Feasibility Study for Waste-to-Energy Anaerobic Digestion Using Small-Scale Meat Processing Facility Waste and Food Waste

Prepared for
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INTRODUCTION

The Sierra Foothills Meat Company (SFMC) has undertaken research to develop a USDA-inspected livestock processing facility to provide livestock producers with the key infrastructure piece they need to direct-market their livestock products to the widest available audience.

Dakota Global Consulting was hired to provide a report on construction costs, processing parameters, energy consumption rates, and waste generated by a facility size to SFMC’s needs. Dakota Global provided their report October 27, 2016, and data from that report is used as the basis of Biogas Energy’s analysis and recommendations in this report.

SFMC secured a USDA Rural Assistance Planning Grant to fund a feasibility study examining the potential for integrating waste-to-energy elements in the facility designed by Dakota Global, and to incorporate other renewable energy technologies into the facility design. Biogas Energy was retained to perform a study to determine the feasibility of integrating anaerobic digestion, wood-waste-to-syngas, biofuels production, and PV solar into the facility. This report presents the results of the feasibility study.

Biogas Energy examined the issues and opportunities surrounding anaerobic digestion, biofuels production, and PV solar. Using extensive experience in anaerobic digestion to incorporate information provided by Dakota Global with industry standard data, Biogas Energy engineers created a functional design of the necessary systems in order to test project viability. While this report is based on Biogas Energy’s expertise in the field of anaerobic digestion, Biogas Energy makes no guarantee or assurance as to the accuracy of the analysis or the viability of the business venture. Any business decision made using this report as a basis must be augmented by the client’s analysis.

TSS Consultants reported on wood-waste-to-syngas technologies and opportunities. That report is submitted with this one.
CHAPTER 1: ANAEROBIC DIGESTION

Anaerobic Digestion basics
Anaerobic digestion (AD) is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which consists of predominantly methane (CH4) and carbon dioxide (CO2) with other gasses in small amounts (H2S, etc.). Biogas is combusted to generate electricity and heat, or can be processed into renewable natural gas transportation fuel (RNG).

Cow manure or food waste are the typical feedstock for anaerobic digesters, however the AD process can be sustained with a variety of organic materials including the waste anticipated to be generated by a meat processing facility: offal, fat, and other materials. Once appropriate feedstocks are identified, consideration must be made for the amounts generated to support the AD process, as well as any potentially inhibiting inputs such as antibiotics, cleaning agents or other chemicals.

As a biological process, anaerobic digestion relies upon stable operations, including consistent feed rate, appropriate temperature, balance of feedstocks, and careful monitoring. Unlike chemical or mechanical processes, anaerobic digestion relies upon living organisms (bacteria) which must be supported with appropriate practices and maintenance. If one parameter goes too far outside acceptable variability, for example temperature in the digester falling too low for too long, the entire biological process is put at risk and can stop biogas production for extended periods of time. AD plant operators must be able to monitor the biological processes and maintain mechanical equipment to support the production biogas.

There are a variety of anaerobic digestion technologies in operations today ranging from low-cost, low-output lagoon digesters to expensive, efficient industrial digesters. The choice of technology depends on the requirements of the project, as trade-offs of different variables must be weighed. For this reason there is no consensus ideal AD technology for all applications.

Biogas Energy digesters are heated to 100degF (mesophilic range) to maintain methanogenic biological processes. Flow of material through the system is automated and regulated by the inflow of material into the tank. Therefore it can be run on continuous feed, but can also be left idle for a few days at a time during non-operation of the meat processing plant. It is not clear whether additional nutrients will be required for the ongoing health of the digester, so analysis will be necessary once the system is operating. In order to start the biological process, an initial dosing of bacteria is required from cow manure or from waste water treatment plant digester sludge. It may be necessary to add bacteria from either source over time to maintain healthy digestion.
Considerations to which digester technology is best for a particular project:

1. **Budget**: Anaerobic digestion can take place in a rudimentary digester such as a pit in the ground, or it can be an automated high-tech facility. Budgetary guidelines help narrow the focus of the technology to what is in the realm of possibility.

2. **Size of project**: Like other technologies and processes, AD enjoys savings with economies of scale, making smaller projects problematic for realizing low-cost installations.

3. **Priorities**: Some AD projects focus on maximizing energy production while others focus on wastewater treatment efficacy.

4. **Feedstock**: While some feedstocks are relatively simple to process and automatically replenish the digester with benevolent bacteria (i.e. cow manure), other feedstocks require constant supervision and support with the addition of micronutrients or other inputs. Combining multiple feedstocks will also create challenges that must be addressed by the AD plant design: everything from waste reception and pre-processing to feedstock dosing and off-take.

