CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

City of Sacramento Liquefied Natural gas Fueling Station Expansion

Meadowview City Service Complex

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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-12-605 to provide funding opportunities under the CTP for projects supporting installation of new natural gas fueling infrastructure. In response to PON-12-605, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards March 18, 2013 and the agreement was executed as ARV-12-047 on June 13, 2013 in the amount of $600,000.

ABSTRACT

The purpose of this report is to document the implementation and results of the City of Sacramento's Meadowview City Service Complex, Liquefied Natural Gas (LNG) Fueling Station Renovation and Expansion which was approved by the California Energy Commission in March 2013. The goal of the project was to increase the capacity of the fueling station and to refurbish the existing fueling units in order to support the growing fleet of LNG vehicles, including the City's fleet of LNG Solid Waste Vehicles.The project consisted of installing two new skid mounted LNG fueling units, doubling the overall capacity of the fueling station, and refurbishing the existing two skid mounted LNG fueling units. The project received $600,000 in support from the California Energy Commission's Clean Transportation Program. Awardee City of Sacramento solicited a Request for Proposal and selected Aztec Consultants to design and construct the required infrastructure for the two new skid mounted LNG fueling units. The two fueling units were designed and built by Chart Inc. who was a subcontractor to Aztec Consultants.

Keywords: Liquefied Natural Gas, LNG, LNG Fueling Station, City of Sacramento, California Energy Commission, Natural Gas Refuse Trucks

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EXECUTIVE SUMMARY

The purpose of this project was to increase the fueling capacity at the Meadowview City Service Complex's liquefied natural gas (LNG) fueling station in order to meet the growing needs of the City of Sacramento LNG vehicle fleet. Aztec Consulting along with their subcontractor Chart Inc. designed and installed two new skid mounted LNG fueling units and refurbished the City's two existing skid mounted LNG fueling units.

The LNG fueling station is located at 2812 Meadowview Road, Sacramento CA. 95823 at the City of Sacramento's Meadowview City Service Complex, where the City's fleet of Solid Waste Vehicles is located. As of May 26, 2016 all of the key project objectives had been met, including:

- Aztec Consulting and their sub-consultants successfully designed the project and obtained a permit from the City of Sacramento's building department.
- Aztec Consulting and their subcontractors, successfully built the required infrastructure, set the new Chart supplied skid mounted LNG fueling units, and completed all required interconnections, including power, controls, fire alarm, water, compressed air, etc.
- Aztec Consulting and their subcontractors successfully refurbished the two existing skid mounted LNG fueling units.
- Aztec Consulting and their subcontractors provided the required operational training of the units for the City of Sacramento's operators.

The City's modified fueling station now has twice the storage capacity as the original station. In addition, there are now four separate filling hoses, allowing more vehicles to fuel at the same time, thus reducing the time a truck must wait to fuel. The additional capacity will continue to support the City's LNG vehicle fleet for many years to come. Prior to the project, the fueling station consisted of two Chart Inc. IMC-6000 skid mounted LNG fueling units, each with a capacity of about 5,500 US gallons. This project installed two additional Chart Inc. IMC-6000 skid mounted LNG fueling units, each with a capacity of about 5,500 US gallons, bringing the total LNG fuel storage capacity to 22,000 US gallons. Additionally, the two existing units that are over 12 years old have now been refurbished, increasing the reliability of the units.

CHAPTER 1: Introduction

Project Goals and Objectives

The primary goal of the project was to increase the storage capacity and fueling capacity of the Liquefied Natural Gas fueling station located at the City of Sacramento's Meadowview City Service Complex. The existing fueling units were also refurbished to improve their reliability and extend their useful life. Two of the fueling units were connected to the onsite standby generator so that in the event of an electric utility power outage, two of the fueling units would remain operational.

