CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Santa Monica SmartFuel® Hydrogen Station

Prepared for: California Energy Commission

Prepared by: Air Products and Chemicals, Inc.

Gavin Newsom, Governor

January 2021 | CEC-600-2021-013

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

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 fueling 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 fueling stations to serve the population of fuel cell electric vehicles and to accommodate the planned large-scale roll-out of fuel cell electric vehicles 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 1819 Cloverfield Blvd., Santa Monica, (Los Angeles County) 90404. The Santa Monica SmartFuel® hydrogen station was approved for construction in February of 2015, and began public fueling in February of 2016. The station receives gaseous hydrogen delivered at elevated pressure from an Air Products and Chemicals, Inc. production facility in southern California. The station is comprised of compression, cooling, and a two-hose dispenser with a customer payment interface that are used to refill fuel cell electric vehicles.

Keywords: Air Products and Chemicals, California Air Resources Board, California Energy Commission, fuel cell electric vehicle, Santa Monica, Inc., SmartFuel® hydrogen refueling station

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EXECUTIVE SUMMARY

Hydrogen fuel cell electric vehicles 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 fuel cell electric vehicles 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 fuel cell electric vehicles 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. Fuel cell electric vehicle 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 fuel cell electric vehicle 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, fuel cell electric vehicles 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 fuel cell electric vehicles. Fuel cell electric vehicles 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-fueling stations in operation in California" (Health and Safety Code 43018.9[e][1]).

The California Energy Commission contributed $597,737 of the total $989,689 budget to design, engineer, permit, construct, and make the Santa Monica SmartFuel® hydrogen station operational.

The site for this project is 1819 Cloverfield Blvd., Santa Monica, (Los Angeles County). A hydrogen refueling station at this location will serve fuel cell electric vehicles in the area. Air Products and Chemicals, Inc. accomplished this goal through the steps outlined below.

As part of its proposal to solicitation PON-09-608, Air Products and Chemicals, Inc. had proposed a site on Santa Monica Blvd. in Santa Monica, but during project execution Air

Products and Chemicals, Inc. determined that the gas station did not have adequate space to accommodate the hydrogen fueling equipment. Air Products and Chemicals, Inc. then identified the Cloverfield Blvd. location as a replacement. Air Products and Chemicals, Inc. developed a site memorandum of understanding which would enable Air Products and Chemicals, Inc. to demonstrate access to the site, to perform site design work and to develop permit application packages for siting and operating the hydrogen fueling equipment in advance of negotiating a land lease agreement. This memorandum was executed on April 22, 2013. The California Energy Commission approved the site change and amended Grant Agreement ARV-10-048 on January 10, 2014 to include this location. Lease terms were negotiated, and Air Products and Chemicals, Inc. and the landlord executed a lease on January 6, 2015.

Air Products and Chemicals, Inc. developed the site configuration and design, and S. Gordin Structural Design and Engineering Services, Inc. performed the detailed engineering design. The site plan was approved by the gas station owner and was provided to the City of Santa Monica as part of a pre-submittal process which can be used to obtain feedback from City agencies prior to beginning site design work. This meeting took place on October 24, 2013. Approval by the City's Architectural Board was received on April 30, 2014 following a revision to the layout to allow for additional room for delivery to the underground gasoline storage tanks (prior approval had been given) initial design packages were completed on August 11, 2014.

Air Products and Chemicals, Inc. submitted the structural and electrical plans to the City of Santa Monica on August 11, 2014. Additional information was requested by the Santa Monica Fire Department and was provided by Air Products and Chemicals, Inc. on September 11, 2014. Comments from all agencies were received by September 25, 2014. The electrical design was then impacted by a change in the location of the power tie-in by Southern California Edison. Following resubmittal of revised plans, the City of Santa Monica approved the station design on February 25, 2015.

Air Products and Chemicals, Inc. provided the hydrogen refueling station equipment. Based upon their excellent safety record and prior experience with hydrogen station construction, Air Products and Chemicals, Inc. selected Fueling and Service Technology, Inc. as the construction contractor on September 3, 2015. Construction began on May 18, 2015. Additional changes to the electrical design were identified by Southern California Edison during the construction phase. Construction of the Santa Monica SmartFuel® hydrogen station was completed on December 4, 2015.

The process of making the Santa Monica SmartFuel® hydrogen station operational began on December 7, 2015 and was completed on January 19, 2016. Automakers performed test fills during this time. Approval of the hydrogen dispenser for retail operations by the California Department of Measurements and Standards was received on January 28, 2016. Initial use of the Fairfax LA SmartFuel® hydrogen station by retail customers occurred in early February of 2016.

The Santa Monica SmartFuel® hydrogen station can dispense 180 kilograms of hydrogen per day with daily deliveries. The station has the potential to contribute to the reduction of more than 1,100 metric tons of greenhouse gas emissions and greater than 164,250 gallons of gasoline consumption annually.