**SFMC’s AD Feedstock Potential**

Biogas Energy was tasked to examine two feedstock scenarios for anaerobic digestion:

1) Feedstock is waste from slaughterhouse and meat processing plant

2) Feedstock is food waste from surrounding area added to meat processing waste

**Feedstock Unknowns**

It should be noted that Biogas Energy did not receive representative samples of the waste proposed for digestion feedstock and Dakota Global based their information on industry standards. Also, the report by Dakota Global provided vague information about the feedstocks which is explained by the fact that a facility of this size has not been built previously. All estimates presented in this report are made with assumptions that should be verified prior to undertaking any project based on this report. Industry standard data was used for anaerobic digestion analysis, however practical on-the-ground implementation of these recommendations should account for possible variables unforeseen by Dakota Global or Biogas Energy. As the first project of its kind, this digester facility will require sufficient contingency to account for unknown issues. Biogas Energy cost estimates do not include contingency.

Dakota Global specified that bones will be removed from the stream of drop going to anaerobic digestion so the information provided below assumes no bone material will be digested. If bone must be processed through the digester, additional equipment and planning must be undertaken.
One potential issue is the classification of the digester output (digestate). Since this is animal viscera/fat/carcass it may require processing at a licensed rendering plant. While the digestion process will extract energy and reduce BOD of the feedstock, it does not process the material with enough heat to replace the cooking process of a rendering plant. Pathogens found in animal products are not destroyed in the digesters. Therefore it is assumed that the separated sludge coming out of the drop-fed digester will need to be trucked to a rendering plant, Sacramento Rendering. Current California regulations do not allow composting of raw animal byproducts. If rendering the material on site is considered, additional equipment will be required as well as heat for the cooking process. While the digester for drop alone will not generate enough heat for the cooking process, the food waste digester may provide heat necessary. Co-located gasification would provide adequate heat for rendering on site.

Meat processing waste
Biogas Energy was supplied with information from Dakota Global Consulting, the engineering firm tasked with the design of the meat processing facility. Dakota Global delivered a report outlining the parameters of the project, and also replied to email queries about the data they presented. They clarified that the figures were estimates since, as they said, a project of this size has no precedent. So Biogas Energy is using data for this report that may produce different results when put into practical application. At this point, this is the best Dakota Global can provide.

Dakota Global’s report gave the following indications for potential waste feedstocks from the meat processing facility.

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fed Cattle</td>
<td>285696</td>
<td>357120</td>
<td>492032</td>
<td>515840</td>
<td>515840</td>
</tr>
<tr>
<td>Cull Cattle</td>
<td>240030</td>
<td>300038</td>
<td>376047</td>
<td>440055</td>
<td>440055</td>
</tr>
<tr>
<td>Hogs</td>
<td>25020</td>
<td>31275</td>
<td>37530</td>
<td>43785</td>
<td>43785</td>
</tr>
<tr>
<td>Sheep/Goats</td>
<td>16872</td>
<td>20246</td>
<td>23620</td>
<td>30369</td>
<td>30369</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>567618</strong></td>
<td><strong>708678</strong></td>
<td><strong>929229</strong></td>
<td><strong>1030049</strong></td>
<td><strong>1030049</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year Usage/Gallon</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fed Cattle</td>
<td>285541</td>
<td>356511</td>
<td>466741</td>
<td>517779</td>
<td>517779</td>
</tr>
<tr>
<td>Cull Cattle</td>
<td>1094</td>
<td>1366</td>
<td>1788</td>
<td>1984</td>
<td>1984</td>
</tr>
</tbody>
</table>

Based on this data, Biogas Energy recommends building the digester facility to manage the maximum throughput, which begins in year 4. Building a smaller facility that must expand every year is a more costly approach and should be avoided.

Total drop available for AD per year will be 1,030,048lbs. Operated 300 days per year, this averages 1.5 tons per day. Further integration planning between the meat
processing facility and the digester will be required since the digester operates best on daily dosing of material while the meat processing plant will presumably be closed weekends. For the purposes of this proposal, 1.5 tons per day average input is assumed.

According to Dakota Global, chemicals in wastewater that could inhibit AD process are negligible. The water is mainly derived from washing the facility.

**Food waste availability in Placer County**
Information on food waste sourced in Placer County came from Eric Oddo, Environmental Engineering Program Manager with the Western Placer Waste Management Authority. As AB1826 continues to be implemented and more waste generators are obligated to divert organics from landfill, the tonnage of digestible waste will increase in the region over existing figures.

Eric Oddo provided the following information on the current status of food waste diversion:
“The western portion of the County is served primarily by three main waste haulers: City of Roseville, City of Lincoln and Recology (serving all other communities outside of Roseville and Lincoln). Roseville has started a commercial food waste collection program and is currently hauling the material to an AD facility in Sacramento. (This facility – Clean World Partners - will be the main competition for securing food waste contracts. –BG) At the same time, Roseville is planning on installing digesters at one of their wastewater treatment plants and is considering introducing food waste to the digesters. (This would be the other competition. –BG)
City of Lincoln does not have a large commercial base and has not (to my knowledge) initiated a food waste collection program. I believe they may work with Recology to periodically pick up food waste but I don’t have any solid confirmation on this. Recology is initiated a collection program for other areas of the County (not sure the coverage) and is hauling the material to one of their other (composting) facilities in Dixon.
Each of these haulers has indicated a willingness to bring the food waste to the WPWMA’s facility if and when we have the infrastructure to process these materials. Planning efforts conducted within the past 2 years suggest between 2,000 and 4,000 tons per year of food waste could be collected. Presumably food waste tonnage will increase as the compliance thresholds from the state start to encompass more businesses. Further, if we are able to cost-effectively recovery food waste at our MRF, there is the potential to capture food waste from the residential sector in addition to the commercial sector.”
When asked if the county have a location where a biogas facility could be built along with the meat processing plant, Eric replied, “The WPWMA does have additional space that may be usable for a biogas facility. We are currently undertaking a master planning/EIR project to look at expanding our operations which could include these types of operations.”
Anaerobic Digestion of Meat Processing Waste
The information from Dakota Global identified two waste streams: process drop and process wastewater. These wastes are not mixed unless done by the operator, which gives the option to either digest both together or digest the drop only. Waste water would be sent to sewer if drop only is digested.

