be marked in mass units—kilograms instead of gallons. Second, DMS endorses the U.S. national method of sale regulation for hydrogen in the National Institute of Standards and Technology Handbook 130, which stipulates that street sign pricing be shown in terms of whole cents (e.g., $9.50 per kg, not $9.499 per kg).[38]

36 Cal. Code Regs, Title 4. Business Regulations, Division 9. Chapter 1. Article 1 Sections 4001. Exceptions and 4002. Additional Requirements, Subsection 4002.9 www.cdfa.ca.gov/dms/regulations.html
37 Fuel Cell Technologies Office: Accomplishments and Progress, Office of Energy Efficiency and Renewable Energy, energy.gov/eere/fuelcells/accomplishments-and-progress
38 NIST Handbook 130, Physical Management Laboratory, last modified 2014, www.nist.gov/pml/wmd/pubs/hb130-14.cfm

PERMITTING

Developing a hydrogen station can be time intensive, especially for the first station in a community. Permitting requirements will differ from station to station depending on the site characteristics, station type, and the local jurisdiction's unique processes. In California, local governments have the ultimate authority to approve or deny any project. A design approved in one community does not guarantee approval of the same design in another community (although it often helps). This section of the guidebook is designed to minimize the research required to permit a station from perspectives of the Authorities Having Jurisdiction (AHJs, or reviewing entities—often a city or county) and the station developer by offering insight and tools from past experiences and general recommendations for streamlining the permitting process.[39]

A major piece of the station permitting process is dedicated to ensuring stations are built to current codes and standards. The following text provides references to California codes and guidance, which can be amended by local jurisdictions in certain circumstances. The California Building Code gives authority to each AHJ's chief building official to be the final authority on the code interpretation in their jurisdiction. Previous experiences have shown that code requests can vary widely with different interpretations from one AHJ to another.

Given this reality, the California Building Standards Code, Title 24, can be used generally to plan a permit strategy that is applicable statewide. However, as discussed in the *Pre-Application Outreach* section below, it is critical for station developers to meet early in the process with local authorities to ensure projects are designed in compliance with local interpretations of codes and standards.

Before proceeding through the detailed information in this section, the reader should be aware that there are a number of opportunities to overwhelm the hydrogen station development process with information. A complex permit application may address any questions that might arise, but also greatly increases the amount of time required to review and approve a package. Each jurisdiction is different, but as a rule of thumb, the best permit applications are concise to make each department's review as simple and straightforward as possible.

State Code Requirements

Code requirements are developed and implemented to provide for the safety of people and property, as well as minimize the environmental impacts associated with project development. The California Building Standards Code provides uniform requirements for buildings throughout the state. These requirements are contained in Title 24 of the California Code of Regulations (CCR). The CCR is divided into 28 separate titles based on subject matter or state agency authority. Title 24 is reserved for state regulations that govern the design and construction of buildings, associated facilities, and equipment. These regulations are also known as the "State Building Standards."

Title 24 applies to all building occupancies and related features and equipment throughout the state. It contains requirements for a building's structural, mechanical, electrical, and plumbing systems, in addition to measures for energy conservation, sustainable construction, maintenance, fire and life safety, and accessibility. Specific areas within Title 24 directly relate to hydrogen stations, such as the California Fire Code, California Electrical Code and California Building Code.

39 It is important to note that a "station developer" might be the same as the station owner, station developer, or station operator. In other cases, each of these may be different. For the purpose of this guidebook, we use the term "station developer" to represent all of these variations.

State regulations should not be confused with state laws enacted through the legislative process. State regulations are adopted by state agencies where necessary to implement, clarify, and specify requirements of state law. The California Building Standards Commission (CBSC) and other state agencies (both adopting and proposing) review the codes and update Title 24 as appropriate. Title 24 is updated every three years. The latest edition of California Building Code was published in 2013, was approved by the CBSC and effective in 2014. An updated edition is expected to be published in 2016, which will likely be approved and effective on January 1, 2017.

Several portions of Title 24 govern installation of a hydrogen station:

- California Building Code, Part 2, Title 24
- California Electrical Code, Part 3, Title 24
- California Energy Code, Part 6, Title 24
- California Fire Code, Part 9, Title 24

The intent of this guidebook is to provide consistent application of these Title 24 requirements throughout the state, as they relate to hydrogen stations. This guidebook is not intended to create, explicitly or implicitly, any new requirements. Updated information regarding new code requirements, as well as the code updating process, is available on the CBSC website.[40]

Local Government Modifications

Cities and counties in California are required by state law to enforce Title 24 building standards. However, cities and counties can, and regularly do, adopt local laws (also called "ordinances") to modify these state building standards to address local climatic, geological, or topographical conditions, and generally are more restrictive. This means that a city or county may have local ordinances that modify or add to the provisions of Title 24 for any section that impacts hydrogen stations. The California Building Code (Sections 1.1.8 and 1.1.8.1) outlines the specific findings that a city or county must make for each amendment, addition, or deletion to the state building codes and be expressly marked and identified to which each finding refers.[41]

Cities, counties, and local fire departments file these local amendments to the state building code with the CBSC. Findings that are prepared by fire protection districts must be ratified by the local government and are then filed with the California Department of Housing and Community Development (refer to Health and Safety Code Sections 13869.7, 18941.5 and 17958.7).[42]

Additionally, changes made by a city or county to the California Energy Code, Part 6, Title 24 relevant to energy conservation or energy insulation must be submitted to the California Energy Commission (CEC) for approval pursuant to the Public Resources Code, Section 25402.1.[43]

Many communities are already familiar with hydrogen and relevant safety codes and standards, through their more traditional industrial purposes, such as food processing, petroleum refining, and the semiconductor industry. Hydrogen is also increasingly used in fuel cell-powered forklifts and cell-tower backup applications. This experience will further help inform communities as they become familiar with hydrogen as a transportation fuel. In addition, a wide variety of resources are available to support AHJs as they prepare to apply codes and standards to hydrogen stations.[44]

40 California Building Standards Commission. Last modified 2014, www.bsc.ca.gov

41 California Building Code, California Code of Regulations, Title 24, Part 2, Volumes 1 and 2, 2013 California Codes, last modified 2013, www.ecodes.biz/ecodes_support/Free_Resources/2013California/13Building/13Building_main.html

42 California Health and Safety Code, www.leginfo.ca.gov/.html/hsc_table_of_contents.html

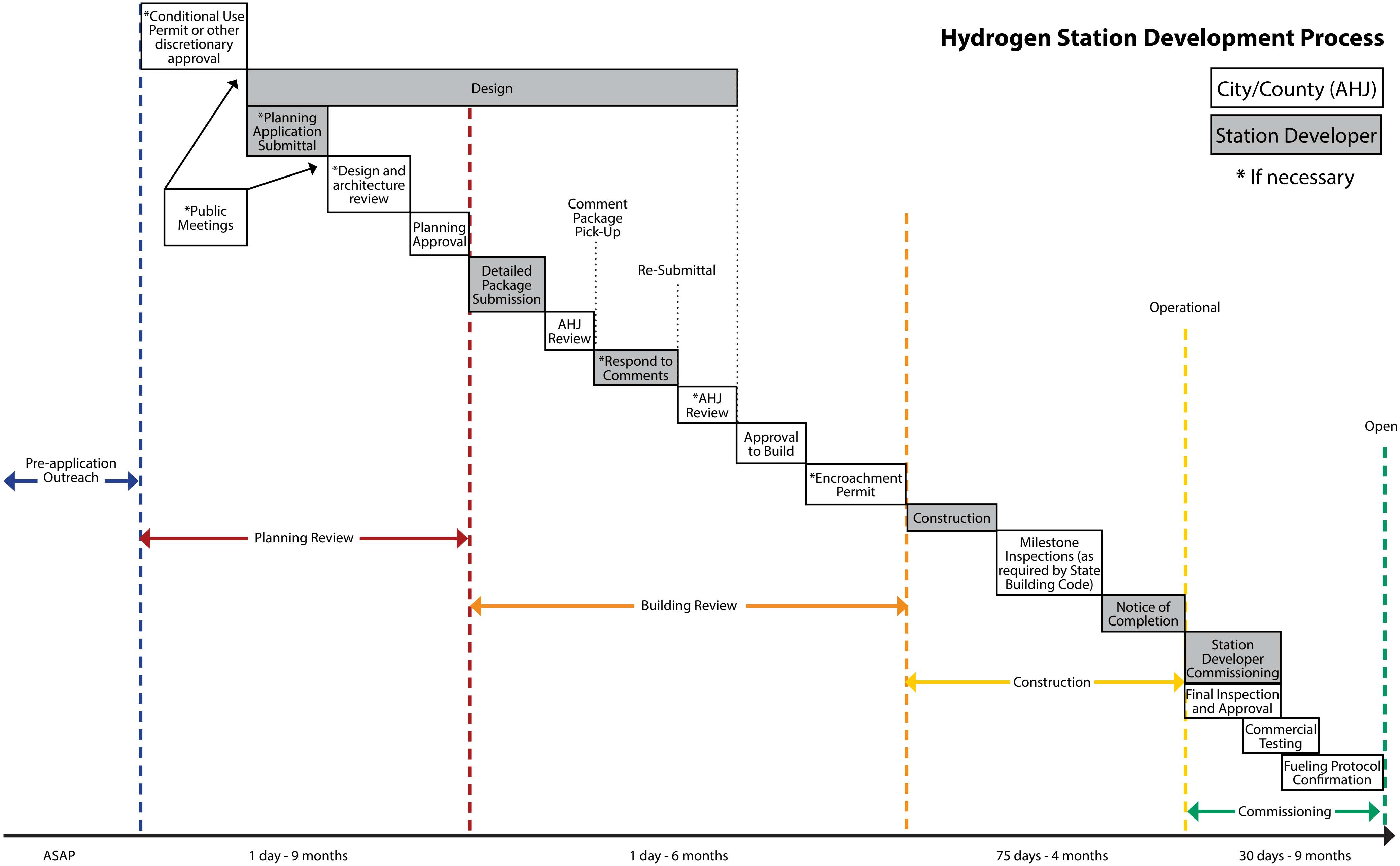
43 California Public Resources Code, www.leginfo.ca.gov/.html/prc_table_of_contents.html

44 In addition to station developers themselves, the California Fuel Cell Partnership is positioned to connect AHJs to a variety of public (federal, state and local) and private hydrogen experts. Please refer to www.cafcp.org or send inquiries to info@cafcp.org.

