CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Long Beach Hydrogen Station

Prepared for: California Energy Commission

Prepared by: FirstElement Fuel, Inc.

Gavin Newsom, Governor

November 2019 | CEC-600-2019-049

California Energy Commission

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Agreement Number: ARV-14-008

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ACKNOWLEDGEMENTS

The construction of the Long Beach hydrogen refueling station has been possible only because of the substantial efforts and funds provided by stakeholders. FirstElement Fuel, Inc. graciously thanks Toyota for its vision and fortitude; Air Products and Chemicals Inc., Black & Veatch, and Aliantel for bringing the project together; Tyson Eckerle for helping push the lease over the goal line; and, of course, Jean Baronas, Phil Cazel, Jim McKinney, Vice Chair Janea Scott, and many others at the California Energy Commission for tremendous, sustained confidence in clean, alternative transportation.

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-13-607 to fund hydrogen refueling stations. In response to PON-13-607, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards May 1, 2014 and the agreement was executed as ARV-14-008 on July 22, 2014

ABSTRACT

FirstElement Fuel, Inc. designed, engineered, permitted, constructed, and commissioned a hydrogen refueling station at 3401 Long Beach Blvd., Long Beach (Los Angeles County). FirstElement Fuel, Inc. plans to own and operate the hydrogen refueling station until at least 2025. The station consists of a concrete reinforced-block compound that encloses hydrogen storage, compression, and cooling equipment; a dispenser with two fueling hoses; a customer payment interface; a canopy; and a dedicated concrete fueling position for fuel cell electric vehicle drivers.

Keywords: California Energy Commission, FirstElement Fuel, Inc., hydrogen refueling station, hydrogen infrastructure, fuel cell electric vehicles

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EXECUTIVE SUMMARY

Hydrogen fuel cell electric vehicles (FCEVs) and hydrogen refueling stations are expected to play key roles as California 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 former Governor Edmund G. Brown Jr.'s goal of 5 million zero-emission vehicles by 2030.

FCEVs offer tremendous potential for the light-duty passenger vehicle market and medium- and heavy-duty truck and bus markets. Fuel cell electric passenger vehicles can drive more than 300 miles on a tank of hydrogen, have zero tailpipe emissions, and can be refueled in three to four minutes the way gasoline passenger vehicles are fueled. However, FCEVs require a new network of refueling stations that dispense pressurized hydrogen for consumer use. This requirement 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. FCEVs cannot be widely marketed and sold to consumers without a minimum network of refueling stations available.

In response to PON-13-607 issued by the California Energy Commission, FirstElement Fuel, Inc. was awarded funding for 19 stations. The California Energy Commission contributed $1,451,000 of the total $2,248,065.88 cost to design, engineer, permit, construct, and commission this station.

FirstElement Fuel, Inc. worked with historical vehicle sales data, academic publications, automakers, and the California Energy Commission's Station Location Areas to select desired market locations. FirstElement Fuel, Inc. then analyzed specific properties within the target locations to find sites that could meet the space requirements for hydrogen fueling equipment. The site selected for this project was 3401 Long Beach Blvd., Long Beach (Los Angeles County). A hydrogen refueling station at this location will serve as a core station in Southern California for at least the next 10 years.

The owner at Long Beach is excited to bring a clean, alternative fuel to his station. FirstElement Fuel, Inc. and the Long Beach owner executed a lease on January 31, 2014.

FirstElement Fuel, Inc. developed site configuration and design and engineering firm Black & Veatch performed the detailed engineering design. The zoning process in Long Beach required just one public hearing, and approval was granted April 13, 2015.

Permits for zoning, building, mechanical, electrical, plumbing, and fire were filed April 8, 2015, and finalized June 22, 2015, over 75 days. Because the Long Beach station is near the exit of a rollover car wash, the fire authority in this jurisdiction was particularly concerned with an errant vehicle leaving the carwash and hitting the hydrogen equipment compound. FirstElement Fuel attained approval by implementing an impact wall into one portion of the equipment compound and adding a backup battery system with an audible alarm.

FirstElement Fuel, Inc. purchased hydrogen refueling station equipment from Air Products and Chemicals, Inc., and the remainder of materials came from a variety of general and specialty

vendors. Aliantel from Murrieta (Riverside County) was selected as contractor for the project because of its relatively low bid, excellent safety record, good standing with Black & Veatch, and willingness to work with FirstElement Fuel, Inc. on multiple projects. Construction began June 29, 2015, and was completed October 30, 2015.

The process of making the station operational began October 8, 2015, and was completed October 30, 2015. The FirstElement Fuel, Inc. team performed the bulk of the commissioning tasks, including cleaning, purging, and pressure testing, with Air Products and Chemicals, Inc. performing final startup.

CHAPTER 1:
Station Design and Construction

There were many steps required to bring the Long Beach 33 percent renewable hydrogen refueling station project to completion. The following synopsis highlights the most critical items.

Site Acquisition—Construction (Fall 2013–October 2015)

Beginning in the fall of 2013, FirstElement Fuel, Inc. took steps to identify and acquire appropriate sites for the station. FirstElement Fuel worked with historical vehicle sales data, academic publications, automakers, and the California Energy Commission's Station Location Areas to select desired market locations. FirstElement Fuel, Inc. then analyzed specific properties within the target locations to find sites that could meet the space requirements for hydrogen fueling equipment.

After selecting general locations and specific sites, FirstElement Fuel, Inc. contacted station owners and operators to negotiate lease opportunities. FirstElement Fuel, Inc. executed a letter of intent with the property owner January 27, 2014. A binding 10-year lease was later executed on December 31, 2014.

FirstElement Fuel, Inc. selected Air Products and Chemicals, Inc. equipment because of the cost, capacity, reliability, and more mature supply chain as compared to other suppliers as detail in the FirstElement Fuel, Inc. PON application. FirstElement Fuel, Inc. executed a contract with Air Products and Chemicals, Inc. for the equipment September 16, 2014, and equipment was delivered to the site September 9, 2015.

FirstElement Fuel, Inc. and Black & Veatch surveyed the site to begin the site layout on August 11, 2014. They generated initial engineering drawings on October 3, 2014. These drawings are referred to as "construction drawing 30s" because they represent 30 percent complete construction drawings and contain only two pages. Figure 1 shows the equipment compound drawing from the construction drawing 30 drawing set. As shown, the drawing lacks specific detail and serves only to outline the site plan.