Anaerobic Digestion of Both Drop and Wastewater
According to data provided by Dakota Global, the meat processing plant will generate 1.5 tons/day drop and 4.0 tons/day wastewater.

Adding the wastewater to the drop will generate negligible additional energy and so is not prioritized in this analysis, which focuses on energy production.

Since sample material was not provided during the study phase, Biogas Energy was unable to determine the BOD reduction expected in the AD process, however industry numbers indicate that BOD will be reduced 60-80% in the digester. The problem with mixing the wastewater in with the drop, however, is that the wastewater will actually be worse after digestion than if it were simply processed separately. The drop BOD is much higher, and will therefore contaminate the wastewater. In addition, the separation of solids from liquids post digestion would be more difficult and costly with the co-digestion of the waste water.

Biogas Energy does not recommend co-digestion of wastewater with drop:
1. The digester size would need to be three times larger than drop alone, thereby increasing capital costs
2. There is no added energy production with the wastewater
3. There is no wastewater treatment benefit (reduced BOD) through co-digestion
4. Separation of solids in digestate becomes more costly with wastewater co-digestion
Anaerobic Digestion of Drop Only

Using drop as the sole feedstock for the AD plant provides the same biogas generation as when it is combined with the wastewater but avoids the negative consequences of co-digestion of wastewater.

Biogas Energy’s core expertise is not wastewater treatment: the anaerobic digestion technology provides some wastewater processing, but the real focus of the technology is energy generation. Since co-digestion will cause wastewater to mix with drop and therefore become worse after digestion than it would have been untouched, and since the wastewater does not add to energy generation, it makes sense to leave it out of the digester.

Integration of the meat processing plant with the digester facility must still be determined. Dakota Global did not provide detail into how the drop is collected in their process so no plan could be made to integrate digestion feeding into the facility. However, it is logical to assume that a drop reception hopper will be necessary for buffering feed flow rate to the digester, and it is yet to be determined how that hopper needs to account for higher input rates for busier days and lower input rates for weekend digester feeding.
In this diagram, biogas is fed to a boiler where heat can be used both for chilling via an absorption chiller and for hot water production. Doing so cuts operation costs (it’s cheaper and easier to run a boiler than a generator) while offsetting most of the electrical load of the meat processing which predominantly goes to chilling and heating water. For 100% renewable energy used at the site, electricity generation can be provided by rooftop mounted PV panels. But the biogas-to-boiler solution is a less complicated and less expensive way to offset 70% or more of the electricity load of the meat processing facility.

With the built-in gas store in the digester roof, biogas can be accumulated overnight during non-meat-processing hours and utilized during working hours. By storing gas overnight and making it available to the boiler during the day when the energy is needed, this configuration effectively doubles the energy output of the system. Unlike a CHP genset that does not operate well when started and stopped regularly, a boiler can be turned on and off at will without repercussions. Integration of the energy production and consumption would need to be coordinated with Dakota Global to ensure that timing works correctly. For example, if a shift starts at 6AM it may make sense to start the biogas boiler at 5AM to prepare hot water and chilling for the day’s work.

If electrical generation is desired, a 20kW Combined Heat & Power (CHP) generator can be installed and operated 12 hours per day. While generators are optimized to run 24 hour per day, the 12 hours per day run time is possible. Heat collected from the CHP genset would be adequate to run the absorption chiller, however it would only be able to make hot water 3-6 hours per day. This amount of hot water may be adequate for the
facility, or it could be augmented by a roof-mounted solar hot water heater.

The flexibility afforded by generating both power and heat enables the facility to load balance the energy generated between electric load, cooling, and heating. Whereas 100% of the energy consumption delineated by Dakota Global is in the form of electricity, as outlined in chapter 4, the implementation of biogas production enables the project to utilize heat as an efficient form of energy.

