



California Energy Commission Clean Transportation Program

FINAL PROJECT REPORT

Sempra Murrieta Compressed Natural Gas Station Project

Prepared for: California Energy Commission Prepared by: South Coast Air Quality Management District



Gavin Newsom, Governor December 2020 | CEC-600-2020-055

California Energy Commission

Phil Barroca Drue Hargis **Primary Authors**

South Coast Air Quality Management District 21865 Copley Drive Diamond Bar, CA 91765

Agreement Number: ARV-11-025

Lindsee Tanimoto Commission Agreement Manager

Elizabeth John Office Manager ADVANCED FUELS AND VEHICLE TECHNOLOGIES OFFICE

John P. Butler II Acting Deputy Director FUELS AND TRANSPORTATION

Drew Bohan Executive Director

DISCLAIMER

This report was prepared as the result of work sponsored by the California Energy Commission (CEC). It does not necessarily represent the views of the CEC, its employees, or the State of California. The CEC, the State of California, its employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the CEC nor has the CEC passed upon the accuracy or adequacy of the information in this report.

ACKNOWLEDGEMENTS

South Coast Air Quality Management District and Southern California Gas Company wish to acknowledge Lindsee Tanimoto of the California Energy Commission. His support and guidance were invaluable during this project and we welcome the opportunity to work with Mr. Tanimoto and his Energy Commission team in the future.

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-11-602 to support the installation of new natural gas fueling infrastructure and upgrades to existing natural gas fueling infrastructure. In response to PON-11-602, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on April 24, 2012 and the agreement was executed as ARV-11-025 on August 9, 2012.

ABSTRACT

For this project, the South Coast Air Quality Management District partnered with the Southern California Gas Company to design, construct and operate a public/private compressed natural gas fueling station. This project is also supported by a grant from the Mobile Source Air Pollution Reduction Review Committee. The new station is located at Southern California Gas Company's Murrieta facility, just over one mile from the Interstate 15/215 interchange, at 25620 Jefferson, Murrieta, CA 92562. This station includes a 125 horsepower, 500 standard cubic feet per minute compressor, two fast-fill dispensers and ten time-fill posts. Eight of the time-fill posts are equipped with four hoses and the other two posts have two hoses for a total of 36 hoses to provide simultaneous overnight fueling. The station shares a 34,000 standard cubic feet of compressed gas storage system. The public access portion of the station is located outside the Southern California Gas Company facility gate and consists of a new fueling island with two dispensers each with two nozzles, rated at minimum five gasoline gallon equivalents per minute, a universal card reader and capacity to add a second compressor in the future. The publicly accessible dispensers are open 24 hours/day, seven days/week.

Operational results from the six-month demonstration period reflect that throughput was 28,813 gasoline gas equivalents, indicating a solid base throughput at the station has been established. Greenhouse gas emission reductions associated with the station's measured throughput during the demonstration period were 100 metric tons of carbon dioxide equivalents. The project also reduced criteria pollutant emissions. A final goal for the project was to increase awareness of and access to compressed natural gas as a transportation fuel. Through a station grand opening event, media outreach and a strong local effort by the Southern California Gas Company marketing team to build load at this station, awareness of the station has been steadily growing.

Keywords: California Energy Commission, South Coast Air Quality Management District, Southern California Gas Company, compressed natural gas, compressed natural gas station, petroleum displacement, greenhouse gas, emission reduction

Please use the following citation for this report:

Barroca, Phil (South Coast Air Quality Management District), Sinclair, E. Stanhope (Southern California Gas Company). December 2020. *Sempra Murrieta Compressed Natural Gas Station Project*. California Energy Commission. Publication Number: CEC-600-2020-055.

TABLE OF CONTENTS

Pa	ge
Acknowledgements	i
Preface	ii
Abstract	. iii
Table of Contents	v
List of Figures	. vi
List of Tables	. vi
Executive Summary	1
CHAPTER 1: Purpose and Approach 1.1 Purpose of the Project 1.1.1 Project Goals 1.1.2 Project Objectives 1.2 Project Approach 1.3 Activities Performed 1.3.1 Problems Encountered and Resolved	3 3 3 4 4
 CHAPTER 2: Project Results. 2.1 Station Commissioning. 2.2 Station Throughput. 2.3 Greenhouse Gas Emissions. 2.4 Reduce Criteria and Toxic Air Pollutant Emissions . 2.5 Increase Awareness, Accessibility and Market Penetration of Natural Gas as a 	6 6 7 7
Transportation Fuel	8 10
CHAPTER 3: Data Collection and Analysis	11 11 15 15 16 16 17
CHAPTER 4: Findings and Conclusions 4.1 Results Obtained 4.2 Conclusions 4.3 Recommendations Glossary	18 18 19 19 20