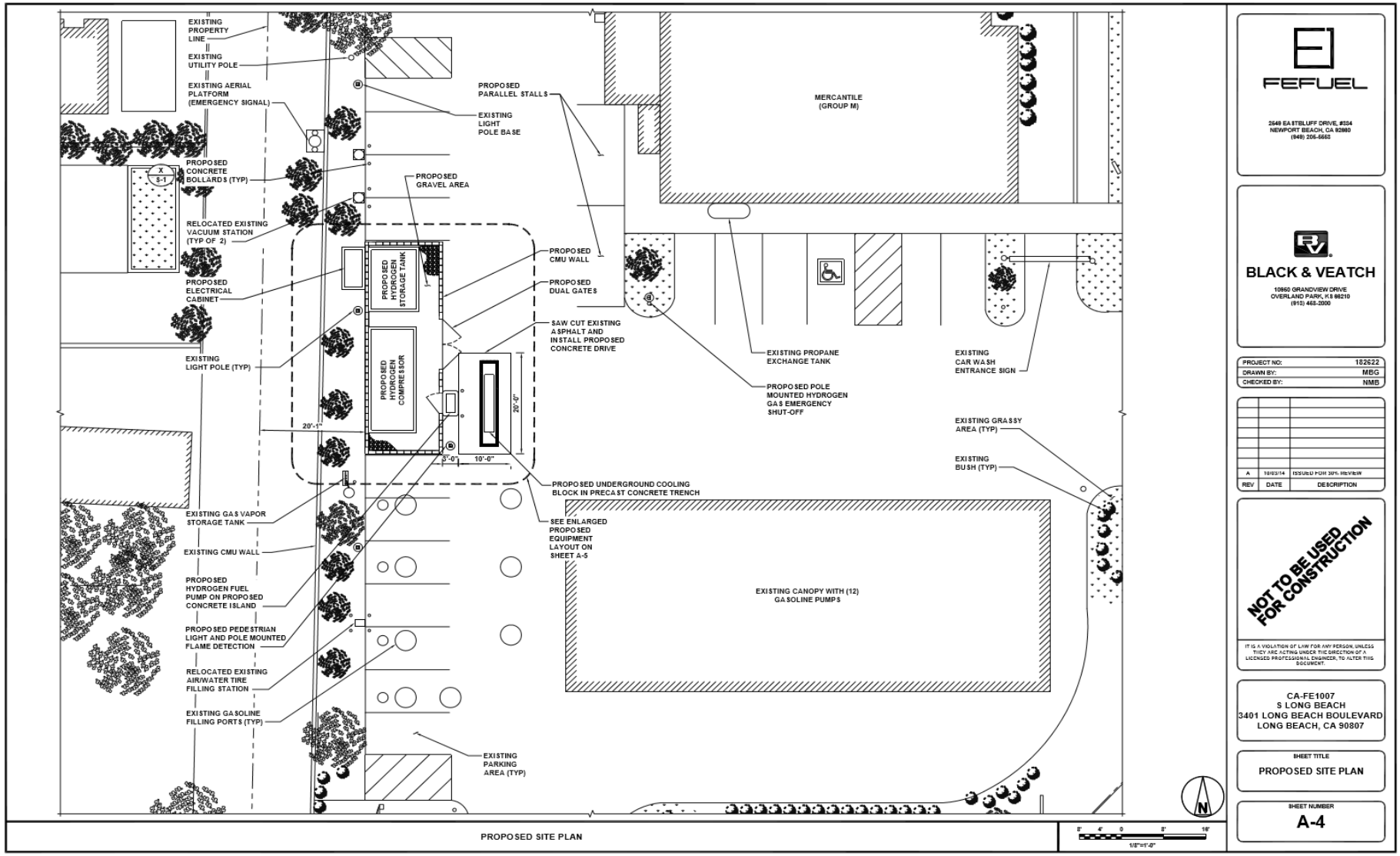
On October 13, 2014, Clark Land Surveying, Inc. performed a detailed engineering survey for the Long Beach station site, as shown in Figure 2.

On December 18, 2014, Clark Land Surveying also generated zoning drawings that provide an accurate but high-level depiction of the project for review by planners at the jurisdiction. These drawings are signed and sealed by the professional engineer of record to ensure accuracy and completeness. Figure 3 shows the equipment compound page of the zoning drawings. The lead planner for this project in Long Beach was particularly detail-oriented and demanded strict adherence to his vision for the hydrogen station. This adherence added to the planning upfront but ultimately resulted in a very smooth and nearly effortless planning commission hearing.

Because the Long Beach station is near the exit of a rollover car wash, the fire authority in this jurisdiction was particularly concerned with an errant vehicle leaving the carwash and hitting the hydrogen equipment compound. FirstElement Fuel attained approval by constructing an impact wall into one portion of the equipment compound and adding a backup battery system with audible alarm.

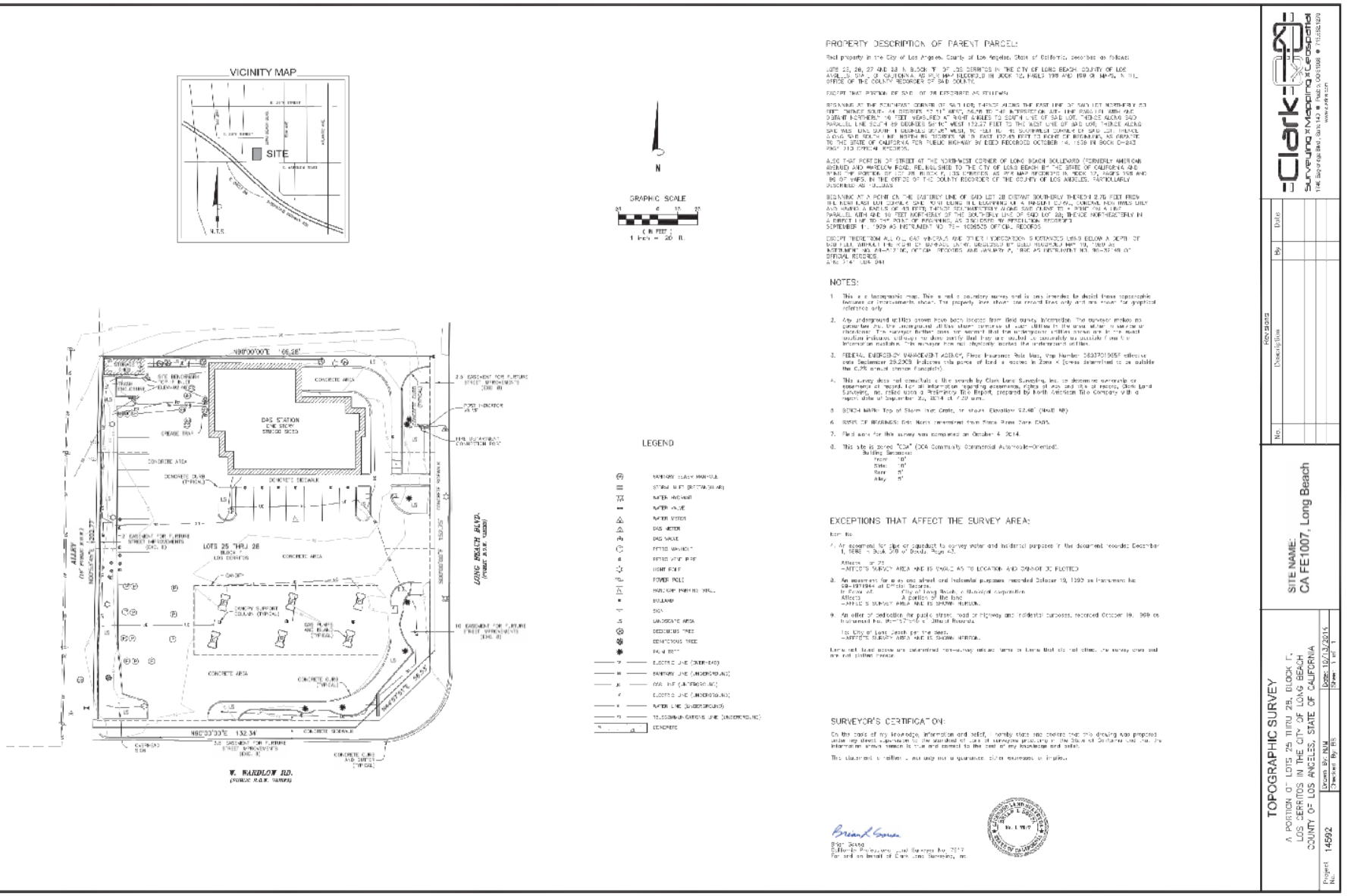
On April 22, 2015, draft final construction drawings (or “construction drawing 90s”) were completed that depict all the details required for construction and the permit review. Final construction drawings (or “construction drawing 100s”) were completed, with 60 pages that depict all the details required for construction and the permit review on May 6, 2015. These drawings are similarly signed and sealed by the professional engineer of record to ensure accuracy and completeness. Figure 4 shows the equipment compound page of the construction drawing 100.