Based on information provided by Dakota Global’s drop feedstock estimates, the drop-only digester project details are as follows:
Capex (excluding land) for a drop-only digester including boiler and absorption chiller: $794,000
Capex for 20kW CHP generator: $100,000 (not included in financial model)
Digester size: 11,000 gallons
Capex for 35kW rooftop PV: $52,000

**Anaerobic Digestion of Food Waste with Waste from Meat Processing**

Co-digestion of food waste with facility waste would increase biogas production significantly thereby enabling the project to export surplus electricity while earning tipping fees for processing waste. There are challenges to implementing this project, however, as feedstock acquisition is threatened by competing digester projects in Sacramento, competing composting projects, and multiple waste suppliers. That said, the mandatory diversion of organics from landfill under AB1826 and the mandatory reduction of short-lived climate pollutants (SLCPs) under SB1383 are creating new demand for organics digestion capacity. As organics are diverted from landfill they will bring with them tipping fees for disposal, adding a new revenue source to the project’s financials.

Based on information provided by Western Placer Waste Management Authority’s 4,000 tons/year source-separated, contaminant-free food waste as feedstock, the project details are as follows:

Capex (excluding land, including 150kW CHP): $1,370,000
Electricity production: 1,200,000kWh/yr (150kW * 8,000hrs/year)
Digester size: 210,000 gallons

Budget for composting operation TBD: $100,000 is placeholder in financial model
Budget for PG&E interconnection TBD: $500,000 is placeholder in financial model
The CHP genset would run 24/7 to generate 1,200,000 kWh of electricity annually: far more than would be required for the meat processing plant and the digester plant. While that might make it possible to wheel the power onto the grid and sell it, there are complications with that scenario:

1. Interconnecting under PG&E’s wholesale distribution tariff can cost anywhere from $250,000 to $2,000,000. The study to determine that cost can be $50,000 paid to PG&E.
2. The price paid for renewable electricity would result from the BioMAT auction mechanism.
3. Exporting power disqualifies the project from the Self Generation Incentive Program (SGIP), eliminating a significant source of funding.

Applying for PG&E interconnection under the Net Energy Metering tariff avoids the problems listed above, but it requires that all power be used on site. Co-location of other energy-intensive businesses who would use the power on-site would be a good way to avoid wheeling power onto the grid, effectively making the biogas project a power plant for the property. Co-location of other businesses on the property can bring ancillary benefits as well, such as lease payments, cost-sharing, and other opportunities for cross-business collaboration.

In this food waste co-digestion scenario, wastewater can be added to the digester if desired, but it is not mandatory, nor does it provide any energy benefit.

Since there will be surplus heat from the CHP genset, it may be feasible to install a
drying system for the digestate to reduce the amount of digestate to be processed. Rotary drum dryers are heated to process the liquid digestate, which can then be pelletized or composted. Hauling costs would be reduced by drying the material, and there is the potential for processing the material into value-added products like agricultural fertilizer.

The same caution should be applied to co-digestion of food waste as to digestion of drop. It may be possible to compost the co-digested sludge, however the input of raw animal waste might necessitate rendering as the end processing. If rendering is required for all digestate from the food waste co-digestion, the tipping fee may be prohibitive since most of the tonnage would be from food waste which does not require to be rendered.

Ideally the digested liquids would be managed as an agricultural nutrient and either sold to area farms or at the very least given away to avoid disposal fees.

Unknown factors to add to all estimates:
- Decontamination requirements for feedstock
- Reception requirements (i.e. housed waste transfer, etc.)
- Electrical interconnection costs

**Scope of Deliverables for Anaerobic Digestion Facility**
The complete mix, mesophilic digester facility includes the following:
- Reinforced concrete tank: dimensions determined by feedstock
- Heat exchange system for heating substrates
- Insulation & cladding for tank
- Dual-membrane roof for gas capture & storage
- Mixing & extraction pump
- Substrate flow meter, temperature sensor, overflow monitoring
- Gas flow meter, gas analyzer, pressure sensor
- Over/Under pressure valve
- PLC controls & PC
- Piping, valves
- H2S reduction
- Engineering and process design
- Electrical and mechanical installation
- Commissioning services

Equipment and systems not included in the digester facility:
- Waste reception & processing pre-digestion
- Post digestion solids separation & digestate handing systems
- CHP Genset
- Site specific requirements based on geotechnical engineering or permitting
Should SFMC decide to proceed with the purchase of a digester system from Biogas Energy, a purchase agreement will be provided outlining the detailed scope of work and fixed price costing.
CHAPTER 2: WOOD WASTE GASIFIER

Co-Location of Anaerobic Digestion Facility with Wood Gasifier Facility

Investigation of woody-biomass gasifier was performed by TSS Consultants and is attached as a separate report. The co-location of the gasifier facility would provide more energy for the meat processing facility, but it would also offer a potential benefit from adding value to biochar produced by gasification. The biochar carbon achieves higher value as an agricultural fertilizer if it is augmented by nutrients. The effluent from the AD plant and the wastewater from the meat processing plant have nutrients that could be added to the biochar to increase its value. Investigation of this possibility, including potential problems with it, are not addressed in this report but warrant investigation.