Overall, the permitting process and code review has five main phases:

1. **Pre-Application Outreach**
2. **Planning Review**
3. **Building Review**
4. **Construction**
5. **Commissioning**

The design and permitting processes are interrelated, which is important to keep in mind because multiple permits and approvals may be required in different stages of the process. The "Hydrogen Station Development Process" diagram outlines the processes involved and includes a range of theoretical timelines. The remainder of this section will follow sequentially.



Potential timelines reflected above. Timelines are expected to improve with additional learning. (Please note the diagram is not to scale.)

Phase 1: Pre-application Outreach

A city or county planning agency is often the most effective place to first engage a local authority. Ultimately, the planning agency will ensure a project meets zoning requirements, is in compliance with the California Environmental Quality Act (CEQA), and fits within the jurisdiction's General Plan. This includes considering impacts to parking, aesthetics, and on-site circulation and traffic flow. Planning departments will often connect applicants with other relevant departments, as appropriate.

Above all else, two of the most important steps in the hydrogen station development process occur during the Pre-application Outreach phase, before a permit application is submitted:

1. *Securing site control*. Seamless communication between the station developer and site owner is absolutely vital in securing the station site. Site owners must be fully committed to the proposed station arrangement and remain part of the process to quickly enable any necessary changes along the way.

2. *Establishing a permitting pathway understanding*. Most communities welcome pre-application meetings with the applicant, key AHJ staff, and the site owner. These meetings help the applicant ensure their application provides all the information a jurisdiction needs to approve the station, saving time and resources for the developer and AHJ staff.

Pre-application meetings are highly recommended and provide an excellent opportunity to bring AHJs up to speed with the broad effort to deploy hydrogen-powered FCEVs. These early meetings provide an opportunity to identify potential issues that may delay the permitting process or lead to the denial of an application, such as:

- Problems with the proposed site, such as parking, circulation, right-of-way, or clearances
- Specific requirements the project must meet to achieve approval
- Issues with similar projects in the jurisdiction
- Neighborhood concerns
- Environmental issues

The pre-application meeting can take place any time before the permit package is submitted, but earlier in the process is typically better, even if a very rough general arrangement document or aerial photo of the site are the only design documents available. During the pre-application meeting, the applicant should layout the overall plan, describe the proposed path forward, learn which permits or approvals will be required to complete the project, and gain a clear understanding of the level of detail each department would like to see in the permit application submittal package.[45]

During Pre-application Outreach, developers and AHJs can leverage a variety of resources to help with community outreach and education, including (but not limited to) automakers, the California Fuel Cell Partnership, the California Energy Commission, the California Air Resources Board, the Governor's Office of Business and Economic Development, and local Air Pollution Control or Management Districts. Contact information for these resources is in Appendix E.

45 Please refer to the Pre-Application Checklist at the beginning of the document for a starter list of questions that should be asked/answered prior to application submittal.

Phase 2: Planning Review

Planning review is a required part of the permitting process that ensures that a proposed station fits within a community's zoning codes, General Plan, and overall aesthetics. Experience has shown that gaining planning approval can be the most time-consuming portion of the permitting process, underscoring the importance of early engagement with the planning department.

> While each jurisdiction will vary slightly, hydrogen stations typically need to satisfy local requirements in each of these areas to obtain planning approval: Zoning, Architectural Review, California Environmental Quality Act (CEQA) and Fire Department Review. In addition, utility connection plans should be arranged as early as possible to ensure they do not impact planning approval.

Depending on the community and proposed project site, the planning process can be as simple as checking a box if the chosen location is zoned to accept more fueling or as complex as CEQA analysis coupled with multiple architectural review and planning commission hearings. If an item needs to be heard by any public body, agenda requests should be made as soon as possible because some communities may have protracted processes and/or a backlog of actions that require a public meeting.

The involvement of the city or county planning agency will vary by jurisdiction and station location. In the simplest case, a proposed station will fit within the parameters designated by a jurisdiction's zoning code and General Plan (a local jurisdiction's plan for long-term development), and not displace any parking spaces or trigger the need to upgrade facilities to comply with the Americans with Disabilities Act (ADA). However, many sites are geographically constrained and require special consideration from the local planning agency.

What to prepare for: Zoning, Architectural Review, CEQA, Fire and Utility Connection

The planning review process does not typically require detailed engineering drawings. However, any required general arrangement or architectural drawings should take code compliance into account.[46] Interpretation of codes can vary by jurisdiction, underscoring the importance of early fire and building department engagement. For example, if a fire wall will be required as a mitigation measure, it needs to be included for planning review to avoid backtracking through the process.

1. Zoning

An AHJ cannot permit a hydrogen station without proper zoning approval. In California, local jurisdictions are responsible for writing or adopting their own zoning ordinances. As such, the rules that govern the siting and construction of hydrogen stations may differ substantially from one jurisdiction to another.[47] For example, jurisdictions may have specific language that covers hydrogen stations in an industrial zone, but not in a commercial zone. Others may simply group hydrogen in with all automotive fuels and, therefore, may allow it in commercial zones. Some jurisdictions may require design reviews or specific discretionary approvals to proceed, while in others, hydrogen dispensers may be installed in existing fueling stations by right or entitlement.

Applicants should refer to a community's General Plan to help make an initial zoning compatibility assessment. In some cases, a location may be covered by a Specific Plan, which provides a more nuanced and detailed land-use description.

46 In many cases, Planning Departments will ask for elevation drawings to understand visual impacts of the station.

47 The National Association of Convenience Stores (NACS) created a guide to help convenience and fueling retailers navigate local zoning processes that may be a helpful resource as well. www.nacsonline.com/YourBusiness/Refresh/Documents/Site-Approval-Toolkit.pdf

Conditional Use Permits and Variances

In the simplest case, the selected project site will already be zoned for vehicle fueling and allowed to add additional fuel "by right," which is one reason many hydrogen stations have been proposed at existing gasoline facilities. In many cases, the station developer or property owner will need to obtain a conditional use permit (CUP) or variance before pursuing approval to build. A CUP defines how a site can be used (e.g., hours of operation, delivery timing, etc.).[48] A variance is a request for a deviation from local zoning code (e.g., eliminating parking spots, greater building height).

Consideration of a CUP or variance is a discretionary act of the AHJ and, if approved, is generally subject to a number of pertinent conditions of approval and mitigation requirements. CUPs and variances typically involve a public meeting by a zoning board, planning commission or zoning administrator.

Rezoning

In some cases, a site may need to be rezoned by the city or county. This process requires public meetings by the local planning commission, city council or county board of supervisors. The council or board is not obligated to approve requests for rezoning and, except in charter cities, must deny such requests when the proposed zone conflicts with the General Plan.

2. Architectural Review

Some communities have design review bodies chartered to review and approve the aesthetics of development plans. These committees play a crucial role in project approval, and approval often needs to occur prior to a project being heard by a planning commission.

Generally speaking, an architectural or design review board works to ensure that projects fit the local aesthetic. The board may ask for changes to roofing, landscaping, or painting to help a station blend in or make a visual statement. These requests can lead to negotiations between the board and project proponents, which lead to a mutually agreeable solution.

At times, aesthetic-driven requests conflict with codes and standards. In this case, it is up to the project proponent to articulate why suggested changes cannot be implemented.

3. CEQA

The California Environmental Quality Act (CEQA, Res. Code §21000 et seq) was promulgated in 1970 to notify the decision makers and public of any potential adverse environmental impacts of projects. The act is implemented through the CEQA Guidelines; regulations found in CCR Title 14 Chapter 3 that explain and interpret the law. CEQA projects are generally construction projects, but also include programmatic or policy changes that could result in an environmental impact.

CEQA applies to projects undertaken by state and local agencies or private entities that require some discretionary approval. For example, adding a piece of equipment that requires a permit from a local Air Pollution Control District would be considered a "project" under CEQA.

In many jurisdictions, installing a hydrogen station fits the definition of a project under CEQA. However, some jurisdictions consider the addition of hydrogen fueling to an existing gasoline station a ministerial, non-discretionary action that does not trigger an extensive CEQA review.

48 Many gas stations operate with an existing CUP. In this case, a proposed hydrogen station would trigger the need to modify the existing CUP.

In recognition of the clear net benefits hydrogen stations bring to a community, several local governments that have taken action under CEQA have filed a categorical exemption or prepared a negative declaration. Most of the recently built hydrogen stations on existing fueling sites have used categorical exemptions. It is important to note that the use of hydrogen does not trigger any special CEQA considerations and that these are common exemptions based on the scope of the project. Commonly filed exemptions for hydrogen stations on existing fueling sites are:

- 15301 (Class 1) for Existing Facilities
- 15303 (Class 3) for Small Structures
- 15304 (Class 4) for Minor Alterations to Land

In the infrequent case that a CEQA review is required, it is important to identify the need as soon as possible because CEQA analyses can be time consuming. Interested agencies can check CEQA Net for references to other hydrogen fuelling station CEQA determinations.[49,50] CEQA Net lists the CEQA categorical exemptions filed by the CEC to encumber funds for hydrogen stations. Local jurisdictions can to defer to the CEC's determination or conduct their own CEQA analysis.

4. Fire Department Approval

The timing of a fire department's review of a project varies by jurisdiction and project. Some fire departments will engage in details early in the process, others will begin their review once a project has planning approval. As with all permitting, early engagement is vital, especially if the project is likely to require mitigation measures because these measures (e.g., a fire wall) can impact the planning review.

Hydrogen station designs need to comply with the California Building Code (Part 2) and the California Fire Code (Part 9) of the California Building Standards Code (Title 24), the California Code of Regulations and/or the local amendment of the California Building and Fire Code. The code ensures proper setback distances, equipment, and mitigation measures for fueling, infrastructure, and storage.

Any hydrogen station design must demonstrate code and standards compliance through plans, notes, and calculations throughout the planning approval phase. Notes and calculations should clearly identify the codes the project will be designed to and demonstrate how the project is proposed to meet the codes. The primary means of resolving any questions relating to code compliance is through the plan check process.[51] However, in some cases, it will make sense to have an "application requirements" meeting when submitting the application. If an AHJ offers such a meeting, station developers should be prepared to give a complete description of each code section the proposed project addresses and how the project will meet or exceed all code requirements.

In July 2014, California became the first state in the nation to adopt and approve the 2011 edition of National Fire Protection Association 2 (NFPA 2 Hydrogen Technologies Code), which stems from considerations in the more familiar NFPA 52 and 55. NFPA 2 is a science-based code that provides fundamental safeguards for the generation, installation, storage, piping, use, and handling of hydrogen in compressed gas or liquid form. It has undergone significant industry examination and engineering peer review through the rigorous NFPA adoption process.

