CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Arcadia Unified School District Compressed Natural Gas Replacement and Upgrade Project

Prepared for: California Energy Commission

Prepared by: Arcadia Unified School District

Gavin Newsom, Governor

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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 provide funding opportunities under the ARFVT Program for projects which develop infrastructure necessary to store, distribute, and dispense electricity, E-85, propane, diesel substitutes, and natural gas. In response to PON-11-602, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards April 24, 2012 and the agreement was executed as ARV-12-003 on October 25, 2012.

ABSTRACT

The Arcadia Unified School District upgraded an existing ten-year-old FuelMaker time-fill fueling station with a 75 standard cubic feet per minute compressor as well as the equipment to provide time-fill and fast-fill capacities. The project was funded by grants from the California Energy Commission, the South Coast Air Quality Management District, and District funds. The project went to bid on January 10, 2013. On February 12, 2013, Allsup Corporation was awarded the compressed natural gas fueling station contract, and Integrity Electric was awarded the electric power upgrade contract. The purpose of the project was to replace aging compressed natural gas fueling station equipment located at 35 Saint Joseph Street in Arcadia, California with equipment that is more reliable, easier to maintain, efficient, and able to meet the school district's future interest in increasing its capacity to replace more diesel buses with natural gas buses. Arcadia Unified School District is committed to continue to use compressed natural gas and improving local and regional air quality. Because of this project, the infrastructure is in place to add a second 75 standard cubic feet per minute rated compressor (thereby totaling 150 standard cubic feet per minute) and two more storage vessels as soon as funds become available. This would provide redundancy for reliability and capacity to offer more agencies a location to refuel.

Keywords: California Energy Commission, South Coast Air Quality Management District, Allsup Corporation, Integrity Electric, Arcadia Unified School District, compressed natural gas, natural gas infrastructure, fueling stations

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EXECUTIVE SUMMARY

Arcadia Unified School District is in the San Gabriel Valley approximately 18 miles from downtown Los Angeles and has 11 schools serving 10,000 students. The school district's fleet of 20 buses transports approximately 460 students daily from home to school daily (including to day care). In addition, the fleet provides 965 field and extra-curricular trips annually. Total mileage for the fleet is over 130,000 miles per year.

While Arcadia Unified School District is currently planning to use the compressed natural gas fueling station for its own fleet vehicles, the fast-fill capability of the new station provides the flexibility of opening access to other compressed natural gas light duty vehicles or small buses. The school district's compressed natural gas fueling station is conveniently located near the 210 freeway in the San Gabriel Valley. This could be especially useful in providing redundancy to other school districts or nearby fleets. Monrovia Unified School District, Arcadia City, and Hemet Unified have indicated interest to use the Arcadia Unified School District's facility for refueling their local compressed natural gas vehicles.

The Arcadia Unified School District compressed natural gas replacement and upgrade project's purpose was to replace a ten year old aging FuelMaker fueling station equipment, located at 35 Saint Joseph Street, Arcadia, California, with equipment that is more reliable, easier to maintain, efficient, and able to meet the district's future clean energy interests.

Arcadia Unified School District is committed to greening its fleet of eleven diesel school buses. To date, with the assistance of the California Energy Commission and the South Coast Air Quality Management District, Arcadia Unified School District has purchased a total of nine natural gas school buses, including 8 Thomas and Blue Bird Type 1 84-passenger capacity buses and one Ford Type 2 16-passenger capacity bus. Arcadia Unified School District was previously fueling these vehicles using a FuelMaker model FMQ-8-36 time-fill station installed in 1999. With the sale of FuelMaker Corporation to BRC Corporation and the discontinuation of these station models, it became increasingly difficult to obtain parts and maintain the fueling system in operating condition. This made it difficult to depend on the FuelMaker station for reliable refueling.

