CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

San Francisco Mission Street Hydrogen Station

Prepared for: California Energy Commission

Prepared by: Equilon Enterprises LLC (dba Shell Oil Products US)

Gavin Newsom, Governor

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California Energy Commission

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ACKNOWLEDGEMENTS

Shell Hydrogen is focused on making hydrogen fuel a mainstream and competitive option for zero-emission transportation. Developing the network of hydrogen fueling stations under this grant funding opportunity has accomplished significant progress for fuel cell electric vehicle customers in California.This includes the fastest delivery of new stations to date in California for improving coverage and capacity in the fueling network, two fueling positions at each station for improving customer service, station reliability through two redundant systems at each station, and integration under the canopy alongside other fuels for safety of traffic flow, convenience, shelter, and the normalcy of refueling. We would like to thank the following individuals and business partners for significant contributions to this success:

- The California Energy Commission (CEC) Lead Transportation Commissioner, Patty Monahan, who provided visionary leadership and direction for the hydrogen mobility in the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program; CEC Hydrogen Unit Supervisor, Jean Baronas, who provided diligent program administration with helpful attention to detail and direct engagement; as well as the various Commission agreement managers and officers who provided thoughtful and constructive oversight of the Mission Street station delivery.
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- The Nel service and operations teams, who are important business partners for increasing the quality and capacity of hydrogen fueling station equipment in these stations and ongoing partnership in the successful operation and maintenance of the stations.
- The Fiedler Group Team who was instrumental in managing the permitting process, which often entailed the challenging task of

introducing jurisdictions to hydrogen refueling stations. Fiedler Group also managed the detailed design and construction on site, drawing from their deep expertise in the retail refueling business.

- The team at Nicosia Construction International, who did an exceptional job with the construction of the site and was on the front line of managing the daily hazardous aspects of construction. Their careful work and planning resulted in no injuries to personnel, assets, or the environment.
- The local authorities having jurisdiction for the stations – Sacramento, San Francisco, Berkeley, Walnut Creek, and San Jose – who worked collaboratively throughout the evaluation and permitting of these stations, and in doing so, have continued to expand upon the base of experience that will enable continued expansion of the hydrogen fueling network that is an important component of the infrastructure to transition to zero emission transportation.

PREFACE

Assembly Bill 118 (Nùñez, 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. AB 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the Energy Commission 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 Grant Funding Opportunity GFO-15-605 to provide grant funds to expand the network of publicly accessible hydrogen refueling stations that serve California's light duty fuel cell electric vehicles. In response to GFO-15-605, the recipient submitted an application that was

proposed for funding in the CEC's notice of proposed awards dated February 17, 2017, and the agreement was executed as ARV-17-007 on September 24, 2017.

ABSTRACT

Equilon Enterprises LLC (dba Shell Oil Products US) designed, engineered, permitted, constructed, and made operational a hydrogen refueling station at 3550 Mission Street, San Francisco California. The station consists of a concrete-reinforced block compound that encloses hydrogen storage, compression, and cooling equipment; two dispensers with one fueling hose each; and two customer payment point of sale terminals. Hydrogen dispensers are co-located with gasoline dispensers under the canopy of an existing Shell gas station.

Keywords: California Energy Commission, Mission Street, Equilon Enterprises, Shell Oil Products, fuel cell electric vehicles, hydrogen refueling station, infrastructure, FCEV

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EXECUTIVE SUMMARY

Equilon Enterprises LLC (dba Shell Oil Products US) built a hydrogen refueling station at its existing gasoline station at 3550 Mission Street, San Francisco. Under Grant Funding Opportunity-15-605, the CEC funded 58.9 percent of the total cost of the station while Shell provided the balance for a total station cost of $3,971,000. The CEC contributed $2,337,500.

The hydrogen station has a refueling capacity of 400 kilograms per day, dispensed via two single-hose dispensers that are located under the canopy, in the same fueling lanes that gasoline cars use for refueling.

Shell's project team comprised of Fiedler Group as engineer of record; Nel Hydrogen as equipment vendor, installer and O&M contractor; and Nicosia Construction International as the general contractor.

The hydrogen station equipment, supplied by Nel Hydrogen, attained a Underwriter Laboratories Certificate of Compliance on October 25, 2018. This certification applies to all stations conforming to this design.

The station took 33 months to achieve an open retail status, from the time when Fiedler Group initiated preapplication meetings with authorities having jurisdiction to the open retail date of February 14, 2020. The open retail date is the date at which the station first became open to the public. The first fueling of a fuel cell electric vehicle was September 30, 2019. The time to open retail after construction crew mobilized was 16 months, which includes a period of about four months of no activity after construction encountered a previously unknown underground structure and plans were redeveloped.

Shell initiated site acquisition negotiations with AU Energy, the joint owner and operator for the Mission Street Shell gasoline station. A complete agreement was executed on August 17, 2016.

Fiedler Group initiated preapplication meetings with the authorities having jurisdiction (AHJ) in May 2017. An entitlement application package was submitted concurrently to the City and County of San Francisco (CCSF) in November 2017. One round of comments was received for the entitlement process. The entitlement approval was received in August 2018. Two rounds of plan check comments were received from the building department. The building department's approval was obtained in September 2018.

Shell initiated equipment procurement with Nel Hydrogen in April 2017. On-site delivery and installation of equipment was completed July 2019.

After a competitive bidding process, Shell awarded Nicosia Contracting International the contract for civil construction. Construction of the station began October 23, 2018.

After about four weeks of mobilization, a previously unknown underground structure was encountered. It was determined to be Bay Area Rapid Transit (BART) infrastructure related to the underground railway tracks. The presence of this structure was not revealed during a search of county records and title search. Construction was suspended for about four months while the new site plan was developed and permitted. The station, with all hydrogen equipment installed, was ready for a pre-startup safety review on July 23, 2019.