49 The database is incomplete, as local governments are not required to submit CEQA documentation. However, the State of California is actively collecting CEQA determinations, and will up the database as possible. www.ceqanet.ca.gov

50 The California Fuel Cell Partnership maintains updated station maps on their website. This is a reliable source for communities looking for jurisdictions that have approved or are reviewing hydrogen station proposals. www.cafcp.org/stationmap

51 During the plan check process, the project is reviewed by multiple local agencies to ensure compliance with particular regulations, codes, etc.

The California Building Standards Commission, on behalf of the Office of the State Fire Marshal, adopted NFPA 2 in what is referred to as an Intervening Code Adoption Cycle, which enabled the publication of NFPA 2 into the California Building and Fire Code on January 1, 2015. NFPA 2 became effective on July 1, 2015, after the mandatory minimum 180-day period provided for in law. Prior to July 1, 2015, NFPA 2 was successfully used as an alternative means of compliance for a number of stations.[52]

5. Utility Power Considerations

Obtaining approval for electrical systems at a hydrogen station is a two-part process:

Connecting to the Local Utility. The level of utility involvement in a station is site and design specific. In the simplest case, the utility company can pull power from adjacent power lines that have excess capacity for the station to access. Project timelines and complexity increase with wider power demand and expansion requirements that might entail an upgrade to the distribution infrastructure in the area of the project.

Obtaining Building Department Approval. The local building department will ensure electrical plans comply with relevant codes. Details are included in the "Phase 3 Building Review" section.

> Potential utility constraints should be prominently factored in during site selection and project planning. Considerable expense and time can be added to the project if existing infrastructure cannot support power demands from a nearby source.

Permit Fees

Current state law requires that fees charged by a local enforcing agency for permit processing and inspection cannot exceed the reasonable cost of providing the service for which the fee is charged. In other words, fee revenue must only be used to defray the cost of permit processing and enforcement and cannot be used for general revenue purposes. These requirements are contained in Government Code Section 66016 and State Health and Safety Code Section 17951.[53] Permit fees will vary by jurisdiction.

52 For example, the City of Los Angeles, West Sacramento and Santa Monica Fire Departments all used NFPA 2 to approve stations in their jurisdiction prior to the July 1, 2015 formal adoption. All new stations are using NFPA 2 to guide approval.
53 California Government Code and California Health and Safety Code, www.leginfo.ca.gov/.html/gov_table_of_contents.htm

Planning Review Tips, Best Practices and Resources

Tips for Planning Approval

Early AHJ engagement can have tremendous benefits, saving developers and AHJs considerable time. A general arrangement schematic, if available, can help calibrate this initial discussion and subsequent path forward. This general arrangement can facilitate a discussion about key constraints on many sites: parking spaces and traffic flow.

Parking spaces fall into one of two categories: general parking and disabled access parking. Both are incredibly important for the local planning process and can significantly impact station design. General parking requirements are typically governed by the jurisdiction's General Plan and zoning requirements. Disabled access spots are determined by the local jurisdiction's interpretation of the Americans with Disabilities Act (ADA), which prohibits discrimination against people with disabilities in employment, transportation, public accommodation, communications, and governmental activities. Care should be taken to incorporate parking constraints and opportunities into the station design as early as possible. If a site has flexibility, AHJs can help by informing the station developer, often resulting in a better design.

Adequate traffic flow and circulation is fundamental to the planning approval and long-term viability of the site. Early engagement and a clear understanding of a site's dynamics and user behavior can help facilitate productive discussions with AHJ staff and planning commission. This is especially true if the proposed project can improve traffic flow on site.

Hydrogen Supply Strategy. For delivered hydrogen station, delivery schedules are likely to be governed by site dynamics and property owner wishes. However, local ordinances, such as limiting nighttime deliveries, may also impact the schedule. Any delivery restrictions should be understood early in the process so that any challenges can be addressed. Plan submittals must be descriptive of the process of how hydrogen will be delivered to the site and vehicle. Graphics can help enhance the plan checker/examiner's understanding of the proposal, and clearly labeled plans will simplify the review.

Aesthetics. A well-engineered station is often only part of the equation. To facilitate quick local approval, a station should be designed to fit the visual landscape as much as possible and should be compliant with the AHJ's published design standards. Designing a station to meet the local aesthetics can save time and money, and help gain community support.[54] Hiring a local architect who understands local nuance can help seamlessly integrate the station into the existing visual landscape and minimize potential back-and-forth between the developer and AHJ. Overall flexibility and a willingness to work with the AHJ on design and local preferences can help the process go smoothly.

General Plan Considerations. Some General Plans specifically state that fueling stations can dispense gasoline or diesel fuel. Communities that want to attract hydrogen stations should ensure their General Plans recognize all fuels, not just gasoline and diesel. Additionally, many hydrogen stations willl not have an attendant or employee on site, as safety systems have been designed to enable unattended fueling. General Plans that allow for unattended fueling can help simplify the station development process. A General Plan may also reference hydrogen dispensing as a way to meet sustainability goals and clean air standards.

Understanding Site Ownership. Fully understanding the ownership structure, lot lines, easements, and deed restrictions on the proposed property can save time in the permitting process. If the site has multiple owners, all owners should agree upon, or have an agreement about, the proposed general arrangement drawings before initiating the design process. If a site has multiple lots tied together, the city or county may require a covenant to tie the properties together. Station owners often rent the space for their station and may not be fully aware of property title restrictions, even if they sign an agreement with a hydrogen station developer. Researching the title can avoid potential issues upfront and save time in the long run.

54 Some communities have architectural or design review boards that will review projects before they receive planning approval. Others allow planning review in parallel with the building review process.

Tips for Fire Approval

The importance of fire approval, or an identified pathway to fire approval, cannot be over-stressed, especially in communities new to hydrogen fueled transportation. While no un-safe hydrogen project would survive the permitting process, the perceived risk of hydrogen can be high for those who have not been exposed to the technology. Experience shows that fire official engagement gives decision makers who have not been exposed to hydrogen use the comfort they need to approve a proposed station. In general, local fire marshals have been very supportive of the State's effort to deploy hydrogen stations once the marshals gain comfort that stations comply with all relevant codes and standards.

Hire an Experienced Fire Protection Engineer. A person with an understanding of the local AHJs' approach to code application can help minimize the back-and-forth associated with the station approval process. A fire protection engineer can succinctly communicate compliance with relevant codes and standards, thus saving fire marshals time and effort.

Early AHJ Engagement. Some fire department work flows are set up to wait for planning approval prior to reviewing projects. However, given the novelty of retail hydrogen use in some communities, out-of-order processes may be required to establish the comfort needed to gain planning approval. Conceptual approval or a willingness to engage on a project early can be the difference between a project stalling and gaining planning approval at the first hearing.

Address All Relevant Codes. The project narrative should show fire marshals that the applicant has done their due diligence - addressing both the California Fire Code (2013 CFC Section 2309 - Hydrogen Motor Fuel Dispensing and Generation Facilities) and the reference standard NFPA 2 (2011 version). The most important considerations involve NFPA 2 requirements in Chapter 10, GH2 Vehicle Fueling Facilities and Chapter 1, LH2 Fueling Facilities.

Safety system innovation and understanding will inevitably evolve as the retail hydrogen fueling market develops. If a new approach is to be considered in a community, resources are available to help ensure appropriate risk mitigation:

> The **Hydrogen Fueling Infrastructure Research and Station Technology** project (H2First) is a public-private partnership co-launched by industry and the U.S. Department of Energy. H2First leverages considerable technical expertise to help facilitate reliable and cost-effective market growth. Given the right project, H2First can help ensure new engineering approaches provide an equivalent level of safety that may be easily replicated in subsequent stations.[55]
>
> The **Hydrogen Safety Panel** was formed in 2003 to support the U.S. Department of Energy Hydrogen and Fuel Cells Program and represents 400-plus years of industry and hydrogen experience. The 14-member panel is comprised of a cross-section of expertise from commercial, industrial, government, and academic sectors. The panel meets regularly to identify safety-related technical data gaps, best practices, and lessons learned, and to help integrate safety planning into hydrogen and fuel cell projects to ensure that the appropriate safety practices are addressed and incorporated. This panel can be consulted to review innovative projects and provide feedback and insights to station developers and AHJs. Information on the panel and hydrogen safety is being continually updated at www.h2tools.org.

55 For more information and program contacts, refer to energy.gov/eere/fuelcells/h2first

Tips for Utility Connection

Early Outreach. Communicating with the local utility is crucial to ensure the utility has sufficient time to provide a new service and deliver any additional power requirements to the site. This early engagement enables project proponents to incorporate utility specs into site drawings.[56]

Service Representative Consultation. Local site knowledge can trump plans approved by utility plan checkers. Early consultation with the utility service representative (in addition to utility plan checker) can save time and effort later in the process.[57]

Establish Separate Service. If a station is being installed at an existing fueling site, but requires a separate meter, a separate address may need to be obtained from the city or county. This is generally a simple process not involving any underlying property changes (for example, 1 Hydrogen Way would become 1A Hydrogen Way for the new meter and 1A would be removed if the meter were to be removed). It is important to engage utilities early to understand how they prefer to handle their accounts.

Evolving Standards. Electrical requirements evolve over time. Depending on code cycle and project development timelines, a project may straddle code changes. An early check-in with the local jurisdiction as well as the California Building Standards Code (Title 24) can avoid surprises during the permitting process. In the context of electrical permits, Title 24, Part 3 of the California Energy Code should be given particular attention for developers who also work outside of California. Part 3 is adopted by the CEC and approved by the CBSC for inclusion in Title 24, and is not based on a model code.

Electrical Load Requirements. These can vary widely between station designs. For example, given the same hydrogen throughput, on-site electrolysis typically consumes much more electricity than delivered hydrogen. These differences may impact local building department review strategies.

Planning for Installation. Some early stations have suffered delays from a lack of availability of utility parts. Effort should be made to help utilities plan their resource allocation to the project as early in the process as possible.

56 Some AHJs will want to see the detailed engineering plans for utility service. Others accept drawings without that detail (e.g. the plans would show any additional footprint added to the site, but not the internal electrical design).

57 Many utilities have staff that focus on service requests and/or site inspections within a general geography. Inspector approval is needed to power up and operationalize a station—early engagement can minimize the potential for costly changes.

