CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Renewable Natural Gas Fueling Station

Atlas ReFuel's Sacramento Biorefinery No. 1

Prepared for: California Energy Commission

Prepared by: Atlas ReFuel

Gavin Newsom, Governor

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California Energy Commission

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We thank CleanWorld, LLC, our working partner on a daily basis in the delivery of RNG to local fleets, and greatly value our partnership with the University of California, Davis, Dr. Ruihong Zhang, inventor of the CleanWorld anaerobic digestion technology. We must thank the Atlas ReFuel fleet customers, responsible for the success of the fueling station: Paladin Security; California State University, Sacramento; City of Sacramento; Mission Linen; Republic Waste; and Sacramento Unified School District. In addition, we are grateful for the support and involvement of dynamic Sacramento civic organizations dedicated to extending our regions utilization of RNG, in particular: Sacramento Clean Cities Coalition; GreenWiseJV; Breathe California; Valley Vision; and the American River College. Finally, we want to thank the people of the City of Sacramento who have attended our events and toured our site and demonstrated their support for sustainable organic waste disposal and renewable transportation fuels.

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 solicitation PON-11-602 to provide funding opportunities under the Clean Transportation Program for Alternative Fuels Vehicle Infrastructure: 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-11-028 on June 20, 2012.

ABSTRACT

The purpose of this report is to document the implementation and results of the Sacramento Biorefinery No. 1 Renewable Compressed Natural Gas Fueling Station approved by the California Energy Commission in April 2012. The overarching goal of the project was to address the critical lack of infrastructure to support fleets that operate on CNG and, in particular, to demonstrate an integrated commercial-scale waste to energy facility that can successfully condition the resulting renewable natural gas (RNG) as a vehicle fuel that reliably meets all fuel and air quality specifications. The project received $300,000 in support from the California Energy Commission's Clean Transportation Program. Awardee Atlas Disposal Industries (now Atlas ReFuel, a wholly owned subsidiary of Atlas Disposal Industries) with partners CleanWorld LLC, BioCNG LLC, and Clean Energy, LLC, designed and constructed a new Renewable Natural Gas and Compressed Natural Gas fueling station to support retail sales for natural gas fueled fleets of light-, medium-, and heavy-duty vehicles.

Keywords: California Energy Commission, alternative fuels, natural gas vehicles, renewable natural gas, RNG, waste to energy, anaerobic digestion

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

EXECUTIVE SUMMARY

The purpose of this project was to address the critical lack of infrastructure to support trucking fleets that operate on compressed natural gas (CNG) and, in particular, to demonstrate an integrated commercial-scale waste to energy facility that can successfully produce and sell renewable natural gas (RNG). Atlas ReFuel, a wholly owned subsidiary of Atlas Disposal Services, in partnership with CleanWorld, LLC, BioCNG, LLC and Clean Energy, successfully designed, installed and is currently operating California's first commercial-scale RNG fueling station utilizing a negative-carbon intensity fuel: biomethane produced by the anaerobic digestion of organic waste.

The new fueling station is located at 8550 Fruitridge Road, Sacramento, CA 95828, the site of the Sacramento Area Transfer Station and Sacramento BioRefinery No.1. The fueling station is currently the largest commercial-scale, high-solids anaerobic digestion (AD) system in California. As of March 31, 2014, all key objectives of the project have been met, including:

- Atlas and partners successfully engineered an integrated waste to energy facility providing RNG and CNG fueling services for commercial fleets;
- Atlas reduced unwanted compounds—such as hydrogen sulfide and siloxane—found in natural gas fuels, and provides important data on CNG/RNG fuel composition;
- Atlas reduced greenhouse gas emissions by using an ultra-low carbon intensity fuel;
- Atlas provided outreach and increased public awareness on the benefits of natural gas vehicles and the specific benefits of RNG; and
- Atlas increased end-user knowledge and acceptance of RNG use by NG fleet owners and operators.

The Atlas ReFuel CNG/RNG fueling station demonstrates the feasibility and economic viability of innovative low-carbon fuel technologies, reducing risk and setting the stage for the larger private investment needed to commercialize RNG facilities and improve natural gas delivery infrastructure statewide. With the success of BioCNG's technology for small-scale RNG refining from digester biogas, the use of mid-sized systems to generate renewable transportation fuels allows smaller AD plants to develop RNG stations for community use. In addition, strong commercial fleet support for the fueling station demonstrates that Sacramento BioRefinery No.1 and Atlas Refuel have improved acceptance of RNG use by natural gas fleet owners and operators. Fleet owners, who may lack knowledge about the benefits and safety of RNG for their vehicles, now have a proven RNG/CNG dispensing facility with a strong track record of fuel constituent sampling and testing.

The California Air Resources Board's completion of a low-carbon fuel standard pathway for AD biomethane/RNG assigned a negative carbon intensity value of -15.29 grams of carbon dioxide equivalent per megajoule. This exceptionally low confidence interval value means that the use of AD RNG as a vehicle fuel actually sequesters carbon dioxide rather than increasing its content in the atmosphere. The Sacramento Biorefinery No.1 and Atlas ReFuel station

demonstrate the central role to be played by *ultra-low carbon* transportation fuels in meeting California's AB 32 GHG emission reduction goals.

CHAPTER 1:
Introduction and Background

Project Goals and Objectives

The primary goal of this project was to address the critical lack of infrastructure to support fleets that operate on compressed natural gas (CNG) and, in particular, to successfully demonstrate an integrated commercial-scale waste to energy facility that can successfully produce and sell renewable natural gas (RNG). By successfully designing, installing, and operating California's first commercial-scale RNG fueling station that utilizes a negative-carbon-intensity fuel, the goal of the project has been met.

The new fueling station—owned and operated by Atlas ReFuel—is located at 8550 Fruitridge Road, Sacramento, CA 95828, the site of the Sacramento Area Transfer Station and Sacramento BioRefinery No.1 (SBR1), currently the largest commercial-scale, high-solids anaerobic digestion (AD) system in California. The completed fueling station is fully powered using a portion of the 569-kilowatt hours of green electricity produced at SBR1—making it the first RNG/CNG Fueling Station in California to not only dispense renewable fuels but to also rely entirely upon renewable fuels for its own operation.

