



California Energy Commission Clean Transportation Program

FINAL PROJECT REPORT

Fresno Unified School District Compressed Natural Gas Fuel Station Expansion Phase 4

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California Energy Commission

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, also 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 non-road 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 *Investment Plan Update for the Clean Transportation Program.* The CEC solicitation PON-14-608 to provide funding opportunities under the Clean Transportation Program for projects to support installation of new natural gas fueling infrastructure and upgrades to existing natural gas fueling infrastructure. In response to PON-14-608, the recipient submitted an application which was proposed for funding in the CEC's Notice of Proposed Awards, dated August 12, 2015, and the agreement was executed as ARV-15-016 on November 24, 2015.

ABSTRACT

The California Energy Commission's Clean Transportation Program awarded Fresno Unified School District \$500,000 to expand its compressed natural gas fueling system by adding nine quad-hosed fueling posts, one tri-hosed fueling post and upgrading of one single-hose post to a double-hose post. These 40 new fueling stations

FUSD revised the parking layout for buses at the transportation yard to install these 40 new fill stations to slow-fill school buses. These improvements in fuel delivery allows FUSD's school bus fleet to curtail its use of offsite fueling facilities which, in addition to reducing fuel costs, reduces the overall miles traveled by the buses.

Keywords: California Energy Commission, Fresno Unified School District, Clean Transportation Program, natural gas fueling facility, compressed natural gas, CNG

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EXECUTIVE SUMMARY

The Fresno Unified School District, to improve California air quality and the health of the community, made a commitment to convert its school bus fleet to compressed natural gas. By 2014, Fresno Unified School District's compressed natural gas school bus fleet had grown to 59 buses, but there were only 36 filling posts with which to fuel them in the fleet yard.

To fuel the buses already acquired and prepare for a larger fleet, Fresno Unified School District applied to the California Energy Commission for a grant to expand the compressed natural gas fueling system. On November 24, 2015, they entered into agreement ARV-15-016 for \$500,000 to expand its compressed natural gas school bus fueling system at its transportation yard.

Fresno Unified School District revised the parking layout for buses at the transportation yard to be able to install 40 new fill stations. The improvements in fuel delivery allows the school bus fleet to curtail its use of offsite fueling facilities which, in addition to reducing fuel costs, reduces the overall miles traveled by the buses.

While installing the infrastructure, Fresno Unified School District replaced 15 diesel buses with compressed natural gas buses, resulting in more than 80 of FUSD's 103 school buses now running on compressed natural gas. Compressed natural gas school bus miles increased 22 percent between the beginning of 2017 and the end of 2018. Diesel school bus miles decreased 38 percent during those 24 months reported.

Fresno Unified School District's diesel fuel consumption has decreased by 50 percent from the previous year. The compressed natural gas consumption increased by 41 percent, for an increased annual reduction of more than one million pounds (454 metric tons) of greenhouse gas emissions.

CHAPTER 1: Conversion to a Green Fleet

Fresno Unified School District (FUSD) is committed to improving not only the health and educational levels of its students, but also the welfare of the overall community. Improving the air quality by converting the school bus fleet to compressed natural gas (CNG) is in alignment with these commitments. As the fourth largest school district in the state, FUSD oversees 65 elementary schools, 17 middle schools, 15 high schools, 6 other academic institutions,¹ and a transportation fleet fueling center. As the fleet of CNG school buses increased, the district explored funding sources for the Compressed Natural Gas Fuel Station Expansion Phase 4 Project (Project) for additional fuel dispensers. The resulting improved bus yard is shown in the Figure 1 photo.



