CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Diamond Bar SmartFuel Hydrogen Station

Prepared for: California Energy Commission

Prepared by: Air Products and Chemicals, Inc.

Gavin Newsom, Governor

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California Energy Commission

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- The California Energy Commission
- The Governor's Office of Business and Economic Development (thanks to Tyson Eckerle for his efforts)
- South Coast Air Quality Management District
- John Cornish and Mike Archibald at Engineering, Procurement and Construction LLC

Air Products and Chemicals, Inc. also acknowledges the efforts of its engineering and operations teams for their ongoing commitment to safety in the deployment of this hydrogen refueling station.

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-09-608 to provide funding opportunities for projects which expand the network of publicly accessible hydrogen refueling stations to serve the population of fuel cell electric vehicles (FCEVs) and to accommodate the planned large-scale roll-out of FCEVs commencing in 2015. In response to PON-09-608, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards November 17, 2010 and the agreement was executed as ARV-10-048 on December 21, 2011.

ABSTRACT

Air Products and Chemicals, Inc. designed, engineered, permitted, constructed, and made operational a hydrogen refueling station at 21865 E. Copley Drive, Diamond Bar (Los Angeles County). The Diamond Bar SmartFuel® hydrogen station was approved for construction on February 14, 2014, and began public refueling in August of 2015. The station receives gaseous hydrogen delivered at elevated pressure from an Air Products and Chemicals, Inc. production facility in southern California. The station, comprised of compression, cooling, and a two-hose dispenser with a customer payment interface, is used to refill fuel cell electric vehicles.

Keywords: California Energy Commission, Diamond Bar, Air Products and Chemicals, Inc., fuel cell electric vehicles, SmartFuel® hydrogen refueling station

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EXECUTIVE SUMMARY

Hydrogen fuel cell electric vehicles (FCEVs) and hydrogen refueling stations are expected to play key roles in California as the State transitions to lower-carbon and zero-emission vehicle technologies for light-duty passenger vehicles, transit buses, and truck transport fleets. Numerous government regulations and policy actions identify FCEVs as a vehicle technology that will be available to meet the California Air Resources Board's zero-emission vehicle regulation and the specific actions to bring FCEVs to California markets specified in the Governor's Zero Emission Vehicle Action Plan.

Hydrogen fuel cell electric drive technology offers tremendous potential for the light-duty passenger vehicle market and medium- and heavy-duty truck and bus markets. FCEV passenger vehicles can drive more than 300 miles on a tank of hydrogen and can be refueled in 3 to 4 minutes the way gasoline passenger vehicles are fueled. They have zero tailpipe emissions, while the carbon footprint of these vehicles is nearly the same as plug-in electric vehicles. The technology can be readily scaled up for sport utility vehicles, family passenger vans, pickup trucks, urban package and beverage delivery trucks, and even heavy-duty trucks and buses. Most auto industry analysts and agencies view fuel cell electric drive technology as a complement to battery electric drive technologies rather than as a competing technology. Both battery and FCEV technologies will be needed in California to achieve the zero-emission-vehicle deployment goals.

In contrast to battery electric and plug-in hybrid electric vehicles that can be charged at home, FCEVs require a new network of refueling stations that dispense pressurized hydrogen for consumer use. This has meant that the auto industry and station development industry have had to develop two new technologies in parallel: hydrogen refueling infrastructure and hydrogen FCEVs. FCEVs cannot be widely marketed and sold to consumers without a minimum network of refueling stations available.

Assembly Bill 8 (AB 8, Perea, Chapter 401, Statutes of 2013) reauthorized the original Assembly Bill 118 funding program (Núñez, Chapter 750, Statutes of 2007) and created new legal requirements for the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program. The bill directs the California Energy Commission to allocate up to $20 million per year, or up to 20 percent of each fiscal year's available funding, to develop hydrogen refueling stations "until there are at least 100 publicly available hydrogen- refueling stations in operation in California" (Health and Safety Code 43018.9[e][1]).

The California Energy Commission contributed $845,490 of the total $1,017,310 budget to design, engineer, permit, construct, and make the Diamond Bar SmartFuel® hydrogen station operational.

The site for this project is 21865 E. Copley Drive, Diamond Bar (Los Angeles County). A hydrogen refueling station at this location will serve FCEVs in the area. Air Products and Chemicals, Inc. accomplished this goal through the steps outlined below.

Air Products and Chemicals, Inc. worked with Engineering, Procurement and Construction LLC, who was responsible for securing site access from South Coast Air Quality Management District. These negotiations were finalized in October of 2014.

Engineering, Procurement and Construction LLC was also responsible for site design, construction, and operation of the Diamond Bar SmartFuel® hydrogen station. The design work was initiated in January of 2012. Following several iterations of the equipment layout to meet the requirements of the host site, Engineering, Procurement and Construction LLC was able to complete the station design and begin discussions with the City of Diamond Bar in June of 2013. Preliminary layout and elevation drawings were submitted to and approved by the City on August 14, 2013. Detailed drawings were then prepared and submitted on November 20, 2013. The City of Diamond Bar and the Los Angeles County Fire Department approved the station design on February 14, 2014.