CHAPTER 1:
Station Design and Construction

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

1.1 Site Acquisition - Construction (January 2012 – December 2015)

Following the kick-off of Grant Agreement ARV-10-048, Air Products and Chemicals, Inc. began working to develop a hydrogen station at 1402 Santa Monica Blvd. in Santa Monica. This site was proposed by Air Products and Chemicals, Inc. in response to solicitation PON-09-608. Air Products and Chemicals, Inc. determined that the gas station did not have adequate space (as determined by the number of available parking spaces) to accommodate the hydrogen fueling equipment.

As a consequence, Air Products and Chemicals, Inc. identified an alternate site (1819 Cloverfield Blvd.) which was located 2.8 miles (driving distance) from the original location. In order to demonstrate access to the new location, Air Products and Chemicals, Inc. developed a site memorandum of understanding which would enable Air Products and Chemicals, Inc. to perform site design work and to develop permit application packages for siting and operating the hydrogen fueling equipment in advance of negotiating a land lease agreement. This memorandum was executed on April 22, 2013. The California Energy Commission approved the site change and amended Grant Agreement ARV-10-048 on January 10, 2014 to include this location.

A template for a property lease agreement was provided by Air Products and Chemicals, Inc. on February 26, 2013. The station lease was formally executed on January 6, 2015.

Air Products and Chemicals, Inc. held preliminary discussions with S. Gordin Structural Design and Engineering Services, Inc. regarding the Santa Monica station. The companies executed a subcontract for design engineering services on May 31, 2013, and an initial site visit took place on June 26, 2013.

Following this meeting, options for equipment layouts were prepared by the architect for review with the gas station owner. Figure 1 provides an initial equipment arrangement drawing. The drawing was amended to change the equipment orientation and to better accommodate the parking spaces. The site plan was approved by the gas station owner on August 12, 2013, and Figure 2 provides the approved equipment arrangement drawing. This document was provided to the City of Santa Monica as part of a pre-submittal process, a method used to obtain feedback from City agencies prior to beginning site design work. This meeting took place on October 24, 2013.

Air Products and Chemicals, Inc. and S. Gordin Structural Design and Engineering Services, Inc. then completed a site survey and electrical audit of the existing gas station, and drawings were provided to the City's urban design office in February of 2014. A package was then prepared and submitted to the City's Architectural Review Board on April 3, 2014, and

approval was received on April 30, 2014. Southern California Edison was also contacted to provide their plans for providing electricity to the hydrogen station.

Following kickoff of structural and electrical designs, Air Products and Chemicals, Inc. was notified by the gas station owner that the site layout needed to be modified to allow for additional room for delivery to the underground storage tanks (prior approval had been given). Initial design packages were completed by Air Products and Chemicals, Inc. and S. Gordin Structural Design and Engineering Services, Inc. on August 11, 2014. Figure 3 provides the equipment layout drawing that was submitted to the City.

Air Products and Chemicals, Inc. began the equipment design and procurement. Immediately after execution of the grant agreement, 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. 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.

The component with the longest lead time was the high-pressure storage vessels which are critical components to the hydrogen fueling process. 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.

The City of Santa Monica did not require a zoning review of the addition of hydrogen equipment to the gas station in Santa Monica. As noted previously, steps were taken prior to submittal for permitting, including the pre-submittal meeting, the urban design office, and the Architectural Review Board.

Air Products and Chemicals, Inc. submitted the structural and electrical plans to the City of Santa Monica on August 11, 2014. Additional information was requested by the Santa Monica Fire Department and was provided by Air Products and Chemicals, Inc. on September 11, 2014. Comments from all agencies were received by September 25, 2014. The electrical design needed to be reviewed to ensure compliance with a recently issued energy standard. The review process was also impacted the review of a submittal of documents unrelated to the hydrogen station permit.