LIST OF FIGURES

	Page
Figure 1: SoCalGas Name on Station Signage	9

LIST OF TABLES

Page

	5
Table 1: Data Collection Results (November 1, 2015 through April 30, 2016)	11
Table 2: Total Energy Consumption	12
Table 3: Fleet Average Fuel Economy (based on EMFAC2014)	13
Table 4: Throughput and Estimated Mileage	13
Table 5: Emissions Reductions of Natural Gas Vehicles Compared to Gasoline and Diesel Vehicles	13
Table 6: Estimated NOx and PM Emission Reductions for Six-Month Demonstration Period	14
Table 7: CNG Fuel Consumption, estimated by Vehicle Class (GGE)	15
Table 8: Major Project Expenditures	16

EXECUTIVE SUMMARY

The South Coast Air Quality Management District, partnered with the Southern California Gas Company, the Mobile Source Air Pollution Reduction Review Committee and the California Energy Commission to design, construct, and operate a public/private compressed natural gas fueling station with compressor capacity of five (5) gasoline gallon equivalents per minute. This station includes a 125 horsepower, 500 standard cubic feet per minute ANGI compressor (Ariel Model NG300E), two fast-fill dispensers, ten time-fill posts that are equipped with 36 hoses and one 34,000 standard cubic feet compressed gas storage system.

The public portion of the station consists of a new single fueling island with two fast-fill dispensers, each with two nozzles rated at a minimum five (5) gasoline gas equivalents/minute. This public access fueling island is available 24 hours per day, seven days per week, providing support to existing fleets from Temecula Valley Unified School District, City of Lake Elsinore and Murrieta Unified School District, as well as natural gas vehicles from the general public. The time-fill equipment is located inside the company base to support overnight fueling of up to 36 Southern California Gas Company fleet vehicles at one time, though currently 13 vehicles conduct nightly fueling using the time-fill station.

The station is located at Southern California Gas Company's Murrieta facility, just over one mile from the Interstate 15/215 interchange, at 25620 Jefferson Ave, Murrieta, CA 92562. This location provides excellent accessibility for natural gas-fueled goods movement trucks that travel to the Inland Empire, local area fleet vehicles and the general public.

This project station location offers an important addition to the state's compressed natural gas fueling infrastructure network. Operational results from the first six months indicate Southern California Gas Company has established a solid base throughput at the station, but there is significant capacity to grow the base fleet of natural gas vehicles. Greenhouse gas emission reductions are estimated to be 100 metric tons (in units of carbon dioxide equivalent) over 6 months, projected at approximately 250 metric tons for 12 months, based on current monthly throughput rates (6,000 gasoline gallon equivalents/month). Criteria pollutants are estimated to have been reduced by 365 pounds of NOx and 2 pounds of particulate matter over the sixmonth data collection period. A grand opening event was held on April 15, 2016. Websites covering transportation news for business covered the event, and Southern California Gas Company prepared informational material for the station and posted it on appropriate websites to ensure it is linked to station location databases.

In addition, energy-efficient light-emitting diode signage enables motorists to see the compressed natural gas fuel prices, and drought-tolerant landscaping adds beauty together with energy and water-saving environmental benefits.

CHAPTER 1: Purpose and Approach

1.1 Purpose of the Project

The purpose of the Southern California Gas Company (SoCalGas) Murrieta Compressed Natural Gas (CNG) Station Project is to increase availability of CNG infrastructure in order to enhance California's energy independence by constructing and operating a new compressed natural gas fueling station. The project station provides convenient, clean, publicly accessible CNG service for a currently underserved region of southern California. The station initially serves fleet vehicles operated by the SoCalGas out of its Murrieta base, using overnight time-fill posts. The public fueling island serves outside fleets that use the station for back-up fueling, as well as natural gas vehicles operated by the general public.

A secondary purpose is to increase throughput at this new CNG infrastructure location. The station itself, and SoCalGas' marketing efforts to increase station throughput, will address the primary barriers to CNG implementation: lack of customer familiarity with the product and limited supply infrastructure.

1.1.1 Project Goals

The primary operational goal of this project is to increase availability of CNG infrastructure in order to enhance California's energy independence by reducing petroleum product consumption. Secondary operational goals include the reduction of greenhouse gas emissions, as well as criteria and toxic air pollutants.

1.1.2 Project Objectives

Project objectives included the following:

- Projected reduction in petroleum fuel consumption by nearly 220,000 gasoline gallon equivalents (GGEs) per year, after three years of full-time operation.¹
- Reduction of greenhouse gas emissions by about 430 metric tons carbon dioxide equivalents/year, after three years of full-time operation.
- Reduction of criteria and toxics air pollutant emissions.
- Increased awareness, accessibility and market penetration of natural gas as a transportation fuel, thus contributing to reduced dependence on foreign oil and reduced greenhouse gas emissions.

¹ Based on original application projections, which were in units of diesel equivalent gallons. Since the CNG is dispensed at the station in units of GGE, all projections were converted and are discussed in this report in units of GGE.

1.2 Project Approach

The project approach was to design, oversee construction and operate a public/private CNG fueling station following current best practices for CNG station construction and operation. The Murrieta site was selected for a new CNG station because of the growth in natural gas vehicle use expected in the area. Also, the region's growth and the continued state agency focus on low-emission vehicles for goods movement are expected to increase the volume of medium-and heavy-duty vehicle traffic in the area.