Figure 1: Coarse Detail of Equipment Compound from Construction Drawing 30 Set



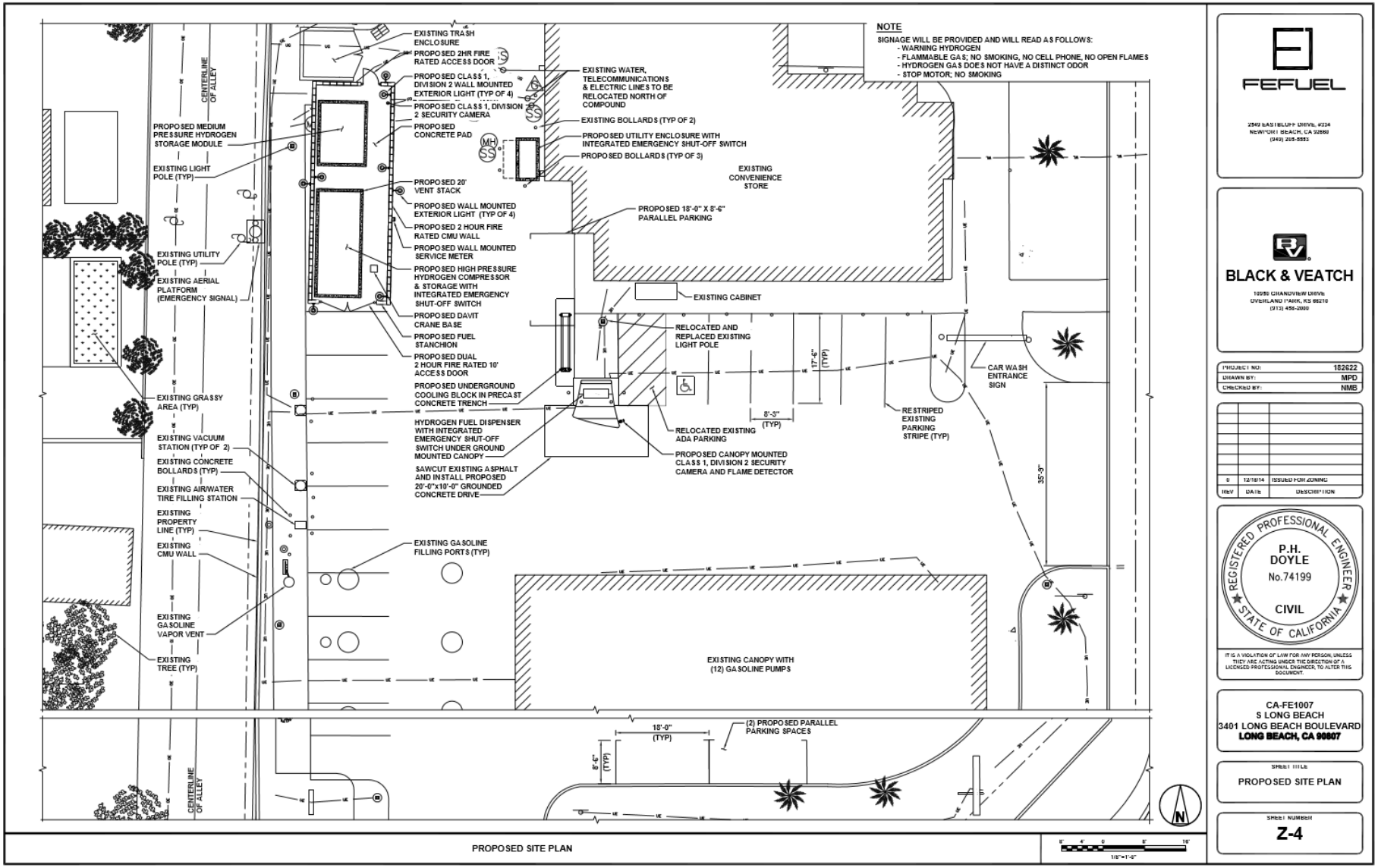
Source: FirstElement Fuel, Inc. Original figure is higher resolution.

Figure 2: Survey of the Long Beach Hydrogen Station Location



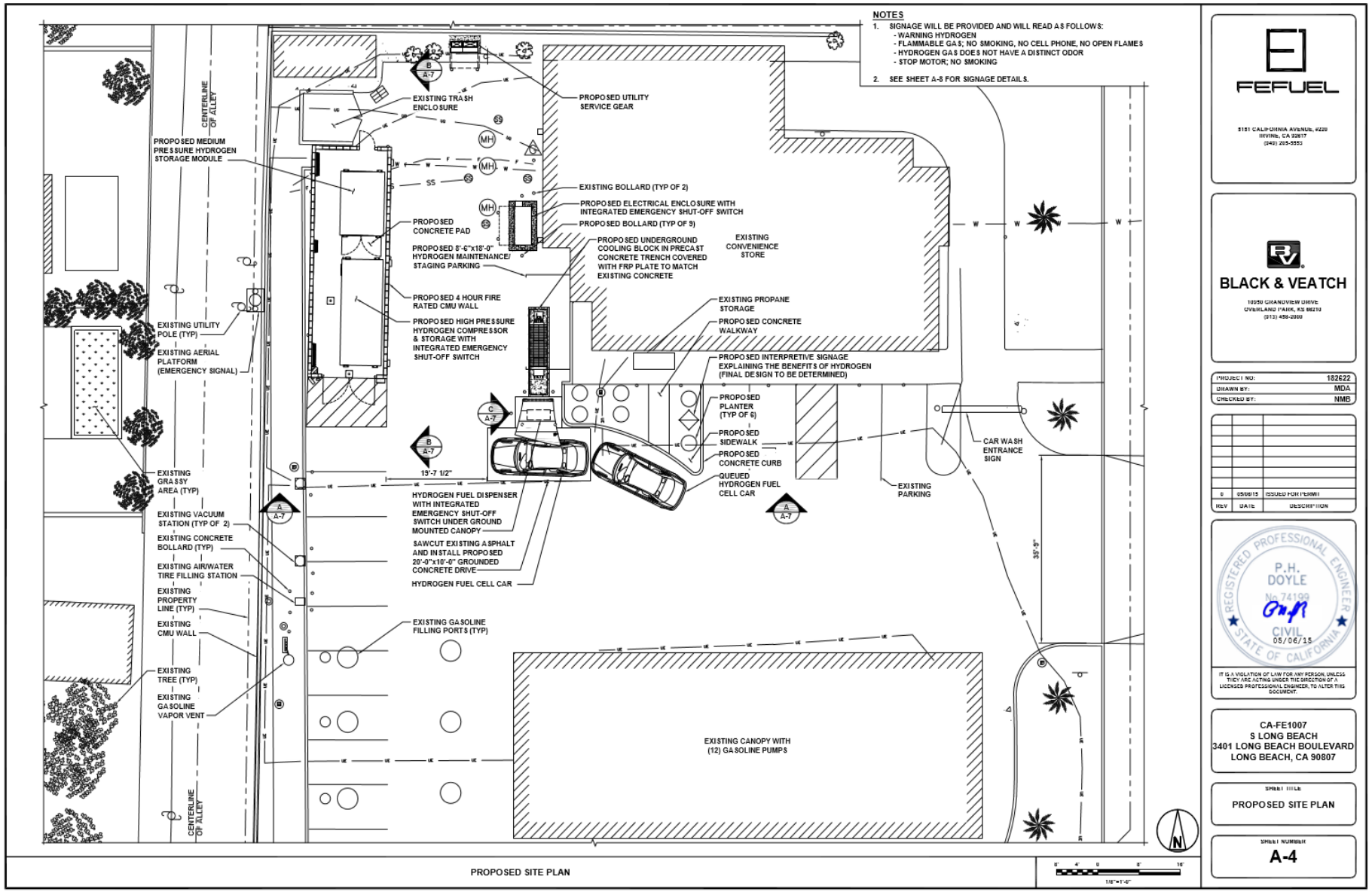
Source: FirstElement Fuel, Inc. Original figure is higher resolution.