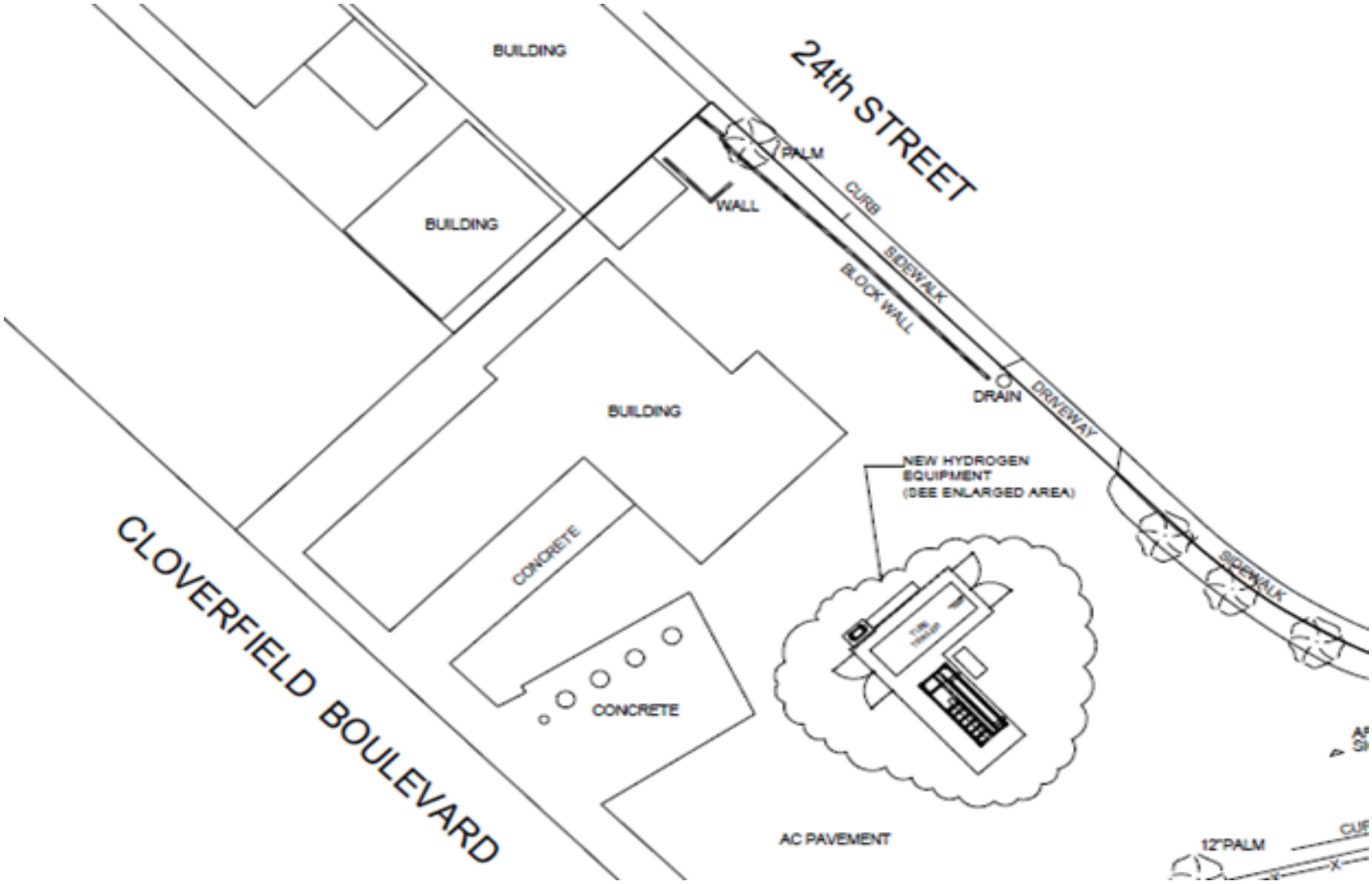
In December of 2014, Southern California Edison provided the installation drawings showing the proximity of the power supply to the hydrogen station equipment. This design showed the power tie-in on the opposite side of the gas station when compared with the original proposal in May of 2014. In order to accommodate this change while minimizing the impact to the operation of the gas station, the site design needed to be modified. Air Products and Chemicals, Inc. and S. Gordin Structural Design and Engineering Services, Inc. then modified the drawings and resubmitted plans to the City on January 13, 2015.

The City of Santa Monica approved the station design on February 25, 2015.

Air Products and Chemicals, Inc. executed the construction subcontract to Fueling and Service Technology, Inc. on April 23, 2015. Fueling and Service Technology, Inc. has an excellent