The station has a dispensing rate of five (5) GGE per minute (at a pressure of 3,600 pounds per square inch gauge, a 500 standard cubic feet per minute ANGI compressor (Ariel Model NG300E), two fast-fill dispensers, 36 time-fill hoses and one shared 34,000 standard cubic foot compressed gas storage system. The public access portion of the station is located outside the SoCalGas facility gate and consists of a newly constructed fueling island, two dispensers, each with two 3,600 pounds per square inch gauge nozzles, a universal card reader and capacity to add a second compressor in the future. This new station supports state and local goals to increase petroleum fuel displacement in the region while enhancing air quality by reducing criteria pollutant and greenhouse gas emissions.

1.3 Activities Performed

The station construction and start-up followed well-established best practices for CNG station implementation (i.e., design, construction and commissioning). Under Task 2, site plan engineering drawings, landscaping and irrigation civil work drawings, and site pictures were submitted to the California Energy Commission Agreement Manager and are on file. This station was designed to meet all applicable codes and standards for CNG fueling stations. These codes and standards were met in order to obtain approved plumbing, electrical and building permits and ultimately commission the station.

Only one major obstacle or problem was encountered during this project. The permitting process took several months longer than was originally anticipated. Walmart had planned to construct a new store across the street from where the SoCalGas Murrieta station would be built. However, after several months of negotiations with the City of Murrieta, the Walmart project was cancelled. As a result of the Walmart project cancellation, the City attempted to place much of the improvement burden that was originally intended for Walmart on the SoCalGas CNG station project. These burdens included street widening, elevation of existing street center median, enhanced street drainage, installation of traffic light signals, and relocation of the existing SoCalGas base entrance and exit gates. These issues took several months to be negotiated, before a final resolution was reached. Plan check also became a significantly longer process because of several of the additional requirements that were placed on the project. Once the construction permits were approved, the project proceeded without further delay.

Operational data were collected for six months in accordance with the California Energy Commission agreement. Results of this data collection effort are documented in Chapter 2, below.

Reliable and consistent station operation was demonstrated and SoCalGas hosted a grand opening event on April 15, 2016, to kick-off its marketing efforts.

1.3.1 Problems Encountered and Resolved

Permit applications were submitted to the City of Murrieta for building plans, grading plans, street encroachment and landscaping plans. As noted above, the City of Murrieta requested significant street improvements, including several drainage upgrades, street striping, driveway relocation and a traffic signal, that SoCalGas argued were unrelated to the project scope. The effort to resolve the permit issues caused a major delay, after which the construction permits were approved, and work was conducted in accordance with revised city requirements. In addition, SoCalGas had revised its own piping standards, and as a result replacement piping had to be reordered to replace the original piping that was available for installation. The new piping took longer than was expected to be manufactured and delivered to the site, thus adding additional construction time to the project. These delays caused an adverse impact on the project schedule, requiring a nine-month contract extension to the grant agreement.

No other problems other than project cost growth resulting from the long lead time to execute grant agreement and the delays discussed above were encountered during the station design and construction phase of the project. Station operation has also been without major problems during this early stage.

Just prior to the official station commissioning, the station experienced only one minor incident, when the station was closed due to a high temperature shutdown. This occurred because the temperature setting was too low and had to be changed to the appropriate setting. The shutdown and diagnosis caused the station to be out of service for two days.

CHAPTER 2: Project Results

2.1 Station Commissioning

The station was successfully commissioned and "opened for business" on September 30, 2015 and has been successfully dispensing CNG to its public customers 24-hours per day, 7-days per week, with only one incident. As reported to the Energy Commission Agreement Manager in the October 2015 monthly report, the station was down in mid-October two days. Upon investigation, it was determined that the control setpoint on the high temperature setting was incorrect. The compressor manufacturer was called out to diagnose the problem and reset the temperature setting to the correct level. There have been no other shutdowns since station commissioning.

2.2 Station Throughput

Upon commissioning the newly upgraded dispenser, SoCalGas began a six-month demonstration, collecting operations data in accordance with the California Energy Commission agreement. This data collection effort also required tracking utility bills to monitor the natural gas and electricity consumption of its station.

The actual measured throughput during the six-month data collection period was 28,813 GGE. At the current monthly throughput rate of approximately 6,000 GGE/month, the annual throughput is projected to be 72,000 GGE/year. For the 182-day demonstration period, which ran from November 1, 2015, through April 30, 2016, station operation resulted in the following:

- Non-SoCalGas fleet customer (public, miscellaneous credit card transactions):
 - \circ More than 2,443 public transactions, or 13 transactions per day,² on average.
 - $_{\odot}~$ A total of 21,774 GGE dispensed, or 120 GGE dispensed per day, on average.
 - Public station throughput represents 76 percent of total station throughput.
- SoCalGas fleet vehicle consumption:
 - $\circ~$ Approximately 1,651 overnight time-fill connections, 13 per day 3 (one for each of the 13 SoCalGas fleet vehicles).
 - \circ 7,039 GGE dispensed in total, or 55 GGE dispensed per day, on average.
 - Fleet vehicle throughput represents 24 percent of total station throughput.

² Public access station operates seven days per week.