Figure 1: Bus Yard CNG Fill Stations

Photo Credit: Fresno Unified School District

Problem Statement

The school bus fleet affects air quality. The City of Fresno covers about 112 square miles with a population of around 500,000 people.² The city is located at the eastern edge of the California's Central Valley and nearly in the middle of the San Joaquin Valley along the north-to-south axis. This location, coupled with northerly prevailing winds that collect air pollutants from regions north and blow them south, has caused Fresno to have some of the worst air

² <u>Quick Facts about Fresno, California</u>

¹ <u>Fresno Unified School District</u> (https://www.fresnounified.org/Pages/schools.aspx)

⁽https://www.census.gov/quickfacts/fact/table/fresnocitycalifornia/PST045218)

quality in the United States.³ The San Joaquin Valley Air Basin is in non-attainment for both State and Federal Air Quality Standards for ozone and particulate matter. The bowl-shaped valley collects and holds emissions caused by the activities of the Valley's three million residents and their two million vehicles, as well as vehicles from other areas traveling on Highway 99 and Interstate 5. Other causes include power generation, industrial facilities, plants, agriculture, wildfires, and windblown dust.

Successful fleet conversion depends on adequate alternate fuel supply. Initially, in 2001, FUSD invested in a two-compressor fueling system that could accommodate 11 school buses. Stepwise, the station fueling capacity expanded to accommodate 36 school buses and then the fleet got larger. In 2015, FUSD replaced these compressors with a much larger one. Still, the additional CNG buses were forced to make fueling trips to offsite stations, causing delays in student transportation and additional miles traveled between standard routes. The number of buses in the fleet was growing. Four new CNG buses had already been awarded from 2014 Congestion Mitigation and Air Quality Improvement Federal funds. Applications to the same program were anticipated in 2015. Plus, 28 buses in the district fleet were being converted from diesel to CNG over the next two years.

To reduce the amount of greenhouse gas (GHG) emissions, air pollutants, and the carbon footprint of its school buses, the FUSD planned to install about 20 CNG fueling infrastructure fill posts to ensure adequate fueling needs for its expanding fleet of CNG buses. The conversion of these school buses to a green fleet could provide significant reductions in vehicle emissions annually and help reach attainment. To prepare for the fleet expansion, FUSD applied to the California Energy Commission (CEC) for a grant to expand the CNG fueling system.

Goals of the Agreement

On November 24, 2015, FUSD and the CEC entered into agreement ARV-15-016, granting FUSD \$500,000 to expand its CNG school bus fueling system at its transportation yard to fuel CNG school buses. This project consists of installation of small new equipment relying on existing compressors.

The goals of this agreement are to increase the fueling capabilities of the existing CNG fueling facility in order to serve the increasing number of CNG school buses in the fleet; in turn, to reduce the need for school buses to travel long distances to fuel at other locations; and to allow FUSD to act as a back-up CNG filling facility for other public agencies to use in an emergency.

To reach those goals, at first FUSD proposed adding at least 10 dual-post fueling stations (Figure 2) and the associated piping and controls that would allow for fueling at least 21 additional school buses at FUSD's transportation yard.

³ <u>American Lung Association</u> (https://www.lung.org/our-initiatives/healthy-air/sota/city-rankings/most-pollutedcities.html)

Figure 2: New Dual-Post CNG Fill Stations



Photo Credit: Fresno Unified School District

Project Planning, Approach, and Process

The FUSD Grants Department submitted a grant proposal application in response to the CEC's solicitation PON-14-608. FUSD's Fiscal Department and Facilities Management & Planning Department prepared the fiscal and technical portions of the proposal. Under the guidance of the Grants Department, FUSD developed the necessary payroll and wage information for the grant application. Facilities staff and subcontractor MDC Engineering designed the technical scope of work. During the design phase, staff determined that instead of installing the originally proposed 21 fueling posts, the project allowed for the installation of 40 new CNG fueling post connections within the original budget. FUSD changed the layout of the bus parking at the transportation yard to allow this.

After the CEC awarded FUSD the grant, FUSD's Public Works Purchasing Department staff prepared final construction documents and announced that it was taking bids for a construction contract. On June 14, 2017, the FUSD Board of Education awarded the contract to Revolution CNG, Inc. of Paso Robles, California.