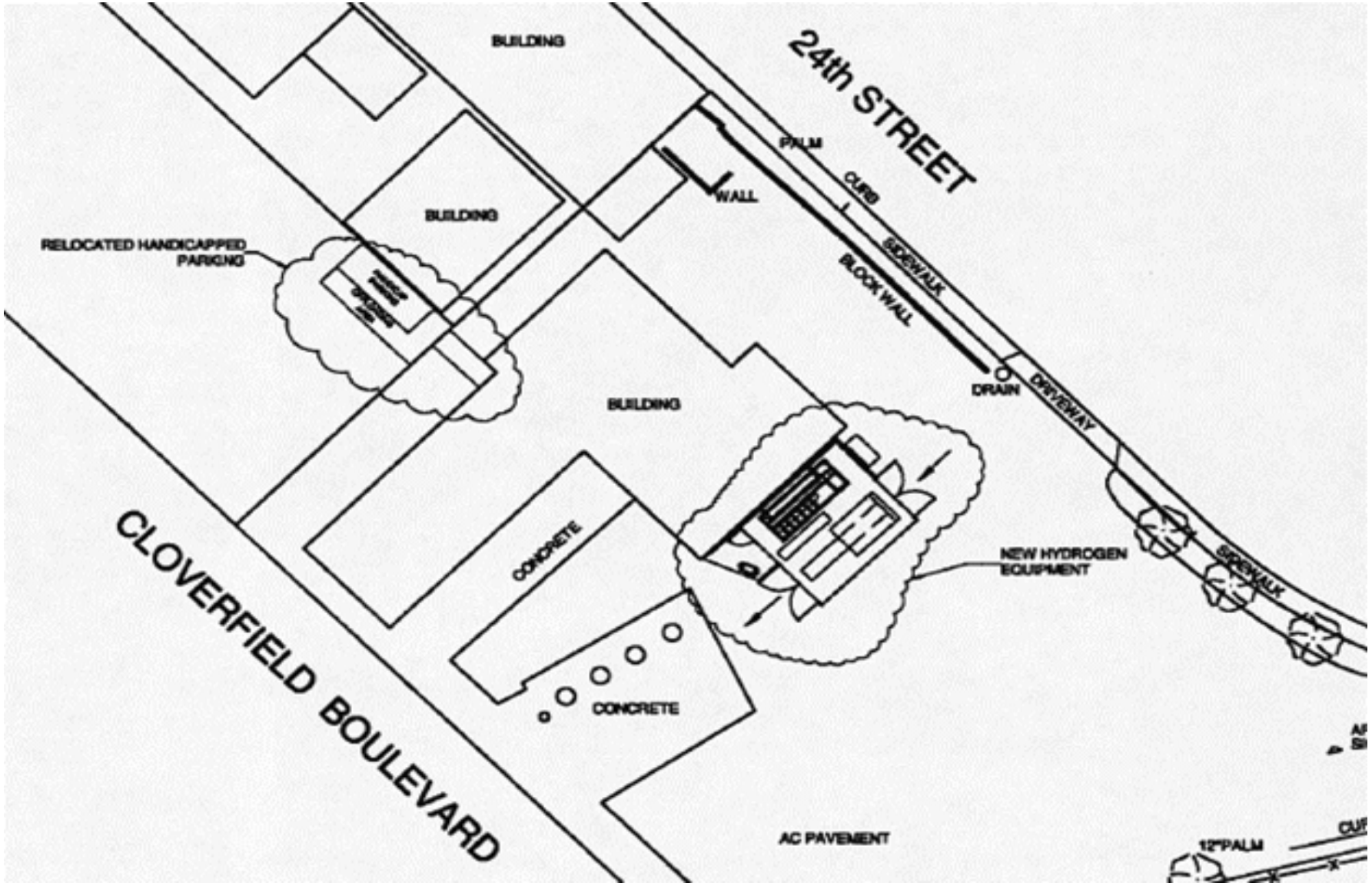
safety record and had prior experience in hydrogen station construction, including work performed for Air Products and Chemicals, Inc. under this Grant Agreement ARV-10-048. Construction started on May 18, 2015, with compression, cooling, and dispensing equipment delivered to the site on July 7, 2015. Additional changes to the electrical design were identified by Southern California Edison during the construction phase. Completion of construction took place on December 4, 2015.

Figure 1: Initial Equipment Arrangement Drawing



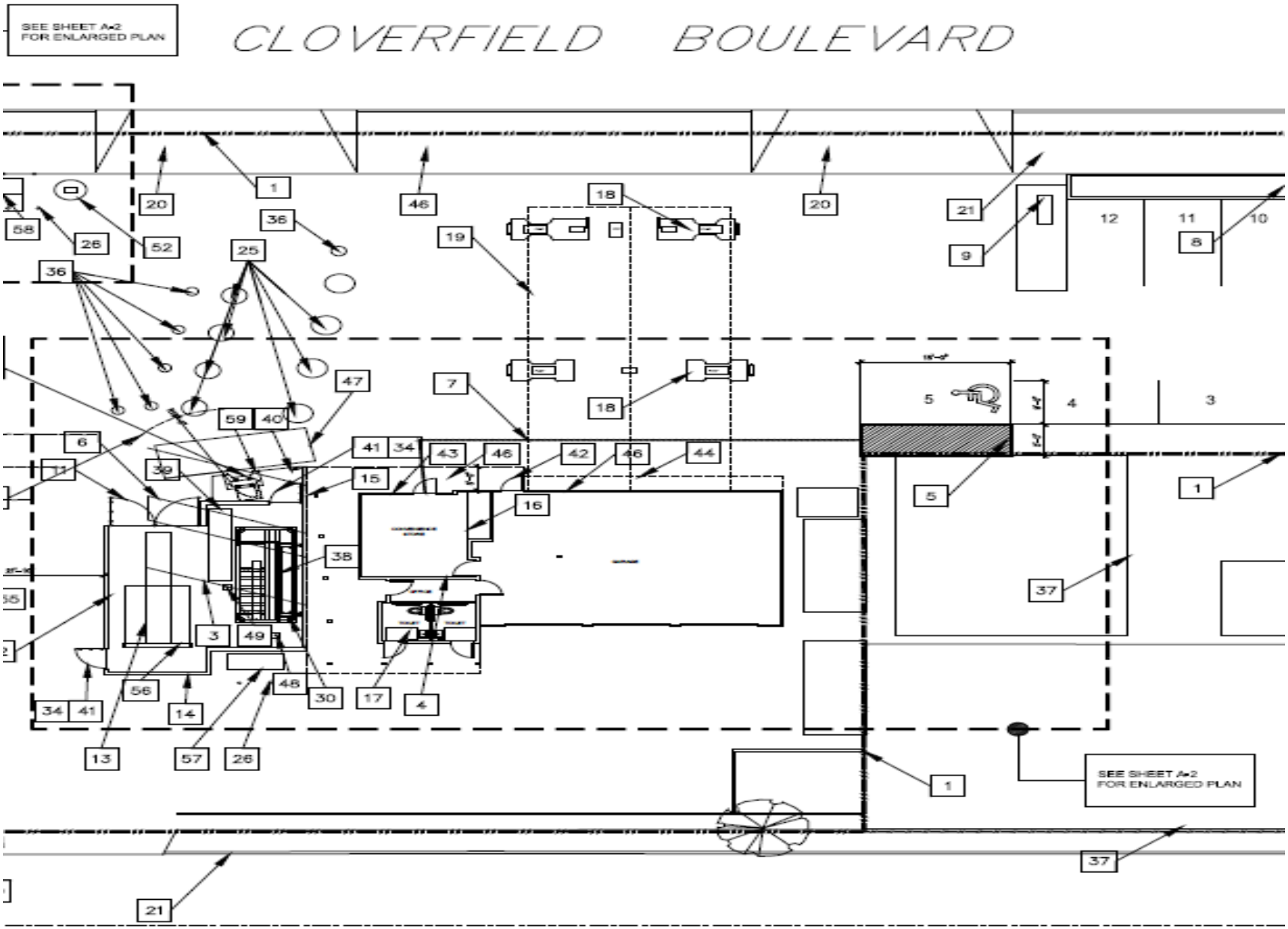
Source: Air Products and Chemicals, Inc. Original figure is higher resolution.