³ SoCalGas overnight time fill occurs only five nights per week.

• Only two days downtime occurred since station commissioning, but this occurred prior to the beginning of the six-month demonstration period.

2.3 Greenhouse Gas Emissions

During the six-month data collection period, 100 metric tons of were reduced. When annualized, greenhouse gas reductions are estimated to be 250 metric tons/year, based on a projection of 72,000 GGE for the first full year of station operation.

The above estimates for greenhouse gas emission reductions for this project were derived using the California Air Resources Board's "Methodology for Determining Emission Reductions and Cost-Effectiveness." This methodology provides direction and factors for carbon intensity and fuel energy density to estimate greenhouse gas emissions based on fuel consumption.

Another way to document the greenhouse gas reduction benefits of natural gas as a transportation fuel is to compare its carbon intensity to baseline fuels. According to the California Air Resources Board, "carbon intensity means the amount of lifecycle greenhouse gas emissions, per unit of energy of fuel delivered, expressed in grams of carbon dioxide equivalent per megajoule.

In the case of CNG, the carbon intensity is typically less than gasoline and diesel. According to the California Air Resources Board, the Energy Economy Ration adjusted carbon intensity of CNG is 88.29 grams of carbon dioxide equivalents per megajoule.⁵ This compares with 102.76 grams of carbon dioxide per megajoule for diesel fuel and 100.53 grams of carbon dioxide equivalents per megajoule for gasoline.⁵ Based on the California Air Resources Board's Energy Economy Ratio adjusted carbon intensity values, CNG provides a net reduction in greenhouse gas emissions of 12 to 14 percent compared to diesel and gasoline.

A method to further reduce the carbon intensity of natural gas fuel is to procure natural gas that is derived from renewable feedstock, i.e., biogas, landfill gas or biomethane. Landfill gas (bio-methane) that is cleaned up to pipeline quality natural gas and compressed in California is rated by the California Air Resources Board with an Energy Economy Ratio adjusted carbon intensity of 21.34 grams of carbon dioxide equivalents per megajoule, far below existing pipeline natural gas.⁵ SoCalGas is investigating the availability of renewable feedstock for its pipeline. Should this become available, the carbon intensity of natural gas at this station would further improve (i.e., be lower than current estimates).

2.4 Reduce Criteria and Toxic Air Pollutant Emissions

Over the past 30 years, clean burning natural gas vehicles provided significant reductions in criteria and toxic air pollutant emissions compared to conventional gasoline and diesel vehicles. When natural gas vehicles were first introduced to the transportation market, initial natural gas vehicles reduced emissions of key pollutants such as NOx and PM by up to 98 percent. More recently, the light-duty CNG-fueled Honda Civic, which unfortunately is no longer being produced, emitted half the oxides of nitrogen, 80 percent less nonmethane hydrocarbon, and 60 percent less carbon monoxide than the gasoline Civic. New CNG-fueled medium- and heavy-duty trucks and buses reduce NOx emissions by more than 90 percent

and PM by 98 percent, compared to older in-use diesel fueled versions. These benefits drive grant programs in California that fund the accelerated replacement of diesel-fueled trucks and buses with alternative fuel technology, with grant funds targeted to cover the higher incremental cost of the cleaner technology over comparable diesel engines. It is noteworthy that natural gas technology's successful in-use operation in all vehicle classes over the past few decades contributed to the California Air Resources Board's ability to continually restrict vehicle and engine emissions, culminating in the current 0.2 and 0.01 gram per brake horsepower-hour of NOx and PM standards, which have been met by both natural gas and diesel fuel technologies since 2010.

More recently, Cummins Westport Inc., certified its natural gas engine with both the United States Environmental Protection Agency and California Air Resources Board at the 90 percent NOx reduction level of 0.02 grams per brake horsepower-hour. The engine is currently available for medium heavy-duty vehicle applications, such as urban transit buses, school buses and refuse trucks. Technologies such as these have the potential to further support the market deployment of medium- and heavy-duty natural gas trucks. By using both biomethane and near-zero (low- NOx) engines, natural gas trucks have the potential to reduce criteria pollutant and greenhouse gas emissions to levels near those of zero emission battery and fuel cell electric vehicles.

All natural gas vehicles fueling at the Murrieta station provide well-established environmental benefits, as evidenced by Southern California Air Quality Management District's seven clean fleet rules,⁴ which require the use of clean fuels such as natural gas in a variety of fleet applications. According to the Natural Gas Vehicle America's summary of environmental benefits for natural gas vehicles, natural gas as a transportation fuel provides a 16 percent NOx reduction for light-duty vehicles and a 40 to 80 percent NOx reduction for heavy-duty vehicles, depending on the age of the vehicle being replaced.⁵ The Natural Gas Vehicle America also estimates that natural gas provides between 20 and 80 percent PM reduction for heavy-duty vehicles, depending on the age of the vehicle being replaced. These percent reductions are applied in Section 3.1 to estimate the NOx and PM reductions for the demonstration period.