As of May 2016, all of the project objectives had been met, including:

- Completed engineering and design for the two new Chart Inc. IMC-6000 skid mounted LNG fueling units.
- Completed all required site infrastructure upgrades for the two new Chart Inc. IMC-6000 skid mounted LNG fueling units.
- Completed all required testing and commissioning for the two new Chart Inc. IMC-6000 skid mounted LNG fueling units.
- Connected both of the new Chart Inc. IMC-6000 skid mounted LNG fueling units to the onsite standby generator.
- Completed the refurbishment of the two existing Chart Inc. IMC-6000 skid mounted LNG fueling units.
- Installed pressure and level sensors on both the two existing and the two new Chart Inc. IMC-6000 skid mounted LNG fueling units so that accurate fuel usage can be tracked.
- Obtained six months of fueling data from all four units.

This project has doubled the fueling storage capacity at the Meadowview City Service complex from 11,000 US gallons to 22,000 US gallons of LNG storage. The project also doubled the number of fueling hoses from two to four so that four trucks can fuel simultaneously. This added capacity helps the City of Sacramento fuel its fleet of 91 solid waste LNG vehicles.

Project Description

The project consisted of installing two new Chart Inc. IMC-6000 skid mounted LNG fueling units, and refurbishing two existing units. Infrastructure modifications and upgrades were required, including the following:

- New structurally designed reinforced concrete pad to support the new LNG skid mounted fueling units.
- 6" concrete filled steel bollards placed around the equipment to protect the equipment from potential damage that could be caused by the large Solid Waste LNG vehicles.
- Built-up asphalt containment berm installed around the fueling units.
- Electrical conduit and wire routed underground between the new skid mounted fueling units and the new control panels, for power, fire alarm and controls.

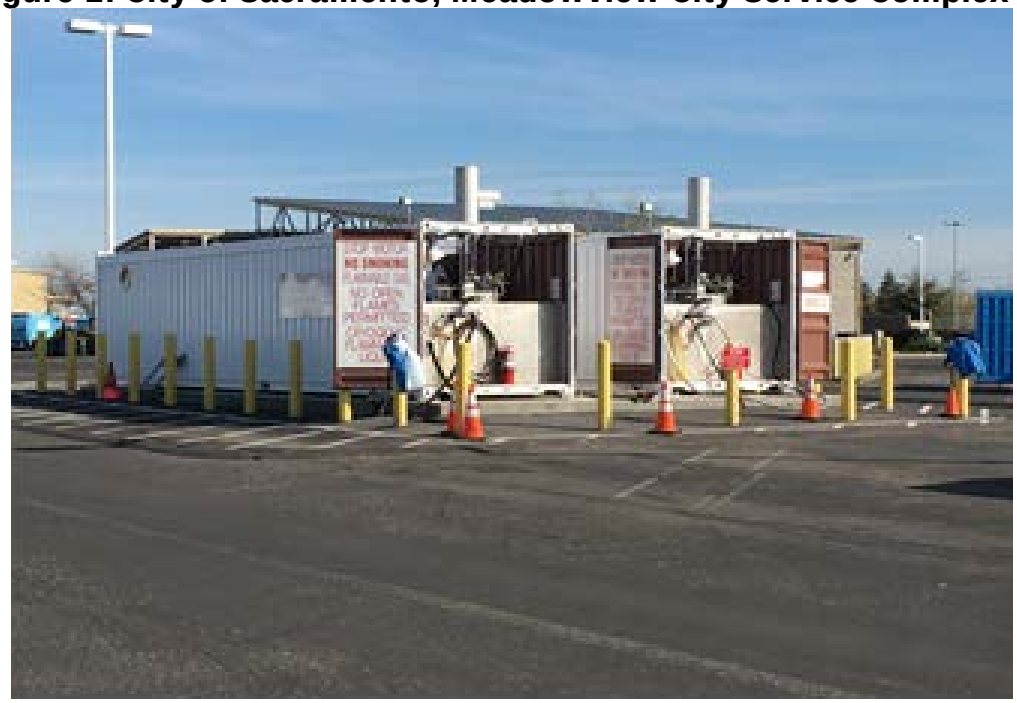
- Pneumatic piping routed between the skid mounted fueling units and the new control panels for pneumatic controls.
- Installation of a new Island Controller Unit card reader and all required interconnections so the drivers can access the fueling units and fuel their trucks.
- Installation of a new emergency eye wash station, including extending potable water to the station.
- New electrical power feeders routed from the emergency generator distribution panel to two of the control panels and skid mounted fueling units.
- Fire alarm devices and connection to the existing site fire alarm panel.
- Installation of a new shade canopy over the eye wash station and the card reader.