Figure 2: Equipment Arrangement Drawing



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

Figure 3: Equipment Arrangement Drawing



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

1.2 Making the Station Operational (December 7, 2015 – January 19, 2016)

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 and into automaker test vehicles were performed during this time.

1.3 Certification (January 28, 2016)

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. FirstElement achieved certification by acting as the registered service agent, dispensing a measured amount of fuel, and confirming the quantity dispensed is accurately reflected by the dispenser in accordance with examination procedures (EPO NO. 40-A)[1] as witnessed by the local county weights and measures officer. The permanent Division of Measurement Standards approval was received for the Santa Monica SmartFuel® hydrogen station on January 28, 2016.

1.4 Station Use (February 1, 2016 – Present)

The first vehicle fueled at the Santa Monica SmartFuel® station in early February of 2016, and the station has been used regularly since then. Dispensed volumes totaled 47 kilograms in February of 2016, 216 kilograms in March of 2016, and 238 kilograms in February of 2016. Figure 4 shows a photograph of the Santa Monica SmartFuel® hydrogen station.

[1] California Department of Food and Agriculture. *Hydrogen Gas-Measuring Devices.* (https://www.cdfa.ca.gov/dms/programs/devices/Hydrogen_Gas-Measuring_Devices_EPO-40.pdf)

Figure 4: Santa Monica SmartFuel® Hydrogen Station

Source: Air Products and Chemicals, Inc.

1.5 Station Operational Status System Activated (February 1, 2016)

The California Fuel Cell Partnership Station Operational Status System provides regularly updated station status information to fuel cell vehicle drivers. Air Products and Chemicals, Inc. has provided California Fuel Cell Partnership station status information regarding its stations since the inception of Station Operational Status System. The Santa Monica station was added to Station Operational Status System on February 1, 2016. A screenshot of the Station Operational Status System network that includes the Santa Monica SmartFuel® hydrogen station is shown in Figure 6.