In 2012 Arcadia Unified School District started to explore the replacement of the natural gas compressors. What initially seemed a small project with little possible financial impact was soon realized as much more than just replacing three compressors. The existing infrastructure including electric and gas supplies were not adequate to supply replacement equipment needs. The rough estimate provided by Clean Fuel Connection. Inc., a compressed natural gas consultant, to replace the station was $579,837. In March 2012, Arcadia Unified School District applied for and was awarded a $300,000 matching grant from the California Energy Commission and a $175,000 grant from the South Coast Air Quality Management District.

Arcadia Unified School District went to bid for the electrical upgrade and compressed natural gas fueling station projects in January 2013. Bids were opened and awarded by the Board of Education in February 2013. Integrity Electric was awarded the power upgrade contract for $167,000 and Allsup Corporation was awarded the compressed natural gas fueling station contract for $633,740 for a total of $800,740 (not including the cost to upgrade the gas supply line from Southern California Gas Company and costs to implement the project). The original plan included a station with two compressors for a total of 150 standard cubic feet per minute

with both time-fill and fast-fill capacities. However, the district did not have the additional funds to allocate to the unexpected cost increase of the project. To continue the project, the school district decided to implement a two-phase installation plan for the fueling station project. The first phase installed all necessary infrastructures for the complete station and only installed one Angi NG50E 75 standard cubic feet per minute rated compressor instead of two, and one storage vessel instead of three, but still had both time-fill and fast-fill capacities. This reduced the contract price by $137,080, from $633,740 to $496,660. It is the school district's intent to seek grants and additional funds to install the second compressor and the two storage vessels as soon as they become available. In the future when the second 75 standard cubic feet per minute rated compressor (150 standard cubic feet per minute total) and the additional two storage units installed, Arcadia Unified School District will have the capacity to provide more fueling needs to surrounding school districts and city vehicles.

In October 2013, the compressed natural gas fueling station was brought online and started to fuel district school buses. The data lines and keypad/card reader system were fully installed and operational by December 2013.

Arcadia Unified School District is committed to continue to use compressed natural gas and improving local and regional air quality. Because of this project, the infrastructure is in place to add a second 75 standard cubic feet per minute Angi Compressor and two more storage vessels as soon as funds become available. This would provide redundancy for reliability and capacity to offer more agencies a location for their compressed natural gas refueling needs.

CHAPTER 1: Introduction

Background

Air pollution and climate change are exacerbated by the exhaust of transportation fuels. Diesel school buses make the air worse than lower emission natural gas buses where it is most critical to the health of school age children. Replacement of diesel with natural gas fueled school buses continues to be a high priority adaptation to protect respiratory health and environmental stability.

By 2012, the compressed natural gas (CNG) refueling system installed in 1999 at Arcadia Unified School District was approaching the end of its useful life. The school district needed to upgrade the existing CNG station that refueled the nine natural gas bus fleet before the old compressors failed.

The recent budget restraints on school districts statewide force the school districts to maintain their older diesel buses instead of replacing them in part because of the expense of the newer type of infrastructure needed to fuel cleaner natural gas buses. The District needed to expand its existing CNG station to increase the capacity to fuel additional natural gas buses. Once the CNG fueling station was complete, the District would have the opportunity to reduce both NOx and CO_2 emissions by replacing older diesel vehicles and offer a fueling source for neighbor districts.

Reductions of Petroleum Use and Greenhouse Gas Emissions

To provide an estimate of greenhouse gas emissions reductions, the following assumptions were used:

- Carbon dioxide emissions from a gallon of diesel = 2,778 grams x 0.99 x (44/12) = 10,084 grams = 10.1 kg/gallon = 22.2 pounds/gallon
- One diesel gallon equals about 135 standard cubic feet of gas, or 1.35 therms.

Based on these assumptions, Table 1 calculates the emissions reductions for the nine CNG buses in Arcadia Unified School District's fleet today, as well as the proposed increments to the CNG fleet. Table 1 is based on the increasing number of buses using the station concretively at 15 and 10 months of bus use per year compared to the same use of diesel buses.