Air Products and Chemicals, Inc. provided the hydrogen refueling station equipment. On March 3, 2013, Engineering, Procurement and Construction LLC started demolition work to remove unused equipment in advance of the installation of foundations, piping and conduit for the hydrogen refueling station. Construction activities were completed on July 14, 2014.

The process of making the Diamond Bar SmartFuel® hydrogen station operational began on July 14, 2014 and was completed in November of 2014. Approval of the hydrogen dispenser for retail operations by the California Department of Measurements and Standards was received in two separate tests: type approval of the SmartFuel hydrogen dispenser on December 19, 2014, and performance testing which was completed on February 11, 2015. The Diamond Bar SmartFuel® hydrogen station was the first station in California to receive H70-T40 type dispenser approval and achieve the H70 5.0 accuracy class.

Following the Division of Measurement Standards approval, automakers and their customers began to use the Diamond Bar SmartFuel® hydrogen station. On March 25, 2015, South Coast Air Quality Management District hosted a ceremony which officially opened the Diamond Bar SmartFuel® hydrogen station.

The Diamond Bar SmartFuel® hydrogen station can dispense 180 kilograms of hydrogen per day with daily truck deliveries of hydrogen. The station has the potential to contribute to the reduction of more than 1,200 metric tons of greenhouse gas emissions and to displace more than 170,000 gallons of gasoline consumption annually.

CHAPTER 1:
Station Design and Construction

This section highlights the most critical items related to the development of the Diamond Bar hydrogen station, provides detail on each, and states the timing required for each step for this particular site.

1.1 Site Acquisition through Construction (January 2012 – July 2014)

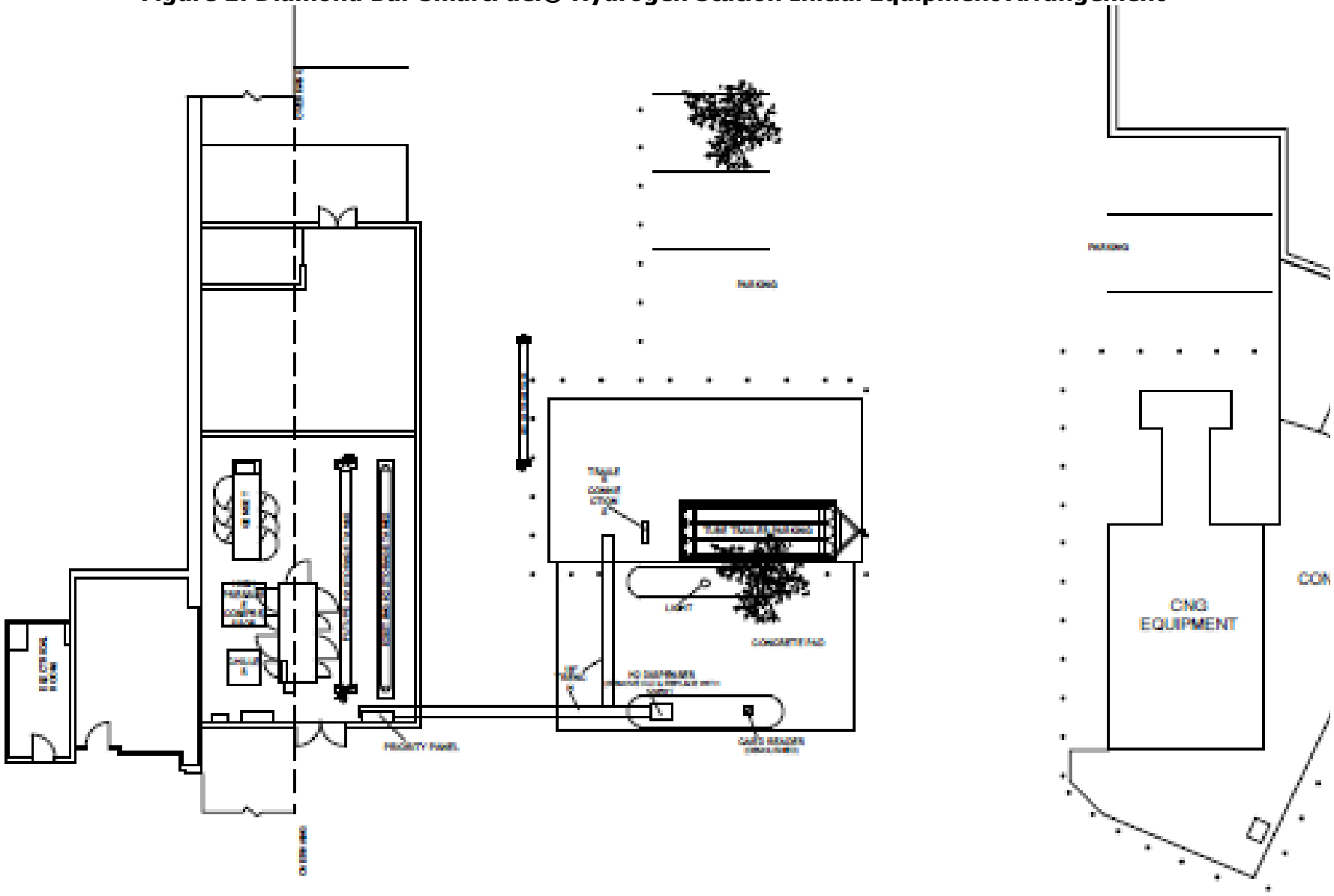
Following the kick-off of Grant Agreement ARV-10-048, Air Products and Chemicals, Inc. began discussions with Engineering, Procurement and Construction LLC, who was responsible for securing site access from South Coast Air Quality Management District, who had agreed to serve as the host site for the hydrogen station project.