2.5 Increase Awareness, Accessibility and Market Penetration of Natural Gas as a Transportation Fuel

Increasing awareness and utilization of the station is the primary responsibility of the SoCalGas local Account Executive and Marketing Department. Through active engagement with the City of Murrieta, other local area governments, our funding partnership with the Marine Spill

⁴ Southern California Air Quality Management District's Fleet Rules.

⁽http://www.aqmd.gov/home/regulations/fleet-rules). (accessed 6/9/2016)

⁵ Natural Gas Vehicle America. <u>Environment.</u> (https://www.ngvamerica.org/natural-gas/environmental-benefits/) (accessed 8/15/2016).

Response Corporation, marketing efforts with existing and potential fleet operators, and continued media outreach, SoCalGas will continue to expand station throughput.

The Murrieta station uses the recently developed SoCalGas brand signage, which also provides excellent visibility of the fuel price. This branding approach helps build on the familiarity and trust customers feel with natural gas and extend it to the idea of vehicle fueling. Figure 1 below shows the prominent display of SoCalGas' name and trademark blue color on the station's signage.



Figure 1: SoCalGas Name on Station Signage

Source: Southern California Gas Company.

In order to mark the successful implementation of the project station, and to maximize awareness of the station's reliable operation and availability to the natural gas vehicle driving public, a grand opening event was held on April 15, 2016. This grand opening and ribboncutting event was promoted to local chambers of commerce and government officials. A press release was issued, and the story was picked up by several online transportation publications including Heavy Duty Trucking, Natural Gas Vehicle America, Fleets & Fuels, Next Generation Transportation News and more. The station was listed on cngprices.com as well as on the socalgas.com website.

In addition, SoCalGas developed an iPhone app that, among other features, helps customers locate CNG stations like the Murrieta station. The <u>SoCalGas app</u> can be downloaded at http://www.socalgas.com/innovation/mobile-app/.

2.6 Advances in Science

The Energy Commission requests its grant recipients to discuss any advances in science that might come out of a completed agreement. Since the design, construction and operation of CNG fueling stations is well-established, there are no advances in science that result from this project.

CHAPTER 3: Data Collection and Analysis

3.1 Throughput, Usage and Operations Data Collected

This section summarizes the average daily throughput and operations data collected during the demonstration period (summarized in Table 1).

Description	Value
Number of days in reporting period	182
Average number of public vehicles fueled per day	13
Number of SoCalGas fleet vehicles fueled per weekday	13
Average GGE dispensed per day to the public	120 GGE
Average GGE dispensed per weekday to SoCalGas fleet	55 GGE
Total GGE dispensed during demonstration period	28,813 GGE
Number of days or hours that the station was inoperative ⁶	0
Maximum capacity of the new fueling system	6,048 GGE/day
Natural gas that was compressed at the station during the demonstration period	37,370 therms ⁷
Electricity required to power CNG compression equipment on a daily basis	117 kilowatt-hours/day

Table 1: Data Collection Results (November 1, 2015 through April 30, 2016)

Source: Southern California Gas Company Operating Data.

Table 2 lists the average daily energy consumption during each month at the Murrieta station. Vehicle types fueling at the station currently consist of 13 SoCalGas light-duty fleet vehicles

⁶ Note that the station was down in mid-October 2015 for two days, but this was prior to the official six-month demonstration period.

⁷ Based on this conversion factor: 1.297 therms per GGE.

using time-fill posts for overnight fueling. The SoCalGas fleet includes nine dedicated CNG vehicles (two sedans, six three-quarter ton service trucks and one service technician van) and four bi-fuel three-quarter ton pick-up trucks. Public access station customers include school buses, transit buses, ready-mix trucks, waste-hauling trucks, street sweepers and miscellaneous light-duty vehicles. Now that the station is fully commissioned, SoCalGas plans to expand its company CNG fleet vehicles at this base by eight vehicles per year over the next two years.

Month	Kilowatt-hour/Day	Therms/Day
November 2015	78	150
December 2015	91	191
January 2016	121	261
February 2016	136	327
March 2016	129	337
April 2016	148	335
Average over Six-Month Demonstration	117	206

Table 2: Total Energy Consumption⁸

Source: Southern California Gas Company Operating Data.

Detailed mileage information for vehicles that fuel at the station is not available. Similar to conventional gasoline fueling stations, the Murrieta station does not have a mechanism to track the vehicle class or mileage accumulation of each vehicle. In order to estimate monthly mileage for vehicles fueled at the station, SoCalGas estimated the fuel consumption for each vehicle class based on the amount of fuel purchased in each transaction. This approach was previously employed during an earlier California Energy Commission grant (ARV-12-004) to co-fund the commissioning of the Lancaster, California CNG station. Specifically, a transaction less than 12 GGE is assumed to be associated with a light-duty vehicle, transactions between 12 and 20 GGE are assumed to be associated with a medium-duty vehicle and transactions over 20 GGE are associated with heavy-duty vehicles. Fleet average fuel economy derived from the California Air Resources Board's emissions inventory model, EMFAC2014, is applied to the monthly fuel consumption to estimate mileage of the vehicles that fuel at the station. The EMFAC2014 model was run for the South Coast Air Basin, 2016 calendar year, aggregate fleet data and annual seasonal data.⁹ Table 3 summarizes the average fuel economy estimated from this EMFAC2014 model run.