Technology Description

Liquefied natural gas is natural gas that has been converted to liquid form for ease of storage and transport. The process of converting natural gas to LNG is called liquefaction. LNG takes up about 1/600th the volume of natural gas in the gaseous state. The liquefaction process involves removal of unneeded components, such as dust, acid gases, helium, water, and heavy hydrocarbons. The natural gas is then condensed into a liquid at close to atmospheric pressure by cooling it to approximately −162 degrees Celsius (−260 degrees Fahrenheit) with a maximum transport pressure around 25 kPa (4 psi).

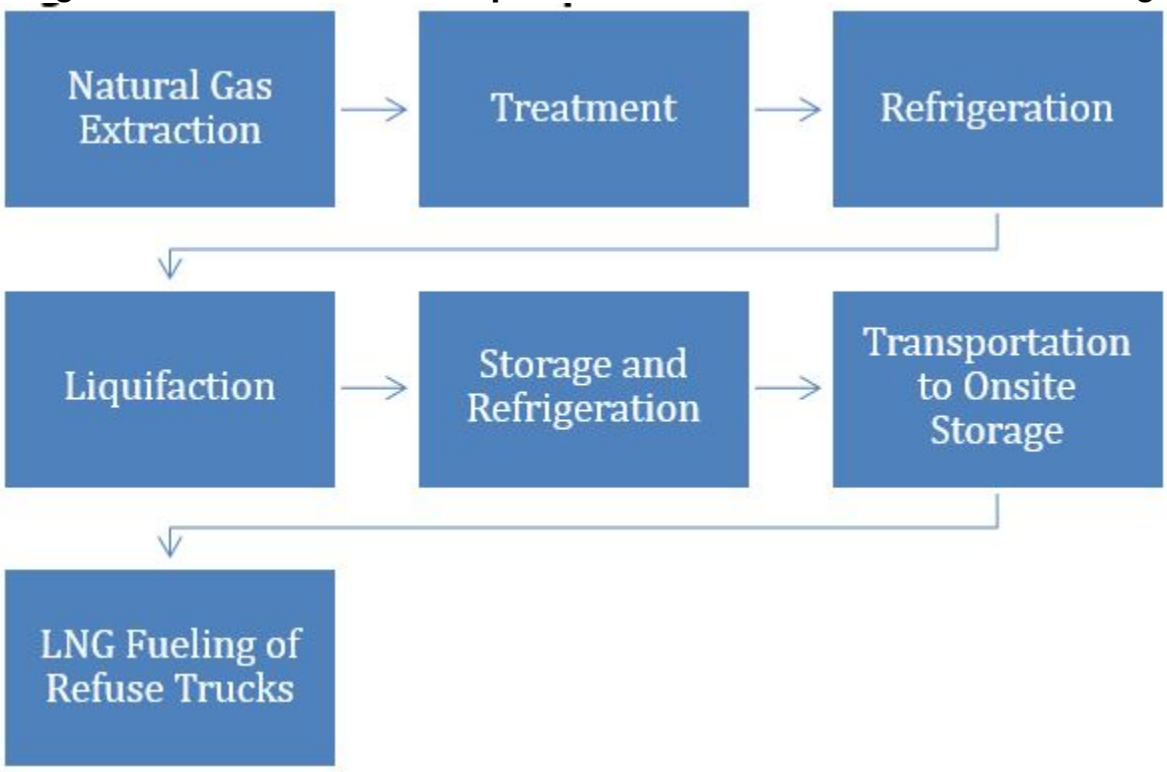
LNG is delivered to the on-site storage tanks via specially designed cryogenic LNG trailers. The on-site storage tanks and fueling station dispenses LNG to vehicle fuel tanks. The vehicle fuel tanks store LNG in liquid form. Vaporizer warms and converts LNG to gaseous natural gas so that it can power the vehicle. Figure 1 shows the complex with the two storage tanks behind some steel poles. Figure 2 shows the process in which the LNG flows between carriers.