Figure 3: Equipment Compound from Zoning Set



Source: FirstElement Fuel, Inc. Original figure is higher resolution.

Figure 4: Equipment Compound from Construction Drawing 100 Set



Source: FirstElement Fuel, Inc. Original figure is higher resolution.

FirstElement Fuel, Inc. and Black & Veatch submitted the zoning application to the appropriate jurisdiction on December 23, 2014. The local planning department had to verify that the project meets the zoning requirements of the proposed location and approve any aesthetic, landscaping, or other details that are important to the community. Approval was received through a public hearing process on April 13, 2015.

All building permit applications were submitted April 8, 2015, and approved on June 22, 2015, over 75 days.

FirstElement Fuel, Inc. and Black & Veatch submitted a detailed bid package to contractors June 12, 2015. The contract was awarded to Aliantel on June 25, 2015. The bulk of Aliantel's construction experience lies in cell towers. Cell towers are roughly similar to hydrogen stations in size, have similar foundations and block walls, and have similar electrical requirements. Aliantel provided a reasonable bid, had a desire to get involved with hydrogen projects, and is based in Southern California. Construction started June 29, 2015. Figure 5 shows the equipment compound before completion.

Figure 5: Interior of Station Equipment Compound before Completion

Source: FirstElement Fuel, Inc.

Hydrogen storage, compression (Figure 6), cooling, and dispensing equipment was delivered to the site September 9, 2015.

Construction progressed quickly, in part because of the time spent throughout the project to gain a common understanding of project requirements, especially those listed in the National Fire Protection Association hydrogen technologies code.

Figure 6: Crane Lifting Hydrogen Compressor Unit

Source: FirstElement Fuel, Inc.

Making the Station Operational (October 8, 2015–October 30, 2015)

The commissioning of the Long Beach hydrogen station included the cleaning and purging of lines, pressure testing, and hydrogen sampling.

Station Declared Operational (October 30, 2015)

The Long Beach hydrogen station met the definition of operational in PON-13-607 by completing installation of all station/dispenser components, obtaining all the required permits from the local jurisdiction, filling the storage tubes of the station with pressurized hydrogen gas, successfully passing a hydrogen quality test (Figure 7), successfully fueling one fuel cell electric vehicle with hydrogen, and opening to the public. FirstElement Fuel Inc. declared the station operational October 30, 2015, upon completion of construction.

Figure 7: Hydrogen Fuel Quality Report October 28, 2015

www.SmartChemistry.com

SAE J2719 Report	SAE J2719 Limits (µmol/mol)	Smart Chemistry Detection Limits (µmol/mol)	FIRST ELEMENT LONG BEACH H70 H_2 @Nozzle sampled on 10/28/2015 Concentration (µmol/mol)	Analytical Method
Water	5	0.2	**1.31**	ASTM D7649
Total Hydrocarbons (C, Basis)	2	1	**3.2**	ASTM D7892
Methane (SAE J 2719 page 5 foot note 6 THC may exceed 2 micromoles per mole due only to the presence of methane, in which case the summation of methane, nitrogen and argon is not to exceed 100 ppm.)		0.001	3.2	
Acetone			0.016	
Ethane			0.042	
Oxygen	5	1	< 1	ASTM D7649
Helium	300	10	< 10	ASTM D1946
Nitrogen, Argon	100			
Nitrogen		5	**18**	ASTM D7649
Argon		0.5	**6.0**	ASTM D7649
Carbon Dioxide	2	0.5	< 0.5	ASTM D7649
Carbon Monoxide	0.2	0.0005	**0.0023**	ASTM D5466
Total Sulfur	0.004	0.000001	**0.000029**	ASTM D7652
Hydrogen Sulfide		0.000001	0.000019	ASTM D7652
Carbonyl Sulfide		0.000001	0.000011	ASTM D7652
Methyl Mercaptan (MTM)		0.00001	< 0.00001	ASTM D7652
Ethyl Mercaptan (ETM)		0.00002	< 0.00002	ASTM D7652
Dimethyl Sulfide (DMS)		0.00002	< 0.00002	ASTM D7652
Carbon Disulfide		0.00001	< 0.00001	ASTM D7652
Isopropyl Mercaptan (IPM)		0.00002	< 0.00002	ASTM D7652
Tert-Butyl Mercaptan (TBM)		0.00002	< 0.00002	ASTM D7652
n-Propyl Mercaptan		0.00002	< 0.00002	ASTM D7652
n-Butyl Mercaptan		0.00002	< 0.00002	ASTM D7652
Tetrahydrothiophene (THT)		0.00002	< 0.00002	ASTM D7652
Formaldehyde	0.01	0.001	< 0.001	ASTM D7892
Formic Acid	0.2	0.005	< 0.005	ASTM D5466
Ammonia	0.1	0.01	< 0.01	ASTM D5466
Total halogenates	0.05		**0.0023**	
Chlorine		0.001	< 0.001	ASTM D5466
Hydrogen Chloride		0.007	< 0.007	ASTM D5466
Hydrogen Bromide		0.007	< 0.007	ASTM D5466
Organic Halides (32 compounds in red and bold listed in "Other Hydrocarbons"). Smart Chemistry limit is for each individual organic halide.		0.001	0.0023	ASTM D7892
Tetrachloro-hexafluorobutanes			0.0023	
Particulate Concentration (Particulate Concentration Calculation Sheet is listed in Table II)	1mg/Kg		**0.16 mg/kg**	ASTM D7651
Particulates Found & Size (Images of particulates found is in Table 1)			**Only one particulate with size of 0.04mm found in the center of the filter**	ASTM D7834
Hydrogen Fuel Index The hydrogen fuel index is the value obtained when the amount of aggregate impurities, as, expressed as percent (µmol/µmol), is subtracted from 100%. (Section 3.5 of SAE J2719)			**99.99717%**	

SMART CHEMISTRY, 3401 La Grande Blvd, Sacramento, CA 95823, (916)391-3300, jphsu@smartchemistry.com

Source: FirstElement Fuel, Inc.

FirstElement Fuel performed automaker testing at the Long Beach hydrogen station to verify correct operation per *SAE J2601 Fueling Protocols for Light-Duty Gaseous Hydrogen Surface Vehicles.*

Certification (January 14, 2016)

The California Department of Food and Agriculture's Division of Measurement Standards is responsible for enforcing California weights and measures laws and regulations and must certify any device used for metering the sale of commercial items within California.

Figure 8 shows that FirstElement Fuels, Inc. 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), as witnessed by the local county weights and measures officer.[1]

Figure 8: Certification at Long Beach Hydrogen Station

Source: FirstElement Fuel, Inc.

1 Examination Procedures for New Station (https://www.cdfa.ca.gov/dms/programs/devices/Hydrogen_Gas-Measuring_Devices_EPO-40.pdf)

Station Use (October 30, 2015-Present)

Figure 9 shows the first vehicle filled was a Hyundai Tucson on October 30, 2015, and the station has been used regularly since then. The Long Beach station dispensed 38.8 kilograms of hydrogen in December 2015, 115.2 kilograms in January 2016, and 144.1 kilograms in February 2016.

Figure 9: First Fueling at the Long Beach Hydrogen Station

Source: FirstElement Fuel, Inc.

Station Operational Status System

The California Fuel Cell Partnership Station Operational Status System is a website portal designed to provide hydrogen station status for motorists.[2] 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 Long Beach hydrogen refueling station began sending automated updates (FirstElement Fuel, Inc. software) regularly to the Station Operational Status System on February 22, 2016.