Air Products and Chemicals, Inc. began the site design efforts with a visit to the station at the end of January of 2012. A preliminary site layout was generated and reviewed, with Engineering, Procurement and Construction LLC who carried out site design, construction, and operation. As additional information on the equipment components became available, Air Products and Chemicals, Inc. provided these details to Engineering, Procurement and Construction LLC, who developed an updated equipment arrangement (Figure 1).

During review meetings in September of 2012, it was reported that South Coast Air Quality Management District needed to limit the amount of space for the hydrogen station. This led to a revised arrangement whereby the drop-and-swap delivery trailer would be replaced by a permanent ground storage module. Once issues for disposal of idle equipment from an existing onsite hydrogen station were resolved, Air Products and Chemicals, Inc. and Engineering, Procurement and Construction LLC finalized the budget and, on January 23, 2013, both parties executed a subcontract for station design. At the same time, Air Products and Chemicals, Inc. and Engineering, Procurement and Construction LLC executed the other contracts related to the Diamond Bar station equipment and hydrogen supply.

Immediately after execution of Grant Agreement ARV-10-048, Air Products and Chemicals, Inc. began the equipment design and procurement activities for the eight sets of SmartFuel® hydrogen station equipment that would be deployed as part of the overall project of eight stations with one set going to Diamond Bar. A draft scope of work for the equipment design efforts was prepared in April of 2012. Purchase orders for long-lead items began to be issued in the summer of 2012, and the design team began to fabricate a prototype of several of the key containerized components; any lessons learned from this effort could then be used in the design and fabrication of the remaining units.

Figure 1: Diamond Bar SmartFuel® Hydrogen Station Initial Equipment Arrangement



Source: Air Products and Chemicals, Inc. Original figure is higher resolution

The high-pressure storage vessels have the longest lead times. At the time of project execution, only one vendor could provide these tubes. The first set of vessels was delivered to Air Products and Chemicals, Inc. in June of 2013, and the remaining tubes were shipped beginning in April of 2014.

Engineering, Procurement and Construction LLC began discussions with the City of Diamond Bar regarding the permitting of the hydrogen station on June 4, 2013. Preliminary layout and elevation drawings were submitted to and approved by the City on August 14, 2013. Detailed drawings were prepared and submitted on November 20, 2013. Plan check corrections were received on December 24, 2013, and updated drawings were submitted on January 17, 2014. The City did not require a zoning for the hydrogen equipment in Diamond Bar. The City and fire department responded quickly to document submittals and the Los Angeles County Fire Department approved the station design on February 14, 2014.

On March 3, 2013, Engineering, Procurement and Construction LLC started removing equipment from the previous station that would not be used prior to installing foundations, piping and conduit. Hydrogen compression, cooling, and dispensing equipment was delivered to the site on May 19, 2014 and construction activities were completed on July 14, 2014.

Site access conditions were finalized by Engineering, Procurement and Construction LLC and South Coast Air Quality Management District in October of 2014 and station commissioning continued following a three-month suspension.

1.2 Making the Station Operational (July 14, 2014 – August 18, 2015)

Following the completion of construction, commissioning activities were undertaken by Air Products and Chemicals, Inc. engineering and operations staff. Initial equipment operation, hydrogen sampling, and test fills into an Air Products and Chemicals, Inc. test tank were performed. Test fills of FCEVs were completed in November of 2014.

1.3 Certification and Initial Operation (December 15, 2014 – February 11, 2015)

The California Department of Food and Agriculture's Division of Measurement Standards enforces, California weights and measures laws and regulations and certifies any device used for metering the sale of commercial items within California. The Diamond Bar site was the first deployment of the SmartFuel® hydrogen dispenser, so type-approval testing was performed from December 15-19, 2014. This allowed Engineering, Procurement and Construction LLC to sell hydrogen to consumers for a 90-day period until permanence testing could be scheduled. These tests, which resulted in the permanent Division of Measurement Standards approval for the Diamond Bar SmartFuel® dispenser, took place on February 10-11, 2015. Figure 2 shows a Daimler vehicle refueling immediately after final certification.

Figure 2: Diamond Bar SmartFuel® Dispenser Following Certification

Source: Air Products and Chemicals, Inc.

The Diamond Bar SmartFuel® hydrogen station was the first location in California to receive H70-T40 type approval and achieve the H70 5.0 accuracy class approval. Following Division of Measurement Standards certification, the City of Diamond Bar approved the operation of the Diamond Bar SmartFuel® hydrogen station on February 17, 2015.

1.4 Station Declared Operational (March 25, 2015)

Following the Division of Measurement Standards type approval in December of 2014, automakers and their customers began to use the Diamond Bar SmartFuel® hydrogen station. On March 25, 2015, South Coast Air Quality Management District hosted a ceremony which officially opened the Diamond Bar SmartFuel® hydrogen station. Following the official opening ceremony automaker testing continued at the station and Air Products and Chemicals, Inc. continued to work with Engineering, Procurement and Construction LLC (station operator) to troubleshoot intermittent issues with the point-of-sale system. Additional discussion may have reduced the time (13 months) between construction completion and first public use including point of sale system issues that added 5 months to the timeline.