Phase 3: Building Review

In some jurisdictions, the building department serves as the central clearing house for project approval.[58] In others, the building department simply conducts a building plan check once a project has been cleared by the planning department. In either case, building departments review complete, fully detailed plans to ensure that projects comply with applicable requirements of the California Building Standards Code (Title 24) and local ordinances. These detailed plans include structural, mechanical, and electrical information.

Electrical approval is one of the key milestones. An electrical engineer will check the plans against the California Electrical Code (Title 24, Part 3), California Energy Code (Title 24, Part 6), and local ordinances that may be more stringent than the California Building Standards Code, Title 24.[59] These codes ensure proper electrical installations, efficiency measures, and load management.

The building department will use its interpretation of the California Building Standards Code to ensure a project is set up for safe installation and operation, with a focus on safety, structural design, and layout. It may issue separate permits for demolition, site grading, and construction. Final construction plans must incorporate all of the planning agency's conditions of approval. When the project is approved, the AHJ will issue the approval to build.[60]

Tips and Best Practices for Building Approval

Balance detail with simplicity. Station developers should note that providing too much information could inundate the plan-check process. The ideal permit application demonstrates department- specific compliance with all relevant codes—nothing less and nothing more. Each department's plan checker (building, electrical, fire, etc.) should be able to quickly assess the section(s) he or she needs to review; not have to hunt through pages of calculations to find the relevant sections. Depending on the AHJ, the best approach may include packages tailored to each department or one set of clearly indexed plans.

Full and complete responses. As the AHJ reviews the application, it will often provide feedback including questions, comments, and definition of changes needed for approval. Ideally, station developers will receive full and complete comments from all agencies of the AHJ within the same time frame. Adjustments in the permit application may be required based on staff input. Applicants should clearly and succinctly address all issues raised by the AHJ, and resubmit the modified package as soon as possible.

Nationally Recognized Testing Laboratory (NRTL) Approval. In an established market, building designs can incorporate off-the-shelf NRTL certified components and designs, simplifying the engineering review process. However, NRTL certified components often do not exist for early market products. Hydrogen stations are no exception. Given this, the onus falls on the station developer to provide information to AHJs so that station designs can be approved. Fortunately, the number of approved and safely operating stations continues to grow globally. As the market expands, the expectation is that certified components or systems will be available for station developers, simplifying infrastructure approval and deployment.

Consistency with Inspection Process. Past experience has illuminated the potential for misalignment between plan check and equipment inspection, as plan checkers and inspectors are often different people. These discrepancies can arise from miscommunication at a variety of process points. To the extent possible, both AHJs and station developers should actively work to ensure inspection requirements are fully understood. This will help stations move from construction to operation as quickly as possible.

Third-party Resources. If staff has questions or concerns regarding a project, third-party resources are available to share insights or connect resources, free of charge. The California Fuel Cell Partnership serves as an information clearing house that can connect project participants to industry and government experts, in addition to knowledgeable staff.[61] A list of organizations and contact information is located in Appendix E.

58 The City of Los Angeles' Building Department is an example of this arrangement.
59 Local ordinances can often be found on an AHJ's website, and should be confirmed at the pre-submittal meeting.
60 See Appendix D for an example building permit.
61 For contact information, refer to cafcp.org/aboutus/contactus.

Phase 4: Construction

After the AHJ issues the final approval to build, construction can begin. During and at the completion of construction, the station is subject to inspections and final approval by the local authorities. The purpose of inspections is to ensure that project developers build their projects in compliance with the specifications agreed upon in previous phases of the process. Work in progress (WIP) inspections are strongly recommended to help avoid potentially costly interpretation misunderstandings and help ensure a station opens on time. When construction is complete, the station developer will file a notice of completion and begin commissioning the station.

Tips and Best Practices for Timely Construction

Inspection processes can vary from jurisdiction to jurisdiction. The local process should be fully understood before commencing construction. Many jurisdictions will require multiple inspections, others a single inspection upon project completion. Either way, inspections should be worked into the project plan and scheduled as soon as possible to avoid long lead times.

Enchroachment Permits must be obtained prior to doing any work that may impact a city or county right of way. These permits are typically obtained by the contractor responsible for installing the station and generally require a performance security (e.g., cash deposit, performance of bond, letter of credit) to ensure completion of work. Applicants should work with the building department to ensure they are prepared to secure all potential encroachment permits. If work needs to be done on a state highway, an encroachment permit from the California State Transportation Agency will be required.

Phase 5: Commissioning

Once a station has been fully constructed and a notice of completion has been submitted, final commissioning begins. This process drives towards two key milestones: a station becoming 1) Operational and then 2) Open. According to the most recent CEC definition, an "operational" station has met the following parameters:

- The AHJ has issued an operational permit
- The station has successfully completed a hydrogen quality test
- The station can fuel a vehicle
- The station is publicly accessible[62]

An "open" station can accept any FCEV driver with a credit card or fleet fueling card.

Currently, final commissioning involves four key parties: the station developer, local AHJ, auto manufacturers, and California Department of Food and Agriculture, Division of Measurement Standards (DMS). The following steps are general milestones not meant to serve as a complete commissioning checklist. This process is expected to evolve as the market matures.

1. **Station Developer Commissioning.**The station developer is responsible for constructing the station to the plans and specifications approved by the AHJ. The developer will also fill the system with hydrogen and administer a series of tests to ensure the station performs as expected. Once construction and verification has been completed, the developer will schedule a final inspection by the AHJ to approve the station for operation.
2. **Fueling Protocol Confirmation.** As of mid-2015, station developers work closely with automakers to ensure new stations safely fill FCEVs and meet the necessary agreed upon performance requirements. Once the market matures, automakers will not need to take part in station confirmation (similar to gasoline stations). The U.S. Department of Energy and State of California are collaborating on a project to help move station confirmation towards some type of third-party verification.[63] The process is expected to be iterative and will include direct automaker involvement into the foreseeable future.
3. **Commercial Testing.** Prior to approval of retail sales, a station must be certified by the California Department of Food and Agriculture. DMS ensures that a kilogram of hydrogen sold is a kilogram of hydrogen received, that the point of sale system functions appropriately, and that hydrogen dispensed meets the purity requirements for use in a FCEV. (The purity tests take place in Step 1, and can be done by a commercial lab.)[64]
4. **Opening the Station for Public Use.** A station will be open to FCEV drivers when each of the following steps have been completed:
    a) The AHJ has issued the final occupancy permit to the station developer
    b) Fueling protocol has been confirmed by the automakers and/or a recognized third party system
    c) The dispenser has been certified to sell hydrogen by the kilogram
    d) The station developer declares the station is ready to serve the public

    In the near-term, the State of California, led by the Governor's Office of Business and Economic Development's (GO-Biz) Zero-Emission Vehicle Infrastructure Project Manager, in collaboration with CaFCP will work with stakeholders to facilitate the steps each party takes to "open" stations to everyday FCEV drivers.[65] Station status will be publicly communicated and displayed on the CaFCP website.

    State of California representatives are actively working with stakeholders to improve the commissioning process so that developers and local jurisdictions across the globe can seamlessly move from "Operational" to "Open." Improvements will be collected and shared through state, local, and industry relationships.

62 Please refer to PON 13-607 for complete definitions. www.energy.ca.gov/contracts/PON-13-607
63 The State is currently working with H2First to develop and implement a HyStEP (Hydrogen Station Equipment Performance) device to help streamline the performance testing and verification process.
64 Refer to "Selling Hydrogen in California" on page 23 for more information.
65 Steps: 1) AHJ issues operational permit, 2) automakers or recognized third party confirm that the station fills to protocol, 3) DMS or local counterpart certify dispenser accuracy, and 4) the station developer completes internal testing.

ADDITIONAL TOPICS

Permitting Mobile Refuelers

As more FCEVs take the road and the hydrogen station network expands, mobile refuelers will be able to provide additional capacity in the case of station repair, or other unforeseen needs. With a hydrogen compressor, storage and dispenser on-board, mobile refuelers have capability to travel to designated locations throughout the state and fill vehicles.

Mobile refuelers require specific approvals. Tanks on the mobile refueler will need to meet U.S. Department of Transportation (DOT) standards for moving flammable gases, either as pre-approved DOT tanks or special permit tanks. (The primary relevant regulation is 49 CFR 173.301.)[66,67]

The Compressed Gas Association TB25 "Design Considerations for Tube Trailers," which has been incorporated by reference into 49 CFR 173.01, offers a solid starting point for planning to comply with DOT regulations. It should be used for performing analysis or performance testing. For composite tanks commonly used to store hydrogen, DOT standards require a full range of testing to verify integrity. Prior to testing, it is recommended that manufacturers of mobile refuelers contact the Pipeline and Hazardous Materials Safety Administration (PHMSA) at DOT to ensure tests and methods meet all requirements.

The California Fire Code and International Fire Code do not contain guidance on mobile fueling, but, depending on the site, there is information on mobile refueling in NFPA 2. Manufacturers of mobile refuelers should review NFPA 2 to ensure project compliance.

Using Mobile Fuelers as Backup. In markets with multiple stations, the likelihood of needing a mobile fueler as backup may be relatively low; customers may be able to fuel at other stations, especially with advanced notice. In others, if a station goes down, a mobile fueler may be the only practical back-up system. In either case, station providers should establish a clear back-up plan. If the back-up plan involves a mobile fueler, the station provider should work with the AHJ and relevant property owners ahead of time to establish pre-approval. Pre-approval can reduce the time it takes to establish mobile back up from weeks to days, or even hours.

Permitting FCEV Repair Facilities

The 2013 California Fire Code Chapter 23 addresses repair garages for vehicles fueled by lighter-than-air fuels. The code has been modified per the adoption of NFPA 2 in the Supplement to the 2013 California Building and Fire Code. These changes went into effect on July 1, 2015. Early use of NFPA 2 and the amendments was previously accomplished on a case-by-case basis in accordance the alternate means and methods of construction provisions contained in CFC or CBC Section 1.11.2.4.[68]

Air Quality Permits

Local air quality improvement is a fundamental motivation for hydrogen and FCEV deployment. As such, most hydrogen stations will not requ

ire an air district permit to construct or operate, given that local emissions will not increase from the sources subject to air district review. This holds true for delivered hydrogen and electrolysis stations. In many cases, on-site generation using natural gas as the feedstock will also be exempt from obtaining an air quality permit. However, this presumption should be verified with the local air district. Regardless of whether or not a permit is required, the

66 www.fmcsa.dot.gov/regulations/hazardous-materials/how-comply-federal-hazardous-materials-regulations

67 49 CFR 173.301 "General requirements for shipment of compressed gases and other hazardous materials in cylinders, UN pressure receptacles and spherical pressure vessels." This regulation incorporates CGA-TB25 "Design Considerations for Tube Trailers" by reference, highlighted here for its direct application to mobile fuelers.