Table 1: Arcadia Unified School District's Petroleum and Greenhouse Gas Emissions Reductions 2012 to 2015

Year	GGE per year	Greenhouse Gas Reductions/year (tons)
2012	26,001	289
2013	31,779	353
2014	37,557	417
2015	43,335	481

Source: EPA's Emission Factors Hub, November 2011. http://www.epa.gov/climateleaders/guidance/ghg-emissions.html

The District continues to look for ways to reduce operating costs. The natural gas fuel itself is cheaper than diesel fuel. Although filling diesel buses with fuel is relatively fast, if the CNG station was not available, each bus driver would be paid 20 minutes of travel and fueling time each day to fuel at a station located in Pasadena 4 miles from the bus yard. Owning the CNG fueling station gives the District energy reliability and reduces staff time.

Project Objective

It is in the interest of Arcadia Unified School District to have a reliable, permanent fueling station at the transportation yard that provides all the CNG fueling needs for its current and future CNG fleet, which has the capacity to provide fueling needs for neighboring districts and cities. The goal of this project is to replace the aging FuelMaker system with a new Angi system that will reduce operating costs and reduce air pollution. While Arcadia Unified School District initially planned to use the fueling station for its own fleet vehicles, the fast-fill capability of the Angi System provides the flexibility of opening access to other CNG light duty vehicles or small buses. The Arcadia Unified School District's CNG station is conveniently located near the 210 freeway in the San Gabriel Valley (Figure 1). This could be especially useful in providing redundancy to other school districts or nearby fleets.

Specific data regarding the number of CNG vehicles within a 25-mile radius is difficult to obtain. However, Monrovia Unified, Arcadia City, and Hemet Unified have expressed their interest to refuel their CNG vehicles at Arcadia Unified School District's new station. There is indication of the potential for additional usage. A recent feasibility study done for a nearby community college indicated a number of CNG fleets in the San Gabriel Valley area including: the City of Pasadena, the City of Los Angeles, the City of Alhambra, the City of Burbank, Foothill Transit, Metro, Pasadena Area Rapid Transport System, Pasadena Department of Water and Power, Alhambra School District, AAA Rubbish, Waste Management, Consolidated, Crown, Napa, Republic, Dy-Dee Diapers, and the Southern California Gas Company.[1] Although these fleets have their own CNG fueling station, a station located at Arcadia Unified School District could provide a backup fueling site.

[1] Gladstein, Neandross & Associates, Pasadena City College CNG Station Outreach April 4, 2011.