2 Hydrogen Station Portal (https://m.cafcp.org/)

Environmental Impacts

Hydrogen will be stored as a compressed gas in an aboveground tank concealed 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 Long Beach 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 ever occurs. No solid or liquid waste will be produced at this site.

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

The use will not cause any unsightly appearances, such as noise, glare, dust, or odor. The hydrogen station is a modern addition to an existing gasoline station. No outdoor sound amplification systems were installed; however, lighting was installed at the station to ease evening fueling.

Long Beach Station in the Network

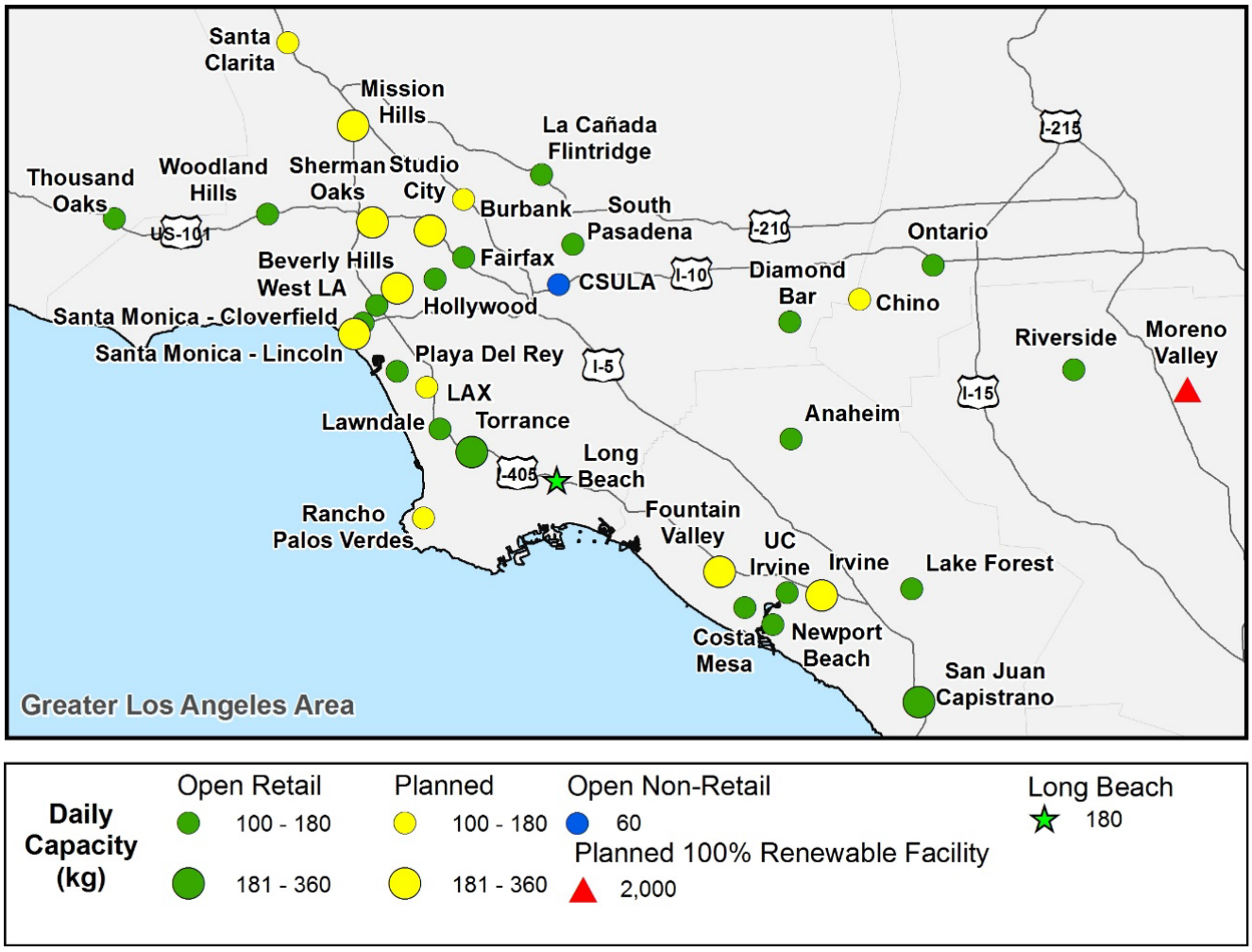
Figure 10 shows the station is open and ready for use.

Figure 10: Long Beach Hydrogen Station

Source: FirstElement Fuel, Inc.

Figure 11 shows the Long Beach hydrogen refueling station in relationship to similar stations in the southern part of the state.

Figure 11: Hydrogen Stations in Southern California: Open Retail and Planned

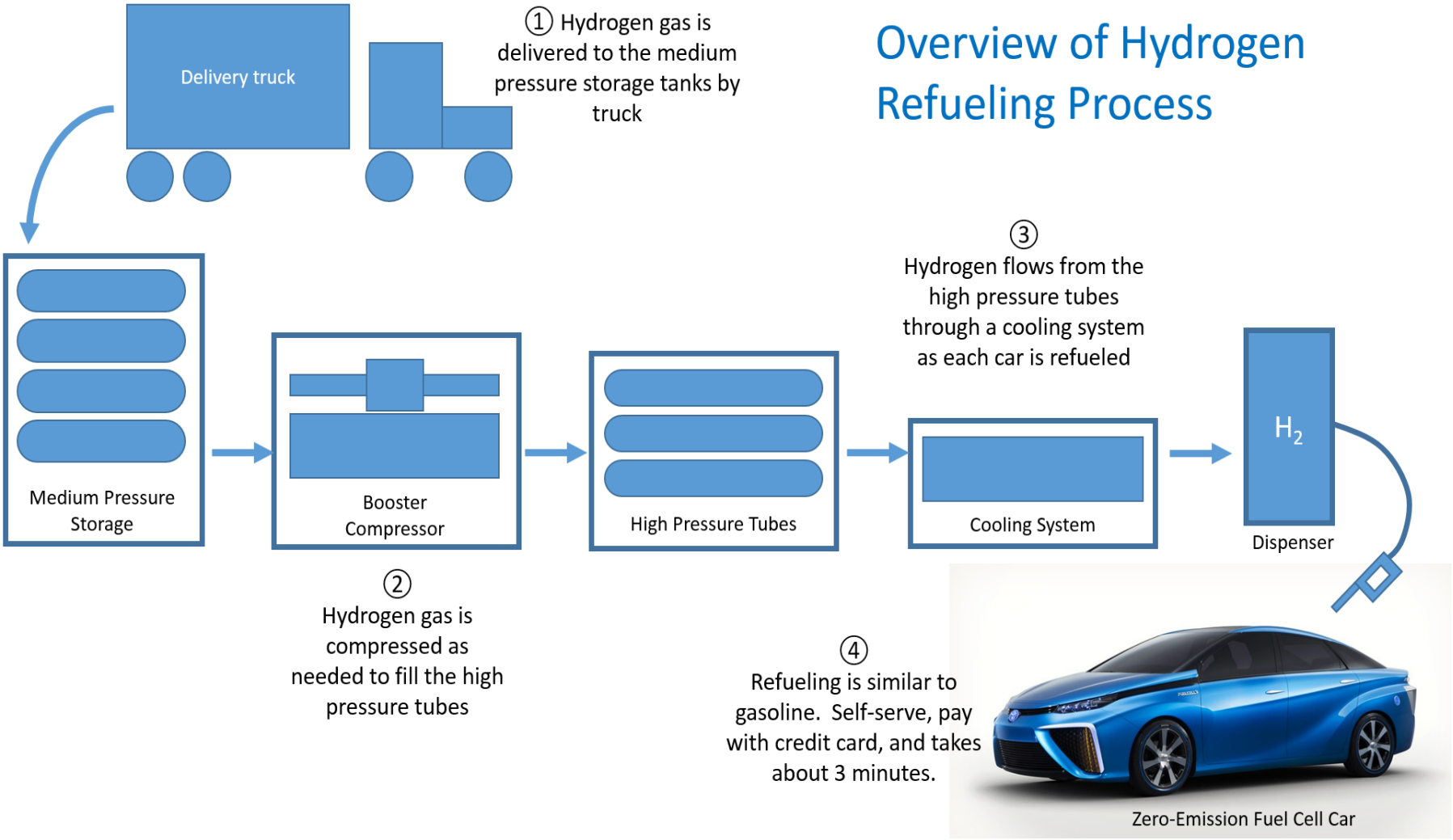


Source: CEC Staff

Schematic Layout of the Long Beach Station

Figure 12 depicts an overview of the Long Beach hydrogen station components and the steps in refueling.