1.5 Customer Use (August 18, 2015 – Present)

The first public customer fueled at the Diamond Bar SmartFuel® hydrogen station in August of 2015, and the station has been used regularly since then. Dispensed volumes totaled 135 kilograms in September 2015, 134 kilograms in October 2015, and 203 kilograms in November 2015.

1.6 Station Operational Status System

The California Fuel Cell Partnership, Station Operational Status System is a website portal[1] designed to provide hydrogen station status for motorist use. This system is important to FCEV drivers during the development phase of the hydrogen refueling station network because it lets drivers know that the hydrogen station, they intend to use is operational before they depart. The San Jose hydrogen station began sending automated updates on a regular basis, to the Station Operational Status System in September of 2015.

1.7 Environmental Impacts

Hydrogen is stored as a compressed gas in an above-ground tank located behind a wall at this station. In accordance with the funding agreement with the California Energy Commission, 33.3 percent of the hydrogen sold at the Playa Del Rey hydrogen station will be produced from renewable sources including biogas. Hydrogen is nontoxic, colorless, and odorless, so hydrogen station equipment is outfitted with appropriate sensors to provide immediate notification in case a leak occurs. No solid or liquid waste will be produced at this site.

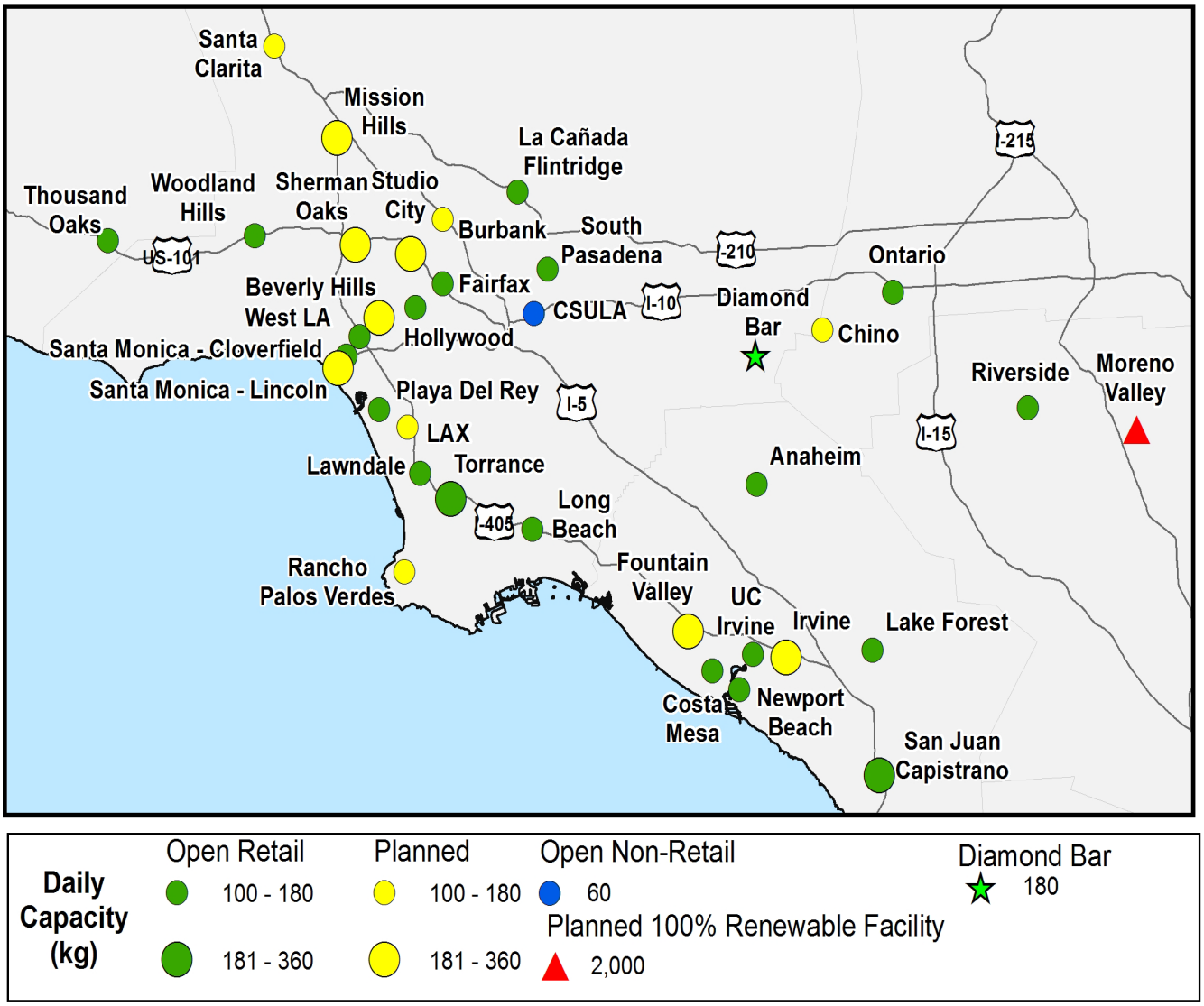
There was no additional landscaping added for the construction of the hydrogen refueling station, and, therefore, no additional irrigation water will be consumed.