The surplus energy supplied by the gasifier system would enable SFMC to potentially process its wastes on-site as a stand alone renderer. With investment into grinders, cookers, shakers, and other rendering equipment, the facility could avoid having to truck waste to rendering for disposal and instead process it on site. With “free” heat supplied by the gasifier system, this becomes a possibility. However challenges remain, including the permitting status of a rendering plant. This may not be an issue if SFMC makes that case that it is not accepting outside meat waste for processing and therefore is not a renderer. Another challenge is the low price for meat and bone meal, the output of the process. For such small amounts produced and with low prices for meat and bone meal, the only reason to do it might be to eliminate trucking and tipping fees going to a rendering plant to dispose of the material. As this report focused on the energy production of the facility, it does not investigate the option for co-locating a dedicated rendering plant on site.

Surplus energy supplied by the gasifier system would also enable SFMC to dry its digester effluent to reduce wastewater disposal. With significant heat generated by the IC genset fed by syngas/biogas, the digestate and wastewater can be dried off into pellets or solid material to cut down trucking and per-ton tipping fees. While this incurs capital expense, it could potentially eliminate waste disposal costs.
CHAPTER 3: BIOFUELS PRODUCTION

Biofuels considered for this study are a) biodiesel and b) bioCNG. Biodiesel is used to replace diesel and can be blended with diesel to reduce carbon emissions. bioCNG (also known as RNG, or renewable natural gas) is used to replace CNG (compressed natural gas) in dedicated CNG vehicles.

**Biodiesel**

Investigations into small scale biodiesel production technology focused on commercial-grade equipment rather than on Do-It-Yourself systems. DIY systems do not offer the robust, technically reproducible processes necessary for this application.

The biodiesel technology identified is a system manufactured in Chico, CA by Springboard Biodiesel (www.springboardbiodiesel.com).

Springboard does not have any installations of their technology at meat processing facilities. However, they claim to have made biodiesel from animal fat. The main difference between vegetable and animal fat is the gel point. Since tallow is solid at room temperature it can be difficult to feed their machine. In addition, since it is solid it can contain contaminants which first need to be removed. Finally, solid fat will cause motor failures in the stirring portion of the production process, so steps to remedy this must be taken.

Springboard recommends pre-heating the animal fat before processing and removing all contaminants. The heating element in the biodiesel equipment must be turned on as well to prevent gelling. Finally, they caution that the fuel made from tallow will also have a gel point of 50-60degF, making it less useful in cold weather.

Springboard offers a range of biodiesel production models, from 7,800 gallon/year production to 62,400 gallon/year, with various levels of automation. Cost ranges from $10,000 to $20,000 plus install costs and ancillary equipment.

This investigation concluded that the amount of animal fat produced at the proposed facility would not justify investment in a biodiesel production system. Whatever fat is produced at the site would be used in the biogas plant to cover core energy consumption, leaving nothing available to biodiesel production.

**BioCNG**

Biogas is typically 55-65% CH4 (methane), 35-45% CO2 (carbon dioxide) and a few trace gases. By removing CO2 from the biogas, a pipeline-grade natural gas is produced which can then be compressed and dispensed as CNG fuel.
There are several manufacturers of biogas upgrading systems on the market offering different separation technologies, but the predominant methods of separating out the carbon dioxide is Pressure Swing Absorption and Membrane Filtration.

Pressure Swing Absorption (PSA) uses elevated pressure to absorb carbon dioxide into a media such as carbon to allow methane to pass through. Upon release of the pressure, the carbon dioxide is expelled as an off-gas. Since this off gas contains some remnant methane, it is typically flared. Membranes use hollow fibers as filtration to enable separation of gasses. Often paired with a filter that captures water, oil, and hydrogen sulfide, the membrane filtration separates methane from carbon dioxide.

Capital expenditure for the upgrade technologies varies depending on size of system, quality of gas, and end use of gas. In order to make vehicle grade bio CNG, equipment required includes dewatering, H2S scrubbing, CO2 removal, compressors, cooling, dispensing, storage.

Given the small amount of gas that will be generated by the project, bioCNG production is not feasible.
CHAPTER 4: ENERGY GENERATION

The anaerobic digestion process will produce biogas and gasification of woody waste material will produce syngas, both of which are used as fuels to generate power in internal combustion engines or other generators. This chapter will look at the options for energy production from the materials planned for the project, as well as rooftop PV solar power generation.

Meat Processing Energy Consumption

Dakota Global’s energy consumption is 100% electrical, including all heating of hot water and chilling of product.

<table>
<thead>
<tr>
<th>Electrical Usage -kWh/yr</th>
<th>kWh/yr Load</th>
<th>Drop AD &amp; PV solar kWh/yr Generated</th>
<th>Drop AD &amp; Food waste kWh/yr Generated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass and Product Cooling</td>
<td>20,574</td>
<td>25,500&lt;sup&gt;1&lt;/sup&gt;</td>
<td>20,574</td>
</tr>
<tr>
<td>Water Heating</td>
<td>50,406</td>
<td>72,000&lt;sup&gt;3&lt;/sup&gt;</td>
<td>50,406</td>
</tr>
<tr>
<td>HVAC/General Usage</td>
<td>31,890</td>
<td>32,000&lt;sup&gt;4&lt;/sup&gt;</td>
<td>31,890</td>
</tr>
<tr>
<td>Total per year</td>
<td>102,870</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This means that aside from electrical equipment operation (power tools, lighting, etc.), 70% or more of the facility’s electricity load can come from heat and absorption chilling driven off heat.

