CALIFORNIA
ENERGY COMMISSION

Energy Research and Development Division

**FINAL PROJECT REPORT**

# Community Scale Digester with Advanced Interconnection to the Electrical Grid

## High Solids Anaerobic Digestion Serving San Luis Obispo County

**Gavin Newsom, Governor**
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# PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company, San Diego Gas & Electric Company and Southern California Edison Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

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For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the CEC at 916-327-1551.

# ABSTRACT

Anaerobic digestion is an excellent solution for extracting value from this organic waste, while additionally producing biofuels and soil amendment, reducing greenhouse gas emissions in the process. Anaerobic digester technologies have been commercially available for decades; however, widespread installation and utilization of these systems have been limited. Despite a regulatory environment encouraging renewable energy production and greenhouse gas reductions, there is a need for technology to lower the system cost as traditional methods require high capital costs to remove organic materials from the wastewater stream to create good quality slurry for an anaerobic digester system.

The California Energy Commission awarded a $4 million grant toward the estimated $9.28 million total cost of an anaerobic digestion organic waste project. HZIU Kompogas-SLO, Inc. (The Recipient), in partnership with Waste Connections and Pacific Organics, built, commissioned, and connected to the grid a state-of-the-art high-solids anaerobic digestion facility designed specifically to meet the organics diversion goals of San Luis Obispo County. This is a first-of-its-kind facility to enter the California market, and lessons learned can influence similar facilities developed to meet several state mandates to increase organic waste from municipal solid-waste sources.

The Kompogas SLO anaerobic digester was one of the fastest-constructed anaerobic digestion facilities in California. During the project, it processed 31,261 tons of organic feedstock reducing greenhouse gas emissions by 4,389.3 MTCO2e by diverting organics from business-as-usual alternatives. It also produced 7,679 tons of solid fertilizer and compost, 1.5 million gallons of liquid fertilizer and exported 2 million kilowatt-hours of renewable electricity while reducing greenhouse gas emissions by 762.2 MTCO2e.

**Keywords:** anaerobic digestion, organic waste, greenhouse gas emissions, biogas, waste-to-energy, bioenergy

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# EXECUTIVE SUMMARY

## Background

The United States is among the world's top 10 food wasters. Americans threw away about a pound of food per person per day in 2017, totaling around 40 million tons per year (TPY). This represents between 30 and 40 percent of the nation's food supply. Californians alone throw away nearly 6 million tons of food waste every year, about 18 percent of all materials that end up in the state's 300 landfills, where it eventually decomposes and releases the potent greenhouse gas (GHG) methane into the atmosphere. Methane accounts for 9 percent of California's GHG emissions. Food waste and its disposal have economic and environmental consequences for California. The environmental consequences of food waste and its disposal and one proposed solution for its mitigation are the subject of the research project described in this report. In 2014 and 2016, the California Legislature passed Assembly Bill 1826 (Chesbro, Chapter 727, Statutes of 2014) and Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) These bills together form the cornerstone of California's organics diversion program, which set ambitious targets for mandatory commercial organics recycling and the diversion of organics from landfills. These targets called for a 50 percent reduction of organics from landfills by 2020 and a 75 percent reduction by 2025 from 2014 levels, For California to achieve these goals, additional organics processing facilities are critically needed to accept increasing volumes of diverted organic waste.

Anaerobic digestion (AD) is an excellent solution for extracting value from this organic waste, while producing biofuels and soil amendment, reducing GHG emissions in the process. AD technologies have been commercially available for decades; however, widespread installation and utilization of these systems have been limited. Despite a regulatory environment encouraging renewable energy production and GHG emissions reductions, there is a need for technology to lower the system cost as traditional methods require high capital costs to remove organic materials from the wastewater stream to create good quality slurry for an AD system.

Historically, there have been several barriers that prevented developers to build digester facilities in California such as feedstock availability, financial and technological challenges associated with the availability of digester infrastructure, preprocessing, feedstock quality, and statewide stricter air and water quality regulations. These issues are addressed largely by the incentives for bioenergy development and bioenergy feed-in tariff (FIT) program known as the Bioenergy Market Adjusting Tariff (BioMAT). Specifically, since the feedstock is an eligible feedstock under Category 1 of the BioMAT program the Kompogas SLO Facility sells renewable electricity to Pacific Gas and Electric Company (PG&E) through a Power Purchase Agreement (PPA) acquired through BioMAT. In addition, issues relating to low-quality feedstock were mitigated by using glycerin as co-substrate in the anaerobic digestion chemical reactions as it binds with the reactant to aid the reaction kinetics.

This project is a technology demonstration and deployment project, as it involves the installation and operation of an AD system technology that has never been installed in the U.S. There are significant barriers associated with the modification of European technology to meet U.S. standards—specifically California environmental requirements—while still remaining cost-effective in California's more challenging marketplace.

Because this facility is the first-of-its-kind in California, the successful completion of the Kompogas SLO Facility represents a model for replication throughout the state. Technology and knowledge transfer were critical components of the development process. To handle increasing organic waste streams from new state environmental mandates, this project brought interested parties together to discuss key successes and issues associated with developing additional AD facilities.

# 1Project Purpose

The purpose of this Agreement is to develop, demonstrate, and operate an innovative, state-of-the-art anaerobic digestion facility designed to convert organic waste from San Luis Obispo County (SLO) into renewable electricity. The community-scale bioenergy facility converts food waste and green waste into renewable electricity, compost, and liquid fertilizer. In cooperation with waste haulers, the feedstock is locally sourced from cities, communities, and unincorporated areas of SLO. Food collection and distribution programs are also incorporated into the project to ensure recoverable food is used for human consumption before being used as feedstock for the facility. The resulting electricity is sold and exported to the grid, while compost and liquid fertilizer is sold and distributed by a local farming supply company.

The main goals of the project were:

1. Prove the technical and economical operation of a unique, community-scale bioenergy facility using Kompogas technology that converts local organic waste into renewable-resource electricity, compost, and fertilizer while meeting California's strict environmental codes and standards.
2. Meet local and state renewable energy and waste diversion goals through collaboration with local governments and agencies, local communities, businesses, waste haulers, and food banks.
3. Contribute to local, regional, and statewide reductions in criteria air pollutants, short-lived climate pollutants, and GHG emissions.

# Project Approach

The project represents a unique public-private partnership between the Local Communities, the franchised waste hauler, and an established technology provider. While the technology has been proven overseas, the system fits the technology demonstration and deployment criteria outlined in the EPIC Grant Funding Opportunity as a technology that is not widely used in California or the U.S. There were significant barriers associated with the modification of the European technology to meet U.S. standards and specifically California environmental requirements and more challenging marketplace. Particularly, odor control, fugitive dust control, exhaust stack height, metering and testing equipment, emissions limits, conditioning systems (including gas H2S removal), emissions controls (e.g., selective catalytic reduction systems, oxidation catalysts), and seismic regulations all present California-specific challenges.

The proposed project is the result of a deep commitment by all the communities in SLO to proactively address organics management in the most socially responsible manner possible. The project approach consisted of processing feedstock and continuously feeding food waste and urban green waste into the AD system; discharged digestate dewatering to yield solid

compost and liquid digestate; treatment of liquid digestate by mechanical-water treatment system; and aerobic stabilization of solid digestate.

The project team has significant experience in managing organic waste and producing renewable electricity and compost. It included a variety of stakeholders including Waste Connections, Pacific Organics, and the SLO Integrated Waste Management Authority (IWMA).The project team put together a technical advisory committee (TAC) comprised of different stakeholders including technology experts, universities, utilities, local air districts, and city and county officials. The TAC met quarterly during the project development process through completion providing strategic guidance for the project including technical expertise, market applications, and development of future and potential projects.

The project had four technical tasks:

- **Objective 1**: Produce renewable electricity for PPA:
    - *Power Production*: Average 733kW
    - *Energy Production*: Average 85 percent capacity factor, a rate that will produce 6.2 million kWh of renewable electricity annually
- **Objective 2**: Develop a facility that can process local organic waste material
    - *Average Daily Feed Rate*: 100 tons per day
    - *Average Annual Feed Rate*: 36,500 TPY
- **Objective 3**: Create value-added fertilizer by-products
    - *Solid Fertilizer Production Rate*: 13,000 TPY from solid digestate
    - *Liquid Fertilizer Production Rate*: 1.6 million gallons from liquid digestate
- **Objective 4**: Validate GHG savings of 5,300 MT $CO_2e$ per year

## Project Results

The Kompogas SLO Facility project was successful and pushed California's technical frontier in the generation of renewable-energy electricity. The AD facility constructed in this project produced electricity using this process for the first time in California. The project achieved its primary four objectives:

Exported 2 million kWh of renewable electricity at a rate of 1.65 million kWh per year.

Processed 31,261 tons of organic feedstock at 25,008 TPY rate.

Produced 7,679 tons of solid fertilizer and compost and 1.5 million gallons of liquid fertilizer at a rate of 6,140 tons and 1.2 million gallons per year, respectively.

Reduced GHG emissions by 762.2 $MTCO_2e$ via renewable electricity production and 4,389.3 $MTCO_2e$ by diverting organics from business-as-usual alternatives at a rate of 609.76 $MTCO_2e$ and 3,511.44 $MTCO_2e$ per year, respectively.

In addition to completing the objectives, the project created seven new jobs in the region, invested more than $24 million in the local community, and will bring more than $1.5 million into the local economy for ongoing operational support and other requirements.

Note that, two major obstacles attributed to the low power production: limited availability of food waste due to gradual SB 1383 implementation and relatively low methane concentrations in the biogas, leading to intermittent engine shutoffs. The first issue was addressed by outreach and education campaign in the community. To address low methene concentration in feedstock glycerin was added to the digester. The result from the test was positive as biogas yieed and methane concentration generally increases when fats, oils, grease, or glycerin is used as a co-substrate, that is, a chemical to facilitate reaction.

The project experienced several unexpected maintenance and operational issues. All of these were unplanned outages largely due to the sand and rocks in the residential green waste. Repairs necessitated shipping spare parts from Europe. In addition, the facility that produced the glycerin was destroyed in a fire, which presented a setback for the project team while a new supplier was secured. Despite these setbacks, there were no major changes during the project construction schedule and actual completion was either on target or ahead of schedule.

## Technology/Knowledge Transfer/Market Adoption (Advancing the Research to Market)

To share information about the project's technology, feasibility, and success, the project team developed an outreach plan on a spectrum of communication platforms for wide distribution. Particularly, presenting to stakeholders and other technical experts in the area of organic waste conversion to energy at different conferences, workshops, and waste expos. The project team held open houses and tours to showcase the Kompogas SLO Facility to educate interested parties. Direct public outreach included dozens of informational and technology-oriented meetings across the state and the US. The project web page targeted potential stakeholders, policy makers, news media, and other future end users of the technology. In addition to two websites, project information appeared on several independent sites for local organizations including San Luis Garbage and the SLO Chamber of Commerce.

Due to the successful outreach efforts by the project team, both SANCO Services and Waste Management of California, Inc. selected The Recipient as a preferred vendor for new facilities in California. Establishing Kompogas SLO Facility as the state's flagship AD facility supporting commercialization of this technology. The California Department of Resources Recycling and Recovery (CalRecycle) awarded both projects funding for safe and effective management of waste streams.

## Benefits to California

A central goal of building this facility was to divert organic wastes from landfills to reduce GHG emissions and convert organic feedstock into a value-added product. To date, HZIU has received 28,225 tons of green waste and 3,126 tons of food waste. Using the California Air Resources Board (CARB) default values, 13,180 tons of green and food wastes were expected to be diverted from landfills.

The following are specific quantified benefits to taxpayers:

- Provided increased reliability to the power grid as a baseload generator.
- Converted local green and food waste to 2 million kWh of renewable electricity.
- Contributed to local waste diversion by processing 31,261 tons of organic feedstock.
- Contributed to local, regional, and statewide reductions in GHG emissions by 5,151.5 MTCO2e by diverting organics from business-as-usual alternatives.
- Produced 7,679 tons of solid fertilizer and compost and 1.5 million gallons of liquid fertilizer for the ratepayers.

In addition to the scoped benefits, the project generated additional benefits for the state. Specifically, according to the CalEnviroScreen Guidance and screen tool, solid waste sites and facilities are negative factors. Kompogas SLO AD facility is removing organic solid wastes and hence positively benefiting the disadvantaged communities (DACs) in the general area by increasing their census tract's score.

# CHAPTER 1: Introduction

## Project Overview

Bioenergy is in a unique position to both reduce greenhouse emissions and produce clean, reliable renewable energy. According to the California Independent System Operator (California ISO), on a day-to-day basis biomass and biogas together produce about 500 megawatts (MW) of electricity or approximately 3 percent of all renewable energy generated during a single day. At night, this percentage grows to 7 percent because, unlike solar and wind, bioenergy is a stable source of fuel that is available 24/7. An increase in bioenergy generation will therefore contribute to reducing overall greenhouse gas (GHG) emissions by displacing natural gas baseline-electricity production.

## Organic Waste Management in California

California currently produces 6 million tons of organic food waste; this represents about 18 percent of the material that ends up in California's 300 landfills. The decomposition of this solid waste produces methane (CH4), which is an 85 percent more potent GHG than carbon dioxide (CO2). To counter this environmental issue, Assembly Bill (AB) 1826 (Chesbro, Chapter 727, Statutes of 2014) and Senate Bill (SB) 1383 (Lara, Chapter 395, Statutes of 2016) were enacted into law to require businesses to improve their organic waste recycling to reduce the state's overall organic waste. Anaerobic digesters (AD) are a viable source of clean, renewable energy that can reduce emissions and help California meet its ambitious mandated renewable-energy goals.

## Bioenergy Production

In the context of renewable energy, bioenergy production has faced a series of barriers that have historically caused developers to be reluctant to build facilities in California. The state and other governing agencies have studied these issues closely. One of the few programs that both incentivizes bioenergy development and eases financial and feedstock barriers is the bioenergy feed-in-tariff (FIT) program known as the Bioenergy Market Adjusting Tariff (BioMAT). Mandated by SB 1122 (Rubio, Chapter 612, Statutes of 2012) in 2015, the California Public Utilities Commission (CPUC) established a program allowing bioenergy facilities to obtain competitive fixed-price standard contracts with investor-owned utilities (IOUs). BioMAT offers up to 250 MW to eligible projects, limiting facilities to between 3-5 MW. Three facility waste streams are incentivized through BioMAT: biogas produced from wastewater treatment, municipal organic-waste diversion, or food processing and co-digestion that together constitute one of the waste streams and received a Category 1 designation. The CPUC oversees this program and requires that 110 MW be developed in this category. HZIU successfully meets Category 1 requirements and operates under the BioMAT program.

A series of policy-driven mandates has encouraged projects like the Kompogas AD facility. A list of some of these key goals follows.

- AB 32 (Nunez, Chapter 488, Statutes of 2006)- The Global Warming Solutions Act of 2006: The project reduces GHG emissions from both the waste management and electric utility sectors.
- The 2012 Bioenergy Action Plan: The project increases bioenergy production consistent with recommendations in the 2012 Bioenergy Action Plan.
- Short-Lived Climate-Pollutant Reduction Strategy: The project reduces methane emissions by beneficially consuming organics to generate renewable energy and reduce on-road black carbon from transportation.
- SB 1122 (Rubio, Chapter 612, Statutes of 2012): The project qualifies for Category 1 status of the BioMAT program, developed through implementation of SB 1122.
- Senate Bill 1383 Lara, Chapter 395, Statutes of 2016: The project increases in-state production of renewable gas through consumption of organics from a municipal-waste stream.
- Assembly Bill 1594 (Williams, Chapter 719, Statutes of 2014): The project provides a cost-effective outlet for the diversion of organics throughout the region.
- Assembly Bill 1826: The project provides a cost-effective outlet for source-separated organics collected from commercial-collection routes.

Even with these supportive state mandates, challenges in California's waste-management sector are multifaceted and involve several state agencies. For one, AB 1826 and SB 1383 will together dramatically increase organic waste streams; additional infrastructure will therefore be required to meet policy goals. Other factors that could influence the success of future AD facilities include feedstock availability, financial feasibility, and technological and regulatory challenges. These concerns are discussed here in more detail.

## Project Description

In 2017, HZIU Kompogas SLO Inc. (The Recipient), was awarded $4 million to support development of California's $25 million Kompogas AD system, the first in the state. Many partners share the success of this community-scale bioenergy facility in proving the technical and economic feasibility of this environmental organic-waste processing project. The project was laid out over seven tasks to plan, construct, install, and monitor this cutting-edge AD technology for its benefits to California and its utility ratepayers. The proposed project is pre-commercial in California. With the challenges of technology adoption and transformation, this first project has higher capital cost associated with first-time engineering and higher risk without local proven performance. The Recipient, in partnership with Waste Connections and Pacific Organics, built, commissioned, and grid-connected, a state-of-the-art high-solids AD facility designed to meet the organics diversion goals of San Luis Obispo County (SLO), in coastal Central California. The Recipient, a subsidiary of Hitachi Zosen Inova USA (HZIU), was established in 2016 to develop and operate this facility, which is centrally located at a Waste Connections truck-parking and maintenance yard at 4300 Old Santa Fe Road in San Luis Obispo, California.

At full capacity, Kompogas SLO AD facility will annually convert up to 36,500 tons of food and urban green waste into 6.8 million kilowatt-hours (kWh) of clean, renewable electricity, 13,000 tons of compost, and 1.6 million gallons of liquid fertilizer. This full-capacity operation is

expected to reduce GHG emissions by 5,300 metric ton (MT) CO2e per year and provide valuable benefits to IOU ratepayers in Pacific Gas and Electric Company's (PG&E's) service territory, including lower costs and electric transmission grid reliability and safety.

Based on a CalRecycle Waste Characterization Study[1], approximately 18 percent of waste headed for a landfill is food waste not currently collected for composting. Recognizing the environmental value of diverting food waste from landfills, Waste Connections has started a program to separately collect food waste from commercial customers and has also initiated a residential food waste collection program. Both programs are important sources of feedstock for the Kompogas SLO AD facility.

## Key Bioenergy Barriers in California

As the first installation in California, this project carries a higher level of financial and technical risk than conventional technologies. The following subcategories describe major barriers for small-scale facilities like Kompogas SLO Facility.

### Feedstock Availability

Feedstock composition and contamination vary by location as well as by collection methodologies and practices. Because of the state mandates just described, the HZIU team could anticipate organic waste streams from municipal waste. Entering into long-term feedstock agreements, however, could create future barriers for several reasons.

HZIU partnered with Waste Connections—the franchised waste collection service provider in the SLO region—to secure a long-term source of feedstock from both residential- and commercial-collection routes. The feedstock is a mixture of food waste and urban green waste that primarily consists of items such as grass clippings and yard trimmings. This urban green waste was previously either composted at an out-of-county windrow facility or used as alternative daily cover (ADC) at the Cold Canyon Landfill. Additional proposed food waste is currently sent to an out-of-county windrow facility.

Based on the most recent CalRecycle waste characterization study,[2] approximately 18 percent of waste that goes to landfills is food waste and is currently not collected for composting. Recognizing the importance of diverting food waste from the landfill, Waste Connections started a program to separately collect food waste from commercial customers and also initiated a residential food-waste collection program.

Feedstock competition can also pose a risk to reliable feedstock procurement. HZIU addressed this risk early on by partnering with Waste Connections. The two alternative disposal methods for existing feedstock are the Cold Canyon Landfill and composting. The Cold Canyon Landfill is owned and operated by Waste Connections and must now divert its organic materials to

1 "2014 Disposal-Facility-Based Characterization of Solid Waste in California" CalRecycle. October 6, 2015. http://www.calrecycle.ca.gov/Publications/Documents/1546/20151546.pdf.

2 "2014 Disposal-Facility-Based Characterization of Solid Waste in California" CalRecycle. October 6, 2015. http://www.calrecycle.ca.gov/Publications/Documents/1546/20151546.pdf

meet statewide requirements that organics not be used as ADC. There is very limited composting capacity in the project's local area, which will require significant investment for transporting organics to nearby facilities.

## Financial Feasibility

The Kompogas SLO Facility represents the first installation of Kompogas technology in California and is one of the state's first high-solids AD facilities to exclusively focus on organic residue recovered from residential and urban waste. As the state's first installation, the project carried a higher level of financial and technical risk than conventional technologies. This additional risk is typically reflected in a substantially higher contingency for new technologies, which in turn increased capital-investment requirements.

Energy Commission funds directly mitigated this elevated capital cost risk and helped reduce its financial risk. By providing resources to mitigate this early risk, Energy Commission funding helped bridge this difficult gap—often called the "valley of death"— toward product commercialization. This demonstration of a full-scale, commercial installation in one of the state's strictest air districts provides the technical and economic validation needed to facilitate adoption of this technology at future sites.

Additionally, the HZIU project qualifies as Category 1 feedstock procurement BioMAT, further reducing financial pressures.

## Technological Challenges

AD technologies have been commercially available for decades though their widespread installation has remained limited. Some of the hurdles to its adoption include engineering conversion to customary, regulated U.S. units, spare parts availability, and transportation restrictions. Seismic regulations also add to the complexity of building these facilities in California.

Kompogas technology has been deployed widely throughout Europe and Asia including in Poland, Switzerland, Portugal, Denmark, the Netherlands, France, Italy, Spain, Austria, Qatar, and Japan. The project team brought this broad technical experience, with its proven history of more than 4,400,000 operating hours across 90 separate global sites, to the SLO site. The business models for technologies globally differed significantly from those in California, so the team expended considerable effort in both converting the European technology design to U.S. standards and validating the California business model.

## Regulatory Challenges

HZIU operates in one of the state's strictest air districts: the SLO Air Pollution Control District (SLOAPCD). In addition to state regulations on air quality, including Title V, the SLOAPCD has additional regulations for compost and water management that govern post-processing requirements of solid and liquid digestate. This proved to be a significant hurdle for both the project team and SLOAPCO. However, by collaborating closely with staff at the air district, HZIU was able to overcome hurdles related to AD technology and complete the construction, commissioning, and interconnection of the project within the project's time frame.

Additionally, the project team worked with Pacific Organics, a regional expert in the compost industry, the SLO Planning and Building Department, and TetraTech, a leading engineering firm, to comply fully with regulations within both the county and airshed.

## Project Need and Technical Merit

This project is a unique public-private partnership between a local community, a franchised waste hauler, and an established technology provider. The project is the result of a deep commitment by the communities in SLO to proactively address organics management in the most socially responsible manner possible. Additionally, the facility incorporates a number of characteristics that increase its technical merit: (1) the technology is not commercially available in California; (2) is not duplicative of past projects funded by the Energy Commission, utilities, or any other entities; and (3) is needed to promote adoption of innovative AD technologies.

In response to AB 1594 and AB 1826, the SLO Integrated Waste Management Authority (IWMA) coordinated with Waste Connections to identify and forecast opportunities for organics waste diversion from current and planned organics-collection programs. Based on its findings, Waste Connections conducted a thorough technology assessment through a competitive solicitation to identify HZIU as its technology partner and facility operator.

Waste Connections and the SLO IWMA coordinated with multiple regional cities (Arroyo Grande, Grover Beach, Morro Bay, Pismo Beach, and San Luis Obispo), numerous community service districts (Avila, Cambria, Cayucos, Los Osos, Nipomo, and Oceano), and the unincorporated areas of SLO to provide reliable, long-term sources of feedstock. These entities are collectively referred to as "local communities" throughout this report.

Throughout the development of the Kompogas SLO Facility, project partners sought to reduce overall transportation costs and emissions associated with urban-waste disposal; promote value-added local businesses; produce renewable-resource electricity; minimize additions to landfills; and reduce GHG emissions, especially methane. The project provides sufficient technoeconomic validation to bring this advanced technology from Europe to California.

Kompogas SLO Facility produces renewable electricity through the anaerobic digestion of food waste and urban green waste. Renewable electricity is sold to PG&E via a power purchase agreement (PPA). The feedstock stream is eligible feedstock under Category 1 of the BioMAT program and, as previously mentioned, this first installation in California carried a higher degree of financial and technical risk than conventional technologies.

## Technology

Technology installed at Kompogas SLO Facility has proven successful in more than 90 other locations throughout Europe and Asia. This AD facility meets county and state standards for receiving organic waste from municipal sources has a dry fermentation, robust agitation process, and is compatible with both bio-waste and green waste. The facility produces 100-percent renewable-resource electricity, high-grade soil amendments, and liquid fertilizer.

**Figure 1: Overview of the Kompogas SLO Facility**

| Waste Receiving and Storage | Anaerobic Digestion | Digestate Discharge and Treatment | Biogas Upgrading and Power Generation |
|---|---|---|---|
| Tipping floor | Plug-flow digester | Discharge pump | Biogas upgrading |
| Bucket loader, Waste crane | Agitator | Dewatering press | Cogeneration plant |
| Shredder, magnet, screen | Inoculation pipe | Compost treatment | Transformer/ grid |
| Tipping hall ventilation | | Liquid digestate treatment | CNG storage/ fuel station |

Source: Kompogas SLO LLC

The Kompogas process is based on the dry digestion of solid organic waste in an oxygen-free environment. There are three byproducts of this process: biogas, solid digestate, and liquid digestate.

- Biogas is composed primarily of methane ($CH_4$) and carbon dioxide ($CO_2$), with trace amounts of hydrogen sulfide ($H_2S$) and ammonia ($NH_3$). Typically, biogas is saturated with water vapor and may contain trace amounts of hydrogen ($H_2$), nitrogen ($N_2$), and oxygen ($O_2$). Biogas can be directly combusted (after $H_2S$ and moisture removal) in a combined heat-and-power (CHP) facility to produce both renewable-resource electricity and, for on-site use, thermal heat.
- Digestate is the remaining solid (or liquid residual) from the AD process. This material can be used as an important soil amendment for agricultural purposes.

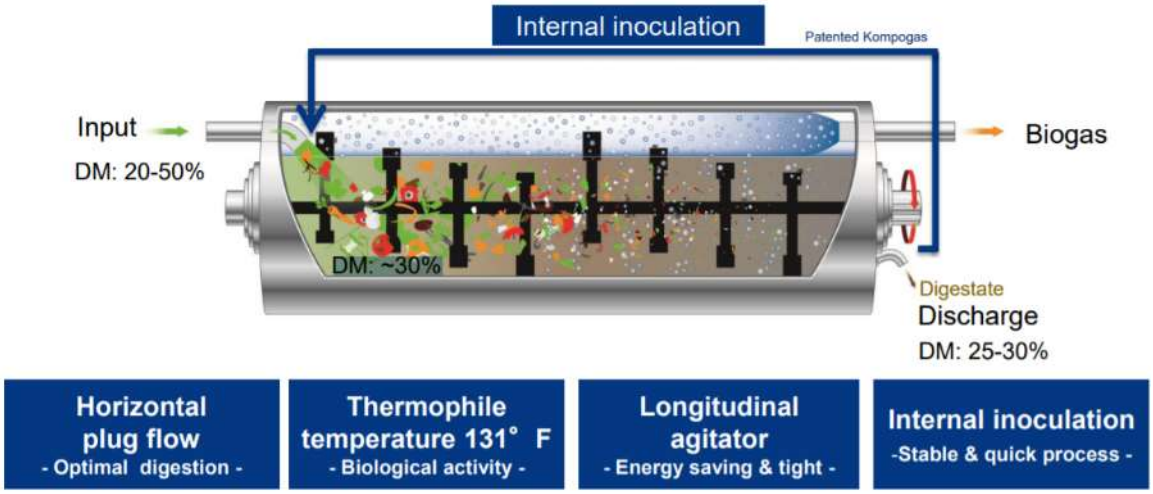
## Step 1: Feedstock Collection

The Kompogas facility uses food waste and urban green waste collected by Waste Connections from local communities that serve 58,000 customers. All organic-material handling is confined to closed and ventilated rooms to minimize odors. High-speed automatic roll-up doors allow trucks to enter the facility and close immediately upon their safe entry. The material is then fed into the processing area by a wheel loader, where it is shredded and screened into pieces approximately two inches big. A star screen removes contaminants like plastic, paper, and other non-organic items. Ferromagnetic particles are also removed with a magnet. The pre-treated material is then transported to an intermediate storage bunker before being picked up by an automated crane and fed into the AD system.

## Step 2: Anaerobic Digestion Facility

The continuously fed, horizontal plug-flow digester (Figure 2) has a nominal capacity of 1,800 $m^3$ (64,000 cubic feet) at a filling level of approximately 85 percent. The digester is a patented steel structure with a special heating system consisting of a central-heat distribution system (installed beneath the digester) and a series of heating lances inserted throughout the digester shell to ensure that the process temperature is reached rapidly and constantly maintained.

**Figure 2: Rendering of the Anaerobic Digestion Process**




Source: Kompogas SLO LLC

The organic waste is anaerobically digested for approximately 14 days in the plug-flow digester at 131°F, which ensures its full sanitation. Biogas is continuously generated, cleaned, and used on site in an internal combustion engine generator set.

## Step 3: Digestate Management

The remaining digestate is removed from the digester by the discharge pump and dewatered by screw presses, which separate the digested substrate into press cake (solid digestate) and press water (liquid digestate). The liquid digestate is piped to a tank where it is treated by an advanced mechanical-water treatment system (decanter) and a portion is recirculated to moisten the input feedstock material.

Solids digestate is taken from underneath the dewatering presses with a shovel loader and deposited into one of several open boxes. The solid digestate is then subject to aerobic stabilization and volatile organic compounds are removed. Air is blown for approximately 21 days through the material through ventilation channels in the floor, enabling its rapid aerobic stabilization.

# CHAPTER 2:
# Project Approach

## Project Purpose

This project supports the development, installation, and interconnection of a state-of-the-art high-solids AD facility designed specifically to meet the organics diversion goals of SLO and the State of California. The project converts up to 36,500 tons per year (TPY) of food waste and urban green waste into 6.8 million kWh of renewable electricity per year, 13,000 tons of compost, and 1.6 million gallons of liquid fertilizer. The project reduces GHG emissions up to 5,300 metric tons (MT) CO2e per year and provides ratepayer benefits in PG&E's service territory including grid reliability, safety, and cost savings.

Because this facility is the first-of-its-kind in California, its successful completion is a model for other jurisdictions to replicate throughout the state. Both technology and knowledge transfer were critical to its successful development. The project has brought many interested parties together to discuss its key successes and issues associated with developing AD facilities in their own respective regions.

Kompogas SLO Facility sells renewable electricity to PG&E through a PPA acquired through BioMAT. The feedstock is an eligible feedstock under Category 1 of the BioMAT program.

## Project Goals

The project had several goals aligned with the state's Electric Program Investment Charge (EPIC) program and other California legislative and regulatory environmental goals.

- Goal 1: Prove the technical and economical operation of a unique, community-scale bioenergy facility using Kompogas technology that converts local organic waste into renewable-resource electricity, compost, and fertilizer while meeting California's strict environmental codes and standards.
- Goal 2: Meet local and state renewable-energy and waste-diversion goals through collaboration with local governments and agencies, local communities, businesses, waste haulers, and food banks.
- Goal 3: Contribute to local, regional, and statewide reductions in criteria air pollutants, short-lived climate pollutants, and GHG emissions.

## Project Objectives

The project's primary objectives were to:

1. Produce renewable electricity under a PPA.
    a. Power production: Average 733 kilowatts (kW)
    b. Energy production: Average 85 percent capacity factor, capable of producing 6.2 million kWh of renewable electricity per year
2. Develop a facility to process local organic and green waste.
    a. Average daily feed rate: 100 tons per day

b. Maximum annual feed rate: 36,500 TPY

3. Create value-added fertilizer by-products.
    a. Solid fertilizer production rate: 13,000 TPY from solid digestate
    b. Liquid fertilizer production rate: 1.6 million gallons from liquid digestate
4. Validate GHG savings of 5,300 MT $CO_2e$ per year.

# Project Team

## Hitachi Zosen Inova

Hitachi Zosen Inova, founded in 1933 as a steel mill and foundry, is today a premier industrial group with global reaches in both thermal-energy generation and environmental technology. Hitachi Zosen Inova acquired Kompogas technology in 2014. More than 90 Kompogas AD plants are operating in 10 countries around the world. However, the Kompogas AD technology had not been exported to the United States before this project.

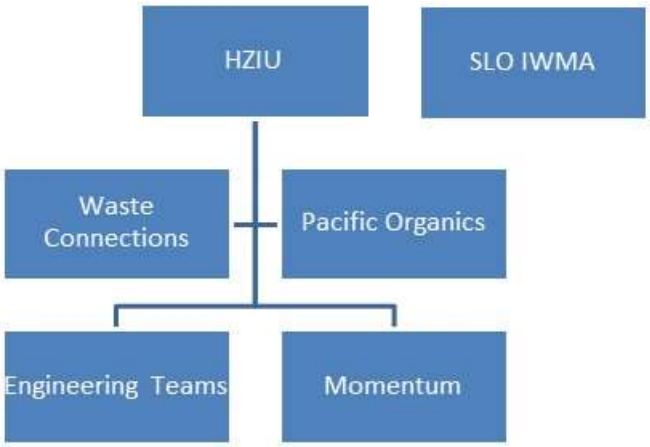
Hitachi Zosen Inova is the parent company of HZIU Kompogas SLO Inc., the special-purpose entity established in 2016 to own and operate the Kompogas SLO Facility and provide the plant's design and engineering in addition to its contracted long-term operation.

# Collaboration with Utilities, Industries, and Others

The project team included a variety of stakeholders including Waste Connections, Pacific Organics, and the SLO IWMA. Waste Connections is an important industry participant that provides long-term feedstock for the project through franchise agreements with local communities. Pacific Organics uses the compost produced through the anaerobic digestion process and provides an interface with competitive agricultural markets. Public agency collaboration, specifically SLO IWMA and local communities, are valuable members of the project team; together they helped ensure that the project reached critical permitting milestones in both timely and cost-effective manners. Lastly, through its participation in the BioMAT program, PG&E was an important utility partner in guaranteeing an important long-term revenue stream through a PPA that anchors the project's financial viability.

In addition to the partners, the project team retained highly qualified and experienced California-based engineering firms including Oasis Associates (San Luis Obispo) as the project planner, Studio Design Group (San Luis Obispo), as the project architect, TetraTech (San Luis Obispo), for the project's civil and electrical engineer, Collings & Associates (Ventura, California), as the project's fire protection engineer, and Dennis Shallenberger (San Luis Obispo), as the project soils engineer. Finally, the project team benefitted from using Momentum for its support and guidance through all stages of grant administration and management. The organizational structure of the entities that made this project possible appears in Figure 3.

**Figure 3: Organization Structure with Partners**




Source: Kompogas SLO LLC

## Tasks and Key Deliverables

The project encompassed three major technical tasks in addition to non-technical tasks associated with project administration and reporting (Task 1). The technical tasks included:

- Task 2, project preparation: The goals of this task were to secure the project site at 4300 Old Santa Fe Road in San Luis Obispo, California, and develop a detailed measurement and verification plan. That plan included a description of monitoring equipment and instrumentation, measurable key input parameters and output metrics, and selected analysis methods.
- Task 3, construction and commissioning: The goal of this task was to construct and commission the community-scale bioenergy facility, using Kompogas technology, to prepare the facility for commercial operation. Key deliverables included a construction management plan and a construction report describing the construction approach, and testing plans and testing reports documenting the commissioning process.
- Task 4, operations, data collection, and analysis: The goal of this task was to commercially operate the community-scale bioenergy facility for at least six months and collect data on that operation.

## Project Challenges

Kompogas SLO Facility worked through several important challenges expected to be common across other related technologies and anaerobic digestion facilities. A summary of those challenges follows.

Project Coordination: Kompogas SLO Facility works closely with Waste Connections, the local franchised hauler, to better understand the process and management of feedstock collection for anaerobic digestion. This is the first time that residents and businesses supported diversion for an anaerobic digestion facility, so it was not surprising that the level, depth, and breadth of education needed to improve the feedstock consistency was initially underestimated.

Feedstock Composition: The implementation of Senate Bill 1383 has been unavoidably delayed across the state due to multiple factors generally outside the control of Waste Connections. These delays have resulted in lower food-waste percentages in the incoming feedstock stream and therefore lower biogas yields (though without negative impacts on the facility itself).

Feedstock Contaminants: The project team worked closely with Waste Connections to accurately evaluate the incoming feedstock. Given the facility's coastal geography, however, initial operations were contaminated with sand. This sand contamination has required additional pre-processing equipment to avoid excessive wear and tear of the equipment. During the project's first year of operation, there was a high proportion of woody biomass in the yard waste delivered to the facility. As discussed earlier, this resulted in a few technological challenges and repairs were made to the shredder to accommodate this feedstock.

In the first quarter of 2020, food-waste suppliers began testing AD compatibility. Colony Energy Partners-Tulare, LLC., sent food waste and other green materials from the Paso Robles collections area. The process worked well and the project team is expected to collect more in the future.

# CHAPTER 3:
# Project Execution

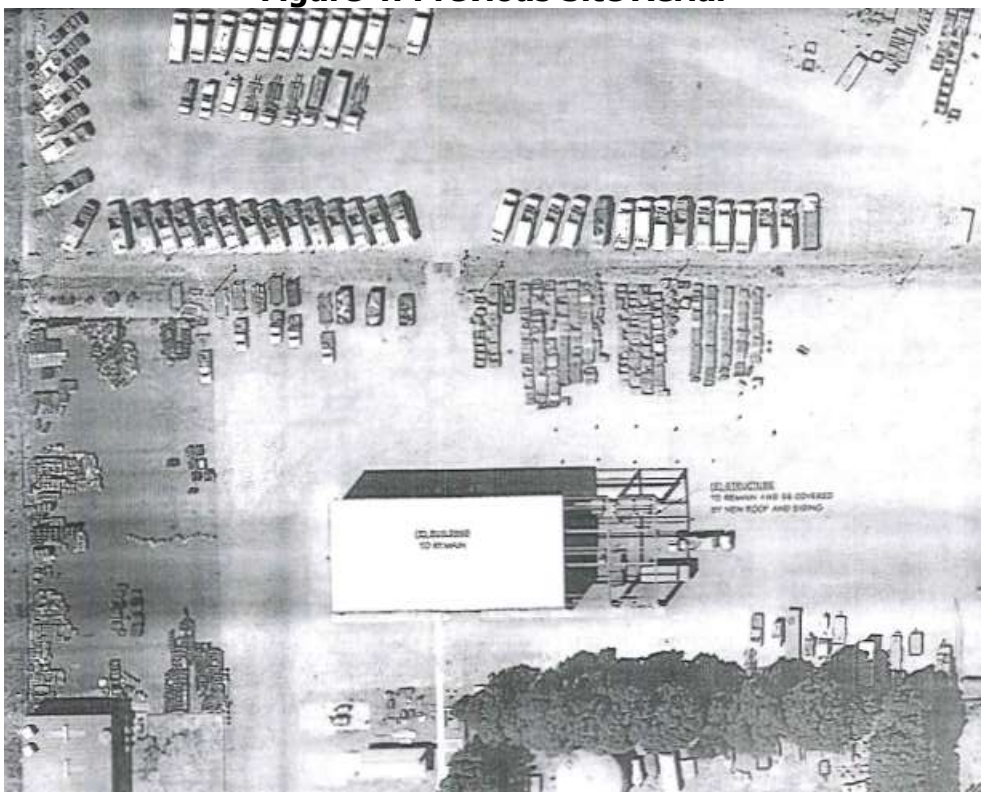
## Site Preparation

### Site Selection

As the technology vendor, Hitachi Zosen Inova was part of the larger process of identifying the site for the Kompogas SLO anaerobic digestion facility. The eventual site, located at 4300 Old Santa Fe Road in San Luis Obispo, California, was selected for several reasons.

- Zoning: The site was zoned as industrial.
- Use: The site was previously used as part of Waste Connection's solids management operations.
- Size: The overall Kompogas SLO Facility operations required approximately 4.8 acres of the 12.5-acre site.
- Ownership: Waste Connections, a project partner, owned the site.

**Figure 4: Previous Site Aerial**



Source: Kompogas SLO LLC

## Site Permitting

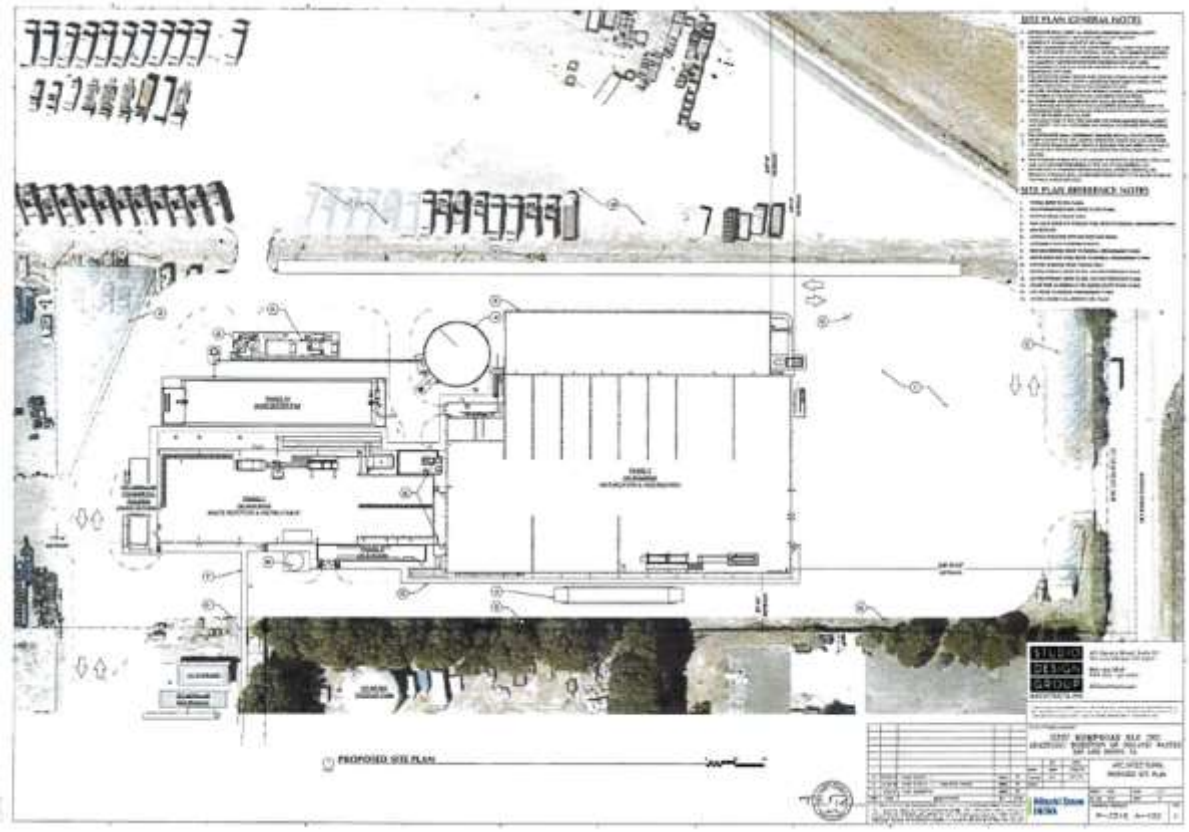
The project team completed a rigorous and detailed permitting process to secure all approvals for the project, including:

- Conditional Use Permit: This permit triggered a detailed California Environmental Quality Act (CEQA) review that required potential impacts to be evaluated and mitigation measures addressed. Overall, the evaluation process ultimately resulted in a mitigated negative declaration, which validated its expected minimal environmental impacts and how any potential impacts could be mitigated. Many of the identified mitigations are considered standard operating procedures, including plans to control odors and fugitive dust and provide fire safety and exterior lighting. The Kompogas SLO Facility site is also unique because of its proximity to the SLO Regional Airport; specific mitigation measures were required during both design and construction to minimize reflections and glare that could affect pilots.
- Grading Permit: This was obtained after a standard permit process without unique considerations or requirements.
- Building Permits: These were obtained after a standard permit process without unique considerations or requirements.
- Air Permits: An authority to construct and a permit to operate were required for the biogas engine generator, flare, and biofilter. These permits included the development and submission of an odor control plan, CHP inspection and maintenance (I&M) plan, and a biofilter I&M plan. Additional design and operating conditions were required for the exhaust stack height, metering and testing equipment, emissions limits, conditioning systems (including gas H2S removal), selective catalytic reduction systems, and oxidation catalysts. These requirements are standard and were expected.
- Stormwater Prevention Plan Permit: This was obtained after a standard permit process without unique considerations or requirements.

## Site Design

The anaerobic digestion development site was leased to The Recipient and site plans were provided to the CEC mid-December 2017 (Figure 5).

**Figure 5: Initial Site Layout**



Source: Kompogas SLO LLC

## Construction Process

Project construction was completed in late 2018 and early 2019. Several deliverables related to facility construction were provided to the Energy Commission between the third quarter of 2018 and the second quarter of 2019. Deliverables related to construction included a construction management plan, major project change lists, written notification of completion of construction and installation, a draft construction report, and a final construction report.

The construction management plan identified the construction management team, key construction and installation milestones, and preferred equipment vendors. The construction plan also provided a construction schedule and Gantt bar chart, identified construction best-management practices, outlined a risk-mitigation strategy, and provided a series of quality assurance/quality control (QA/QC) procedures. The project team adhered to the requirements and guidance outlined in the construction management plan during the construction and installation processes.

**Figure 6: Facility Design (left) and Facility Build Completed (right)**

Source: Kompogas SLO LLC

There were no major project changes during the construction project and actual completion was either on target or ahead of schedule, as shown in Table 1.

**Table 1: Schedule of Completed Milestones**

| Milestone | Construction Management Plan | Actual Completion |
|---|---|---|
| **Groundbreaking** | **12/15/2016** | **12/15/2016** |
| **Civil Works** | **1/5/2018** | **1/5/2018** |
| Site, Pad, Utilities Installation | 9/21/2017 | 9/21/2017 |
| New Hall and Biofilter | 11/24/2017 | 11/24/2017 |
| Pre-Engineered Metal Building | 12/7/2017 | 12/7/2017 |
| Existing Hall | 12/6/2017 | 12/6/2017 |
| E-House Foundation | 12/8/2017 | 12/8/2017 |
| Equipment Foundations | 1/5/2018 | 12/22/2017 |
| Building Services | 1/3/2018 | 1/3/2018 |
| **Electro-Mechanics** | **5/23/2018** | **5/23/2018** |
| Digester System | 4/19/2018 | 4/19/2018 |
| Gas Systems | 3/27/2018 | 1/4/2018 |
| Liquid Storage | 3/27/2018 | 1/4/2018 |
| Pretreatment | 5/10/2018 | 5/10/2018 |
| Posttreatment | 5/10/2018 | 5/10/2018 |
| CHP System | 5/23/2018 | 5/23/2018 |
| Pump Room | 5/23/2018 | 5/23/2018 |
| Pneumatics | 5/23/2018 | 5/23/2018 |
| Biofilter | 5/23/2018 | 5/23/2018 |
| HVAC | 5/23/2018 | 5/23/2018 |
| EIC | 5/23/2018 | 5/23/2018 |
| **Test Run** | **9/26/2018** | **9/26/2018** |
| **PAC** | **11/14/2018** | **11/14/2018** |

Source: Kompogas SLO LLC

Figure 7 through Figure 11 show site photos taken during construction.

**Figure 7: December 2017: Site Completion (left), Digester Construction and Center Shaft Alignment and Installation Inspection (right)**

Source: Kompogas SLO LLC

**Figure 8: February 2018: Conveyor Construction (left), Tank Construction (right)**

Source: Kompogas SLO LLC

**Figure 9: May 2018: Star Sieve Installation (left), Switch Gear Set and Anchored (right)**

Source: Kompogas SLO LLC

**Figure 10: June 2018, Bio-Filter Wall and Plenum Installed (left), Poles Set for PG&E Interconnection (right)**

Source: Kompogas SLO LLC

**Figure 11: Entrance to the Receiving Hall at the Completed Kompogas SLO Facility**

Source: Kompogas SLO LLC

A time-lapse video was also taken during construction. The video can be found online at: https://app.truelook.com/?m=14925893730172864435945#tl_shared. Figure 12 through Figure 16 show photographs of major construction milestones.

**Figure 12: Time-Lapse Image 1 of 5: Feedstock Receiving Facility Constructed**

Source: Kompogas SLO LLC

**Figure 13: Time-Lapse Image 2 of 5: AD Reactor Structure Components Installed**

Source: Kompogas SLO LLC

**Figure 14: Time-Lapse Image 3 of 5: AD Reactor Enclosed**

Source: Kompogas SLO LLC

**Figure 15: Time-Lapse Image 4 of 5 – Gas Conditioning Skids and Engine Equipment Installed**

Source: Kompogas SLO LLC

**Figure 16: Time-Lapse Image 5 of 5 – Ready for Operation**

Source: Kompogas SLO LLC

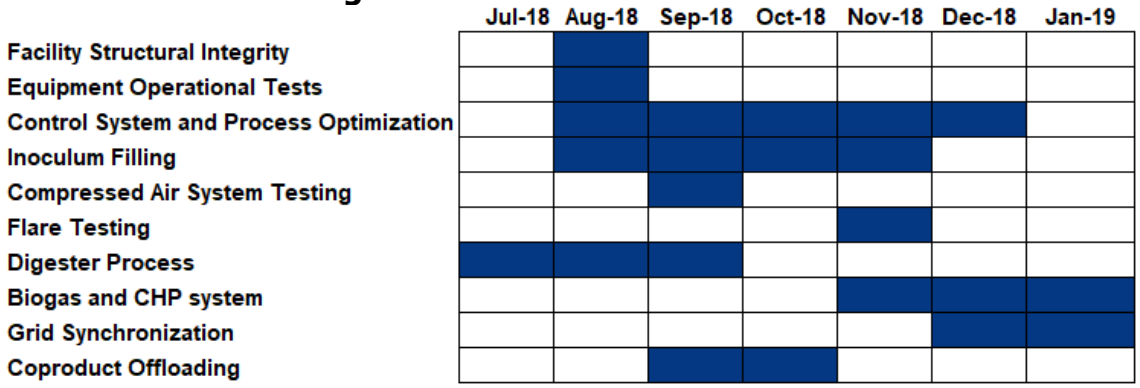
## Facility Commissioning

Consistent with approved testing plans, HZIU deployed specific test conditions and procedures for three key facility processes during commissioning:

- Inoculum Filling (cold)
- Compressed Air System (cold)
- Flare System (cold)
- Digester Process (hot)
- Biogas and CHP Systems (hot)
- Grid Synchronization (hot)
- Co-product Offloading (hot)

During cold commissioning, devices and equipment were tested either individually or in tandem with other related equipment before starting up the primary process chain. In contrast, hot commissioning, which typically follows cold commissioning, entailed testing processes and equipment on site during initial, preliminary operations. Commissioning results were documented daily by testing engineers and summarized in the Cold and Hot Testing Report.

**Figure 17: Commission Timeline**




Source: Kompogas SLO LLC

One change was made based on findings of the cold- and hot-testing processes. Clogging of the process discharge line was observed during the testing process. This issue was managed through an update and design change, which included installation of new line elements that alleviated the clogging issue.

By February 2019, the facility completed its first stage of commissioning and was ready for start-up operations. AD systems are made up of a complex microbiome with living organisms that serve as the operational foundation of the system. AD start up is therefore typically a two-year process where system engineers monitor microbes and feedstock to grow and develop a healthy ecosystem.

# Facility Operations

## Electrical Interconnection

The project team retained TetraTech, a California engineering firm, to assist with the interconnection study. The team completed initial review (January 25, 2016) and the electrical independence test (June 10, 2016), and initiated the system impact study on July 12, 2016. The team received the test results in October 2016. Upon completion of the system impact study, the project followed through with the remaining registration steps required for participation in the BioMAT auction.

In September 2019 the project received its commercial operation permit by PG&E to enable billing the utility for electricity delivered to the electric grid. This was an important and groundbreaking milestone. The Kompogas SLO Facility was only the second facility to participate in the BioMAT program; it was the first to begin construction after the BioMAT program was created.

## Process Improvements

In June 2019 operations staff from Cesaro Mac Import, an Italian company with experience in AD plant operations, agreed to review this project to suggest changes or modifications. The project team sought additional system review from Engineered Compost Systems of Seattle, Washington, to further fine-tune operations. Cesaro Mac Import suggestions included adding additional ventilation in the compost hall to allow dryer air in the drying process, installing a smaller screening-and-sieve system, reworking the ventilation system at the bottom of the compost piles to allow more air flow, and installing additional temperature and moisture probes. Those probes would be attached to the project's supervisory control and data acquisition (SCADA) system, which would allow automated fan controls and a hot-water exchange system (utilizing existing heat from the CHP) to assist heating the air before introducing it into the drying process.

The project team integrated a suggestion from the Cesaro Mac review and sought ways to improve the drying process, which at the time was forcing air up through a system of fans, essentially blowing moist air onto moist material. Specifically, a ventilation system was installed that would bring in outside air to improve the drying process. Before Cesaro Mac's suggestions, the team had already installed and commissioned a smaller screen and sieve system.

While testing a glycerin addition to the digester was positive as biogas yield and methane concentration generally increases when fats, oils, grease, or glycerin is fed into the anaerobic digestion process, the facility that produced the glycerin was destroyed in a fire, which presented a set-back for the project team while a new supplier was secured.

During November and December, theproject experienced several unexpected maintenance issues. Efforts to repair the shredder and belt system, overhead crane, and dewatering system reduced feedstock loading at that time. All of these were unplanned outages largely due to the sand and rocks in the residential green waste. Repairs necessitated shipping spare parts from Europe, further adding to the down time. The project analyzed the frequency of repairs and stocking necessary spare parts for future use. These types of repairs did not usually occur in similar plants located in Europe.

There were odor issues in the first three months that generated some complaints, but none since the biofilter sprinkler system was installed. The sprinklers use about 2,000 gallons of water per day in the summer and little-to-no water in the winter. The wood chips in the biofilter should last seven-to-eight years. If food waste becomes a major component of the feedstock and odors increase, an ammonia scrubber may be required.

During the project's first year of operation, there was a high proportion of woody biomass in the yard waste delivered to the facility. As discussed earlier, this resulted in a few technological challenges and repairs were made to the shredder to accommodate this feedstock.

In the first quarter of 2020, food-waste suppliers began testing AD compatibility. Colony Energy Partners-Tulare, LLC., sent food waste and other green materials from the Paso Robles collections area. The process worked well and the HZIU project team is expected to collect more in the future.

# Data Collection and Results

## Data Collection Methodology

To perform the tasks in the project 15 types of data needed to be collected during the duration of the project to analyze and hence assess the throughput, usage, operation, production process, and output. The data collection plan was submitted in April 2019. The plan is included in this report for completeness in Table 2 which summarizes the types of collected data, the locations from where the data were extracted and the frequency at which the data collections were performed within the Kompogas SLO Facility. During ongoing operations, HZIU collected data based on this list, and assembled the data into a central database for future analysis.

**Table 2: Data Collection Methodology Summary**

| Target Parameter | Units | Collection Location | Frequency |
|---|---|---|---|
| **Throughput, Usage, and Operations** | | | |
| Total Feedstock Received | Tons | Scale during delivery | Following each delivery |
| Green waste Feedstock Received | Tons | Scale during delivery | Following each delivery |

| Target Parameter | Units | Collection Location | Frequency |
|---|---|---|---|
| Commercial Food Waste Received | Tons | Scale during delivery | Following each delivery |
| Contaminants Rejected | Tons | Scale during haul-out | Following each haul-out |
| Feedstock Injected into Digester | Tons | Feedstock injection | Daily |
| Digester Uptime | Hours | SCADA system | Continuous |
| Digester Downtime | Hours | SCADA system | Continuous |
| **Production Process** | | | |
| Digester Temperature | Degrees C | Digester | Continuous |
| Digester pH | pH units | Digester | Monthly |
| Biogas Volume | $Nm^3/d$ | Meter downstream of digester | Continuous |
| Biogas Composition | % $CH_4$, | SCADA System | Monthly average |
| **Outputs** | | | |
| Electricity | kWh | Utility meter | Continuous |
| Biogas Flared[3] | $Nm^3/d$ | SCADA | As needed |
| Fertilizer Produced | Tons | Scale during haul-out | Following each haul-out, tons per month |
| Other / Back End Rejects (Items screened from finished product) | Tons | Scale during haul-out | Following each haul-out, tons per month |

Source: Kompogas SLO LLC

## Parameter Trend

The data that were collected over 15 months of operation according to the schedule in Table 2 are presented in Table 3 and Table 4. These time history of operation parameters that represent specifications and monthly measurement of the throughput, usage, operation, production process, and output of Kompogas SLO facility were used to estimate the four primary targets proposed in the project objectives. In particular, Table 3 and Table 4 lists the 15 parameters, which includes monthly received and injected feedstock quantities, digester temperature, chemical composition, monthly electric generation, compost and liquid digestate production. These data were plotted in the following figures to identify the trend of throughput, usage, and production.

[3] Biogas flared is only measured during flaring.

**Table 3: Parameter Trend Summary (April 2019 – December 2019)**

| | Apr-19 | May-19 | Jun-19 | Jul-19 | Aug-19 | Sep-19 | Oct-19 | Nov-19 | Dec-19 |
|---|---|---|---|---|---|---|---|---|---|
| **Throughput, Usage, and Operations** | | | | | | | | | |
| Total Feedstock received (tons) | 3162 | 2835 | 2654 | 2823 | 2502 | 1754 | 1959 | 893 | 429 |
| Green waste feedstock received (tons) | N/A | 2656 | 2478 | 2624 | 2267 | 1634 | 1652 | 628 | 172 |
| Commercial Food waste received (tons) | N/A | 179 | 175 | 198 | 235 | 210 | 307 | 264 | 257 |
| Contaminates Rejected (tons) | N/A | N/A | N/A | N/A | N/A | N/A | 5.39 | 6.9 | 10.33 |
| Feedstock injected into Digester (metric tons) | 2618 | 2232 | 2408 | 2302 | 2159 | 1611 | 2127 | 682 | 665 |
| Digester Uptime (hours) | 407 | 744 | 720 | 744 | 744 | 720 | 744 | 720 | 744 |
| Digester Downtime (hours) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CHP Runtime (%) | 56.5% | 85.8% | 94.2% | 92.7% | 97.8% | 42.0% | 50.3% | 26.9% | 9.4% |
| **Production Process** | | | | | | | | | |
| Digester temp avg / month (F) | 129.8 | 131.3 | 130.6 | 128.8 | 129.8 | 121.6 | 126.2 | 129.3 | 131.6 |
| Digester pH | | 7.8 | 7.91 | 7.66 | 7.84 | 7.93 | 7.7 | 7.93 | 7.95 |
| Biogas Volume (Nm3/d avg) | 5676 | 5480 | 6157 | 6068 | 6109 | 4749 | 5178 | 3535 | 3227 |
| Biogas Composition (% CH4 avg) | 52 | 52 | 50.1 | 48.8 | 51.1 | 46.3 | 52.3 | 50.9 | 51.4 |
| **Outputs** | | | | | | | | | |
| Electricity to Grid (kWh / month) | 47991 | 110731 | 253048 | 238697 | 253181 | 83811 | 117377 | 63756 | 21271 |
| Biogas Flared (Nm3/d per month) | 25 | 13 | 5 | 8 | 4 | 23 | 24 | 21 | 27 |
| Fertilizer/Compost Produced (tons/month) | 250 | 883 | 611 | 810 | 582 | 306 | 604 | 508 | 263 |
| Rejects to ADC (tons/month) | 1739 | 1413 | 1341 | 1461 | 1311 | 562 | 1873 | 771 | 371 |
| Liquid Digestate Produced (gal/month) | 223990 | 214070 | 162640 | 97530 | 116510 | 44850 | 25790 | 131480 | 153391 |

Source: Kompogas SLO LLC

**Table 4: Parameter Trend Summary (January 2020 –June 2020)**

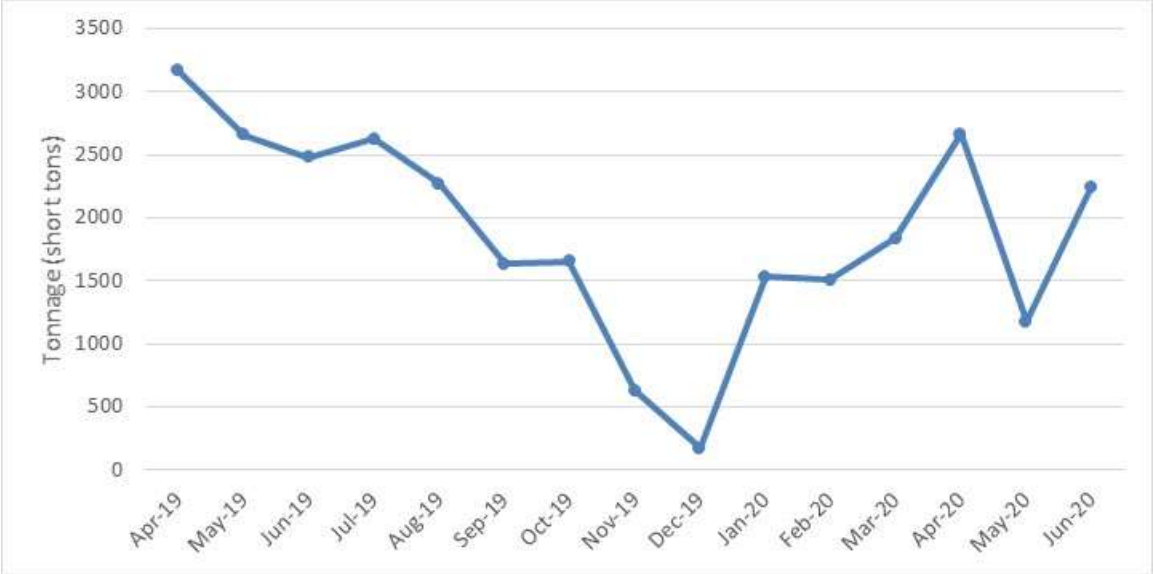
| | Jan-20 | Feb-20 | Mar-20 | Apr-20 | May-20 | Jun-20 |
|---|---|---|---|---|---|---|
| **Throughput, Usage, and Operations** | | | | | | |
| Total Feedstock received (tons) | 1788 | 1723 | 2068 | 2878 | 1341 | 2451 |
| Green waste feedstock received (tons) | 1533 | 1507 | 1835 | 2662 | 1178 | 2237 |
| Commercial Food waste received (tons) | 255 | 216 | 233 | 216 | 164 | 214 |
| Contaminates Rejected (tons) | 12 | 27 | 21 | 42 | 19 | 31 |
| Feedstock injected into Digester (metric tons) | 1589 | 1599 | 1713 | 2555 | 1843 | 2434 |
| Digester Uptime (hours) | 744 | 696 | 744 | 720 | 744 | 720 |
| Digester Downtime (hours) | 0 | 0 | 0 | 0 | 0 | 0 |
| CHP Runtime (%) | 71.4% | 83.6% | 61.2% | 83.5% | 44.2% | 89.3% |
| **Production Process** | | | | | | |
| Digester temp avg / month (F) | 131.2 | 131.7 | 131.1 | 131.4 | 131.3 | 130.9 |
| Digester pH | 8.15 | 8.10 | 8.70 | 8.10 | 8 | 7.75 |
| Biogas Volume (Nm3/d avg) | 4580 | 4842 | 4380 | 5020 | 4459 | 5687 |
| Biogas Composition (% CH4 avg) | 53.1 | 51.0 | 50.5 | 50.3 | 50.7 | 49.0 |
| **Outputs** | | | | | | |
| Electricity to Grid (kWh / month) | 146846 | 155709 | 123028 | 166090 | 90692 | 186470 |
| Biogas Flared (Nm3/d per month) | 15 | 23 | 12 | 16 | 23 | 14 |
| Fertilizer/Compost Produced (tons/month) | 66.09 | 825 | 248 | 466 | 452 | 801 |
| Rejects to ADC (tons/month) | 650 | 736 | 1070 | 1060 | 648 | 879 |
| Liquid Digestate Produced (gal/month) | 10520 | 37750 | 82040 | 110090 | 121520 | |

Source: Kompogas SLO LLC

**Feedstock throughtput and usage**

During the data collection period, the AD system was fed with 31,390 tons of material, an average of 69 percent of total operating capacity. Feedstock included two components: green waste (Figure 18) and food waste (Figure 19).

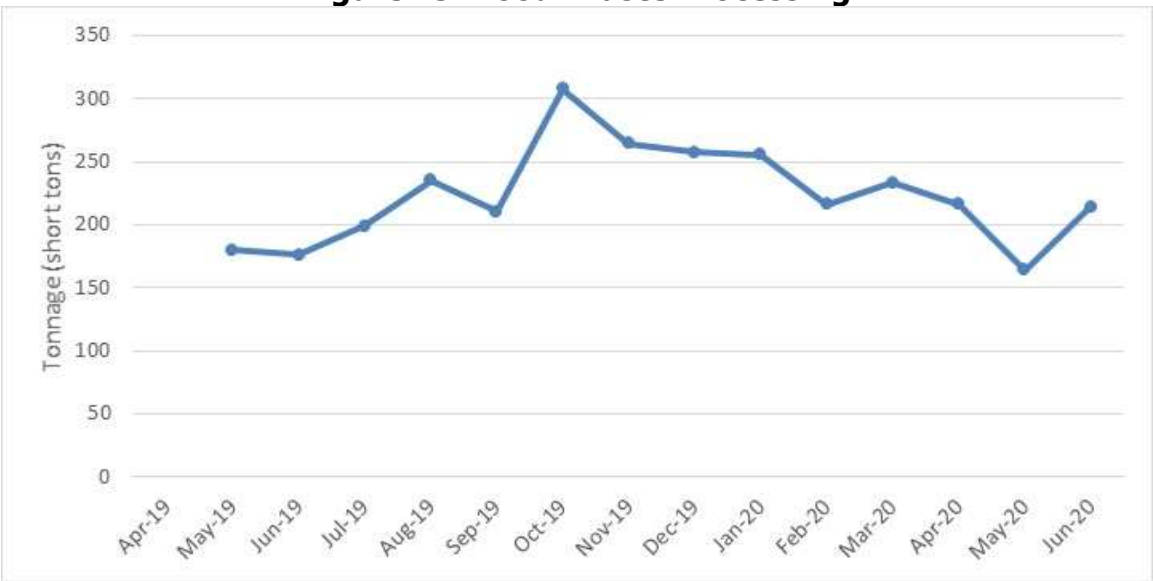
**Figure 18: Green-Waste Feedstock Processing**




Source: Kompogas SLO LLC

While data is limited, Kompogas SLO Facility saw a significant reduction in green waste collection during the winter months, when vegetation growth is naturally slow.

**Figure 19: Food-Waste Processing**



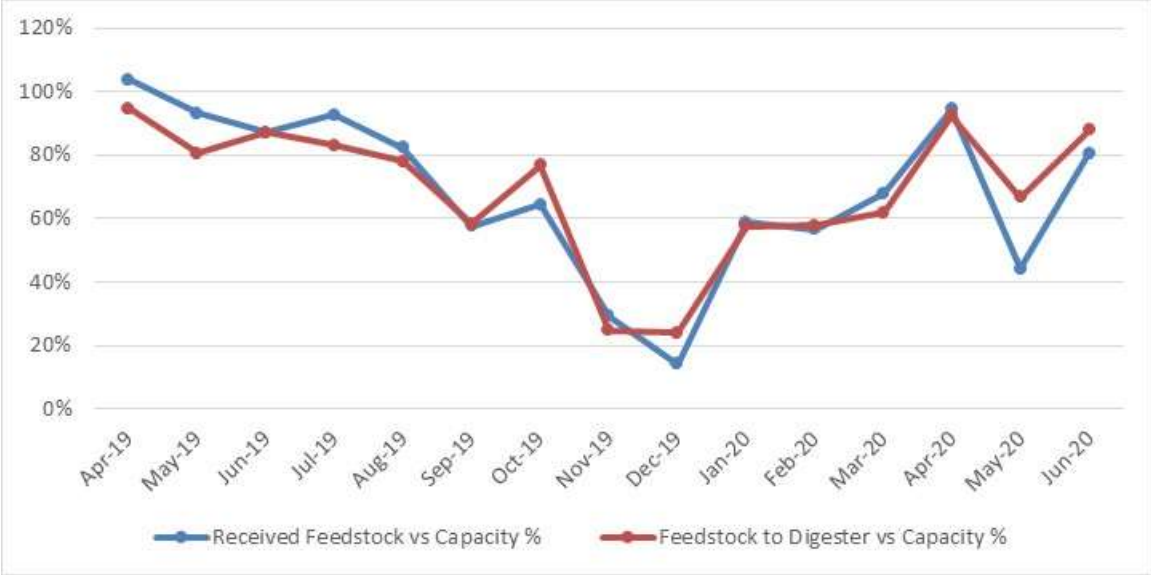

Source: Kompogas SLO LLC

While the percentage of food waste was lower than originally anticipated, Kompogas SLO Facility foresees increased food-waste feedstock as implementation of SB 1383 expands within the region and the state. With additional food-waste capacity, the Recipient was able to solicit

outside food-waste collection. At the time of this report's writing, the project is actively seeking additional food waste from outside the Waste Connections franchised region.

SLO IWMA released an educational flyer to SLO residents that generated attention on green-waste bin use. The project team anticipates an increase of food waste through this outreach effort and from meetings IWMA is holding to discuss the implications of SB 1383 expansion.

**Figure 20: Feedstock Processing Versus Anaerobic Digester Feed Rate**




Source: Kompogas SLO LLC

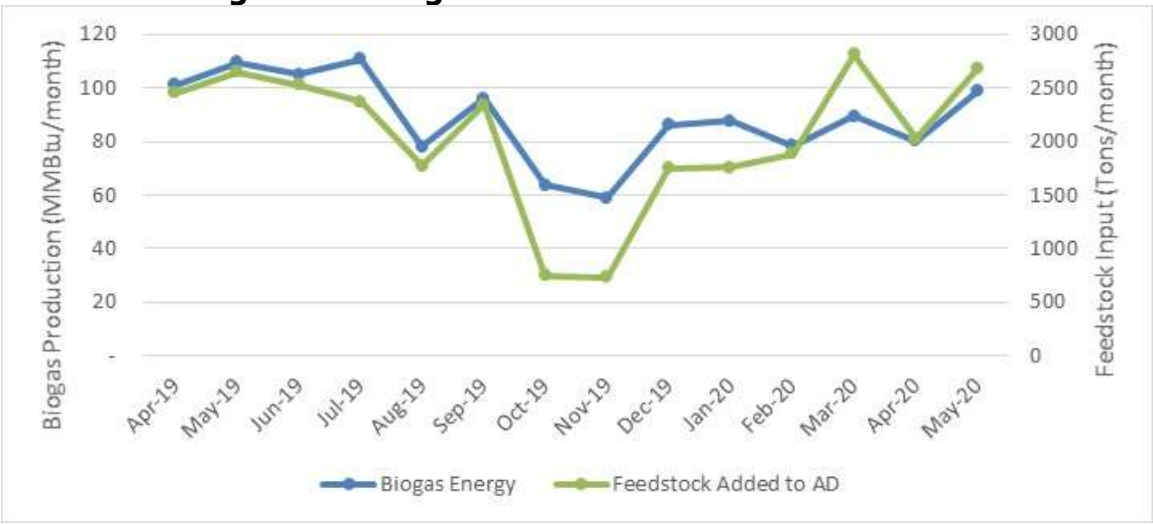
Kompogas SLO Facility quickly processed incoming material into feedstock for the digester while contamination levels were low, with an average of 1.2 percent rejects on front-end processing. (Data on contaminants was not collected until October 2019.)

## Energy production trend

The Kompogas SLO Facility was designed to generate 6.2 million kWh of renewable electricity annually, reducing reliance on foreign or imported fuels. To date, the project has produced approximately 2.1 million kWh of electricity. Two primary factors have contributed to reduced electricity production: limited availability of food waste due to gradual SB 1383 implementation and relatively low methane concentrations in the biogas, leading to intermittent engine shutoffs. Both challenges were expected during the initial phases of operation and were actively addressed.

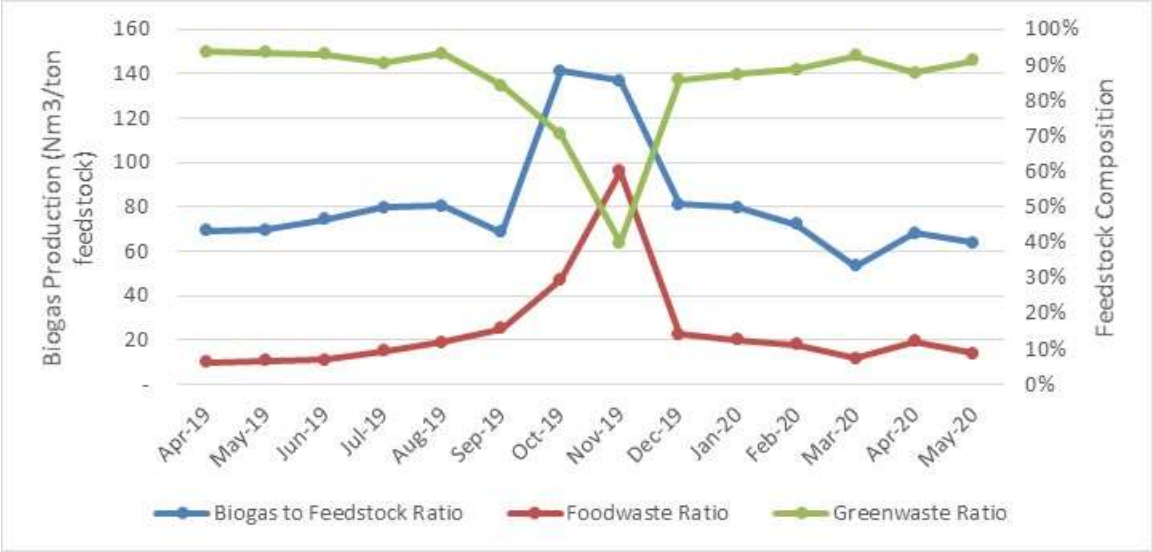
The first factor is the limited availability of high-energy-content food waste (Figure 21). This is a result of slow adoption of SB 1383 by residents in the local region. Additional outreach and education campaigns are addressing this challenge. A parallel effort to improve biogas yield is the design and installation of a fats, oils, grease, and glycerin feedstock system to enhance overall biogas production and methane concentrations that will even out seasonal feedstock variations and fluctuations.

**Figure 21: Biogas Production Versus Feedstock**




Source: Kompogas SLO LLC

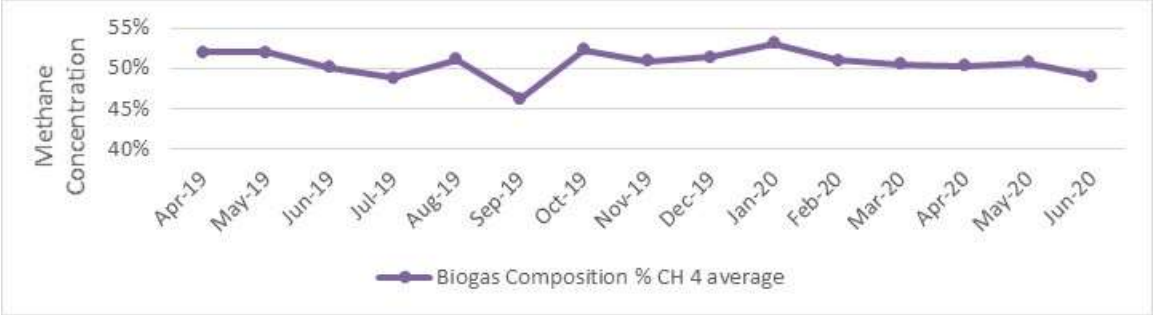
**Figure 22: Biogas Production Normalized to Feedstock Input**




Source: Kompogas SLO LLC

Overall, the digester has produced biogas with relatively consistent average methane concentrations (Figure 23).

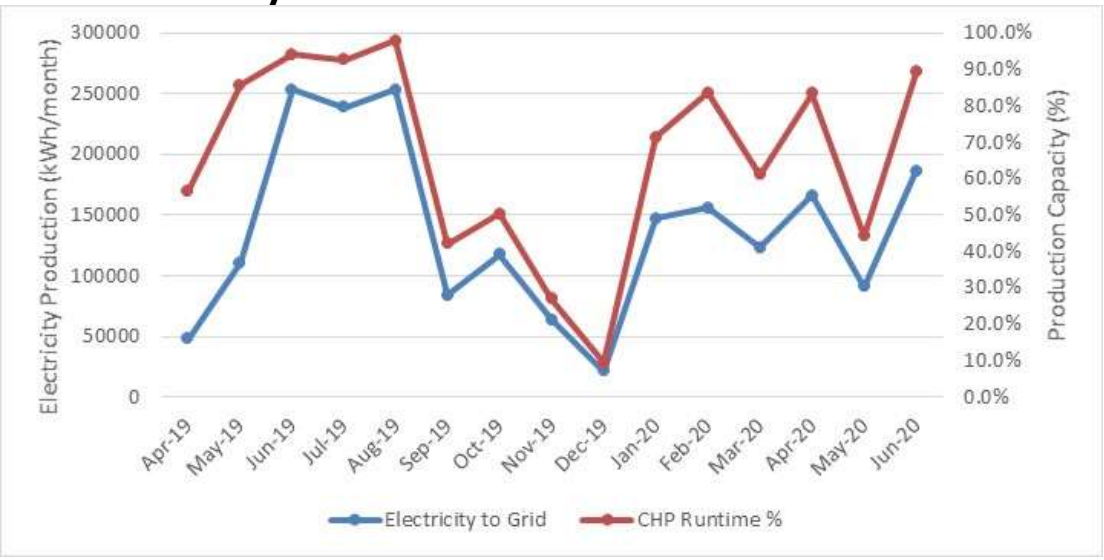
**Figure 23: Biogas Methane Concentrations**




Source: Kompogas SLO LLC

When methane concentration falls below 50 percent, the engine's shutoff is automatically triggered for the safety of the engine. The engine is restarted manually when methane concentration levels are greater than 50 percent. During establishment of the microbial environment, this intermittent production is expected. But during the start-up phase, if the automatic shutoff occurs overnight, the engine restart may not occur until morning shift operators arrive on site. Total electricity production is presented in Figure 24.

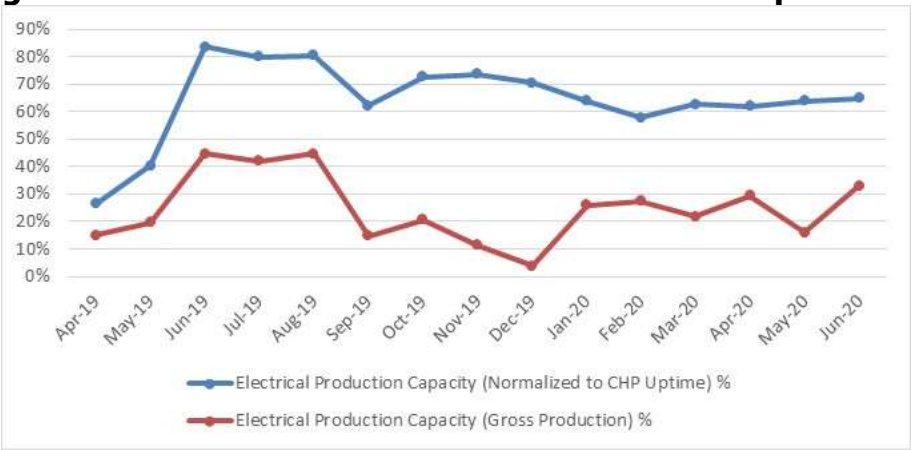
**Figure 24: Electricity Production and Combined Heat and Power Run Times**




Source: Kompogas SLO LLC

Figure 25 shows the utilization rate of the CHP system in two scenarios. The first is based on total electricity production during the month (gross energy produced divided by maximum theoretical potential for all time in the month). The second is based on total electricity production only during times when the CHP unit is running during the month (gross energy produced divided by maximum theoretical potential only for the time when the unit is running). This data shows the impacts of intermittent shutoffs, with gross-production capacity averaging 25 percent of total capacity and operational capacity averaging 65 percent. The operational capacity reflects the impacts of reduced biogas-energy production, based on limited high-energy food-waste feedstock.

**Figure 25: Combined Heat and Power Use when Operational**




Source: Kompogas SLO LLC

All electricity generated by the project is produced from local feedstock. The electricity is sold to PG&E at a contract-negotiated price of $127.72 kWh, which supports low-cost renewable-bioenergy production for IOU customers within PG&E's service territory in central and northern California.

Overall, the project was still in startup by the end of the agreement term with the CEC. Typically, a start-up process can take up to two years. This relatively long start-up period is acknowledged and accounted for in the BioMAT program, which was specifically designed to allow participants to update their electricity-production forecasts during the first two years of operation without incurring any penalties.

## Co-Product Production

Kompogas SLO Facility produces compost and liquid fertilizer as by-products of biogas power generation. It is challenging to find off-takers for these products in the competitive agricultural markets, though the project team identified Pacific Organics as an essential member to promote the compost. Pacific Organics has signed a letter of intent to accept all compost and liquid digestate. Over the demonstration period, 7,679 tons of solid fertilizer and 1.5 million gallons of liquid fertilizer were produced. All the amendment was used in local vineyard operations.

### Compost

The first samples of compost were produced in April 2019 and showed positive lab results concerning the concentration of metals and nitrogen. Local growers and customers subsequently purchased the compost although it was still in an immature stage (high carbon-to-nitrogen ratio). Local growers and customers allowed the compost to further mature on their property; microbes continue to consume carbon during the maturation stages. The Recipient was able to obtain organic certification through the California Department of Food and Agriculture (CDFA) for the compost, which increased its attractiveness for growers, especially grape growers. The project team reallocated money from the CalRecycle funding pool to improve the compost quality by installing a ventilation system that injects drier air into the mixture.

Additionally, The Recipient secured an agreement with a local grower in the nearby Santa Maria area to store compost during the wet winter months. This will ensure that the compost will be protected from rains and seasonal crop rotation schedules.

### Liquid Fertilizer

The project facility has the capacity to convert feedstock into 1.6 million gallons of liquid fertilizer per year. To avoid odor concerns, aeration is applied to the by-product. The CDFA has not yet approved the liquid fertilizer because its composition differs from the digestate approved under the Healthy Soils Initiative Program. A resolution on this matter is expected soon. Currently, liquid fertilizer is being produced and utilized at a compost site in the Central Valley. It is replacing water normally used at the site to dampen compost windrows.

# CHAPTER 4: Technology/Knowledge/Market Transfer Activities

To share information about the project's technology, feasibility, and success, the project team developed an outreach plan with a spectrum of communication platforms for wide distribution.

An initial technology/knowledge transfer fact sheet was provided to the Energy Commission in the first quarter of 2017, draft and final plans were provided in the third quarter of 2018, and several digital photos have been provided to various reports to date. The deliverables included the final project fact sheet, draft and final presentation materials, additional digital photos, and the draft and final technology transfer report.

The Project Team conducted the outreach activities to share share information about the project's technology updates with interested stakeholders via four primary means: 1) direct outreach and project tours, 2) presentations at conferences, to stakeholders, 3) technology presentations to interested parties, 4) publications and website, 5) TAC participation.

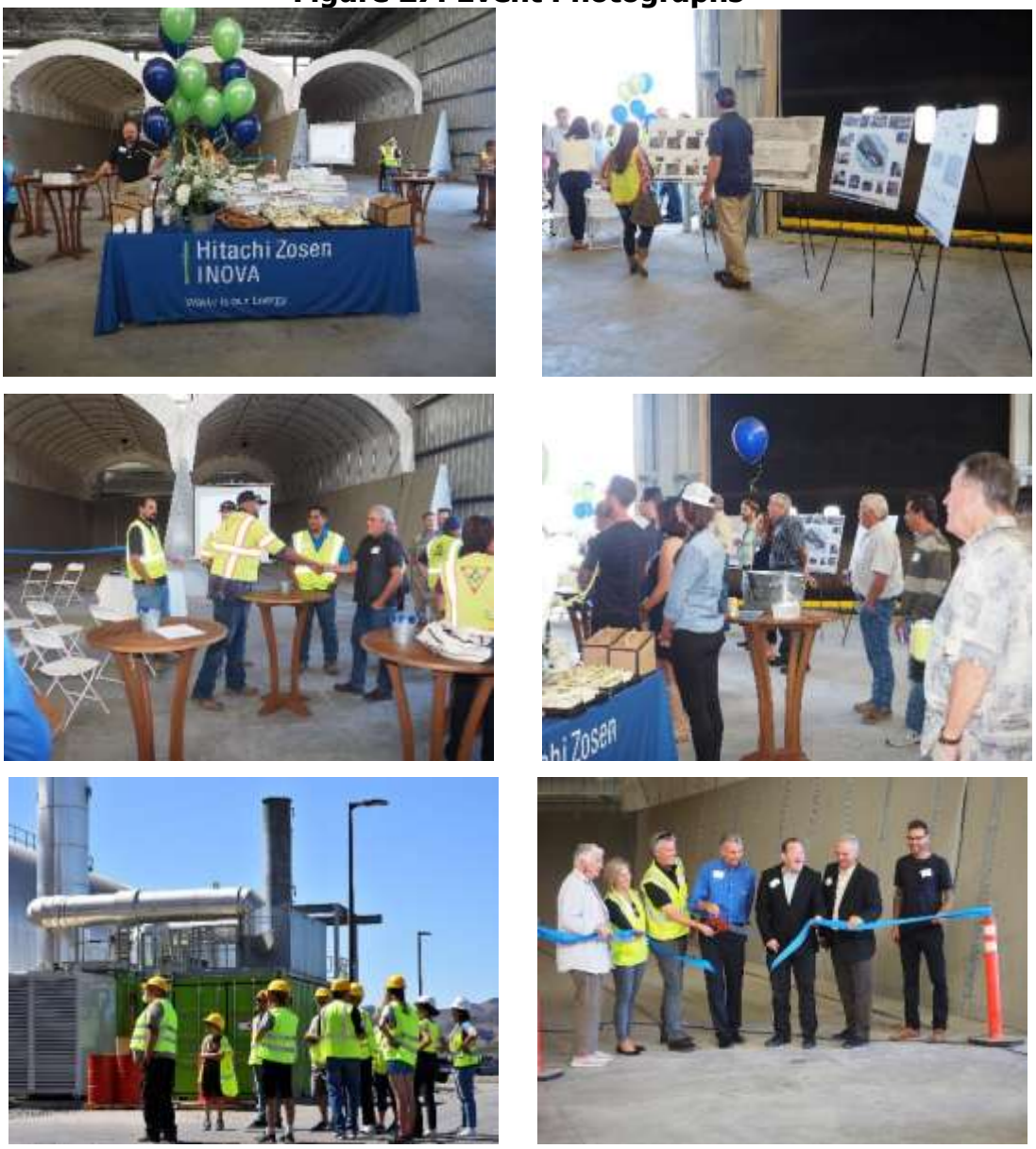
### 1) Direct outreach and project tours

As part of the project's technology/knowledge transfer activities, the project team held an open house on September 21, 2019. The open house was advertised to area residents on a website that went live several weeks before the event: https://go.blueascension.com/kompogas-slo/ (Figure 26). The event offered facility tours, free compost pick-ups, and discussions about anaerobic digestion and its community benefits.

**Figure 26: Kompogas SLO Open House Website Screen Capture**


Source: Kompogas SLO LLC.

**Figure 27: Event Photographs**




Source: Kompogas SLO LLC

The open house was successful; 80 individuals signed up for the facility tours, with a tour conducted every 30 minutes by the management team. Eight tours with 10 residents in each were scheduled and began with a short video of the Kompogas SLO Facility process and a safety briefing. All tours lasted about an hour and showed all the steps in the anaerobic digestion process. All 24 slots for the free compost were filled. Each resident received half-a-yard of compost and was asked to bring a truck or trailer and tarps to cover the material before leaving. All were pleased with the material and some wanted to share it with their neighbors. Many encouraged the project team to hold similar events twice a year, in the spring and fall. An event scheduled in April 2020 was cancelled due to COVID-19 concerns but will be rescheduled in the future.

### 2) Presentations at conferences, to stakeholders

Presentations at conferences and to stakeholders were another outreach focus. The project team continues to attend technical conferences and present the status and results from the project with other technical experts in the area of organic waste conversion to energy. These conferences include state, regional, national, and international gatherings of experts in the field, as well as trade organization conferences to educate municipalities, technology providers, and other end users. The team gave two technical conference presentations per year during project development.

A list of conference presentations to date follows.

- Waste Expo 2019, Las Vegas, Nevada – 100 people
- Power of Waste Conference 2019, Phoenix, Arizona – 70 people
- BioCycle West Conference 2019, Portland, Oregon – 50 people
- Rethink Methane Conference, Sacramento 2019, California – 30 people
- BioCycle Conference 2018, Raleigh, North Carolina – 50 people
- CoGeneration Conference 2018, Long Beach, California – 80 people
- Renewable Gas Strategy Workshop 2018, Downey, California – 50 people
- Waste Expo 2018, Las Vegas, Nevada – 100 people

### 3) Technology presentations to interested parties

The team also held presentations for industry, government, and community members interested in the Kompogas technology, organic waste management, and, generally, the production of energy from organic waste. Direct public outreach included dozens of informational and technology-oriented meetings across the state and the nation.

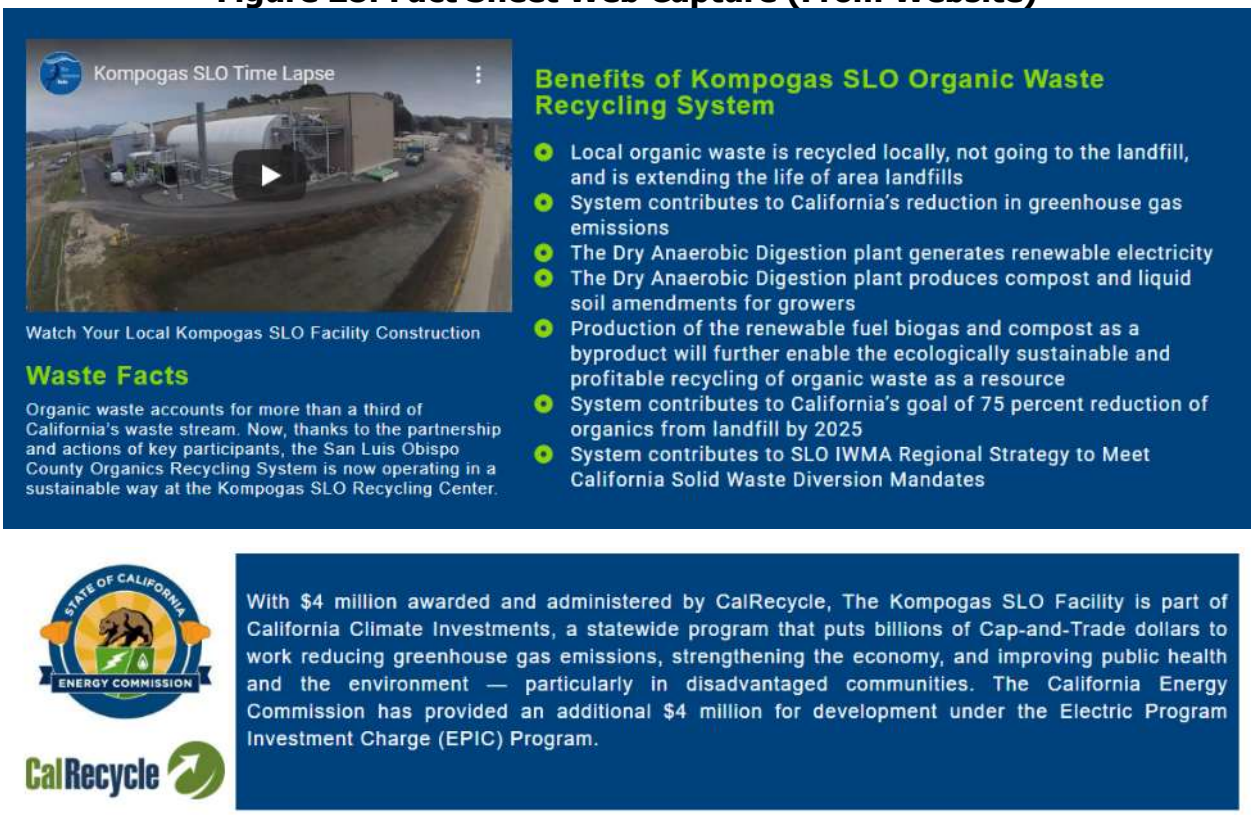
### 4) Publications and website

The team utilized both a website and multiple publications to reach a larger audience that might not be accessible through other outreach activities. . The project web pages (www.kompogas-slo.com and http://www.hz-inova.com/) targets potential stakeholders, policy makers, news media, and other future end users of the technology. In addition to two websites, project information appears on several independent sites for local organizations including San Luis Garbage and the SLO Chamber of Commerce.

- Examples of news releases appear at: http://www.hz-inova.com/cms/en/home?p=5297, and http://www.hz-inova.com/cms/wp-content/uploads/2017/03/Media_Release_Kompogas _Plant_San_Luis_Obispo_EN.pdf.
- Flyers available both online and in print include: http://www.hz-inova.com/cms/wp-content/uploads/2018/10/SanLuisObispo_EN_online.pdf.
- The project is highlighted on the main Hitachi Zosen website, at: http://www.hz-inova.com/cms/en/home?page_id=1870.

In addition to the project's websites, project overviews were also highlighted in Waste Today magazine, Waste Management World, Biogas Channel, and Business Wire.

**Figure 28: Fact Sheet Web Capture (From Website)**




Source: Kompogas SLO LLC

### 5) Technical Advisory Committee

As defined in Task 1.10, the technical advisory committee (TAC) was created to support facility development and identify ways to promote the AD system to broadly meet California waste-management requirements for in-state markets. On October 10, 2018, HZIU finalized the membership of its TAC:

- Ron Munds, Utility Division Manager, Public Works, County of San Luis Obispo
- Sam Vigil, Professor Emeritus, Cal Poly, San Luis Obispo
- Steve Harriman, Public works Division Manager, City of Rancho Cordova
- Val Tiangco, Biomass Program Manager, Sacramento Municipal Utility District
- Brian Aunger, Permit Engineer, Air Pollution Control District, San Luis Obispo County (retired)

The TAC met quarterly during the project development process through final completion. The kick-off meeting was held on April 18, 2018. Meetings were held via teleconference except for one or two in-person meetings at the project site. The overall charge of the TAC was to provide strategic guidance for the project, including to:

- Provide guidance regarding market applications and development including linkages to future and potential projects and technical expertise.
- Review select products and results and provide recommendations for adjustments, refinements, and enhancements.

- Assess the tangible benefits of the project to the State of California and to in-state waste managers and municipalities.
- Recommend market pathway developments, information dissemination, and commercialization strategies relevant to the project.

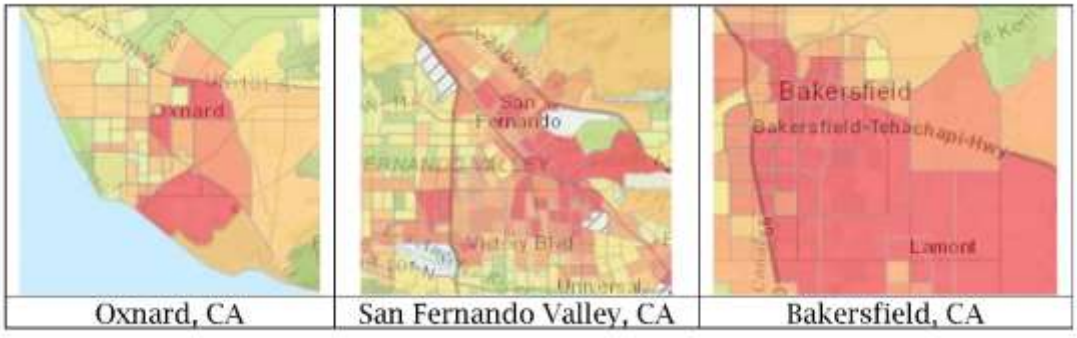
TAC meeting minutes were provided to the CEC.

## Disadvantaged Communities Outreach

The project is located in a U.S. Census tract in the 6th to 10th percentile score in the CalEnviroScreen model, which means that disadvantaged communities (DACs) in the general area benefit from removing organic solid wastes and processing them in Kompogas SLO Facility, a non-DAC.

The CalEnviroScreen Guidance and screen tool identify solid waste sites and facilities as negative factors in determining a census tract's score. Therefore, the development of a new anaerobic digestion facility (considered a solid-waste facility by CalRecycle) outside of a DAC census tract positively benefits those communities by removing their organic waste.

**Figure 29: Disadvantaged Communities Served by the Kompogas Facility**




Source: Kompogas SLO LLC

## Direct Influence on Other Facility Development

Due to project successand outstanding outreach effort by the project team, Kompogas SLO Facility was selected as a preferred vendor for a new facility with SANCO in Escondido, California. The proximity of the Kompogas SLO Facility site allowed the SANCO Serves team to learn about the facility first-hand and see it operate with comparable feedstock. The Escondido project will be able to divert nearly three times more organic waste from landfills (100,000 tons vs. 36,000 tons in the current demonstration facility) and also produce renewable biogas for transportation fuel.

Another Kompogas AD facility in Lancaster, California, is currently in the development stages and has further established Kompogas SLO Facility as the state's flagship AD facility. Both upcoming projects have been awarded CalRecycle grants to reduce the state's GHG emissions. The SANCO Services project is under construction at SANCO Resource Recovery, 6750 Federal

Blvd. Lemon Grove, CA 91945[4] and the Waste Management of California, Inc. Lancaster project[5] is in the permitting process.

The Recipient is actively working with several other clients throughout the state for development of additional AD projects.

[4] https://www2.calrecycle.ca.gov/SolidWaste/Site/Summary/4518

[5] https://www2.calrecycle.ca.gov/SolidWaste/Site/Summary/1035

# CHAPTER 5:
# Benefits to Ratepayers

The core goals of the facility were to meaningfully benefit both the environment and the local community. More specific benefits included reduced GHG emissions, landfill diversion, food rescue, and economic development.

## Key Project Benefits:

- Was one of the fastest-constructed anaerobic digestion facilities.
- Was one of the first producers of electricity within the BioMAT program.
- Exported 2,058,698 kWh of renewable electricity, resulting in GHG emission reductions of 580.14 MTCO2e from reduced fossil-fueled electricity generation.
- Processed 31,261 tons of organic feedstock, resulting in GHG emission reductions of 4,828.23 MTCO2e due to the diversion of organics from business-as-usual alternatives.
- Produced 7,679 tons of fertilizer and compost.
- Created seven new jobs in the SLO region.
- Resulted in the investment of more than $21 million in the facility's local infrastructure.

Environmental and Community Impact

## Reduced Greenhouse Gas Emissions Calculations

To calculate emission reduction benefits, the project team applied the same emission-reduction factors used by the California Air Resources Board (CARB) when calculating the benefits of biogas to transportation fuel (using the updated Tier 1 Simplified carbon intensity (CI) calculator for biomethane) from the anaerobic digestion of organic waste:

- 370.22 gCO2e/kWh for grid electricity for the California-Mexico Power Area sub-region electricity mix
- 129,255 gCO2e/metric ton for avoided emissions from diversion of green waste Embedded in this value is CARB's default assumptions:
    - 64.1 percent of green waste would go to composting without the AD facility.
    - 35.9 percent of green waste would go to landfill without the AD facility.
    - 66 percent of green waste is yard trimmings.
    - 33.3 percent of green waste is woody material.
- 377,351 gCO2e/metric ton for avoided emissions from landfill of food waste.
    - 2.5 percent of food waste would go to composting without the AD facility.
    - 97.4 percent of food waste would go to landfill without the AD facility.

GHG emission reductions are calculated as:

$$\frac{Tons\ of\ Green\ Waste}{1.1\ \frac{short\ tons}{metric\ tons}} * 0.129255 \frac{MT\ CO2e}{metric\ ton} + \frac{Tons\ of\ Food\ Waste}{1.1\ \frac{short\ tons}{metric\ tons}} * 0.377351 \frac{MT\ CO2e}{metric\ ton}$$
$$+ kWh\ Exported * 0.00037022 \frac{MT\ CO2e}{kWh}$$

$$\frac{28{,}225.54\ tons}{1.1\ \frac{short\ tons}{metric\ tons}} * 0.129255 \frac{MT\ CO2e}{metric\ ton} + \frac{3{,}126.91}{1.1\ \frac{short\ tons}{metric\ tons}} * 0.377351 \frac{MT\ CO2e}{metric\ ton}$$
$$+ 2{,}058{,}698\ kWh * 0.00037022 \frac{MT\ CO2e}{kWh} =$$

$$3{,}316.6\ MT\ CO2e + 1{,}072.7\ MT\ CO2e + 762.2\ MT\ CO2e = 5{,}151.5\ MT\ CO2e$$

## Reduced Landfilling of Organic Wastes

A central goal of building this facility was to divert organic wastes from landfills to reduce GHG emissions and convert organic feedstock into a value-added product. To date, HZIU has received 28,225 tons of green waste and 3,126 tons of food waste. Using the ARB default values just described, 13,180 tons of green and food wastes were expected to be diverted from landfills. This report used this methodology for assessing landfill diversion; it is challenging to directly measure what would have happened if the AD facility were not built since market conditions change and might not be the same as they were before the project was built. This approach is more conservative than the market conditions at the time of the grant application when most of the green waste was being used as ADC in landfills.

## Rescued Food Waste

In March 15, 2018, Kompogas SLO Facility partnered with Valley Food Bank in a rescued food-waste program. Rescued food is unspoiled food suitable for human consumption. Through an ongoing program, Valley Food Bank rescued 665,096 pounds of food by the end of 2019. This program is expected to expand as project operations continue.

## Community Benefits

### Economic Development

To date, HZIU has invested a total of $25 million in the project, including $7.2 million of state funds from the Energy Commission and CalRecycle. These investments have supported local and in-state economic development, including support for jobs and businesses in the construction contracting, engineering, design, professional, and other related industries. In addition, HZIU has invested a total of $ 1.3 million in ongoing operational support per year. These investments support economic development in local California communities.

### Increased Safety

The project provided increased reliability to the power grid as a baseload generator. The project improves air quality for IOU ratepayers in local communities by utilizing waste organic material that would otherwise contribute to GHG emissions, short-lived climate pollutants, and other criteria pollutants that cause chronic and acute health impacts.

## Cost Effectiveness

SB 1122 requires California IOUs to procure 250 MW of biomass electricity. This project is a cost-effective option for utilities to acquire this capacity. The calculated, levelized cost of electricity using the Black & Veatch calculator is competitive in the BioMAT program. The project's high degree of project readiness also allowed rapid development.

HZIU is the second BioMAT project to begin exporting electricity under the tariff. The facility is therefore a pioneer in achieving the environmental goals and objectives of the BioMAT program. These goals and objectives were achieved at the starting price for the BioMAT Category 1 projects, which have not changed since initiation of the program; this suggests that they are consistent with market pricing for AD systems using urban feedstock. HZIU will sell power to PG&E at a contract-negotiated price of $127.72 kWh, which supports low-cost renewable bioenergy production for IOU customers within PG&E's service territory.

As of this report, HZIU has successfully ramped up CHP generation rates to 65 percent of ultimate target capacity. Gas generation rates are influenced by a combination of feedstock quality and microbial process efficiency, both of which increased during the first year of operation.

# CHAPTER 6:
# Conclusions and Recommendations

The Kompogas SLO Facility was the first project in the U.S. to be developed by Hitachi Zosen Inova, USA. For many aspects of this first-of-its-kind project, there was a steep learning curve, from the construction and costs of an unknown project, from its staffing and operations to its feedstock variances to the marketing of its final compost products. The Recipient learned a great deal working through various challenges presented by this project and has had several meetings with both U.S. and Swiss staff to address problems encountered throughout the project's development. These meetings resulted in a lessons learned program that will apply to future projects in the U.S. and elsewhere in the world. These lessons provide an invaluable learning experience that will ensure the success of projects to follow.

California's EPIC funding allowed this technology to advance from technology readiness level (TRL) 7 (with its first operating facility in the U.S.) to TRL 9, with two more commercial operating facilities under construction. EPIC funding was critical for supporting the cost of translating the Kompogas design from metric to U.S. standards, critical for ensuring standard sizes for materials.

## Key Lessons Learned

The three most important lessons learned from this project follow.

- Education: The Recipient worked closely with Waste Connections, the local franchised hauler, to fully understand the process of managing feedstock collection for anaerobic digestion. This was the first time that residents and businesses have supported the diversion of organic waste to an anaerobic digestion facility. The level, depth, and breadth of required public education about the process were initially underestimated.
- Feedstock contaminants: While the project team worked closely with Waste Connections to evaluate the potential for incoming feedstock, initial operation of the facility resulted in a higher level of sand contamination because of its coastal location. This sand contamination required additional pre-processing equipment to avoid accelerated equipment wear and tear.
- Feedstock composition: Implementation of SB 1383 throughout California has been delayed because of multiple factors generally outside the control of Waste Connections. These delays caused lower food-waste percentages in the incoming feedstock stream and consequently lower biogas yields, though without negative impact on facility operations.

# LIST OF ACRONYMS

| Term | Definition |
|---|---|
| AD | Anaerobic digester |
| ADC | Alternative daily cover |
| BioMAT | Biomass Market Auction Tariff |
| CARB | California Air Resources Board |
| CI | Carbon Intensity |
| DAC | Disadvantaged Community |
| EPIC | Electric Program Investment Charge |
| FIT | Feed-in Tariff |
| GHG | Greenhouse Gas |
| HZIU | Hitachi Zosen Innova USA LLC, Project Recipient |
| IOU | Investor-Owned Utility |
| IWMA | Integrated Waste Management Authority |
| kWh | Kilowatt hour |
| MSW | Municipal Solid Waste |
| MT CO2e | Million Metric Ton Carbon Dioxide equivalent |
| PG&E | Pacific Gas and Electric Company |
| PPA | Power Purchase Agreement |
| SLO | San Luis Obispo |
| SLOAPCD | San Luis Obispo Air Pollution Control District |
| TPY | Tons Per Year |
| TRL | Technology Readiness Level |