⁸ Averages based on total monthly throughput divided by 182 days in the demonstration period.

⁹ California Air Resources Board. <u>EMFAC Model</u>. (http://www.arb.ca.gov/emfac/). (Accessed 5/15/2016)

Vehicle Class	Average miles per gallon	
Light-duty vehicles	22	
Medium-duty vehicles	14	
Heavy-duty vehicles	6.3	

 Table 3: Fleet Average Fuel Economy (based on EMFAC2014)

Source: Southern California Gas Company.

Table 4 provides throughput and an estimate of vehicle mileage derived from the GGE for each vehicle class fueled at the station during the six-month demonstration.

Vehicle Class	GGE	Estimated Mileage ¹⁰		
Light-duty vehicles	17,180	377,960		
Medium-duty vehicles	2,274	31,836		
Heavy-duty vehicles	9,359	58,962		
Total:	28,813 GGE	468,758 miles		

 Table 4: Throughput and Estimated Mileage

Source: Based on Southern California Gas Company Operating Data and EMFAC2014 results.

Since it is not possible to track the exact vehicle class, engine model year, make and model of each vehicle fueling at the station, it is impossible to quantify the exact emission reductions for each vehicle fueled at the station. However, a rough estimate can be made using the emission reduction percentage estimates discussed above in Section 2.4. The conservative end of the range is summarized in Table 5 below.

Table 5: Emissions Reductions of Natural Gas Vehicles Compared to Gasoline and
Diesel Vehicles

Vehicle Class	% NOx Reduction	% PM Reduction		
Light-duty vehicles	16	0		
Medium-duty vehicles	40	20		
Heavy-duty vehicles	40	20		

Source: Natural Gas Vehicle America. (accessed 8/15/16).

¹⁰ This estimate is based on results from the California Air Resources Board's Emissions Factor model for on-road vehicles, EMFAC2014. From EMFAC, the average fuel consumption for light-, medium- and heavy-duty vehicles was applied to the total GGE for each vehicle class during the demonstration period.

Emission factors (grams per mile) were derived for baseline gasoline-fueled light-duty vehicles and diesel-fueled medium- and heavy-duty vehicles using EMFAC2014, similar in approach to the derivation of fuel economy discussed above. Essentially, this estimate uses the California Air Resources Board's on-road fleet emissions inventory to establish baseline emissions estimates from the six-month demonstration mileage (Table 4) and emission rates for the average light-, medium- and heavy-duty fleet in the South Coast Air Basin. The percent reductions in Table 5 are applied to this general baseline to provide a rough estimate of emission benefits of natural gas vehicles using the Murrieta station. See Table 6 for the derived emission rates and estimated emission reduction results for the six-month demonstration period.

Vehicle Class	NOx gm/ mile	PM gm/ mile	Baseline NOx Emissions (pound)	Baseline PM Emissions (pound)	NOx Emission Reductions (pound)	PM Emission Reductions (pound)
Light-duty vehicles	0.231	0.0031	193	2.59	30.86	0
Medium-duty vehicles	0.372	0.0030	26	0.21	10.46	0.0424
Heavy-duty vehicles	6.227	0.0897	809	11.66	323.77	2.3322
6-Month Total:			1028	14	365	2

Table 6: Estimated NOx and PM Emission Reductions for Six-Month DemonstrationPeriod

Source: Derived from Southern California Gas Company Operating Data and EMFAC2014 results, with application of Table 5 percent reduction.

As indicated above, conservative assumptions were used in order to ensure that criteria pollutant emission reductions were not over estimated or exaggerated. It is important to acknowledge that while natural gas vehicles provided significant reductions of criteria pollutant emissions through 2009, the introduction of ever more stringent emission standards for conventional fuels has narrowed the "gap" to the point where natural gas vehicles no longer provided significant criteria pollutant benefits. The recent introduction of the low-NOx engine (0.02 grams per brake horsepower-hour of NOx) will reverse this trend and combining its use with renewable natural gas will further enhance the greenhouse gas emission reduction benefits of natural gas vehicles.

3.2 Petroleum Fuel Displaced

Table 9 provides a summary of the CNG fuel (in units of GGE) purchased at the Murrieta CNG station. These results are based on actual transaction data for the six-month demonstration period; these data are annualized to provide a projection for the gallons per year results. Station transaction records do not track the vehicle class associated with each purchase. As such, SoCalGas estimated the fuel consumption for each vehicle class based on the amount of fuel purchased in each transaction (i.e., transactions less than 12 GGE are light-duty vehicles, between 12 and 20 GGE are medium-duty vehicles and over 20 GGE are heavy-duty vehicles). These data are presented in Table 7.

Vehicle Class	6-month CNG Fuel Consumption (GGE)
Light-duty vehicles (\leq 12 GGE) plus all overnight time fill GGE	17,180
Medium-duty vehicles (12 <gge<u><20)</gge<u>	2,274
Heavy-duty vehicles (>20 GGE)	9,359
Total	28,813

Table 7: CNG Fuel Consumption, estimated by Vehicle Class (GGE)

Source: Southern California Gas Company.