Precommissioning activities began July 2019, and the first FCEV was filled on September 30, 2019, after obtaining a certificate of accuracy for the dispensers, issued September 25, 2019, by California Department of Food and Agriculture, Division of Measurement Standards.

Shell collected one year of operational data, which was submitted to the CEC. The data included quarterly reporting of all fueling, maintenance, operations data; four hydrogen quality reports; and three reports of dispensed renewable hydrogen. If one average hydrogen FCEV takes one average gasoline mid-sized sedan off the road, the amount of gasoline displaced due to Mission Street operation using one year of data (March 2020 to March 2021) would equal nearly 14,000 gallons displaced per year.

Shell plans to operate the Mission Street station for at least the next 10 years and plans to operate up to 56 other light-duty stations in California in addition to heavy-duty stations. Shell is a committed participant and supporter of California's vision for the hydrogen refueling station network.

CHAPTER 1: Introduction

Objectives

The Mission Street station is one of seven stations that Equilon Enterprises LLC (dba Shell Oil Products US) designed and constructed under awards from the California Energy Commission (CEC), granted under its grant funding opportunity, GFO-15-605. The objective of this project was to design, build, commission, and open a retail hydrogen service station co-located at an existing Shell gasoline station at 3550 Mission Street, San Francisco, CA 94110. The objective of this station was to demonstrate that a hydrogen refueling station is capable of meeting FCEV consumer convenience needs safely and reliably.

Approach

Shell's overall approach to the development of its hydrogen refueling station infrastructure has the following key elements:

- Make the customers refueling experience as similar as possible to that of refueling gasoline powered vehicles. This is achieved by co-locating hydrogen dispensers and associated point-of-sale (POS) terminals with the gasoline dispensers under the canopy of its branded gas stations.
- Employ standardized equipment design, and performance characteristics across all its hydrogen refueling stations.
- Employ modular equipment with the smallest possible footprint to permit installation in existing stations that are space constrained. Such stations are typically located in urban, densely developed sites. The modular equipment allows Shell to bring hydrogen refueling stations to city centers.
- Team with engineering firms, equipment manufacturers, and construction contractors with a proven record of designing and building service stations.

Activities Performed

Shell performed the following activities:

- Site acquisition
- Preliminary investigations
- Equipment procurement
- Entitlements

- Design and permitting
- Bid solicitation
- Construction
- Commissioning and startup
- Operational and open retail station
- Data collection and analysis

CHAPTER 2:
Station Design, Construction and Startup

Major Activities and Timeline

Construction of the Mission Street station required many activities that are listed and described below along with an approximate timeline for their execution. Shell negotiated site acquisition agreement and procured the hydrogen station equipment.

Shell retained Fiedler Group (FG) to prepare documents required for design, entitlements, permitting, bid solicitation, and construction services. FG implemented its phased approach to accomplish the preparation of the documents, exhibits and attain a permit ready to issue status. The project team comprised of Shell, Nel Hydrogen (Nel), FG and the construction contractor, Nicosia Contracting International, LLC (NCI), implemented a phased approach to achieve an open retail station.

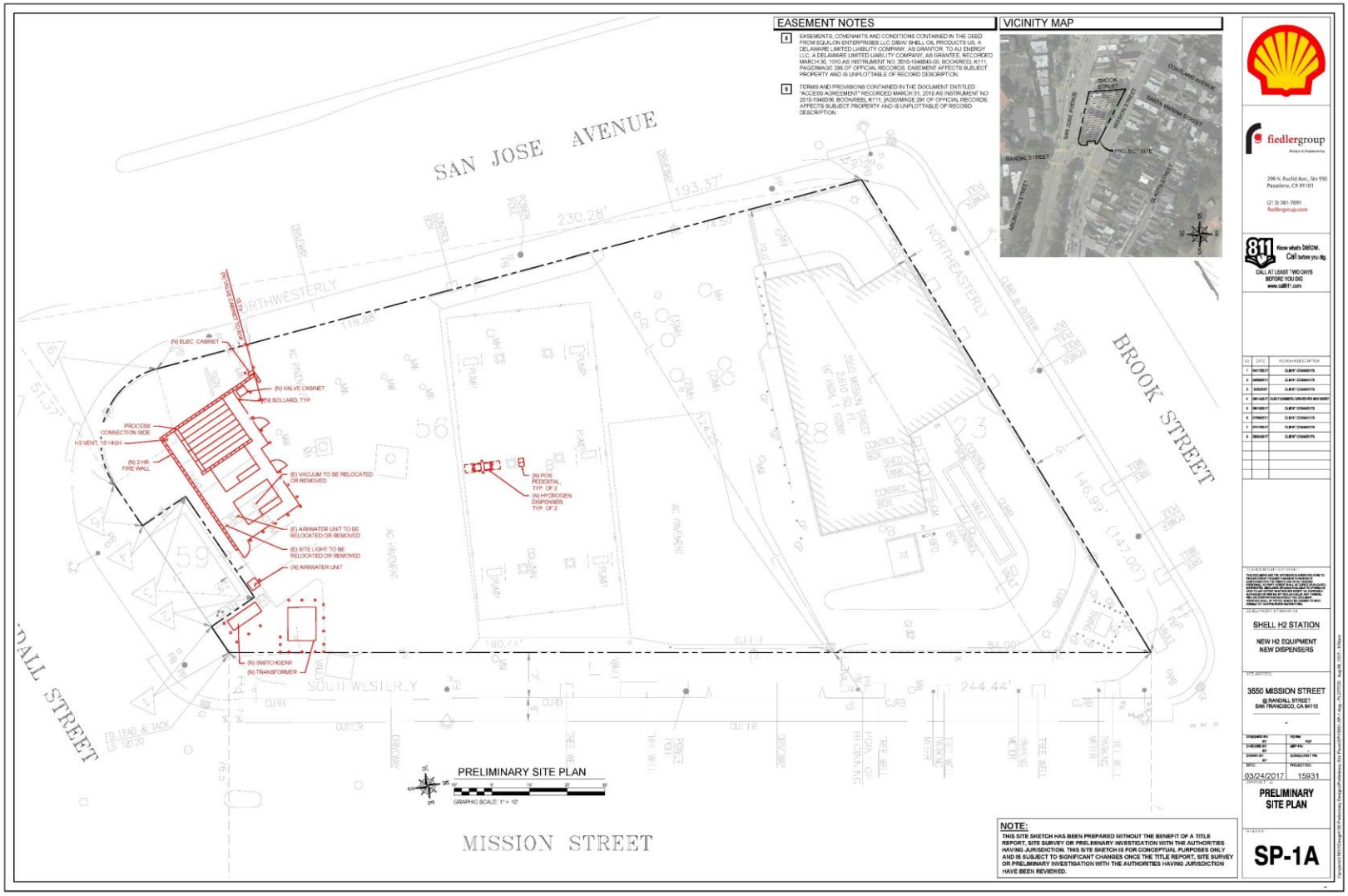
Site Acquisition (August 2016)