Figure 1: Map of Arcadia Unified School District

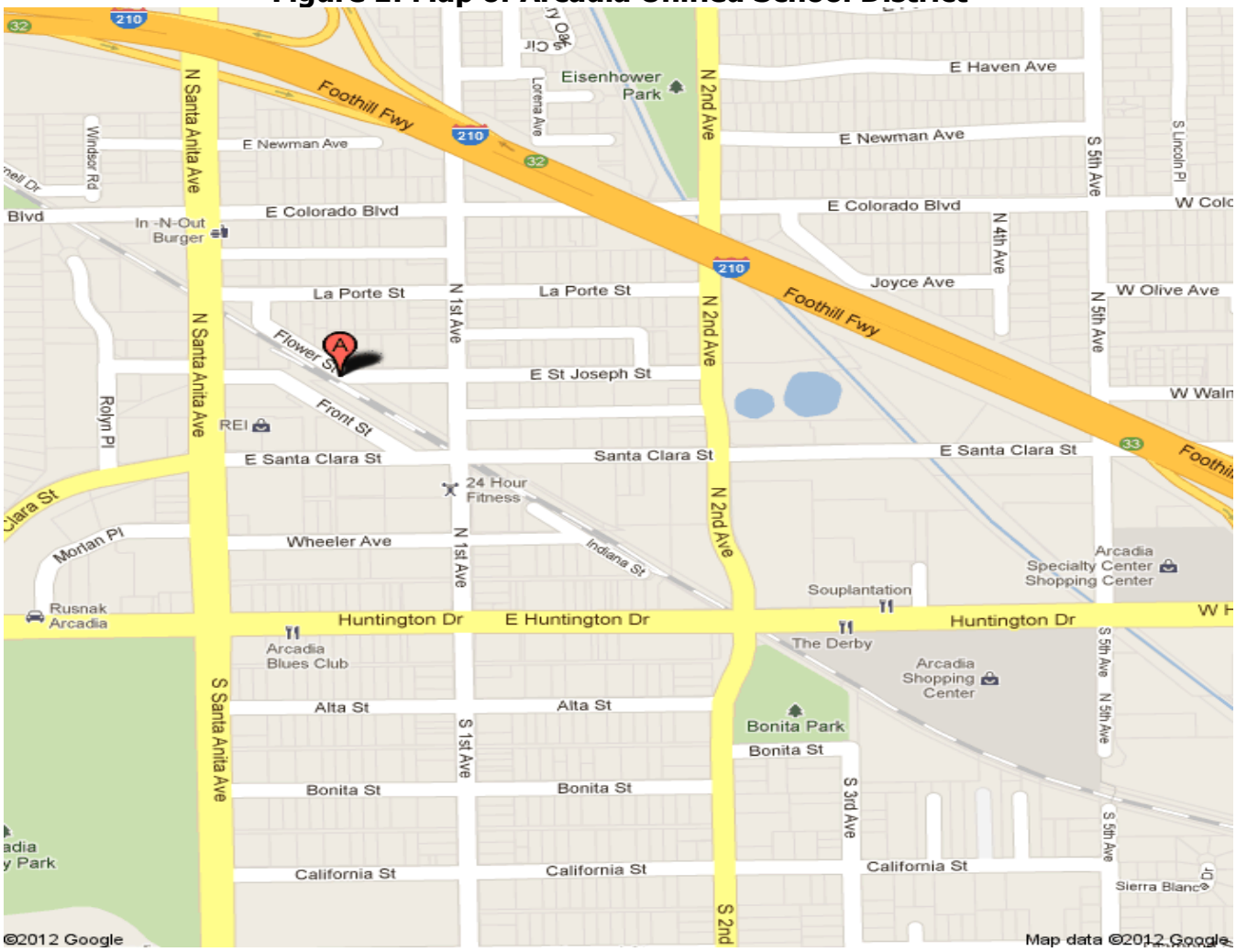

Photo Source: Google Maps

Data collected by South Coast Air Quality Management District on the number of CNG vehicles acquired as a result of District fleet rules provide a conservative estimate of potential station users within the South Coast Basin now and in the future, as shown in Table 2. With recent announcements of new CNG or bi-fuel CNG/gasoline vehicles by Chrysler and GM, as well as new CNG heavy-duty engine models, the number of CNG vehicles is expected to grow over the next few years.

Table 2: Current and Future Natural Gas Population Based on South Coast Air Quality Management District Fleet Rules

Rules	Current Natural Gas Vehicle Population (2012)	Projected Natural Gas Vehicle Population (2020)
Rule 1191: Light- and Medium-Duty Public Fleet Vehicles (adopted June 16, 2000)	Not Tracked	Not Tracked
Rule 1192: Clean On-Road Transit Buses (adopted June 16, 2000)	4,538	4,700
Rule 1193: Clean On-Road Residential and Commercial Refuse Collection Vehicles (amended July 9, 2010)	1,886	4,500
Rule 1194: Commercial Airport Ground Access (amended October 20,2000)	737	800
Rule 1195: Clean On-Road School Buses (amended May 5, 2006)	1,481	2,000
Rule 1196: Clean On-Road Heavy-Duty Public Fleet Vehicles (amended June 6, 2008)	508	700

Source: South Coast Air Quality Management District, Larry Watkins, email 3/13/12

Finally, a 2008 count provides the number of natural gas vehicles by type for the South Coast Air Quality Management District's four county region. This data is summarized below in Table 3.