Figure 1: City of Sacramento, Meadowview City Service Complex



Source: City of Sacramento

Figure 2: Process Flow for Liquefied Natural Gas: Extraction to Fueling



Source: City of Sacramento

Need for Project Funding and Funding Sources

The project received funding from the CEC towards the purchase of equipment through a grant award of $600,000. The grant award required the city to match the grant with at least $600,000 of funding. The total cost of the project was $1,725,000 which included all design, construction, equipment, installation, project management, inspections, commissioning and project closeout. The city provided the remainder of the funding, totaling $1,125,000, in excess of the required $600,000 grant match.

CHAPTER 2:
Permitting, Construction and Commissioning

Design and Construction

Design for the expanded LNG fueling station began in November of 2013. Through a request for proposal process, the City of Sacramento selected Aztec Consultants to design and construct the new fueling units, and to refurbish the existing fueling units. In May of 2014 the City of Sacramento's Community Development Department issued a building permit for the project. Construction of the project began in June of 2014 as shown in Figure 3. Figure 4 shows the final steps in the construction phase in November 2014. Table 1 lists the dates of deadlines and milestones for the entire project.

Figure 3: Concrete Pour in the LNG Site June 2014

Source: City of Sacramento

Figure 4: LNG Units Installed by Crane Receive First Delivery of LNG Fuel, November 2014

Source: City of Sacramento

Table 1: Milestones in the Construction and Operation of the City of Sacramento's LNG fueling station.

Milestone	Date
Advertise Request for Proposal	7/12/2013
Close Request for Proposal	8/30/2013
Select Contractor for the Project	9/6/2013
Report to City Council for contract review	10/15/2013
Report to City Council for contract award	10/22/2013
Notice to Proceed to Contractor	11/5/2013
Pre-Design / Kick off Meeting	11/25/2013
Project design completed	5/26/2014
Site Preparation for the new LNG Fueling Stations	8/13/2014
Arrival and setting of the new LNG Fueling Stations	8/13/2014
Completion of the installation of the New Fueling Stations	10/31/2014
Refurbishing of the existing LNG fueling Stations	8/25/2015
Final Commissioning and Testing	2/18/2016
Complete six months of data collection	4/30/16

Source: City of Sacramento

Description of Fleets Served

The City of Sacramento currently has 91 LNG vehicles. The vehicles are used by the Solid Waste Department for picking up refuse and mixed recycles. The 91 vehicles consist of (1) one heavy truck, (11) eleven rear loaders and (79) seventy-nine side loaders. Final project completion is shown in both Figures 5 and 6.