The Mission Street station is at an existing Shell branded station operated by AU Energy (AUE). The site is jointly owned by Shell and AUE. Shell and AUE entered into negotiations to build a hydrogen station and executed a completed agreement August 17, 2016.

Preliminary Investigations (May 2017 to November 2017)

FG investigated the requirements of various government agencies and utilities. This entailed discovery of requirements, codes, ordinances, and regulations that impact entitlements, permitting, and design criteria. A site investigation report was developed based on agency contact. Shell contacted the following agencies: City and County of San Francisco, Planning Department, Building Department, Fire Department, Department of Public Health [Environmental Health], Bay Area Air Quality Control District, and local utility Pacific Gas and Electric Company (PG&E). A preliminary site plan was prepared based on Shell's design requirements, agency findings and site visit. Figure 1 illustrates the preliminary site plan.

Figure 1: Preliminary Site Plan



Source: Fiedler Group/Shell

Equipment Procurement (April 10, 2017, to July 23, 2019)

Shell selected Nel to supply the hydrogen station equipment. Shell contracted with Nel to supply, install, and commission all equipment necessary to achieve an operational hydrogen station. Nel supplied the following major hydrogen station equipment: station module (containing compressor and hydrogen cooling system), storage module and associated valve panels, supply cabinet and associated human machine interface, hydrogen dispensers, and all interconnecting mechanical pipe and tubing between the equipment. The equipment delivery was timed to synchronize with the construction schedule. All the equipment was delivered to the site and installed by July 23, 2019. Shell purchased the POS terminals from COMDATA.

Entitlement Process (November 14, 2017, to August 24, 2018)

FG submitted the entitlements drawing package to the authorities having jurisdiction (AHJ) on November 14, 2017. The planning department verified that the project meets the zoning requirements and approved aesthetic, landscaping, and other details that are important to the community. One set of plan check comments were received and addressed. Shell received approval August 24, 2018. Figure 2 illustrates the site plan approved by the planning department.

Site Design and Permitting (November 14, 2017, to October 4, 2018; and February 12 to April 4, 2019)

FG submitted the first design drawing package to the City and County of San Francisco (CCSF) November 14, 2017. Two sets of plan check comments were received and addressed. Final approval of the construction permit was obtained on September 27, 2018. Figure 3 illustrates the site plan permitted for construction. Once construction started, a previously unknown, large underground structure owned by Bay Area Rapid Transit (BART) was discovered in the area of construction. This necessitated a revision to the site plan and another round of building department review and approval. The H2 station equipment compound had to be moved to avoid the BART structure. Permit documents were submitted to CCSF February 12, 2019, and the permit was ready to re-issue April 4, 2019. Figure 4 illustrates the new approved site plan.

Permission to Enter BART Easement (May 2017 to December 2018)

Title search of the Shell station revealed that BART had obtained an easement from the property owner to build the BART underground rapid transit tunnel, facilities and for incidental purposes. The presence of the easement necessitated that we obtain BART's permission to enter upon and build the equipment compound in an area that is subject to the easement. BART issued a fully executed permit to enter on December 19, 2018.

BART performed a design review and assessed risk to their adjacent aboveground structures. As a condition of issuing its permit, BART required that the Concrete Masonry Units (CMU) wall between the equipment compound and their aboveground structure be reinforced with blast protection,which added approximately $65,000 to construction cost.

Bid Solicitation (June 22, 2018, to August 10, 2018)