1.8 Diamond Bar SmartFuel® Hydrogen Station in the Network

Figure 3 shows the greater Los Angeles area map which indicates where the Diamond Bar station is situated in relationship to other facilities in the southern part of the state.

[1] California Fuel Cell Partnership Station Status. (https://m.cafcp.org/).

Figure 3: The Diamond Bar SmartFuel® Hydrogen Station

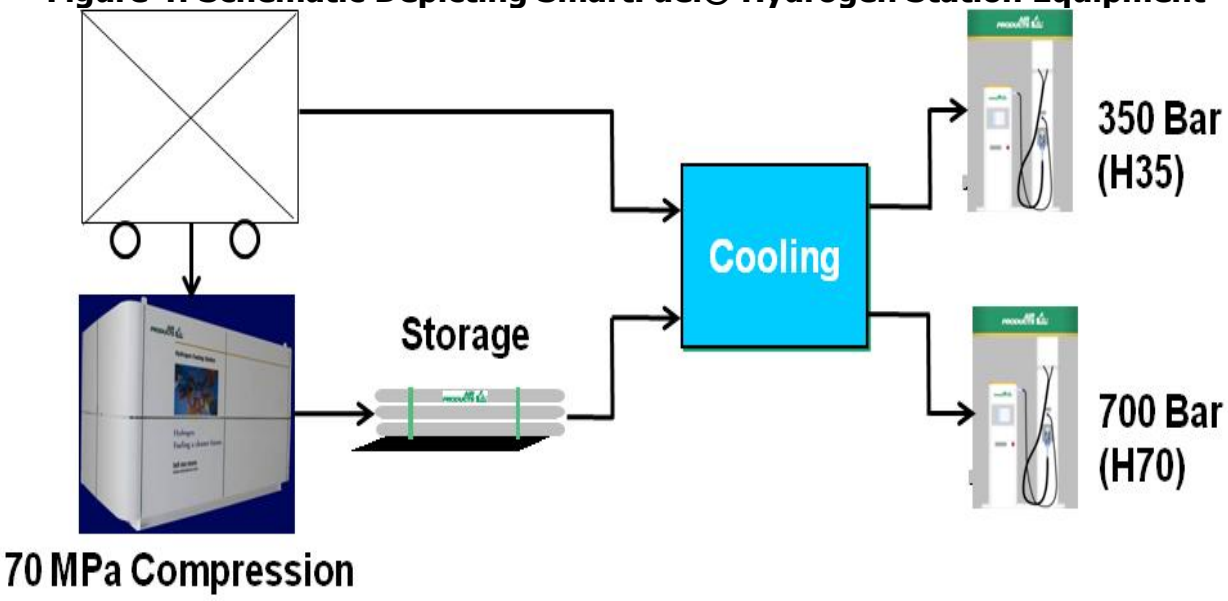


Source: California Energy Commission Staff

1.9 Schematic Layout of the Diamond Bar SmartFuel® Hydrogen Station

Figure 4 depicts an overview of the Diamond Bar SmartFuel® hydrogen station equipment. Hydrogen is produced by Air Products and Chemicals, Inc. at a central fill system located in southern California, and the gas is delivered by a high-pressure tube trailer. Hydrogen is compressed as needed to fill the high-pressure storage tubes that are integral in providing a full fill to FCEVs that use the H70 nozzle. Gas is taken from storage and cooled based on the dispenser programming that meets the Society of Automotive Engineers J2601 *Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles.*; Air Products and Chemicals, Inc. has patents which cover elements of the station operation and the dispensing process.