Table 3: 2008 Count of CNG Vehicles for the Los Angeles County

Vehicle Classification	All Vehicles	Natural Gas
Light Duty	6,846,376	5,953
Medium / Heavy Duty	201,157	3,442
Totals	7,047,533	9,395

Source: South Coast Air Quality Management District, Larry Watkins, email 3/13/12

CHAPTER 2:
Project Approach

The objective of this project was to replace, upgrade, and expand the existing CNG fueling station owned by Arcadia Unified School District. In 2012 the Arcadia Unified School District, started to explore the replacement of the CNG compressors. The existing infrastructure including electric and gas supplies were not adequate to supply replacement equipment needs. The rough estimate provided by Clean Fuel Connection. Inc., a CNG consultant, to replace the station was $579,837. In March 2012 Arcadia Unified School District applied for and was awarded a $300,000 matching grant from the California Energy Commission and a $175,000 grant from the South Coast Air Quality Management District.

Arcadia Unified School District went to bid for the electrical upgrade and CNG station projects in January 2013. Bids were opened and awarded by the Board of Education in February 2013. Integrity Electric was awarded the power upgrade contract for $167,000 and Allsup Corporation was awarded the CNG fueling station contract for $633,740 for a total of $800,740, not including the cost to upgrade the gas supply line from SoCal Gas Company and costs to implement the project. The original plan included a station with two compressors for a total of 150 standard cubic feet per minute (SCFM) with both time-fill and fast-fill capacities. The District did not have the additional funds to allocate to the unexpected cost increase of the project. To continue the project, Arcadia Unified School District decided to implement a two-phase installation plan for the fueling station project. The first phase installed all infrastructures for the complete station, but only installed one Angi NG50E 75 SCFM rated compressor (instead of two) and one storage vessel (instead of three), but still had both time-fill and fast-fill capacities. This reduced the contract price by $137,080 from $633,740 to $496,660. It is Arcadia Unified School District's intent to seek grants and additional funds to install the second compressor and the two storage vessels as soon as they become available. In the future when the second 75 SCFM rated compressor (150 SCFM total) and the additional two storage units have been installed, the fueling station will have the capacity to provide more fueling needs to surrounding school districts and city vehicles.

Utility Service Upgrade

To meet the new fueling station's utility needs, Arcadia Unified School District had to upgrade the current electrical panel to provide the 480-volt system needed for the station and upgrade the natural gas line to a two-inch gas supply line. Arcadia Unified School District went to bid for the electrical upgrade and CNG station projects in January 2013. Bids were opened and awarded by the Board of Education in February 2013. Below summarizes the timing for completed work on the electrical upgrade and CNG station work.

- Integrity Electric Power Upgrade (Figure 2 and Figure 3 show the electrical upgrade at different stages)
    - December 2012 – Drawings Complete
    - January 8, 2013 – Board Approval for Bid
    - January 10, 2013 – First Advertisement
    - January 17, 2013 – Second Advertisement
    - January 21, 2013 – Job Walk
    - January 31, 2013 – Opened Bids
    - February 12, 2013 – Board Approval of Contract
    - February 25, 2013 – Notice to Proceed
    - July 26, 2013 – Electric Work Complete

Figure 2: During Electrical Upgrade

Photo Credit: Arcadia Unified School District

Figure 3: After Electrical Upgrade

Photo Credit: Arcadia Unified School District

- SoCal Gas Supply Line Upgrade (Figure 4 and Figure 5 shows the supply line upgrade at different stages)
    - March 12, 2013 – Submitted request for service upgrade to the City
    - April 16, 2013 – Plans were approved
    - May 2, 2013 – Engineering meeting with SoCal Gas Company
    - August 16, 2013 – Gas line installed by SoCal Gas Company
    - October 1, 2013 – Pressure test prior to install SoCal Company equipment
    - October 10, 2013 – SoCal Gas Company installed their equipment