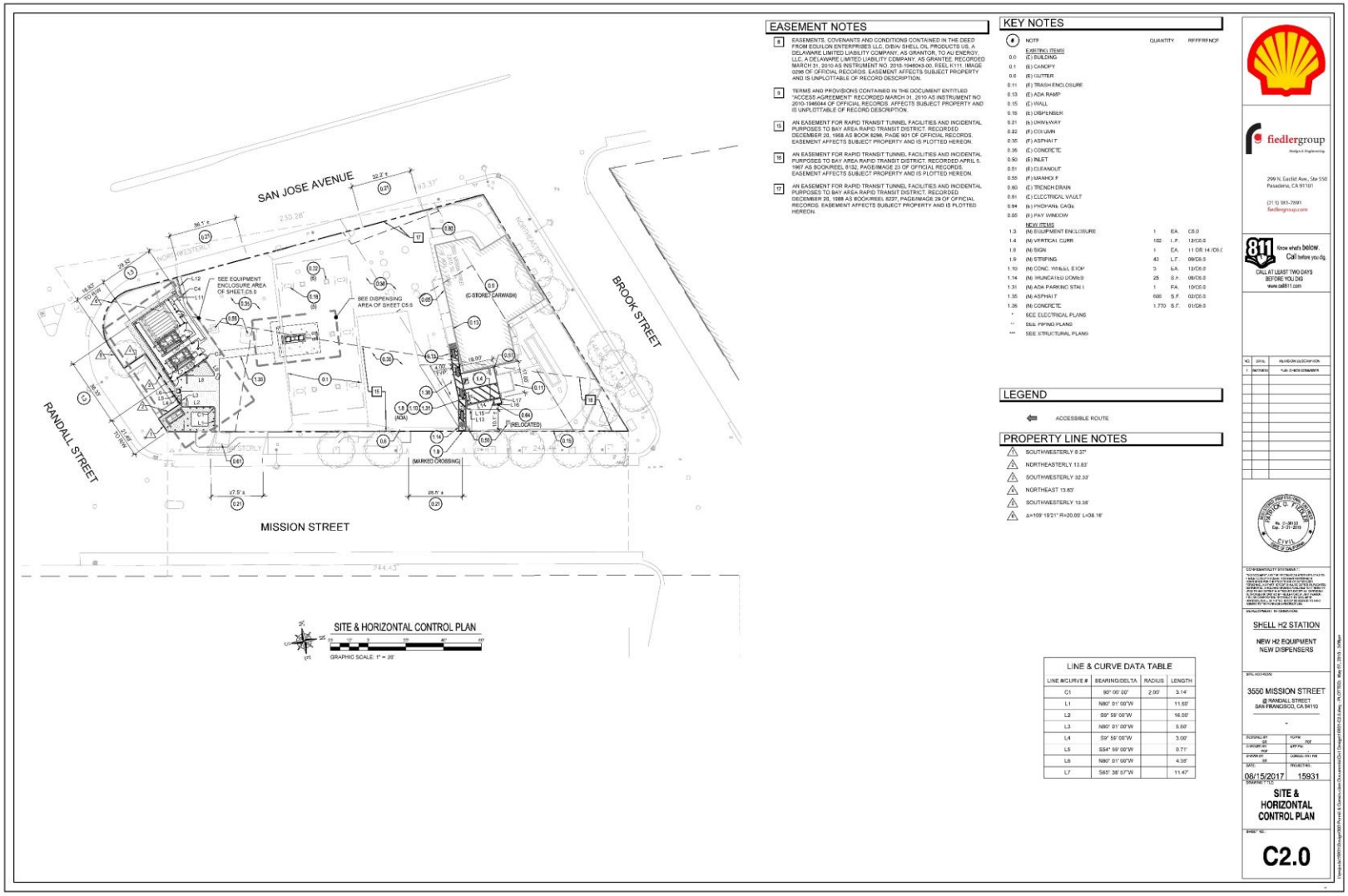
FG prepared a bid solicitation package consisting of the drawing set, technical documents, and project manual. Shell invited three prequalified general contractors to bid. Shell received three bids and evaluated them against an engineer's independent cost estimate. In addition to cost, other factors that Shell used to evaluate bids were prior similar experience and current capability, safety performance, financial strength, and ability to mobilize and complete construction per required schedule. Shell awarded a construction contract to Nicosia Contracting International, LLC (NCI) on August 10, 2018.

Construction (October 23, 2018, to December 21, 2018, and April 9, 2019, to July 23, 2019)

NCI mobilized to the site October 23, 2018. Due to reasons discussed above, construction was suspended in December 2018 until a revised site plan was prepared and re-permitted. Construction resumed in April 2019. All hydrogen station equipment was installed by July 23, 2019.

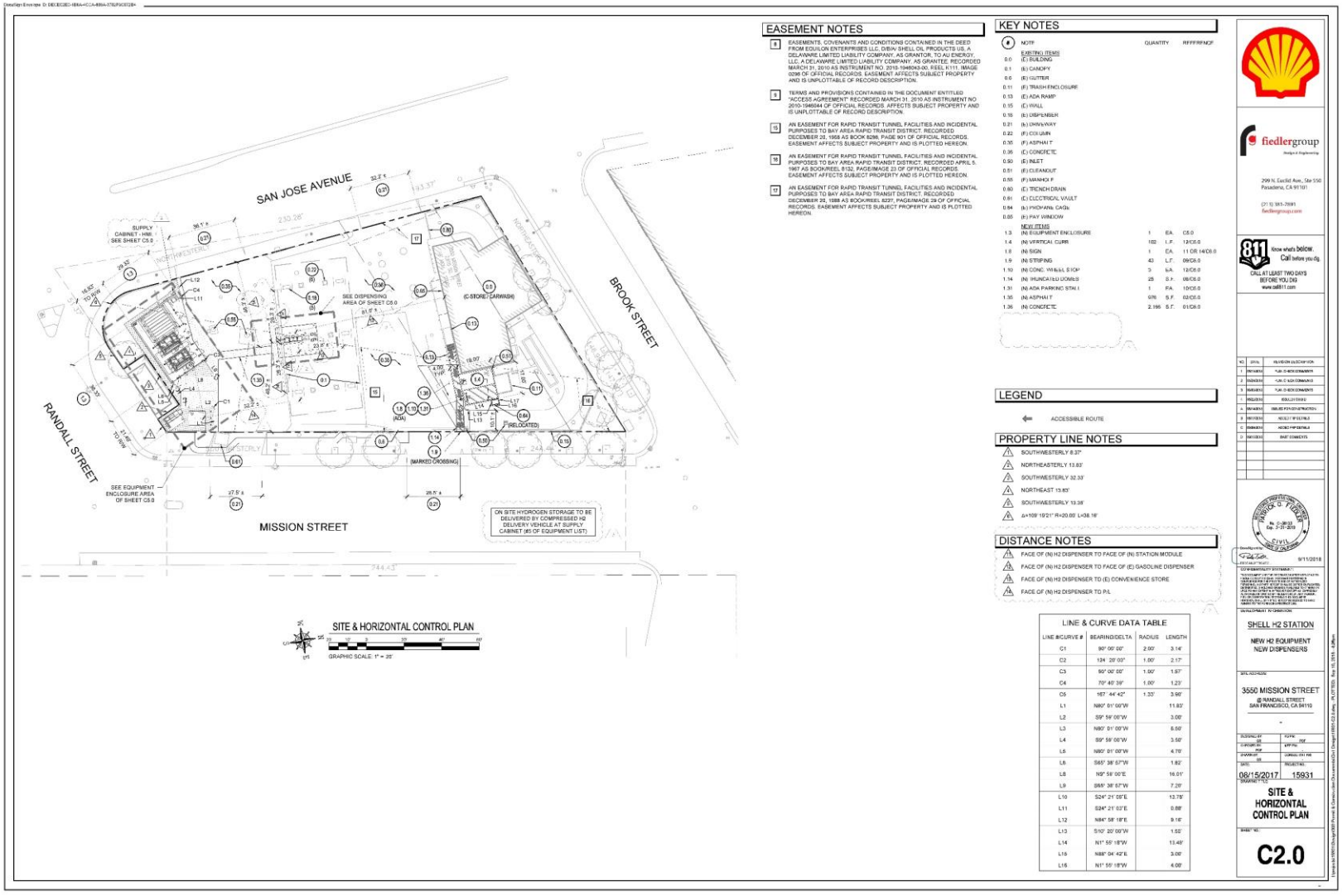
The utility service was energized on July 18, 2019. The pre-startup safety review (PSSR) was conducted by Shell project managers in conjunction with NCI and the operations and maintenance contractor on July 23, 2019, and a check list of actions was developed. Figure 5 illustrates assembly of the storage module and the two compressor modules set on their foundation. Figure 6 illustrates the completed hydrogen station dispensers and points of sale. Figure 7 illustrates the completed storage module and station module.