As of March 31, 2014, all key objectives of the project had been met, including:

- Atlas successfully designed and engineered an integrated waste to energy facility providing RNG and CNG fueling services;
- Atlas reduced unwanted compounds—such as hydrogen sulfide and siloxane—found in natural gas (NG) fuels and provide data on CNG/RNG fuel composition;
- Atlas reduced greenhouse gas emissions by using a lower carbon intensity fuel;
- Atlas provided outreach and increase public awareness on both the benefits of natural gas vehicles and the specific benefits of RNG; and
- Atlas increased end-user knowledge and acceptance of RNG use by NG fleet owners and operators.

This project is also expected to result in continued indirect benefits, such as the creation of jobs, including specialized jobs in RNG fueling station construction, maintenance, and repair. The project will also heighten the atmosphere of competition among NG vendors, which will ultimately result in increasing the size of the NG fueling station network.

Project Description

The Sacramento BioRefinery No. 1 Renewable Compressed Natural Gas Fueling Station (herein referred to as 'SBR1' or 'Atlas ReFuel fueling station' or the 'fueling station') addresses the critical need identified by the California Energy Commission for the establishment of alternative transportation fuels infrastructure to accommodate the deployment of a growing number of

natural gas fueled vehicles, and for a reduction in the use of petroleum fuels to help the state achieve its greenhouse gas policy goals. Figure 1 shows the completed RNG/CNG fueling station. Note that the natural gas storage tanks are visible in the background and fuel dispensing area in the left foreground.

Figure 1: Atlas ReFuel RNG/CNG Fueling Station completed April 17, 2013

Source: Atlas ReFuel

Atlas ReFuel, a wholly owned subsidiary of Atlas Disposal Industries, with partners Cleanworld LLC, BioCNG LLC, and Clean Energy, LLC, designed and constructed a new RNG and CNG fueling station (Figure 1) to support retail sales for natural gas fueled fleets of light-, medium-, and heavy-duty vehicles.

The fueling station—the first commercial-scale RNG Fueling Station in California—is novel in California for other reasons as well:

- RNG production and subsequent distribution as a fuel are fully integrated components of a commercial-scale, high solids anaerobic digestion system.
- The integrated SBR1 waste-to-energy facility receives organic waste materials from the surrounding county, converts the waste to biogas through the AD process, and subsequently purifies biomethane to the final RNG product.

- The fueling station incorporates a biogas refining technology from BioCNG LLC that supports the flexible blending of onsite RNG with pipeline-drawn natural gas and nominated RNG.

Technology Description

At the core of SBR1 is the Anaerobic Phased Solids Digester, an innovative high-solids AD system initially developed at pilot scale on the University of California, Davis campus by Dr. Ruihong Zhang. AD is best understood as a series of processes in which natural microorganisms break down biodegradable material in the absence of oxygen and produce gaseous products, including methane, carbon dioxide, and small amounts of hydrogen and hydrogen sulfide. Building on available base technology, Dr. Zhang sought to overcome some of AD's remaining operational and material-handling limitations. The resulting Anaerobic Phased Solids Digester system is innovative because it combines favorable features of both batch and continuous biological processes in a single system and makes it possible to achieve efficient and stable production of both hydrogen and methane gases from a variety of organic solid and liquid wastes, including grass clippings, food scraps, food-processing byproducts, crop residues, paper products, and animal wastes. The patented Anaerobic Phased Solids Digester is one of the first commercial biological energy-conversion systems for co-production of hydrogen and methane gases from organic wastes.

The SBR1 Anaerobic Phased Solids Digester comprises four hydrolysis reactors and a single bio-gasification reactor. The digester is a two-phased, sequenced, batch-fed solids digester capable of producing a steady biogas production rate. When compared to traditional AD systems, the Anaerobic Phased Solids Digester employs fewer moving parts; requires smaller volume reactors (the material does not need to be hydro-pulped and is held for a shorter period of time); uses less energy to operate; is highly scalable; relies upon commercially available components; and possesses innovative design features that optimize the bacterial degradation of organic wastes and minimize pretreatment time.