Work began on July 3, 2017 and completed on January 17, 2018. FUSD used two phases of work to minimize any adverse impacts to the operations of the school bus fleet. The first phase consisted of the underground and civil work for the installation of the electrical conduits, fuel line sleeves, and fueling post bases prior to start of school in August 2017. The second

phase of work was the installation of fueling posts, fuel lines and related dispensing equipment. During all phases of construction, subcontractor Matt Luna was the inspector of record for all work, and he witnessed all the testing required by the project documents.

FUSD started using the new fueling stations in January 2018; however, final installation of the correct hoses and hose retractors was not completed until April 18, 2018.

FUSD spent \$500,000 of CEC funds and provided more than \$80,000 in cost share.

The Fueling System Expansion

Subcontractor Revolution CNG, Inc. installed 10 new Tulsa Gas Technologies time-fill fuel posts: nine quad-hosed fueling posts, and one tri-hosed fueling post. In addition, they upgraded one single-hose post to a double-hose post. The OPW-brand CNG hose retractors hold the hoses off the ground when not in use as shown in Figure 3.

FUSD had recently upgraded its CNG compressor and storage to provide fueling capacity for existing and future fueling stations, so FUSD spent the CEC funds only on the construction of these new filling stations. This allowed the project to add 40 new fueling stations to the 36 that were already in place, which increased the fueling capacity to 76 school buses.



Figure 3: Bus Transportation Yard Fill Stations

Photo Credit: Fresno Unified School District

Figures 4 shows the safety feature, the CNG Emergency Shutdown Kiosk installed in the middle of the parking lot.



Figure 4: CNG Emergency Shutdown Kiosk

Photo Credit: Fresno Unified School District

At a fueling station, CNG is sold in gasoline gallon equivalents (GGE), the amount of alternative fuel it takes to equal the energy content of one gallon of gasoline. Similarly, a diesel gallon equivalent (DGE) is the amount of alternative fuel it takes to equal the energy content of one gallon of diesel fuel. This equivalents system allows consumers to compare the energy content of competing fuels or the price. Diesel has more energy in a gallon than gasoline. One gasoline gallon equivalent (GGE) equals 0.88 diesel gallon equivalent (DGE).

CNG is sold in therms on a utility gas bill. The fuel purchased by the school district is shown on Tables 2 and 3. One gasoline gallon equivalent (GGE) equals 1.2 therms.

Chapter 2 Fueling Equipment Expansion and Benefits

Increased CNG Vehicles

While installing the infrastructure, FUSD replaced 15 diesel buses with CNG buses, resulting in more than 80 of FUSD's 103 school buses running on CNG by April 2018. Buses last about 25 to 30 years each. The fueling equipment might last 10 to 15 years. The benefit of the fueling equipment expansion project is better air quality for up to 10 years.

Increased CNG Vehicle Miles Traveled

FUSD's school buses travel approximately the same number of miles every year; with an increase of 3.2 percent over the 24 months ending December 31, 2018, two calendar years. All bus types combined traveled 1.67 million miles during the 2018 calendar year. Nearly 1.36 million of those miles are with the CNG school buses (Table 1). CNG school buses were increasing their travel distance 41 percent while diesel school bus miles were being decreased 38 percent deliberately. Reducing diesel engine vehicle miles traveled produces better air quality.

Increased CNG Consumption

During the two years the diesel buses were fueled the most in July 2017, during construction. Diesel fuel consumption decreased by 50 percent year over year.

Tables 2 and 3 show that FUSD's CNG fueling facility now delivers nearly 400,000 therms of CNG per year, the equivalent of just over 290,000 gallons of diesel fuel (330,000 GGE/y). During the data collection period, CNG consumption increased by 116,000 therms, comparing the two years. That is about the same as displacing about 84,500 DGE/y (96,500 GGE/y). The energy of the natural gas consumed increase is much more than the diesel fuel reduced, almost double, due to the reduced use of offsite fueling facilities, increased miles per year, and the changed bus engines.