Figure 2: Site Plan Approved by the Planning Department



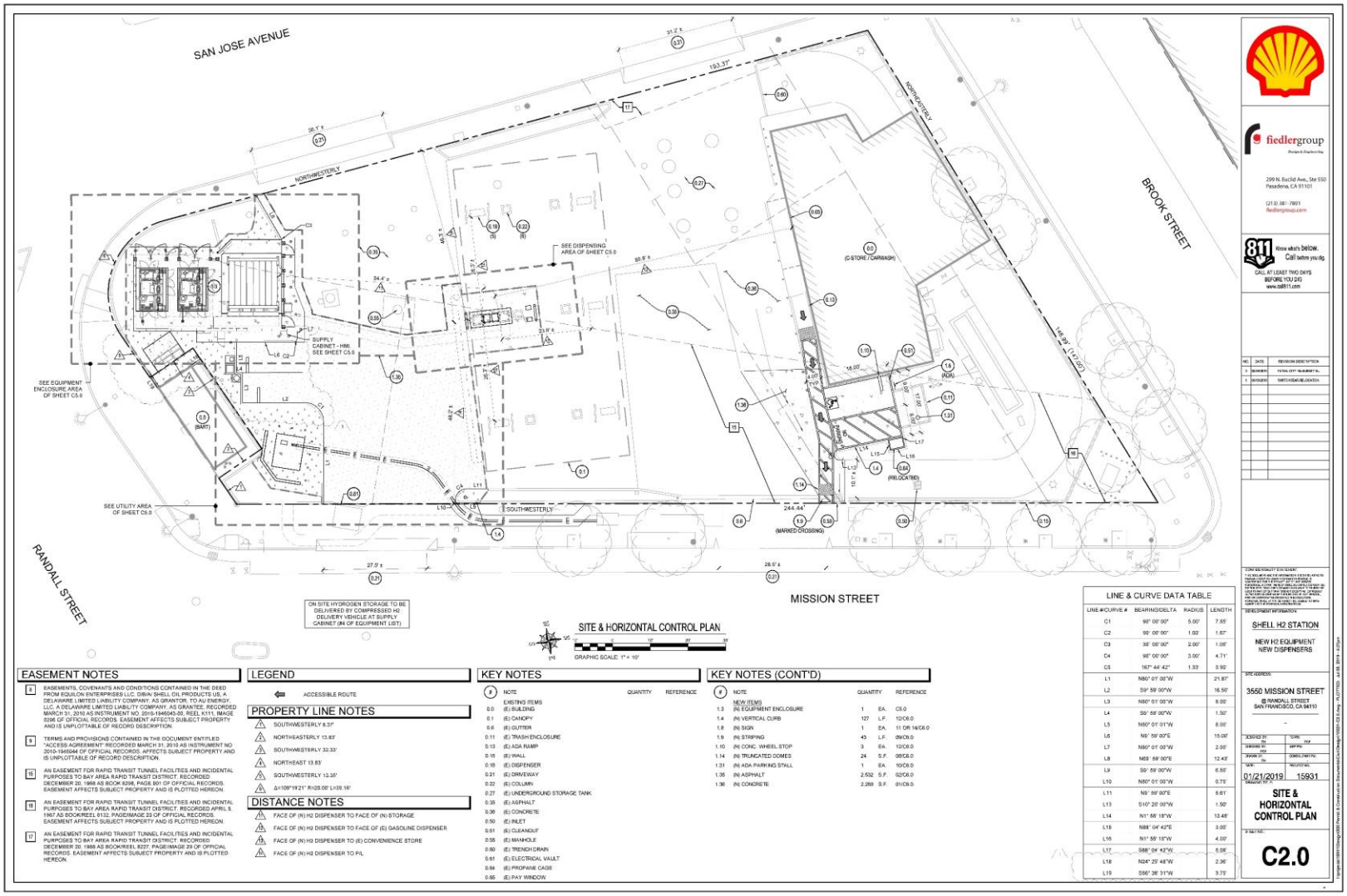
Source: Fiedler Group/Shell

Figure 3: Site Plan for Construction



Source: Fiedler Group/Shell

Figure 4: Revised Site Plan (due to underground discovery)



Source: Fiedler Group/Shell

Figure 5: Field Assembly of Storage Module (above); Two Station Modules Under Construction (below)