1.6 Environmental Impacts

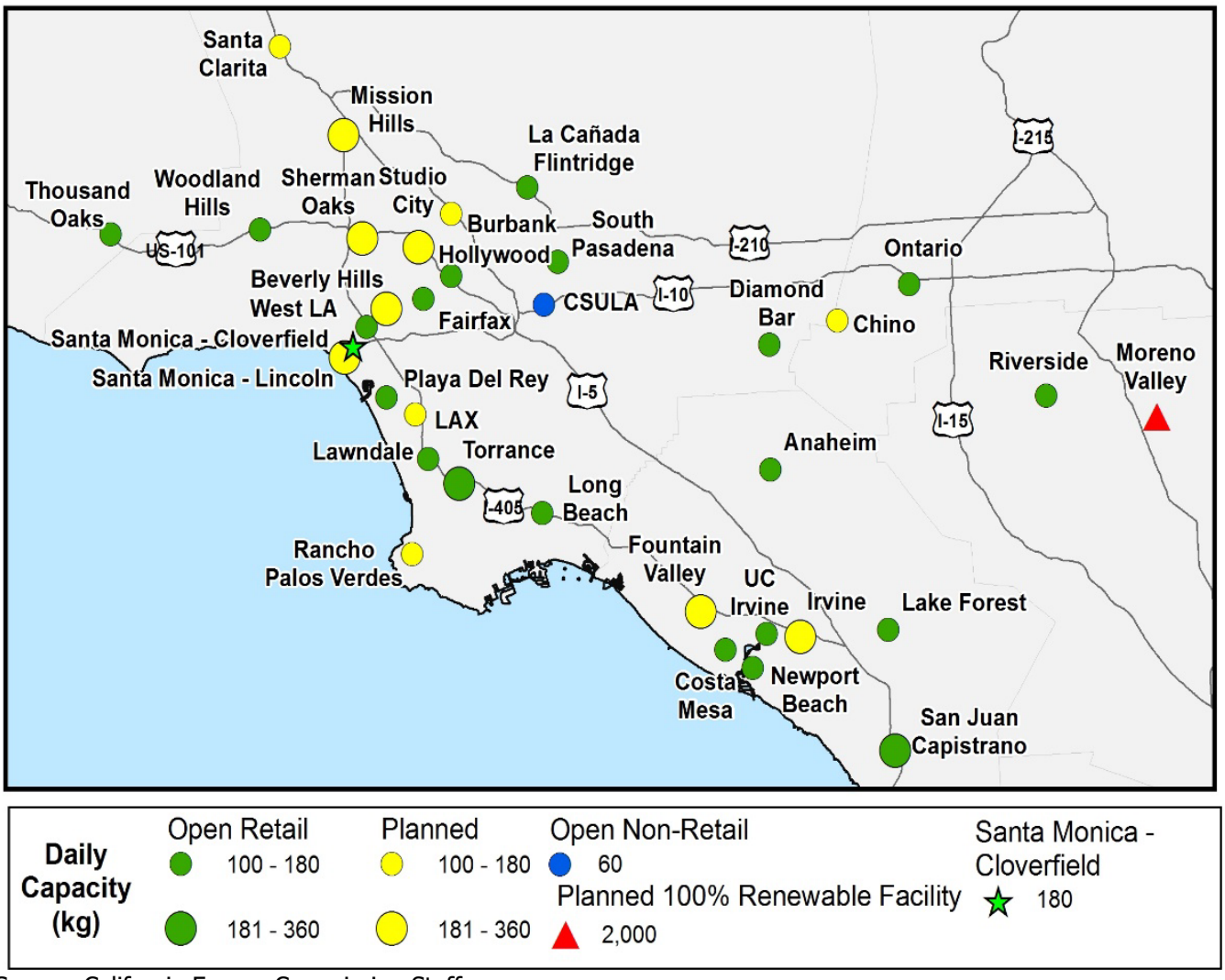
Hydrogen is stored as a compressed gas in an above-ground tank located behind a wall at this station. Hydrogen is nontoxic, colorless, and odorless, so hydrogen station equipment is outfitted with appropriate sensors to provide immediate notification in case a leak occurs. No solid or liquid waste will 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.

1.7 Santa Monica SmartFuel® Hydrogen Station in the Network

Figure 5 shows the greater Los Angeles area map which indicates where the Santa Monica SmartFuel® station is situated in relationship to other facilities in the southern part of the state.

Figure 5: The Santa Monica SmartFuel® Hydrogen Station



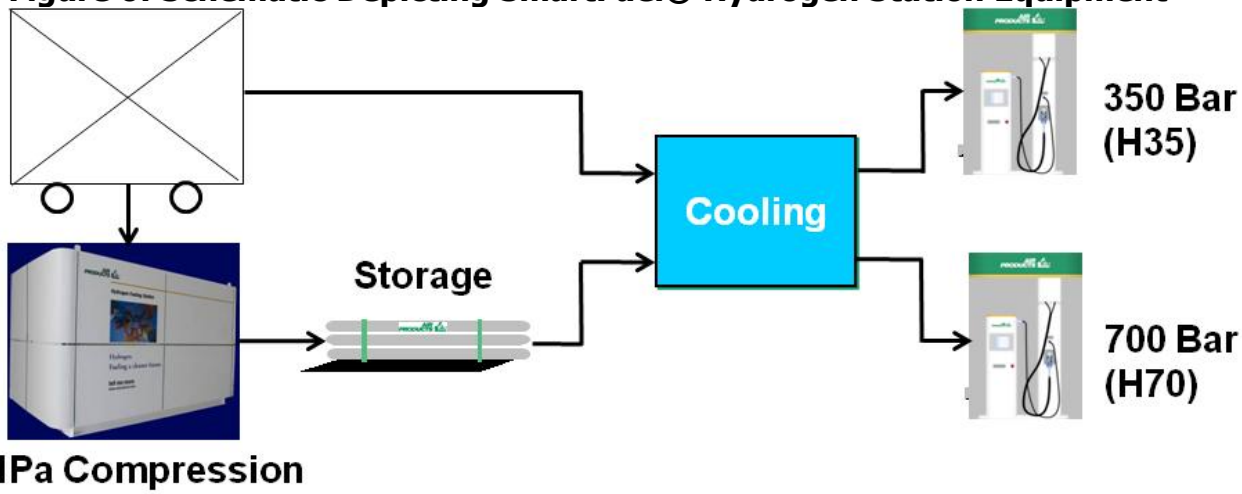
Source: California Energy Commission Staff.