Table 1: School Bus Fleet Miles Summary

Source: Fresno Unified School District

The expanded CNG fueling facility under CEC grant agreement ARV-15-016 has reduced FUSD's diesel fuel consumption by half, more than 46,773 gallons (Tables 2 and 3). Actual fuel reduced is the basis of the annual net project emission pollution reduction on Table 3. It is estimated that 1,046,800 pounds of carbon dioxide, 33 ounces of particulate matter with a diameter less than 2.5 micrometers, $PM_{2.5}$, 6,866 ounces of NO_x (429 pounds), and 19 ounces of SO_x were avoided that year. Criteria air pollutants were all reduced.

Table 2: Data Collection – January-June 2017 POST PROJECT DATA COLLECTION

				Period 1
Data	FUSD CNG	FUSD CNG	CNG Volume	CNC Values
Period	Station Volume	Station Volume	Amount	CNG Volume
Month	2017 CNG	2018 CNG *	Trend Increase	% Trend
JAN	18,677.00	35,998.00	17,321.00	92.7%
FEB	27,903.00	35,590.00	7,687.00	27.5%
MAR	32,945.00	33,801.00	856.00	2.6%
APR	26,950.00	46,495.00	19,545.00	72.5%
MAY	20,665.00	43,888.00	23,223.00	110.0%
JUN	21,105.00	13,763.00	(7,342.00)	-34.8%
Total	148,245.00	209,535.00	61,290.00	41.3%

Data Period	Diesel Volume	Diesel Volume	FUSD Diesel	Diesel Volume % Decrease	Net Project Emission Pollutant Reduction (Reduced Diesel Consumption)				
Month	2017 DV	2018 DV	Diesel Trend Decrease	Diesel % Trend	Carbon Dioxide (lbs.) 22.38 multiplier	PM 2.5 (oz.) 0.0007 multiplier	NOx (oz.) 0.1468 multiplier	SOx (oz.) 0.0004 multiplier	
JAN	7,858.10	4,974.30	(2,883.80)	-36.7%	(64,539.44)	(2.02)	(423.34)	(1.15)	
FEB	8,336.50	4,583.20	(3,753.30)	-45.0%	(83,998.85)	(2.63)	(550.98)	(1.50)	
MAR	11,951.90	4,651.20	(7,300.70)	-61.1%	(163,389.67)	(5.11)	(1,071.74)	(2.92)	
APR	7,515.70	5,000.90	(2,514.80)	-33.5%	(56,281.22)	(1.76)	(369.17)	(1.01)	
MAY	10,889.90	5,784.40	(5,105.50)	-46.9%	(114,261.09)	(3.57)	(749.49)	(2.04)	
JUN	3,590.40	2,431.30	(1,159.10)	-32.3%	(25,940.66)	(0.81)	(170.16)	(0.46)	
Total	50,142.50	27,425.30	(22,717.20)	-45.3%	(508,410.94)	(15.90)	(3,334.88)	(9.09)	
*POST PI	ROJECT DATA COLI	LECTION							

Source: Fresno Unified School District and <u>Diesel Emissions Quantifier</u> (https://cfpub.epa.gov/quantifier/index.cfm?action=main.home)

Table 3: Data Collection – July-December 2017 POST PROJECT DATA COLLECTION

				Period
Data Period	FUSD CNG Station Volume	FUSD CNG Station Volume	CNG Volume Amount	CNG Volume
Month	2017 CNG	2018 CNG	Trend Increase	% Trend
JUL	1,700.00	2,045.00	345.00	20.3%
AUG	21,835.00	35,436.00	13,601.00	62.3%
SEPT	36,894.00	40,594.00	3,700.00	10.0%
OCT	29,207.00	45,868.00	16,661.00	57.0%
NOV	26,553.00	34,817.00	8,264.00	48.9%
DEC	16,897.00	29,325.00	12,428.00	73.6%
Total	133,086.00	188,085.00	54,999.00	41.3%