Source: Fiedler Groups/Shell

Source: Fiedler Group/Shell

Figure 6: View of the Dispensers (above) and POS (below)

Source: Fiedler Group/Shell

Source: Fiedler Group/Shell

Figure 7: Storage Module (above); Station Module (below)

Source: Fiedler Group/Shell

Source: Fiedler Group/Shell

Commissioning and Startup (August 26, 2019, to September 5, 2019)

PSSR actions that were deemed prerequisite for introduction of hydrogen into the system were completed August 26, 2019. Hydrogen was introduced into the system August 27, 2019. The delay in introduction of hydrogen was due to hydrogen supply disruption experienced by the hydrogen vendor. California Department of Food and Agriculture, Division of Measurement Standards (DMS) certified both dispensers' accuracy September 25, 2019. Commissioning and startup activities continued until September 30, 2019, when the first FCEV was filled. Figure 8 illustrates fueling of the first FCEV. Figure 9 illustrates results of the hydrogen purity test.

Operational Station (January 27, 2020)

The project team deemed the station "operational" on January 27, 2020. Shell achieved connection to the Station Operational Status System (SOSS) on October 3, 2019. Figure 10 illustrates the SOSS status of the Mission station.

Open Retail Station (February 14, 2020)

The station served the first retail customer on February 14, 2020. The project team deemed the station to be open retail as of the same date.

The first compressor came online February 14, 2020, while the second compressor came online in November 2020.

Figure 8: First Fueling of an FCEV (Hyundai Nexo on September 30, 2019)

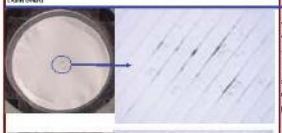
Source: Fiedler Group/Shell

Figure 9: Hydrogen Fuel Quality Report (September 26, 2019)

SmartChemistry

SAE J2719 — Sample Sampled on 09/23/2019 — **Shell SF Mission H70**

SUMMARY	SAE J2719 Limits considered	SmartChemistry Detection Limits considered	Concentration (µmol/mol)
H_2O			< 2
Total Non-Methane Hydrocarbons			1.4
-C_1 Basis			
Ethane			0.34
Propane			0.13
C12 Hydrocarbons			0.06
O_2			< 2
He			26
CH_4 N_2 Ar			15
CH_4			2.7
N_2			9.5
Ar			2.9
CO_2			< 0.03
CO			< 0.0004
Total S			0.000050
Hydrogen Sulfide			0.0000054
Carbonyl Sulfide			0.000041
Methyl Mercaptan			< 0.000002
Ethyl Mercaptan			< 0.00001
Dimethyl Sulfide			< 0.000002
Carbon Disulfide			0.0000030
Isopropyl Mercaptan			< 0.00001
Tert-Butyl Mercaptan			< 0.00001
n-Propyl Mercaptan			< 0.00001
Thiophene			< 0.00001
Diethyl Sulfide			< 0.00001
n-Butyl Mercaptan			< 0.00001
Dimethyl Disulfide			< 0.00001
Tetrahydrothiophene			< 0.00001
Formaldehyde			< 0.002
Formic Acid			< 0.0005
Ammonia			< 0.02
Total Halogenates			< 0.01
Cl_2			< 0.0001
HCl			< 0.0004
HBr			< 0.0007
Total Organic Halides (92 compounds in red and bold listed in "Non-Methane Hydrocarbons")			< 0.001
Particulate Concentration	3 reads	Dispenser #1	0.14 mg/kg
Particulate Concentration	3 reads	Dispenser #2	0.037 mg/kg



This is the 0.2µm Teflon particulate filters after Particulate sampling @Dispenser #1. No pinhole is found.

Dispenser#1: Particulate Sizes

This is the 0.2µm Teflon particulate filters after Particulate sampling @. Neither pinhole nor oil stain is found.

Dispenser#2: Particulate Sizes

Oil Stain;

some oil stain found in the back of the filter, as shown in right picture

There are total 54 particulates found in the center (sizes in micrometer) - 272, 125, 97, 86, 82, 66, 61, 59, 58, 56, 49, 46, 45, 37, 33 (2), 32, 31 (2), 29, 28, 27 (3), 23, 19 (8), 16 (4), 14 (9), 13 (8).

Hydrogen Fuel Index			99.994195%

Source: Shell

Figure 10: Screen Shot of the SOSS Web Page With Mission Street Listed

Source: California Fuel Cell Partnership (https://m.cafcp.org/)

List of Subcontractors and Value

Table 1 and Table 2 list the equipment suppliers and subcontractors, and the value of their contracts. Table 3 shows the total project cost and the total CEC cost share.

Table 1: List of Equipment Suppliers and the Value of Their Contracts

Equipment Supplier	Description	CEC Grant	Shell Match	Total Cost Allocated to the Project	Vendor Invoices Total
Nel Hydrogen, San Leandro, CA	Hydrogen station equipment -- supply, install and commission the station	$2,284,379.00	$557,600.00	$2,841,979.00	$2,841,979.00
COMDATA, Brentwood, TN	Supply POS terminals for recording sale transactions	$34,333.94	$0.00	$34,338.94	$34,333.94
Benfield, White Plains, NY	Supply switchgear for power distribution	$18,787.06	$8,511.94	$27,299.00	$27,299.00
Equipment Total		**$2,337,500.00**	**$566,111.94**	**$2,903,611.94**	**$2,903,611.94**

Source: Fiedler Group/Shell

Table 2: List of Subcontractors and the Value of Their Subcontracts

Subcontractor	Description	CEC Grant	Shell Match	Total Cost Allocated to the Project	Vendor Invoices Total
NCI, Cape Coral, FL	General contractor for civil construction	$0.00	$1,068,101.06[1]	$1,068,101.06	$1,084,792.75
Subcontractors Total		**$0.00**	**$1,068,101.06**	**$1,068,101.06**	**$1,084,792.75**

Source: Fiedler Group/Shell

[1] Applied a partial amount of NCI's invoices towards Shell Match Share to make the total match share align with the budget for subcontracts match share.