- CNG Fueling Station
    - October 18, 2013 – Equipment commissioned and started fueling
    - December 13, 2013 – Data equipment on-line
    - January 15, 2014 – Official ribbon cutting

Figure 4: Before One Inch Gas Supply Line

Photo Credit: Arcadia Unified School District

Figure 5: After Two Inch Gas Supply Line Upgrade

Photo Credit: Arcadia Unified School District

Construction and Commissioning

Arcadia Unified School District went to bid for the CNG station projects in January 2013. Bids were opened and awarded by the Board of Education in February 2013. Allsup Corporation was awarded the first part of the CNG contract for $496,660. This included installing all necessary infrastructures for the complete station and one Angi NG50E 75 SCFM rated compressor and one storage vessel. The second part will install the second compressor and the two additional storage vessels. The complete station will have two 75 SCFM rated compressor (150 SCFM total) and three 48” diameter storage units (Figure 6 and Figure 7 shows the old station prior to construction and after the upgrade was complete). Currently Arcadia Unified School District has the capacity to meet its current CNG needs, but when funds become available and the next phase of the project has been completed, Arcadia Unified School District will have the capacity to provide more fueling needs to surrounding school districts and city vehicles.

Figure 6: Old Station Prior to Construction

Photo Credit: Arcadia Unified School District

Figure 7: Upgraded CNG Arcadia Unified School District Station

Photo Credit: Arcadia Unified School District

System Design and Specifications

Allsup Corporation designed and installed the Arcadia Unified School District's CNG fueling station consisting of one Duplex Angi Model NG50E compressor rated for 75 SCFM with 8 dual hose time-fill posts, each refueling at 3,600 psi on a time-fill basis, and one fast-fill dispenser. The following (Table 4) shows the equipment used for the project.

Table 4: Project Equipment

Quantity	Equipment	Specifications
1	STR 24 NGX-2 Xebec Gas Dryer	Single tower natural gas dryer with desiccant filled chamber
1 (of 2)	Duplex Angi Model NG50E compressor	75 SCFM ANGI compressor features modular design for site integration and on-skid PLC controls with sound attenuated enclosure for outdoor weather-proof protection.
1	ANGI Series II Dispenser	Single Hose Designs, One, Two, or Three-bank Sequencing, Coriolis Mass Flow Metering, Internal Microprocessor Controller, Electronic Temperature Compensation and Sequencing, Certified for Weights and Measures, Minimum Flow 3 lbs./min, Max Flow Rate 75 lbs./min
1	Electronic Valve Panel	Valves in electronic panels are actuated by an electronic control system that is monitoring pressures.
1 (of 3)	48’ diameter Storage Sphere	48" inside diameter, 100+ year life, 4,000 - 5,000 PSI design pressure, 5500 psi Max pressure, 90-gallon capacity
8	Hoses	Dual Hose x 20’ long time-fill post. Snap-tight inline breakaways for time-fill and fast-fill.
	Tubing	Stainless Steel

Source: Arcadia Unified School District, AllSup Corporation

Site Preparation

Site preparation needed to install CNG fueling station included the following steps:

- Allsup prepared drawings for submittal to the City of Arcadia’s Planning Department.
- Permitting process in conjunction with the Fire Marshall to ensure the station meets all the NFPA 52 and 57 codes as well as performance requirements.
- Approval of design, all equipment necessary for the project was ordered.
- Obtained necessary final permits to begin construction, including electrical, trenching for utilities and construction of concrete pads and the placement of the time-fill and fast- fill dispensers.