Data Period	Diesel Volume	Diesel Volume	FUSD Diesel	Diesel Volume % Decrease	Net Project Emission Pollutant Reduction (Reduced Diesel Consumption)				
Month	2017 DV	2018 DV	Diesel Trend Decrease	Diesel % Trend	Carbon Dioxide (lbs.) 22.38 multiplier	PM 2.5 (oz.) 0.0007 multiplier	NOx (oz.) 0.1468 multiplier	SOx (oz.) 0.0004 multiplier	
JUL	654.40	736.30	81.90	12.5%	1,832.92	0.06	12.02	0.03	
AUG	6,896.70	3,617.70	(3,279.00)	-47.5%	(73,384.02)	(2.30)	(481.36)	(1.31)	
SEPT	10,345.70	5,168.90	(5,176.80)	-50.0%	(115,856.78)	(3.62)	(759.95)	(2.07)	
ОСТ	11,392.40	3,628.10	(7,764.30)	-68.2%	(173,765.03)	(5.44)	(1,139.80)	(3.11)	
NOV	8,295.50	3,149.60	(5,145.90)	-62.0%	(115,165.24)	(3.60)	(755.42)	(2.06)	
DEC	5,344.00	2,571.40	(2,772.60)	-51.9%	(62,050.79)	(1.94)	(407.02)	(1.11)	
Total	42,928.70	18,872.00	(24,056.70)	-56.0%	(538,388.95)	(16.84)	(3,531.52)	(9.62)	
*POST PI	ROJECT DATA COLI	ECTION			(1,046,799.88)	(32.74)	(6,866.41)	(18.71)	

Source: Fresno Unified School District

CHAPTER 3: Economic Benefits

This project's buses run in disadvantaged communities with the 2018 CalEnviroScreen 3.0 ratings⁴ between 81-100 percent shown in medium orange and dark orange in Figure 1. Multiple sources of pollution and population characteristics that make the communities more sensitive to pollution are combined with family income, race, ethnicity, age, and language barriers. This color-coded tool is used to prioritize environmental justice in distribution of state grant funds.



Source: California Office of Environmental Health Hazard Assessment

The expansion of the CNG fueling system under ARV-15-016 reduced FUSD's diesel fuel consumption by over 46,700 gallons/year which would have cost about \$106,700. That diesel fuel is the equivalent of about 58,500 therms. By using the average cost of \$1.0293 per therm of CNG, the cost is about \$60,200. Subtracting the cost of CNG from the cost of diesel fuel,

⁴ <u>CalEnviroScreen 3.0 ratings</u> (https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30)

the expansion saved FUSD more than \$46,500 in fueling costs during the data collection period.

In addition to reducing diesel fueling expenditures, FUSD also eliminated the need to travel approximately 20 miles per bus per day to fuel at off-site facilities. By being able to refuel the school buses overnight while parked at its own transportation yard, FUSD has been able to reduce additional CNG fuel purchase costs, vehicle wear and tear, and driver labor costs.

The CNG fueling facility expansion supported local material suppliers and created about 20 temporary construction jobs for about six months.

Drivers gain a resume benefit when trained in an alternative fuel vehicle.



Figure 6: CNG Fill Station Fueling School Bus

Photo Credit: Fresno Unified School District

CHAPTER 4: Conclusions

The California Energy Commission's Clean Transportation Program awarded Fresno Unified School District's school bus fueling facility \$500,000 to expand its compressed natural gas fueling system. This project, grant agreement ARV-15-016, has achieved the goals set by FUSD to:

- Increase fleet CNG use.
- Reduce fleet diesel fuel consumption.
- Improve the air quality for its students and community.