Table 3: Total Project Cost and Total CEC Cost Share

Category	CEC Grant	Shell Match	Total Cost Allocated to the Project	Vendor Invoices Total
Equipment Total	$2,337,500.00	$566,111.94	$2,903,611.94	$2,903,611.94
Subcontracts Total	$0.00	$1,068,101.06[2]	$1,068,101.06	$1,084,792.75
Grand Total	**$2,337,500.00**	**$1,634,213.00**	**$3,971,713.00**	**$3,988,404.69**
Total CEC Cost Share	**58.9%**	**N/A**	**N/A**	**N/A**

Source: Fiedler Group/Shell

[2] Applied a partial amount of NCI's invoices towards Shell Match Share to make the total match share align with the budget for subcontracts match share.

CHAPTER 3:
Data Collection and Analysis

Data Reporting

Shell collected one year of operational data and submitted to the CEC. This includes quarterly reporting of all fueling, maintenance, operations data; four hydrogen quality reports; and three reports of dispensed renewable hydrogen.

Economic Impact

The project required construction and high-tech firms to build and maintain the Mission Street station. The funding was predominantly awarded to California construction and technology firms who had the expertise and qualifications. The workers and firms developed hydrogen dispensing expertise during the construction and support of the refueling station which was valuable and will be directly transferable to other hydrogen refueling station developers in California and abroad for the foreseeable future.

The on-site jobs to handle the initial construction for the Mission Street station included roughly 25 full-time temporary positions including, local engineering resources, masonry and electrical workers, pipefitters, welders, truck drivers, environmental engineers, and others. Internally, Shell created two full-time permanent roles to manage the construction and project phase of the development of the station, and one full-time permanent role to maintain the station, collect and report the technical data, and support the operations. Shell also created one full-time role to develop future hydrogen refueling station growth within California.

Shell estimates the funding awarded to California-based companies and employees to be about $750,000 for the Mission Street station. The California-based companies that Shell contracted with included Nel, Air Products, and Chemicals Inc. Nel supplied critical fueling dispenser and equipment for the station and established full-time positions solely to prepare market expansion and provision of equipment for California. The team consists of California-based technicians who are qualified and trained to conduct maintenance as well as any advanced station repair. Air Products and Chemicals Inc. supplies and transports the hydrogen fuel to the Mission Street station and manufactures the hydrogen fuel predominantly from California-based operations.

The generation of California taxes is a direct and immediate economic benefit. These taxes can be utilized to provide government services to disadvantaged communities, which can provide a direct benefit to the community. These taxes

were generated upon launch of the project and continue throughout station operation.

Environmental Impact

If one average hydrogen FCEV takes one average gasoline mid-sized sedan off the road, the amount of gasoline displaced due to the Mission Street station operation using one year of data (March 2020 to March 2021) would equal nearly 14,000 gallons displaced per year. This value does not account for the full capability of the station as only one compressor was online for part of this time period.

The resulting air emissions reduction is estimated to be at least 121 metric tons of carbon dioxide equivalent (CO2e) per year. The assumptions used to calculate this emissions reduction are listed below.

- Average mileage of a mid-sized hydrogen FCEV is 312 miles per tank, and one tank is on average 5 kilograms of hydrogen.
- Average mileage of a mid-sized gasoline sedan is 434 miles per tank, and one tank is on average 12 gallons of gasoline.
- The amount of CO2e for a hydrogen FCEV is 145 grams of CO2e per mile.
- The amount of CO2e for a gasoline vehicle is 390 grams of CO2e per mile.
- Both these CO2e values are simulated per the Greenhouse gases, Regulated Emissions, and Energy use in Transportation(GREET) model.[3]
- The calculation does not account for any offsets using greenhouse gas credits.

Carbon Intensity Value

The carbon intensity value for the supply chain for the Mission Street station is 139 grams of CO2 per megajoule. The energy efficiency ratio for light duty passenger vehicles is 2.5.

Energy Efficiency Measures

While a Title 24 report was not required for the Mission Street station, Shell monitors and manages energy use and efficiency for continuous improvement and the global greenhouse gas emission inventory is subject to independent assurance.

[3] Argonne National Laboratory. The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model, https://greet.es.anl.gov/.

CHAPTER 4:
Statement of Future Intent

Shell plans to operate the Mission Street station for at least the next 10 years. Shell has further subcontracted with the equipment vendor, Nel, for the operation, maintenance, and repairs of the system. Nel has local maintenance and engineering capability and staff in Northern California. The system is outfitted with remote monitoring and automatic alarm communication systems that will send alerts to designated Shell and Nel personnel.

Shell is a committed participant and supporter of California's hydrogen refueling station network. To this end Shell has matched funds with CEC for the construction of six other hydrogen refueling stations in Northern California. Shell's commitment is further demonstrated with its match share for the construction of a heavy-duty vehicle fueling station at the Port of Long Beach, Wilmington, and Ontario, as well as the GFO-19-602 proposed award to build 50 additional light-duty stations in California.

CHAPTER 5:
Findings, Conclusions, and Recommendations

The Mission Street station was built at a rapid pace. Time elapsed from the day of submission of the entitlement exhibits to "retail open" status was 33 months. Time elapsed from mobilization to "retail open" status was 16 months. The construction took longer than at other stations built by Shell due to the discovery of an underground BART structure which necessitated a change in site plan and re-permitting of the same. Construction was suspended for approximately 3.5 months while the permit was processed. Once construction resumed, all the equipment was installed and ready for pre-startup safety review in 3.5 months. After discounting for the suspension period, the site was built, and equipment installed in approximately 4.5 months.

Establishing new power service is a time-consuming process and it can easily become the critical path for project completion. Early engagement with the utility to obtain a detailed understanding of their process, procedures, inspection milestones, and their timeline is recommended.