Figure 12: Schematic Depicting Hydrogen Station Equipment and Refueling Process

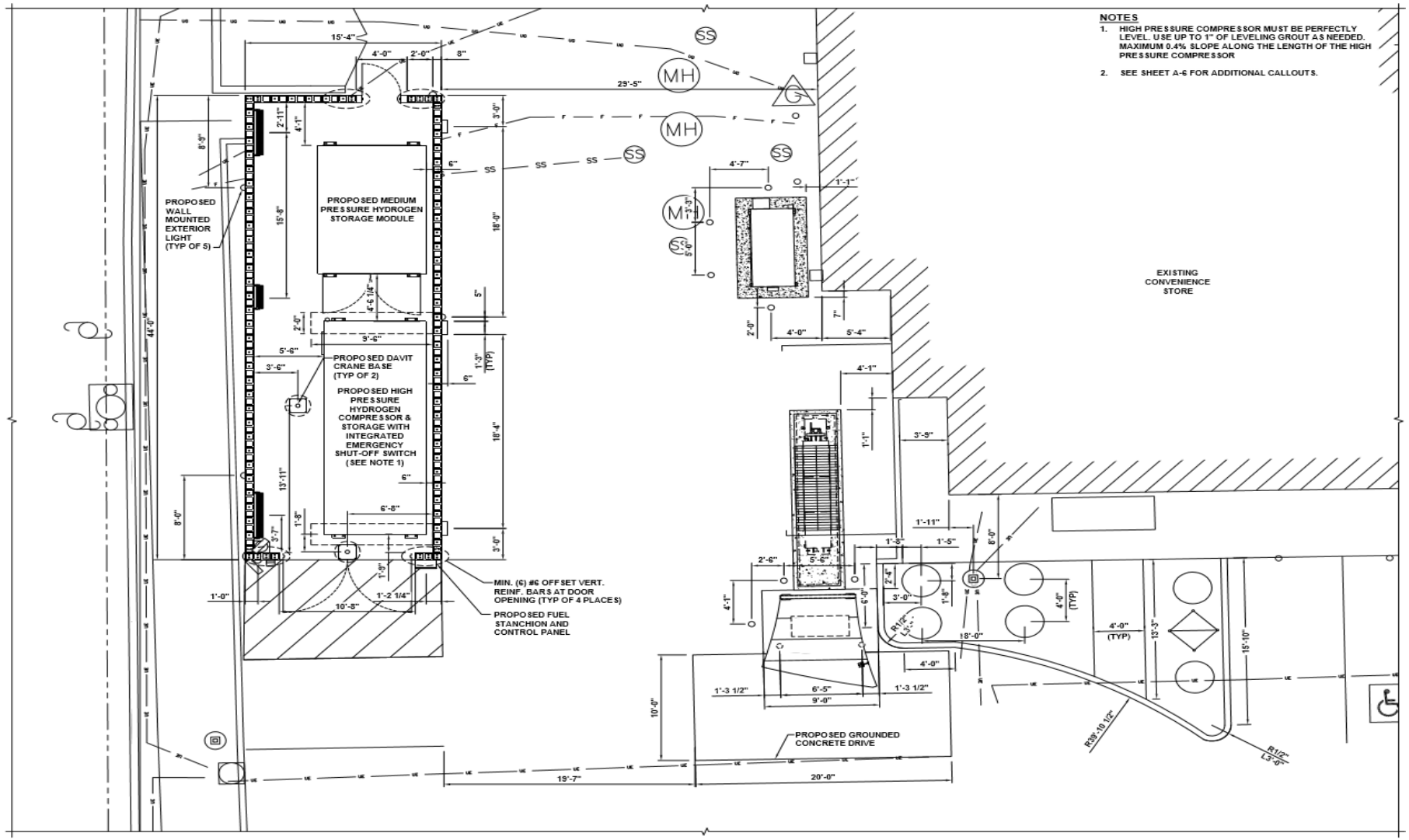


Source: FirstElement Fuel, Inc.

Final Configuration and Budget

Figure 13 shows a detailed view of the actual final, as-built configuration of the Long Beach station.

Figure 13: Enlarged View of Final Long Beach Layout



Source: FirstElement Fuel, Inc.

Figure 14 shows a detailed view of the budget to construct the Hayward hydrogen station.

Figure 14: The Project Grant Funding and Match Funding

Air Products and Chemicals, Inc., Allentown , PA	
H2 station equipment	$1,480,192.21
Black & Veatch, Overland Park, KS	
Construction	$509,859.09
Engineering	$45,493.20
Permitting	$83,399.64
Project Management	$18,197.53
Various Vendors	
Construction Materials (tubing, wire, etc.)	$23,866.36
Fixtures (doors, lights, etc.)	$65,980.45
MSI Tech, Irvine CA	
Data Collection Tool	$3,582.24
Karen Calhoun, Newport Beach, CA	
Legal services	$13,150.03
Vertical Advisors LLP, Newport Beach, CA	
Financial services	$4,345.13
Total Project Costs	$2,248,065.88
California Energy Commission grant	$1,451,000.00
Remaining match funding provided by FirstElement Fuel, Inc.	$797,065.88
Total California Energy Commission cost share	64.5%

Source: FirstElement Fuel, Inc.

CHAPTER 2:
Energy Analysis

The Long Beach 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):

$$CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$$

Per FirstElement Fuel, Inc.'s funding agreement with the CEC, 100 percent of the hydrogen sold at the Long Beach hydrogen station will be produced from renewable sources. Hydrogen is supplied to the hydrogen fueling stations from Air Products and Chemicals, Inc.'s hydrogen production plants in Wilmington/Carson, California. Renewable biogas will be procured as feedstock for the station, resulting in delivered hydrogen product that is 100 percent renewable (sources of biogas shown in Figure 15).