This final report documents the planning, budget, specifications, and throughput for the upgraded fueling station.

This project improves the FUSD regional back-up fueling facility capacity for other public agencies in case of an emergency.

The expansion included nine quad-hosed fueling posts, one tri-hosed fueling post and upgrading of one single-hose post to a double-hose post. Additionally, electrical upgrades and underground fuel piping lines were added. By project completion, FUSD installed a total of 40 new fueling stations, which increased the fueling capacity to 76 school buses. Increasing the number of fill sites in the parking lot has also removed the need for 40 FUSD school buses to travel long distances to fuel up at other stations, saving time and money.

The expansion saved FUSD more than \$46,500 in fueling costs for one year. By being able to refuel the school buses overnight while parked at its own transportation yard, FUSD has been able to reduce outside CNG fuel purchase costs, vehicle wear and tear, and driver labor costs.

By installing 40 new CNG slow-fill dispensers, the primary objective of expanding the CNG fueling capacity to allow further conversion of FUSD's diesel fleet to CNG has resulted in a substantial reduction in exhaust emissions. While installing the infrastructure, FUSD replaced 15 diesel buses with CNG buses, resulting in more than 80 of FUSD's 103 school buses now running on CNG. This increased use of more than 116,000 therms of CNG is equivalent to removing more than 84,500 gallons of diesel fuel and it displaced more than one million pounds (454 metric tons) of greenhouse gas emissions in one year.

GLOSSARY

BRITISH THERMAL UNIT (Btu) – The standard measure of heat energy. It takes one Btu to raise the temperature of one pound of water by one degree Fahrenheit at sea level. For example, it takes about 2,000 Btu to make a pot of coffee. One Btu is equivalent to 252 calories, 778 foot-pounds, 1055 joules, and 0.293 watt-hours. Note: In the abbreviation, only the B is capitalized.

CALIFORNIA ENERGY COMMISSION (CEC) – The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The CEC's five major areas of responsibilities are:

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

Funding for CEC activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, Alternative and Renewable Fuel and Vehicle Technology Funding, and other sources.

CARBON DIOXIDE (CO_2) – A colorless, odorless, nonpoisonous gas that is a normal part of the air. CO_2 is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO_2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO_2 also serves as the reference to compare all other greenhouse gases.

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

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

FRESNO UNIFIED SCHOOL DISTRICT (FUSD) - The fourth largest school district in California, FUSD oversees a school bus fleet fueling facility, 65 elementary schools, 17 middle schools, 15

high schools, and 6 other academic institutions.⁵ To improve air quality for students and the community, FUSD is converting about 100 diesel-powered school buses to CNG school buses.

GALLON – A unit of liquid volume. A U.S. gallon has 231 cubic inches or 3.785 liters.

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.

GREENHOUSE GASES (GHG) – Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), halogenated fluorocarbons (HCFCs), ozone (O₃), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

NITROGEN OXIDES (OXIDES OF NITROGEN, NO_x)—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.

 $PM_{2.5}$ – This type of criteria air pollutant includes tiny particles with an aerodynamic diameter less than or equal to a nominal 2.5 microns. This fraction of particulate matter penetrates most deeply into the lungs.

POUND (lb.) – A unit of mass. A U.S. pound is equal to 0.45359237 kilograms.⁶

SULFUR OXIDES (SO_x)—Pungent, colorless gases (sulfates are solids) formed primarily by the combustion of sulfur-containing fossil fuels, especially coal and oil. Considered major air pollutants, sulfur oxides may impact human health and damage vegetation.

THERM – A unit of energy. One hundred thousand (100,000) British thermal units (1 therm = 100,000 Btu).

⁵ <u>Fresno Unified School District</u> (https://www.fresnounified.org/Pages/schools.aspx)

⁶ <u>Pound</u> (https://en.wikipedia.org/wiki/Pound_(mass))