National Fire Protection Association – Hydrogen Technologies Code (NFPA 2) is a critical tool for working with permit agencies. The code clearly defines fire safety guidelines that enable local jurisdictions and builders to reach common ground while ensuring safety via the rigorous NFPA code writing process. For this project, the station siting and setback decisions were based on the Performance Based Analysis provisions of the NFPA 2 code. NFPA 2 makes the construction of hydrogen stations in an urban environment practical and feasible.

Building in a densely populated, urban environment presents its own unique challenges. The project site was exceptionally small in area and presented considerable obstacles in both design and construction.

The location of the Mission Street is a perfect illustration of the risks of building in urban locations with a long history of development. Despite due diligence, which includeda search of CCSF records and title search, the presence of the underground BART structure was not revealed until actual construction began. Upon initial inquiry, even BART was unable to state whether the structure belonged to them. Only after BART did an internal search of their historical documents were they able to confirm that the structure was indeed part of their railroad system. Significant changes to the site plan had to be made to move the equipment compound so that it would not impose a load on the BART

infrastructure. Changes to the site plan required a re-permitting effort, which was accomplished in a period of 3.5 months.

Despite these challenges, the project was able to be built in astounding time thanks to close coordination between engineering, construction, CCSF staff, and Shell. In future projects, there are several risks of locating stations in an urban location that should be considered such as:

- Disagreement and tensions with adjacent neighbors
- Disruption to existing operations
- Limited space for vehicle queuing
- Significantly increased cost and schedule risk during construction
- Extended AHJ review and permitting obstacles

The Mission Street station has contributed towards the fulfillment of the goals of CEC's Clean Transportation Program and specifically toward the goals of GFO-15-605. The goals were achieved with extensive teamwork by Shell and contracting partners, as well as a robust operations & maintenance plan that built on Shell's maintenance philosophies to track reliability threats and respond to maintenance required in a timely manner. Customer feedback was positive and indicated pleasant fueling experiences that were equivalent in ease and speed to refueling conventional vehicles. Some concerns were noted regarding communication issues of the point-of-service screen, and improvements to the customer-facing interface are underway to address these issues. Insights gained from the project are invaluable and will be applied towards future projects to continue to further the success of hydrogen refueling stations.

Some recommendations for changes in future projects include completing site scans to identify underground structures and support site plan development, extensively testing the POS system and its integration with the dispenser for a flawless customer experience, as well as adding visual signage aids to guide customers to the hydrogen dispensers, especially if they are located in the forecourt between other gasoline dispensers. Improvements to the project management process include starting the permitting process with the utility companies as soon as possible, given that it is often the critical path on projects, as well as finding ways to optimize the commissioning process and lessen the time it takes to perform DMS certification, Hydrogen Station Equipment Performance (HyStEP) testing, and automaker approval. Technical improvements are continuously reviewed throughout the lifecycle of the project and operational phases.

GLOSSARY

Alternative and Renewable Fuels and Vehicle Technology Program (ARFVTP) – Created by Assembly Bill 118 (Nunez, Chapter 750, Statutes of 2007), the program with an annual budget of about $100 million supports projects that develop and improve alternative and renewable low-carbon fuels, improve alternative and renewable fuels for existing and developing engine technologies, expand transit and transportation infrastructures, and establishing workforce training programs, conduct public education and promotion, and create technology centers, among other tasks.

AU Energy (AUE) – a fuel wholesaler and retailer which owns and operates Shell retail stations in California.

Authority Having Jurisdiction (AHJ) – An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

California Division of Measurement Standards (DMS) – Enforcement of California weights and measures laws and regulations is the responsibility of the Division of Measurement Standards. The Division works closely with county sealers of weights and measures who, under the supervision and direction of the Secretary of Food and Agriculture, carry out thvast majority of weights and measures enforcement activities at the local level. Ensuring fair competition for industry and accurate value comparison for consumers are the primary functions of the county/state programs.

Carbon Dioxide Equivalent (CO2e) – A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)" or "million short tons of carbon dioxide equivalents (MSTCDE)" The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. MMTCDE= (million metric tons of a gas) * (GWP of the gas) For example, the GWP for methane is 24.5. This means that emissions of one million metric tons of methane is equivalent to emissions of 24.5 million metric tons of carbon dioxide. Carbon may also be used as the reference and other greenhouse gases may be converted to carbon equivalents. To convert carbon to carbon dioxide, multiply the carbon by 44/12 (the ratio of the molecular weight of carbon dioxide to carbon). (EPA)

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.

Human-Machine Interface (HMI) – the hardware or software through which an operator interacts with a controller. An HMI can range from a physical control panel with buttons and indicator lights to an industrial PC with a color graphics display running dedicated HMI software.

Hydrogen Station Equipment Performance (HyStEP) device – a device that has been designed to carry out the test methods of CSA HGV 4.3 to measure that stations follow the fueling protocols standard SAE International J2601.

Kilogram (kg) – The base unit of mass in the International System of Units that is equal to the mass of a prototype agreed upon by international convention and that is nearly equal to the mass of 1000 cubic centimeters of water at the temperature of its maximum density.

National Fire Protection Association (NFPA) – is a global self-funded nonprofit organization, established in 1896, devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards.

Nicosia Construction International, Inc (NCI) – the engineer of record for the Mission Street hydrogen refueling station.

Pre-startup safety review (PSSR) – a safety review conducted prior to startup of a new or modified facility to ensure that installations meet the original design or operating intent to catch and re-assess any potential hazard due to changes during the detailed engineering construction phase of a project.

Ready to issue (RTI) – The permit application is ready to be issued once the building permit issuance fees are paid.

Pacific Gas and Electric Company (PG&E) – an electric and gas utility serving the greater San Francisco, California, region.

Station Online Status System (SOSS) – a mobile-friendly website that shows station availability and provides other station information such as hours of operation, address, and the hydrogen station operator and developer.