68 See California Building Code, Section 1.11.2.4, www.ecodes.biz/ecodes_support/free_resources/2013California/13Building/PDFs/Chapter%201%20-%20Administration.pdf

project may need to be formally registered with the local air district.[69]

Safety Planning

Ultimately, communities will define the success of hydrogen stations and FCEVs. A thoughtful permitting process will help ensure that hydrogen stations are as safe as, or safer than, conventional gasoline stations.

However, the concept of hydrogen as transportation fuel remains new to many. A smooth permitting process can hinge on neighbors being educated and exposed to the technology, and misconceptions actively dispelled. Extensive and ongoing outreach to the general public—especially local elected officials, businesses, and residents—in the area has proven to be advantageous for projects in California. CaFCP maintains a robust education and outreach program that project and community leaders can and should leverage. This resource and CaFCP's expertise help expose communities to hydrogen FCEVs and their benefits.

As with any project that could impact the health and safety of a community, a hydrogen station operator should develop a project safety plan to addresses potential risks and impacts to personnel, equipment, and the environment. The plan should describe how project safety is communicated and made available to the operating staff, neighboring occupancies, and local emergency response officials. A communication plan that employs regular dissemination of safety procedures and practices is crucial to avoiding potential safety incidents and assuring proper incident response.

Interfacing with CUPAs

Certified Unified Program Agencies (or CUPAs) are consolidated local entities with jurisdiction over the management of hazardous materials and wastes in California. During the hydrogen station development process, station developers and AHJs should be aware of the standard CUPA requirement to develop a Hazardous Materials Business Plan (HMBP).

HMBPs are overview documents that contain information on the location, type, quantity, and health risks related to hazardous material stored, used, or disposed of by businesses operating in the state. As with any fueling project, a hydrogen station operator is required to develop a HMBP.[70] The station's HMBP is kept on file with the AHJ, which is typically the local fire or environmental health department. The HMBP should include a complete inventory of all hazardous materials on site, demonstration of compliance with the California Fire Code, emergency response plans and procedures, a training plan, and procedures for documenting compliance with training and inspection requirements. AHJs can provide clear guidance on what should be included in the HMBP and what level of detail is necessary to meet CUPA requirements.[71]

Another related CUPA program is the California Accidental Release Program (Cal-ARP), which requires implementation of a risk management program and submission of a risk management plan to prepare for accidental releases of hazardous substances. Hydrogen dispensing stations are exempt from (Cal-ARP) if less than 10,000 pounds of hydrogen (4,536 kilograms) are stored or processed on site at one time.[72] Current and planned hydrogen stations in California range from 130 to 5,300 pounds (60 to 2,400 kg) of hydrogen at one time and, therefore, are not required to participate in the Cal-ARP program at this time. Cal-ARP enforcement officials can contact California Office of Emergency Services for further information on the program and requirements.[73]

69 California Air District websites can be found at www.arb.ca.gov/capcoa/dismap.htm
70 Hazardous Materials Business Plan/EPCRA 312, CA Governor's Office of Emergency Services, modified 2011, www.caloes.ca.gov/HazardousMaterials/Pages/Business-Plan.aspx
71 It is also important to note that hydrogen is not an "Extremely Hazardous Substance," so it will not be subject to additional reporting requirements for this category (Appendix A, 40CFR, Part 355).
72 California Accidental Release Prevention (Cal-ARP), California Governor's Office of Emergency Services, last modified 2011, www.caloes.ca.gov/HazardousMaterials/Pages/California-Accidental-Release-Prevention-%28CalARP%29.aspx.
73 "Agency Contacts," California Governor's Office of Emergency Services, www.caloes.ca.gov/NewsandMedia/Pages/Agency-Contacts.aspx

Who's done this already?

Several communities in California have already developed hydrogen stations and others are well on the way. A recent report to the CEC, *Alternative and Renewable Fuel and Vehicle Technology Program Project Report: Status of Existing Hydrogen Refueling Stations*, provides detailed descriptions of existing stations.[74] Additional information is at www.cafcp.org.

HUMAN RESOURCES

Local AHJs, station developers, and consultants gain hydrogen permitting experience in California and elsewhere every day. Outreach to communities statewide has confirmed that local permit authorities are more than willing to share lessons learned and insights with other permit authorities. Challenges are often similar across jurisdictions and sharing information can significantly improve the overall development process. However, identifying the right person to connect and begin a dialogue with can take time. With this in mind, the State continues to work with local jurisdictions and professional associations to maintain a list of key contacts that have played a role in the permitting of a hydrogen station. The Governor's Office of Business and Economic Development (GO-Biz) frequently updates a contact list and welcomes the opportunity to provide connections. Interested parties can contact GO-Biz at ZEVinfrastructure@gov.ca.gov for additional information.

In addition to local contacts, state and federal governments, academia, and non-profit organizations have considerable knowledge about the hydrogen station permitting process. While they cannot make local decisions, they can help jurisdictions work through potentially complex issues. For example, the Hydrogen Safety Panel, highlighted in the Permitting section, could provide unique hydrogen projects with recommendations for strategies to improve (or maintain) safety profiles. Appendix E provides a table listing organizations, their purpose as it relates to hydrogen, and contact information.

WHAT'S NEXT?

California is a vital piece of a much larger national puzzle to incorporate ZEV technologies into the active fleet. Successful FCEV deployments in California will help open the market to the rest of the United States and some parts of the world.

In 2014, the State of California joined H_2USA, a public and private initiative dedicated to enabling the broad scale adoption of FCEVs across the nation. This guidebook will ultimately feed into the national effort to simplify the hydrogen station permitting process. As such, we appreciate insights from readers of this document about how to improve suggestions and make the next iteration of the guidebook more helpful. Your insights will make it easier for stations and FCEVs to be adopted in other jurisdictions, resulting in a healthier environment and greater energy security for us all.

74 Andris R. Abele, Alternative and Renewable Fuel and Vehicle Technology Program Project Report: *Status of Existing Hydrogen Refueling Stations* (San Clemente, CA: TechCompass, 2015)

CODES AND STANDARDS

As with any development project, ensuring compliance with relevant codes and standards is critical to obtain approval and successfully construct a project.

The list that follows is for informational purposes only and does not list all standards likely to be used in a hydrogen station. Please use the most-recent relevant version of the codes and standards.

In addition to the list below, H2tools.org offers a centralized of codes and standards database maintained by the Pacific Northwest National Laboratory Department, through U.S. Department of Energy support.

California Codes[75,76]

- California Fire Code
- California Electric Code
- California Building Code
- California Mechanical Code

National Hydrogen Specific Codes[77]

- NFPA 2 Hydrogen Technologies Code
- NFPA 30A Motor Fuel Dispensing Facilities and Repair Garages
- NFPA 55 Compressed Gases and Cryogenic Fluids Code

Component Design Standards

- ASME Boiler and Pressure Vessel[78]
- ASME B31.12–Hydrogen Piping and Pipelines
- ASME B31.1–Power Piping
- ASME B31.8–Gas Transmission and Distribution Piping Systems
- ASME B31.8S–Managing System Integrity of Gas Pipelines
- ASME B31.3–Process Piping
- CGA S-1.1-3: Pressure Relief Device Standards
- CGA-G-5.5: Hydrogen Vent Systems
- SAE J2600–Compressed Hydrogen Surface Vehicle Fueling Connection Devices
- UL 2075–Standard for Gas and Vapor Detectors and Sensors
- NFPA 77 and API RP 2003 offer guidance on grounding and static electricity

75 Office of the State Fire Marshal, "Code Development and Analysis," Office of the State Fire Marshal, osfm.fire.ca.gov/codedevelopment/codedevelopment.php

76 California Building Standards Commission, "Current 2013 Codes," California Building Standards Commission, last modified 2014, www.bsc.ca.gov/Home/Current2013Codes.aspx

77 National Fire Protection Association, "Home Page," modified 2015, www.nfpa.org

78 The American Society of Mechanical Engineers, "Home Page," www.asme.org

Component Listing and Design Standards

Currently, few existing components are tested to listing standards implemented by a nationally recognized testing laboratory (NRTL). AHJs may allow the station manufacturer to provide technical information to prove that the compression, storage, and dispensing components used are fit for service. As the market develops, the list of listed components (and systems) is expected to grow.

Station Developer Standards (For informational use)

- SAE J2601–Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles[79]
- SAE J2799–Hydrogen Surface Vehicle to Station Communications Hardware and Software
- SAE J2719–Hydrogen Fuel Quality for Fuel Cell Vehicles
- HGV CSA Series Standards (currently being updated)

Additional Resources:

U.S. Department of Energy:

- energy.gov/eere/fuelcells/safety-codes-and-standards
- www.afdc.energy.gov/uploads/publication/57943.pdf

NREL Permitting for Officials:

- www.nrel.gov/docs/fy13osti/56223.pdf

Sandia Technical Reference on Hydrogen Compatibility of Materials:

- www.sandia.gov/matlsTechRef/chapters/SAND2012_7321.pdf http://www.ca.sandia.gov/matlsTechRef/

79 SAE International, "Home Page," last modified 2015, www.sae.org

SELECTING A WORKABLE SITE: SETBACK REQUIREMENTS

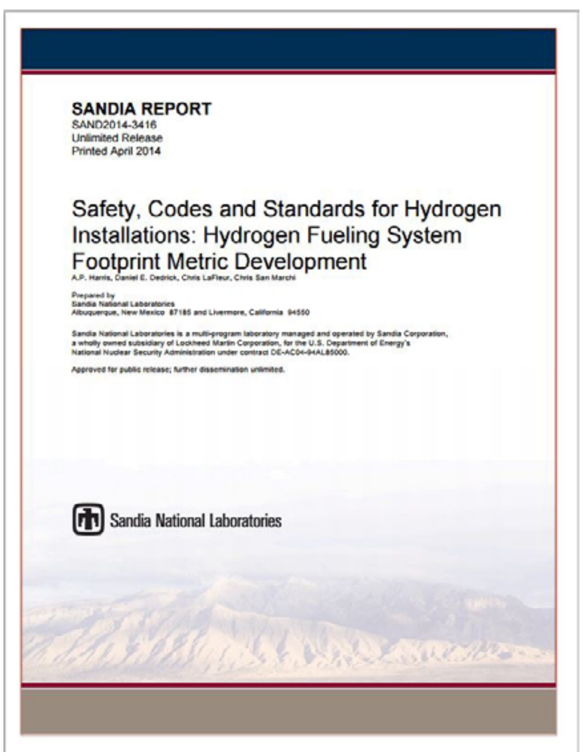
A variety of factors determine whether or not a piece of land is suitable for a hydrogen station. These include two fundamental categories:

1. Social constraints: property ownership and structure, adjacent property owners, zoning, and planning issues (traffic flow, aesthetics, parking, etc.)
2. Physical constraints: equipment design/footprint and associated setback distances.