Figure 4: Schematic Depicting SmartFuel® Hydrogen Station Equipment



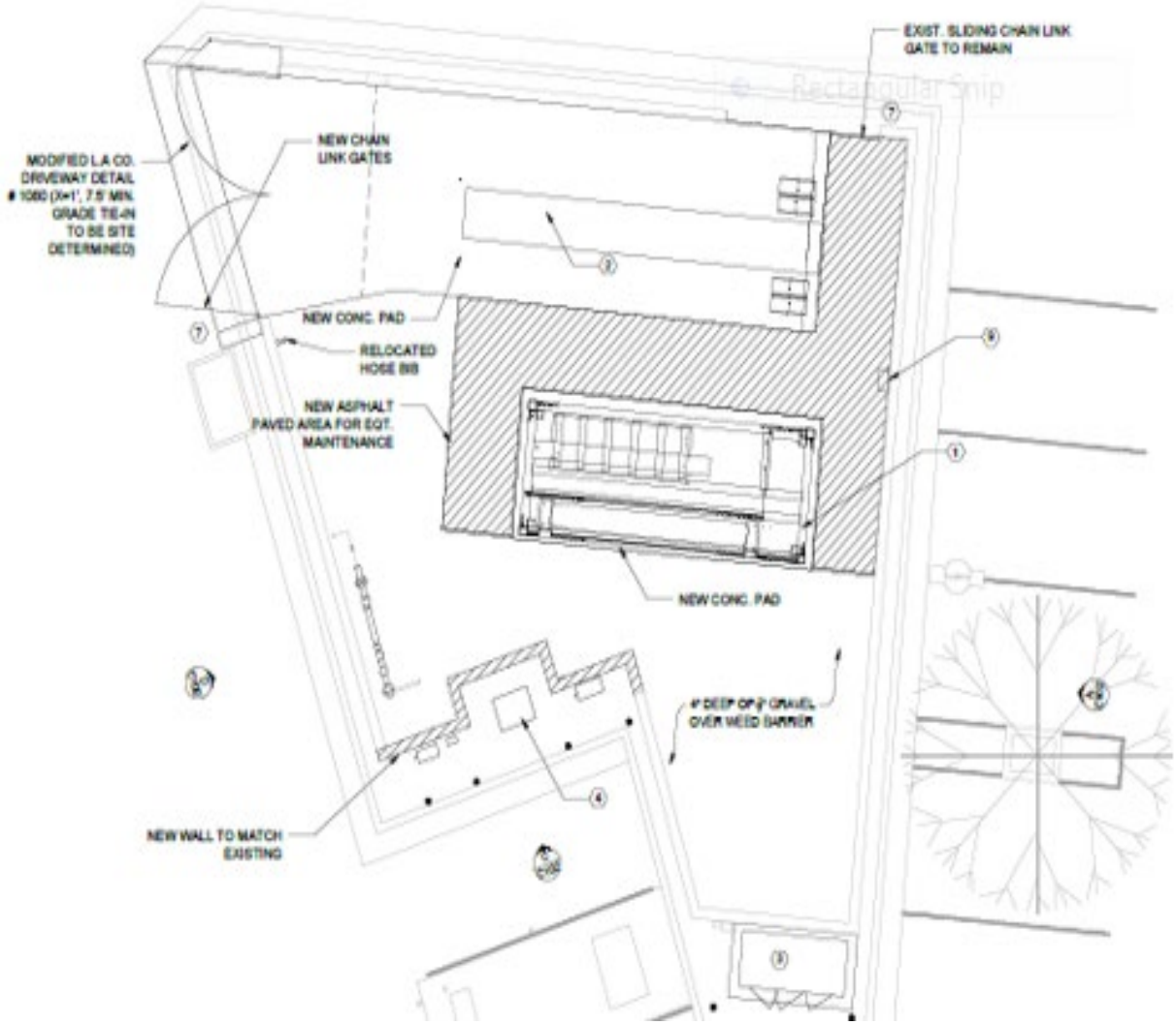
Source: Air Products and Chemicals, Inc.

1.10 Final Configuration and Budget

Figure 5 shows a detailed view of the actual final, as-built configuration of the Diamond Bar SmartFuel® hydrogen station.

Table 1 shows a detailed view of the budget to construct the Diamond Bar SmartFuel® hydrogen station.

Figure 5: Final Diamond Bar SmartFuel® Hydrogen Station Layout



Source: Air Products and Chemicals, Inc. Original figure is higher resolution.

Table 1: The Project Grant Funding and Match Funding

Company / Contribution	**Grant Agreement**
Air Products and Chemicals, Inc., Allentown, Pennsylvania / Station equipment	$817,810
Engineering, Procurement and Construction LLC, Denver Colorado / Design, permitting services, and construction	$199,500
Total Project Cost	**$1,017,310**
California Energy Commission grant	$845,490
Air Products and Chemicals, Inc. Cost Share	$171,820
Total California Energy Commission Cost Share	83%

Source: Air Products and Chemicals, Inc.

CHAPTER 2:
Energy Analysis

The Diamond Bar SmartFuel® hydrogen refueling station is supplied by hydrogen generated via steam methane reformation that converts methane (CH_4) and water (H_2O) to hydrogen (H_2) and carbon dioxide (CO_2) along with an equilibrium amount of carbon monoxide (CO):

Steam/Methane Reforming Reaction $CH_4 + H_2O + Heat \Leftrightarrow CO + 3H_2$

Water-Gas Shift Reaction $CO + H_2O \Leftrightarrow CO_2 + H_2 + Heat$

Per PON-09-608, which adopts California Senate Bill 1505 (Lowenthal, Chapter 877, Statutes of 2006), at least one-third of the hydrogen dispensed is to be produced from renewable energy sources. Hydrogen for the Diamond Bar Station is supplied to the hydrogen refueling station from Air Products and Chemicals, Inc. hydrogen production facilities in Wilmington/Carson, California. Renewable biogas is procured as feedstock for the Wilmington/Carson facilities, resulting in delivered hydrogen that meets the 33 percent renewable requirements of California Senate Bill 1505. The sources of biogas are shown in Table 2.