Figure 15: Renewable Biomethane Supply Sources

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

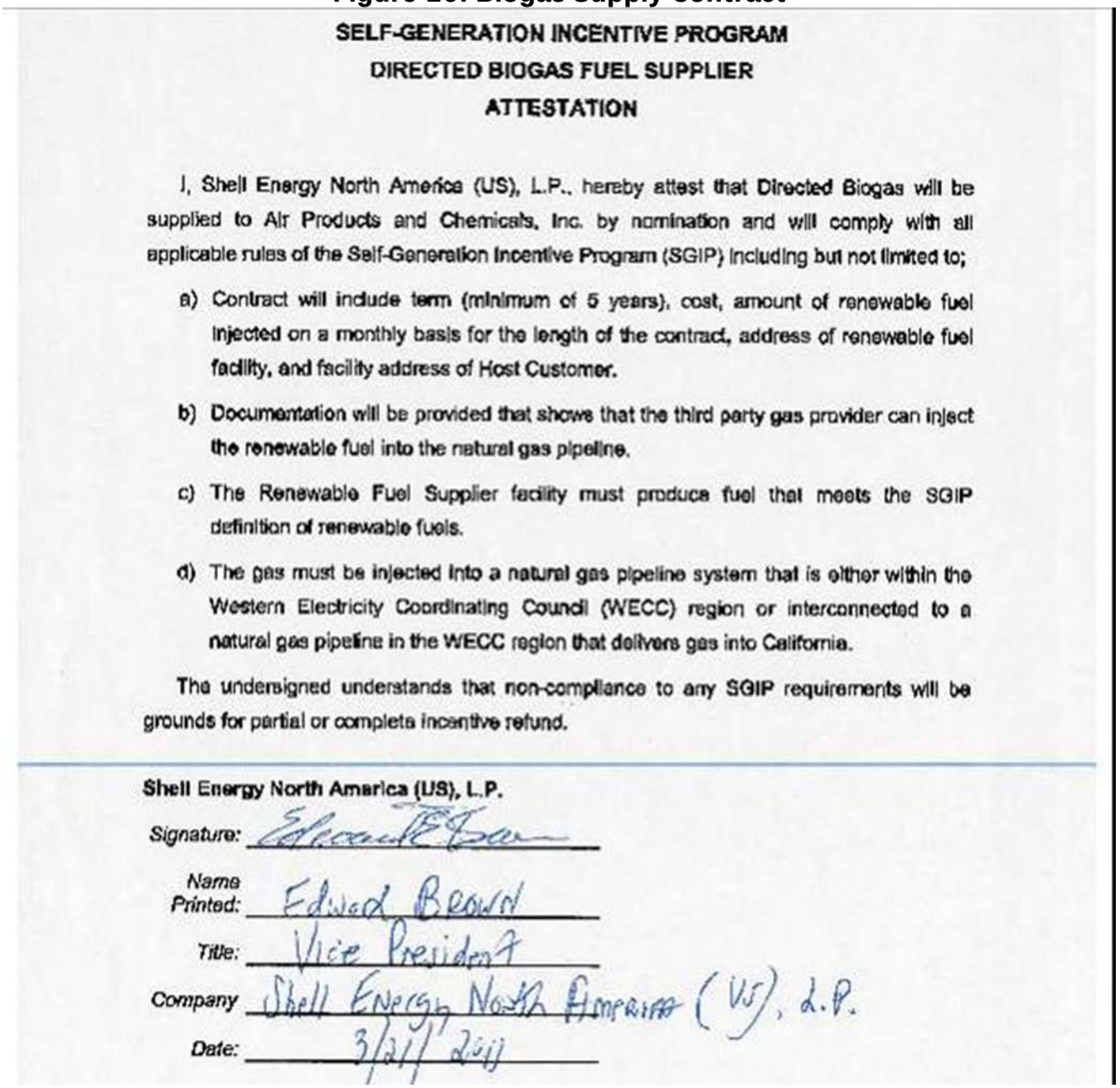
Supply Source	Address	Pipeline/LDC	Receipt	Delivery
Greentree Landfill	635 Toby Road Kersey, PA 15846	National Fuels Gas TETCO NGPL EPNG SoCal Gas FAR	Landfill meter Nat Fuel-Bristoria Tetco-Sweet Lake 3825 EPNG Jal 3083 Topock	Bristoria NGPL-Sweet Lake EPNG Jal 3083 Topock SoCal Citygate
Imperial Landfill	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 of the renewable biogas that meets Public Resources Code Section 2574 (b) (1); Figure 16 provides the documentation. 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.'s biogas supply for this project comes from outside California and transported to California with connection to a natural gas pipeline in the Western Electricity Coordinating Council region that delivers gas into California[3].

3 The Western Electricity Coordinating Council promotes bulk electric system reliability in the Western Interconnection. (https://www.wecc.biz/Pages/AboutWECC.aspx)

Figure 16: Biogas Supply Contract



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: FirstElement Fuel, Inc.

Hydrogen is delivered to all FirstElement Fuel, Inc. stations (including Long Beach) by a U.S. Department of Transportation-certified high-pressure delivery trailer.

The Long Beach hydrogen station can dispense 180 kilograms of hydrogen each day. Based on average hydrogen use by FCEVs, the dispensing capacity of this station is enough to support up to 260 FCEVs, depending on driver habits. Assuming that FCEVs average 52 miles/1 kilogram of hydrogen (*The Greenhouse Gases, Regulated Emissions, and Energy Use in*

Transportation Model,)[4] and consumption of 180 kilograms/day for the next 10 years, the station will offset 8,384 metric tons of total greenhouse gas compared to equivalent gasoline vehicles. Furthermore, the Long Beach hydrogen station will eliminate more than 1.54 million gallons of gasoline, assuming the 2013 national passenger fleet average fuel economy of 21.6 miles per gallon.

As part of a separate grant agreement (ARV-15-030) for operations and maintenance funding through the California Energy Commission, data on the operation of the station will be collected and reported quarterly for three years (December 22, 2015, to October 31, 2018). Data collected and reported will include the fuel log, dispensing, compression, storage and delivery, maintenance, and other monthly operating costs such as rent, electricity, property tax, and license and permit fees.

4 GREET® Model (https://greet.es.anl.gov/)

CHAPTER 3:
Future Activities

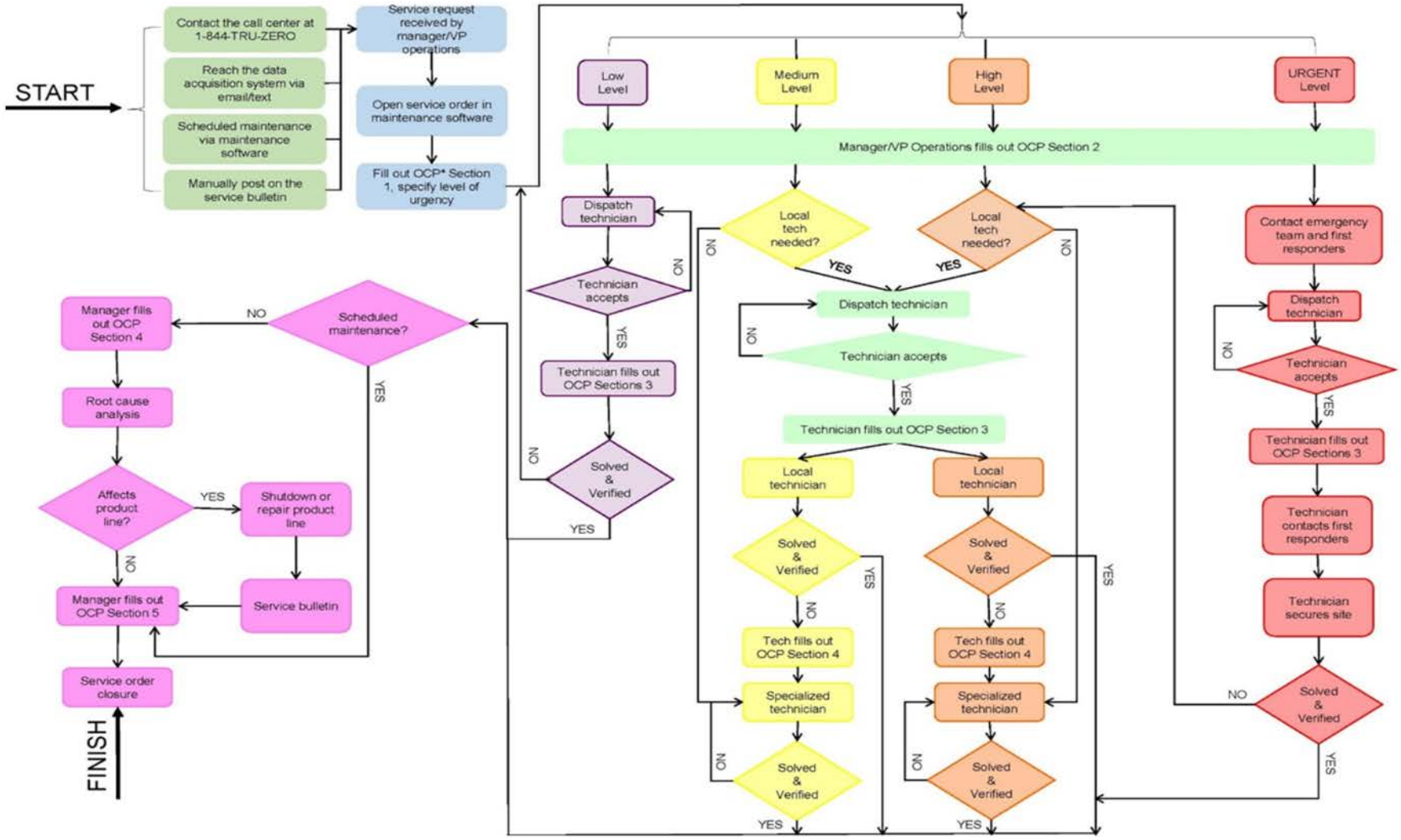
FirstElement Fuel, Inc. intends to own and operate the Long Beach refueling station for at least 10 years. FirstElement Fuel, Inc. has invested substantial capital to build the station and will require many years of operation to recoup the development costs. FirstElement Fuel, Inc. has executed an initial 10-year lease with the landowner with the possibility for extension.