Many of the social factors are discussed in the main body of the guidebook. This appendix focuses on the physical aspects of a adding a hydrogen dispenser to an existing gasoline/diesel station or other site. If fueling equipment cannot fit on the site, with or without mitigation measures in place, the project will not move forward.

Ultimately, the local fire marshal decides whether or not a site can physically host a proposed hydrogen station. This decision is based on the fire marshal's review of proposed plans and interpretation of locally recognized fire code. Local interpretation and on-the-ground reality can result in different solutions in different locations. However, information from NFPA 2, Hydrogen Technologies Code (2011 version) can and should be used to estimate a site's ability to host a hydrogen station.[80]

Table B.1 is a summary table that consolidates information from the NFPA 2 (2011 edition). The table is pulled from the Sandia National Laboratories April 2014 *Safety, Codes and Standards for Hydrogen Installations: Hydrogen Fueling System Footprint Metric Development* report (hereafter referred as the "Sandia H2 Footprint Study").[81]


SANDIA REPORT
SAND2014-3416
Unlimited Release
Printed April 2014

Safety, Codes and Standards for Hydrogen Installations: Hydrogen Fueling System Footprint Metric Development

A.P. Harris, Daniel E. Dedrick, Chris LaFleur, Chris San Marchi

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Approved for public release; further dissemination unlimited.

Sandia National Laboratories

80 The State of California adopted the 2011 version of NFPA 2 in July 2014. It became effective on July 1, 2015. The notice from the Office of the State Fire Marshal can be found in Appendix F.

81 *Safety, Codes and Standards for Hydrogen Installations: Hydrogen Fueling System Footprint Metric Development*, A.P Harris, Daniel Dedrick, Chris LaFleuer, Chris San Marchi. Sandia National Laboratories. SAND2014-3416 (April 2014). energy.sandia.gov/wp-content/gallery/uploads/SAND_2014-3416-SCS-Metrics-Development_distribution.pdf

Table B.1: Summary of example separation distances from NFPA 2 (2011 edition). Critical distances used in developing the diagrams below are shown in bold. Note: the distances below reflect one pressure and pipe diameter case; a change in either variable could impact separation distances. For example, a smaller pipe diameter would decrease the necessary separation distance.

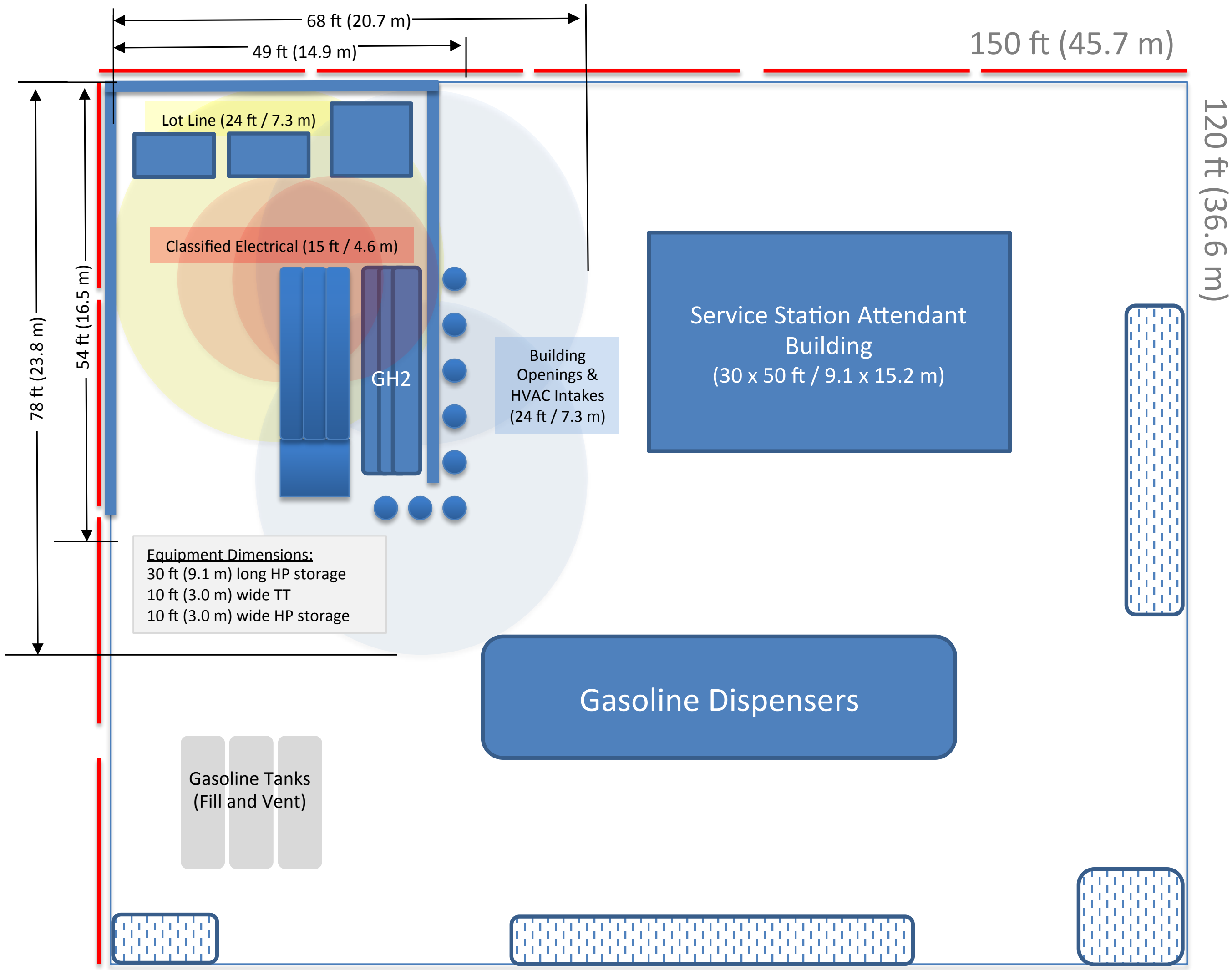
Separation Distances and Areas Required		
Fuel system descriptions: GH2 – 12,500 psi (862 bar) storage, 100 kg, 0.4 in (10 mm) ID tubing with a barrier wall LH2 – 3,500 - 15,000 gallon (13,250-56,780 liters) with barrier wall and insulation	GH2 ft (m)	LH2 ft (m)
Lot lines	24 (7.3)	33 (10)
Public streets, alleys	24 (7.3)	33 (10)
Parking (public assembly)	13 (4.0)	75 (23)
Buildings (sprinklers, fire rated)	10 (3.0)	5 (1.5)
Building openings or air intakes	24 (7.3)	75 (23)
Flammable and combustible liquid storage, vents or fill ports	10 (3.0)	50 (15)
Parking from fill concentrations on bulk storage	13 (4.0)	25 (7.6)
Class 1 Division 2 area diameter	15 (4.6)	15 (4.6)
Maximum bulk storage equipment dimension with lot lines	54 (16)	40 (12)
Minimum bulk storage equipment dimension with lot lines	49 (15)	40 (12)
Maximum bulk storage dimension with separation distances	78 (24)	123 (37)
Minimum bulk storage dimension with separation distances	68 (21)	123 (37)
Reference Area: bulk storage equipment with lot lines	2,646 ft^2 (246 m^2)	1,600 ft^2 (149 m^2)
Reference Area: storage with separation distances	**5,304 ft^2 (493 m^2)**	**15,129 ft^2 (1406 m^2)**
Note: Add 5 feet (1.5 meters) for vehicle protection on vehicle facing sides of equipment		

From: Safety, Codes and Standards for Hydrogen Installations: Hydrogen Fueling System Footprint Metric Development. Sandia National Laboratories. SAND2014-3416 (April 2014)
energy.sandia.gov/wp-content/gallery/uploads/SAND_2014-3416-SCS-Metrics-Development_distribution.pdf

The Sandia H2 Footprint Study uses the bolded numbers presented in Table B.1 to establish two reference stations—gaseous and liquid—that llustrate baseline setback distances. For illustration, stations are placed on a typical 18,000-square-foot lot.

Figure B.1: Gaseous hydrogen reference station

18,000 ft^2 (672 m^2) station site with 5,500 ft^2 (11 m^2) of open space. This figure reflects the example separation distances shown in Table B.1.