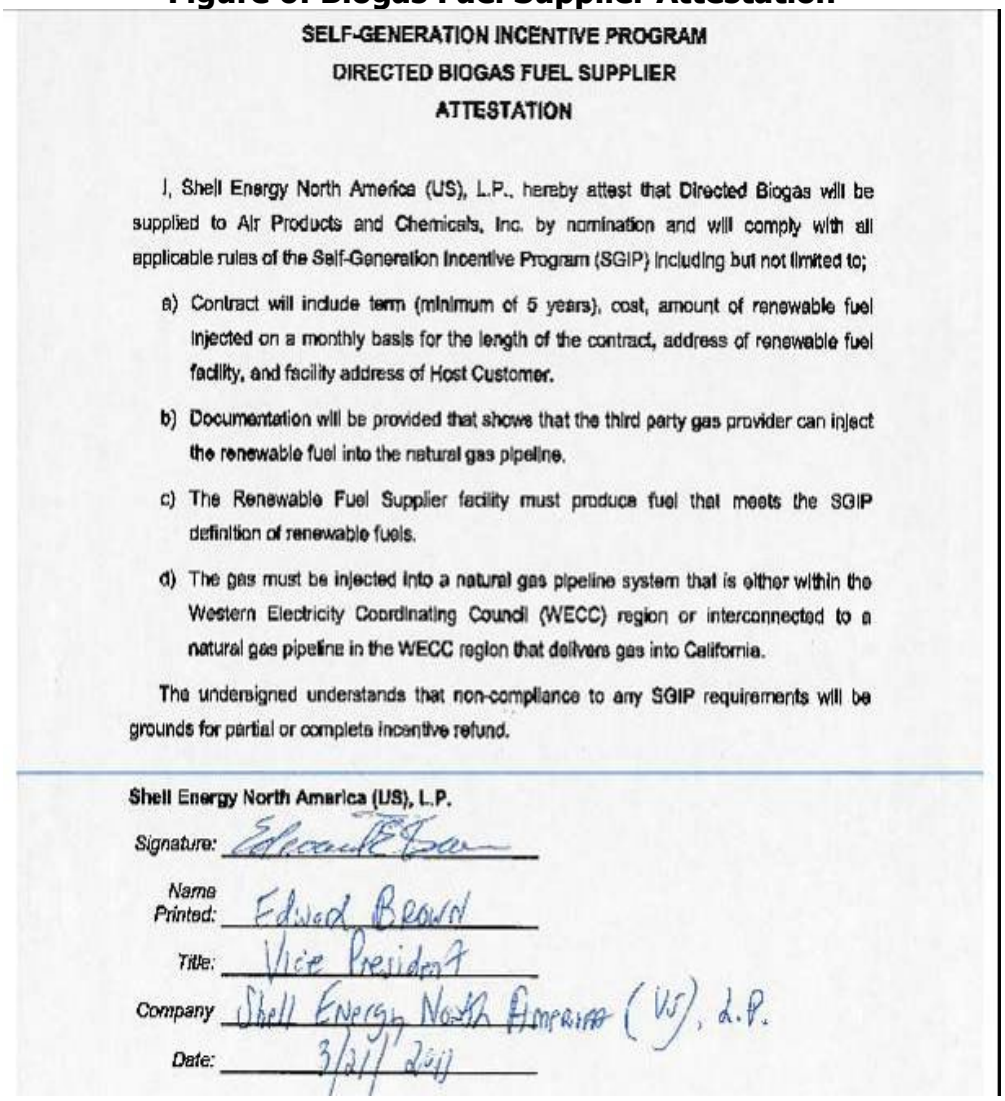
Table 2: Renewable Biomethane Supply Sources from Shell Energy North America (United States), L.P.

Supply Source	Address	Pipeline / LDC	Receipt	Delivery
Greentree Landfill	635 Toby Road Kersey, PA 15846	National Fuels Gas TETCO NGPL EPNG Socal Gas FAR	Landfill meter Nat Fuel-Bristoria Tetco-Sweet Lake 3825 EPNG Jal 3083 Topock	Bristoria NGPL-Sweet Lake EPNG Jal 3083 Topock Socal Citygate
Imperial Landfill	11 Boggs Road Imperial, PA 15126	National Fuels Gas TETCO NGPL EPNG Socal Gas FAR	Landfill meter Nat Fuel-Bristoria Tetco-Sweet Lake 3825 EPNG Jal 3083 Topock	Bristoria NGPL-Sweet Lake EPNG Jal 3083 Topock Socal Citygate

Source: FirstElement Fuel, Inc.

Air Products and Chemicals, Inc. has a contract for sourcing the renewable biogas that meets Public Resources Code Section 2574(b)(1); documentation is provided in Figure 6. Although California has a substantial amount of biogas, local supply cannot be injected into California pipelines under California Health and Safety Code Section 25420. Air Products and Chemicals, Inc. biogas supply for this project is sourced outside California and transported to California with connection to a natural gas pipeline within the Western Electricity Coordinating Council 2 region that delivers gas into California.

Figure 6: Biogas Fuel Supplier Attestation



SELF-GENERATION INCENTIVE PROGRAM

DIRECTED BIOGAS FUEL SUPPLIER

ATTESTATION

I, Shell Energy North America (US), L.P., hereby attest that Directed Biogas will be supplied to Air Products and Chemicals, Inc. by nomination and will comply with all applicable rules of the Self-Generation Incentive Program (SGIP) including but not limited to;

a) Contract will include term (minimum of 5 years), cost, amount of renewable fuel injected on a monthly basis for the length of the contract, address of renewable fuel facility, and facility address of Host Customer.

b) Documentation will be provided that shows that the third party gas provider can inject the renewable fuel into the natural gas pipeline.

c) The Renewable Fuel Supplier facility must produce fuel that meets the SGIP definition of renewable fuels.

d) The gas must be injected into a natural gas pipeline system that is either within the Western Electricity Coordinating Council (WECC) region or interconnected to a natural gas pipeline in the WECC region that delivers gas into California.