1 Uses heat from CHP for hot water & absorption chiller. Uses self-generation for HVAC/General Usage load and digester facility load; the balance is exported.

2 kW calculated as energy value; in this case in cooling and not electricity. 17kW * 5hrs/day * 300 days/yr = 25,500kWh

3 kW calculated as energy value; in this case heating and not electricity 30kW * 8hrs/day * 300 days/yr = 72,000kWh

4 Load for HVAC/General Usage and Digester Load covered by 35kW PV rooftop solar

5 Assumes 31,890kWh for HVAC/General Usage and 68,110kWh for digester load used on site. NOTE: prioritized on-site use of power may not be possible under BioMAT tariff which may require 100% export of power.
Combining biogas and syngas

Biogas generated in an anaerobic digester can be mixed with syngas generated from a gasifier system since both are combustible gasses: CH4 in the case of biogas and H for syngas. The challenge is in setting the burners of the combustion device (internal combustion engine, for example) to accommodate the potentially fluctuating gas constituency in the gas flow. However, this should not prove a barrier to implementing the combination of gasses from the two systems.

A standard internal combustion engine is the best technology for generating electricity from the combined fuels. Unlike fuel cells, which require removal of carbon dioxide from the gas, internal combustion engines can consume the raw gas without pre-processing (other than reduction of H2S and H2O).

When using an internal combustion engine for any type of gas, air emissions for NOx and H2S must meet regulator standards set forth by local Air Quality Management Districts. While each district is able to set its own standards as dictated by the air quality in that region, most California AQMDs have adopted the most stringent regulations as outlined by the San Joaquin Valley Air Quality Management District, which can be as low as 9ppmv @ 15% O2 for NOx. Since NOx is the most closely regulated emission from IC engines, an installation will require some mitigating technology such as a Selective Catalytic Reduction (SCR) system. The SCR technology can be supplied by the genset manufacturer or can be sourced separately. All air emissions must be source tested to comply with AQMD permits.

PV solar

General Usage electricity estimated by Dakota Global is 31,890kWh/yr. General usage includes HVAC, lighting, electrical equipment, etc. It does not include cooling of product or heating water. The digester will consume 24,000kWh/yr for operations as well, bringing total electricity requirement to ~56,000kWh/yr

In Placer County the generation of 56,000kWh/yr would require a 35kW PV solar array. Using 280W panels, it would require 260 panels on 5,600 sq ft roof space. The budget to use for a 35kW PV installation is $52,000.

Consideration for the structural load of the panels would need to be calculated into the engineering of the building, and that cost is not accounted for in this report. In addition, the direction the roof faces as well as the pitch of the roof will have an effect on the PV install. Biogas Energy can perform the PV solar installation at the same time as the digester installation.

Placer County’s mPower program is an option to finance the PV system. However, it is recommended to first include the PV solar in all grant applications to cover costs.
CHAPTER 5: FINANCIAL ANALYSIS

A financial model was created to examine the performance of the two anaerobic digestion options recommended in this proposal: 1) drop only digestion and 2) co-digestion of food waste with drop. The analysis examined the financial implications of each project in order to determine an internal rate of return for funds invested in the technologies.

Grant funding is a critical input variable for the technology, since a dollar to dollar comparison to using conventional energy sources does not take into account the environmental and social benefits that accrue to integrating renewable energy generation into the project. Therefore, the project assumes 25% grant funding, which is reasonable as the amount provided by the USDA REAP program, with more grant funding available to make the project more financially viable.

Financial Model Assumptions

<table>
<thead>
<tr>
<th>Capital Cost Drop-only digester</th>
<th>$794,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost food waste co-digestion</td>
<td>$1,370,000</td>
</tr>
<tr>
<td>Interconnect Cost</td>
<td>$200,000- $2,000,000 Determined by PG&amp;E. There is no way to predict.</td>
</tr>
<tr>
<td>Electricity purchased</td>
<td>$0 Assumes 100% of power covered by on site production</td>
</tr>
<tr>
<td>Economic life</td>
<td>20 years Industry standard</td>
</tr>
<tr>
<td>Interest rate</td>
<td>N/A CalRecycle loan is 5%</td>
</tr>
<tr>
<td>Debt term</td>
<td>N/A</td>
</tr>
<tr>
<td>Grant coverage</td>
<td>100%</td>
</tr>
<tr>
<td>Financing</td>
<td>None required 100% grant coverage</td>
</tr>
<tr>
<td>Labor for Drop-only digester</td>
<td>None for drop only: part time work for meat processing plant operator Part time work for 3 workers for co-digestion plant. Operation of equipment should be part-time task of meat processing employee.</td>
</tr>
<tr>
<td>Labor for food waste co-digestion</td>
<td>80 hours/wk @ $35/hr Ideally operation would be done part time by meat plant employees, but handling food waste can be an issue depending on reception.</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>% of energy produced</td>
</tr>
<tr>
<td>Cap spending reserves</td>
<td>As needed</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
</tr>
</tbody>
</table>
| Tax rates             | Federal: 34%  
State: 9%  
County 2%  
Assumes sales tax exemption via CAEATFA. | Since the project does not make profit, federal tax write off can be passed through to meat processing, or if S corp, to owners. County tax is a significant expense. Please note that any grant funding received by the project would be subject to federal income tax, so a CPA should be consulted for the implications of that tax. |
| Waste disposal costs  | N/A       | Not included in this model since they are presumably part of the meat processing plant model and would not change with the proposed technology. |

**Drop Only**

As a small project the financial outlook for a profitable operation has been in question, especially if funded without grant money. The financial model shows clearly that the revenue of the project, if the project is not financed with grant funding, does not justify the expense. Debt or investor financing for a project that has no chance of making a return on investment is not possible.