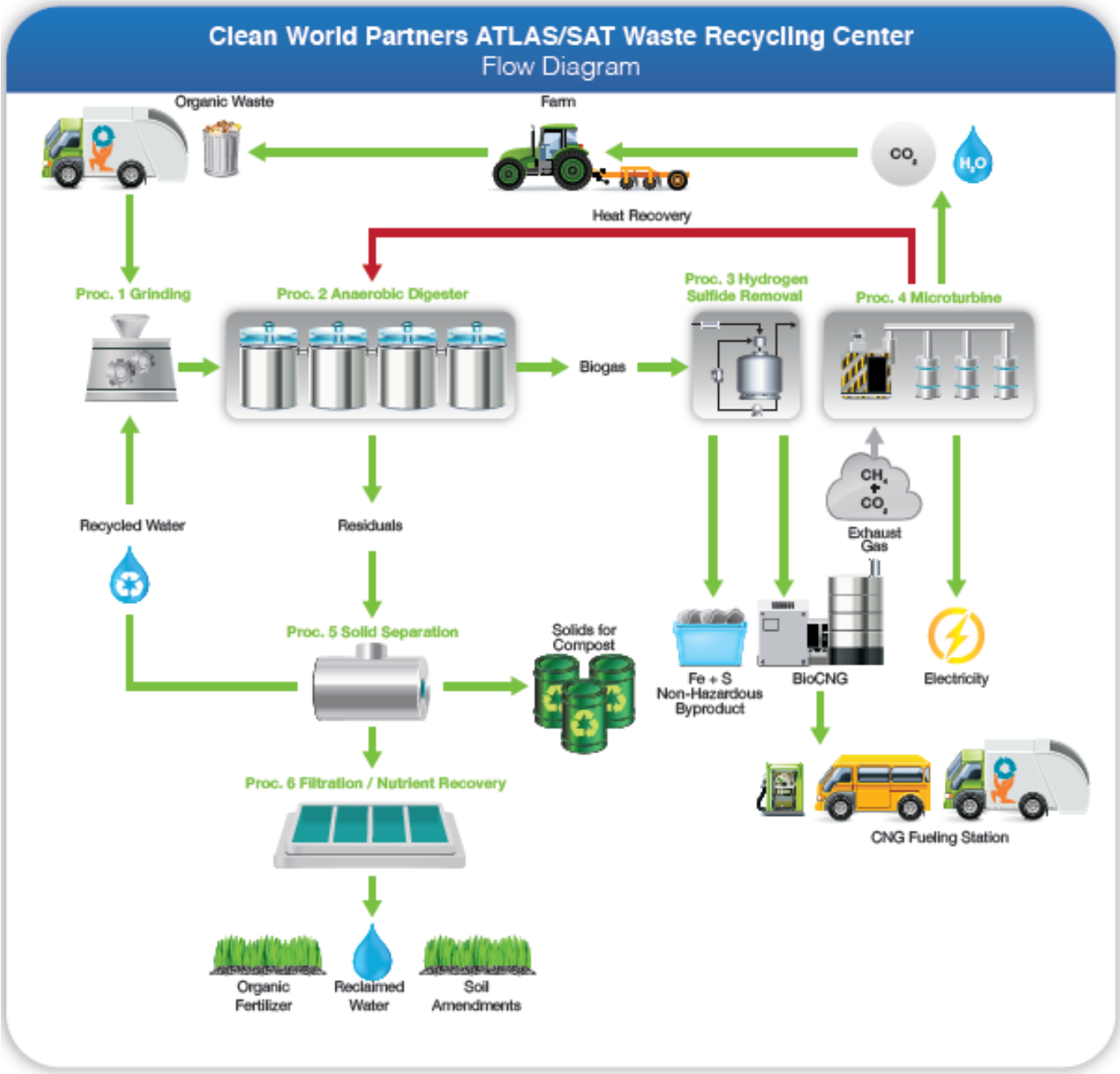
Additionally, the system's exceptionally low parasitic load increases system efficiency in comparison with traditional, power-hungry, high-liquid AD systems. The Anaerobic Phased Solids Digester operates at a thermophilic temperature (125-130ºF) and destroys pathogens in the waste, making the residual materials safe for use as compost and organic soil amendment products. It has proven to be both reliable and stable at the pilot level for converting organic wastes to biogas. Once the source-separated food and waste is introduced into the hydrolysis reactors, the feed material is acted on by hydrolytic and acidogenic bacteria, liquefied, and then converted to simple organic acids. At the time of this conversion, the material releases hydrogen and carbon dioxide as gaseous products. The organic acids are transferred to the bio-gasification reactor, where they are further converted into biogas by methanogenic organisms. The resulting biogas is a flammable mixture of methane, hydrogen, and carbon dioxide. Multiple hydrolysis tanks enable sequential feedstock loading so that each reactor is at a different stage of acidogenesis. The combined organic acids fed into the bio-gasification reactor are maintained at relatively constant levels, contributing to a steady biogas production rate in the bio-gasification reactor despite a staggered batch-loading schedule. To maximize

biogas yields and achieve optimum microorganism growth—especially of methanogenic bacteria—special measures are taken to ensure optimum nutrient levels and environmental conditions within the digesters.

Biofuel Production and Distribution

The waste industry has been moving toward the use of CNG vehicles for its operations to reduce costs and build a greener business model. Atlas Disposal is a leader in this transition to cleaner vehicles, has converted half of its fleet from diesel to CNG, and will convert its entire fleet over the next 24 months. Many waste operators currently operate their own CNG fleets but have to travel long distances to obtain CNG fuel. The SBR1 system provides a replicable, closed-loop solution to waste haulers by digesting the collected organic waste, creating biogas that is upgraded to renewable CNG, and innovatively implementing a combined heat and power system that uses exhaust gas to generate electricity.

Figure 2: Process Flow Diagram



Source: Atlas ReFuel

As shown in Figure 2, The SBR1 Renewable Compressed Natural Gas Fueling Station is part of an integrated commercial-scale waste to energy facility. Anaerobic digestion converts organic waste to biogas, which is then refined by a biogas upgrading system to RNG. RNG is stored in tanks and dispensed to vehicles by the fueling station. Atlas ReFuel solely owns and operates the fueling station.

At SBR1, biogas produced during the AD process passes through a BioCNG system designed to handle biogas at a flow rate of 7,200 standard cubic feet per day (Figure 2). This system

consists of moisture and hydrogen-sulfide removal sub-systems, a compression and dehydration sub-system, and a membrane-mediated carbon dioxide removal sub-system (See Figure 2; Unit Processes #4 and #5). The effective removal of contaminants from the biogas is essential to meet natural gas vehicle specifications. This project also utilizes waste gas to generate the electricity needed to run the system. The resulting biomethane stream comprises at least 90 percent methane (although typically the membrane produces gas with more than 98 percent methane) and ≤ 0.3 percent carbon dioxide. It also meets the gas quality requirements of Society of Automotive Engineers J1616 Recommended Practices for Compressed Natural Gas Vehicle Fuel. To comply with National Fire Protection Association standards for properties of natural gas as a transportation fuel, biomethane is odorized.

The methane that is not recovered as fuel by the BioCNG system is piped as part of the BioCNG exhaust gas to a chiller/compressor skid that feeds the waste gas into a 65 kW micro-turbine and a supplementary 250-killowatt FlexEnergy Powerstation™ (Figure 2; Unit Process #8). The FlexEnergy Powerstation's thermal oxidizer combined with a microturbine is capable of accepting the low-pressure, low-British thermal unit exhaust gas. At full capacity, the two generators produce 7,560 kilowatt hours per day of electricity, which is enough to cover the entire parasitic load of the AD system and the energy needs of the fueling station.

In Unit Process No. 5 (Figure 2), the clean biomethane is introduced into the Atlas ReFuel fueling facility, which was designed and built by Clean Energy, Inc.

Barriers to Deployment of RNG Infrastructure

Major barriers exist to the widespread deployment of alternative fuel vehicles, in particular for fleets utilizing natural gas vehicles that would like to use renewable natural gas. The Atlas ReFuel Fueling Station project examines or addresses these barriers, as shown in Table 1.