3.3 Duty Cycles

At the end of the six-month data collection period, SoCalGas fueled its own fleet, which consists of 13 light-duty vehicles using the overnight time-fill system. In addition, CNG was dispensed to a growing population of light-, medium- and heavy-duty vehicles such as those operated by Superior Ready Mix, a regular customer of late. Based on projections of its own fleet operation plans, SoCalGas estimates an increase in light- and medium-duty natural gas vehicles using this station by eight vehicles per year over the next two years.

Although the high occupancy vehicle-lane incentive was extended to January 1, 2019, Honda's announcement in mid-2015 to cancel its CNG Civic adversely affects light-duty natural gas vehicle growth. Fortunately, SoCalGas anticipates continued growth in the light- and medium-duty truck category, transit bus, school bus, waste hauler and goods movement vehicle sectors. In fact, Ford's recent announcement to roll-out its first CNG F-150 Pickup in 2016 as an original equipment manufacturer offering,¹¹ and the Cummins Westport, Inc., near-zero low- NOx engine certifications are expected to spur interest in conversion to natural gas technology.

¹¹ Based on this conversion factor: 1.297 therms per GGE.

3.4 Jobs and Economic Development

This project resulted in significant funding paid to in-state companies that participated on the project team. In addition, state sales tax revenues were generated on equipment purchased for this project. See Table 8, Major Project Expenditures, for additional detail.

Description	Total Cost
PID Engineering, Global Geo Engineering and EDM Services	\$37,693
Amtek, General Construction Contractor	\$492,400
ANGI Compressor, Ariel Model NG300	\$201,650
Kraus Dispenser (2)	\$73,413
Romac Switch Gear	\$24,544
High Pressure Gas Dryer	\$61,878
Three-Pack CPI High Pressure Storage Tubes	\$93,960
Priority Panel	\$26,552
Starter Panel	\$25,735
Calcraft Canopy	\$39,200

Table 8: Major Project Expenditures

Source: Southern California Gas Company.

3.5 Alternative Fuel Source and Renewable Energy

The project station is supplied by the Southern California Gas Company's existing natural gas pipeline system. The natural gas provided by this system is derived from fossil fuels and does not have a renewable energy component. As discussed above in Section 2.3, the Energy Economy Ratio adjusted carbon intensity of pipeline natural gas is currently 88.29 grams of carbon dioxide equivalents per megajoule. SoCalGas is currently investigating options to enhance its current system with the addition of renewable natural gas. As discussed in Section 2.3, landfill gas (biomethane) that is cleaned up to meet pipeline natural gas quality and compressed in California has a carbon intensity of just 21.34 grams of carbon dioxide equivalents per megajoule. SoCalGas is investigating the availability and practicality of integrating renewable feedstock into pipeline natural gas. According to the Energy Commission's 2016-2017 Alternative and Renewable Fuels and Vehicle Technology Program Investment Plan, the recently certified Cummins Westport, Inc., natural gas engine at the 90 percent NOx reduction level of 0.02 gram per brake horsepower-hour (i.e., "low- NOx engine")

fueled with biomethane has the potential to reduce criteria pollutant and greenhouse gas emissions to levels near those of zero emission battery electric and fuel cell vehicles.¹²

3.6 Energy Efficiency

The station was built in accordance with City permitting requirements, which have built-in minimum energy efficiency requirements. While the station equipment meets current codes and standards applicable to CNG station design, without going above and beyond current requirements, there is an operational scenario where additional energy efficiency is realized: the use of the time fill station during the overnight/off-peak hours. During the overnight hours, demand for electricity is at its lowest, when there is little possibility of drawing on less efficient electricity sources sometimes utilized for peak shaving. Also, time-fill requires continuous use of the compressor. However, the time-fill provides a more complete fill than the public fast-fill because of the slower process, thereby reducing the heat of compression while fueling.

Methane releases into the atmosphere are minimized to the extent that is possible with today's technology. When a vehicle has completed refueling and the fueling nozzle is decoupled from the vehicle's fueling receptacle, a very small amount of methane is released as a result of the "air-space" that exists between the fueling nozzle's shut-off valve and coupling. The nozzle's design and coupling mechanism provides a closed, sealed refueling process that does not allow any natural gas leakage at the vehicle-dispenser interface. Natural gas vehicle on-board fueling systems are also closed systems.

In addition, energy-efficient light-emitting diode signage enables motorists to easily view current CNG fuel prices, and drought-tolerant landscaping adds beauty together with energy and water-saving environmental benefits.

¹² Orenberg, Jacob. 2016. 2016-2017 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program. California Energy Commission, Fuels and Transportation Division. Publication Number: CEC-600-2015-014-CMF. Page 3.

CHAPTER 4: Findings and Conclusions

4.1 Results Obtained

The primary goal of this project was to increase availability of CNG infrastructure in order to enhance California's energy independence by reducing petroleum-based transportation fuel consumption. Secondary operational goals include the reduction of criteria and toxic air pollutants as well as greenhouse gas emissions and providing a more stable fuel source in times of high petroleum-based fuel costs.