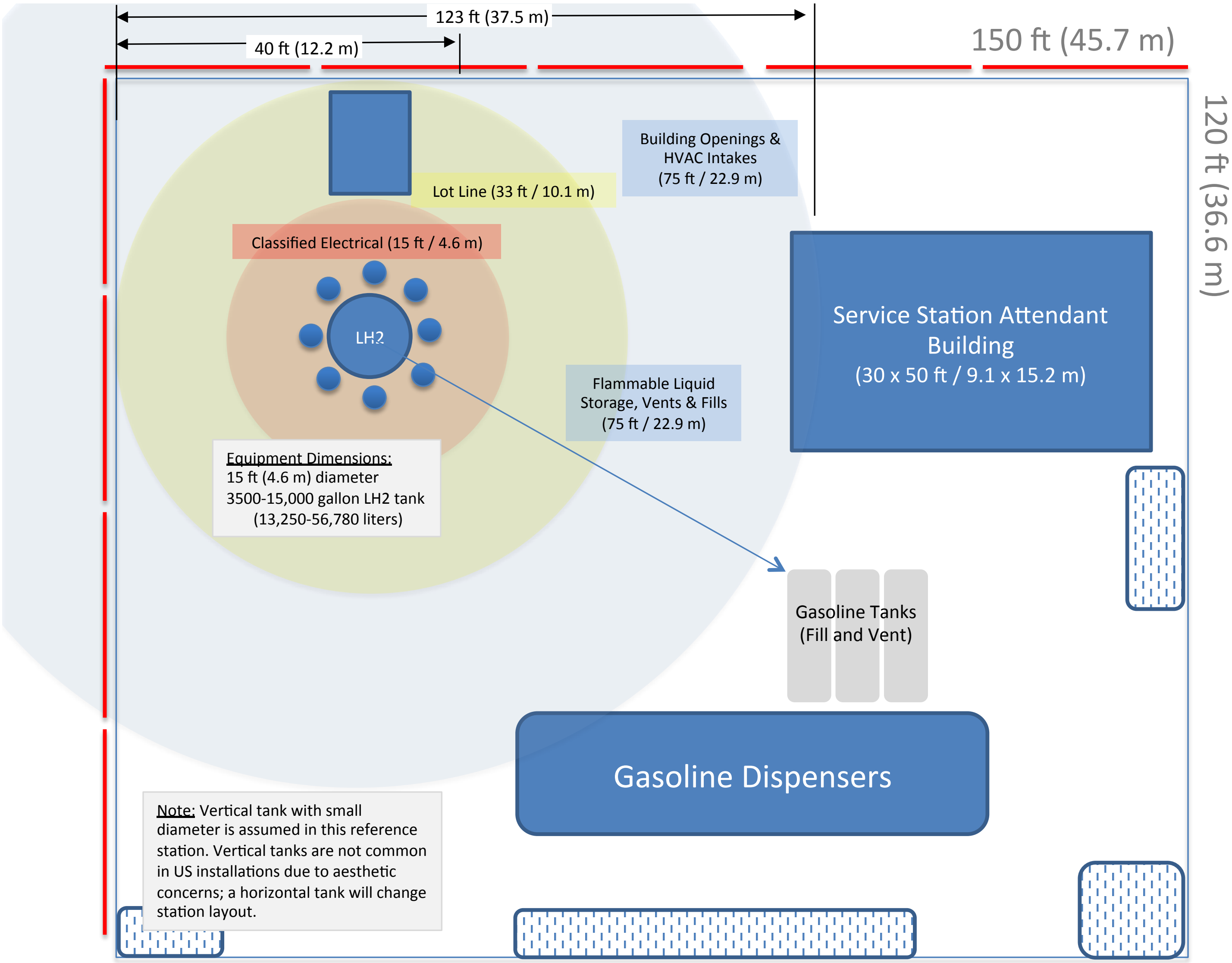


Credit: Sandia H_2 Footprint Study

- 100 kg GH2 storage
- 3 bank cascade and tube trailer
- 1 compressor and associated pre-cooler equipment (70 kg/day capacity
- 1 dual hose dispenser

Figure B.2: Liquid hydrogen reference station

18,000 ft^2 (672 m^2) station site with 5,500 ft^2 (11 m^2) of open space. This figure reflects the example separation distances shown in Table B.1.



Credit: Sandia H_2 Footprint Study

- 3,500-15,000 gallons (13,250-56,780 liters) (910-1,300 kg)
- LH2 storage (200-300 kg/day capacity)
- 1-2 dual hose dispensers

The GH2 station and associated setback distances fit on the sample lot without the need for setback distance mitigation. The LH2 system, however, faces two related challenges. First, the required setback distances are greater than what the site can accommodate. Second, the diagram assumes the most-forgiving setback arrangement: a vertical tank and cryogenic cooling system, which is unlikely to be approved in many jurisdictions given aesthetic restrictions related to equipment height. In all likelihood, the storage tanks would need to be horizontally arranged, increasing the required setback area.

Setting up a Station for Success

The process of actual station siting can be a flexible, iterative process with local officials. As discussed above, Figures B.1 and B.2 reflect pure setback distances without mitigation measures. In the simplest permitting scenario, setback distances would be fully supported by the site. However, in reality, each site is likely to have one or more constraints that well-designed mitigation measures can overcome. Mitigation measures may include firewalls, obtaining setback credit from adjacent sites, and alternative designs.

Code Development

Hydrogen has been safely used in commercial applications for decades, a fact that is reflected in hydrogen codes and standards. The challenge is bringing this operational history into the retail environment, which generally offers less free space and untrained public access. There is substantial interest in increasing the flexibility associated with bringing hydrogen into retail environments while maintaining acceptable risk profiles.[82]

NFPA 2 demonstrates considerable progress toward safe and practical retail hydrogen deployment, and code officials will continue to learn through its application. As the above reference stations demonstrate, liquid hydrogen has a particular challenge: it is difficult to find sites with 75-foot separation between potential equipment placement and buildings/parking. This challenge is far from the end of the story. An active effort is underway to determine if lesser setback distances can be justified and codified for liquid hydrogen. There is reason to believe that answer is yes, as the required separation distances have been cut in half in Europe.

82 Risk exists for all fuels: gasoline, diesel, CNG, electricity, hydrogen, etc. Risk tolerance is subjective, but also quantifiable. The current codes and standards regime ensures that a hydrogen station is as safe or safer than a typical gasoline station.

VEHICLE DIAGRAMS

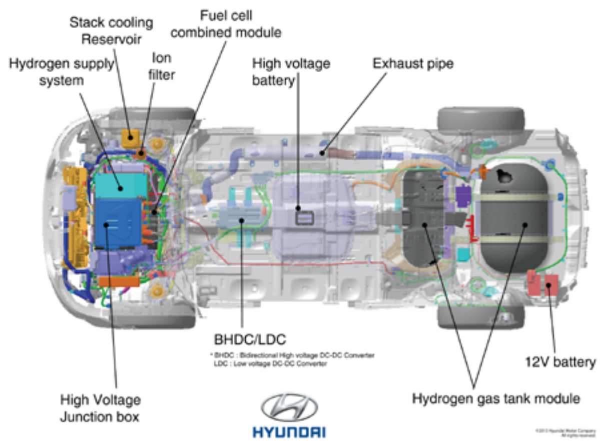
The "Fuel Cell Electric Vehicles" section describes how a FCEV works. The following diagrams offer windows into commercially available FCEVs. More information can be found on each manufacturer's website.

Honda FCX Clarity

automobiles.honda.com/fcx-clarity/

Hyundai Tucson Fuel Cell

www.hyundaiusa.com/tucsonfuelcell

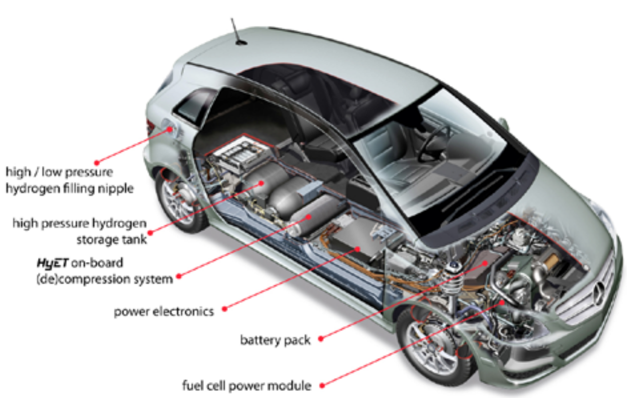


Toyota Mirai

www.toyota.com/mirai/

Mercedes F-CELL

www.mbusa.com/mercedes/benz/green/electric_car



EXAMPLE BUILDING PERMIT

Section 1: Basic Identifying Information

Example

Jurisdiction of ___________________, ______________(state)
Building/ Fire Permit For Hydrogen Dispensing Installation

Compliance with the following permit will allow the construction and operation of a hydrogen dispensing installation in the __________________ jurisdiction. This permit addresses the following situations:

1. The addition of a hydrogen dispensing and storage system to an existing fueling station
2. TBD

This permit contains a general reference to the California fire and Building Codes or equivalent codes used in the jurisdiction. All work and installed equipment will comply with the requirements of XXXX code used in the jurisdiction. The jurisdiction maintains the authority/responsibility to conduct any inspections deemed necessary to protect public safety.

Section 2: Code Requirements

Identifies code requirements and addresses specific elements of station safety:

1. Approval/listing and labeling requirements
2. Piping code compliance
3. Storage vessel stamps/approval

Example

Topic	Permit Requirements
Siting	Do storage and dispenser systems meet separation distance requirements?
Mechanical	Is equipment listed or approved? Valves, Pressure Relief Devices (PRDs), Piping, Containers, Hoses, Nozzles
Electrical	Is equipment proximate to dispenser classified?
Maintenance	Have maintenance requirements been defined in permit application? Is documentation required?
Emergency response	Are E-stops accessible? Do they have a plan? Are personnel trained? Is communication with the fire department and other emergency responders clearly defined?
Sensors	Do sensors detect releases or upset conditions? Is the information from sensors conveyed to the process equipment, operators, and fire department?

Section 3: Standard Certification Statement

By signing the certification statement the applicant agrees to comply with the standard permit conditions and other applicable requirements. This consent would give the jurisdiction the option of allowing the applicant to proceed with installation and operation of the dispensing equipment.

Example

I hereby certify that the electrical work described on this permit application shall be/has been installed in compliance with the conditions in this permit, NFPA 70, National Electric Code, and the Fire Code currently adopted and enforced within the jurisdiction of installation. By agreeing to the above requirements, the licensee or owner shall be permitted to construct and operate the hydrogen station.

Signature of Owner *Date*

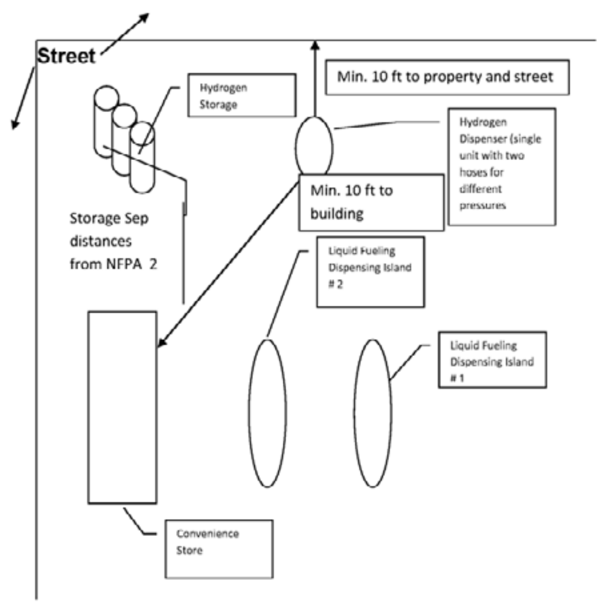
Section 4: Jurisdiction Checklist

A checklist the jurisdiction could develop to track key information on the application. A few items of the many that the jurisdiction might wish to track are:

1. Unique requirements in the jurisdiction such as seismic requirements
2. Summary of California Risk Management Plan (RMP) analysis if subject to RMP
3. Summary of California Environmental Quality Act Compliance (CEQA) analysis

Section 5: Schematic (optional)

A schematic drawing that shows the arrangement of the equipment. The example is to show how the station equipment could be arranged and is not intended to convey any permit requirements.