In addition, FirstElement Fuel, Inc. is building an in-house maintenance team that will have the personnel and equipment to maintain and repair any of its stations as quickly as possible throughout California. Figure 16 shows a flow diagram for response from the operations and maintenance team.

To augment onsite personnel across the FirstElement Fuel, Inc. network, a comprehensive data collection and monitoring system has been implemented. Figure 17 shows a screenshot of one page of the system. FirstElement Fuel, Inc. maintenance personnel can access a breadth of real-time performance and sensor data, live video feeds, and historical usage data and can control some features of the station remotely, 24 hours per day.

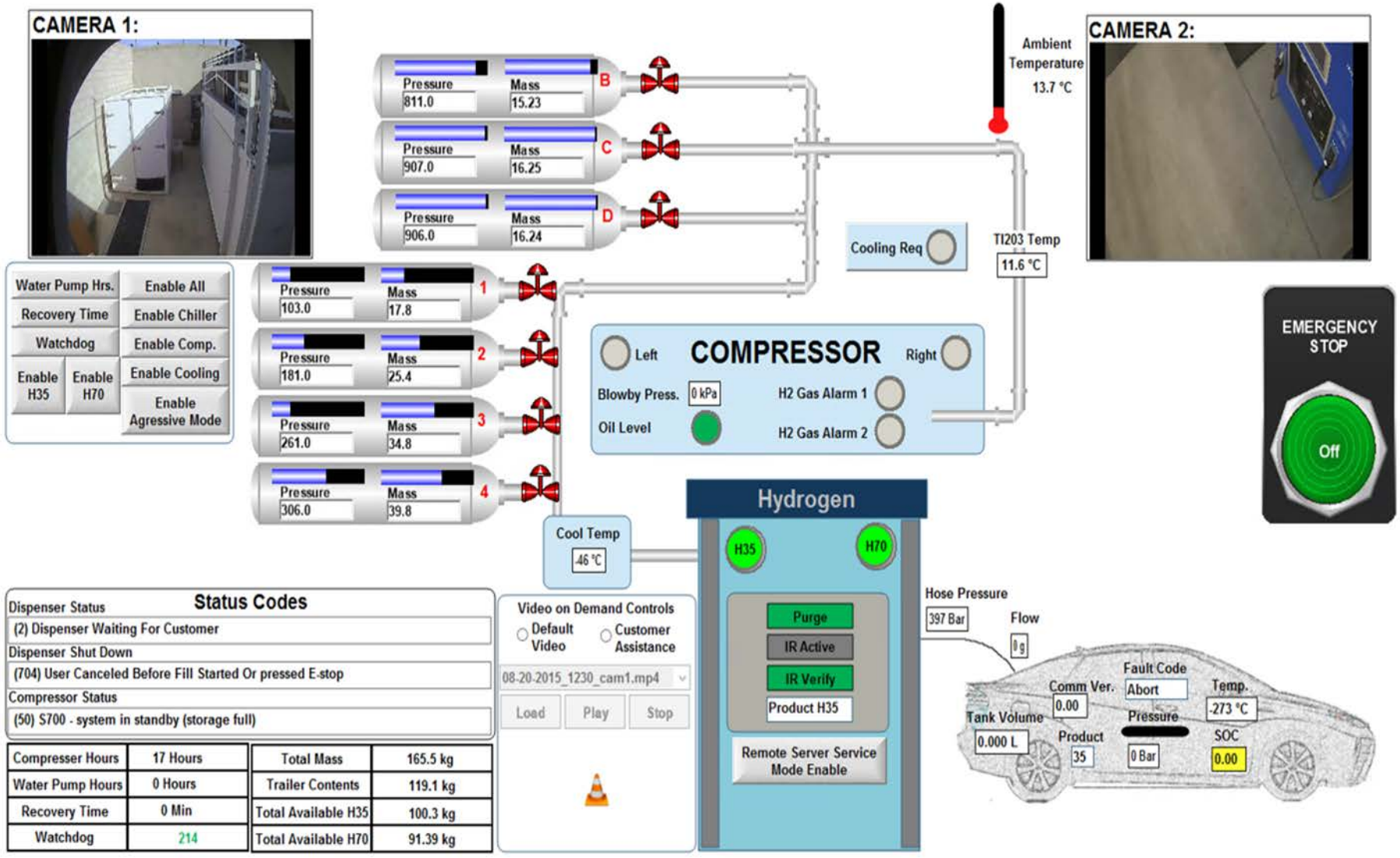
In addition to remote monitoring, FirstElement Fuel, Inc. has implemented rigorous computerized maintenance management systems and enterprise asset management systems to schedule and track maintenance, repairs, and inventory. Work orders will be generated, completed, and logged for all maintenance and repair. This will help maximize station uptime and enable tracking of key performance indicators.

Figure 17: FirstElement Fuel, Inc. Response Flow Chart



Source: FirstElement Fuel, Inc.

Figure 18: Screenshot of FirstElement Fuel, Inc.'s Remote Monitoring System



Source: FirstElement Fuel, Inc.

CHAPTER 4:
Conclusions

The following is a list of important findings from the Long Beach hydrogen station project:

The lead planner for this project in Long Beach was particularly detail-oriented and demanded strict adherence to his vision for the hydrogen station. This adherence added to the planning upfront but ultimately resulted in a very smooth and nearly effortless planning commission hearing.

Because the Long Beach station is near the exit of a rollover car wash, the fire authority in this jurisdiction was particularly concerned with an errant vehicle leaving the carwash and hitting the hydrogen equipment compound. First Element Fuel attained approval by constructing an impact wall into one portion of the equipment compound and adding a backup battery system with an audible alarm.

National Fire Protection Association hydrogen technologies code is critical for technical projects of this nature. The code clearly defines fire guidelines that enable local jurisdictions and contractors to construct hydrogen stations uniformly and ensure safety. The key is for station builders and station permit agencies to understand and appreciate fully the content of National Fire Protection Association hydrogen technologies code.

GLOSSARY

CALIFORNIA ENERGY COMMISSION—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:

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

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).

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 GASES (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), 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 (CH4)—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, enteric fermentation in animals and is one of the greenhouse gases.