1.8 Schematic Layout of the Santa Monica SmartFuel® Hydrogen Station

Figure 6 depicts an overview of the Santa Monica 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 fuel cell vehicles 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 6: Schematic Depicting SmartFuel® Hydrogen Station Equipment



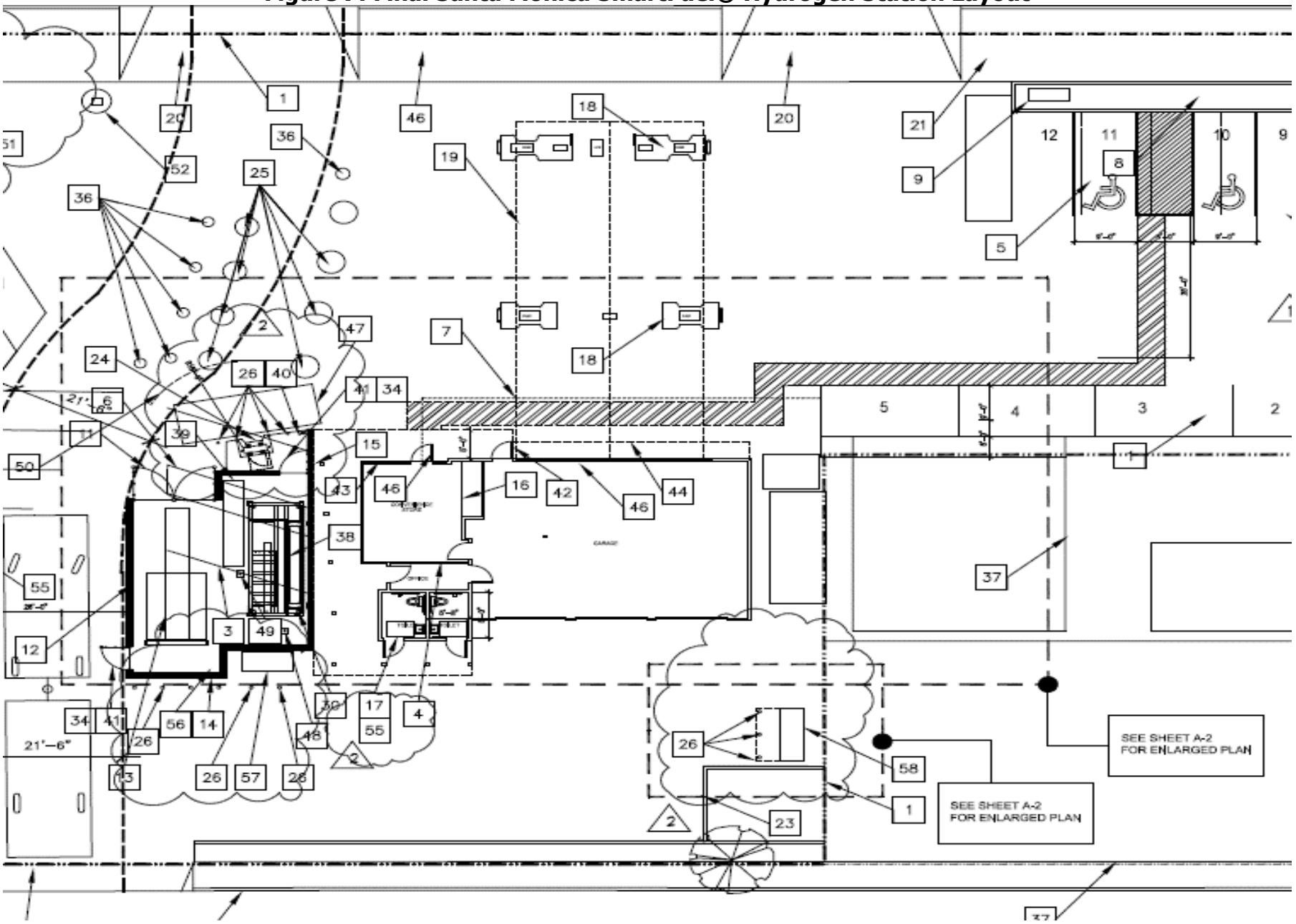
Source: Air Products and Chemicals, Inc.

1.9 Final Configuration and Budget

Figure 7 shows a detailed view of the actual final, as-built configuration of the Santa Monica SmartFuel® hydrogen station.

Figure 8 shows a detailed view of the budget to construct the Santa Monica hydrogen station.

Figure 7: Final Santa Monica SmartFuel® Hydrogen Station Layout



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

Figure 8: The Grant Recipient, Subcontractors, and Budget

Company / Contribution	**Grant Agreement**
Air Products and Chemicals, Inc., Allentown, Pennsylvania / H2 station equipment	$678,887
Fueling and Service Technology, Inc., Buena Park, California / Construction	$246,571
S. Gordin Structural Design & Engineering Services, Inc., Carson City, Nevada / Design and permitting services	$64,231
Total Budget	**$989,689**
California Energy Commission grant	$597,737
Air Products and Chemicals, Inc. cost share	$391,952
Total Energy Commission cost share	60%

Source: Air Products and Chemicals, Inc.

CHAPTER 2:
Energy Analysis

The Santa Monica 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 Santa Monica 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 1.

Table 1: Biogas Sources from Shell Energy North America (United States), L.P.