Table 1: Market and Technology Barriers to RNG Fueling

Barrier	Atlas ReFuel Response
Market Barriers: lack of knowledge about the benefits and safety of RNG and a pathway to adoption; undefined pricing and delivery models, as well as a clear understanding of supply and demand for RNG as a transportation fuel.	Through direct meetings, public outreach and an ambitious media and press campaign, Atlas significantly increased knowledge about safety and benefits of RNG; defined a reasonable price for RNG attractive to market partners; and developed a constituency of fleet and consumer partners seeking RNG as a fuel solution.
Policy Barriers: lack of federal tax credit for RNG that is injected into the pipeline or used as transportation fuel; resistance from utilities to injection of RNG into pipelines; lack of clear definition of the value RNG has within the LCFS framework.	Atlas and project partner CleanWorld successfully utilized the LCFS process to produce additional revenues for a negative-carbon intensity transportation fuel. Atlas also worked with state regulators to properly permit the state's first commercial-scale RNG fueling facility.
Technology Barriers: lack of RNG fuel sampling and testing data showing that RNG meets NG engine specifications; lack of demonstrated technology to integrate CNG, RNG and nominated RNG.	Atlas and CleanWorld have adopted a stringent sampling and testing protocol in keeping with state and federal regulations for engine specifications, and demonstrated successful utilization of RNG in real-world applications through the fueling of its own vehicles with RNG for the past 12 months.

Source: Atlas ReFuel

Need for Project Funding and Funding Sources

As the Atlas ReFuel fueling station represented a truly innovative and transformational project to produce negative-carbon RNG at commercial scale, Atlas requested support from the California Energy Commission to fund a portion of the added cost represented by creating this first-in-California system. Funds from the California Energy Commission were critical in assisting Atlas ReFuel to demonstrate the feasibility of the above innovative technologies, reducing risk and setting the stage for the larger private investment needed to commercialize RNG facilities and infrastructure statewide.

The project received funding from the California Energy Commission towards the purchase of equipment through an award of $300,000. The total cost of the SBR1 Fueling Station was $2,500,000. Atlas Disposal Industries / Atlas Refuel provided the balance of the investment.

CHAPTER 2: Implementation

Design and Construction of the Fueling Facility

Design of the SBR1 fueling facility began in May 2012 with a final site layout and construction plans. In June 2012, Atlas ReFuel was created as a wholly owned subsidiary of Atlas Disposal Services. Atlas ReFuel owns and operates the SBR1 fueling facilities and is responsible for all management functions. Approval to proceed with construction was received in September 2012 (Figures 3 and 4).

Figure 3: Atlas ReFuel station site, September 2012

Source: Atlas ReFuel

Figure 4: Construction of the SBR1 Fueling Facility

Source: Atlas ReFuel

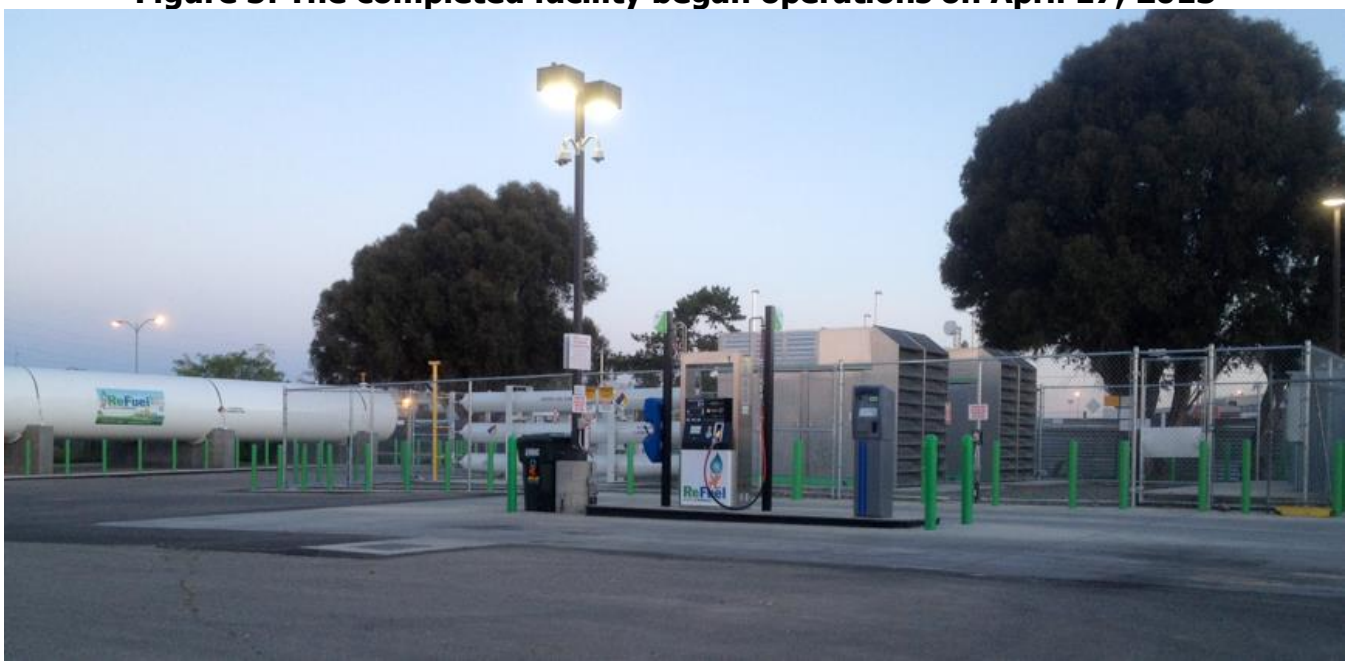
Biogas produced by the AD system is conditioned and upgraded to biomethane—otherwise known as renewable natural gas—using a biogas system designed and built by BioCNG, LLC. BioCNG completed assembly and testing onsite in April 2013. The final facility component is the actual vehicle fueling system, which includes compression, storage, and fuel dispensers. It was designed and built by Clean Energy, LLC, and was also completed in April 2013.