In order to ensure project viability, 100% (or close to that) grant financing would be optimal. Grant funding would come from a combination of state and federal sources that are looking to support rural business development, renewable energy generation, and greenhouse gas mitigation. Since there are multiple benefits to the digestion of the drop aside from the income or savings associated with it, SFMC should investigate all grant resources possible.

**Co-Digestion of Food Waste**

Capital required for the project increase significantly, as does energy production. The conundrum created by the added energy is what to do with it, since it will be far more than is required by the meat processing facility. If power will be used on site in order to
access SGIP funding, significant unused capacity must be added to the project, i.e. co-
located tenants who can purchase the power on site and use up whatever is generated.
This scenario is not included in the modeling since it creates more complex dynamics in
the project and shifts priorities to “let the cart drive the horse”.

The financial model assumes that the surplus electricity generated will be sold via the
Bioenergy Market Adjusting Tariff\(^6\), and therefore the project is not eligible for SGIP
funds. The other issue is that utility interconnection costs can be crippling. In order to
interconnect and sell power onto the grid, the project must first pay PG&E to perform a
Systems Impact Study which can cost $15,000 or more. The results of the study
determine what the interconnection cost will be, and we have seen that cost come to
$2,500,000.

One striking figure to note is that the Income Statement shows a loss of $133,000 per
year which can be used to offset taxation on the grant funding. Meanwhile the cash flow
shows $7,124 increase each year.

Explanation of Assumptions in .xls files
- **Inputs** Describes tons of digester feedstock per day, 7 days per week.
- **Production Estimates** Contains biogas produced and how that biogas is utilized in the
  facility.
- **Capital Cost** Estimates budgets for each project category.
- **Revenue Sources** Describes monthly revenue from each category. Change cells in grey
to change income statement
- **Capital Sources** Lists categories of where the capital comes from
- **Bank Loan** Used if Longterm bank loans are included in Capital Sources
- **mPower Financing** Fill in with information from
  http://www.mpoweradvantage.net/calculators/annual-payment
- **Operating Expenses Per Month** Lists variables for operating expenses. Note the burden
  of county property taxes.
- **Valuation and IRR** Uses data from Income Statement to calculate Internal Rate of
  Return

Please note: monthly numbers in the Income Statement & Cashflow tab can be hidden
or expanded by clicking the -/+ symbol above column BK

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\(^6\) https://www.pge.com/en_US/for-our-business-partners/floating-
pages/biomat/biomat.page
CHAPTER 6: GRANTS, CREDITS, INCENTIVES

Incentives to build renewable energy projects depend upon federal and state legislatures who approve funding for various programs. While California offers several grant and incentive programs, the federal government has limited offerings and only time will tell how the current political climate changes in the coming months.

State-Level Incentives
California enjoys some of the most aggressive incentives of any state in the USA as it prioritizes climate change mitigation, renewable energy generation, and environmental protection. Several state agencies provide financing and grant programs to fund projects like the one considered.

California Energy Commission
The goals of the California Energy Commission (CEC) include funding projects that achieve energy efficiency, generate renewable energy, and demonstrate new means of conserving and making energy. They invest millions of dollars annually in grants on a competitive application basis, and this project meets eligibility criteria for several past programs. The challenge for SFMC is to coordinate its grant application in a timely manner when grant opportunities come up. It would behoove SFMC to assemble its project plan in such a way that it could be tailored to the specific requirements of a particular grant announcement.

Current solicitations that the project would have qualified for, but are either expired or expiring:

- Advanced Cutting-Edge Technologies and Strategies to reduce energy Use and Costs in the Industrial, Agriculture and Water Sectors (GFO-16-305)
- Emerging Energy Efficient Technology Demonstrations (EEETD) (GFO-16-304)
- Novel Solutions to Accelerate Deployment of Small and Micro-Scale Combined Cooling Heating and Power Systems (GFO-16-503)

CEC grants often require match funding, but this can be in the form of cash or in-kind contributions, giving applicants some flexibility in their approach.

SFMC should subscribe to CEC email notifications for upcoming grant solicitations at http://www.energy.ca.gov/listservers/ and work with a consultant to prepare applications when they come up.
**CalRecycle**
CalRecycle manages the state’s recycling and waste management industries and provides key financing vehicles that would apply to this project.