Template from NREL's *Regulations, Codes, and Standards (RCS) Template for California Hydrogen Dispensing Stations* at www.nrel.gov/docs/fy13osti/56223.pdf and available at h2readiness.com.

ORGANIZATIONS

Organization	Purpose (as it relates to hydrogen and FCEVs)	Website	Contact
Governor's Office of Business and Economic Development (GO-Biz)	GO-Biz provides resources and assistance for zero-emission vehicle infrastructure development and permitting processes.	www.business.ca.gov/Programs/Permits.aspx	Tyson Eckerle Zero-Emission Vehicle Infrastructure Project Manager (916) 322-0563 Tyson.eckerle@gov.ca.gov
California Energy Commission (CEC)	Through the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), CEC invests up to $20 million annually in fueling infrastructure to grow the network of hydrogen stations in California.	www.energy.ca.gov/drive/technology/hydrogen_fuelcell.html	Miki Crowell (916) 653-0363 Miki.Crowell@energy.ca.gov
California Air Resources Board (ARB)	ARB adopts technology-advancing vehicle emission standards under California's Advanced Clean Cars program, aiming to improve public health and air quality. Specific to hydrogen, ARB issues an annual evaluation of FCEVs and station deployment, pursuant to AB8. The evaluation assesses the current and future FCEV vehicle numbers and current and future hydrogen stations and capacity. In addition, ARB works with FCEV and hydrogen stakeholders to identify and proactively resolve potential impediments.	www.arb.ca.gov/msprog/zevprog/hydrogen/hydrogen.htm	Catherine Dunwoody Chief, Fuel Cell Program (916) 324-5070 Catherine.dunwoody@arb.ca.gov
California Department of Food and Agriculture, Division of Measurement Standards (DMS)	DMS regulates the quantity and quality of hydrogen fuel, to protect the public and ensure fair competition within industry. DMS certifies the accuracy of hydrogen dispensers, enforces fuel quality standards, and enforces advertising and labeling standards.	www.cdfa.ca.gov/dms	Kevin Schnepp Alternative and Renewable Fuels Program Manager (916) 229-3000 Kevin.schnepp@cdfa.ca.gov
California Building Standards Commission (CBSC)	CBSC is authorized by California Building Standards Law to administer the many processes related to the development, adoption, approval, publication, and implementation of California's building codes.	www.bsc.ca.gov	Jim McGowan Executive Director (916) 263-0916 Jim.mcgowan@dgs.ca.gov
California Department of Forestry and Fire Protection, Office of the State Fire Marshal (OSFM)	The mission of OSFM is to protect life and property through the development and application of fire prevention engineering, education, and enforcement. In relation to hydrogen, OSFM provides guidance on the California Fire Code for station development and safe handling of materials. In 2011, California became the first state jurisdiction in the nation to adopt NFPA 2, a code that provides fundamental safeguards for the generation, installation, storage, piping, use, and handling of hydrogen in compressed gas or liquid form.	osfm.fire.ca.gov	Steve Guarino Supervising Deputy State Fire Marshal (916) 341-6641 Steve.guarino@fire.ca.gov

Organization	Purpose (as it relates to hydrogen and FCEVs)	Website	Contact
California Fuel Cell Partnership (CaFCP)	The California Fuel Cell Partnership is a collaboration of organizations, including auto manufacturers, energy providers, government agencies and fuel cell technology companies, that work together to promote the commercialization of hydrogen fuel cell vehicles.	www.cafcp.org	Jennifer Hamilton Safety & Education Specialist California Fuel Cell Partnership (916) 371-2870 jjhamilton@cafcp.org
Bay Area Air Quality Management District (BAAQMD)	BAAQMD is the public agency entrusted with regulating stationary sources of air pollution in the nine counties that surround San Francisco Bay. BAAQMD also provides incentive funding for alternative fuel vehicle and infrastructure projects and is responsible for issuing necessary air quality permits for stations that conduct regulated activities.	www.baaqmd.gov/grants	Chengfeng Wang Supervising Air Quality Specialist (415) 749-8647 cwang@baaqmd.gov
South Coast Air Quality Management District (SCAQMD)	SCAQMD is the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties. SCAQMD provides funding for hydrogen stations in the region, helping to promote the commercialization of fuel cell electric vehicles. In addition, SCAQMD is responsible for issuing air quality permits for certain types of hydrogen stations during the development process.	www.aqmd.gov/home/library/technology-research/projects	Lisa Mirisola Program Supervisor Science & Technology Advancement (909) 396-2638 Lmirisola@aqmd.gov
U.S. Department of Energy (DOE)	Through the Hydrogen and Fuel Cells Program, DOE works in partnership with industry, academia, national laboratories and international agencies to overcome technical barriers of hydrogen technology, address safety concerns, validate new technologies in real-world conditions, and educate key stakeholders in the early marketplace.	www.hydrogen.energy.gov	Charles (Will) James Jr, PhD Safety, Codes, and Standards Program Manager (202) 287-6223 Charles.James@EE.Doe.Gov
Sandia National Laboratories	Sandia's Hydrogen Program supports the nation's energy strategy, helping to diversify America's energy sector and reduce our dependence on foreign oil. Sandia provides the science and engineering to accelerate the deployment of clean and efficient hydrogen and fuel cell technologies.	energy.sandia.gov/transportation-energy/hydrogen	Chris San Marchi Hydrogen and Fuel Cells Program (925) 294-4880 cwsanma@sandia.gov
Pacific Northwest National Laboratory (PNNL)	PNNL works to advance the frontiers of science and address some of the most challenging problems in energy, the environment, and national security. PNNL provides research and engineering to advance fuel cell commercialization.	www.pnnl.gov	Jamie Holladay Sector Lead Hydrogen Fuel Cells (509) 371-6692 Jamie.holladay@pnnl.gov

Organization	Purpose (as it relates to hydrogen and FCEVs)	Website	Contact
Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST)	H2FIRST is a project launched by DOE's Fuel Cell Technologies Office (FCTO) within the Office of Energy Efficiency and Renewable Energy. The project leverages capabilities at the national laboratories to address the technology challenges related to hydrogen refueling stations. The H2FIRST objective is to ensure that fuel cell electric vehicle (FCEV) customers have a positive fueling experience similar to conventional gasoline/diesel stations as vehicles are introduced (2015–2017) and transition to advanced fueling technology beyond 2017. The H2FIRST activities are expected to positively impact the cost, reliability, safety, and consumer experience of FCEV stations.	energy.gov/eere/fuelcells/h2first	Joe Pratt H2FIRST Project Co-Lead Sandia National Laboratories (925) 294-2133 jwpratt@sandia.gov Chris Ainscough H2FIRST Project co-Lead National Renewable Energy Laboratory (720) 431-7296 Chris.Ainscough@nrel.gov
Hydrogen Safety Panel (HSP)	The HSP is a 14-member group having a broad cross-section of expertise from the commercial, industrial, government, and academic sectors. The HSP seeks to identify safety-related technical data gaps, best practices, and lessons learned, and to help integrate safety planning into hydrogen and fuel cell projects to ensure that the appropriate hydrogen safety practices are addressed and incorporated. The Panel's project-related activities include reviewing equipment and facility designs, risk assessments and safety plans, and conducting site safety reviews.	www.h2tools.org/hsp	Nick Barilo Manager Hydrogen Safety Program (509) 371-7894 nick.barilo@pnnl.gov
University of California, Berkeley (UC Berkeley)	Through the Transportation Sustainability Research Center (TSRC) at the Institute of Transportation Studies, UC Berkeley analyzes the real world and potential future performance of hydrogen fuel cell electric vehicles. TSRC research focuses on technical performance, economics, policy analysis, behavioral response and environmental impacts of fuel cell technology. TSRC works with automakers to assess infrastructure needs and analyze and test vehicles and fueling stations.	tsrc.berkeley.edu/projectarea/advancedvehicles	Timothy Lipman Co-Director TSRC, UC Berkeley (510) 642-4501 telipman@berkeley.edu
University of California, Davis (UC Davis)	Through the Sustainable Transportation Energy Pathways research consortium at the UC Davis Institute of Transportation Studies, researchers are exploring new areas such as hydrogen/electricity systems, regional transition case studies, understanding the impact of alternative policies, and enhancing key hydrogen pathways models for infrastructure development strategies.	steps.ucdavis.edu/?energy-category=hydrogen	Dr. Joan Ogden Professor, Environmental Science and Policy, and STEPS Director (530) 752-2768 jmogden@ucdavis.edu

Organization	Purpose (as it relates to hydrogen and FCEVs)	Website	Contact
University of California, Irvine (UC Irvine)	UC Irvine is home to the National Fuel Cell Research Center, dedicated in 1998 by the U.S. Department of Energy and the California Energy Commission to accelerate the development and deployment of fuel cell technology, to provide an outreach to the market, to address market hurdles, and to provide leadership in the preparation of educational materials and programs throughout the country. In addition, UC Irvine's Hydrogen Program, a component of the Advanced Power and Energy Program, actively develops and demonstrates energy technologies that generate and utilize hydrogen.	www.nfcrc.uci.edu/3/research/keyInitiatives/hydrogen/Index.aspx	Professor Scott Samuelsen Director National Fuel Cell Research Center (949) 824-5468 gss@nfcrc.uci.edu
H2USA	H2USA is a public-private partnership to promote the commercial introduction and widespread adoption of hydrogen fueled fuel cell electric vehicles across America. H2USA's mission is to address hurdles to establishing hydrogen fueling infrastructure, enabling the large scale adoption of fuel cell electric vehicles.	h2usa.org	Morry Markowitz Secretariat (202) 261-1331 info@h2usa.org
Fuel Cell and Hydrogen Energy Association (FCHEA)	FCHEA is the trade association dedicated to the commercialization of fuel cells and hydrogen energy technologies. FCHEA represents the full global supply chain, including material component and system manufacturers, hydrogen producers and fuel distributors, government laboratories and agencies, trade associations, utilities, and other end users.	www.fchea.org	Connor Dolan Director of External Affairs (202) 261-1331 cdolan@fchea.org
Clean Cities	Hydrogen Best Practices book and website	h2readiness.com	Your Clean Cities Coordinator


Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC