California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

SoCal Biomethane Anaerobic Digester Upgrade and Renewable Natural Gas Production Expansion Project

Prepared for: **California Energy Commission**

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Technology partner Anaergia provided critical engineering and design for the project, including integration of the proposed equipment within Victor Valley Wastewater Reclamation Authority's overall facility.

SoCal Biomethane also thanks the student and community groups that have toured the project sites and hopes that what they learned inspires them to create ambitious low-carbon projects of their own.

PREFACE

Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007), created the Clean Transportation 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, clean air, and alternative energy policies. Assembly Bill 126 (Reyes, Chapter 319, Statutes of 2023) reauthorized the funding program through July 1, 2035. The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Develop and deploy zero-emission technology and fuels in the marketplace.
- Produce alternative and renewable low-carbon fuels in California.
- Deploy zero-emission fueling infrastructure, fueling stations, and equipment.
- 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 released a grant funding opportunity (GFO-20-608) entitled "Ultra-Low-Carbon Fuel: Commercial-Scale Production Facilities & Blending Infrastructure" on April 12, 2021. This competitive grant solicitation was an offer to fund ultra-low-carbon transportation fuel in two funding categories: commercial-scale production facilities and blending infrastructure at new and existing advanced fuel production or fuel blending facilities. Existing fuel production and fuel blending facilities must expand or modify facilities to increase production or blending capacity. In response to GFO-20-608, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on November 5, 2021, and the agreement was executed as ARV-21-052 on April 28, 2022.

ABSTRACT

Southern California Biomethane, LCC in partnership with Victor Valley Wastewater Reclamation Authority, Anaergia Services, LLC, and Momentum, completed an Anaerobic Digester Upgrade and Renewable Natural Gas Production Expansion Project in November 2023 at the Victor Valley Wastewater Reclamation Authority plant in Victorville, CA. The project, funded by a CEC "Ultra-Low-Carbon Fuel: Commercial-Scale Production Facilities & Blending Infrastructure" grant, substantially increased organic and food waste handling and digester throughput capacity, and carbon-negative renewable natural gas production at the facility. This was accomplished by upgrading existing anaerobic digester tanks, installing new mixers, a new food storage tank, and a new thickener, and expanding and adding resiliency to the existing gas treatment and renewable natural gas compression equipment. The renewable natural gas is being sold to Southwest Gas, which in turn sells the product for transportation fuel to its network of end users, displacing gas and diesel, reducing emissions of carbon dioxide, nitrous oxides, and other pollutants.

Keywords: Anaerobic digester, biogas, biomethane, LCFS, low carbon fuel standard, pipeline interconnection, RFS, renewable fuel standard, renewable natural gas, RNG.

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EXECUTIVE SUMMARY

Landfills are the largest point sources of methane emissions in California.[1] To showcase a solution, the Anaerobic Digester Upgrade and Renewable Natural Gas Production Expansion Project is effectively recycling organic waste and helping California meet its net-zero greenhouse gas emissions goals. In response to California Senate Bill 1383, which mandates methane emission reductions, this project diverts organics from landfills while generating renewable, low-carbon natural gas.

SoCal Biomethane, in partnership with Victor Valley Wastewater Authority (VVWRA), Anaergia Services, LLC, and Momentum, completed an upgrade to VVWRA's existing anaerobic digester and biogas system to increase digestion of a combination of municipal sludge generated at the wastewater treatment plant (WWTP) and liquid organic waste streams including liquid food wastes and fats, oils, and grease. The project increased digester throughput capacity, and more than doubled carbon-negative, 100% renewable natural gas (RNG) production from biomethane through high solids digestion. The RNG is being sold to Southwest Gas, which sells the product RNG for use as transportation fuel to its network of end users.

SoCal Biomethane achieved the RNG production increase by improving, expanding, and refurbishing the existing, on-site organic waste reception equipment, without constructing new digester tanks. New equipment was installed to increase digester throughput and improve resiliency of the existing gas treatment and RNG compression equipment. The existing anaerobic digester tank was upgraded, and a new mixer, food storage tank, and thickener were installed. Project construction was completed in November 2023.

The project was funded by a CEC "Ultra-Low-Carbon Fuel: Commercial-Scale Production Facilities & Blending Infrastructure" grant. The VVWRA facility is the first wastewater treatment plant in California to inject renewable natural gas made from wastewater solids and food waste into a utility (Southwest Gas) pipeline. The project greatly expanded ultra-low carbon fuel availability in the greater vicinity of the VVWRA plant, displacing gas and diesel used for transportation, thereby reducing emissions of carbon dioxide (CO_2), nitrous oxides (NO_x), particulate matter ($PM_{2.5}$), and other pollutants. The project will also result in reduced emissions of toxic air contaminants by diesel trucks, providing health benefits, including reduced pollution burdens relevant to asthma and cardiovascular disease. This is benefitting the health of disadvantaged communities in the Los Angeles and Inland Empire regions, which are suffering from high levels of pollution burden.

The project, located in a low-income and disadvantaged community in Victorville, California, supported five full-time construction jobs and four permanent on-site jobs. SoCal Biomethane also offered educational tours to numerous school and community groups to promote understanding of renewable energy and waste management technologies.

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[1] Bourguet, Elizabeth, 2020, "'super-emitters' in California: The few facilities with outsize methane emissions", Yale Environment Review. https://environment-review.yale.edu/super-emitters-california-few-facilities-outsize-methane-emissions.

The anaerobic digester and RNG production technology is prime for replication by medium to large scale wastewater treatment plants where sufficient volumes of food waste or other organic waste are also available in proximity. In California, an estimated 200 wastewater treatment plants have sufficient capacity to support a similar system. Of those facilities, SoCal Biomethane estimates that at least 80 plants have available digester capacity and regionally available organic waste that could be used to enhance the production of biogas on site.

Chapter 1: Background

Problem Statement and Project Need

Every year, California landfills nearly six million tons of organic and food waste. In response, the state has approved stringent requirements for organic waste management, targeting recycling by municipal waste managers and businesses that generate organic waste. Unfortunately, existing organic and food waste infrastructure is insufficient to manage the targeted amount of waste without landfilling.

The state of California has established ambitious greenhouse gas (GHG) reduction targets, including achieving net-zero emissions by 2045. One of the leading sources of in-state GHG emissions results from the emission of methane from landfills, arising from the decomposition of organic matter in landfills. To minimize methane emissions, California passed Senate Bill 1383, which mandates the reduction of methane emissions in the state.

Food waste co-digestion enables carbon negative biomethane production, beneficially reusing organic waste, achieving net-zero emissions, and offering financial benefits to municipal wastewater treatment plants. There are 156 wastewater treatment plants in California that have some amount of available capacity for co-digestion, which greatly increases biogas generation.

VVWRA initiated co-digestion on site in 2013. Upgrades of VVWRA's digester and biogas upgrading system were needed to further increase organic and food waste handling capacity and renewable natural gas production. More generally, economically beneficial solutions to manage large volumes of food and organic waste are needed to support further advancement of state goals for both waste management and renewable fuels production across California. SoCal Biomethane offers critical in-state infrastructure that enables the diversion of organics from landfills while also generating carbon-negative renewable energy.

Recipient Background: SoCal Biomethane

SoCal Biomethane, LLC is a wholly-owned and operated subsidiary of Anaergia Services, LLC, which was formed for the specific purpose of constructing and operating the project. As such, SoCal Biomethane is initially funded and entirely staffed by parent company Anaergia.

Anaergia successfully led the completion of VVWRA's first high solids digester built in 2013. SoCal Biomethane began operating in 2021 and has been injecting carbon-negative biomethane into Southwest Gas' distribution service area since 2022. Anaergia delivered this Anaerobic Digester Upgrade and RNG Production Expansion project through a design, build, own, operate, and finance model.

Anaergia boasts extensive experience in the wastewater and renewable energy industry, having deployed over 1,700 projects totaling 380 megawatts of renewable power production capacity during 20 years of experience globally. Anaergia's California qualifications include five major projects, totaling 15 megawatts of renewable power generation capacity, with full capacity of diverting up to half a million tons per year of municipal waste from landfills. Anaergia is also a leader in the development and deployment of innovative new technologies aimed at sustainably managing wastewater and solid waste.

In addition to its leadership in biogas and RNG, Anaergia has internally developed an impressive portfolio of mature and maturing wastewater and food waste management technologies. These include digester retrofit enhancement equipment that allows co-digestion of biosolids and other feedstocks while increasing digester capacity and throughput without increasing physical size (deployed previously at VVWRA), organics pre-treatment systems to separate difficult-to-remove contaminants from incoming food waste and other organic wastes, and organic extrusion systems that extract 90% of organic fractions from municipal solid waste.

Anaergia, with support from other members of the project team and funding support from the CEC and other agencies, is combining these advanced technologies with commercially available biogas upgrading systems across California. Anaergia's end goal is to transform existing low-value end use waste streams and flared biogas into RNG and bioenergy that will reduce California's transportation fuel carbon footprint and drive full utilization of California's waste biomass resources.

Project Partners

Victor Valley Wastewater Reclamation Authority (VVWRA)

The Victor Valley Wastewater Reclamation Authority serves an extensive 279 square mile service area that includes Victorville, Apple Valley, Hesperia, Spring Valley Lake, and Oro Grande. As the sole wastewater treatment provider and recycler for these communities, VVWRA's existing wastewater reclamation facility—located outside of Victorville, California, treats and reclaims about 10.7 million gallons of wastewater every single day. Wastewater treated at its facility is discharged to the Mojave River, where it supports groundwater recharge. VVWRA is a regional leader in the deployment of advanced biogas production technologies and environmental stewardship in the Inland Empire, as they continue to develop additional on-site biogas production streams and efficiency to support renewable energy and renewable fuels development in the Inland Empire.

Southwest Gas Corporation

Founded in 1931, Southwest Gas Corporation (Southwest Gas) is a subsidiary of Southwest Gas Holdings Inc. The company provides natural gas service to more than 2 million customers in the desert Southwest, including Arizona, Nevada, and portions of California. The company serves its customers with both residential and commercial utility connections in its service area. In California specifically, the company strongly supports the development and deployment of clean vehicle fleets that rely on compressed natural gas (CNG) and/or RNG for operation. This project provides high-demand RNG for use as a vehicle in the company's existing distribution lines across California.

Momentum

Momentum is an independent grant services consulting firm with nearly two decades of experience developing and administrating grant funding awards for organizations working to deploy transformative energy, transportation, and emission reduction technologies. Since 2005, Momentum has successfully developed and managed over $5.5 billion in funded cleantech projects in collaboration with more than 1,000 partners, including water agencies, utilities, equipment manufacturers, commercial, and industrial customers. Momentum provided grant management services—including support with project management, invoicing, reporting, community and agency engagement, and media and knowledge transfer.

Project Goals and Objectives

The project goal was to more than double the capacity of an existing, recently-completed 500 standard cubic feet per minute (scfm) anaerobic digester facility owned by the VVWRA to produce a total of 1200 scfm biogas (a 700 scfm increase). The project proposed to upgrade the new biogas into approximately 420 scfm (1,640,988 diesel gallon equivalent per year) of 100% renewable, low-carbon natural gas, to be transported via pipeline for sale as transportation fuel. The work included a new thickener, mixers, a new membrane holder, a microgrid controller, new piping, and a small modification of the existing facility. The project sought to offset fossil fuel emissions from transportation by at least 18,256 metric tons of carbon dioxide equivalent per year from offsetting conventional diesel fuel.

The objectives of this agreement were to:

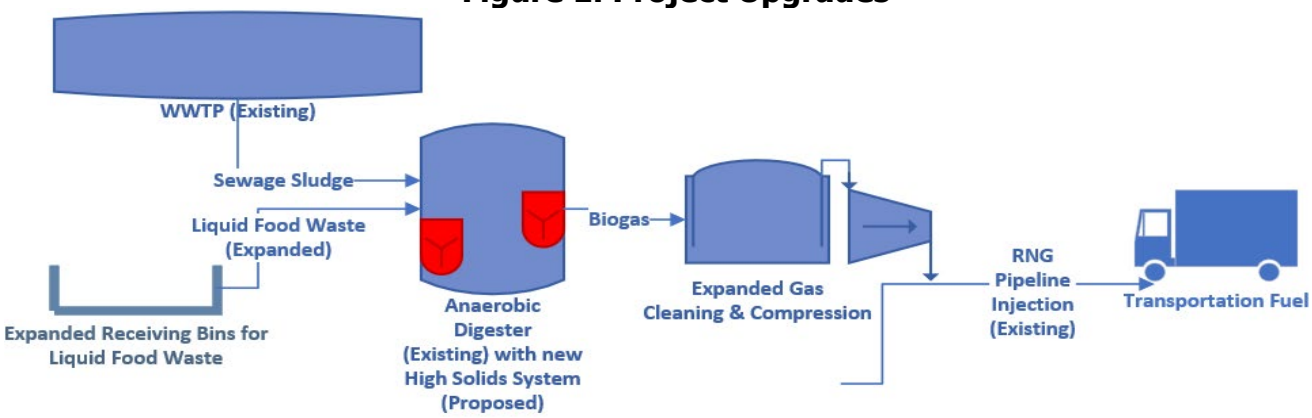
- Expand the existing waste receiving bins to handle an additional 100,000 gallons per day of organic food waste (from 20,000 pre-project to 120,000 gallons per day).
- Increase the effective throughput capacity of the existing digester by approximately 100,000 gallons per day by installing high solids management equipment.
- Expand gas cleaning and compression system capacity to process at least 1,200 scfm (700 scfm expansion) of incoming biogas.
- Sell product biogas for use as transportation fuel under California's Low Carbon Fuel Standard.
- Deploy a streamlined microgrid controller on site to further improve GHG emissions reduction potential of produced fuel.
- Support direct benefits to local disadvantaged and low-income communities through new employment and education opportunities.

Chapter 2:
Project Implementation

Project Overview

To achieve the project goals and objectives, the existing anaerobic digester tank was upgraded, and a new mixer, food storage tank, and thickener were installed. Upgrades included the existing liquid food waste receiving bins, the anaerobic digester, and gas cleaning and compression as summarized in the graphical abstract presented in Figure 1.

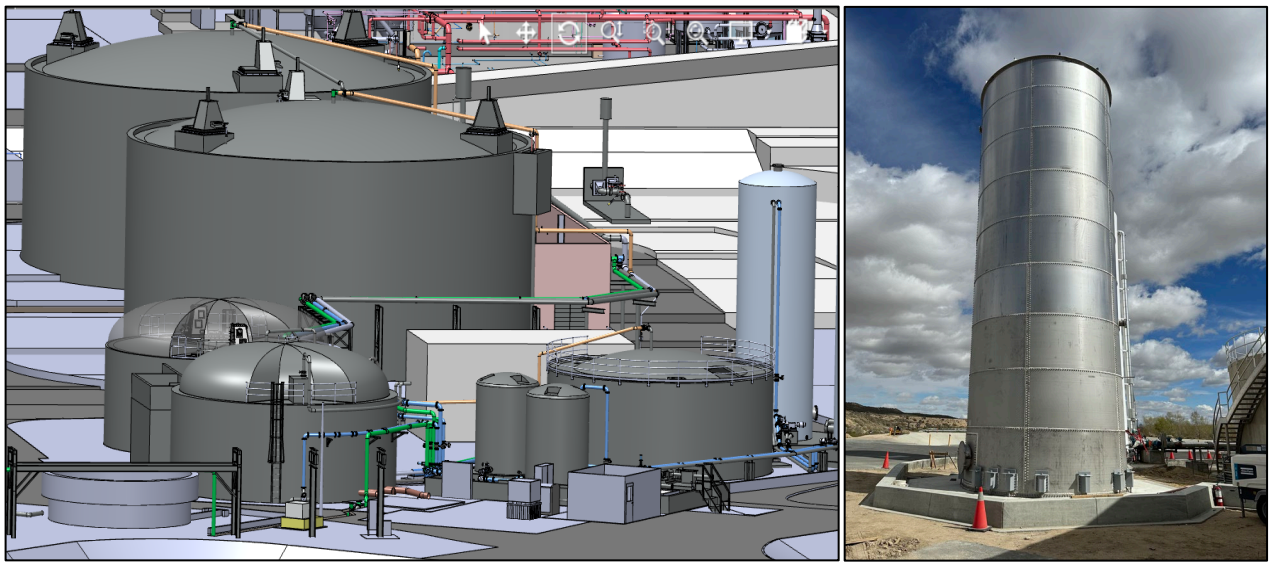
Figure 1. Project Upgrades



Source: SoCal Biomethane LLC

The existing liquid food waste bins were expanded to be capable of handling additional liquid food waste (Figure 2). These bins were designed to accept from incoming trucks a wide array of liquid food wastes including de-packaged condiments, bread wastes, greases and oils, and various other food wastes.

Figure 2. Additional Food Waste Storage Tank



An additional food waste storage tank was installed and integrated into the system as displayed in the system diagram on the left. Installation of the food waste storage tank is shown on the right.

Source: SoCal Biomethane LLC

Piping modifications to the food waste storage tanks and digester were similarly made to handle the expanded capacity as shown in Figure 3.

Figure 3. Piping Modifications

Piping modification at the Food Waste Storage Tank #1 (left) and Digester #2 (right).

Source: SoCal Biomethane LLC

Anaergia's Omnivore™ high-solids anaerobic digestion system was also added as a bolt-on system for the existing anaerobic digester. The Omnivore™ process converts a conventional anaerobic digester into a high-solids system with the addition of specially designed mixing and thickening systems. As a result, the digester's throughput was expanded to handle additional liquid food waste.

The gas cleaning and compression system was expanded with the installation of equipment to increase the total membrane-based gas cleaning and compression system throughput to handle an increased volume of incoming biogas. Specific equipment included additional compression, blowers, and similar equipment. The upgrades also supported increased resiliency of the system, helping to avoid flaring or system downtime in the event of a failure, loss of electricity supply, or other potential reliability events.

Core Project Technologies

The following technologies were deployed as part of the project.

Omnivore High Solids Anaerobic Digestion

The project deployed Anaergia's Omnivore™ high solids digestion technology. Anaergia's Omnivore™ digester retrofit triples digester capacity by thickening anaerobic digestate to concentrate biomass, thus increasing throughput without increasing digester size, enabling co-digestion of sludge, food waste, and other feedstocks. The technology allows wastewater treatment plants to increase digester loading and biogas production using relatively low-cost and exceptionally low-risk modifications to existing infrastructure. The technology combines advanced mixing and thickening systems that are directly integrated into existing systems, resulting in a cost-effective increase in biogas generation with effectively zero increase in

footprint, improved operational control, flexibility, dependability, and an improved maintenance process.

Solids Sludge Thickener

The solids sludge thickener uses a screw-based mechanism to increase the solids content in the existing digester, enabling high-solids digestion and increased biogas production. The thickener design allows for reduced energy consumption (90% reduction versus an equivalent capacity decanter centrifuge), as well as adjustments in the rate of capture, hydraulic throughput, and percent solids to optimize downstream processes while controlling odors in a fully contained system. Figure 6 shows the completed thickener.

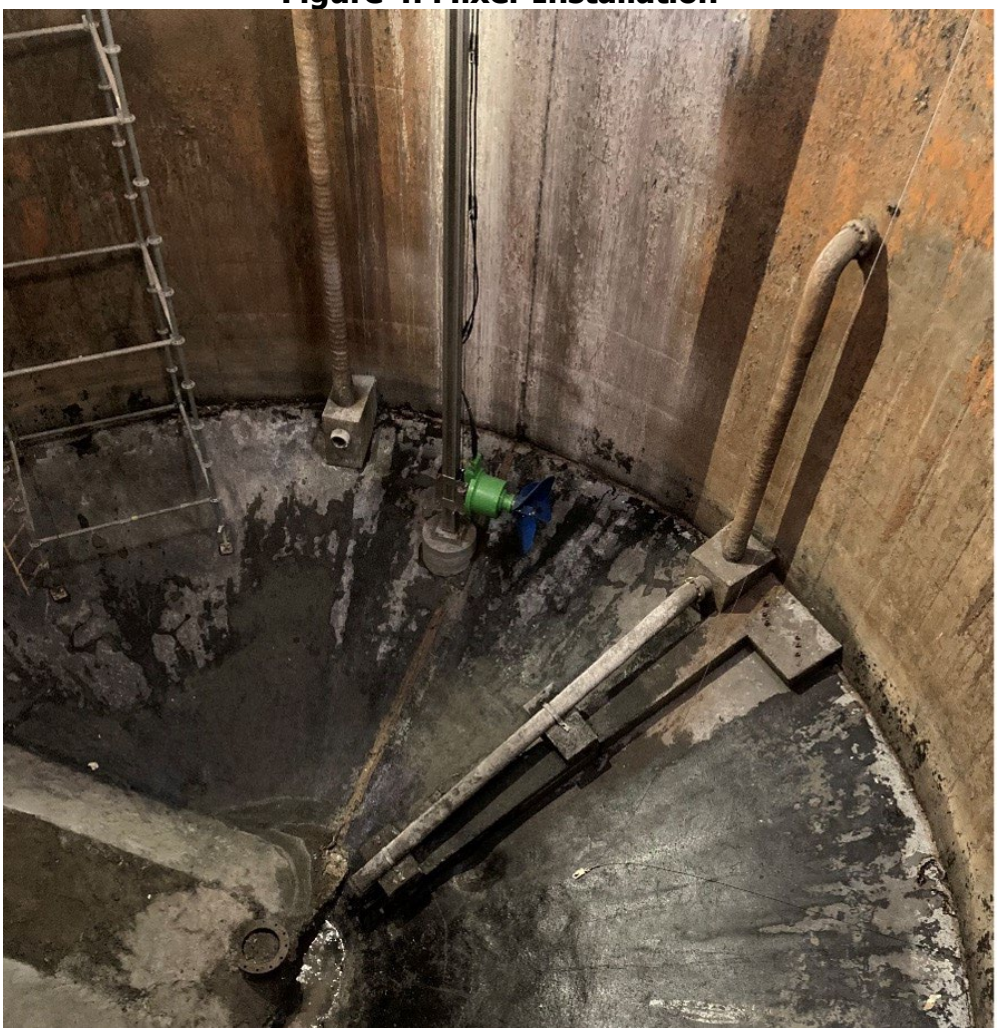
Figure 3. Thickener Completion

Source: SoCal Biomethane LLC

High Solids Mixers

Inside the digesters, the project deployed a series of high solids mixers (Figure 7). Anaergia's mixers effectively mix the high viscosity fluids generated by the solids sludge thickener during the digestion process. The mixers use an innovative design and variable-speed, high-torque motors to mix high viscosity fluids effectively and efficiently. Each mixer was mounted on a service box which allows real-time adjustment while also facilitating rapid access for maintenance and inspection.

Figure 4. Mixer Installation



Source: SoCal Biomethane LLC

Membrane Cassettes for Expanded Biogas to RNG Upgrading Capacity

RNG upgrading capacity was expanded easily and rapidly by installing additional treatment cartridges to the existing, fully expandable biogas upgrading system. SoCal Biomethane installed additional gas upgrading membrane equipment, sufficient to process an additional 700 scfm of biogas into high quality RNG for pipeline injection.

Ground Mounted Biogas Storage

The project team also installed a double membrane biogas holding or storage system that temporarily stores biogas—immediately downstream of the digester system—to provide a stabilized supply to the biogas upgrading system. The double membrane gas storage system was ground mounted. The system can store up to 1,200 scfm of biogas at any given time.

Facility Design, Construction, and Commissioning

The engineering for the SoCal Biomethane project was completed on January 27, 2023. All plans are available upon request and include the following:

- Site Plan
- Structural Plans
- Mechanical Plans
- Electrical Plans

- Equipment Drawings and Design Calculations
- 3D Model

Getting plans to the completion stage took longer than anticipated, particularly since the project involved refurbishment of an existing facility that is restricted in space and electronic plans that reflect the as-built status were limited.

The core project elements were constructed and commissioned between September 2022 and November 2023, as detailed in Table 3 below. A full construction and equipment list can be found in Appendix A.

Table 1. Significant Project Milestones

Project Element	Completion Date
Piping Modifications at existing Food Waste Tanks and Digester #2	September 2022
Mixers at Digester 3 Installed	December 2022
Foundation Works for Food Waste Storage Tank	February 2023
Erection of Food Waste Storage Tank	March 2023
Hydrotest Food Waste Storage Tank	April 2023
Site Preparation Works for New Thickener	May 2023
Piping and Electrical Works at Food Waste Storage Tank	June 2023
Commissioning and Start-up of Food Waste Storage Tank	August 2023
Manufacture of Thickener	August 2023
Thickener Delivered to Site	September 2023
Insulation and Lagging Installation of the Food Waste Storage Tank	November 2023
Demolition, Removal, and Salvage of the Existing Thickener and Installation of the New Thickener	November 2023
Startup and Commissioning of the Thickener	November 2023

Source: SoCal Biomethane LLC

Outreach and Community Support Activities

The project also provided a variety of benefits to improve educational outcomes among members of affected priority populations. SoCal Biomethane conducted eight tours of the project for schools and community groups from March 2023 to October 2024, as detailed below in Table 3.

Table 2. VVWRA Tours 2023-2024

Date	Organization	Number of Participants
March 16, 2023	Granite Hills High School	27
May 10, 2023	Chamber of Commerce Leadership group	19
January 17, 2024	Victor Valley High School	31
March 8, 2024	Granite Hills High School	20
March12, 2024	Mojave High School	12
April 1, 2024	Japanese exchange students	15
April 20, 2024	Earth Day event	25
October 4, 2024	Mojave High School	10

Source: SoCal Biomethane LLC

Chapter 5:
Project Results

Throughput, Usage, and Operations

The project completed all the proposed anaerobic digester upgrades and RNG production deliverables. Throughput capacity was expanded for the existing waste receiving bins to handle an additional 80,000 gallons per day of liquid food waste and were paired with an increase in digester capacity by a commensurate 80,000 gallons per day (100,000 gallons total). This was accomplished by installing high solids management equipment. Furthermore, the intake and processing capacity of digester gas was expanded to a combined maximum capacity of 1,600 scfm.

Cumulatively, the expansion upgrades made as part of the SoCal Biomethane Anaerobic Digester Upgrade resulted in an increased overall capacity of the facility to process a daily average of 693,000 scf of digester gas. The average daily throughput to carbon-negative RNG of RNG produced and exported to Southwest Gas was of 457,000 scf, meaning that 66% percent of the digester gas processed was exported. The monthly totals of digester gas processed and RNG exported over 6 months of operations (August 2024 to January 2025) of the project are presented below in Table 3.

Table 3. Monthly RNG Production

Month	Total Digester Gas (SCF)	RNG Exported (SCF)	RNG Exported (DGE)
August 2024	22,758,532	14,639,287	114,980
September 2024	21,809,481	14,795,730	116,142
October 2024	22,528,393	15,114,708	118,654
November 2024	18,176,188	12,459,037	97,979
December 2024	20,714,657	11,909,540	93,493
January 2025	21,663,233	15,395,714	120,798

Source: SoCal Biomethane LLC

Operational Costs

Over six months of operations, the operations and maintenance costs of the facility amounted to $92,000, roughly $15,000 per month. Core activities included managing feedstock inputs, maintaining optimal digester conditions, and overseeing the mechanical systems that move and process materials. Operators regularly monitor temperature, pH, gas production rates, and methane content to keep the biological process stable and maximize gas yield. On the gas upgrading side, maintaining systems like pressure swing adsorption units or membrane separators to remove CO_2 and other impurities from the biogas is essential. Facilities also manage moisture removal systems and monitor RNG purity to comply with utility interconnection requirements. In addition to technical tasks, operators oversee safety systems such as emergency flares and leak detection protocols, while also ensuring regulatory reporting and environmental compliance.

The facility costs in the same six-month period were $850,371. This is higher than the forecasted facility costs in the next six months due to some one-time purchase of additional

storage tanks and an organic polishing system. These systems will aid the processing of digester gas by pre-cleaning the feedstock. The increased facility efficiency is expected to cover this investment.

Jobs and Economic Development

The project has created expanded business opportunities for California-based businesses, including suppliers, project participants, and distributors. The production increase will generate at least $6.5 million in annual revenues. The facility will provide meaningful economic benefit to local and regional communities. In addition to creating five construction jobs and four full-time permanent positions, the project is creating 25 indirect jobs over its lifetime of operation. One hundred percent of annual project expenses are spent in California.

In addition, 100% of the plant's RNG output is being sold within California, delivered by Southwest Gas to its fleet partners located across the Inland Empire and Southern California generally, creating business opportunity both for Southwest Gas and its partners. Use of RNG by fleets helps to enable green certifications, achieve corporate emissions reduction targets, and support new and emerging consumer product lines and services that rely on green freight transport as an element of their business models.

By using fees collected from food waste and the existing wastewater treatment system to make renewable natural gas (RNG), the project creates extra income for VVWRA. This extra money helps pay for the advanced recycled water system on VVWRA's main line.

Feedstock Supply Summary and Carbon Intensity

The project targets material that is being diverted from landfills, as well as material that comes from manufacturing. The multiple feedstock sources included sodas, outdated milk products, de-packed material, and other post-consumer food waste being diverted from landfills. The anaerobic digestion processed the combination of municipal sludge generated at the wastewater treatment plant and liquid organic waste streams, including liquid food wastes and fats, oils, and grease, to create carbon-negative RNG.

The carbon intensity of the RNG produced was calculated using the CARB's Tier 1 Simplified CI Calculator for Biomethane from Anaerobic Digestion of Organic Waste. This calculator considered the type and volume of feedstock, the digester gas intake, the methane content of the digester gas, the facility consumption of utility-sourced CNG, and the facility consumption of electricity as shown in Table 2.

Table 4. Carbon Intensity Calculator Inputs

Month	Food Scraps (Tons)	Total Digester Gas (SCF)	Methane Content (%)	Utility-sourced CNG (MMBTu)	Grid electricity (kWh)	RNG Exported (MMBTu)
Aug	13,950	22,758,532	60%	118.4	207,008	14,773
Sep	13,500	21,809,481	60%	116.5	297,636	14,923
Oct	13,950	22,528,393	60%	121.9	299,543	15,246
Nov	13,500	18,176,188	60%	120.0	299,334	12,589
Dec	13,950	20,714,657	60%	122.0	274,493	12,013
Jan	13,950	21,663,233	60%	122.0	272,858	15,521

Source: SoCal Biomethane LLC

The resulting carbon intensity of the SoCal Biomethane Anaerobic Digester Upgrade is carbon negative at a rate of -86.06g CO_2e/MJ.

Emission Reductions

The production and utilization of RNG present a significant opportunity to reduce GHG emissions and improve air quality. The project accomplished this goal by displacing conventional gasoline and diesel used for transportation. Specifically, the RNG produced was transported via a Southwest Gas pipeline for sale as transportation fuel in the greater vicinity of the project, displacing gas and diesel used in medium- and heavy-duty vehicles.

Quantifying this benefit requires that the carbon intensity of the RNG be compared to that of the displaced transportation fuels. These estimates assume displacement of conventional diesel-fired medium-heavy duty in-state trucks, which achieve a diesel gallon equivalent (DGE) mileage equivalent of at least 8.4 miles per gallon—with RNG fuel combustion using low-NO_X engines. The standard CI of fossil diesel under California's Low Carbon Fuel Standard (LCFS) is 100 gCO_2e/MJ while the energy content of diesel is 128.5 MJ per diesel gallon equivalent (DGE).

$$\frac{\mathrm{gCO^2e}\ Emissions\ Reduction}{DGE\ of\ RNG\ Produced} = \frac{(100-(-86))\frac{\mathrm{gCO2e}}{\mathrm{MJ}}}{128.5\frac{MJ}{DGE}}$$

The result shows that each DGE of RNG exported for use in transportation will result in an estimated net emission abatement of 1.43 grams of carbon dioxide equivalent (gCO_2e).

In the six-month operational period, the facility exported 662,000 DGE of RNG, resulting in 948 MT CO_2e of GHG emission reductions. At this rate, the project will reduce emissions by close to 1,900 Metric Ton (MT) each year, 9,500 MT over five years, and close to 38,000 MT over the entire 20-year life of the facility.

At the same time, the facility will be offsetting criteria air pollutants. Using Argonne National Lab's AFLEET Emissions Tool, the criteria for pollutant emissions reduction were calculated for heavy-duty vehicles using RNG. The results show that 15,700 lbs NOx have been reduced in the first six months. The CO_2e and NOx emission reductions to date (6-months) and forecasted reductions up to the 20-year facility life are summarized below in Table 4. Over the 20-year project life close to 38,000 MT of CO_2e and 623,000 lbs of NOx will be abated.

Table 5. Emission Reductions

Period	RNG Exported to SWG (DGE)	CO_2e Emissions Reduction (Metric Tons)	NOx Emission Reduction (lbs)
6 Months	662,046	948	15,698
1 Year	1,324,093	1,897	31,396
5 Years	6,620,463	9,483	156,981
20 Years	26,481,854	37,931	627,923

Source: SoCal Biomethane LLC

Chapter 6: Conclusions

Lessons Learned

Implementing SoCal Biomethane Anaerobic Digester Upgrade valuable lessons in technical performance, operations, and stakeholder engagement. The project team refined its understanding of how feedstock variability impacts gas production, the importance of robust gas cleanup systems, and the need for accurate, real-time monitoring to maintain system stability.

Operational takeaways include the need for timely preventative maintenance, the need for well-trained staff to manage both biological and mechanical systems, and the complexities of handling digestate byproducts in an environmentally responsible way.

On the financial and stakeholder side, the lessons were centered around the importance of accurate cost estimates, long-term planning for RNG market participation, and navigating regulatory frameworks like California's Low Carbon Fuel Standard (LCFS). The team identified that early engagement with regulators, utilities, and local communities was critical to project success, helping to streamline permitting and build public support.

Examples of operation pain points identified included:

- Firmware updates unexpectedly causing process shutdowns or causing erroneous calculations being performed and sent to the RNG Programmable Logic Controller
- Digester fuses being at risk of fault due to being at pipeline injection limit. Requiring that staff disconnect power supply that leads to greater communications fault, resulting in shutdown.

By being aware of these faults and their impacts, the project team is better able to prepare to implement required operations and maintenance while exploring process improvements.

Conclusion

Ultimately, the project shows that investments in expanding California's carbon-negative RNG production result in meaningful environmental benefits. The transition to low-carbon RNG in Southwest Gas's transportation fuel network not only supports California's Low Carbon Fuel Standard (LCFS) and federal clean energy initiatives but also helps create a cleaner and more sustainable fuel supply chain. Emission reductions achieved through this process highlight the environmental and regulatory benefits of deploying carbon-negative RNG in the transportation sector.

Beyond environmental benefits, the project inferred economic and job benefits, having created five construction jobs, four full-time jobs, and as many as 25 indirect jobs. The forecasted $6.5 million in annual sales shifts market share further towards low- and no-carbon solutions, expanding access to renewable fuels while generating tax revenues for the state.

The anaerobic digester and RNG production technology is prime for replication by medium to large scale wastewater treatment plants where sufficient volumes of food waste or other organic waste are also available in proximity. In California, an estimated 200 wastewater treatment plants have sufficient capacity to support a similar system. Of those facilities, SoCal

Biomethane estimates that at least 40 percent of those facilities (i.e., 80 plants) have available digester capacity and regionally available organic waste that could be used to enhance the production of biogas on site.

GLOSSARY

BIOGAS—The mixture of methane, carbon dioxide, and other minor gases formed from the decomposition of organic materials. Gas produced from the anaerobic digestion of organic matter such as dairy manure, containing approximately 65 percent methane, 35 percent carbon dioxide and traces of hydrogen sulfides and water.

BIOGAS CONDITIONING FACILITY—Facility that processes conditioned biogas from the dairy digesters into pipeline quality biomethane that is compressed to high pressure (~800 psi) for injection into a utility natural gas pipeline.

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.

MMBtu—One million British thermal units (Btu)

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.

CALIFORNIA ENERGY COMMISSION (CEC)—The state's primary energy policy and planning agency. The agency was established by the California Legislature through the Warren-Alquist Act in 1974. It has seven core responsibilities:

- Developing renewable energy
- Transforming transportation
- Increasing energy efficiency
- Investing in energy innovation
- Advancing state energy policy
- Certifying thermal power plants
- Preparing for energy emergencies

CARBON INTENSITY (CI)—The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels.

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.

CONDITIONING PLANT—Facility located at each digester for the purpose of scrubbing H2S, water and particulates from the biogas and delivering low-pressure (30 to 50 pounds per square inch) to the gathering pipeline.

DIESEL GALLON-EQUIVALENT (DGE)—The amount of alternative fuel it takes to equal the energy content of one liquid gallon of diesel gasoline. 1 gallon of finished gasoline (containing about 10% fuel ethanol by volume) = 120,286 Btu[2]
1 gallon of diesel fuel (with sulfur content less than 15 parts per million) = 137,381 Btu ibid

DIGESTER—A covered sealed container where there is the absence of air and the presence of anaerobic bacteria that react with organic matter to produce biogas.

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 (HCFCs) , ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs). (EPA)

HYDROGEN SULFIDE (H2S)—A colorless, flammable, poisonous compound having a characteristic rotten-egg odor. It is used in industrial processes and may be emitted into the air.

LOW CARBON FUEL STANDARD (LCFS)—A set of standards designed to encourage the use of cleaner low-carbon fuels in California, encourage the production of those fuels, and therefore, reduce greenhouse gas (GHG) emissions. The LCFS standards are expressed in terms of the "carbon intensity" (CI) of gasoline and diesel fuel and their respective substitutes. The LCFS is a key part of a comprehensive set of programs in California to cut greenhouse gas emission and other smog-forming and toxic air pollutants by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options.

PACIFIC GAS & ELECTRICITY COMPANY (PG&E)—Owner of the utility natural gas pipeline used in this project. PG&E is an American investor-owned utility. The company is headquartered at Kaiser Center, in Oakland, California.

RENEWABLE COMPRESSED NATURAL GAS (RCNG)—Purified biogas, captured from decomposing organic waste (like landfills, farms, wastewater), processed to meet natural gas quality, then compressed for use in vehicles or injection into pipelines as a near-identical, cleaner substitute for fossil natural gas, significantly cutting emissions by repurposing waste methane. It is a sustainable fuel for fleets (buses, trucks) and can replace conventional gas for heating, offering a circular economy solution without fracking.

RENEWABLE NATURAL GAS (RNG)—Pipeline-quality methane captured from decomposing organic waste (like landfills, farms, food scraps, and wastewater) that is purified and injected into the existing natural gas grid, making it interchangeable with fossil natural gas for heating, electricity, or vehicle fuel, but offering lower lifecycle greenhouse gas emissions by preventing methane release and utilizing waste. It is considered carbon-neutral or even "carbon-beneficial" because the source material (plants/animals) absorbed CO2 from the atmosphere, creating a closed loop, unlike traditional fossil gas. Also called biomethane.

STANDARD CUBIC FEET PER MINUTE (SCFM)—A flow rate measurement for gases (like compressed air) standardized to specific conditions (typically 68°F, 14.7 PSI absolute, and 0% humidity) to allow for accurate comparisons and calculations, unlike Actual CFM (ACFM) which varies with actual temperature, pressure, and humidity, making SCFM crucial for compressor

sizing and system efficiency. It ensures that regardless of site conditions, the quantity of gas molecules is consistent, preventing miscalculations in energy use or equipment performance.

VICTOR VALLEY WASTEWATER RECLAMATION AUTHORITY (VVWRA)—A resource recovery facility that provides wastewater treatment services for Apple Valley, Hesperia, Victorville, Spring Valley Lake, and Oro Grande.

WASTEWATER TREATMENT PLANT (WWTP)—An industrial facility that uses physical, chemical, and biological processes to remove contaminants from sewage and industrial wastewater, making it safe to return to the environment or reuse for purposes like irrigation, involving steps like screening, settling (primary), aeration (secondary), disinfection (UV/chlorine), and filtration, preventing water pollution and protecting public health.

APPENDIX A:
Construction and Equipment List

System	Scope of Supply
Food Waste Storage Tank	• 14.85ft Dia x 42.58ft Height 304SS insulated food waste storage tank • Rerouting the existing underground pipes for new tank foundation • Construction of tank foundation • Installation of the equipment (pumps, heater, etc.) and all the piping for new 304SS tank • Run all the wires (power, control) from each tank's component to designated control panel and power source
Structural Engineering	• Perform structural calculation and foundation design for the new 304SS Slurry tank
Discharge Pump	• 7.5HP Discharge Pump for transferring the food waste from the new 304SS Tank to the Digesters
Recirculation Pump	• 20HP Recirculating pump for mixing the food waste inside the new 304SS tank
Heater	• 6.7HP Flanged connection immersion heater for new 304SS tank
Valves	• 6" Cast Iron Plug Valves for new 304SS tank (Qty:3) • 6" 316SS Pneumatic Actuated Knife-Gate Valves (Qty:2) • 6" 3166SS Manual Knife-Gate Valves for Recirculation Line (Qty:2) • 6" SS Swing Check Valves for Discharge line from ADM tank to the digesters (Qty:3) • 2" SS Threaded Ball Valves for Sampling/Bleeding before and after the discharge pump (Qty:2) • 2" SS Flanged connection Ball Valve for Isolating Level Transmitter mounted on new tank (Qty:1) • 4" SS Flanged connection Ball Valve for Drain Line on the new 304SS Tank • 6" 316SS Flanged Connection Gate Valves (Qty: 3) • 6" 316SS Flanged Connection Swing Check Valve (Qty:1)
Instruments	• Pressure Switch with Isolation Ring to be placed downstream of the discharge pump on new 304SS tank • Hydrostatic Level Transmitter for new 304SS tank • Temperature Transmitter for new 304SS tank • Magnetic Flow meter with transmitter and cable to be mounted at the inlet of the new 304SS tank
Thickener	• WesTech DAF Thickener Model DAFS6N with all components including drive, center shaft, feedwell, rake arms, baffles, skimmers, control valve assembly, float box
Mixers	• PSM 940 Explosion Proof Submersible Mixers (Qty:2) • High Pressure Service Boxes (Qty:2) • Gas Curtains and Mixer Posts (Qty:2)

System	Scope of Supply
	• Mixer Control Panel NEMA 12 including Allen-Bradley PowerFlex 755 VFDs • Structural Modifications to Digester 3 • Demolition of existing equipment • Installation of mechanical and electrical equipment (mixers, service boxes, gas curtains, posts, control panel)
Piping Modifications / Plant Upgrades	• Installation of new pipeline with valves to ADM tank #1 and 2 • Pipe and Valve installation on ADM tank #1 and 2 • Adding extra port at higher elevation on ADM tank #1 and 2
Digester #2 Modifications	• Installation of Inspection Window on Digester 2 • Pipe Modifications on Digester 2 to align with Digester 1 pipeline • 6" Rupture Disk on Digester 2 overflow pipeline
Overall Plant Modifications and Upgrades	• Added check valves to ADM skid discharge • Added 2nd Biogas Analyzer panel • Modifications to PRC-11 • TSA Skid instrumentation spools • Modify 3" BG from membrane skid due to RIO-1 Panel • Add 8" Flame Arrestor • Membrane Filters cold vent pipe support • "sugared" welds inside of Ammonia Scrubber nozzles • Add biogas analyzer panel at Flare area • Flow Meter added to 2" NG line at Flares (FIT-6678) • Ammonia Scrubber removable spools for future maintenance • PRV-86123 vent pipes and supports • Add 1" insulation to Hot Oil lines at RNG (9/22 email) • ADM bypass switches for the UPS in ADM area • Added disconnects at Flares - (2ea) for sump pumps • Add UPS and bypass switches to Flare area • Granite fuel CAT6 change to hardwire (7/20 email) • Added solenoid valve to HS2 system • Thermal Oxidizer vent pipe • Procure and install a NG pressure regulator at Thermal Ox • Additional compressed air service to 3 locations at RNG area • Upsize to 6" BG 023 from Membrane skid to 6" BG 019 • Cut and weld 12" SS pipe to add (2ea) 12" BFV • Additional Pipe supports at Digester 1, 2 & 3 tie-in (required concrete pads to be poured) • Added O2 analyzer panel and sample lines in RNG • Modifications to Thermal Oxidizer inlet to tee and actuated damper for fresh air inlet • Modify and re-fabricate RNG Pressure Reducing station to per drawing revision from • Sajeev on 11/9/21 • Add 2" CPVC ball valve to Sulfuric Acid fill line (not shown on P&ID) • 7ea additional biogas sample points at RNG • Insulate potable water and service water PVC pipes at RNG.

System	Scope of Supply
	• Addition of anti-foam injection system to Digesters 1, 2 & 3 • Add pressure relief valves to H2S vessel • Add pressure regulating valve to discharge of membrane skid (6 BG-022) • FST Tank 3 - 8" PVC vent pipe extend to ground • Add 6" 45-degree elbow to suction side of ADM reception skid 1 & 2 • RNG Compressor Return Line Check Valve • Replace 1/2" electric ball valve with a class 1 div 1 solenoid valve on O2 injection panel. (labor only) • Heat trace add to ADM feed pipe to FST tank #3 • Move magmeters outside containment area • Mem 1-2 valve limit switches seal offs • Modify pipes and install added level instrumentation to Digesters 1, 2 & 3 per VVWRA • Remove FST Tank 3 instrument and replace with SS blind flange • H2s sample analyzers - Biogas 3000 - vent lines at digesters 4/5 • 8in TWAS check valves