Table 2: Milestones in the construction and operation of the Atlas Refuel CNG/RNG fueling station

Milestone	Date	Description
Fuel station design	May 2012	Final site layout and construction plans complete
Approval to proceed with construction	September 2012	Written notice to construct
Construction started	December 2012	Project moves to active construction. Poured slabs, foundations; laid underground electrical.
Atlas ReFuel	June 2012	Atlas ReFuel is created as a wholly owned subsidiary of Atlas Disposal Services
Fuel station operations begin	April 17, 2013	Opening ceremony. Station is operational and begins fueling AD onsite RNG and CNG.
Nominated RNG	January 2014	Line-drawn nominated RNG available for fueling in addition to AD RNG and CNG
Ramp up period	May 2013 to July 2013	Initial two-month period of ramp up, system testing, and optimization
SBR1 Phase 2 completed	July 2013	AD system capacity increased 20 to 100 tons per day (tpd) of waste
Demonstration period	July 2013 onward	12-month demonstration period of station operation and data collection

Source: Atlas ReFuel

Figure 5: The completed facility began operations on April 17, 2013



Source: Atlas ReFuel

The first fuel dispensed was on April 17, 2013 and the station has been continuously in operation since that date (Figure 5). The station is open 7 days a week and has appointment-based filling and priority use available 24 hours a day. This eliminates extra wait times and labor costs for NG fleet managers. In addition, real-time 'Open Pump' notification on pump availability is available via multiple channels, including web, text, email, and Twitter.

Atlas ReFuel is also tied to pipeline natural gas delivered 24/7 via the Clean Energy national natural gas pipeline infrastructure. In January 2014, contracting with Clean Energy was completed for delivery through the pipeline of their nominated RNG product (Redeem, an RNG product derived mostly from landfill gas capture). Based on the technology put in place by BioCNG, the Atlas ReFuel project became a demonstration site for a fueling station that integrates AD RNG with line-drawn CNG and line-drawn RNG.

The initial two weeks dispensing fuel in April 2013 occurred at a slower pace as work proceeded to get all systems functioning together. In May, Atlas ReFuel began the project's 2-month ramp-up and system-optimization period. A year-long ramp up, optimization, data collection and demonstration period began in July 2013.

Outreach and Public Awareness

Atlas ReFuel has ambitiously sought to provide outreach and training on the benefits of natural gas vehicles, and the specific benefits of waste to energy production of renewable natural gas. To this end, Atlas ReFuel developed a communications strategy based on public media sources and has widely marketed the SBR1 facility and the new fueling station (Figure 6).

Figure 6: Atlas Recycling and Atlas ReFuel's Branded Fleet Vehicles

Source: Atlas ReFuel

As an illustration of Atlas ReFuel's public outreach activities, Atlas formed strategic partnerships with the City of Sacramento, the Green Restaurant Alliance, and the Clean Cities Coalition. With these partners, Atlas ReFuel leveraged Sacramento's first annual "Farm to Fork" festival to become the "Farm to Fork to Fuel" festival. Weeks of publicity surrounding the festival increased public awareness of the entire farm-to-table-to-food-waste-to-energy closed loop. As a festival kickoff, Atlas ReFuel hosted an onsite Open House with various speakers, including City Council member Kevin McCarty. Approximately 150 stakeholders attended and toured the SBR1 site and fueling station.

Media examples, among many, include:

- NGV Today. September 2, 2013. Fuel from farm and forks: Follow Sacramento as it paves a biogas path to sustainable transportation. http://atlasdisposal.com.previewdns.com/wp-content/uploads/2014/03/Natural-Gas-Vehicle-Markets-NGV_2013-09-02.pdf
- CBS Sacramento: Channel 13. September 13, 2013. Food Becoming Fuel for Sacramento Trucks and Street Sweepers. http://sacramento.cbslocal.com/2013/09/13/food-becoming-fuel-for-sacramento-city-trucks-street-sweepers/
- Government Fleet. July 2013. Sacramento to Fuel Refuse Vehicles with Renewable Natural Gas. http://www.government-fleet.com/channel/green-fleet/news/story/2013/07/sacramento-to-fuel-refuse-vehicles-with-renewable-natural-gas.aspx.
- Energy Vision. Sacramento: the first city to refuel on food waste. http://energy-vision.org/wordpress/wp-content/uploads/2012/05/EV-Recognizes-Sacramento-Waste-to-Fuel-Project.pdf

Description of Fleets Served

Atlas ReFuel ***exceeded its projected fleet service numbers***. Atlas projected that its RNG/CNG facility would serve 67 fleet-operated vehicles in Year One, growing to approximately 131 fleet operated vehicles by 2016. As of April 2014, Atlas ReFuel **serves a total of 112 fleet-operated vehicles.** These service numbers compare favorably to a recent California Air Resources Board (CARB) study that showed that each California station could currently serve 114 vehicles on average, increasing to 119 in 2013, assuming additional CNG vehicle sales and an estimated 32 new CNG fueling stations[1].

Since beginning operations in April 2013, Atlas ReFuel has steadily grown its base of fleet customers. As of April 2014, nine months into the initial year-long operation and data collection period, Atlas ReFuel has 8 major fleet customers: Clean Energy, Atlas Disposal Services, California State University, Sacramento, City of Sacramento, Mission Linen, Paladin

[1] California Air Resources Board, *Status of Alternative Fuel Infrastructure for Non-ZEV Alternative Fuel Vehicles*, Appendix C, page C-2, 2011.

Security, Republic Services, and the Sacramento Unified School District (Table 2). Atlas Disposal Services began fueling at the station from the first days of operation and is the single largest fuel user. Paladin Security began fueling 40 of its CNG Ford Crown Victoria fleet in May 2013.

In the first quarter of 2014, four new fleets began utilizing the station. California State University, Sacramento fuels its Express Shuttle Buses and the City of Sacramento fuels its newly purchased Department of Public Works natural gas refuse trucks and road sweepers. In March of 2014, Mission Linen was added as a fleet customer for delivery trucks, including its 12-liter tractor trailer, and the Sacramento Unified School District began fueling its CNG school buses. Most recently, Republic Services, a waste and recycling company, began fueling its refuse trucks at Atlas ReFuel. Vehicle types include refuse trucks, sweeper trucks, shuttle buses and full-size school buses, automobiles, small vans, a large delivery van, and a 12-liter tractor trailer. Most engines are made by Cummins Westport.