Figure 5: Installed Control Units

Source: City of Sacramento

Figure 6: Installed Fueling Units

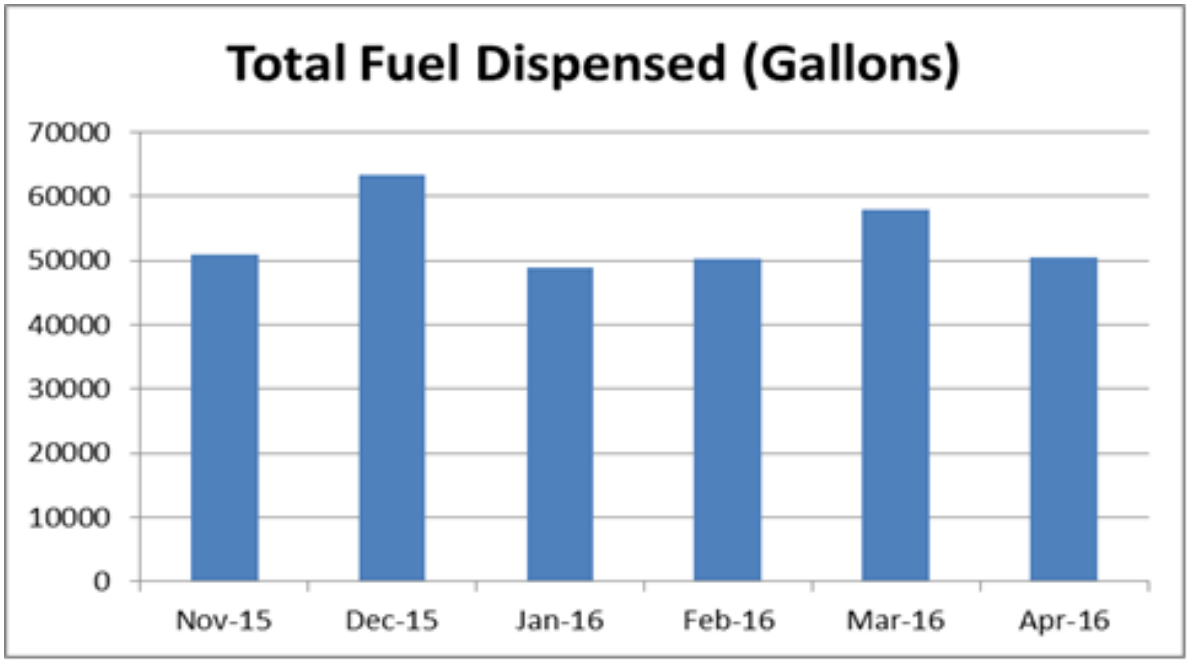
Source: City of Sacramento

CHAPTER 3: LNG Fueling and Petroleum Displacement

LNG Fuel Dispensed

The total volume of LNG dispensed during the six-month data collection period between November 2015 and April 2016 was 322,097 gallons. (See Figure 7 and Table 2). Figure 7 shows a graph of how much fuel was dispended per month during the collection period.

Figure 7: Volume of total monthly Liquefied Natural Gas Dispensed during the Data Collection Period.



Source: City of Sacramento

Table 2 shows how much LNG was dispensed by each fueling unit, 41, 52, 53 and 54 for each month during the data collection period. It also shows the total fuel dispensed each month and the total LNG dispensed.

Table 3, 4, 5 and 6 provide a breakout of the fuels dispensed during the six-month data collection period. The tables provide the number of vehicles fueled per month, how many fuel stops made per month, the average number of fuel stops per day and the average gallons of fuel dispensed per stop. This information is separated by each of the four fueling units. It is interesting to note that unit 54 was used more than the other three units averaging significantly more stops per day.

Table 2: Volume of Monthly Liquefied Natural Gas (LNG) (Gallons) Dispensed at the Meadowview City Service Complex LNG Fueling Units

Year:	2015		2016				Totals
Month:	Nov	Dec	Jan	Feb	Mar	Apr	
Unit 54	23129	23279	17933	20370	27701	22258	134670
Unit 53	9870	13269	9967	8771	7313	4928	54119
Unit 52	10585	15419	11068	14089	12866	10960	74987
Unit 41	7268	11515	9989	7072	10117	12360	58322
Totals	**50,853**	**63,482**	**48,957**	**50,302**	**57,998**	**50,506**	**322,097**

Source: City of Sacramento

Table 3: Operations and Usage: November, 2015 - April, 2016. Pump 41

Month	Number of vehicles fueled	Total number fuel stops	Average fuel stops per day	Averaged gallons per fuel stop
Nov 15	47	119	3.97	61.08
Dec 15	59	201	6.48	57.29
Jan 16	53	151	4.87	66.15
Feb 16	45	116	4	60.96
Mar 16	49	181	5.84	55.9
April 16	50	189	6.3	65.39