The undersigned understands that non-compliance to any SGIP requirements will be grounds for partial or complete incentive refund.

Shell Energy North America (US), L.P.

Signature: Edward Beard

Name Printed: Edward Beard

Title: Vice President

Company Shell Energy North America (US), L.P.

Date: 3/21/2011

Source: Air Products and Chemicals, Inc.

Hydrogen is delivered to the Diamond Bar SmartFuel® hydrogen refueling station by a Department of Transportation-certified high-pressure delivery trailer.

For an analysis of greenhouse gas emissions, the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model for gaseous hydrogen was used to calculate the

[2] The Western Electricity Coordinating Council promotes Bulk Electric System reliability in the Western Interconnection. (https://www.wecc.biz/Pages/AboutWECC.aspx).

emissions due to the production and delivery of compressed hydrogen gas with 33.3 percent renewable energy content from a large hydrogen production facility in Wilmington/Carson to a cluster of hydrogen stations in Southern California. For the hydrogen supply pathway and hydrogen fueling station, the lifecycle emission of hydrogen energy supply is estimated at 80.1 grams of carbon dioxide equivalent (CO_2e) per megajoule on a full well-to-wheels basis. California Air Resources Board's Low Carbon Fuel Standard lifecycle emissions estimate for a similar pathway for compressed hydrogen from central reforming of natural gas (low carbon fuel standard pathway HYGN005) is 88.3 grams CO_2e / megajoule. In factoring in an Energy Efficiency Ratio of 2.5 for FCEV's established under low carbon fuel standard the resulting emissions performance for FCEVs is 157 grams CO_2e / mile. In comparison to a low carbon fuel standard light-duty gasoline vehicle baseline, the hydrogen supply pathway (according to low carbon fuel standard data) results in a 61 percent reduction in wheel-to-wheel greenhouse emissions relative to California gasoline.

Relating to the Diamond Bar SmartFuel® hydrogen refueling station, this level of relative greenhouse gas reduction to the low carbon fuel standard 2016 baseline for gasoline vehicles means that each FCEV deployed in the market will reduce greenhouse gas emissions by 4.3 metric tons per year. The station has the potential to contribute to the reduction of greater than 1,100 metric tons of greenhouse gas emissions and greater than 164,250 gallons of gasoline consumption annually. The long-term greenhouse gas and petroleum reduction that could be realized by widespread adoption of FCEVs in the marketplace is enormous.

CHAPTER 3: Conclusions

The following considers findings from the 33.3 percent renewable hydrogen Diamond Bar SmartFuel® hydrogen station project.

To shorten the time needed to permit a hydrogen refueling station, the applicant, host site, and the various agencies responsible for review and approval provided timely and complete responses to correspondence between the parties. The City of Diamond Bar and the fire department to responded quickly to document submittals.

To expedite hydrogen refueling station development, it is imperative for hydrogen refueling station developers to work closely with site owners and regulatory agency project planners to envision the project and determine potential project acceptance as early in the project as possible. Additional discussion may have reduced the time (13 months) between construction completion and first public use including point of sale system issues that added five months to the timeline.

Engineering, Procurement and Construction LLC is responsible for the ongoing operation of the Diamond Bar SmartFuel® hydrogen station and access to the site with South Coast Air Quality Management District. Air Products and Chemicals, Inc. and Engineering, Procurement and Construction LLC have ongoing agreements in place for equipment and hydrogen supply.

Data on the operation of the station will be collected and reported to the Energy Commission throughout the term of operations and maintenance under Grant Agreement ARV-14-030 (December 30, 2014 to October 31, 2018).

As part of its ongoing support to hydrogen refueling stations in California, Air Products and Chemicals, Inc. has a fully staffed operations department which can address station maintenance and emergency situations. Air Products and Chemicals, Inc. utilizes a 24-hour Equipment Support Team to monitor for alarms from the hydrogen station (in addition to any local alarms at the point of use). Air Products and Chemicals, Inc. employs technicians in the Los Angeles Basin area that are trained in the specialized requirements for hydrogen refueling stations.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The CEC's five major areas of responsibilities are:

1. Forecasting future statewide energy needs.
2. Licensing power plants sufficient to meet those needs.
3. Promoting energy conservation and efficiency measures.
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels.
5. Planning for and directing state response to energy emergencies.

Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources.

CARBON DIOXIDE (CO_2)—A colorless, odorless, nonpoisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO_2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO_2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent).

CARBON DIOXIDE EQUIVALENT (CO_2e)—A metric used to compare emissions of various greenhouse gases. It is the mass of carbon dioxide that would produce the same estimated radiative forcing as a given mass of another greenhouse gas. Carbon dioxide equivalents are computed by multiplying the mass of the gas emitted by its global warming potential.

FUEL CELL ELECTRIC VEHICLE (FCEV)—A zero-emission vehicle that runs on compressed hydrogen fed into a fuel cell "stack" that produces electricity to power the vehicle.

HYDROGEN (H_2)—A colorless, odorless, highly flammable gas, the chemical element of atomic number 1.

METHANE (CH_4)—A light hydrocarbon that is the main component of natural gas and marsh gas. It is the product of the anaerobic decomposition of organic matter and enteric fermentation in animals and is one of the greenhouse gases.