Installation

Installation of the CNG fueling station included the following steps:

- Trench electrical to new power supply
- Disconnect and relocate current compressors to allow fueling during construction
- Install underground electric conduit and pull wire
- Concrete work
- Equipment placement
- Electric and equipment connections
- Fire Department pressure test for SoCal Gas Company
- SoCal Gas Company equipment installed
- Time-Fill hoses installed
- Gas Company switch over
- Fire Department inspection
- Final sign-off of permit

Commissioning

Allsup secured all final inspections of the equipment from the City and Fire departments. Equipment was certified to work within the factory specifications. The CNG fueling stations components including the compressors, dispensing units, and monitoring equipment are operating correctly.

Training

End users were trained to use the fueling station. Key personnel were trained to operate the monitoring equipment and run reports. Mechanical staffs were trained to maintain, troubleshoot, and repair the equipment as required.

CHAPTER 3:
Data Collection and Analysis

Six months of throughput, usage, and operations data from the project was collected, and is shown in Table 5 below.

Table 5: Six Months of Data Collection

	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Therms as Documented by Utilities Bills	975	1741	1,242	1,460	1,603	2,268
Compressor Run Time (Hours)	23	39	28	32	36	50
SCF	97,500	174,100	124,200	146,000	160,300	226,800
Average Number of Non-District Vehicles Fueled per Month	0	0	0	0	0	0
Average Number of Type 1 Bus Fueled per Month	8	8	8	8	8	8
Average Number of Type 2 Bus Fueled per Month	1	1	1	1	1	1
Number of Days per Month Vehicles Were Fueled	28	22	21	21	24	25
Maximum Capacity of the New Fueling System (SCFM)	75	75	75	75	75	75
Miles Traveled per Bus by Ondometer Reading	8,576	6,581	5,267	5,109	6,121	10,264
Gallons of Gasoline and/or Diesel Fuel Displaced by Using Natural Gas (with Associated Mileage Information)	1,715	1,364	973	1,144	1,256	1,777

Source: Arcadia Unified School District

The greenhouse gas emission reductions from this project can be estimated using the estimated diesel displacement from the bottom row of Table 5 in combination with the carbon intensity values from the Low Carbon Fuel Standard. Based on Table 5, the average diesel fuel displaced by this project is approximately 1,371 gallons per month. The Low Carbon Fuel Standard estimates the carbon intensity of diesel fuel to be 98.03 grams carbon dioxide-equivalent per megajoule, and the carbon intensity of CNG to be 67.70 grams carbon dioxide-equivalent per megajoule. Based on these intensities, the average greenhouse gas reduction

from the project would be approximately 5.6 metric tons carbon dioxide-equivalent per month, or 67.2 metric tons carbon dioxide-equivalent per year.[2]

Conclusion

In October 2013, the compressed natural gas fueling station was brought online and started to fuel district school buses. The data lines and keypad/card reader system were fully installed and operational by December 2013.

Arcadia Unified School District is committed to continue to use compressed natural gas and improving local and regional air quality. Because of this project, the infrastructure is in place to add a second 75 SCFM Angi compressor and two more storage vessels as soon as funds become available. This would provide redundancy for reliability and capacity to offer more agencies a location for their compressed natural gas refueling needs. It is Arcadia Unified School District's intent to seek grants and additional funds to install the second compressor and the two storage vessels as soon as they become available.

[2] Carbon intensity values derived from ULSD001 and CNG001 pathways under the California Low Carbon Fuel Standard, as well as a diesel energy density of 134.47 megajoules per gallon. California Air Resources Board, "Table 7: Carbon Intensity Lookup Table for Diesel and Fuels that Substitute for Diesel," available at: http://www.arb.ca.gov/fuels/lcfs/lu_tables_11282012.pdf.

GLOSSARY

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.

STANDARD CUBIC FEET PER MINUTE (SCFM)—The molar flow rate of a gas corrected to standardized conditions of temperature and pressure, thus representing a fixed number of moles of gas regardless of composition and actual flow conditions.