Table 4: Operations and Usage: November, 2015 - April, 2016. Pump 52

Month	Number of vehicles fueled	Total number fuel stops	Average fuel stops per day	Averaged gallons per fuel stop
Nov 15	53	192	6.4	55.13
Dec 15	57	254	8.19	60.7
Jan 16	48	191	6.16	57.95
Feb 16	52	216	7.45	65.23
Mar 16	49	181	5.84	55.9
April 16	50	189	6.3	65.39

Table 5: Operations and Usage: November, 2015 - April, 2016. Pump 53

Month	Number of vehicles fueled	Total number fuel stops	Average fuel stops per day	Averaged gallons per fuel stop
Nov 15	54	168	5.6	58.75
Dec 15	58	194	6.26	67.52
Jan 16	49	159	5.13	62.69
Feb 16	48	140	5	62.65
Mar 16	42	114	3.68	64.15
April 16	36	78	2.6	63.18

Table 6: Operations and Usage: November, 2015 - April, 2016. Pump 54

Month	Number of vehicles fueled	Total number fuel stops	Average fuel stops per day	Averaged gallons per fuel stop
Nov 15	54	335	11.17	63.4
Dec 15	61	318	10.26	68.68
Jan 16	55	271	8.74	66.17
Feb 16	51	282	9.72	66.92
Mar 16	53	377	12.16	68.96
April 16	56	337	11.23	66.05

Source: City Sacramento

GHG Emission Reductions

The City of Sacramento's fleet of LNG vehicles has replaced Diesel-fueled vehicles. During the six-month reporting cycle, 322,097 gallons of LNG fuel was dispensed at the Meadowview LNG fueling station. That equates to approximately 1,400 metric tons of CO2 released into the atmosphere. If the City was still using diesel vehicles for this fleet, the diesel vehicles would have released approximately 1950 metric tons of CO2 into the atmosphere. Thus the LNG fleet offset 540 metric tons of CO2. On an annual basis that equates to 1,080 metric tons of CO2 offset. The calculations are based on the following formulas:

- 1.68 LNG gal = 1 DGE
- 1 LNG gal = 82,644 Btu
- 1 DGE = 139,000 Btu
- 117 lbs CO2 per 1 million Btu for LNG
- 161.3 lbs CO2 per 1 million Btu for Diesel
- 1 lb = 0.000453592 metric tons

Project Benefits and Summary

The LNG project at the City of Sacramento's Meadowview City Service Complex LNG fueling station met all of the proposed goals. The two existing Chart Inc. IMC-6000 skid mounted LNG fueling units were successfully refurbished. Two new Chart Inc. IMC-6000 skid mounted LNG fueling units were installed on the new infrastructure. With the refurbishment of the old units and the two new units the fueling storage capacity has been doubled, and the addition of two fueling hoses has doubled the amount of vehicles that can be fueled at the same time from two to four vehicles. In addition, two of the units are now backed up by the onsite standby generator, so fueling can continue through a utility power outage. The completed LNG fueling station project was a success and will provide clean fuel to the City of Sacramento's LNG vehicle fleet for many years to come.

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. MMBtu stands for one million Btu.

CARBON DIOXIDE (CO2) —A colorless, odorless, nonpoisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent).

DIESEL GALLON EQUIVALENT (DGE) — The amount of alternative fuel it takes to equal the energy content of one liquid gallon of diesel gasoline.

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

KILOPASCAL (kPa) — One thousand times the unit of pressure and stress in the metre-kilogram-second system. Standard atmospheric pressure (or 1 atm) is defined as 101.325 kPa.[1]

LIQUEFIED NATURAL GAS (LNG) — Natural gas that has been condensed to a liquid, typically by cryogenically cooling the gas to minus 260 degrees Fahrenheit (below zero).

[1] Definition for Kilopascal (https://www.britannica.com/science/kilopascal).