The projected annual throughput during the first year of operation was presented in the project proposal as 66,399 GGE.¹³ During the first six months of operation, the station dispensed 28,813 GGE, and is on track to reach 72,000 GGE during the first full year of operation. SoCalGas is encouraged about the station's initial results compared to projections.

However, the longer-term projections will be a more challenging goal to achieve. The original proposal projected annual throughput of 184,569 diesel equivalent gallons, or nearly 210,000 GGE per year, once the station is at full utilization (after three years).¹⁴ At current monthly rates, the annual throughput GGE is likely to approach a much lower value of 72,000 GGE in the first year of operation. The original projection was estimated based on a couple of key assumptions. First, and most important, the Riverside Transit Agency indicated their intention to fuel ten of its transit buses at this station. Second, SoCalGas had vehicle procurement plans to place 40 natural gas vehicles at the Murrieta base by 2015. Based on these two anchor fleets, significant throughput was expected at the station early in its operation. The year 2016 represents the station's first year of operation, a full three years past the projected first year of operation in the project proposal. During these years, the transit agency built its own station and no longer needed access to Murrieta, except for emergencies. Further, the growth of the SoCalGas fleet was curtailed because of the station commissioning delay and a shift in corporate plans. Now that the station is fully commissioned, the SoCalGas fleet at this base will be expanded.

In spite of these setbacks, the project team is confident that the marketing efforts of SoCalGas, combined with strong grant support in the state for natural gas vehicles, will grow station throughput and demonstrate a cost-effective investment of Energy Commission funding.

¹³ Projections discussed in this section refer to the original proposal submitted for grant consideration.

¹⁴ One diesel equivalent gallon is equal to 1.136 GGE. The proposal estimated throughput using diesel equivalent gallons, but the station dispenses CNG on the basis of GGE.

It should be noted that the original project budget was \$878,200, but the actual project costs were \$1.6 million. These escalated costs were the result of the long time between project cost estimates and actual project implementation, as well as adding a second dispenser, adding infrastructure to meet City of Murrieta requirements, and upgrading the facility to accommodate an additional compressor in the future.

4.2 Conclusions

The successful design, construction and reliable operation of the Murrieta CNG station have been demonstrated during the first six months of station operation. The station had 2,443 transactions from vehicles operated by the public or fleets other than SoCalGas during its first six months of operation. In addition, the station fueled 7,039 GGE using its overnight time-fill equipment to SoCalGas fleet vehicles assigned to the base. Key results are summarized below:

- 28,813 GGE displaced
- 100 metric tons of carbon dioxide equivalents reduced
- 365- and 2-pounds NOx and PM emissions, respectively, reduced (rough estimate)

At the current throughput rate of 6,000 GGE per month, 250 metric tons of carbon dioxide equivalents are projected to be reduced in the first full year of operation. The California Energy Commission funding in the amount of \$217,000 was provided to support this project. The cost/benefit ratio for this funding is:

- \$217,000 / 250 metric tons of carbon dioxide equivalents = \$868/ metric ton of carbon dioxide equivalents reduced in the first year of station operation.
- \$217,000 / 72,000 gallons of gasoline fuel displaced = \$3 per gallon of gasoline fuel displaced.

Southern California Air Quality Management District and SoCalGas are pleased with the results of this project. The project's success could not have been achieved without our committed project team and customer partners.

SoCalGas appreciates the Energy Commission's support, especially the agreement manager, Lindsee Tanimoto.

4.3 Recommendations

Southern California Air Quality Management District and SoCalGas are excited about the throughput already achieved by the project station. SoCalGas will track overall demand at the station against marketing plans and new customer growth to learn from this experience when planning future stations.

SoCalGas recommends that future station projects include sufficient planning time to coordinate with the local permitting agencies. This will avoid unplanned delays in future projects.

Continued support for natural gas vehicle implementation is important to ensure that existing and future natural gas fueling stations maximize their station throughput.

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 Energy Commission'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.

COMPRESSED NATURAL GAS (CNG)—Natural gas that has been compressed under high pressure, typically between 2,000 and 3,600 pounds per square inch, held in a container. The gas expands when released for use as a fuel.

GASOLINE GALLON EQUIVALENT (GGE)—The amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline. GGE allows consumers to compare the energy content of competing fuels against a commonly known fuel—gasoline. GGE also compares gasoline to fuels sold as a gas (natural gas, propane, and hydrogen) and electricity.

NITROGEN OXIDES (OXIDES OF NITROGEN, NOx)—A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes and are major contributors to smog formation and acid deposition. NO2 is a criteria air pollutant and may result in numerous adverse health effects.

PARTICULATE MATTER (PM)—Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

SOUTHERN CALIFORNIA GAS COMPANY (SoCalGas)—As the nation's largest natural gas distribution utility, Southern California Gas Company delivers energy to 21.8 million consumers through 5.9 million meters in more than 500 communities in Central and Southern California.¹⁵

¹⁵ <u>SoCalGas Website</u> (https://www.socalgas.com/about-us/company-profile).