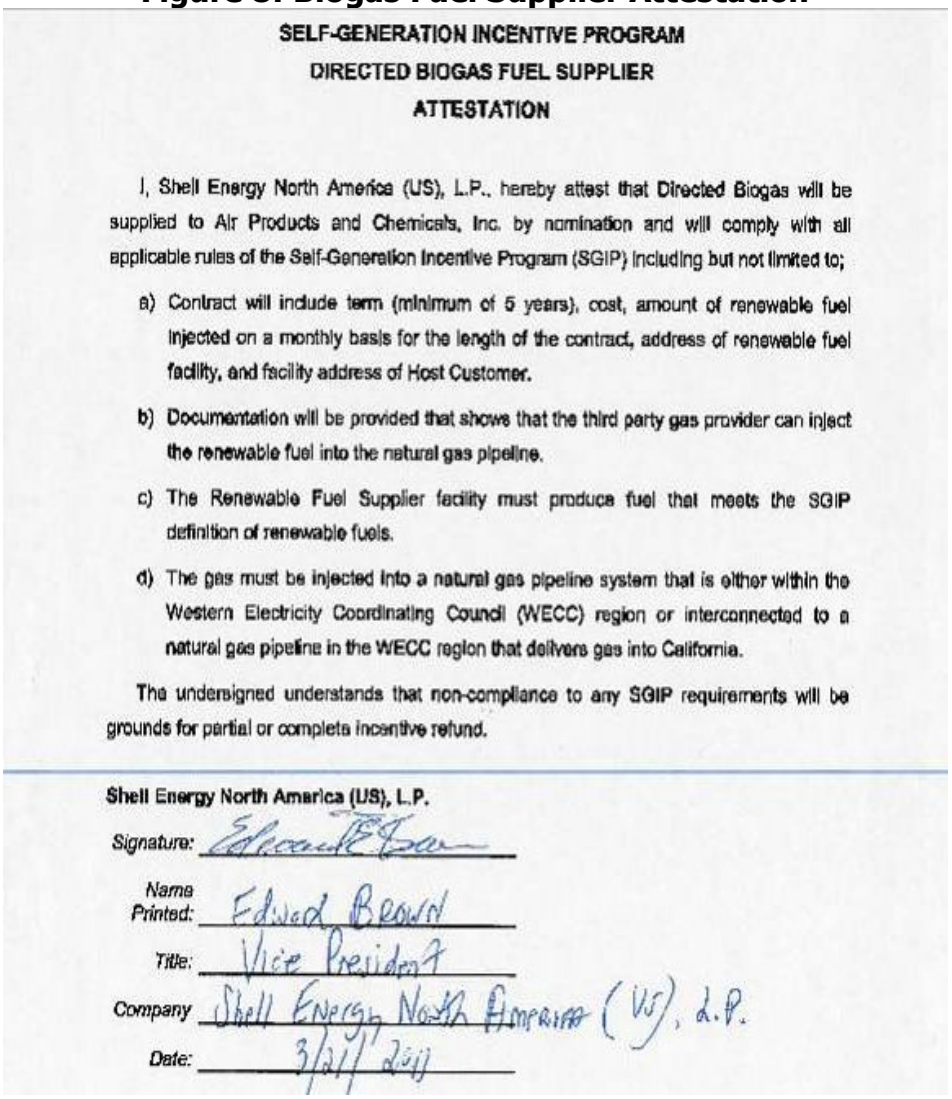
Supply Source	Address	Pipeline / LDC	Receipt	Delivery
Greentree Landfill	635 Toby Road Kersey, PA 15846	National Fuels Gas TETCO NGPL EPNG Socal Gas FAR	Landfill meter Nat Fuel-Bristoria Tetco-Sweet Lake 3825 EPNG Jal 3083 Topock	Bristoria NGPL-Sweet Lake EPNG Jal 3083 Topock Socal Citygate
Imperial 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 9. 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 8: 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 Santa Monica 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 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 fuel cell 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 per megajoule on a full well-to-wheels basis. The California

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

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_2 equivalent / 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_2 equivalent / 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 Santa Monica SmartFuel® hydrogen refueling station, this level of relative GHG reduction to the low carbon fuel standard 2016 baseline for gasoline vehicles means that each FCEV deployed in the market will reduce GHG 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 GHG 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 Santa Monica SmartFuel® hydrogen refueling station project led to the following conclusions.

- To shorten the time needed to permit this hydrogen refueling station, the applicant and various agencies responsible for review and approval provided timely and complete responses to correspondence between the parties.
- To expedite hydrogen refueling station development, hydrogen refueling station developers 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.
- Air Products and Chemicals, Inc. has executed an initial lease with the landowner with options for annual extensions.
- 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-15-025.
- As part of its ongoing support to hydrogen fueling 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 fueling 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 MONOXIDE (CO)—A colorless, odorless, highly poisonous gas made up of carbon and oxygen molecules formed by the incomplete combustion of carbon or carbonaceous material, including gasoline. It is a major air pollutant on the basis of weight.

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.

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_x), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

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.