Grants: CalRecycle’s Greenhouse Gas Reduction Fund was established in 2012 to receive Cap-and-Trade proceeds to fund projects that reduce GHG emissions. The GHG Reduction Grant program has an Organics Grant Program that promotes infrastructure development that achieve GHG reductions. The eligibility of this grant for SFMC is questionable if food waste is not digested, since the grant requires that the feedstock for the project be diverted from landfill. Since the meat waste is going to rendering, it may not be eligible for the CalRecycle GHG grant. That said, CalRecycle can be approached to make the case that the project’s AD component is reducing GHG emissions in a novel way, so they may allow the application.

If the food waste digester is implemented into the project, the digester system is eligible for CalRecycle grant and loan financing. The grant program is expected to be announced Q1 2017, so preparation should begin immediately for an application.

Loans: CalRecycle’s Greenhouse Gas Reduction Loan Program funds new organics infrastructure, including AD, to reduce methane emissions from landfills and “further GHG reductions in upstream resource management and manufacturing processes”

Loan applications undergo a rigorous vetting process, but they work closely with applicants to submit successful proposals. Interest rates are low. Again, the food waste AD would be a natural fit for this financing, but the animal waste may be problematic since it is not going to landfill. Timing for applying for loans is ongoing, so no deadlines are approaching.

SFMC should subscribe to CalRecycle email notifications at http://www.calrecycle.ca.gov/Listservs/ including Organic Materials Management, Greenhouse Gas Reduction Programs, Climate Change, and California’s 75% Recycling Initiative.

**California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA)**
CAEATFA provides sales and use tax exclusions to manufacturers that promote alternative energy. Companies that take advantage of this incentive are exempted from state sales tax, which can save 8-9% of the cost of the renewable technology. The application process is straightforward with staff providing assistance. It should be noted

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7 [http://www.calrecycle.ca.gov/Climate/GrantsLoans/GHGLoans/default.htm](http://www.calrecycle.ca.gov/Climate/GrantsLoans/GHGLoans/default.htm)
that the program has administration fees that are due upon acceptance of terms and is 0.4% of the equipment value, and not less than $15,000.

**Self Generation Incentive Program (SGIP)**

SGIP provides rebates for renewable electricity generation. Biogas currently has $1.31/Watt incentive, and when paired with the $0.42/Watt internal combustion (IC) engine incentive, would earn $1.73/Watt total. So a 120kW generator running on biogas in an IC engine would receive $207,600.

For projects 30kW and higher, the SGIP program pays 50% up front and 50% over 5 years based on actual production.

This is a popular incentive that fills quickly, so planning for the next SGIP opening (typically February of each year) is critical.

This incentive only works for electricity production, so a boiler replacing power consumption would not be eligible. Solar is also not eligible for SGIP funding.

**Net Energy Metering (NEM)**

The NEM tariff enables businesses that generate enough electricity to cover their consumption to “net out” their electricity bill at the end of the year, potentially avoiding having to pay for any power supplied by the utility. During times when the on-site generator is producing more power than can be consumed, surplus power is fed to the utility grid. Then when the on-site demand exceeds the generator’s capacity, electricity is taken from the utility grid. At the end of the year the power draw and push net each other out so no electricity is paid for by the consumer.

**Federal Incentives**

**USDA Rural Energy for America Program (REAP) Grants and Loans**

The REAP program provides up to $500,000 in grants (funding up to 25% of total project costs), and loan guarantees to eligible projects (guaranteeing up to 85% of up to 75% of total project costs). The SFMC project fits eligibility criteria as a small business in a rural area.

The applicant must come up with 75% of the project cost for the grant program, however that funding can come in the form of a grant received at the state level.

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For loan guarantees, the applicant must work with a commercial bank who must process the loan on their own terms. Clearly the USDA guarantee will help the bank justify the loan.

**County Level Incentives**
Placer County will assess property taxes on the project. However, they may be amenable to providing tax incentives for a project like this since it is creating jobs, keeping capital in the county, and providing a critical service. A conversation with the county supervisors is in order sooner than later to see what arrangements may be possible since county tax accounts for the largest cost center for the project (see financial models)

As described previously, Placer County’s mPower program provides financing for energy efficiency and water saving technology. It would finance a PV installation and amortize the cost over the 20 year life of the technology.

**CONCLUSIONS**

Anaerobic digestion of the meat processing drop feeding biogas to a boiler, coupled with rooftop PV is the simplest path to a self-powered facility. As a small project, however, the financial benefits of the project are not significant even with 100% grant funding. Motivation for adopting the waste-to-energy system must be driven by factors in addition to profit: stewardship, self-sustenance, research, etc.

Integration of food waste digestion will generate significantly more energy for the project, but that also comes with the added burden of becoming a waste and power generation company rather than on focusing on meat processing.

In order to move forward with either option, grants are the only viable path to financing the projects. As projects that create ancillary benefits to the state at large, the grant funding has a legitimate social value.

In either path the anaerobic digestion technology described by Biogas Energy is ideal for processing the waste into biogas.

**ATTACHMENTS**

Drop Financials.xls
Food Waste Financials.xls
(Both in e-versions)