Table 3: Major fleet customers utilizing Atlas ReFuel as of April 2014

Fleet	Type of Vehicle; Manufacturer	No. of Vehicles Served
Atlas Disposal Services	Refuse truck; Autocar Rear Loader; Cummins ISLG engine	20
Clean Energy	Van; Ford F350	2
Paladin Security	Auto; Ford Crown Victoria	40
California State University, Sacramento	Express Shuttle Bus	4
City of Sacramento, Public Works	Refuse truck; Sweeper truck; Autocar Rear Loaders; Freightliner Elgin Broom Sweepers	14
Mission Linen	12-L Tractor Trailer; Delivery van	2
Republic Waste Services	Refuse truck	16
Sacramento Unified School District	School bus	14
Total		**112**

Source: Atlas ReFuel

Usage data was analyzed for March and April 2014. These months were chosen as sample months representative of current throughput and operations. During the 31 days of March, there were 7 fleet customers using the fueling station for a total of 820 separate fuel stops. The station is open 24 hours a day, 7 days a week; therefore, on average March had 26.5 fuel stops per day (820/31). In April, 8 fleet customers used the station for a total of 1142 separate fuel stops. On average, April had 38 fueling events per day (1142/30). **Averages show that about 24 to 26 gallons (GGE) is dispensed per fuel stop.**

Table 4: Operations and Usage: March – April 2014

Month	Number of vehicles	Total number fuel stops	Average fuel stops per day	Averaged gallons per fuel stop
March 2014	96	820	26.5	26.2
April 2014	112	1122*	37	24.6

Table Note: *Incomplete data last week of April, estimated total

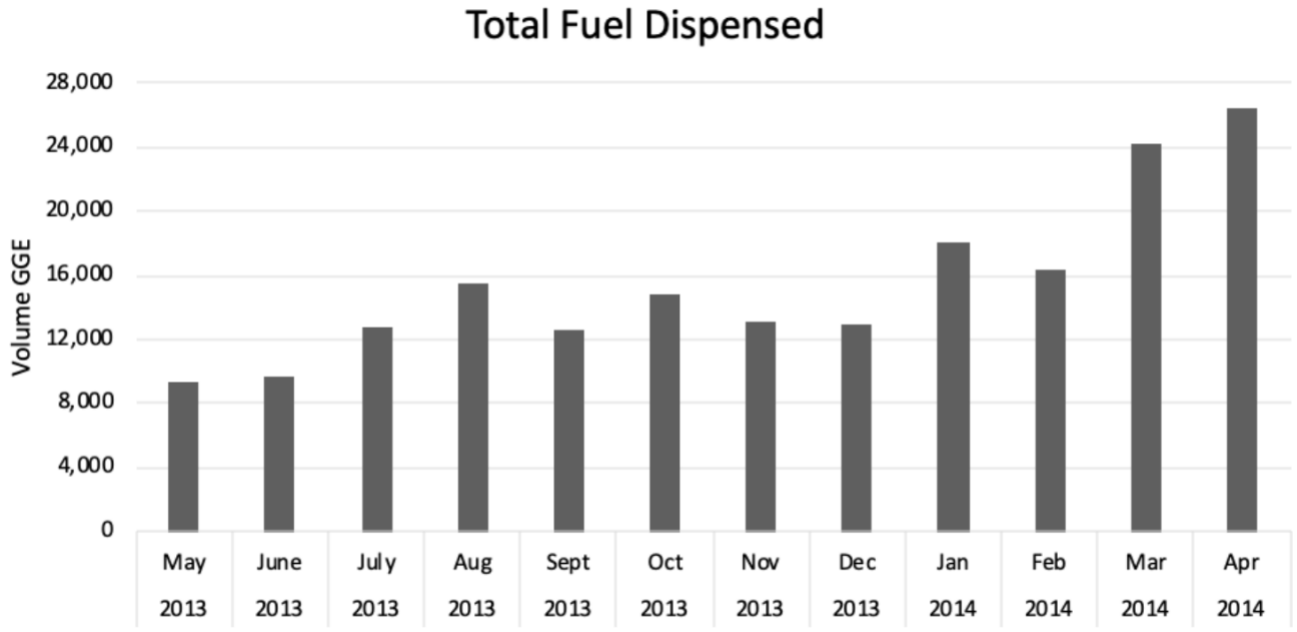
Source: Atlas ReFuel

CHAPTER 3:
RNG Fueling and Petroleum Displacement

Fuel Dispensed

The volume of RNG/CNG dispensed since the fueling station opened mid-April 2013 has a very positive trend and has steadily increased (see Figure 7 and see Appendix A). In 2014, Atlas ReFuel dispensed over 16,000 gasoline gallon equivalents (GGEs) each month.

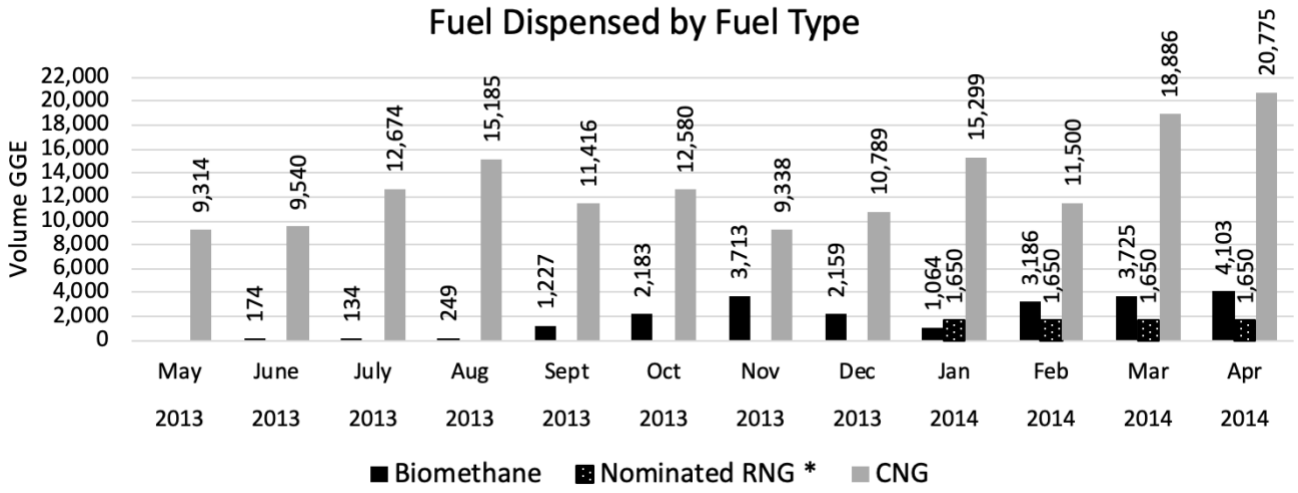
Figure 7: Volume of total monthly Gasoline Gallon Equivalents dispensed



Source: Atlas ReFuel

Nominated RNG, a renewable natural gas product from Clean Energy, was added to the fuel mix delivered by Atlas ReFuel in January 2014 (Figure 8). The nominated RNG is produced from landfill gas or dairy digesters and delivered by pipeline to the Atlas fueling station. The fueling station incorporates a novel biogas refining technology from BioCNG LLC that supports the flexible blending of onsite RNG with pipeline-drawn natural gas and nominated RNG. **During January through April of 2014, 28.10 percent of fuel dispensed was a RNG product, and 19 percent of fuel dispensed was biomethane RNG produced on-site by the SBR1 anaerobic digestion system**.

Figure 8: Volume of Monthly Gasoline Gallon Equivalents Dispensed by Fuel Type
CNG, Biomethane RNG from SBR1, and nominated RNG.



Source: Atlas ReFuel

Fuel Sampling and Testing

Biogas resulting from the AD process has to be refined using a biogas upgrading system. It consists of 30 – 50 percent methane, ~40 percent carbon dioxide and a mix of nitrogen, oxygen, hydrogen sulfide, and siloxanes. Hydrogen sulfide results from the bacterial anaerobic digestion process. Siloxanes are widely used in industrial materials and can be a residual constituent. Hydrogen sulfide and siloxanes are undesirable impurities in RNG.

The Atlas ReFuel Fueling Station uses the BioCNG patented biogas cleaning and conditioning system to convert biogas to biomethane. Biomethane, or RNG, is the near chemical equivalent of pipeline natural gas. Atlas ReFuel conducts rigorous gas composition analysis. Fuel is tested compared to Cummins Westport fuel specifications, based on standards issued by the Society of Automotive Engineers J1616 Recommended Practices for Compressed Natural Gas Vehicle Fuel and the American Society for Testing and Materials International standard, ASTM 40.

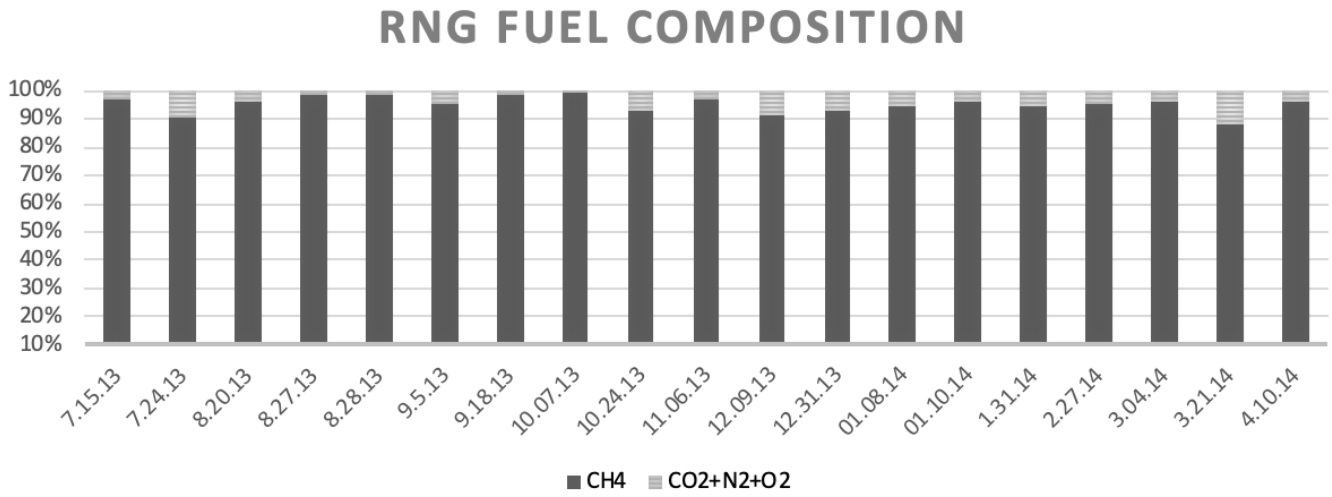
Table 5: RNG fuel composition (Fremont Analytical, ND is non-detectable)

Constituent	Allowable Limit	Range of Values	Most Recent Measurement 4/10/2014
CH4	>90%	92-95%	96.30%
CO2 + N2 + O2	<10%	3-5%	3.72%
H2S	<6,000 ppb	ND ppb	ND ppb
Siloxanes	<3,000 ppb	ND – 1320 ppb	290.41 ppb

Source: Atlas ReFuel

Fuel constituent test results for an 8-month period from mid-July 2013 to mid-April 2014 are shown in Table 5. Tests were performed using a Cummins Engine, Specification Range 20067. Methane content is well above the accepted minimum. Test results show very low levels of all undesirable constituents (Figure 9).

Figure 9: Fuel composition by test date from July 2013 to April 2014 shows an overall average of 95.25% CH4 (methane)



Source: Atlas ReFuel

Greenhouse Gas Emission Reduction

The environmental attributes of RNG are superior not only to fossil-based fuels but also to all other alternative fuels: it has the lowest carbon intensity of any commercially available fuel. Notably, a vehicle running on RNG generates 1/2 to 1/3 the emissions of an all-electric vehicle based on California Air Resources Board wells-to-wheels analyses. Life cycle analysis for RNG for high solids anaerobic digestion facilities was completed by CARB in 2012 using CARB's GREET 1.8 model. CARB concluded that RNG vehicle fuel produced by anaerobic digestion of food waste represents net-negative greenhouse gas emissions[2]. CARB's final approved summary of greenhouse gas (GHG) emissions and proposed high solids anaerobic digestion pathway carbon intensity value is -15.29 grams of carbon dioxide equivalent per megajoule.

[2] California Air Resources Board, April 2012. "Staff Report: Proposed Low Carbon Fuel Standard Pathway for the Production of Biomethane from High Solids Anaerobic Digestion of Organic Food and Green Wastes," Stationary Source Division, Fuels Evaluation Section. April 2012.

Table 6: Carbon Intensity values for fossil-based fuels vs. the CNG, RNG and nominated RNG[3]

Fuel	Pathway	Pathway Description	Carbon Intensity gCO2e / MJ
Diesel	ULSD001	ULSD - based on average crude oil supplied to California refineries and average California refinery efficiencies	98.03
CARBOB	CBOB001	CARBOB - based on average crude oil supplied to California refineries and average California refinery efficiencies	99.18
Compressed Natural Gas	CNG002	North American NG delivered via pipeline; compressed in CA	68
	CNG003	Landfill gas (bio-methane) cleaned up to pipeline quality NG; compressed in CA (Nominated RNG)	11.26
Biomethane	RNG	Biomethane produced from the high-solids (greater than 15 percent total solids) anaerobic digestion of food and green wastes.	-15.29

Source: Atlas ReFuel based on ARB LCFS LookUp Table

Analysis of fuels dispensed from January through April 2014, using the CARB-approved Carbon Intensities shows a total carbon offset reduction of 476 metric tons of carbon dioxide equivalent. Biomethane RNG, 12,078 GGEs in 2014, displaced 166 metric tons of carbon dioxide equivalent compared to its diesel fuel equivalent. Line-drawn nominated RNG, 6600 GGEs in 2014, displaced 69 metric tons of carbon dioxide equivalent compared to its diesel fuel equivalent. And line-drawn compressed natural gas, CNG, 66,460 GGEs, displaced 241 metric tons of carbon dioxide equivalent compared to its diesel fuel equivalent.

It is important to note that the RNG component of fuel dispensed provided almost half (49.35 percent) of the GHG emission reductions although it was 28 percent of the total natural gas dispensed.

3 California Air Resources Board (CARB) website: Carbon Intensity Lookup Table for Gasoline, Diesel and Fuels that Substitute. Carbon Intensity from Registered Biofuels Facilities. http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

CHAPTER 4:
Project Benefits and Summary

The SBR1 Renewable Compressed Natural Gas Fueling Station met all proposed goals and objectives. SBR1 and Atlas ReFuel successfully demonstrate an integrated commercial-scale waste to energy facility that produces and sells renewable natural gas. Importantly, it demonstrates the feasibility and economic viability of innovative technologies, reducing risk and setting the stage for the larger private investment needed to commercialize RNG facilities and improve natural gas delivery infrastructure statewide.

With the success of BioCNG's technology for small-scale RNG refining from digester biogas, the use of mid-sized systems to generate renewable transportation fuels will allow for smaller AD plants than previously available to develop RNG stations for community use. This widens the availability of CNG for consumers who wish to purchase CNG vehicles to reduce fossil fuel dependence and the environmental impacts of their vehicles. Proving the technical and financial feasibility of this technology in a high-profile setting, such as Sacramento and the county-owned waste transfer station site that houses the SBR1 facility, bolsters the rate of adoption at future locations.

The effective integration of AD RNG, pipeline CNG, and pipeline RNG was a significant technological accomplishment, as well as an important demonstration of environmental benefits. For the period January to April 2014, more than 28 percent of fuel dispensed by Atlas ReFuel was RNG. CARB's completion of a low-carbon fuel standard pathway for AD biomethane assigned AD RNG a negative carbon intensity value of -15.29 grams of carbon dioxide equivalent per megajoule. This exceptionally low carbon intensity value means that the use of AD RNG as a vehicle fuel actually sequesters carbon dioxide rather than increasing its content in the atmosphere. For this same period, fuels dispensed by Atlas offset 476 metric tons of carbon dioxide equivalent compared to the diesel fuel it displaced. It is very important for GHG emission reduction efforts by the State of California (per AB32) to increase the amount of *ultra-low-carbon* fuels used in transportation. This is illustrated by the fact that the RNG component of fuel dispensed provided almost half (49.35%) of the GHG emission reductions achieved, although it comprised only 28% of the natural gas dispensed.

The SBR1 and Atlas Refuel site has improved acceptance of RNG use by natural gas fleet owners and operators. Fleet owners, who may lack knowledge about the benefits and safety of RNG for their vehicles, have a proven RNG/CNG dispensing facility with a strong track record of fuel constituent sampling and testing. Seven months of sample data show consistently high levels of methane content, negligible undesirable constituents, and fuels that meet the recognized standards of the Cummins Westport engine specifications. The steady growth in fleet customers from a single fleet (Atlas Disposal Services) when the station opened to eight government and industrial fleets, demonstrates both the demand for CNG/RNG and assists in understanding pricing and delivery models.

GLOSSARY

ANAEROBIC DIGESTION (AD)—A biological process in which biodegradable organic matters are broken down by bacteria into biogas, which consists of methane (CH4), carbon dioxide (CO2), and other trace amount of gases. The biogas can be used to generate heat and electricity.

CALIFORNIA AIR RESOURCES BOARD (CARB)—The "clean air agency" in the government of California, whose main goals include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.

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 EQUIVALENTS (GGEs)—Is 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 GAS (GHG)—Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

RENEWABLE NATURAL GAS (RNG)—Renewable natural gas (RNG) is any pipeline compatible gaseous fuel derived from biogenic or other renewable sources that has lower lifecycle CO2e emissions than geological natural gas.[4]

[4] American Gas Association. https://www.aga.org/natural-gas/renewable/

APPENDIX A

Table A1: Volume of monthly Gasoline Gallon Equivalents (GGEs) dispensed by Atlas ReFuel by type of natural gas: AD RNG, nominated RNG, and CNG

	2013								2014				
Volume GGEs	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**Total**
RNG Biomethane		174	134	249	1,227	2,183	3,713	2,159	1,064	3,156	3,725	4,130	21,916
RNG Nominated*									1,650	1,650	1,650	1,650	6,600
CNG	9,314	9,541	12,674	15,185	11,416	12,580	9,338	10,789	15,299	11,500	18,886	20,775	136,521
Total	9,314	9,714	12,808	15,434	12,643	14,763	13,050	12,948	16,363	14,686	22,611	26,528	154,334

Table Note: * Nominated RNG is renewable natural gas delivered by pipeline from Clean Energy. (It has since been relabeled as "Redeem"). Clean Energy's RNG product is derived from landfill gas or dairy digesters. The amounts shown are approximate, since totals are provided quarterly. In the first quarter of 2014, Atlas ReFuel pumped approximately 5,000 GGE of nominated RNG.